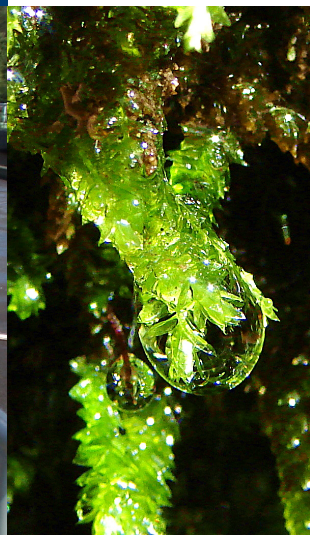

EMWATER
EFFICIENT MANAGEMENT OF WASTEWATER

EMWater Trainer's Toolkit

Efficient Management of Wastewater

One World – German Development Policy

InWEnt
Internationale Weiterbildung und Entwicklung gGmbH
Capacity Building International, Germany

MEDA Water

EMWater
Trainer's Toolkit

Efficient Management of Wastewater

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Preface

Dear trainers,

The Trainer's Toolkit (TTK) is designed as a support tool for trainers and experts who work in the field of wastewater treatment and reuse in preparing their lectures for engineers and students. The TTK should provide these trainers with modules on different subjects in this field, including examples of case studies from the region, with theoretical and practical background of the topic, innovative aspects of the subject, exercises and group work, problems and solutions related to the topic, references, check lists and skill tests.

A total of four modules on the topics was developed:

- Waste Water Management (module 1)
- Conventional Wastewater Treatment (module 2)
- Alternative Solutions of Wastewater Treatment (module 3)
- Wastewater Reuse (module 4)

For modules 1 – 4, materials are provided in the TTK which allow for 3 days of training with 6 training hours per day. While the TTK includes a suggested training schedule, the trainers are strongly encouraged to alter this schedule according to their own preferences and especially according to the training needs of the target group. As the EMWater TTK is designed for a very wide target group it may not cover all the specific needs of each target group.

A module on methodology is designed to provide the trainers with resources for the training design and implementation ranging from creativity techniques to project management.

Yours sincerely,

Andreas Bethmann
InWEnt - Capacity Building International, Germany
Division Environment, Energy and Water

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Timetable

The EMWater Project

EMWater – "Efficient Management of Wastewater, its Treatment and Reuse in the Mediterranean Countries" – is an EU-funded project co-funded by the German Government that encourages reuse-oriented wastewater management. The EMWater project promotes innovative wastewater treatment and reuse solutions in its four partner countries Jordan, Palestine, Lebanon and Turkey through:

- Trainings of staff involved in water resources management,
- Development of a guide for decision-makers and water resources planning engineers,
- Applied research and demonstration of innovative solutions by the implementation and operation of pilot plants, and
- Dissemination and awareness raising activities.

Experts from the field, decision-makers, interested citizens, and civil organisations are involved in all stages of project implementation.

Project Partners

InWEnt – Capacity Building International, Germany, an international foundation for capacity building, is the leading institution in the project consortium and contributes with its strong experience in human resources development by designing and implementing training programmes throughout the world.

The **Birzeit University in West Bank/Palestine** has a range of institutes, centres and programmes that carry out community-oriented activities, aiming at a sustainable development of Palestine and the preparation of the younger Palestinian generation to become responsible leaders and citizens.

The **Al Al-Bayt University of Al Mafraq in Jordan** serves the local community and helps the country in solving problems of national and international concern by applying their expert knowledge in improving environmental protection.

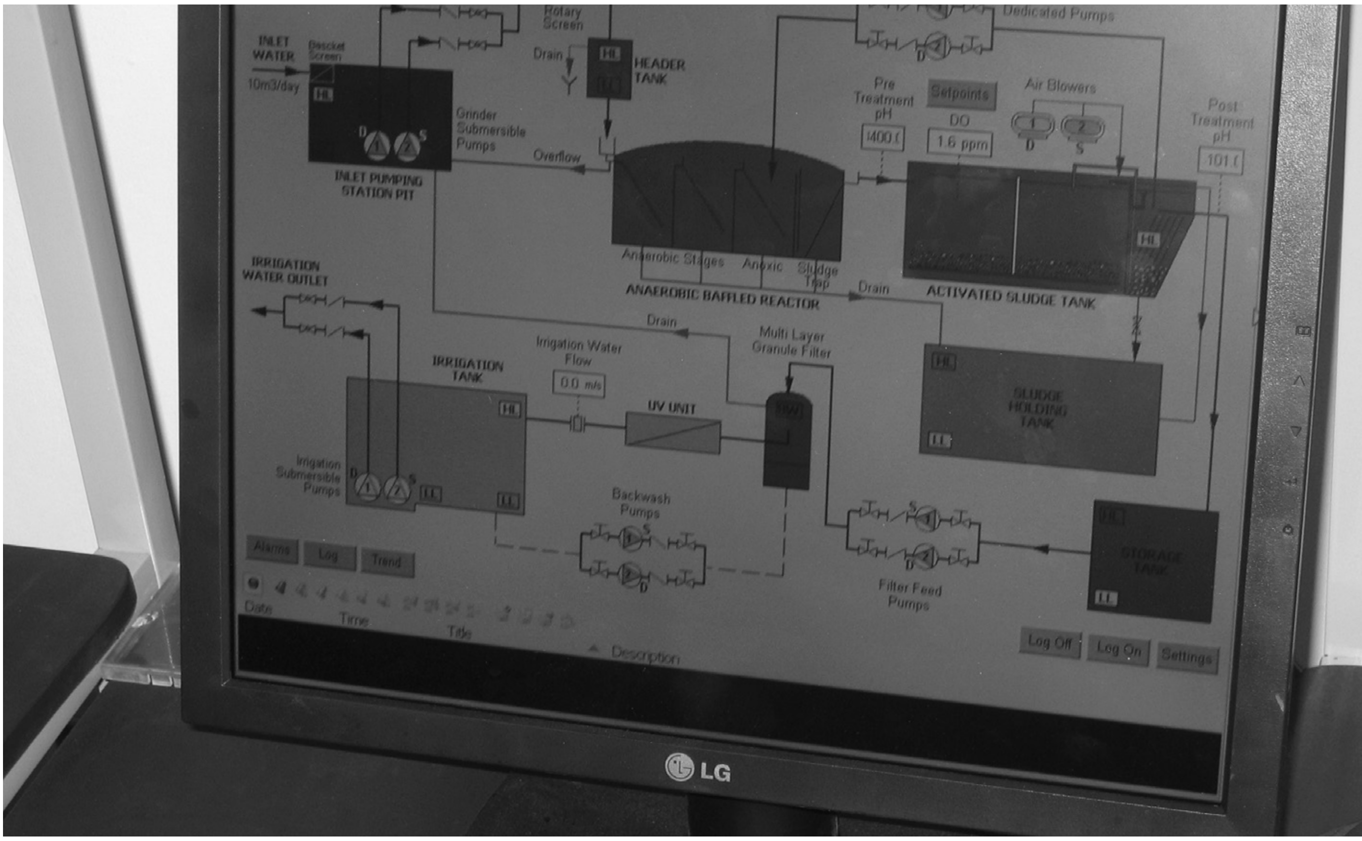
The two Lebanese partners the **University of Balamand in Tripoli** and the **Lebanese American University in Byblos** are private, non-profit, independent Lebanese institutions of higher learning. One of key aims of both universities is to provide an intellectual, moral and cultural antidote to the long years of internal war in Lebanon.

The **YILDIZ Technical University of Istanbul in Turkey** is a Government University which defines and continues to update methods of engineering and architecture. It has a modern educational environment and a strong academic staff.

The **Hamburg University of Technology** is a young university of technology highly regarded in Germany for the interdisciplinary and industrial orientation of its research.

ENEA, the **Italian National Agency for New Technologies, Energy and the Environment**, is one of the largest scientific and technological state-owned Italian institutions with a specific mission in applied research activities, technology transfer and dissemination of innovation to companies.

Adelphi Research, an independent, non-profit research institute, develops and implements innovative sustainable development strategies. Adelphi Research increases awareness and understanding of the political, economic and technological forces driving global change, and provides expert knowledge and advice to decision-makers at all levels of policy-making.



Module 1
Wastewater Management

2007

1. Introduction

The module on conventional wastewater treatment covers five topics:
1. Sources and flows of wastewater
2. Wastewater management in urban, peri-urban and rural areas
3. Economic instruments for wastewater management
4. Wastewater composition and parameters
5. Wastewater analytics

with the following objectives:
- Introduce the basic concepts of water quality management
- Demonstrate the relevance and applicability of wastewater analysis
- Draw up the connection between water demand management and wastewater treatment
- Basic differences between centralised and decentralised treatment systems

After completing the course participants should be able to:
- Have a basic understanding of the most relevant water and wastewater parameters
- Be familiar on a theoretical basis with common analytical techniques for water and wastewater parameters
- Understand tools for water demand management and be enabled to design a practical water demand management system

For each module 1 – 4 materials are provided in the Trainer`s Toolkit which allow for a 3 day training, 6 training hours per day. While the Trainer`s Toolkit includes a suggested training schedule, the trainers are strongly encouraged to alter this schedule according to their own preferences and especially according to the training needs of the target group. The EMWater Trainer`s Toolkit which is designed for a very wide target group, can of course not fulfill the needs of each specific target group

2. Suggested timetable for training

Wastewater Management

Training module 1

Day 1

9:00 – 9:30	Introductory Session
Topic 1: Sources and flows of wastewater	
9:30 – 10:30	Session 1 – Topic Presentation I
10:30 – 11:00	Coffee Break
11:00 – 12:30	Session 2 – Topic Presentation II
12:30 – 14:00	Lunch
Topic 2: Wastewater management in urban, peri-urban and rural areas	
14:00 – 15:30	Session 1 – Topic Presentation I
15:30 – 16:00	Coffee Break
16:00 – 17:30	Session 2 – Role play

Training module 1

Day 2

Topic 2: Wastewater management in urban, peri-urban and rural areas	
9:00 – 11:00	Session 3 – Topic Presentation II
11:00 – 11:30	Coffee Break
11:30 – 12:30	Session 4 – Case Study
12:30 – 14:00	Lunch
Topic 3: Economic instruments for wastewater management	
14:00 – 15:30	Session 1 – Topic Presentation
15:30 – 16:00	Coffee Break
16:00 – 17:30	Session 2 – Case Study Exercise

Training module 1

Day 3

Topic 4: Wastewater composition and parameters	
9:00 – 10:30	Session 1 – Topic Presentation
10:30 – 11:00	Coffee Break
Topic 5: Wastewater analytics	
11:00 – 12:30	Session 1 – Topic Presentation
12:30 – 14:00	Lunch
14:00 – 15:30	Session 2 – Exercise
15:30 – 16:00	Coffee Break
16:00 – 16:30	Session 2 – Exercise (Continuation)
16:30 – 17:30	Final / Feedback Session

3. Introductory Session

Session overview

Time
Introductory Session: Round of Introductions – 30 – 60 min

Objectives
- To get to know participants and give them an opportunity to get to know each other.
- To make participants feel comfortable in the seminar group.
- To clarify organisational issues.
- To give participants an overview of the module contents and structure.

Material
- Projector
- Paper, pens
- Flipchart (or blackboard)
- Marker (or chalk)
- 4 thick felt pens or markers
- 4 large sheets of paper (flipcharts) with four different beginnings of sentences in the centre (you can encircle them to make it clear that they form a kind of starting point):
  - "I signed up for the seminar because ..."
  - "I would like the following topics/ questions to be dealt with in the seminar: ..."
  - "In this seminar, I would not like to ..."
  - "I will be satisfied on going home if ..."

Session guide

1. Welcome participants and introduce yourself.

2. Ask participants to introduce themselves to the group, and to state their experience in the wastewater sector and their motivation to attend the seminar. If you feel that any motivations or expectations do not match well with the scope of the seminar, take a note and discuss them after the introductory round.

3. Group mind map: Spread out the four posters and distribute the felt pens (one for each sheet). Ask participants to split into four groups and choose one of the sheets. Each group is requested to compile and take down their expectations, motivations and dislikes regarding the contents and course of the seminar, but also those relating to the group and the trainer. In the manner of a mind map, each new aspect should be written down close to the centre and connected with a line to the circled half-sentence. Every idea that forms a sub-item is connected to the higher-ranking aspect. After 5 minutes, ask the groups to move on to the next poster. Once the groups have completed all four "stations", pin the posters to the wall next to each other (where this is not possible, you can also fix them on the flipchart in succession). Now read out what has been taken down, and inquire if you do not understand any of the points made. If any expectations do not match with the contents you intend to deal with, or cannot be treated in such detail, raise and explain this point immediately to avoid disappointments later in the course. After the discussion, leave the papers hanging at the wall or store them away for the summing-up session.

4. Present the schedule for the next three days as displayed in the presentation. Alternatively, you can hand out copies/ prints of the schedule to the participants.

4. Topic 1:

Sources and flows of wastewater

Topic overview

Time
Session 1: Topic Presentation I – 60 min
Session 2: Topic Presentation II – 90 min

Objectives
- To discuss the importance of integrated water demand and wastewater management
- To recall the different streams of wastewater and their quantities
- To present legal effluent quality requirements and those depending on follow-up uses

Participants should be able to
- Reproduce the relationship between water demand and wastewater quantities, and have in mind some core water consumption figures.
- Recall the types of wastewater to be expected from different sources, including municipalities and industries, and know where to find all relevant information when assessing a specific situation.
- Give the major reasons for wastewater treatment, and explain their significance for priority-setting in decision-making.
- Explain what kinds of effluent quality requirements exist and what institutions are involved in setting them.

Material
- Projector
- Flipchart (or blackboard)
- Marker (or chalk)
- Pocket calculators (one for 3-4 participants)
- Slides
- Assignment paper

This topic is covered in 2 sessions:

1. Session 1 – Topic Presentation I

This session mainly serves to recall the different wastewater streams and their particular characteristics and typical quantities in different parts of the world. This should bring to mind that the concentration of contaminants in wastewater strongly depends on water consumption, and prepares the ground for the ensuing discussion of treating wastewater flows separately in sustainable wastewater management.

2. Session 2 – Topic Presentation II

The presentation illustrates the importance of water demand management for wastewater management. The second part is dedicated to effluent quality requirements to be respected for risk-minimisation in different reuse options, and to the types of legal requirements that may exist at various administrational levels.

4.1 Session 1 – Topic Presentation I

Types of wastewater and wastewater flows

Session overview

Title Types of wastewater and wastewater flows

Objectives
- To recall the purpose of wastewater treatment, bearing in mind that this can be helpful when setting priorities in decision-making.
- To present typical water consumption figures, types of wastewater, and wastewater flows, introducing also the core factors used in wastewater management.

Teaching method presentation using PowerPoint-slides and group exercise in groups of 3-4 participants

Time estimation 60 minutes

Needed material Projector, slides, flipchart (or blackboard), marker (or chalk), pocket calculators (one for 3-4 participants), assignment paper

Session guide

1. Give participants a brief overview over the contents of this session with slides 2-3.

2. Begin with a discussion about the purpose of wastewater management and treatment: What priorities have participants developed through their professional experience? Write answers down on the flipchart. See if there are grossly contradictory opinions, or if the group reaches a consensus.

3. Display slide 5 to sum up the discussion, and add into the slide whatever further arguments have been put forward.

4. Present slide 6 to explain the different qualities that can be reached, corresponding to different levels of treatment.

Levels of Treatment

Treated effluent	refers to an effluent after the lowest level of treatment.
Reclaimed water	is an effluent treated to the extent of being suitable for reuse, e.g. in agriculture.
Repurified water	represents the highest level of treatment, which would be suitable for human consumption.

5. This raises the question to which level the effluent should be treated. Treatment to the highest standard is highly costly, requires skilled maintenance of treatment facilities and is highly energy-consuming. Use slide 8 to discuss what priorities should be set.

6. Display slides 10-13 to recall the origin of wastewaters and the terms used for different wastewater streams.

7. Discuss the concept of flow factors using slide 15. Flow factors are a highly important tool in the design of wastewater treatment systems as they allow for an estimation of the wastewater quantity to be treated.

For example, a unit that is to be designed based on short detention periods, say 2 hours, should be designed based on the maximum flow, while units with rather high detention periods, say 24 hours, may be designed based on average flows.

The precision of the estimate depends on the accuracy of the variables, such as per capita water consumption, and on the correlations between them, which are mostly established empirically and may thus vary between regions.

Future projections

Given the lifetime of wastewater infrastructure, assessing the quantity of wastewater to be treated has to take into account future changes. One of them is economic growth rates, which are not easy to foresee, and the increased per capita use connected with higher living standards. Another major factor is population growth.
A formula for projection is given on slide 19. While n as the planning period is often taken as 20 (i.e. 20 years into the future), it is better to calculate the projection in 5-year intervals: n = 5, 10, 15, 20, "in order to phase the development of the proposed wastewater treatment facilities. Phasing is important since... it is financially more sensible to build it for the population in, say, 5 years time and then expand it in 4 years time to serve the population anticipated in 10 years time, and so on." (Mara 2003)
Not only wastewater quantities, but also the contaminant loads, e.g. organic matter, increase with growing prosperity. No correlation has, however, been established for the MENA region so far.

8. Introduce the formula for the daily municipal dry weather flow based on the number of inhabitants, using slide 16. Finding out "q", the daily per capita water consumption, may require some initial research, as does "k", the return factor for wastewater, especially where these variables are not centrally monitored by one local water supplier, or where only a part of all citizens is included in the monitoring.

9. Slide 17: The industrial wastewater flow (denominated "E" in the previous formula) is more challenging to assess still, as it depends on the type of industry (cf. slide 10) and the time of day. Large plants or production sites are, however, more likely to have an individual metering, as they are mostly charged on the basis of actual water consumption rather than on a flat rate (e.g. per capita) basis.

10. Display slide 18-19: Besides the daily dry weather flow, further flow figures are relevant as it comes to conceiving a collection and treatment system. The most important ones include the mean daily flow, average flow and the peak flow.

All formulae, however, need to be adapted to local circumstances: In regions with seasonal rainfalls, for example, precipitation can exceed the factor assumed for the peak flow. Where a combined sewer or open decentralised treatment (ponds or lagoons) are envisaged, local meteorological figures on precipitation maximums and averages should be consulted.

11. Explain extrapolations of current use into the future (slide 20).

12. Bring to mind once more that the formulae are approximations based on empirical findings, which have to be adapted to local conditions (slide 21)!

13. Finish with a small exercise (see below). Ask participants to split into groups of 3 or 4, and distribute paper, pens, and a pocket calculator to each group. Give groups 15 minutes to solve the task, and discuss the results briefly in the plenary.

Exercise

Consider a city with 150 000 inhabitants with a daily per capita consumption of 70 l and a return factor k = 0.8. All inhabitants are connected to the network.

What is the

- Dry Weather Flow
- Mean Daily Flow
- Maximum Daily Flow

to be expected?

Consider a city with 150 000 inhabitants with a daily per capita consumption of 70 l and a return factor k = 0.8. All inhabitants are connected to the network.

What is the

- Dry Weather Flow
- Mean Daily Flow
- Maximum Daily Flow

to be expected?

4.2 Session 2 – Topic Presentation II

PPT

Water demand and effluent quality

Session overview

Title Water demand and effluent quality

Objectives
- To recall the relationship between water demand and wastewater quantities
- To understand what effluent quality requirements are set for, and by whom

Teaching method presentation using PowerPoint-slides and exercise either in pairs or with the whole group

Time estimation 90 minutes

Needed material Projector, slides, flipchart (or blackboard), marker (or chalk), assignment paper

Session guide

1. Briefly give an overview of the session contents (slide 2-3).

2. Recall the four types of water use(r)s (slide 5) and the typical daily water consumption per capita (slide 6) and in industry (slide 7).

3. Introduce the aims (slide 9) of water demand management. Water demand is an issue not only for those concerned with water supply, but has to be taken into account when assessing the wastewater treatment capacities required.

4. Water demand depends on a number of factors (slide 10) and can be influenced through political, institutional, economic and technological instruments (slides 11-12)

5. Assessing water demand (slide 13) can be as simple as inquiring with the one municipal water supplier who covers 100% of urban residents. In areas where large parts of the population are not connected to the piped water network or neighbourhood standposts, but rather buy their water from water vendors or draw it from wells, this can become more of a challenge.

Disclosing patterns of informal water supply can be important also with respect to the effluent quality required: If the treated effluent is to be discharged near the sources that residents use for water supply, the hygienic standards (e.g. concentrations of pathogens) may have to be stricter.

6. Let participants do a short brainstorm exercise, either in the whole group or in pairs with their neighbour:

Exercise

1. Which industries in the participants region are particularly water-intensive?
2. How does domestic water consumption increase with different types of water supply (public well / tap, private well, individual tap)?
3. Do the participants know how an increase in water consumption would - or does - affect the wastewater management systems in place?

1. Which industries in your region are particularly water-intensive?

2. How does domestic water consumption increase with different types of water supply (public well / tap, private well, individual tap)?

3. Do you know how an increase in water consumption would - or does - affect the wastewater management systems in place?

7. Present slide 15: How far should a wastewater be treated? Not everything that is technically possible is financially feasible and sustainable, nor realistically necessary. The requirements for the envisaged reuse or discharge should be carefully assessed before deciding on a specific treatment: Will the effluent be re-used in agriculture? Will it be discharged into a water body hosting a sensitive ecosystem? Participants should realise that the selection of a technology has far-reaching consequences; thus the first 40% of treatment can usually be attained at affordable level, the next 40% is more costly, and the last 20% will often be inhibitive.

8. Explain the principles of the regulatory regime (Slide 16). Legislation laying down effluent quality requirements will usually be set and enforced by the competent regulatory agency. This can be a part of the administration at national (i.e. belonging to government) or district or province level, or of a municipality. Applicable legislation can be set down in a law with subordinate decrees and complementing local by-laws. Requirements can be set either for the receiving environment or for a type of discharger. The former includes critical values for discharge of wastewaters into coastal waters or into rivers of different quality. The latter includes thresholds applying for direct dischargers, such as sewage plants and (large) industrial entities, and indirect dischargers (smaller industrial works, households). These may or may not be differentiated again depending on follow-up use.

9. Slide 17: Upper limits are usually set for the most critical wastewater parameters (cf. topic 4): BOD (or TOC) to limit eutrophication, suspended solids, ammonia for its toxicity, and escherichia coli as an indicator of contamination with faecal pathogens in total, to reduce the risk posed to public health.

10. Show the standards of the UK Royal Commission on Sewage Disposal for wastewater effluents discharged into rivers and the thresholds set by the Aruba Protocol for domestic wastewater discharged into the marine environment of the wider Caribbean region (slides 18-19) as examples of quality requirements for different effluents into inland and coastal waters.

11. Slide 20 gives a brief summary of the lesson.

12. Take the rest of the lesson for a self test..

4.3 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. Give three principal reasons why wastewater should be treated.

a) ______________________________

b) ______________________________

c) ______________________________

2. What is the quality wastewaters should be treated to?

a) The best quality possible.
b) It needs to fulfil national regulatory requirements.
c) The quality depends on the concentration of contaminants before treatment.
d) The quality depends on the follow-up use of the effluent.

3. What is the difference between reclaimed and repurified water?

a) Reclaimed water is higher in quality.
b) Reclaimed water is treated for re-use in agriculture.
c) Repurified water is suitable for drinking.
d) None, both are of the same quality.

4. How do the sources of wastewater differ?

a) Unlike industry and households, agriculture is mostly a non-point source of pollution.
b) The effluents of industry, households and agriculture differ in quantity and quality.
c) Industries always have longer connections to the main sewer network than households, to retain some of the contaminants.
d) The concentrations of domestic wastewater components are higher in arid regions where less water is consumed per capita.

5. How do we calculate the dry weather flow of wastewater of a municipality?

a) Per capita use times the population served, plus infiltration plus industrial discharges.
b) 14 * (per capita use)$^{-1/6}$
c) Per capita use times inhabitants, plus infiltration.
d) Per capita use times mean daily flow.

6. What is an "equivalent population unit"?

____

____

7. What factors does the daily variation in flow depend on?
a) On the number and types of industries or workshops.
b) On the mean daily water consumption of industries or workshops.
c) On the number of households.
d) On the daily rhythm of households (mealtimes, working hours).

8. Why construct short-time detention units?
a) Short-time detention units are only constructed in areas with heavy rainfalls.
b) To be able to conduct maintenance works in the treatment system.
c) To match peak wastewater flows.
d) To buffer the mean daily flow.

9. What factors need to be taken into account in projecting wastewater quantities into the future?
a) Development of industries, which determine the composition of the wastewater.
b) Development of industries, which determine the amount of wastewater.
c) Expected increases in household income.
d) Expected distribution of industries within the municipality.

Answers:

1. Wastewater should be treated

- To prevent health risks by eliminating pathogens
- To reduce impact on aquatic ecosystems
- To eliminate unpleasant odours
- To make it re-usable in agriculture, horticulture, industry, etc.

2. b) and d)

3. b) and c)

4. a), b) and d)

5. a)

6. The effluent quantities of industrial facilities vary greatly, and need to be assessed individually for every case. Possible sources of information include:
   - Flow measurements
   - Questionnaires
   - Inspections

7. a) and d)

8. b) and c)

9. b) and c)

4.4 Literature

Brooks, D.; Rached, E.; Saade, M. eds. (1997), Management of water demand in Africa and the Middle East: Current practices and future needs. Ottawa: IDRC.

Gulyas, H.; Gajurel, D.R.; Otterpoh, R. (w/o yr.), Resource management sanitation. EMWater Computer-based training, Lesson B1.

Mara, Duncan (1994), Domestic wastewater treatment in developing countries. London: Earthscan.

Metcalf & Eddy (2003), Wastewater Engineering Treatment and Reuse. 4th ed. New York: McGraw Hill.

Özoguz, Y. (w/o yr.), Efficient management of wastewater, its treatment and reuse in the mediterranean countries. EMWater Computer-based training.

4.5 Recommended Reading

Mara, Duncan (1994), Domestic wastewater treatment in developing countries. London: Earthscan.

Metcalf & Eddy (2003), Wastewater Engineering Treatment and Reuse. 4th ed. New York: McGraw Hill.

4.6 Internet Resources

IDRC: WaDImena Regional Water Demand Initiative North Africa and Middle East
http://www.idrc.ca/wadimena/

InWEnt MENA Water Portal
http://gc21.inwent.org/ibt/en/site/mena/ibt/index2.htm

5. Topic 2:

Wastewater management in urban, peri-urban and rural areas

Topic overview

Time
Session 1: Topic Presentation I – 90 min
Session 2: Role Play – 90 min
Session 3: Topic Presentation II – 90 min
Session 4: Case Study – 90 min

Objectives
- To contrast the different paradigms of conventional and sustainable (waste)water management
- To discuss the key principles of wastewater management
- To present the different framework conditions in and requirements of urban, peri-urban and rural areas
- To emphasize the importance of stakeholder involvement and support for sustainable wastewater management solutions, and introduce methods and examples how to go about that

Participants should be able to
- Explain the concept of sustainable material flows in water and wastewater management.
- Explain and apply the key principles of wastewater management.
- Take into consideration the differences between urban, peri-urban, and rural areas in the design of centralised and decentralised wastewater management systems.
- Design a planning process that would involve stakeholders in the needs assessment, options analysis, and decision-making.

Material
- Projector
- Slides
- Paper
- Pens
- Flipchart (or blackboard)
- Marker (or chalk)
- Presentation

This topic is covered in 4 sessions:

1. Session 1 – Topic Presentation I

- The presentation covers the foundations of wastewater management, from the water and sanitation cycle to the different concepts of conventional and sustainable wastewater management and some key principles for concrete wastewater management projects. The importance of awareness-raising is highlighted with view to stakeholder support and cost-recovery.

2. Session 2 – Role Play

- Tying in with the end of the previous session, the role play allows participants to enact a stakeholder meeting at the beginning of a wastewater management scheme, and to try out how a joint needs assessment, options analysis and decision-making bringing together water users and wastewater managers can be carried out.

3. Session 3 – Topic Presentation II

- The second topic presentation on wastewater management in urban, peri-urban and rural areas is concerned primarily with the specific requirements of different settings. Centralised and decentralised wastewater management solutions are characterised especially with view to their suitability for different framework conditions.

4. Session 4 – Case Study

- The case study of the TepozEco project, Mexico, illustrates well the concept of a sustainable and locally adapted wastewater management solution, and gives insights on the process that led to decision-making and the implementation of the scheme.

5.1 Session 1 – Topic Presentation I

PPT

Conceptual Foundations of Wastewater Management

Session overview

Title: Conceptual Foundations of Wastewater Management

Objectives
- To introduce the concept of sustainable material flows in (waste) water management.
- To make participants familiar with the differences between urban, peri-urban, and rural areas.
- To recall the importance of awareness raising to gain public support for wastewater management.

Teaching method presentation using PowerPoint-slides and discussion and exchange of experiences between participants

Time estimation 90 minutes

Needed material Projector, slides, paper, pens

Session guide

1. Briefly give participants an overview of the session, using slides 2-3.

2. Discuss the rationale of wastewater management: Avoiding wastewater production (water demand management) is better than having to treat it for reuse, which is often a better option than full treatment or purification (slides 5-6). The relationship of water and wastewater should be discussed with respect to the typical changes in water quality that certain uses bring about.

3. Briefly recall the water and sanitation cycle (slides 8-9).

4. With that in mind, discuss the different paradigms of conventional and sustainable wastewater management: Centred on the idea of carrying wastewater and excrement away from households, conventional wastewater management uses treated water in large quantities to convey wastes to a central treatment system. Nutrients are diluted to a degree that does not allow for recovery and mixing domestic with industrial effluents and urban run-off makes it necessary to treat a large amount of water to a high degree. Sustainable wastewater management aims to separate the streams at the source, so as

to reuse resources and minimise the amount of water that needs full treatment (slides 10-13).

Talk with participants about their experiences and opinions: How does use in the household or in agriculture change the water's qualities? What components – e.g. nutrients – can be reused, and how?

5. Conditions for wastewater management vary significantly between urban, peri-urban and rural settings. Water uses, but also wastewater quantities and quality can be quite different, and so are various other factors including the economic situation of the users and the use of space in the settlement. Taking enough time to thoroughly assess the situation and the water users' needs is crucial to set targets and eventually decide on the treatment system of choice (slides 15-18).

6. Discuss the role of awareness raising for wastewater management. Especially in places where wastewater has not been treated at all previously and the state has no capacity to enforce the collection of fees, any wastewater treatment system will depend on water users' support and financial contribution for long-term sustainability. Any project in this field should therefore ensure the commitment of its beneficiaries, and foresee potential obstacles (slides 20-23).

5.2 Session 2 – Role Play

Municipal planning and people's needs

Session overview

Title Municipal planning and people's needs

Objectives
- To re-enact a real-life situation where awareness-raising and participatory needs assessment play a significant role in the planning process.
- To create awareness among participants what communication patterns can develop and manifest themselves, and to discuss how stakeholders feel in their respective roles.

Teaching method role play with ensuing discussion

Time estimation 90 minutes

Needed material flipchart (or blackboard), marker (or chalk)

Session guide

1. A staff member of the waste and wastewater unit of the municipal authority for public works has been assigned to assess the situation in an uncontrolled peri-urban settlement of a 1-million-city where no formal water supply or wastewater management system exists to date. She/he meets with the mayor of the urban district in question, and they decide to summon the residents of the area to a first meeting to discuss the need for sanitation and wastewater treatment.

2. Give each roleplay character 15 minutes preparation time and then take about 30 minutes for the role play. Two participants take the role of the staff member of the competent authority, another that of the urban district. The other participants play the residents of the area.

3. So far, water is bought from vendors, and the sewage drains onto the streets. The starting point of discussion is how residents feel about the current situation, what possible alternatives could be and which priorities they would have.

4. If the group is large enough (> 8 members), one or two participants can assume the role of an observer, listening to the play and observing communication patterns. They can contribute their findings to the ensuing discussion.

5. Take another 30 min. for the discussion, writing down the group's findings on the flipchart:

- What were residents' priorities?
- What concerns were raised?
- Did all stakeholders have a chance to voice their opinions?
- Did the powerful stakeholders 'talk down' on those with less influence?

Compare the outcomes of the discussion as the "look behind the curtain" with the suggested solutions noted on the flipchart during the roleplay:

- Have the communication patterns manifested themselves in the choice or formulation of solutions taken down?

5.3 Session 3 – Topic Presentation II

PPT

Wastewater Management in urban, peri-urban and rural areas

Session overview

Title Wastewater Management in urban, peri-urban and rural areas

Objectives
- To introduce the key principles of wastewater management.
- To become familiar with the respective advantages and disadvantages of centralised and decentralised wastewater management systems in urban, peri-urban and rural settings.
- To discuss criteria for technology selection.
- To place the processes of situation assessment and technology selection in the context of a typical project cycle.

Teaching method presentation using PowerPoint-slides and group exercise with ensuing discussion

Time estimation 90 minutes

Needed material Projector, presentation, paper, pens

Note:
Please bear in mind that the presentation contains more slides than can usually be shown in a 90 min session. We suggest reselecting the slides according to the topics considered most relevant for the course in question.

1. Give participants a brief overview of the session's contents and its embedding within the training structure, using slides 2-3.

2. Present the key principles of wastewater management, using slides 5-6: Do participants have any examples of how to implement the principles? What can go wrong if they are disregarded?

3. Outline the historical development of the conventional centralised wastewater management system, so as to make it clear that its strengths and weaknesses have to be seen as a historical development and in an urban setting (slide 8).

4. Introduce the centralised – piped – system of water supply and wastewater management depicted on slide 9.

5. Beginning with the collection of wastewater in centralised wastewater management, show the different types of sewer systems and explain their characteristics (slides 10-11), then give a brief characterisation of treatment in large wastewater treatment plants (slides 12-13) and conclude with the advantages and drawbacks of centralised systems (slide 14).

Conventional sewer
Requires slope (gravity) or energy (vacuum) and pumping stations for the transportation of the wastewater; allows for infiltration of run-off. Conventional sewer systems are most appropriate in densely developed areas.

Vacuum sewerage
Uses vacuum-driven transportation in areas where the gradient is too low to convey the wastewater by gravity. Capital costs are high, but lower than for conventional sewerage. Blockage can occur due to smaller pipe diameters; generally, the system requires skilled maintenance. The system is thus suitable for an urban setting.

Simplified sewerage
In principle similar to the conventional system, but using smooth-bore plastic drainage pipes, which allows for a reduction of the self-cleansing gradient and smaller pipe diameters. Due to small rodding inlets, fewer manholes are needed. The system is mostly applied in the transfer of smaller settlements using on-site systems to a semi-centralised system.

Settled sewerage
Again based on the conventional sewerage, but interposing a septic tank on properties, where most solids settle before the effluent enters the sewerage system. As the septic tanks have to be emptied, skilled maintenance is required; operation and maintenance costs are low, however.

6. Introduce the rationale of proximity in decentralised wastewater management (slides 16-17) and the various technologies of decentralised treatment systems (slides 18-19).

7. Decentralised wastewater management differs from centralised wastewater management in particular in that it requires a higher degree of maintenance and awareness on the part of the users. This has a number of implications for operation and maintenance,

which are discussed on slides 20-22. Conclude with the advantages and drawbacks of decentralised systems (slide 23).

8. Discuss what criteria need to be considered when deciding either on a centralised or a decentralised solution, using slides 25-27. Slide 23 gives a comparison of how much wastewater should be accounted for with any given type of water supply.

9. Begin the discussion of the actual planning phase with a short exercise:

Exercise

Which criteria does a planning team have to consider in designing a wastewater management system?

Let participants split into groups of 4-5 "planners" to discuss which aspects an assessment of the situation needs to address to guide the selection of an appropriate technology. Ask each group to briefly present their assessment questions and discuss the findings, taking them down on the flipchart.

10. Display slides 29-31 and compare with the group's findings.

11. Slide 32 and 33 show the correlation of project phase and influence on project costs: Planners have the highest influence on overall costs – including long-term operation and maintenance – during the concept development phase

12. Integrate the activities that have been discussed so far into the project cycle, showing where they come in the overall process (slides 34-39).

Project cycle in a wastewater management intervention

Assessment

- Assess situation, problems, and stakeholders
- Identify need for action

Planning

- Set objectives and standards (environmental, emission).
- Define criteria for social, environmental and economic sustainability of the system.
- Consider all appropriate measures (treatment technology, campaigns for hygiene promotion, pollution prevention).
- Select an appropriate technology (participatory!)

- Conduct a multi-criteria analysis for technology selection (i.e. the technology should be: - environmentally sound, - appropriate to local conditions, - resilient to disturbances, - affordable to users; users must also be willing to pay for it; further requirements are – problem awareness on the part of residents, - appropriate regulatory framework and institutional setting, - capacities for enforcement of regulation, - human resources for design / construction / operation / maintenance of the system, financial resources for long-term operation).
- Conduct a Cost-Benefit Analysis, weighing the costs (i.e. of – planning, - construction, - house alteration, as required, - monitoring of receiving water bodies, measures for environment protection, - education programmes and awareness campaigns, - materials and energy required for operation, - operation activities (such as emptying septic tanks), - maintenance of hardware, replacement of parts) against the benefits (i.e. avoiding costs of medical treatment and of labour time lost to illness).
- Decide on the most suitable technology on the basis of social, environmental and economic sustainability.
- Adapt the management plan as necessary and adopt it with all stakeholders.
- Design the technical setup of the (collection and) treatment system.

Implementation
- Establish the treatment system according to the plan.
- At the same time, implement the management plan: - institution building (e.g. user associations for centralised / semi-centralised systems), - training programmes and campaigns, - establishment of forums etc.

Operation and Maintenance
- Operation and maintenance of the system according to management plan (which will differ considerably between centralised and decentralised systems, and also between decentralised systems where maintenance remains with property owners (users) and such that are maintained under contract).
- Safeguard regular monitoring of proper system function, and of quality of effluent (emission) and environment (immission).
- Ensure monitoring and evaluation of the treatment and management system to allow for well-timed improvement and adaptation. Feed experiences back into larger policy system to modify overall policy if required.

5.4 Session 4 – Case Study

Case Study TepozEco, Mexico

Session overview

Title Case Study TepozEco, Mexico

Objectives

- To give a practical example of a wastewater and sanitation management process, introducing the case of peri-urban Tepoztlán, Mexico.
- To point out the relevance of institutional networking and early stakeholder involvement for locally adapted solutions.
- To portrait a system integrating water demand management, water supply and wastewater management to allow for inexpensive treatment technologies and nutrient recycling while safeguarding hygiene requirements.

Teaching method presentation with ensuing discussion

Time estimation 90 minutes

Needed material Projector, presentation

Session guide

Note
A description of the TepozEco project by one of the project partners is given in the annex, which provides useful details and background information as a preparatory reading for the trainer.

1. Begin by giving participants an idea of the gist of the case study (slide 2): The case of Tepoztlán is exemplary for an integrated management approach to water supply and wastewater management, and illustrates well the development process of the system unfolding, including the formation of a stable network of partners.

2. Introduce the project setting (slide 3), scope of resource uses and activities (slide 4), and main partners (slide 5-6).

3. Slides 7-8 depict the project context and the findings of a preliminary study which later led to the beginning of the initiative.

4. Discuss the core features of the project approach (slides 9-10): Identifying a common ground in their different agendas, NGOs and governmental institutions at different levels

gradually joined forces to pursue an integrated approach to (waste)water resources management benefitting public health and food security. The multi-faceted network of partners and its interaction with local population required an adaptive and flexible planning process taking into account that the understanding of what project planning should look like is significantly different from that in Western culture.

5. Outline the development of the project as described in slides 11-14. It should be noted that the lead organisation SARAR originally was focused on the setup of ecological sanitation infrastructure in the peri-urban areas of the town, and reluctant to get involved with municipal wastewater management on a larger scale. However, SARAR decided to support local government in the wastewater management for downtown areas not within the project scope, in order not to become marginalised and to develop a trustful partnership.

6. Slide 15 introduces TepozEco's operation and maintenance arrangements for sanitation infrastructure.

7. Slides 16-18 describe the technologies applied in the project, including sanitation, composting/ nutrient recycling, urban agriculture, greywater treatment, and rainwater harvesting.

8. Briefly recall the project components and the activities associated with them (slide 19).

9. Slide 20 shows how the ecosanitation concept of "closing the loop" can be put into practise.

10. Summarise the project outcomes and remaining challenges (slides 21-23), then give room for discussion: Are there any particular aspects that participants like or do not like about the concept? What part(s) of the project would be transferable to other contexts?

5.5 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. How is water demand management relevant to wastewater management?

2. What is the change in paradigm between conventional wastewater management and sustainable wastewater management?

3. What are the core characteristics of the peri-urban interface?
a) Other than in rural areas, residents are connected to the urban sewer system.
b) People often live in illegal settlements.
c) Livelihood activities often heavily rely on water.
d) Peri-urban areas have a high population density.

4. In how far does public perception of wastewater and sanitation services differ from that of other services?

5. Give some core advantages and disadvantages of centralised wastewater management systems.

6. Give some core advantages and disadvantages of decentralised wastewater management systems.

7. What has to be taken into account regarding the location and its characteristics when selecting an appropriate technology? Indicate some key factors.

8. Which project phase is particularly important for the intervention's projected costs?
a) The assessment phase: It is then that the conditions of the project become clear.
b) The planning phase: This is when the technological solution is chosen.
c) The implementation phase: Here, the project planner has most control over the actual performance of works, which is where the costs accrue.

Answers:

1. Water demand management aims to promote water conservation and thus reduce the amount of wastewater to be collected and treated by raising awareness of water scarcity.

2. Sustainable wastewater management seeks to treat the different wastewater streams separately to enhance a closed-loop flow of all components.

3. b) and c)

4. Wastewater and sanitation differences are often perceived differently in that:
   - There is no tangible product (unlike, say, in public transport or water supply sectors)
   - Users have already paid for the water
   - Sanitation and wastewater may be a cultural taboo.
   - It is difficult to enforce applicable regulations and fees.

5. Advantages:
   - High degree of hygienic safety
   - Convenient for wastewater producer (no maintenance or treatment on property)
   - „Economy of scale" for treatment in densely populated areas

   Disadvantages:
   - Mixing of wastewater of all origins and compositions => no re-use of nutrients
   - (Potable) Water as a carrier => water-intensive; effluent reaches treatment highly diluted
   - Cost ratio of sewer and treatment systems: **4:1** => 80% of costs accrue to transport system
   - Acute impact in case of malfunction/ natural catastrophe

6. Advantages:
   - Costs: no sewerage system necessary, internal labour possible, no high long-term investment
   - Better adjustment to the individual grade of pollution
   - Flexible (expandable) and adaptable
   - Minimises risk of epidemics (separation of pathogens, etc.)
   - Preserves resources: water and nutrients
   - Independence
   - No concentrated point source input into the ground
   - In case of failure small damage (risk minimisation)

Disadvantages:
- Lower treatment efficiency is possible (N, P, pathogens)
- Insufficient control
- Finding qualified personnel for operating and maintenance can be difficult

7. Key factors concerning the setting are:
   - Size of the community served (including industrial contributions)
   - Social and economical conditions
   - Human development index factors (health, education and welfare)
   - Legal requirements / regulatory regime
   - Water availability
   - Existence (and characteristics) of a sewer system
   - Wastewater sources (domestic, industrial, run-off), volume and composition
   - Availability of land
   - Geology, geomorphology, climate

8. b)

5.6 Literature

Allen A., Davila J., Hofmann P. (2006), Governance of water and sanitation services for the peri-urban poor A framework for understanding and action in metropolitan regions. London: University College London

Gulyas H., Gajurel D.R., Otterpohl R. (w/o yr.), Resource management sanitation. EMWater Computer based training Lesson B1.

House S., Ince M., Shaw R. (w/o yr.), Water, sanitation and hygiene understanding. WELL Technical Brief No. 51.

Otterpohl R., Braun U., Oldenburg M. (2002), Innovative technologies for decentralised wastewater management in urban and peri-urban areas. In: Proceedings of the 5th Specialised conference on small water and wastewater treatment systems. Istanbul-Turkey, 24-26 September 2002.

Otterpohl R. (2006), Regional planning and decentral vs. central wastewater management. Presentation held at the 3rd EMWater Regional Training Hamburg, 11 Sept 2006.

Özuguz Y. (w/o yr.), Efficient management of wastewater, its treatment and resuse in the mediterranean countries Summary. EMWater Computer based training Lesson.

Parkinson J., Tayler K. (2003), Decentralized wastewater management in peri-urban areas in low-income countries. In: Environment and Urbanization, Vol. 15, p 75-90. London: IIED.

Parr J., Smith M., Shaw R. (w/o yr.), Wastewater treatment options. WELL Technical Brief No. 64.

Petta L. (2005), Wastewater treatment plant operation and maintenance, decentralized wastewater treatment systems. Presentation held at the EMWater Local Training Course Lebanon, 18-21 July 2005.

Sawyer R., Delmaire A., Buenfil A. (2003), Holistic ecosan small-town planning: The TepozEco pilot program. In: ecosan – Closing the loop. Proceedings of the 2nd international symposium on ecological sanitation, 07-11 April 2003, Luebeck.

UNEP (2002), Directory of Environmentally sound technologies for the integrated management of solid, liquid and hazardous waste for Small Island Developing States (SIDS) in the Pacific.

UNEP/ WHO/ HABITAT/ WSCC (2004), Guidelines on municipal wastewater management. Version 3. The Hague: UNEP/ GPA Coordination Office.

UNESCO IHE/ GPA, Training on sanitation and wastewater. Available at: **http://www.training.gpa.unep.org/** Downloaded 06. Sept, 2007

Veenstra S., Alaerts G.J., Bijlsma M. (1997), Technology Selection. In: Helmer R., Hespanhol I. (eds.), Water Pollution Control – A guide to the use of water quality management principles. Chapter 3. Nairobi: UNEP.

5.7 Recommended Reading

GTZ (2004), ecosan – Closing the loop. Proceedings of the 2nd International symposium on ecological sanitation 07-11 Apr 2003, Luebeck.

UNEP DTIE, 2002. International Source Book On Environmentally Sound Technologies
for Wastewater and Stormwater Management. Technical Publications Series No. 15

UNEP/ WHO/ HABITAT/ WSCC (2004), Guidelines on municipal wastewater management. Version 3. The Hague: UNEP/ GPA Coordination Office.

Vesilind P.A., 2003. Wastewater treatment plant design. Water Environment Federation/ IWA Publishing

5.8 Internet Resources

Building Partnerships for Development in Water and Sanitation
http://www.bpd-waterandsanitation.org

GTZ ecosan – Ecological Sanitation Website of the German Association for Technical Cooperation
http://www.gtz.de/en/themen/umwelt-infrastruktur/wasser/8524.htm

IRC International Water and Sanitation Centre
http://www.irc.nl/

TepozEco Project Website
http://www.sarar-t.org/tepozeco.htm

UNESCO IHE/ GPA, Training on sanitation and wastewater. Available at:
http://www.training.gpa.unep.org/ Downloaded 06. Sept, 2007

Water and Sanitation Program, multi-donor programme of the World Bank
http://www.wsp.org

WatsanWeb – Portal for people working in the water and sanitation sector
http://www.watsanweb.ch/

6. Topic 3:

Economic instruments for wastewater management

Topic overview

Time
Session 1: Topic Presentation – 90 min
Session 2: Case Study Exercise – 90 min

Objectives
- To highlight the need for cost-recovery in wastewater management services in order to ensure sustainability
- To introduce the different kinds of economic instruments, discuss their impacts on water consumption and social equity, and look at a couple of real-life cases.

Participants should be able to
- Explain the significance of a viable financing for any wastewater management activity.
- Characterise the types of economic instruments in wastewater management regarding their working mechanism and their advantages and disadvantages in different settings.
- Design different financing options for a given project in the water supply and sanitation sector, and consider their respective advantages and disadvantages.
- Involve stakeholders in the identification of the most appropriate technology and corresponding financing mechanism (as part of the overall planning process).

Material
- Projector
- Slides
- Flipchart (or blackboard)
- Marker (or chalk)

This topic is covered in 2 sessions:

1. Session 1 – Topic Presentation

The introductory presentation outlines the different types of economic instruments, including fees and charges for households and industry.

2. Session 2 – Case Study and Exercise

In three consecutive case studies from Zimbabwe, Colombia and India, participants learn about the financing schemes set up for different water and sanitation solutions. While the first two are presented by the trainer, the third case takes the form of a exercise, in which participants are made familiar with the setting and can work on a solution in groups. In the end, the results from the working groups and the solution that was implemented are discussed in the plenary.

6.1 Session 1 – Topic Presentation

Economic instruments for wastewater management

Session overview

Title Economic instruments for wastewater management

Objectives
- Introduce the different types of economic instruments available in wastewater management.
- Discuss how these instruments can help to realise the underlying key principles of wastewater management of equity, cost recovery - required for long-term sustainability - and fairness ("polluter pays" principle): Are subsidies a prerequisite to ensure equity? Are they counterproductive with view to resource conservation, and thus to the sustainability of the system?
- Discuss direct and indirect effects of the pricing of (waste)water services, and give room for an exchange of experiences with participants.
- Participants should be aware that there is not the one best solution to wastewater treatment, but that the technology to be selected needs to fulfil a complex array of health-related, environmental, social, economic, and geological criteria.

Teaching method presentation using PowerPoint-slides and discussion and exchange of experiences among participants

Time estimation 90 minutes

Needed material Projector, slides, flipchart (or blackboard), marker (or chalk)

Session guide

1. Give participants a brief overview of the session's contents using slides 2-3.

2. Present the key criteria for sustainable wastewater management, and discuss the role of economic instruments as compared to technical, legal, and institutional tools (slide 5).

3. Explain the underlying principles and aims of financial tools (slide 6).

4. Conduct a short brainstorm exercise using the flipchart/ blackboard: What costs do wastewater services entail? It should be highlighted that these pertain not only to the

wastewater treatment system itself, but also to the environmental and health-related costs induced by the quality and quantity of the effluent that is ultimately discharged into the environment.

5. Present the graph on slide 7, depicting the types of economic and of environmental costs. Slide 8 shows the various cost recovery levels and the types of costs they include.

6. Give a brief overview of the kinds of economic instruments that are used in the wastewater sector using slide 10, pointing out first that they charge users either for discharge of a certain amount of pollution or of a given water quantity, or for connection to the sewerage system. These tools are then described in greater detail in the following.

7. Explain the mechanism of pollution charges, giving the example of the German Effluent Charges Act (slides 11-13). It should be clear that pollution charges are calculated for individual substances irrespective of their dilution, and for that reason apply to industry or other large emitters.

8. By contrast households, discharging smaller quantities of water of a very heterogeneous composition, are usually charged by volume of effluent. These are then effluent charges (slide 14).

9. Present the concept of indirect local taxes (slide 15). Point out that these tend to "vanish" in the overall tax bill, and are thus less transparent. The incentive to save water and produce less wastewater is thus considerably smaller.

10. Discuss the concept of discharge permits (slide 16). Comparable to the concept of "emission trading" in the Kyoto Protocol, this approach has the advantage of setting a ceiling on the total of emissions of a substance, thereby taking into account the limited carrying capacity of receiving ecosystems. Emphasize that, in the conception of the wastewater (service) pricing system, the capacities for enforcement have to be taken into account.

11. Introduce the basic principles in the pricing of wastewater services that should be considered in developing a tariff structure (slide 18).

12. Show slides 19-21 on the principles of tariff calculation.

13. Explain fixed charge tariffs (slide 22), giving the example of water pricing in Uganda (slide 23). Point out that fixed charge tariffs do not create an incentive for economising with water.

14. Present volumetric charge tariffs, and explain the different tariff structures (slides 24-26): Decreasing, uniform and increasing, and linear or block tariffs. Highlight that, while in agreement with the rules of "economy of scale", decreasing tariffs encourage wastewater production. Especially in water-scarce regions, they are not viable.

15. Explain the composition of two-part tariffs using slide 27. Their major asset is the fixed monthly service charge, which takes into account the investment, capital and maintenance costs of wastewater treatment, which are usually high in comparison to operation costs and independent of the amount of wastewater currently produced.

16. Present the concept of seasonal and zonal tariffs as directly reflecting local conditions in the pricing system (slide 28). While economically sound, this can cause regional imbalances and problems of social equity. Give the example of water pricing in Lebanon (slide 29).

17. Present the idea behind subsidies, their various forms and their impact, using slides 30-31.

18. Finally, discuss the direct and indirect effects of water pricing (slides 33-34).

19. Water pricing is more than an economic calculation; it is an issue of high social and political relevance, seeing that water is a vital resource which is related to social welfare and prosperity. Ask participants if they have had any first-hand experience with any of the different tariff structures, and which ones they have found to work best under which conditions. Discuss for about 15 minutes, taking down key arguments on the flipchart or blackboard.

6.2 Session 2 – Case Study Exercise

Case studies Zimbabwe, Colombia, India

Session overview

Title Case studies Zimbabwe, Colombia, India

Objectives

- To discuss practical examples of financing mechanisms and tariff structures in the supply of water and wastewater services in urban, peri-urban and rural contexts.
- To develop, in the manner of a group exercise, a management approach for a given setting.

Teaching method presentation and group exercise with ensuing discussion

Time estimation 90 minutes

Needed material Projector, paper, pens, flipchart (or blackboard), marker (or chalk)

Session guide

1. Begin by giving participants a short overview of the issues at stake in these three case studies:

- In rural Zimbabwe, users carry most parts of the costs of domestic water supply and sanitation, while a trust in collaboration with government provides seed finance, technical competence and programme implementation.
- In the town of Marinilla, Colombia, a public private partnership for municipal water supply and wastewater services scales up economic sustainability through higher cost recovery, tariff structures and long-term planning for the financing of larger infrastructure investments.
- The last case, which is concerned with sanitation services in Indian urban slums, will take the form of an exercise.

2. Present the situation in the first case study (slides 2-4): Economic restraints impeded governmental plans for rural water supply and sanitation services, based on communal water stand pumps and Ventilated Improved Pit (VIP) latrines. This gradually led to a regional bottom-up initiative between rural population and local NGOs to improve the traditional shallow wells at household-level, which were already existing in some 30% of rural households and had hitherto not been considered a serious option in the government programme because of contamination problems. What evolved from these partnerships and thorough scientific research was the Upgraded Family Well, which is properly bordered, with a lid on the well head and often a pump to reduce contamination of the well with pathogens etc.

3. Slide 5: Retrace the process, which led to the creation of the Mvuramanzi Trust, drawing on the technical competence of a renowned research institute and capital funds from Water Aid and the wider international donor community. The Trust joins forces with the Ministry of Health for scaling up of the initiative, which is now part of the Ministry's rural water supply and sanitation programme. Community-level consultations and needs assessments precede the actual implementation of the programme, which is important with view to the high investments required from users themselves.

4. Introduce the cost repartition for infrastructure built under the programme (slide 6).

5. Sum up the experience of the project (slide 7): With their personal benefits at hand, rural population are willing to carry the lion's share of construction costs, leaving more public funding for a wider regional coverage and for other activities, such as capacity building and technical training. The willingness to make large financial contributions is strongly related to awareness-raising and a programme planning allowing for users to have a say in project implementation.

6. Describe the situation in the second case study (slide 8-9): In the case of Marinilla, Colombia, the state's incapacity to manage water supply and sanitation services centrally led to decentralisation of the water sector, devolving responsibilities to municipalities. When the regional water supply agency Acuantioquia responsible for the town faced increasing financial problems due to inefficient management practices, the local government decided to liquidise the agency and convey operation responsibilities to a private sector partner. When public resistance formed against the privatisation of local WSS services, it was decided to directly involve the inhabitants in the development of the management contract to create trust and ensure transparency. The municipality retains responsibility for planning, financing and supervision of the private operator's performance.

7. The new operator shows commitment to the community and actively communicates with users through meetings and educational campaigns. WSS services have improved considerably, and the 20-year sector plan drawn up by the municipality projects substantial amendments including the construction of a first wastewater treatment facility (slides 10-11).

8. Slides 12-13: Regarding financing of the water supply and wastewater services, recovery of maintenance and operation costs is largely separated from investment in infrastructure. Users are charged water and sewerage fees along a two-part tariff scheme in which high-income earners pay a higher price per unit water than lower-income earners, thus cross-subsidising tariff rates for the poor that are below cost recovery requirements. The installation of meters has contributed to enhancing cost recovery for the service.

9. Slide 14: Investments in the new treatment plant and further infrastructure extensions are not passed on to users, but will be financed through money transfers from government and grants, one of which a loan from the private operator, which was made possible through revenue surpluses.

10. As a lesson learned, water supply and wastewater services were put on economically sustainable feet through a public-private-partnership in which all crucial management competencies (and, not least, ownership of the infrastructure) lie with public institutions, and operation is undertaken by a private sector partner in close cooperation with the municipality and in consultation with the public (slide 15).

Exercise

The last case study takes the form of an exercise. Briefly give an introduction to the situation in the slum areas of Tiruchirappalli, using slides 16-17. Then let participants divide into groups of 3-4 and hand out paper and pens if necessary. Ask the groups to put themselves in the situation of the NGO, trying to find a sustainable solution to the sanitation problems at Tiruchirappalli. All options should be considered and their advantages and disadvantages weighed against each other: Community-based or household-level latrines; public, private sector, or user funding. Ask groups to take down the suggested solutions and their advantages and disadvantages for discussion in the plenary. The groups can sit together and work on the question for 30 minutes.
Now ask the groups to present their findings and discuss proposals in the plenary.

11. Finally, present the arrangement that evolved from the original situation: public pay-and-use latrines managed by Sanitation and Health Education teams and maintained by hired personnel, with revenue surpluses financing further community infrastructure (slides 19-21).

6.3 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. What do economic instruments in wastewater management aim to do?

2. What is the difference between the recovery of "full economic costs" and of "full costs"?

3. What is the difference between charges and fees?

a) Fees are charged to commercial users (i.e. industry) only.
b) Fees are charged for wastewater services (i.e. collection and treatment).
c) Charges are levied for the discharge of a certain pollutant into the environment.
d) Charges are levied for the use of municipal wastewater infrastructure.

4. What is the underlying rationale of discharge permits?

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5. Characterise the three types of volumetric charge tariffs (constant, increasing, decreasing)

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6. What is the idea of seasonal tariffs for water supply and wastewater services?

a) In the harvest time, farmers can better afford to pay wastewater bills.
b) In the dry season, the same amount of contaminants causes more harm to water bodies.
c) In remote areas, wastewater discharge is cheaper because the effluent needs to fulfil lower requirements.
d) In some areas, water is available at lower costs.

7. What are cross subsidies?

a) Industry is charged more for water supply services, so that wastewater service fees for poor households can be lowered.
b) Wealthier households are charged more than their own share in cost recovery, so that poor households can be charged less.
c) There is a small surcharge on all users' water bills, the revenues of which are then used for subsidies.

8. What are possible indirect effects of any water pricing policy?

Answers:

1. Economic instruments aim to
   - raise revenues to finance wastewater services (cost recovery)
   - set incentives for an efficient and conscious use of water
   - create awareness of environmental and societal costs of water pollution

   to achieve financial viability.

2. While full economic costs include all costs accruing to human society for the provision of the services (incl. social costs), full costs also include environmental externalities, such as damage to ecosystem.

3. b) and c).

4. Discharge permits principally aim to put an upper limit on overall discharges of a certain pollutant, and thereby to set incentives for emission reductions and technological innovation. Another reason is to raise revenues for the wastewater management system or for the protection of water bodies.

5. Constant Volumetric Tariffs: All users pay same price per unit of wastewater discharged.

   Increasing Linear Volumetric Tariffs: Price per unit of wastewater increases with increasing total of wastewater discharged.

   Decreasing Linear Volumetric Tariffs: Price per unit of wastewater decreases with increasing total of wastewater discharged.

6. b) and d)

7. b)

8. Indirect effects may include:
   - Social inequity
   - Restraints on economic development
   - Technological innovation
   - Macroeconomic savings (infrastructure, water transfer)
   - Ecosystem conservation

   Avoiding and attenuating these can best be achieved through a thorough assessment phase and participatory decision-making.

6.4 Literature

Cardone R., Fonseca C, 2003. Financing and Cost Recovery. IRC Thematic Overview Papers 7. International Water and Sanitation Centre

Kramer A., Post J., w/o yr. Economic instruments in wastewater management. EMWater Computer based training Lesson D3

McIntosh A., 2003. Asian water supplies. Reaching the urban poor. Asian Development Bank

Otterpohl R., 2004. Economic aspects of wastewater management. Presentation held at the EMWater Regional Training Jordan 26 Sept – 11 Oct 2004.

Özoguz Y., w/o yr. Efficient management of wastewater, its treatment and reuse in the mediterranean countries. EMWater Computer-based training.

Rivera D., 2000. Management models for small towns Management contract in Marinilla, Colombia. In: Rosensweig F. (ed), Case studies on decentralization of water supply and sanitation services in Latin America. EHP Project, Washington, D.C.

UNEP/ WHO/ HABITAT/ WSCC, 2004. Guidelines on municipal wastewater management. Version 3. The Hague: UNEP/ GPA Coordination Office.

6.5 Recommended Reading

Cardone R., Fonseca C (2003), Financing and Cost Recovery. IRC Thematic Overview Papers 7. International Water and Sanitation Centre. Downloadable at: http://www.irc.nl/content/download/8160/126955/file/TOP7_CostRec_03.pdf

UNEP/ WHO/ HABITAT/ WSCC (2004), Guidelines on municipal wastewater management. Version 3. The Hague: UNEP/ GPA Coordination Office. Downloadable at:
http://esa.un.org/iys/docs/san_lib_docs/guidelines_on_municipal_wastewater_english.pdf

6.6 Internet Resources

InterAmerican Development Bank: International Conference Financing Water and Sanitation Services 2003
http://www.iadb.org/sds/doc/

International Water and Sanitation Centre (IRC): Financing and Cost Recovery
http://www.irc.nl/page/113

World Bank: Rural Water Supply and Sanitation Financing
http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTWSS/0,,contentMDK:20523736~menuPK:557584~pagePK:148956~piPK:216618~theSitePK:337302,00.html

7. Topic 4:

Wastewater composition and parameters

Topic overview

Time
Session 1: Topic Presentation – 90 min

Objectives
- To make participants familiar with the physical, chemical and biological characteristics and constituents of domestic and industrial wastewater.

Participants should be able to
- Name the different categories of wastewater components and explain the chemical, physical and biological characteristics given in the presentation.
- Characterise the typical composition of different domestic wastewater flows (greywater, yellow water, black water).
- Explain the impact of water shortage and water-saving devices on wastewater concentration.

Material
- Projector
- Slides
- Flipchart (or blackboard)
- Marker (or chalk)
- Paper, pens

This topic is covered in 1 session:

1. Session 1 – Topic Presentation

The session covers the physical, chemical and biological characteristics and parameters of wastewater, including their impact on human and aquatic life. It ties in with the lesson on wastewater quality management and standards, in that it makes participants familiar with the parameters that are usually determined and addressed by legally binding threshold values.

7.1 Session 1 – Topic Presentation

PPT

Wastewater composition and parameters

Session overview

Title Wastewater composition and parameters

Objectives
- Make participants familiar with the physical, chemical, and biological core characteristics and components of wastewater.
- Create an awareness for the importance of paying attention to the setting in deciding which parameters to investigate further: Many contaminants will accrue (in larger quantities) from few economic activities only, such as certain industries. Some components may be present to a higher degree owing to geological conditions, if they have not previously been removed through water treatment.

Teaching method presentation using PowerPoint-slides

Time estimation 90 minutes

Needed material Projector, slides, flipchart (or blackboard), marker (or chalk), paper, pens

Session guide

1. Briefly give an overview over the contents of the session and its placement in the module (slides 2-3).

2. Show slide 5: Wastewater characteristics can be classified as either physical, chemical or biological. In wastewater analytics, however, we mostly distinguish between sum parameters, group parameters, and individual substances. The present session follows the first pattern (left side); the subsequent presentation on wastewater analytics is based on the second (right side).

3. Present the physical, chemical and biological characteristics of wastewater (slides 6-9).

4. Go through the parameters one by one (slides 11-37). From experience, some will be quite easy to ‘tick off’; while others need further explanation, such as alkalinity and the carbonate buffer system. Preferably, leave room for questions immediately as they arise.

The presentation of the parameters follows the same pattern throughout:[1]

Definition What is the parameter about? What does it say about the quality of the water?

Due to: What factors have an influence on the intensity or value of the parameter? Which water uses is it linked to?

Measure: How, in which units should the parameter be quantified?

Impact: What does the component, or its products of decomposition, lead to? What is its impact on man, or ecosystems, or sewer systems?

Specific parameters

Alkalinity, acidity and pH

While alkalinity, acidity and pH are closely interrelated, they are not the same. Understanding the difference is important because of the impact of each parameter on treatment facilities and processes. Alkalinity of water depends on the carbonate buffer system, i.e. the equilibrium of carbon dioxide, carbonic acid, **bicarbonate**, and **carbonate** ions. If an acid (H^+ ions) is added to the water, the equilibrium is shifted. Carbonate ions combine with the hydrogen ions to form bicarbonate. The bicarbonate then combines with hydrogen ions to form carbonic acid, which can dissociate into carbon dioxide and water.

$$CO_2\ (g) \rightleftarrows CO_2\ (aq)$$
$$CO_2\ (aq) + H_2O \rightleftarrows H_2\ CO_3$$
$$H_2CO_3 \rightleftarrows H^+ + HCO_3^-$$
$$HCO_3 \rightleftarrows H^+ + CO_2^-$$
$$H_2O \rightleftarrows H^+ + OH^-$$

As nitrifying bacteria feed on ammonia, a reduced alkalinity will slow down the nitrification process through the shift in the NH_3 - NH_4^+ equilibrium.

Acidity, on the other hand, defines the water's total content in acidic components, including weak and strong acids as well as hydrolysing salts. It thus plays a crucial role for its corrosiveness in sewer and treatment systems, but also for biological processes and chemical reactions, such as coagulation/flocculation.

pH is a measure of the activity of hydrogen ions in the water. It is, in a way, a result of the processes described for alkalinity and acidity. Many biological processes will only take place within a limited pH range, which may be in the acid, the alkaline, or the neutral milieu.

[1]) Where self-evident, "Definition" and "Measure" have occasionally been omitted, as in the case of colour and odour.

Pathogens

Pathogenic microorganisms can be *water borne* (ingestion through potable water), *water-washed* (contact with skin, eyes, nose etc), *water-based* (infection through parasitic worms, usually introduced through excrement), or *water related* insect vectors (bite of insects near water)

Below is a classification of diseases by transmission routes:

Diseases

↓

Infectious

↓

Water-related infections	Excreta-related infections
Transmission routes: • **Water-borne** Cholera, Typhoid, Dysenteries, Diarrhoeas, Infectious hepatitis • **Water-washed** Skin and eye infections Louse borne typhus • **Water-based** Schistosomiasis Guinea worm • **Water related insect vector** Yellow fever, River blindness, Malaria Sleeping sickness	• Diseases which are faecal-orally transmitted usually enter the environment by the excretion of faeces from infected persons.

Category	Infection	Pathogenic agent	Dominant transmission mechanisms	Major control measures (engineering measures in italics)
Faecal-oral (non-bacterial) Non-latent, low infectious dose	Poliomyelitis Hepatitis A Rotavirus diarrhoea Amoebio dysentery Giardiasis Balantidiasis Enferobiasis Hymenolepiasis	V V V P P P H H	Person to person contact Domestic contamination	*Domestic water supply* *Improved housing* *Provision of toilets* Health education
Faecal-oral (bacterial) Non-latent, medium or high infectious dose, moderately persistent and able to multiply	Diarrhoeas and dysenteries *Campylobacter enteritis* *Cholera* *E. col I diarrhoea* *Salmonellosis* *Shigellosis* *Yersiniosis* Enteric fevers *Typhoid* *Paratyphoid*		Person to person contact Domestic contamination Water contamination Crop contamination	*Domestic water supply* *Improved housing* *Provision of toilets* *Excreta treatment prior to re-use or discharge* Health education
Soil-transmitted helminths Latent and persistent with no intermediate host	Ascariasis Trichuriasis Hookworm Strongyloidiasis	H H H H	Yard contamination Ground contamination in communal defecation area Crop contamination	*Provision of toilets with clean floors* *Excreta treatment prior to land application*
Beef and pork tapeworms Latent and per-sistent with cow or pig intermediate host	Taeniasis	H	Yard contamination Field contamination Fodder contamination	*Provision of toilets* *Excreta treatment prior to land application* Cooking and meat inspection
Water-based Helminths Latent and persistent with aquatic interme-diate host(s)	Schistosomiasis Clonorchiasis Diphyllobothriasis Fasciolopsiasis Paragonimiasis	H H H H H	Water contamination	*Provision of toilets* *Excreta treatment prior to discharge* *Control of animals harbour-ing infection* Cooking
Excreta-related insect vectors	Filariasis (transmitted by *Culex pipiens* mosquitoes) Infections in Categories I-V, especially I and II, which may be transmit-ted by files and cock-roaches	H M	Insects breed in various faecally contaminated sites	*Identification and elimination of potential breeding sites* Use of mosquito netting

B: Bacterium; V: Virus; H: Helminth; P: Protozoon; M: Miscellaneous

5. Having completed the discussion of the wastewater parameters, present slides 39-42 to look at the typical composition of domestic wastewater, greywater and blackwater. Compare the distribution of COD, N and P concentrations in these wastewater streams with view to wastewater reuse potentials and risks.

7.2 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. What categories of wastewater components can be distinguished: physical, ... and ...?

2. What kind of a parameter is turbidity?

3. How do you explain acidity and what does it have an impact on?

4. What are the possible ways heavy metals can impact on living organisms?

5. What are the main sources of organic halogen compounds?

6. What is particularly problematic about organic halogen compounds?

7. What groups of pathogenic organisms do you know?

8. What are the main transmission paths for pathogens stemming from faeces, and how can they be eliminated?

Answers:

1. Physical, chemical and biological components.

2. Turbidity is a physical parameter.

3. Acidity is the capacity of the water to neutralise bases through reaction with dissolved H^+-ions. Acidity is measured using the pH-scale: a pH of 7 is neutral, a pH above 7 is termed alkaline and below 7 is termed acid.

   A low pH value increases the solubility of salts and metals, thereby impacting on the corrosivity of the effluent, decelerates biochemical reactions and either lowers or accelerates the rate of chemical reactions, and can have an influence on toxicity, odour and colour.

4. Heavy metals can be toxic, carcinogenic or mutagenic.

5. Organic halogen compounds mostly stem from pesticides and herbicides used in agriculture and from the chemical industry.

6. They are persistent, i.e. not biodegradable, which leads to an accumulation in the fat tissue of human and animals (bioaccumulation).

7. Pathogens can be bacteria, fungi, protista, helminths, and viruses. Mind that not all organisms falling under one of these groups are pathogenic for humans!

8. Pathogens can be conveyed via
   - the hands, the risk of which can be reduced by washing;
   - flies to food, which can be hindered to some degree by covering foodstuffs;
   - drainage of excreta into the groundwater used as potable water supply, which can be hindered through properly maintained latrines and toilets;
   - drainage of excreta into soils, or re-use of untreated yellow or black water in agriculture, and from there to the food. Here again, the risk can be eliminated through toilets (in the case of seapage) and proper treatment of effluents to be used as fertiliser.

7.3 Literature

Akcin G., Alp Ö., Gulyas H., Büst B., w/o yr. Characteristic, analytic and sampling of wastewater. EMWater Computer Based Training Lesson A 1.

GEMS/Water Programme, 2006. Water quality for human and ecosystem health. UN GEMS/ Water Programme, Ontario.

Metcalf & Eddy, 2003. Wastewater Engineering Treatment and Reuse. 4th ed. McGraw Hill, New York.

7.4 Recommended Reading

Feachem R., Bradley D., Garelick H., Mara D., 1983. Sanitation and Disease: Health aspects of excreta and wasstewater management. John Wiley & Sons, Chichester

Funk W., Damman V., Donnevert G., 1995. Quality assurance in analytical chemistry. Wiley-VCH, Weinheim

GEMS/Water Programme, 2006. Water quality for human and ecosystem health. Ontario: UN GEMS/ Water Programme.

Greenberg A. et al., 2005. Standard Methods for the Examination of Water and Wastewater. 21st ed. American Water Works Association (AWWA).

Henze M., Ledin A., 2001. Types, characteristics and quantities of classic, combined domestic wastewaters. Chapter 4. In: Lens P. et al (eds.), 2001. Decentralised sanitation and reuse, concepts, systems and implementation. pp 59-72. IWA Publishing, London

Metcalf & Eddy, 2003. Wastewater Engineering Treatment and Reuse. 4th ed. McGraw Hill, New York.

Snoeyink V.L., Jenkins D., 1988. Water Chemistry. 2nd edition. John Wiley & Sons, New York

Tchobanouglos G., Schroeder E.D., 1985. Water quality : Characteristics, modeling, modification. Addison-Wesley, Reading/ MA.

Tomar M., 1999. Quality assessment of water and wastewater. Lewis Publishers, Boca Raton.

7.5 Internet Resources

Chehalis River Council Water Quality Guide
http://www.crcwater.org/wqmanual.html

The Water Quality Association
http://www.wqa.org/

State of Nevada, Dpmt. Of Conservation and Natural Resources – Water Words Dictionary
http://water.nv.gov/WaterPlanning/dict-1/wastewater-index.cfm

Water Pollution Guide, UK
http://www.water-pollution.org.uk/

Wilkes University Center for Environmental Quality Environmental Engineering and Earth Sciences
http://www.water-research.net/Inorganic_Testing.htm

8. Topic 5:

Wastewater analytics

Topic overview

Time
Session 1: Topic Presentation – 90 min
Session 2: Exercise – 120 min

Objectives
- To introduce participants to the analytics of the commonly used individual and group parameters in wastewater.
- To discuss the commonly used methods of sample-drawing.

Participants should be able to
- Indicate and explain the core parameters and individual substances commonly used in wastewater analytics, as well as their major sources of origin and their impact on aquatic (bio)chemical reactions, aquatic life and human beings.
- Indicate and explain the analytic methods used to measure these (both laboratory analytics and on-site testing).
- Select a sample-drawing method appropriate to the purpose of the analysis.
- Indicate which parameters need to be analysed on site, and which can be preserved in what way.

Material
- PC, Projector
- Slides
- Flipchart (or blackboard)
- Marker (or chalk)
- Paper, pens

This topic is covered in 2 sessions:

1. Session 1 – Topic Presentation

In this session, participants become acquainted with commonly used analytic methods for the key wastewater constituents and characteristics. Given that costly appliances such as atomic absorption spectrometers will not usually be standard laboratory equipment, the scope is restricted to technically feasible methods, and a cursory introduction to some core methods of instrumental analytics.

2. Session 2 – Exercise

By asking participants to set up a design for the sampling and analysis of a peri-urban sewer outlet, this final exercise combines the learning contents of topics 4 and 5, to consolidate the input and see if further questions arise.

8.1 Session 1 – Topic Presentation

Wastewater analytics

Session overview

Title Wastewater analytics

Objectives
- Bring to mind the significance of wastewater analytics.
- Present the most important sum, group, and individual parameters, as well as sampling techniques and analytical methods.

Teaching method presentation using PowerPoint-slides

Time estimation 90 minutes

Needed material Projector, slides, flipchart (or blackboard), marker (or chalk), paper, pens

Session guide

1. Recalling the previous session, give participants an overview over the session's contents (slides 2-3).

2. Having introduced wastewater characteristics and components as physical, chemical, or biological properties, the analytics session follows a distinction into sum, group, and individual substance parameters. Explain the principle behind them, showing slides 5-8.

Sum and group parameters

Allow for the joint assessment of several substances sharing a particular chemical property of interest, e.g. determining the hardness of water, or its toxicity on fish. Assessing the intensity of these properties rather than the concentration of individual substances takes into account that analysing individual substances throughout is costly and not always meaningful.
While group parameters comprise substances that belong to the same group, such as polychlorinated biphenyls (PCB) or tensides, sum parameters embrace substances differing in chemical group or structure, such as solids or organic matter.

3. In the following, the analytical methods and units for the major sum and group parameters are given. Discuss them one by one, using slides 10-20. The presentation of each parameter follows the same pattern:

?	Is a definition of the parameter
	Briefly describes how the parameter is analysed (to actually conduct an analysis, a detailed instruction will however be needed).
Unit	Indicates the measuring unit used for quantification

4. Sampling is an art in itself, and should be paid proper attention, as inaccuracies in sampling can falsify the analytic results considerably. The presentation gives the most important aspects to be considered when drawing (slides 22-23) and conserving samples (slides 24-26).

5. Present the different types of samples and their comparative strengths and weaknesses, using slides 27-29.

Note on the presentation of the analytical methods
The presentation of analytical methods is confined to the basic methods of sample preparation and analysis. Costly instruments such as atomic emission spectrometers (AES) will not be among participants' everyday working equipment. Instead, the main principles underlying these instruments are contained, and room is given for an overview of easier to handle and more inexpensive methods for on-site testing.

6. Introduce liquid-liquid-extraction and the headspace analysis as the two common methods of water sample preparation (slides 31-32). These methods concentrate and extract the substance into a gas phase, which may be necessary depending on the substance (group) to be analysed, its concentration in the wastewater, and the subsequent analytical method chosen.

7. Present the analytical principles of titration, chromatography and spectroscopy (slides 33-35). Among spectroscopic methods, photometric analyses deliver more accurate results than colorimetric ones, while colorimetric ones are less expensive.

8. Discuss the purpose of and equipment for on-site testing (slide 36). For one, samples cannot be conserved for transport to the laboratory for some parameters. Moreover, conducting exploratory tests for further parameters makes sense in order to reduce the number of more extended and costly laboratory analyses, and to gain a first impression of the wastewater qualities, so as to take further samples where this seems advisable.

It should be kept in mind, however, that on-site tests are usually semi-quantitative, meaning they are not as precise – and possibly not as sensitive for low concentrations of a substance – as instrumental analytics in the lab, which allow for a quantitative determination of the substance.

What needs to be analysed immediately

Some parameters, including CO_2, dissolved oxygen (DO), pH, conductivity, temperature, colour and odour, have to be analysed immediately after sampling.
A pH- and conductivity meter was presented earlier; an oxymeter is displayed on the last slide in the upper right hand corner. The temperature is measured with a digital thermometer; colour and odour are usually assessed with the sampler's senses. All findings need to be taken down in the analysis protocol at once.

9. Discuss the comparative advantages and disadvantages of the on-site testing methods available (slide 37).

10. Slide 38 gives a number of examples of substances or substance groups that can be analysed by the different rapid tests.

11. Finally explain how the different types of tests work (slides 39-40).

8.2 Session 2 – Exercise

Assessing the wastewater quality of a peri-urban sewer outlet

Session overview

Title Assessing the wastewater quality of a peri-urban sewer outlet

Objectives
- To consolidate the contents presented in the previous session.
- To assess if participants have understood the analytical methods presented in the course, and if they are able to apply them in a typical water analysis.

Teaching method group exercise in groups of 3-4 with ensuing discussion

Time estimation 90 minutes

Needed material copies of exercise sheets (at least one for 3-4 participants), large sheets of paper (e.g. flipcharts), pens (felt pens)

Session guide

1. Ask participants to gather in groups of 3-4.

2. Distribute the exercise sheet, flipchart papers and pens, and explain the exercise.

3. Give participants 45 minutes to discuss in groups. All groups are then asked to present their solutions subsequently. Discuss questions as they arise. For a suggested solution of the exercise, see notes for the trainer further below.

Assessing the wastewater quality of a peri-urban sewer outlet

You are a mixed team of employees from a private laboratory for water and soil analytics and officials from the Department for Public Health and Environment of a municipal authority. Your team has been commissioned to line up a wastewater treatment project for a poor peri-urban neighbourhood in a large city of approximately 4,5 million. You are given the following information:

The area itself has about 380,000 inhabitants and disposes of a centralised sewer system, to which about 70 percent of residents are connected. Further to the south, one of the outlets of the sewer system discharges most of the area's effluents directly into a receiving water without pretreatment. The other three outlets of the sewerage, carrying the wastewater of the other parts of the city, discharge a 1.5, 2.5 and 4 km further upstream into the river; two of them are connected to treatment facilities: one primary treatment facility (removing sand, silt, settleable solids, grease and oil), and one secondary treatment plant (reducing significantly also the amount of biodegradable organic matter).
In the neighbourhood, households mingle with small workshops, such as butcheries, dairy workshops, a couple of dyeing mills and garages partly including paint-shops. The settlement gradually gives way to fields mostly tilled by residents of the neighbourhood.
During a rather hot period in summer, a fish die-off has now been observed. Furthermore, several villages border the river downstream, which partly draw on the river's water for agricultural and drinking water supply.

It is considered to build a treatment facility for the wastewaters of the peri-urban settlement. You are called upon to analyse the wastewater and answer the following questions:

- What quality does the mixed wastewater stream of the area have?
- What characteristics can the fish die-off be due to?
- What quality should the treatment facility achieve, i.e. what negative impacts should be eliminated or reduced? (Recall that wastewater treatment should be designed to meet the quality requirements of the follow-up use)

For the team conducting the analysis, this implies a range of further questions:

- When and where, how and how often do you draw a sample?
- What parameters do you test on site, and how do you preserve the sample(s) for analysis in the lab?
- What further parameters do you analyse in the lab?

Set up a design for the sample-drawing and analysis; think also about what further information you might need before you start, and where to get it from.

Trainer's notes

A. Useful information that should be obtained beforehand or in the course of the analysis:

- To gain an idea of the contaminants to be expected, the team should assess all water uses prevalent in the area. This can be done through field trips and interviews or informal talks with inhabitants. The range of industries enumerated above already suggests a range of pollutants on top of the load of mostly organic contamination caused by the domestic wastewaters.
- To investigate the reasons of the fish die-off, it can be of interest to take a field trip along the river bed to have a look at the stream and the river banks: Algae blossoms that can be observed especially where the current is weaker (i.e. in the inner bank of bends) indicate a high degree of contamination with biodegradable organic matter.

B. Sample-drawing:

- For a first assessment, 2-3 composite (time-integrated) samples should be drawn directly from the middle of the outlet stream in question. These samples should be taken on different days and at different times of the day, including both working days and week-ends, and the morning, day-time, and night hours, to get an idea of the variation in wastewater concentration and composition. It is important that the peak times are covered by the sample-taking.
- As it comes to the protection of aquatic ecosystems downstream, the required effluent quality will depend not only on the so-far untreated outlet of the peri-urban settlement, but on the combined effluents of the city's four outlets. The water quality should therefore also be analysed immediately above the neighbourhood's sewerage outlet: If the river yields high concentrations of certain pollutants deriving from the outlets further upstream, it may be more cost-efficient to install another primary or secondary treatment facility upstream than building one high-performing treatment plant at the outlet considered here.
- With view to the water quality required downstream for agricultural irrigation and potable water supply, the water quality should also be assessed close to the first settlement drawing its water supplies from the river.
- The exact time, place and method of sample drawing needs to be documented in the sampling protocol, including the materials used for sample drawing and storage of the samples, the methods of sample preservation (see below) and any notable circumstances.

C. On-site testing:

- Parameters that should be analysed on site include Dissolved Oxygen and temperature (particularly with view to the fish die-off!), pH, odour, colour and turbidity, and conductivity and CO_2.

D. Sample preservation:

- Core parameters that should be analysed in the laboratory with view to the domestic effluents include:
  - BOD and TOC (to establish the ration of biodegradable and total organic carbon); if a photometer for COD analysis is available, the COD can replace the TOC
  - Solids: Total Solids and Settlable Solids
  - Nitrogen: Nitrate, Nitrite and Ammonia (fish toxicity!)
  - Phosphorous: Total Phosphorous
  - Faecal coliforms as an indicator of contamination with faecal pathogens
- Looking at the range of contaminants to be expected from the different workshops, the analysis should also include:
  - Heavy metals (Cadmium, copper, chromium, nickel, mercury, zink, lead);
  - PAH (Polycyclic aromatic hydrocarbons, as typical derivates of mineral oils)
  - A fish toxicity or bioluminescence test.
- Each sample should be split in three sub-samples, to be preserved:
  - by chilling at 2-5°C and storage in the dark: TOC, BOD, E.coli, Solids, PAH
  - by acidifying to pH <2, using sulfuric acid: Total Phosphorous, Nitrogen (all three parameters)
  - by acidifying to pH <2, using nitric acid: heavy metals
- Mind that the time of stability varies between parameters: Faecal coliforms tests should be started within 6 hours, nitrogen compounds will be stable for about an hour in an acidified sample, meanwhile heavy metals are stable for about 6 months. Ideally, the analysis should be done upon return to the laboratory immediately after sampling.

E. Analysis in the laboratory:

- **BOD**: The dissolved oxygen (DO) content in the sample is measured, then allowed to stand in the dark in an airtight dish at about 20°C for x days (usu. five). The DO is measured once more to determine the oxygen is used up in the process.

  BOD = (DO1 – DO2)/ V

  DO1: DO before biodegradation; DO2: DO after biodegradation; V: Volume of sample
- **TOC**: Acidify (acid ph < 2) the sample to convert all anorganic carbon compounds to dissolved carbon dioxide, which is taken away by a CO_2-free carrier gas. The sample is then heated to some 850°C to convert the organic carbon compounds to carbon dioxide, which is then measured using a NDIR (non-dispersive infrared spectrometer). Alternatively, the **COD** can be determined using a photometer if an NDIR is not available.
- **Total Solids**: Evaporate a specified volume of the sample at 105 °C (→ so as not to boil away volatile solids!) in a pre-weighed dish and weigh after cooling in an exsiccator

  TS = (M1 –M2) / V

  M1: Mass of dish before drying; M2: Mass of dish after drying; V: Volume of sample

- **Settlable Solids**: Allow a specified volume of the sample to stand for one hour in an Imhoff cone, read the volume of settled solids at the marking of the cone
- **Nitrate, Nitrite, Ammonium**: Photometer, *alternatively:* testtubes (Further methods of analytics exist, however, these have not been presented as they will likely exceed the technical means available)
- **Total Phosphorous**: Testtubes (also available for Phosphate)
- **E.coli**: Dip slides
- **Heavy metals**: Photometer
- Polycyclic aromatic hydrocarbons **(PAH**): liquid-liquid-extraction, gaschromatographer (or other form of chromatography, e.g. High Performance Liquid Chromatography, HPLC)
- **Fish toxicity test**: The test determines the maximum wastewater concentration in which all test fish (species: orfe) survive during 48 hours in a basin of a defined volume at a defined temperature and DO concentration. The value TF is the factor by which the sample is diluted: TF1 means undiluted water, a TF of 21 a wastewater : dilution water ratio of 1:20. *Alternatively:* **Bioluminescence test**: The intensity of bioluminescence is measured initially on exposing the bacteria to the wastewater, and then in regular intervals with a luminometer.

F. Final remarks:

- The fish die-off can be due to substances that are immediately toxic for aquatic life, such as heavy metals, but given the correlation with the hot weather, the load of organic pollutants has at least a major role to play. An increased water temperature favours biodegradation of organic matter, resulting in a seizable oxygen depletion. On top of that, a higher temperature will decrease the solubility of oxygen, so that less oxygen is taken up from the atmosphere (Henry's Law). The fish may therefore quite simply have stifled.
- The impact of the river water's quality on aquatic ecosystems and human uses downstream depends on the four outlets of the entire city (presuming no larger pollutants are situated upstream of the municipality). When deciding on the effluent quality to be achieved for the particular outlet, the impact of the other three outlets should therefore likewise be considered. This is the main train of thought participants should develop.

8.3 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. What types of parameters are used in wastewater analytics?

____

2. What is the key parameter for organic matter and why?

a) BOD b) TOC
c) COD d) DO

3. What substances are included under "AOX"?

____

4. What properties of the wastewater are assessed using the fish test?

a) Its concentration in dissolved oxygen.
b) Its concentration of toxic heavy metals.
c) Its overall toxicity on fish.
d) Its conductivity (i.e. impact on the fish's equilibrium organ).

5. How should the sample be drawn and why?

____

6. What is the best conservation for the effluent's concentration in DO?

a) Acidification with H_2SO_4. b) Alkalinisation with NaOH.
c) Freezing at –18-20 °C. d) None, DO has to be analysed on site.

7. For how long can the BOD be conserved with the different methods?

a) For 8 days when alkalinised.
b) For 8 days when acidified to pH < 2.
c) For 32 days after addition of $HgCl_2$.
d) For 32 days when frozen.

8. How do you determine the pollution load for a specific substance of a (point source) discharger?

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9. What are the advantages and disadvantages of rapid tests?

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10. Why conduct on-site tests?

Answers:

1. Sum, group, and individual substance parameters.

2. b) The TOC is used because it captures all organic matter (biodegradable and non-biodegradable), while its analysis is less environmentally harmful as the common method for the COD.

3. Adsorbable organic halogen compounds.

4. c)

5. Approx. 1 m below the surface in the wastewater stream, so as to ensure that the sample is representative with view to its composition (stagnating water allows solids to settle; floatable constituents such as grease and tensides form a layer at the surface)

6. d)

7. a) and d)

8. Calculating the pollution load for a discharger requires composite sampling over the period for which the pollution load is to be assessed.
[Pollutant concentration (kg/ m^3 wastewater) * volume flow (m^3 / h) = pollution load]

9. Advantages:
    - requires less instruments; thus less expensive;
    - quicker results than with laboratory analytics.

   Disadvantages:
    - less accurate;
    - less sensitive.

10. On site tests are conducted
    - for parameters that cannot be conserved, such as pH, DO, and conductivity.
    - in order to gain an impression and adapt further sampling and analytics, thus reducing the number of expensive laboratory analyses.

8.4 Literature

Akcin G., Alp Ö., Gulyas H., Büst B., w/o yr. Characteristic, analytics and samplling of wastewater. EMWater Computer Based Training Lesson A1.

Schwedt G., 1996. Taschenatlas der Umweltchemie. Thieme, Stuttgart

8.5 Recommended Reading

Ayres R.M., Mara D.D., 1996. Analysis of wastewater for use in agriculture: A laboratory manual of parasitological and bacteriological techniques. World Health Organisation (available at: **http://www.who.int/water_sanitation_health/wastewater/labmanual.pdf)**

Bartram J, Balance R., 1996. Water quality monitoring: A practical guide to the design and implementation of freshwater quality studies and monitoring programmes. World Health Organisation (available at: **http://www.who.int/water_sanitation_health/resources/wqmonitor/en/index.html)**

Funk W, Damman V, Donnevert G., 1995. Quality assurance in analytical chemistry. Wiley –VCH, Weinheim.

Gary D.C., 2003. Analytical Chemistry. 6th edition. John Wiley & Sons, New York

Greenberg A. et al., 2005. Standard Methods for the Examination of Water and Wastewater. 21st ed. American Water Works Association (AWWA).

Hawkins M.D., 1988. Safety and laboratory practice. 3rd edition. Cassell Publishers Ltd., London.

Henze M., Ledin A., 2001. Types, characteristics and quantities of classic, combined domestic wastewaters. Chapter 4. In: Lens P. et al (eds.), 2001. Decentralised sanitation and reuse, concepts, systems and implementation. pp 59-72. IWA Publishing, London

Tomar M., 1999. Quality assessment of water and wastewater. Lewis Publishers, Boca Raton

8.6 Internet Resources

Premier Laboratory Sampling Guide
http://www.premierlaboratory.com/downloads/SamplingGuide2006.pdf

Standard Methods for the Examination of Water and Wastewater
http://www.standardmethods.org/Dedication.htm

The Water Quality Association
http://www.wqa.org/

University of Missouri, Dpmt of Agricultural Engineering: Sampling and Sample Preservation
http://extension.missouri.edu/explore/agguides/agengin/g01895.htm

World Health Organisation – Water Quality Monitoring
http://www.who.int/water_sanitation_health/resources/wqmonitor/en/index.html

9. Final/Feedback Session

Session overview

Time
Final/Feedback Session – 60 min

Objectives
- To recapitulate the contents of the past three days.
- To reflect on how to go about the transfer of what has been learned.
- To jointly find out if expectations have been met, fears have come true etc.
- To close the seminar.

Material
- Flipchart
- Marker
- 1-2 large sheets of paper (e.g. flipchart), depending on group size, with the rhombs of a fisher net drawn on it; you can also decorate it with some fish, shells etc.
- Moderation cards (cardboard cards, about the size of a hand) and felt pens
- Sellotape or blue tack
- Questionnaires (see below, according to the number of participants)
- (Felt) pens
- The four group mind maps developed in the first session
- One item relating to the seminar (piece of water pipe, water meter; item from the seminar room, such as a statuette or like)

Teaching method individual reflection and group discussion

Session guide

1. The first part of the session is a recapitulation of the key insights participants will take home from the seminar. - Distribute stacks of moderation cards on the tables, so participants can take more than one, and pass around the felt pens.

2. Hang up the "fishernet" at the wall or on the flipchart. Now ask participants to take the time to reflect and write down their key insights of the seminar – what has got caught in the "meshes of memory"? Each experience or insights is noted on an individual moderation card. Whenever a participant is finished, she/ he can come up to the poster and stick her/ his cards to the fishernet.

3. Once all participants are ready (usually after 5-10 min.), read out the results and discuss them in the plenary; you can ask what has made a particular aspect such a special insight, what relevance it has in the context of the participant's work life etc..

4. The second part of the session is dedicated to the idea of transfer: How do I transfer the insights into practice? Where will the input of the seminar help me with the challenges in everyday worklife, or with one particular problem? What toolbox do I take home? – Distribute the questionnaire and pens to the participants and ask them to gather in groups of 3-4.

5. Explain the purpose of the questionnaire and the peer group principle: Each group is a peer group within which participants will keep in touch for some time following the seminar to support each other in their respective implementation processes. This can be via telephone conference, mails, skype or personal meetings; however, communication should always include all members, so that each benefits from the advice and experiences (successes and failures!) of the other two. Ask peer groups to exchange contact details among themselves.

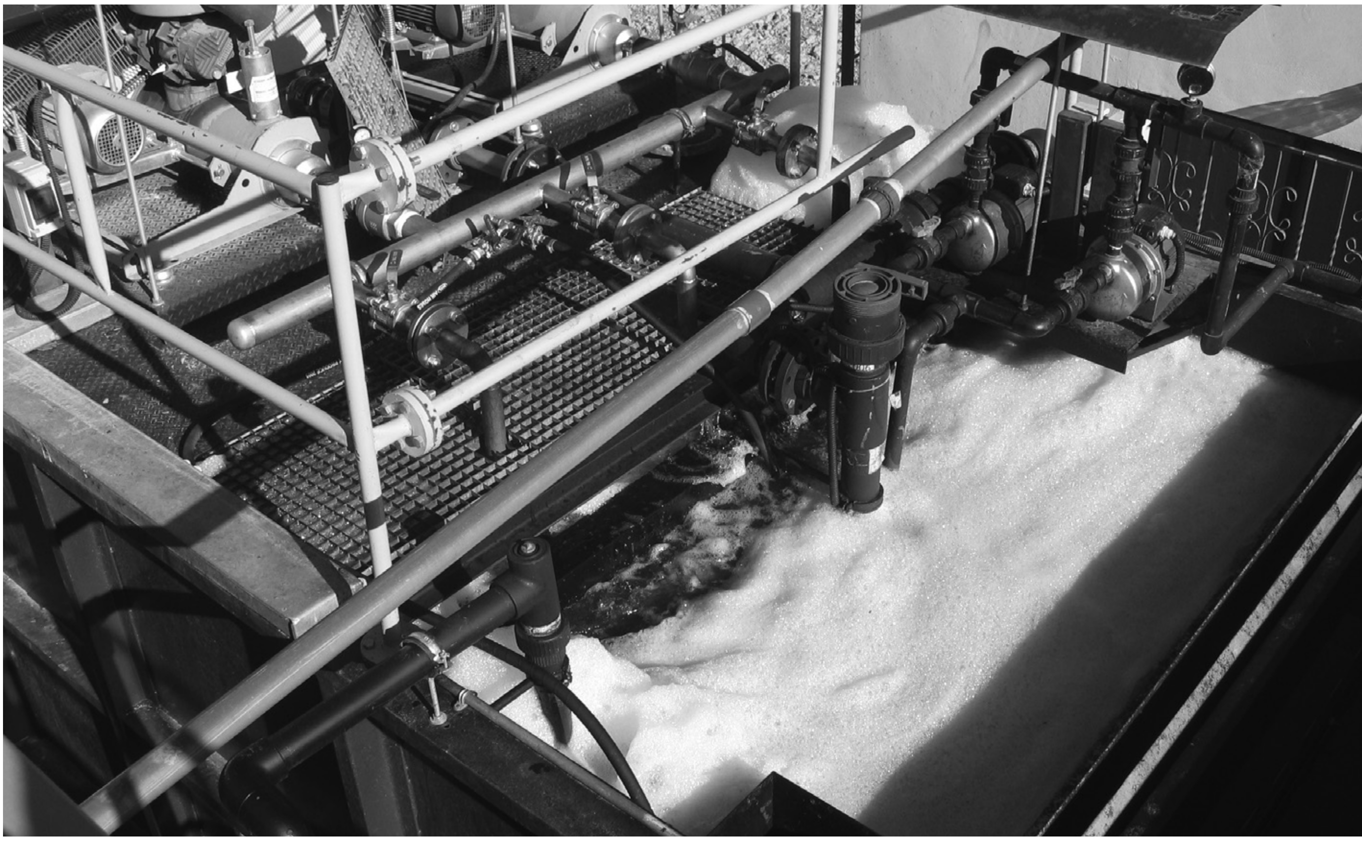
6. At first, participants fill out the questionnaire in silence for about 10 min. Then they present and discuss their findings within their group for about 30 min.; each participant has to have the chance of asking the others for their perception and advice on implementation and expected obstacles.

7. The final part of the session is dedicated to a group discussion of the seminar achievements. Hang up the four posters with the group mind maps drawn in the first session. Read them out and consider with the group which topics have indeed been dealt with, which expectations have been met and which haven't etc. Expectations and topics that have been discussed are ticked off or marked with a green point (marker/ felt pen). For the other ones, refer to the reasons given in the introductory discussion why they have not been addressed, or offer sources where participants can inform themselves.

8. Finally, let participants form a circle if the arrangement has been other, and place the item relating to the seminar in the middle. Participants are asked to share their impressions and ideas about the seminar with the group: What did they like about the course? What did they not like? How did they feel about working in this group? The first who would like to speak up takes the item; when having finished, she/ he passes it on to another participant, not necessarily an immediately neighbour, but anyone in the circle. At the end of a three-day seminar people will usually not be reluctant about making a start. If inhibition is too high to pick up the item and make the first statement, you can also keep the item in your hands while explaining the principle, and pass it on to your neigh-

bour on the right or left, asking her/ him to make the start. Participants' statements are not judged, although everyone can refer to or tie in with previous statements.

9. Once people have said everything they want to share, it is time to officially close the seminar, thank everyone for their participation, and wish them good luck for their future undertakings.



Module 2
Conventional Wastewater Treatment

2007

1. Introduction

The module on conventional wastewater treatment covers four topics:
1. Conventional wastewater treatment design
2. Wastewater treatment processes
3. Wastewater treatment plant operation and maintenance
4. Cost of conventional wastewater treatment

with the following objectives:
- To present the main design parameters for a wastewater treatment plant
- To present the wastewater treatment process
- To analyze common operational procedures and problems
- To estimate investment, operation and maintenance costs

After completing the course participants should be able to:
- Understand design parameters of a wastewater treatment plant
- Understand the wastewater treatment processes
- Understand main procedures applied in a wastewater treatment operation
- Comprehend the differences in effluent quality
- Estimate operational and maintenance costs of a wastewater treatment plant

For each module 1 - 4 materials are provided in the Trainer`s Toolkit which allow for a 3 day training, 6 training hours per day. While the Trainer`s Toolkit includes a suggested training schedule, the trainers are strongly encouraged to alter this schedule according to their own preferences and especially according to the training needs of the target group. The EMWater Trainer`s Toolkit which is designed for a very wide target group, can of course not fulfill the needs of each specific target group.

2. Suggested timetable for training

Conventional Wastewater Treatment

Training module 2

Day 1

9:00 – 10:30	Introductory Session

Topic 1: Conventional wastewater treatment design

10:30 – 11:00	Coffee Break
11:00 – 12:30	Session 1 – Exercise Topic Presentation (Continuation)
12:30 – 14:00	Lunch
14:00 – 15:30	Session 2 – Topic Presentation
15:30 – 16:00	Coffee Break
16:00 – 17:00	Session 3 – Case Studies

Training module 2

Day 2

Topic 2: Wastewater treatment processes

9:00 – 10:30	Session 1 – Topic Presentation
10:30 – 11:00	Coffee Break
11:00 – 12:30	Session 2 – Case Study Based Exercise
12:30 – 14:00	Lunch
14:00 – 15:30	Session 2 – Case Study Based Exercise (Cont.)
15:30 – 16:00	Coffee Break

Topic 3: Wastewater treatment plant operation & maintenance

16:00 – 17:30	Session 1 – Topic Presentation

Training module 2

Day 3

Topic 3: Wastewater treatment plant operation & maintenance

9:00 – 10:30	Session 2 – Case Study
10:30 – 11:00	Coffee Break

Topic 4: Cost of conventional wastewater treatment

11:00 – 11:30	Session 1 – Topic Presentation
12:30 – 14:00	Lunch
14:00 – 15:30	Session 2 – Exercise
15:30 – 16:00	Coffee Break
16:00 – 17:30	Final / Feedback Session

3. Introductory Session

Session overview

Time
Presenting the course objectives and agenda – 30 min
Get to know each other game – 60 min - see module 5 for suggestions

Objectives
- To present the objectives of the course to the participants
- To asses the participants' initial knowledge on the topic and their expectations
- To create a group atmosphere

Material
- Marker
- Flipchart
- Projector

Session guide

1. The suggestion is that you start by introducing yourself and asking the participants why we treat wastewater.

2. Continue by explaining what the course will cover and what participants can learn from attending this course.

3. Organise an introductory classroom activity following the suggestions from module 5.

4. Topic 1:

Conventional wastewater treatment design

Topic overview

Time:
Session 1: Exercise – 60 – 90 min
Session 2: Topic Presentation – 60 – 90 min
Session 3: Case Study – 30 – 45 min

Objectives
- To get an overview of wastewater characteristics
- To present and define commonly used design parameters
- To present population estimation techniques
- To select an appropriate treatment technique

Participants should be able to
- Understand wastewater characteristics
- Recognize physical and chemical constituents of wastewater
- Understand parameters used in designing wastewater treatment facilities

Material
- Marker
- Pin board
- Flipchart
- Projector
- Assignment material

This topic is covered in 3 sessions:

1. Session 1 – Exercise

The suggestion is that you start this topic with the exercise session. This session serves as a simple introduction to explain some of the basic parameters of wastewater flow and using statistics in the design phase of wastewater treatment development. Furthermore, this exercise is meant to create a more relaxed atmosphere and better group coherence at the beginning of this module.

2. Session 2 – Topic Presentation

The topic presentation can be covered in 70-100 minutes according to the level of knowledge and experience of participants. Some aspects of this presentation (the part describing influent quality) are also covered in the Wastewater Management module. Hence; some slides are made optional regarding the overall organization of the course.

3. Session 3 – Case Study

The suggestion is to have this session at the end of this topic presentation. The case study should show the application of the design principles that participants were introduced to in the topic presentation, using a real world example.

4.1 Session 1 – Exercise

Estimating domestic wastewater flow

Session overview

Title Estimating domestic wastewater flow

Objectives
- To gain an understanding of the wastewater flow concept
- To understand the use of statistics in wastewater design

Teaching method interactive participation, discussion

Time estimation
- 10 minutes exercise explanation
- 20 minutes for completing forms
- 10 minutes for writing down the results
- 30 minutes for discussion

Needed material markers, paper, flipchart, form

Session guide

1. Ask every participant to estimate his or her wastewater production in one day. Participants need to identify all their daily activities where wastewater is created and estimate the quantities in litres on the provided form.

2. Ask participants to write the total daily quantity on a flipchart with big numbers that are easy to read from a distance.

3. Ask participants with the lowest and highest number obtained to present how they came up with these numbers and discuss any differences.

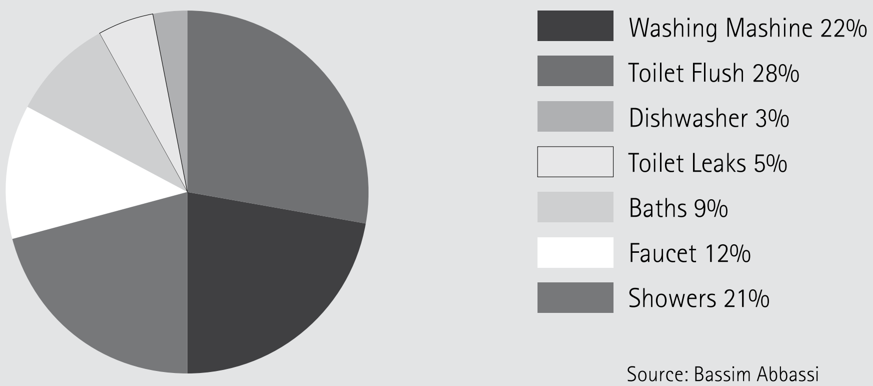
4. Discuss different activities of participants and how wastewater varies from individual to individual. E.g. you might use 15 litres to wash dishes by hand, someone else might use 20. You may or may not leave the water running when you brush your teeth.

5. Ask the participants what the population of the place where the lecture is held is and write this number on the flipchart.

6. Ask participants how they would come up with the projection of the total wastewater flow

7. Introduce them to the statistical method for estimating total wastewater flow – let them average all daily flow quantities written on a flipchart and use this number to multiply it with the population size.

Typical wastewater distribution



Source: Bassim Abbassi

Estimating domestic wastewater flow

Individual daily wastewater inventory

Activity	Wastewater created [l]
TOTAL	

Trainer’s notes

Example of the individual daily wastewater inventory

Activity	Wastewater created [l]
1. Showering	50
2. Shaving	2
3. Brushing teeth	3
4. Flushing toilet	25
5. Cooking	5
6. Washing dishes	15
7. Washing clothes	30
8. Hands washing	5
TOTAL	**135**

4.2 Session 2 – Topic Presentation

PPT

Wastewater Treatment Plant Design

Session overview

Title Wastewater Treatment Plant Design

Objectives
- Overview of wastewater characteristics
- Presenting commonly used design parameters
- Selection of appropriate treatment techniques

Teaching method lecture

Time estimation 70 – 100 minutes

Needed material projector, flip chart, markers

Session guide

The trainer might decide to cover the topic in less or more detail by rearranging or completely excluding some of the slides according to the participants' prior experience and knowledge. To facilitate the lecture, notes providing additional content information for trainers are included within the presentation itself.

1. Introduction - At the beginning, design parameters which are covered in this lecture are presented (slide 5).

2. Design period - Wastewater treatment plants are designed to serve for a relatively long period of time. They should meet the treatment needs of today as well as estimated needs in the future (slide 7).

3. Wastewater characterization – the suggestion is first to explain the differences between influent and effluent. Influent analysis shows the input quality of wastewater, while the effluent quality requirements influence the level of treatment (slides 8-10).

4. Wastewater quality is described by physical, chemical and biological parameters (slide 11). These parameters are described in slides 12-61. Since the Wastewater Management module covers a number of these parameters in greater detail, some of the slides may be taken out depending on the course organisation.

5. Slides 12 to 18 cover the physical parameters that are typically analysed. Additional information is provided in the slide notes for some parameters.

Colour

The quality of water can be judged by the colour. Pure water is colourless. In wastewater treatment, colour is not necessarily a problem, but instead is an indicator of the condition of the wastewater. Condition refers to the age of the wastewater, which is determined qualitatively by its colour and odour. Fresh wastewater is a light brownish-grey colour. The colour of wastewater changes sequentially from grey to dark grey and ultimately to black as the travel time in the collection system increases (flow becomes increasingly more septic) and more anaerobic conditions develop.

Temperature

Temperature is a very important parameter because of its effect on chemical reaction rates, aquatic life, and the solubility of essential gases such as oxygen in water. The temperature of domestic wastewater is higher than that of the water supply because of the addition of warm water from households. Depending on the geographical location, the mean annual temperature of wastewater varies from about 10 to 21.1 °C. The temperature of a wastewater sample can be measured with an ordinary mercury or digital thermometer.

Turbidity

The major effect turbidity has on humans might be simply aesthetic - people don't like the look of dirty water. However, turbidity also adds real costs to the treatment of surface water supplies used for drinking water since the turbidity must be virtually eliminated for effective disinfection (usually by chlorine in a variety of forms) to occur. Particulates also provide attachment sites for heavy metals such as cadmium, mercury and lead, and many toxic organic contaminants such as PCBs, PAHs and many pesticides.

Turbidity is reported in nephelometric units (NTUs), which refers to the type of instrument (turbidimeter or nephelometer) used for estimating light scattering from suspended particulate material. Turbidity can be measured in several ways. Turbidity is most often used to estimate the TSS (total suspended solids).

6. Slides 20 to 51 cover the chemical parameters that are typically analysed. The suggestion is to keep the short description of organic material tests and the explanation of the relation between BOD and COD in the presentation (slides 22-29).

Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand is a sum parameter for the amount of oxygen required to biochemically oxidise organic matter present in the water. Thus, BOD is an indirect measure of the concentration of organic contamination in water. BOD analysis does not oxidise all of the organic matter present in the waste. Only the organics that are biochemically degradable during a period of n days at 20°C are oxidised. The period in days is given as the index in BODn. The standard for usual measurements is a 5-day period.

Chemical Oxygen Demand (COD)

The chemical oxygen demand (COD) is the equivalent amount of oxygen required to oxidise organic matter present in a water sample by means of a strong chemical oxidising agent. COD is also a sum parameter and is used to measure the content of organic matter of wastewater. The COD values include the oxygen demand created by biodegradable as well as non-biodegradable substances. As a result, COD values are greater than BOD. In comparison with BOD5, COD measurement has an advantage in that it requires a short digestion period of about 3 hours rather than an incubation period of 5 days required for BOD5 measurement. For many types of wastes, it is possible to correlate COD with BOD. Once the correlation has been established, COD measurements can be used to good advantage for treatment-plant control and operation.

Nitrogen

Nitrogen compounds with environmental relevance frequently analyzed in wastewater are ammonia, nitrite, nitrate, and Kjeldahl nitrogen. Ammonia discharged to surface water can be nitrified in the aqueous environment if nitrifying microorganisms are present. The nitrifying bacteria consume dissolved oxygen for this process, thus depleting the oxygen content of the surface water with the consequence of massive dying of fish. Moreover, if the pH of the surface water is in the alkaline range, NH_3 is formed which is toxic to fish. The nitrate ion represents a nutrient leading to eutrophication of surface water, and nitrite is toxic and can react with amines (formed e.g. from amino acids of proteins) to yield N-nitrosamines which are powerful carcinogens.

Phosphorous

Phosphorus is essential to the growth of algae and other biological organisms. The amount of phosphorus compounds present in wastewater discharge has to be controlled in order to avoid noxious algal blooms occurring in surface water. The usual forms of phosphorus found in aqueous solutions include orthophosphate, polyphosphate, and organic phosphate.

7. Slides 53 to 60 describe common biological parameters of wastewater; including bacteria, viruses, protozoa and helminths.

Bacteria

Most of the organisms found in faeces are bacteria. There are several billion bacteria in every gram of faeces.
The diseases they cause generally spread rapidly, and consequently bacteria have been responsible for most of the world's major epidemics derived from water.
Two of the most well known diseases caused by bacteria are typhoid fever and cholera.

8. To conclude this part of the presentation, typical domestic wastewater characteristics are presented on slide 59.

9. Wastewater quantity and flow factors – slides 63 to 65 present the concept of population equivalent and population estimation techniques. The parallel can be drawn to the exercise session.

Population Estimation

A number of mathematical models are available for predicting population figures. These include:

1. Arithmetic method

dP/dt = k P where k = ΔP/ ΔT

$Pt = P_0 + kt$

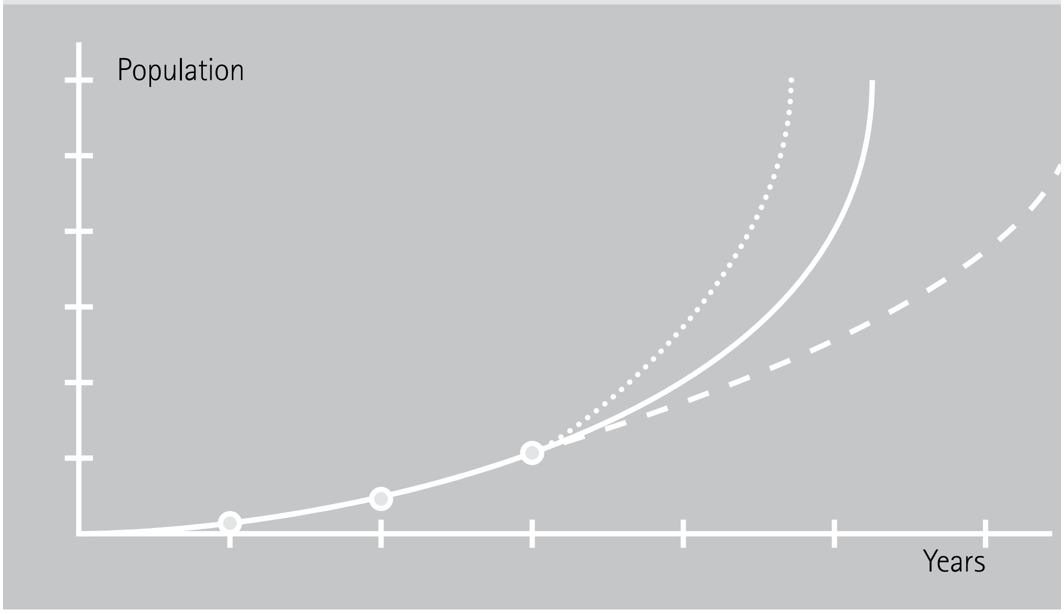
2. Uniform Percentage Method

dP/dt = k'P where k' = (lnP –lnP_0)/ Δt

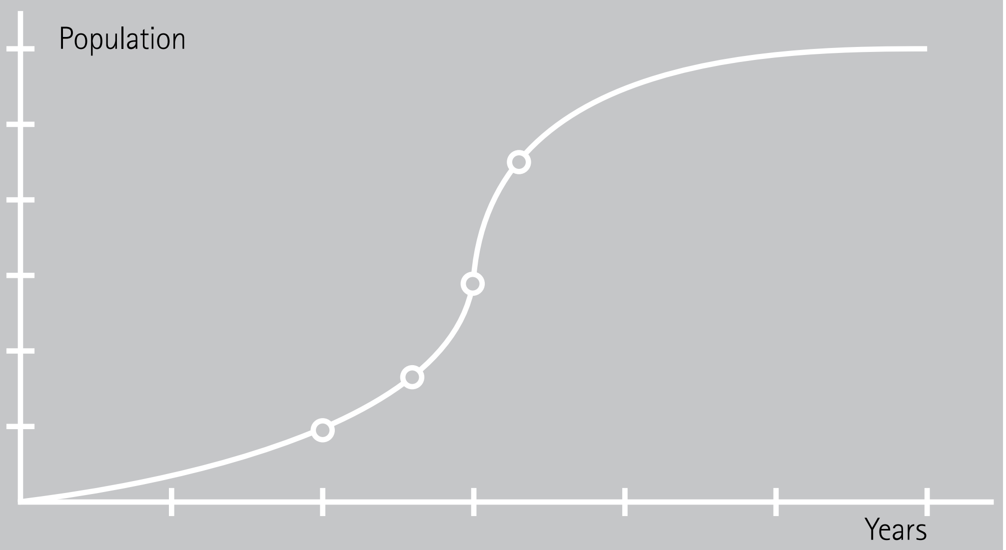
lnP = lnP_0 + k' Δt

P and P_0 are recorded the populations separated by a time interval Δt.

3. Curvilinear Method



4. Logistic Method



$P = P_{sat} / (1 + e^{a+b\Delta t})$; $Psat = \dfrac{2P_0P_1P_2 - P1^2(P_0+P_2)}{P_0P_2 - P_1^2}$

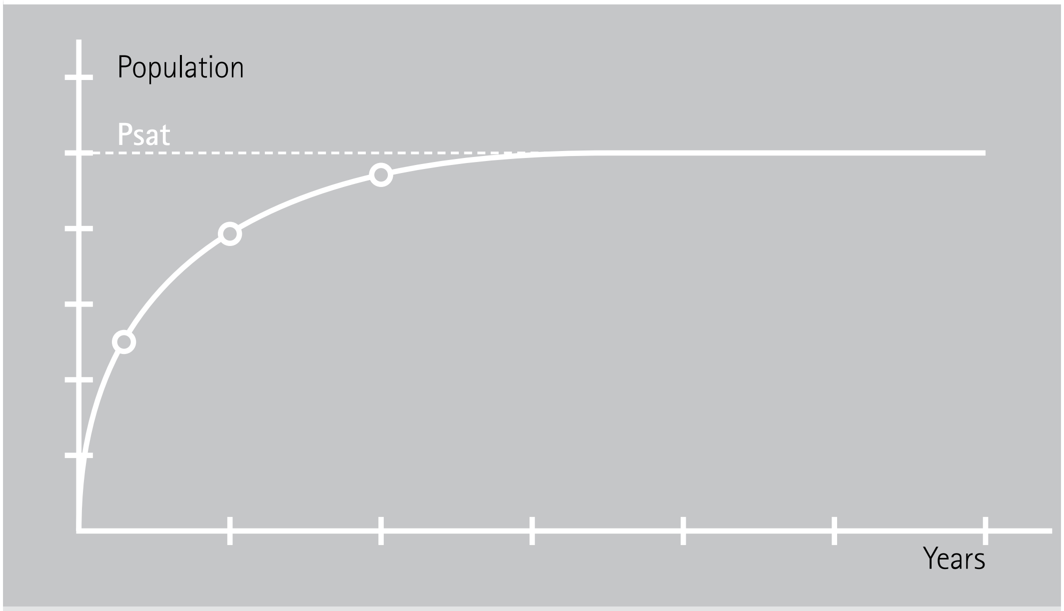
$a = \ln [(P_{sat} - P_2)/ P_2]$

$b = 1/n \ln \{ [P_0(P_{sat} - P_1)] / [P_1(P_{sat} - P_0)]\}$

P_0 = base year;

n = years (time interval between successive censuses)

5. Declining Growth Rate



$dP/dt = K'' (P_{sat} - P);$

$K'' = 1/n \ln[(P_{sat} - P) / (P_{sat} - P_0)]$

$P = P_0 (P_{sat} - P_0)(1 - e^{k''\Delta t})$

10. Wastewater flow factors are introduced describing the concepts of maximum and average flow in slides 66-68. The use of calculations and more detailed flow analysis is intentionally avoided, taking into account the broad scope of the 3 day module. The trainer should guide the participants with more technical skills to the recommended reading literature on this topic.

11. Location of wastewater treatment plant – location recommendations and guiding principles for choosing the appropriate treatment system according to the spatial availability are presented in slides 70 and 71.

Typical composition of untreated domestic wastewater				
	Unit	**L. S.**	**M. S.**	**H. S.**
Total Solids (TS)	mg/L	390	720	1230
Total dissolved solids (TDS)	mg/L	270	500	860
Total suspended solids (TSS)	mg/L	120	210	400
Settleable solids	mg/L	5	10	20
BOD5	mg/L	110	190	350
Total Organic Carbon (TOC)	mg/L	80	140	260
COD	mg/L	250	430	800
Total Nitrogen	mg/L	20	40	70
Free Ammonia	mg/L	12	25	45
Total Phosphorus	mg/L	4	7	12
Chlorides	mg/L	30	50	90
Sulphate	mg/L	20	30	50
Oil and Grease	mg/L	50	90	100
Volatile organic compounds	mg/L	<100	100 – 400	>400
Total coliforms	No./100ml	106 – 108	107 – 109	107 – 1010
Faecal coliforms	No./100ml	103 – 105	104 – 106	105 – 108

4.3 Session 3 – Case Study

Dilovası Industrial Organized District (DOSB)

Session overview

Title Dilovası Industrial Organized District (DOSB)

Objectives
- To show the application of design principles in the real-world example of wastewater treatment plant development.

Teaching method presentation

Time estimation 60-90 minutes

Needed material overhead projector

Session guide

1. The introduction to the Turkish Dilovası District and the planned wastewater treatment plant development is given in slides 2 to 4.

Dilovası Organised Industrial District

Dilovası is located in the Gebze district of Kocaeli province in Turkey and it is home to a number of industries of various sizes and production sectors. The rapid development in the area resulted in an unplanned urbanization where industrial and residential areas are located in close proximity to each other.
Efforts to develop an Organized Industrial District in Dilovası started in the 1990s, championed by the Dilovası Industrialists Foundation (DISAV). The goals were curbing unplanned development, maintaining coordination among industries, minimizing environmental impact and taking advantage of the Organized Industries Law No. 4562.
DOSB covers a total area of approximately 1000 hectares, surrounded by the D 100 (formerly E-5) highway to the north and east, the Trans-European Motorway to the west, and a railroad and the harbour to the south. Because of the existing industries and transportation alternatives, the area has an exceptionally good location.

2. Slides 5 and 10 show the present population and industrial figures and present growth estimates up to 2035.

3. The present and estimated future average, maximum and minimum flow-rates are shown in slides 10 to 17.

4. Slides 17 to 20 show the present and estimated future wastewater quality characteristics.

5. The required effluent characteristics defining the level of treatment are presented in slides 21-23.

6. The expected plant construction timing is given in the last slide.

Design Stages and Useful Life

There are uncertainties as to the future changes in flow and composition of the industrial wastewater from DOSB industries as the character of the future industries is not known at the present time. To be able to most effectively deal with such possible changes, a staged implementation of the common wastewater treatment plant is suggested.

Furthermore, the actual rate at which new industries will establish in DOSB is uncertain. The feasibility study will therefore comprise an assessment of these different projections incorporating the economic consequences and risks incurred.

Based on the above considerations, a staged construction with two stages is initially proposed, which will be consolidated or modified according to this risk analysis at a later phase of the feasibility study. The following staging strategy would thus be applicable:

- The main collector system in DOSB shall already be designed for the ultimate hydraulic load in the first stage (design horizon 2035).
- Internal piping of the treatment plant and hydraulic structures not staged shall also be designed for the ultimate hydraulic load.
- All other process and hydraulic structures shall be designed for the projected loads in 2015. (Some structures shall be prepared physically for future connection of further treatment units as found appropriate to ease future extensions when required).

The timing of the second stage will depend on the actual development of land occupation in DOSB and on the types of industry.

The useful life of the civil works structure is assumed to be 30 years and 15 years for mechanical and electrical equipment.

4.4 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. What is municipal wastewater treatment plant influent?

a. Untreated sewage water
b. Water discharged from a wastewater plant

2. What is the typical BOD/COD ratio for untreated municipal waste?

a. 3-5
b. 10-20
c. 0.3-0.8
d. 0.01 – 0.05

3. What is a common cause of odour in wastewater?

a. Hydrogen-sulphide
b. Methane
c. Carbon-dioxide
d. Benzene

4. Which of the following are types of solids in wastewater?

a. Settleable Solids
b. Suspended Solids
c. Dissolved Solids
d. Polluted Solids

5. Regarding the site selection for a rainwater infiltration facility, which of the following factors do you consider as advantageous?

a. The bedrock is 1 meter below the surface.
b. The surface is covered by grass.
c. The distance to the groundwater is more than 3 meters.
d. The soil is clay.

Answers

1. a
2. c
3. a
4. a,b,c
5. b, c

4.5 Literature

Bassim A (2004). presentation, InWEnt Training program on Chemical, Physical, and Biological Methods for Water and Wastewater Analysis

El-Hoz M. (2006), presentation, Water Quality Parameters For Wastewater Treatment Plant, Training Program for Lebanese Officials and Stakeholders

Giordano A., Petta L. (2005), EMWater e-Learning Course No. 1, Lesson c1: Operation and management of wastewater treatment plants

George M. A. (2006), presentation, General Considerations in Designing a Wastewater Treatment Plant, American University of Beirut

Göksel A., Öznur A., Holger G. Birgit B., EMWater e-Learning Course No. 1, Lesson a1:Characteristic, analytic and sampling of wastewater

Greenberg, A.E., Trussell, R.R., Clesceri, L.S., and *Franson, M.A.H.*, eds. (1985) Standard methods for the examination of water and wastewater, 16th ed. American Public Health Association, Washington, DC.

Henze, M. and *Ledin, A.*(2001) Types, characteristics and quantities of classic, combined domestic of classic, combined domestic. In: Decentralised sanitation and reuse, concepts, systems and implementation (eds. Lens, P., Zeeman,G., Lettinga, G). IWA Publishing.

Snoeyink, V.L., and *D.Jenkins,* Water Chemistry, second ed., John Wiley&Sons, New York, 1988.

Tchobanoglous, G., and *Burton, F.L.* (1991) Wastewater engineering: treatment, disposal, reuse, 3rd ed. McGraw-Hill, Inc., New York.

Tchobanoglous, G., and *Schroeder, E.D.* (1987) Water quality: characteristics, modeling, modification. Addison-Wesley Publishing Company, Reading, MA.

Wastewater Engineering – Treatment, Disposal and Reuse, third edition, McGraw-Hill Companies,1991.

Tchobanoglous, G., and E.D.Schroeder: Water Quality: Characteristics, Modeling, Modification, Addison-Wesley, Reading, MA, 1985.

Tomar, M. (1999). Quality Assessment of Water and Wastewater. Lewis publishers German Chemists Association (1981) Preservation of water samples. Wat. Res. 15, 233-241.

M.N. Pons, H. Spanjers, D. Baetens, O. Nowak, S. Gillot, J. Nouwen, N. Schuttinga (2004),Wastewater Characteristics in Europe, European Water Association

4.6 Recommended Reading

American Water Works Association, American Society of Civil Engineers, Water Treatment Plant Design, 3rd edition, McGraw-Hill Professional, 1997

American Society Of Civil Engineers, Design of Municipal Wastewater Treatment Plants, Water Environment Federation, 1992

Samuel D. Faust, Osman M. Aly, Chemistry of Water Treatment, Second Edition, CRC; 2 Sub edition, 1998

Mackenzie L Davis, Susan J Masten, Mackenzie Davis, Susan Masten, Principles of Environmental Engineering and Science, McGraw-Hill, 2003

Göksel Akcin, Öznur Alp, Holger Gulyas, Birgit Büst, Characteristic, analytic and sampling of wastewater, Emwater e-learning course

4.7 Internet Resources

http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-15/main_index.asp
International Source Book on Environmentally Sound Technologies for Wastewater and Stormwater Management

http://www.marsh-mcbirney.com/flowcalculator/index.htm
Online flow calculator.

http://dnr.wi.gov/org/water/wm/glwsp/facilities/designflow.htm
Guidance for Wastewater Treatment Facility Design Flow Determinations

www.cowiprojects.com/envest/PDF-files/IP2-Dilovası/EHCIP_IP2_DOSB_Design%20Criteria_ver%201.pdf
Design Criteria Report of Dilovası Industrial Organized District Wastewater Management Project Feasibility Study

http://www.epa.gov/owm/
The United States Environmental Protection Agency's Office of Wastewater Management (OWM)

http://www.chemeng.queensu.ca/courses/CHEE370/outline/
Queen's University course on waste treatment processes.

http://ec.europa.eu/environment/water/water-urbanwaste/index_en.html
C Urban Waste Water Directive Overview

http://www.rem.sfu.ca/FRAP/9409.pdf
Wastewater characterization of four industrial discharges in the Fraser river basin

5. Topic 2

Wastewater treatment processes

Topic overview

Time
Session 1: Topic Presentation – 70 -100 min
Session 2: Case Study Based Exercise – 180 - 200 min

Objectives
- To present the biological, chemical and physical processes in wastewater treatment
- To explain preliminary, primary, secondary and tertiary stages of wastewater treatment
- To examine sludge characteristics and treatment methods

Participants should be able to
- Understand specifics of different processes
- Comprehend the treatment sequence and what is going on in each step
- Recognize sludge management options

Material
- Marker
- Pin board
- Flipchart
- Projector
- Assignment material

This topic is covered in 2 sessions:

1. Session 1 – Topic Presentation

The topic presentation should introduce participants to different processes and stages of conventional wastewater treatment. It is possible to reduce the scope of this presentation by excluding a number of slides to better match participants' needs and technical skills. The slides contain notes with additional information for trainers to facilitate the lecture delivery.

2. Session 2 – Case Study Based Exercise

This case study based exercise builds upon the content of the last case study following the same example of the Dilovası wastewater plant development. Participants will design different treatment schemes making use of acquired knowledge on treatment processes.

3. Additional Assignment

This small case study exercise can be given to participants as an individual home-work assignment and then latter discussed in class, depending on time constraints.

5.1 Session 1 – Topic Presentation

Wastewater Treatment Processes

Session overview

Title Wastewater Treatment Processes

Objectives
- To present the biological, chemical and physical processes in wastewater treatment.
- To explain preliminary, primary, secondary and tertiary stages of wastewater treatment.
- To examine sludge characteristics and treatment methods.

Teaching method lecture

Time estimation 70 – 100 minutes

Needed material projector, flip-chart

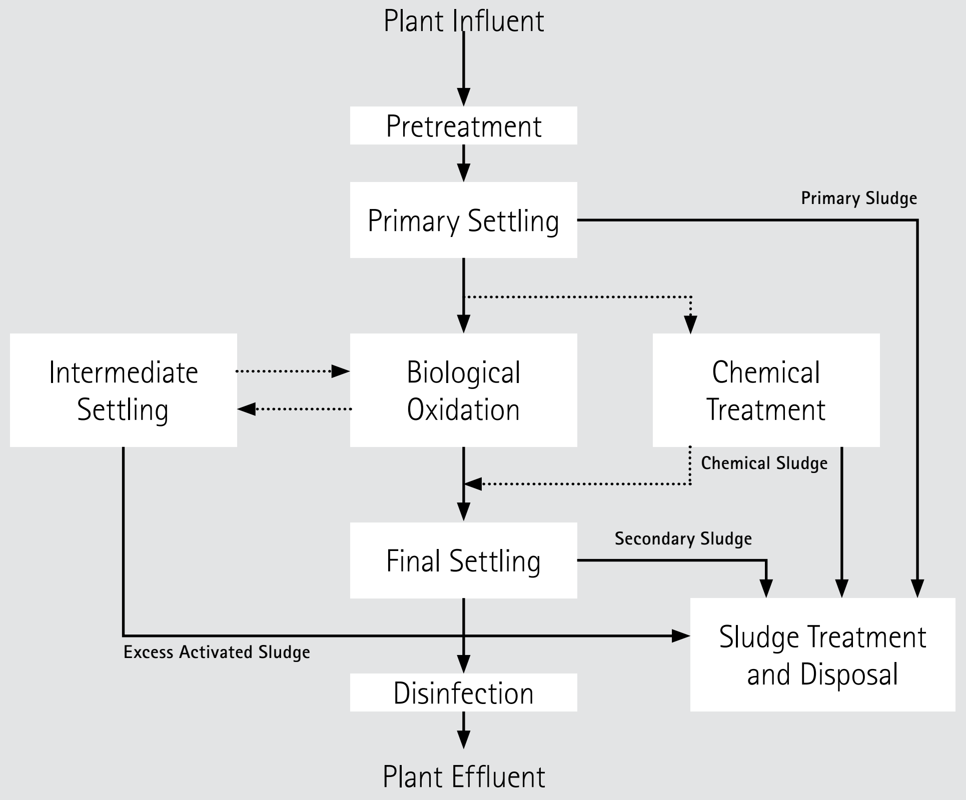
Session guide

It is possible to reduce the scope of this presentation by excluding a number of slides to better match participants' needs and technical skills. The slides contain notes with additional information for trainers to facilitate the lecture delivery.

1. Three different types of processes occurring in wastewater treatment, i.e. biological, chemical and physical are briefly presented in slides 5-8.

2. The scheme of typical wastewater treatment stages is presented in slide 9. The trainer can refer to this slide when later explaining different process stages.

Wastewater Treatment



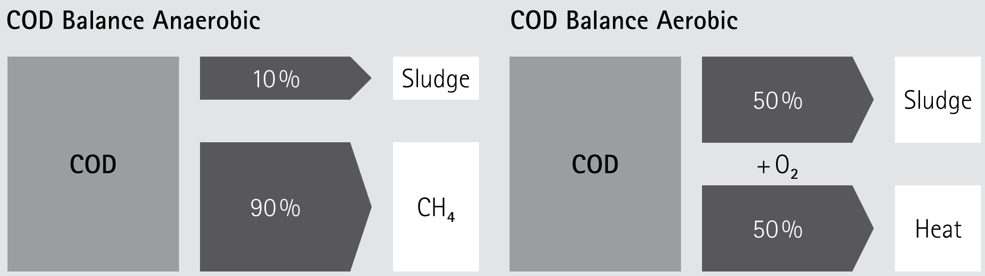
Preliminary/Primary treatment is applied to reduce oils, grease, fats, sand, grit, and coarse (settleable) solids. This step is done entirely with machinery.

Secondary treatment is designed to substantially degrade the dissolved content of the sewage within a biological degradation system, such as an activated sludge system. These systems use the capability of microorganisms to degrade dissolved components in water. The final step in the secondary treatment stage is to separate the used biological media from the cleared sewage water with very low levels of organic material and suspended matter.

Tertiary treatment or advanced treatment is not yet applied widely. It provides a final stage to raise the effluent quality to the standard required before it is discharged to the receiving environment. More than one tertiary treatment process may be used at any treatment plant. In most cases, it is further nitrogen or phosphate elimination and/or disinfection. Additional steps like lagooning or constructed wetlands are also counted as a tertiary step if they are used after secondary treatment.

3. The preliminary and primary treatment stages are presented in slides 11 – 16.

4. Biological processes in secondary treatment are presented on slides 18 to 36. A number of common aerobic and anaerobic treatment technologies is presented. You can reduce the presentation scope by excluding some slides.



Aerobic and anaerobic treatment

A big advantage of anaerobic wastewater treatment is the production of much less sludge than in aerobic systems because of low growth rates of anaerobic bacteria. If the primary and secondary treatment is replaced by an anaerobic step, the sludge production is less than 10% of the aerobic system.

The COD in wastewater during anaerobic treatment is mostly converted to methane, which is a valuable fuel. Very little COD is converted to sludge. No major inputs are required to operate the system. Nevertheless it depends on stable preconditions i.e. temperature to make the process stable.

Much of the COD in wastewater is converted to sludge during aerobic treatment, a bulky waste product, which costs lots of money to get rid of in developed countries with less area, but can be of interest as a low-cost fertilizer in developing countries if the sludge is not contaminated. Elemental oxygen has to be continuously supplied by aerating the wastewater.

5. The advantages and disadvantages of the common biological methods of treating wastewater are compared in slides 37 to 41.

6. Tertiary treatment options are presented in slides 44 to 52 including nutrient removal and disinfection options, such as chlorination, ozonation and UV treatment.

Nitrogen removal

The removal of nitrogen is effected through the biological oxidation of nitrogen from ammonia (nitrification) to nitrate, followed by denitrification, the reduction of nitrate to nitrogen gas. Nitrogen gas is released to the atmosphere and thus removed from the water. Nitrification itself is a two-step aerobic process, each step facilitated by a different type of bacteria. The oxidation of ammonia (NH_3) to nitrite (NO_2^-) is most often facilitated by Nitrosomonas spp. (nitroso=ammonium). Nitrite oxidation to nitrate (NO_3^-), though traditionally believed to be facilitated by Nitrobacter spp. (nitro=nitrite), is now known to be facilitated in the environment almost exclusively by Nitrospira spp.
Denitrification requires anoxic conditions to encourage the appropriate biological communities to form. It is facilitated by a wide diversity of bacteria. Sand filters, lagooning and reed beds can all be used to reduce nitrogen, but the activated sludge process (if designed well) can do the job the most easily.

7. Slide 53 gives an overview of pollutants removed in different treatment stages.

8. Finally the options for sludge treatment and disposal are given in slides 55 to 68. Slide 61 presents an overview of disposal options. The trainer might discuss advantages and disadvantages of each option with the class before showing the complete slide.

Overview of Sludge Disposal Options

Disposal option	Advantage	Disadvantage
Landfill	no spreading of heavy metals	no nutrient recovery
		danger of groundwater infiltration
Incineration	phosphorus recovery possible (but rarely done)	loss of nitrogen
	no spreading of heavy metals	expensive
Agricultural utilisation	full nutrient recovery	heavy metals and organic pollutants are applied, too
	cheap fertilizer	
	low disposal costs	pathogenes may be spread
Application to disturbed land	low disposal costs	concentrated application of heavy metals and organic pollutants

9. The trainer might discuss the feasibility of agricultural utilization of sludge in the area where participants come from according to the limitations presented in the last slide.

5.2 Session 2 – Case Study Based Exercise

Dilovası Industrial Organized District Wastewater Management Project

Session overview

Title Dilovası Industrial Organized District Wastewater Management Project

Time estimation 180 - 200 minutes

Objectives
- To understand different unit processes and stages of the wastewater treatment process.

Teaching method group work, discussion

Time estimation
- 10 minutes to divide into groups
- 10 minutes to explain the exercise
- 45 minutes for groups to prepare designs
- 60 minutes for presenting the designs
- 45 minutes for discussion

Needed material group assignment paper, markers, pin board, flip chart

Session guide

1. Divide participants in 2-3 groups and give them the exercise materials.

2. Each group will make a design scheme of a wastewater treatment process for one of the proposed alternatives according to the assignment paper.

3. Give groups time to draw the design. Provide them with help if necessary.

4. Each group needs to present their design on a pin board in front of the class.

5. Ask them to identify different treatment stages in their design and what is happening in each. Why do they consider such a design appropriate?

6. Let all participants discuss the possibilities to improve the design or to identify problem areas.

Dilovası Industrial Organized District Wastewater Management Project

Dilovası Industrial Organized District in Turkey is planning to construct the new wastewater treatment plant which would serve the needs of the industry located in the district as well as the needs of the neighbouring residential areas.
In order to fulfil the discharge criteria to the recipient water body Dil Creek, a number of unit treatment processes must be combined in the new common wastewater treatment plant. Substantial removal efficiencies are required for the following substances in the wastewater:

- Organic matter, particulate or soluble
- Inorganic matter, particulate or soluble
- Oil and grease
- Nutrients (nitrogen and phosphorus)
- Heavy metals
- pH

Thus various combinations of the following unit processes will be assessed as possible wastewater and sludge treatment configuration options.

- Equalization
- Preliminary treatment (screening, grit and oil removal)
- Primary settling
- Chemical precipitation (heavy metal and P removal)
- Biological treatment
    - Carbon removal
    - Nitrogen removal (nitrification, denitrification)
    - Biological phosphorus removal
- Disinfection
- Filtration

Due to the expected complex character of the wastewater and the area limitations for the common treatment plant, options that require area such as stabilisation ponds and sludge drying beds are not considered.
Final sludge disposal options include incineration and landfill application.
Agricultural use of the sludge is not considered an option due to the expected character of the wastewater and, consequently, the resulting composition of the sludge.
The three treatment plant configurations proposed have been selected in a screening process.

Task:

1. Draw a design scheme of a treatment process.
2. Show in the scheme the domestic and industrial influent entry points and effluent exit point in Dil Creek.
3. Show where the sludge is created and propose the sludge treatment prior to landfill application.
4. Show on the scheme which processes belong to preliminary, primary, secondary and tertiary treatment.

Alternative A

In Alternative A, all wastewaters, namely industrial and municipal wastewaters, are combined before entering the treatment processes.
After equalising the stream, a preliminary treatment shall be applied to remove large sized particulates, grits and oil & grease. Then a chemical precipitation unit is proposed to remove mainly TSS, heavy metals and phosphorus. Organic matter will also be removed here to a limited extent. The third step is a biologically activated sludge process including nitrification and denitrification to remove carbon and nitrogen. After disinfection, wastewater will be discharged to Dil Creek.
For the wastewater stream, the system comprises the following treatment units:

1. Screening
2. Aerated grit and grease removal
3. Equalization
4. Chemical precipitation
5. Biologically activated sludge with nitrification and denitrification
6. Disinfection

Alternative B

Alternative B is mainly based on the segregation of industrial and domestic wastewaters. Only industrial wastewaters are treated in the chemical treatment unit, while all the municipal wastewater enters the biological treatment process.
In this configuration, the size of the chemical treatment unit is decreased.

For the wastewater stream, the system comprises the following treatment units:

1. Screening for industrial wastewater
2. Aerated grit and grease removal for industrial wastewater
3. Equalization for industrial wastewater
4. Chemical precipitation for industrial wastewater

5. Screening for domestic wastewater
6. Aerated grit and grease removal for domestic wastewater
7. Primary settling for domestic wastewater (optional)
8. Biologically activated sludge with nitrification and denitrification
9. Disinfection

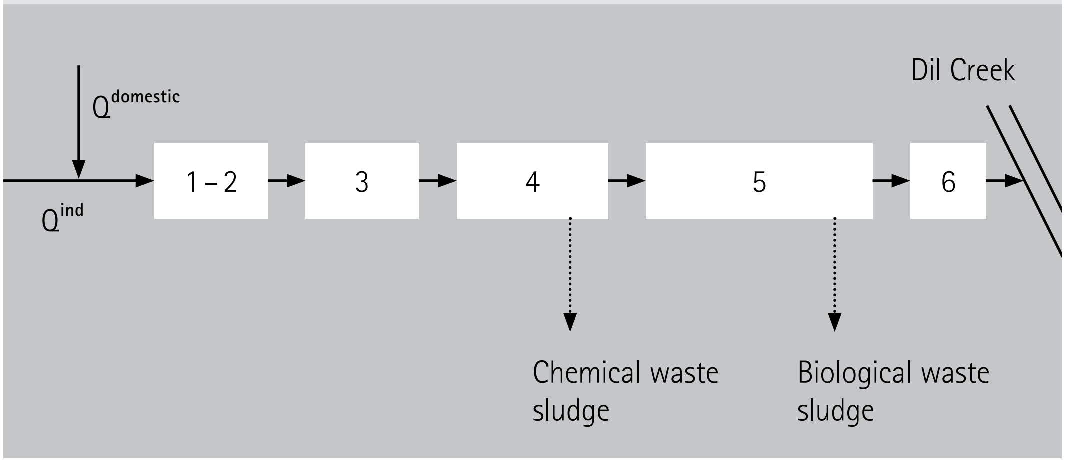
Alternative C

Alternative C is proposed to be same as Alternative B, but with the addition of a filtration unit at the final stage of the treatment plant. The reason for this unit is to re-use the treated wastewater for cooling, fire fighting and/or irrigation purposes at the DOSB.
The unit processes of Alternative C for the wastewater stream are as follows:

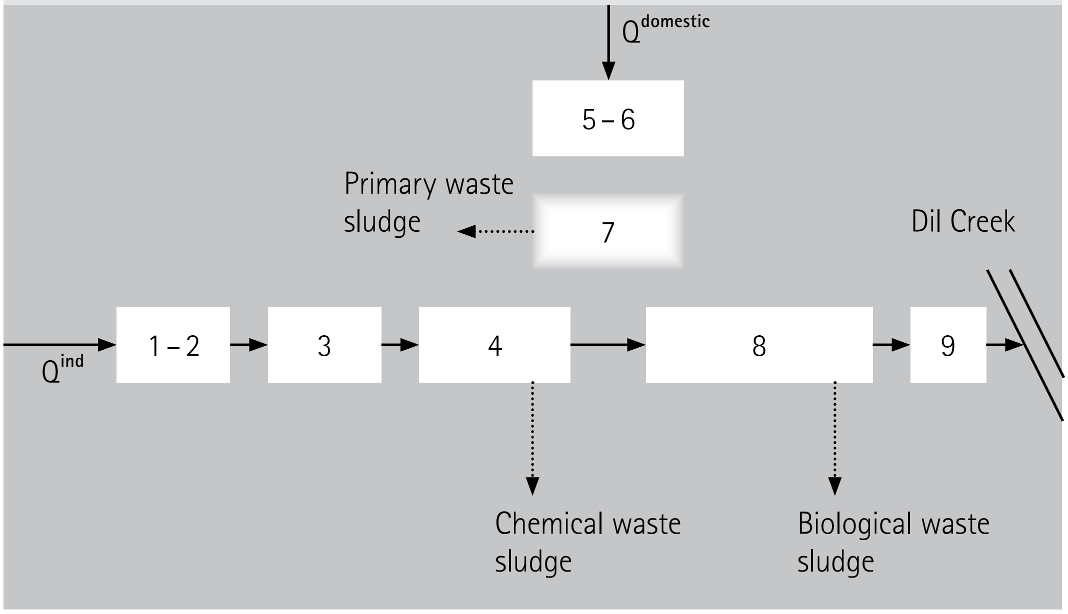
1. Screening for industrial wastewater
2. Aerated grit and grease removal for industrial wastewater
3. Equalization for industrial wastewater
4. Chemical precipitation for industrial wastewater
5. Screening for domestic wastewater
6. Aerated grit and grease removal for domestic wastewater
7. Primary settling for domestic wastewater (optional)
8. Biological activated sludge with nitrification and denitrification
9. Disinfection
10. Filtration with chemical injection for reuse purposes

Trainer's notes

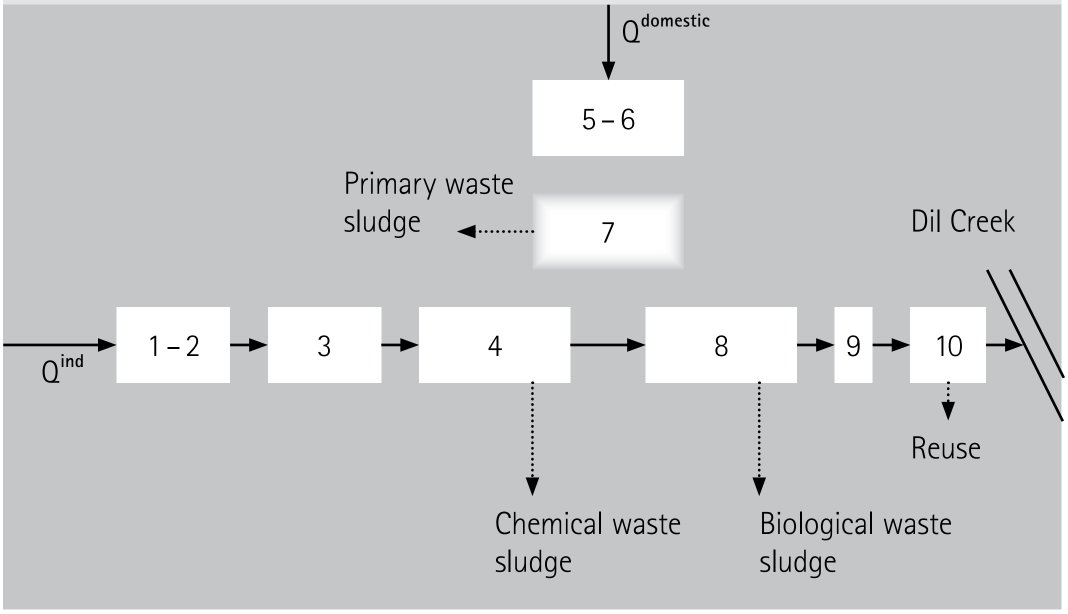
Alternative A



Alternative B



Alternative C



For the excess sludge stream, the following options are proposed:

Option a
- Thickening and dewatering of chemical waste sludge separately.
- Thickening, anaerobic digestion and dewatering of biological waste sludge.

Option b
- Thickening, chemical stabilisation and dewatering of combined chemical and biological waste sludges.

5.3 Additional Exercise

This small case study exercise can be given to participants as an individual homework reading assignment and then latter discussed in class, depending on time constraints.

Project: Four Corners, Mont., wastewater treatment system

Product application: A small-scale sewage treatment plant

Small cities, townships, and counties nationwide face many complex wastewater treatment issues, as well as diverse opinions regarding their solution.

Protection of natural resources, including water supply and quality where wells are the predominant home water source, and concern about the loss of community identity are just two challenges faced by these communities. Developing high-quality, cost-effective wastewater management solutions, while protecting the character of the community, can be a difficult goal to meet.

In areas of the United States that do not have sewer service, reducing non-point source pollution is a major concern that is forcing a shift in how treatment is provided and managed. In this case, designing small-scale treatment facilities that consistently meet high treatment standards by using advanced products combined with proper management is a cost-effective, environmentally responsible solution.

Four Corners, Mont., located just west of Bozeman, Mont., in the popular and rapidly growing Gallatin County, overcame several hurdles in an effort to improve its wastewater management and allow for future development. Since it is not located within an incorporated area, until 2004 there were insignificant public water and wastewater systems in place. Most of the existing residents used onsite wells and septic systems to provide for their needs.

In 2002, a group of property owners in the area formed the Four Corners County Water and Sewer District to provide water and wastewater services to subdivision projects they were undertaking and also to provide capacity for adjoining properties whose owners were interested in participating.

Management plan

The task of providing a new wastewater system involved collecting, transporting, treating, and disposing of the wastewater in the area. To begin the process, a facility plan was developed to predict wastewater flows during the next 20 years. The plan provided for flows up to 0.6 million gallons per day (mgd) that would be treated by an oxidation ditch primary treatment plant with secondary clarification, aerobic sludge digestion, UV disinfection, and subsurface disposal in rapid infiltration basins. Permitting challenges included Montana Department of Environmental Quality (MDEQ) and Gallatin County Health Department review of all infrastructure plans, including the facility plan, and a rigorous groundwater discharge permitting process, also conducted by MDEQ. By using industry standards and innovative ideas, infrastructure designs were developed and ultimately approved by the reviewing agencies.

Meeting regulatory and industry standards proved to be more achievable than negotiating the political aspects of the project.
Many of the existing homeowners were deeply concerned about potential sewage contamination that might affect their existing wells and the health of the nearby Gallatin River. They were convinced that the new wastewater system would not perform to expectations and would contaminate their drinking water along with the Gallatin River basin. In addition, many homeowners had their own opinion about how wastewater should be handled in Gallatin County, with some advocating a central wastewater treatment facility many miles to the northwest at the headwaters of the Missouri River.

System design and installation
Wastewater is collected via a conventional collection system of manholes and sewer piping, then it is pumped by a series of lift stations to an upstream wastewater treatment plant. Wastewater flows over a grit chamber to the primary clarifier and then to the activated sludge bio-reactor. After final settling, the effluent is disinfected with UV radiation. The excess sludge from the bio-reactor is aerobically digested, dewatered and sent for agricultural application. Following treatment, the effluent is transported to the disposal site where it is stored in two 42 m^3 fibreglass dose tanks. The complete wastewater system is designed for modular construction with future expansions in mind according to facility planning.
There were a few options considered for wastewater effluent disposal, including surface water discharge, spray irrigation, and groundwater discharge. A surface water discharge to any nearby waterway could be a practical and most likely a permissible option, but the process would be lengthy and there would be political opposition. Spray irrigation also is viable, but requires a large amount of land and can only be utilized during the summer growing season. The option of subsurface groundwater disposal made the most sense from a practical, economical, and timing standpoint.

Task:

1. How would you advocate using a small local treatment facility instead of the centralised system?

2. What would you say to the homeowners concerned that the wastewater treatment plant could contaminate their drinking water?

3. Draw a design scheme of the described wastewater treatment plant.

5.4 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. In which treatment stage is a biological process used?

a. Preliminary   b. Primary
c. Secondary   d. Tertiary

2. Which treatment technologies are aerobic treatment technologies?

a. Activated sludge process   b. Extended aeration
c. Sedimentation   d. UASB

3. What are disinfection options?

a. Ozonation   b. UV radiation
c. Chlorination   d. Sedimentation

4. Why is preliminary treatment applied?

a. To remove large suspended materials
b. To remove heavy metals
c. To reduce organic content
d. To reduce nutrient levels

5. In which process is more sludge created; anaerobic or aerobic?

Answers

1. c
2. a,b
3. a,b,c
4. a
5. Aerobic

5.5 Literature

Ahring, B.K. (1994). Status on science and application of thermophilic anaerobic digestion, Water, Science and Technology, 30, 241-249

FAO 1992. Wastewater treatment and use in agriculture - FAO irrigation and drainage paper 47, ISBN 92-5-103135-5

Bassim A (2004). presentation, InWEnt Training program on Chemical, Physical, and Biological Methods for Water and Wastewater Analysis

El-Hoz M. (2006), Presentation, Water Quality Parameters for Wastewater Treatment Plant, Training Program for Lebanese Officials and Stakeholders

George M. A. (2006), presentation, General Considerations in Designing a Wastewater Treatment Plant, American University of Beirut

Kallab F. (2006), presentation, Wastewater Treatment, LAU – Byblos

Metcalf and *Eddy* (1991). Wastewater Engineering: Treatment Disposal Reuse. McGraw- Hill, Inc.

Pabsch, J. Pabsch, H and Purrmann, A. (2003) Sewage sludge humification in a sequential conversion procedure. GTZ/IWA Conference in Ecosan, Germany (Downloaded from
http://www.gtz.de/ecosan/download/ecosan-Symposium-Luebeck-session-f.pdf page 39-46)
http://www.sandec.ch/Publications/PublicationsHome.htm
http://europa.eu.int/comm/environment/waste/sludge/index.htm
http://www.unep.or.jp/ietc/Publications/Freshwater/SB_summary/10.asp

Presnitz, W. (2000): The real dirt on sewage sludge. Natural Life Magazine, November. http: // www.life.ca

USEPA 1993 40 CFR Part 503. The standards for the Use and Disposal of Sewage Sludge. Federal Register 58, 9248-9404

Van Lier, J. (1996). Limitations of thermophilic anaerobic wastewater treatment and the consequences for process design. Antonie van Leeuwenhoek, 69, 1-14

5.6 Recommended Reading

MWH (2005), Water Treatment: Principles and Design, Wiley

Ernest F. Brater, Horace W. King, James E. Lindell, C. Y. Wei (1996), Handbook of Hydraulics, McGraw-Hill Professional; 7 edition

American Water Works Association (1999), Water Quality & Treatment Handbook, McGraw-Hill Professional; 5th edition

Joanne E. Drinan (2000), Water and Wastewater Treatment: A Guide for the Nonengineering Professionals, CRC

Franklin L Burton (2002), Wastewater Engineering, McGraw-Hill College

Udo Wiesmann, In Su Choi, Eva-Maria Dombrowski (2007), Fundamentals of Biological Wastewater Treatment, Wiley-VCH; 1 edition

Frank R. Spellman (2003), Handbook of Water and Wastewater Treatment Plant, CRC

5.7 Internet Resources

http://en.wikipedia.org/wiki/Sewage_treatment
Wikipedia entry for sewage treatment. Good overview of the sewage treatment processes.

http://www.fao.org/landandwater/aglw/waterquality/treatproc.stm
Overview of wastewater treatment processes prepared by FAO.

http://www.water.siemens.com/en/Municipal/Wastewater/CaseStudies/default.htm?&ShowTop=true&Page=2&Next=3
List of municipal wastewater case studies produced by Siemens

http://www.ipcri.org/watconf/papers/akram.pdf
Wastewater characterization and the reuse of recycled effluent in irrigating agricultural crops in Palestine

http://www.geocities.com/RainForest/5161/wwtps.htm
Description of biological, physical and chemical processes of wastewater treatment. Description of a typical WWTP.

http://web.mit.edu/seagrant/edu/res/bostonsewage/
Non-technical Boston sewage tour

6. Topic 3:

Wastewater treatment plant operation and maintenance

Topic overview

Time
Session 1: Topic Presentation – 70 - 90 min
Session 2: Exercise – 45 - 60 min

Objectives
- To describe the main procedures to be usually applied for any WWTP operation.
- To identify and estimate operating and maintenance costs of a wastewater treatment plant.

Participants should be able to
- Understand main procedures of WWTP operations.
- Identify operational problems and possible solutions.

Material
- Marker
- Flipchart
- Projector
- Assignment material

This topic is covered in 2 sessions:

1. Session 1 – Topic Presentation

The topic presentation covers the content of an Operation and Maintenance manual, as well as symptoms, causes and remedial actions to the common operational problems of a conventional wastewater treatment plant.

2. Session 2 – Case Study

The case study presents the operation and maintenance situation of the various wastewater treatment plants in Lebanon mostly funded by USAID. The most common problems are outlined and analysed, providing recommendations for future improvements.

6.1 Session 1 – Topic Presentation

PPT

Operation and Maintenance of Wastewater Treatment Plant

Session overview

Title Operation and Maintenance of Wastewater Treatment Plant

Objectives
- To describe the content of the Operation and Maintenance manual.
- To present the most common problems and solutions in wastewater treatment plant operation.

Teaching method lecture

Time estimation 70 – 100 minutes

Needed material projector, flip-chart

Session guide

The trainer might decide to cover the topic in less or more detail by rearranging or completely excluding some of the slides according to the participants' prior experience and knowledge. To facilitate the lecture, notes providing additional content information for trainers are included within the presentation itself.

1. The first part of the presentation focuses on presenting the Operation and Maintenance manual for a wastewater treatment plant. At the beginning it is recommended you help participants understand the importance of such a manual and the obligation of the building contractor to provide it.

2. In slides 5 to 18, the chapters of the Operation and Maintenance manual are briefly described. It would be useful to circulate a copy of such manual around the class during a presentation, or have it available for participants to look through after the class.

Emergency operating and response program

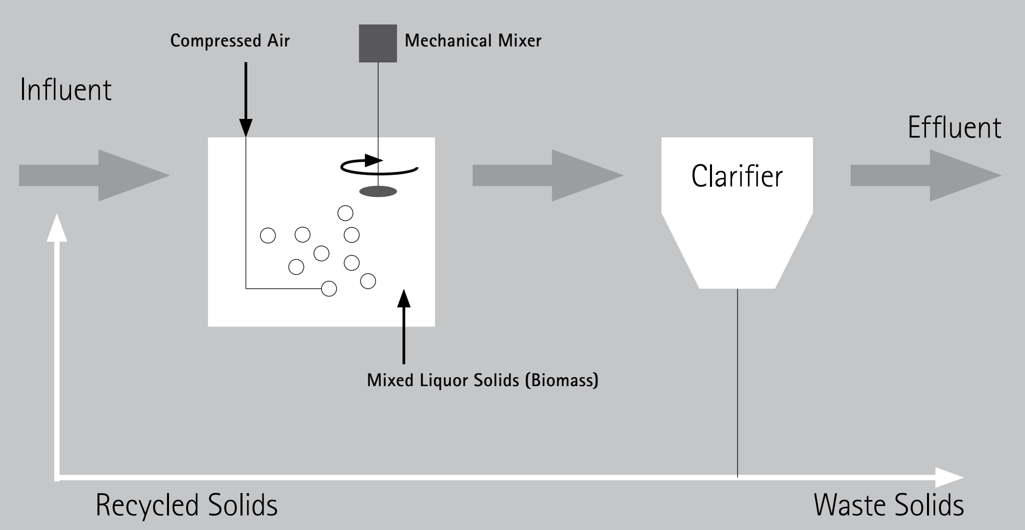
An emergency operating and response program details the procedures to be followed in the event of the following emergency situations: power failures, storms, flooding, hydraulic overload/ruptures, fire, explosions, equipment failure, spills of hazardous materials, maintenance shutdowns, and personnel injury. A description of who should be notified, and when, for each emergency situation shall be provided along with an appropriate telephone number. The procedures to follow shall include information as to identifying the emergency condition, investigating the severity of the emergency, actions to be taken and notification of responsible authorities, corrective actions to rectify the situation, and necessary follow-up. Follow-up procedures should include feasible measures to prevent or minimize the likelihood of a similar situation from reoccurring. At the minimum, the following telephone numbers should be incorporated into the Emergency Operations & Response Section: local fire department, local police department, ambulance, poison control centre, Regional Office of the Department and local Board of Health. This section should state where the phone numbers are posted within the treatment plant.

3. The second part of the presentation focuses on the common Operation and Maintenance problems of a conventional wastewater treatment plant. This part will be more useful to the participants with more practical experience in wastewater treatment plant operation. If this is not the case, this part can be reduced to just briefly naming the problems affecting different treatment stages.

4. The different maintenance strategies are explained in slides 20 and 21. The importance of preventive maintenance for proper plant operation should be stressed. In reality, every plant management operates their system using a combination of corrective and emergency maintenance, preventive maintenance and predictive maintenance methods.

5. In slides 23 to 69, problems are analysed according to the treatment processes. To facilitate better understanding, each process is generally described before presenting the associated problems. Every problem is described with symptoms, main causes, investigation and remedial actions.

Aeration Reactor



Activated Sludge Process

The activated sludge process uses microorganisms to feed on organic contaminants in wastewater, producing a purified effluent. The basic principle behind all activated sludge processes is that microorganisms grow in the wastewater, thus metabolizing dissolved organic material. They form particles that clump together. These particles (flocks) in most cases are able to settle, so that they can be separated using a simple settling process, which works according to the same principle as the pre-settling process. Wastewater supply is mixed with the return feed of activated sludge (see figure 6) containing a high proportion of organisms taken from final sedimentation. This mixture is stirred and injected with large quantities of air to provide the oxygen demand of microorganisms and keep solids in suspension. After a period of time, the mixed liquor flows to a clarifier, which is in most cases a settling tank. In special cases also a flotation tank or membranes can be used to separate microorganisms. Partially cleaned water flows on for further treatment if needed. The resulting settled solids, the activated sludge, are returned to the first tank to begin the process again. Due to the fact that during the process microorganisms grow, the excess sludge has to be removed from the system to keep the concentration of microorganisms approximately constant.

6. At the end of this presentation, participants should understand that no treatment plant is maintenance free and that its successful operation requires Operation and Maintenance planning from the early design phase.

6.2 Session 2 – Case Study

Lebanese Example – Study of USAID financed WWTP

Session overview

Title Lebanese Example – Study of USAID financed WWTP

Objectives
- To present lessons learned from design and Operation and Maintenance problems of wastewater treatment plants in Lebanon.
- To provide recommendations for the corrective measures and the future project.

Teaching method presentation

Time estimation 45 – 60 minutes

Needed material projector

Session guide

1. At the beginning, the number of wastewater treatment plants in Lebanon financed by USAID in recent years is presented according to the treatment process. The overview of their functional status is given on slide 16. It is clear that only 6 plants out of 42 constructed plants operate as designed.

2. Problems faced by various plants are described and illustrated using photos in slides 17 to 27. The last three slides give recommendations about what is to be done to correct this situation.

3. After the presentation, you can discuss the following questions in class: Who has the responsibility for such a situation? What could have been done differently and what is the responsibility of financial donors, construction companies, consultants and the local administration?

6.3 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. Which of the following is not a part of the Operation and Maintenance manual?
- a. Description, Operation and Control of Wastewater Treatment Facilities
- b. Sampling and Laboratory Analysis Description
- c. Emergency Operating and Response Program
- d. Financial plan

2. Which of the following should be included in the emergency procedures?
- a. Identifying the emergency and assessing its severity
- b. Immediate actions to be taken
- c. Notification of responsible authorities
- d. Corrective and follow-up actions

3. What are the main causes of sand accumulation in screen channels?
- a. Reduced influent velocity
- b. Physical obstructions
- c. Unsuitable pumps
- d. Incorrect skimmer operation

4. What causes foaming in a biological reactor?
- a. High content of foaming agents
- b. High content of sand
- c. Oils and greases in the incoming wastewater
- d. Low influent velocity

5. What is the reactor temperature range needed for anaerobic treatment?
- a. 5 – 10 °C
- b. 25 – 35 °C
- c. 50 – 60 °C
- d. 70 – 90 °C

Answers:

1. d
2. All.
3. a, b
4. a, c
5. b

6.4 Literature

Crites, R. and *G. Tchobanoglous*, 1998, Small and Decentralized Wastewater Management Systems. The McGraw-Hill Companies. Boston, Massachusetts.

Commonwealth of Massachusetts Department of Environmental Protection Division of Watershed Permitting (2004) - Guidelines for the Design, Construction, Operation, and Maintenance of Small Wastewater Treatment Facilities with Land Disposal.

EPA (2003) - Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems.

EPA (2003) - Handbook for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems.

Metcalf, Eddy (1991) - Wastewater Engineering: Treatment Disposal Reuse. McGraw-Hill International Edition.

Passino, R. (1995) - Manuale di conduzione degli impianti di depurazione delle acque - Zanichelli, Bologna

Queens University, Kingston, Ontario, Canada, Lecture 17, held in 2004 Water Resources & Water Quality 2

Wilderer, P. Schreff, D. (2000). Decentralised and Centralised Wastewater Management: a Challenge for Technology Developers, Wat. Sci. Tech. 41 (1), 1-8.

6.5 Recommended Reading

Operation of Wastewater Treatment Plants (A Field Study Training Program, Volume 1) (2004), California State University; 6th edition

Ronald L. Droste (1996), Theory and Practice of Water and Wastewater Treatment, Wiley; 1st edition

Water Environment Federation (2005), Biological Nutrient Removal (BNR) Operation in Wastewater Treatment Plants, McGraw-Hill Professional; 1 edition

Frank R. Spellman, Joanne Drinan (2002), Blueprint Reading: Fundamentals for the Water and Wastewater Maintenance Operator, CRC

Philippe Quevauviller, Olivier Thomas, Andre Van Der Beken (2007), Wastewater Quality Monitoring and Treatment, Wiley

Frank R. Spellman, Joanne Drinan (2001), Piping and Valves: Fundamentals for the Water and Wastewater Maintenance Operator, CRC; 1st edition

Syed R. Qasim (1998), Wastewater Treatment Plants: Planning, Design, and Operation, CRC; 2 edition

Edward Haller (1995), Simplified Wastewater Treatment Plant Operations, CRC

Joanne K. Price (1991), Basic Math Concepts for Water and Wastewater Plant Operators, CRC; 2 Sub edition

Giordano A., Petta L. (2005), EMWater e-Learning Course No. 1, Lesson c1: Operation and management of wastewater treatment plants

Glenn M. Tillman (1996), Wastewater Treatment: Troubleshooting and Problem Solving, CRC

Frank R. Spellman, Joanne Drinan (2000), Water Hydraulics: Fundamentals for the Water and Wastewater Maintenance Operator, CRC

Frank R. Spellman (1999), Choosing Disinfection Alternatives for Water/Wastewater Treatment Plants, CRC

Ruth Ann Buzzi(1992), Chemical Hazards at Water and Wastewater Treatment Plants, CRC

Frank R. Spellman (2000), Safe Work Practices for Wastewater Treatment Plants, Second Edition, CRC; 2nd edition

6.6 Internet Resources

http://www.poopreport.com/Consumer/poop_plant.html
A Sewage Treatment Photo Tour

http://www.epa.gov/owm/mab/smcomm/104g/index.htm
Wastewater Treatment Plant Operator On-Site Assistance Training Program

http://www.dep.state.fl.us/WATER/wastewater/dom/docs/ompr.pdf
Guidelines for preparation of operation and maintenance performance reports from the Florida Department of Environmental Regulation

http://www.deq.state.la.us/portal/Portals/0/remediation/madisonville-o&m.pdf
Operation and maintenance manual of Madisonville wastewater treatment plant

7. Topic 4:

Cost of conventional wastewater treatment

Topic overview

Time
Session 1: Topic Presentation – 70 - 90 min
Session 2: Exercise – 50 - 70 min

Objectives
- To identify and estimate investment, and operating and maintenance costs of a wastewater treatment plant.

Participants should be able to
- Estimate costs of setting up, operating and maintaining a wastewater treatment plant.

Material
- Marker
- Pin board
- Flipchart
- Projector
- Assignment material

This topic is covered in 2 sessions:

1. Session 1 – Topic Presentation

This presentation gives a cost break-down for the development of a conventional wastewater treatment plant. The components of capital and Operation and Maintenance costs are further elaborated and presented with their share of the total costs. The concept of life-cycle costs is explained and presented as a tool for comparing different treatment alternatives. At the end, the overview of financing options available for wastewater treatment development is given.

2. Session 2 – Exercise

The exercise is a combination of individual work and class discussion. Participants are expected to compare different competing offers of a fictive wastewater treatment plant construction tender using life-cycle cost analysis. Different financial and non-financial costs which could influence the final tender winner are discussed in class, as well as the costs of 'no development'.

7.1 Session 1 – Topic Presentation

Cost of Wastewater Treatment

Session overview

Title Cost of Wastewater Treatment

Objectives
- To estimate costs of setting up, operating and maintaining a wastewater treatment plant.
- To give an overview of financing options available.

Teaching method presentation

Time estimation 70 - 90 minutes

Needed material projector

Session guide

1. At the beginning, the usual breakdown of capital and operation and maintenance costs is given. The cost of borrowing money is not explicitly described because of the variety of public and private financing options available; however, some references are given when presenting financing alternatives at the end.

Corrective Maintenance (These maintenance activities are also called reactive):
Maintenance classified as corrective, including emergency maintenance, is reactive. Only when equipment or a system fails is maintenance performed. Corrective maintenance is characterized by the inability to plan and schedule work, the inability to budget adequately, the poor use of resources and a high incidence of equipment and system failures.

Preventive / Predictive Maintenance (These maintenance activities are also called proactive):
Preventive Maintenance is defined as a programmed, systematic approach. This type of maintenance will always result in improved system performance except in the case where major chronic problems are the result of design and/or construction flaws that cannot be corrected by operation and maintenance activities. Major elements of preventive maintenance programs are planning and scheduling, records management, spare parts management, cost and budget control and training programs for the involved personnel.

2. Capital costs are presented in slides 5 to 12. The economic cost is introduced for certain categories. E.g. even if the government provides land for free, the land economic cost should be calculated.

3. Operation costs are divided into 6 categories. Each category is further elaborated in slides 13 to 29.

Operation costs

For a rough calculation it can be assumed that operation costs may amount to 50% of the total costs for wastewater treatment. On average, for wastewater treatment plants in Europe with more than 10,000 p.e., the specific operation costs can be up to 25– 35 €/p.e. and year. Smaller installations can achieve more than twice that number.

As it has been the case in Europe, the more restrictive the discharge norms are – for example concerning nitrogen and phosphorous content –, the more demanding the treatment must be. This means that more technical requirements (like longer treatment times, conversion of existing structures or building new ones) are needed to achieve the limit values. Such extra requirements also represent more operational expenses.

Personnel

The qualification of operation staff is of crucial importance for an adequate and professional operation. There is a high need for a profound education and special training as an essential prerequisite. Plant operators can make a plant of poor and insufficient design perform well, conversely, they can cause the best designed plant to perform poorly. Smaller treatment plants employ fewer scientific personnel and fewer unskilled labourers, with a higher number of technical personnel. There are likely to be two reasons for this: Firstly, small treatment plants are less complicated and easier to operate, and secondly it is difficult to find more highly educated personnel with a scientific education in small towns, which rely instead on local personnel.

Chemical engineers and chemists are the most dominant graduate employees in wastewater treatment plants. Chemical, electrical and mechanical engineers mainly work as control engineers, while technologists are in charge of the technical supervision. Technologists come from technical colleges which do not have a university status. Ideally, a wastewater treatment plant would have an input from all kinds of professionals. However, this is unfeasible for all but the very large installations and centralized agencies with a number of plants under their jurisdiction.

4. The operation costs of different activated sludge systems are compared in slide 30.

5. The Life cycle costs calculation is presented in slide 31. The topic exercise requires participants applying this method to analyse the costs of alternative WWTP construction offers. Participants who are interested in additional information should be referred to the recommended reading.

Life Cycle Cost

Sometimes called a "cradle-to-grave analysis", or "Womb-to-Tomb". This is a good method of comparing costs of different treatment alternatives over the whole expected life-span of the facility.
A life cycle cost analysis is important for cost accounting purposes. If all costs cannot be recovered, it would not be wise to proceed with that treatment alternative. Typically, life cycle analyses for wastewater treatment facilities are based on a 20-year facility life.
The life cycle cost is calculated as:

Capital costs + total O&M costs – residual value of facility

where the residual value of the facility is the remaining value at the end of the study life time period, or at the time it is replaced during the study period. Residual values can be based on value in place, resale value, salvage value, or scrap value, net of any selling, conversion, or disposal costs.

6. In the last part of the presentation, usual financing options for construction of treatment plants are presented. This section can be modified to include donor organisations active in the country that the participants come from.

7.2 Session 2 – Exercise

Cost of Wastewater Treatment

Session overview

Title Cost of Wastewater Treatment

Objectives
- To understand the use of life-cycle cost calculation
- To discuss different financial and non-financial cost aspects of wastewater treatment
- To discuss costs of not-treating wastewater

Teaching method individual and class work

Time estimation
- 10 minutes to explain the exercise
- 20 minutes for individual work
- 40 minutes of class discussion

Needed material flip-chart, assignment paper

Session guide

1. Hand out the assignment paper to each participant and give them 15 minutes to complete the tasks. The first three questions are meant as an individual exercise, while questions 4 and 5 should be discussed in class.

2. Provide individual help in calculations, if necessary.

3. Ask one participant who has the correct answer to read the results obtained for life-cycle and annual wastewater treatment costs. Ask others if they agree with the results.

4. Ask participants to name additional information they would require bidding companies to provide which could influence the final decision. Write down on a flip-chart their answers and discuss them with the class.

5. Ask participants to name the costs of not treating wastewater. Write down on a flip-chart their answers and discuss them with the class.

Costs of Wastewater treatment

The small rural community located on the Mediterranean coast has been collecting its wastewater and discharging it without any treatment into the sea. Reacting to the rising environmental concerns and possible health risks of such a practice, the community council decided after having technical consultations to construct a conventional activated sludge wastewater treatment plant. This plant, with a capacity of 50,000 P.E., is expected to serve community needs for the next 20 years. The community council also decided to provide the land necessary for the plant construction for free.
They made a tender for the construction of such a plant and received three valid offers from experienced and reliable companies. Each tender meets the required technical criteria, but they differ in the capital and operation and maintenance costs.

Alternative A
Cost of construction and equipment - $ 1,200,000
Annual operation and maintenance cost - $ 500,000

Alternative B
Cost of construction and equipment - $ 2,000,000
Annual operation and maintenance cost - $ 350,000

Alternative C
Cost of construction and equipment - $ 2,200,000
Annual operation and maintenance cost - $ 310,000

Questions:

1. What are the life-cycle costs of the different alternatives? For the purpose of this exercise we will disregard inflation and the remaining value of each plant after 20 years.

2. What are the annual wastewater treatment costs per population equivalent for the different alternatives?

3. Which alternative is the most economical based on the provided information?

4. What additional information that could influence the final decision would you ask the bidding companies for?

5. What possible costs can you think of that are incurred by not treating the wastewater?

Trainer's notes

1. Life Cycle Cost = Capital cost + O&M costs of 20 years

	A	B	C
Capital cost	$1,200,000	$2,000,000	$2,500,000
O&M	$500,000	$350,000	$310,000
Life Cycle Cost	$11,200,000	$9,000,000	$8,700,000

2. Cost of wastewater treatment per P.E. = (Life Cycle Cost / 20 yrs)/50,000 P.E.

	A	B	C
Annual wastewater treatment cost [$/P.E.]	$11.2	$9.0	$8.7

3. Solely based on this financial information, alternative C is the most economical.

4. Possible answers:

- Land requirements – even if the land is free, it has an economic cost – how much money would the community earn selling that land to a commercial buyer?
- Personnel requirements and qualification - are there enough people with the required qualification in the local labour market or do these people have to be trained or found somewhere else?
- Energy requirements – energy prices are likely to rise in the future, increasing the Operation and Maintenance costs – the processes requiring less energy or producing energy (methane production) are more favourable.
- Sludge quantities and management – there might be an added value to the community farmers in using sludge as agricultural fertilizer.
- Guarantees and extended support - how long is the guarantee period and what kind of extended support does a company offer?

5. Possible answers:
- Degradation of sea water quality – less revenues from tourism.
- Greater human health risks – more health related expenditures and cost of people not working while being ill.
- Legal costs – paying penalties for not meeting the national environmental standards for wastewater discharge - possibility of people pressing charges against the community in case of health accidents.
- Damage to the marine flora and fauna – biodiversity reduced.

7.3 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. What is not a capital cost?

a. Land purchase
b. Start-up costs
c. Labour cost
d. Costs of engineering design

2. What is not an operation and maintenance cost?

a. energy cost
b. cost of process chemicals
c. cost of the environmental impact assessment
d. cost of sludge disposal

3. Which process is considered to consume the most energy in a conventional wastewater treatment plant?

a. Mesophilic anaerobic sludge digester
b. Primary Sedimentation
c. Secondary clarifier
d. Aeration tanks

4. What is life cycle cost?

a. Cost of constructing a plant + cost of labour
b. Cost of wastewater treatment for average human life time
c. Amortized capital costs + O&M costs over a plant life-time period
d. Costs of plant O&M for 20 years

5. What influences the number of employees on treatment plants?

a. Size of plant
b. Climate of the site
c. Degree of automation
d. Managerial efficiency

Answers:

1. c	2. c
3. d	4. c
5. a,c,d	

7.4 Literature

ATV (2003); Marktdaten Abwasser 2003, ATV-DVWK & BGW, Korrespondenz Abwasser,Nr. 9, 2004

Bassim A (2004). Presentation, InWEnt Training program on Chemical, Physical, and Biological Methods for Water and Wastewater Analysis

Bohn, T. (1993); Wirtschaftlichkeit und Kostenplanung von kommunalen Abwasserreinigungsanlagen, Universität Stuttgart, 1993

EPA (1999), Biosolids Generation, Use and Disposal in the United States; U.S. Environmental Protection Agency, EPA530-R-99-009, Office of Solid Waste and Emergency Response: Washington, DC, September 1999

EWA (2001), Secure disposal routes for sewage sludge?, Conclusions from the EWA/ÖWAV conference on 10 and 11 September in Vienna

El-Hoz M. (2006), Presentation, Water Quality Parameters for Wastewater Treatment Plant, Training Program for Lebanese Officials and Stakeholders

Giordano A., Petta L. (2005), EMWater e-Learning Course No. 1, Lesson c1: Operation and management of wastewater treatment plants

George M. A. (2006), presentation, General Considerations in Designing a Wastewater Treatment Plant, American University of Beirut

Halbach, U. (2003); Abwasserentsorgung in Brandenburg, Orientierungswerte Jahr 2003, Land Brandenburg, 2003

Kampet, T. (2000), The cost planning for building, operating and maintaining wastewater treatment plants. Presentation in the frame of the Tacis Project: “Water environmental monitoring and management in the Kaliningrad Oblast”. MVV / Innotec.

Medina, M. (2005), EMWater e-Learning Course No. 1, Lesson d1: cost planning and cost analysis for wastewater projects

Michel, R., Pelmoter, A.L., Plange, R.C. (1969); Operation and maintenance of municipal wastewater treatment plants, Journal WPCF 41(3), 335-354

Müller, K. (2003), Parameters for Effective Service / Checking costs and performance in wastewater treatment, European Water Management Online, Official Publication of the European Water Association, EWA 2003

NRW (1999) Handbuch „Energie in Kläranlagen", Ministerium für Umwelt, Raumordnung und Landwirtschaft des Landes Nordrhein-Westfalen (MURL, heute MUNLV), 1999

Kadar, Y. and Siboni, G; Optimization of energy economy in the design and operation of wastewater treatment plants, Mekorot Water Company, Ltd. and DHV-MED, Ltd., Tel-Aviv, Israel, published in World Energy Council

Kaste, A., (2003), Erkenntnisse und Erfahrungen aus dem Förderprogramm "Energie in Kläranlage", Jahresbericht des Landesumweltamtes Nordrhein-Westfalen, 2003

Reicherter, E., (2003); Untersuchungen zu Kennzahlen als Grundlage für Kostenbetrachtungen in der Abwasserbeseitigung, Oldenburg Industrieverlag, München 2003

Tsagarakis, K.P., Mara, D.D., Angelakis, A.N. (2003), Application of cost criteria for selection of municipal wastewater treatment systems, published in Water, Air and Soil Pollution 142, Kluwer Academic Publishers, 2003

Wendland A. (2005), EMWater e-Learning Course No. 1, Lesson c2: Operation Costs of wastewater Treatment Plants

European Commission (2002), Disposal and Recycling Routes for Sewage Sludge, Economic sub-component report, January 2002

7.5 Recommended Reading

U. S. Environmental Protection Agency (1993), Municipal Wastewater Treatment Technology: Recent Developments, Noyes Publications

Glen T. Daigger (1998), Upgrading Wastewater Treatment Plants, Second Edition (Water Quality Management Library, Vol 2), CRC; 2nd edition

Alphonse Dell'Lsola (2003), Life Cycle Costing for Facilities, Reed Construction Data

Sperling M.(1996), Comparison amongst the most frequently used systems for wastewater treatment in developing countries, Wat.Sc.Tech, Vol.33, No.3, pp59-72

Wolter J. Fabrycky, Benjamin S. Blachard, Benjamin S. Blanchard (1991), Life-Cycle Cost and Economic Analysis (Prentice Hall International Series in Industrial and Systems Engineering), Prentice Hall

7.6 Internet Resources

http://firehole.humboldt.edu/wawttar/wawttar.html
WAWTTAR is a predictive program intended to assist planners in selecting suitable water and wastewater treatment options appropriate to the material and manpower resources available to particular communities throughout the world.

http://faculty.engineering.ucdavis.edu/jenkins/CBC/Calculator/index.html
Energy Cost Calculator

http://en.wikipedia.org/wiki/Life_cycle_cost_analysis
Wikipedia entry for Life Cycle Cost analysis

http://213.186.164.75:2000/downloads/pdf/papers/2003_12_16.pdf
he Drarga Wastewater Treatment and Reuse Project: A Model for Small Communities

http://www.lakehurst.navy.mil/p2/pdf/AircraftDeicingandAFFFWastewaterTreatmentSystem_P_CA.pdf
Cost analysis of aircraft deicing and aqueous film forming foam wastewater treatment system

Module 3
Alternative Solutions of Wastewater Treatment

2007

1. Introduction

The module on alternative solutions of wastewater treatment covers four topics:
1. Small wastewater treatment systems
2. Aerobic and anaerobic wastewater treatment systems
3. Decentralised options for rural areas vs. centralised urban systems
4. Separation and management at source of wastewater on a household level and the Ecosan concept

with the following objectives:
- Enhance the knowledge on alternative solutions on wastewater treatment
- Explore the types of appropriate alternatives in small scale wastewater treatment systems
- Present how to plan and design adequate wastewater treatment technologies
- Give an overview of environmental and economical valuation in wastewater treatment solutions

After completing the course participants should be able to:
- Understand the fundamental design criteria for alternative solutions on wastewater treatment
- Understand and apply sustainability principle in wastewater engineering
- Apply sustainable alternative solutions to small scale wastewater treatment facilities

For each module 1 – 4 materials are provided in the Trainer`s Toolkit which allow for a 3 day training, 6 training hours per day. While the Trainer`s Toolkit includes a suggested training schedule, the trainers are strongly encouraged to alter this schedule according to their own preferences and especially according to the training needs of the target group. The EMWater Trainer`s Toolkit which is designed for a very wide target group, can of course not fulfill the needs of each specific target group.

2. Suggested timetable for training

Alternative Solutions of Wastewater Treatment

Training module 3

Day 1

9:00 – 10:00	Introductory Session

Topic 1: Small wastewater treatment systems

10:00 – 10:30	Session 1 – Topic Presentation
10:30 – 11:00	Coffee Break
11:00 – 12:30	Session 1 – Topic Presentation (Continuation)
12:30 – 14:00	Lunch
14:00 – 14:30	Session 2 – Case Studies
14:30 – 15:30	Session 3 – Exercise
15:30 – 16:00	Coffee Break
16:00 – 17:00	Session 3 – Exercise (Continuation)

Training module 3

Day 2

Topic 2: Aerobic and anaerobic wastewater treatment systems

9:00 – 10:00	Session 1 – Topic Presentation
10:00 – 10:30	Session 2 – Case Study
10:30 – 11:00	Coffee Break

Topic 3: Decentralised options for rural areas vs. centralised urban system

11:00 – 12:30	Session 1 – Topic Presentation
12:30 – 14:00	Lunch
14:00 – 15:00	Session 2 – Case Studies
15:00 – 15:30	Coffee Break
15:30 – 17:00	Session 3 – Exercise

Training module 3

Day 3

Topic 4: Separation, management at the source of wastewater on a household level and the ecosan concept

9:00 – 10:30	Session 1 – Topic Presentation
10:30 – 11:00	Coffee Break
11:00 – 11:30	Session 1 – Topic Presentation (Continuation)
11:30 – 12:30	Session 2 – Case Study
12:30 – 14:00	Lunch
14:00 – 15:15	Session 3 – Exercise
15:15 – 15:45	Coffee Break
15:45 – 17:00	Session 3 – Exercise (Continuation)
17:00 – 17:30	Final / Feedback Session

3. Introductory Session

Session overview

Time 60 min

Objectives
- To learn about the participants' work and their knowledge of wastewater treatment systems.
- To understand participants' expectations in the workshop.
- To explain objectives and contents of the workshop and relate them to participants' expectations.

Material
- Marker
- Pin board
- Pinpoint Cards
- Flipchart
- Projector
- Slides

Session guide

Introduction, Workshop Objectives and Participants' Expectations

1. Welcome to the participants and start of the session with personal presentations.

Participants' presentation
Prepared pin board with six categories:
Name
Country
Place of work
Working position / and or tasks
How does the job relate to WWT
Expectations with regard to this workshop

Participants are asked to take several cards and a pen each and fill in one card for each category. When finished, participants pin up the cards onto the pin board and introduce themselves by explaining what they have written on the cards.

2. Workshop objectives and schedule of the workshop are explained to the participants (slides 2–6).

3. The proposed objectives and planned time schedule of the module are discussed with the participants to see if they are in accordance with their expectations. If necessary, proposed changes are discussed.

Facilitator notes
Instead of using an projector, objectives and contents of the module can be written on a sheet of the flipchart.

Introduction of Participants and Facilitators

4. To introduce participants and facilitators to each other in an informal atmosphere, short games could be proposed.

Game

A) The participants are asked to stand up and gather in the middle of the room. It is important that there is sufficient space for all participants to stand in a row. The participants are asked to imagine the room as a world map and position themselves in the place in the room where they were born. The room is divided into three parts, representing village, small town, and big city. The participants are then asked to form three groups in accordance with their place of birth. The exercise can be repeated by asking them where they live today.

B) The participants are asked to form a row according to their age. They are not allowed to talk to each other during this exercise. The exercise is repeated using the criteria of the number of years of working experience.

C) Participants form three groups, the criteria are, according to their own opinion, those with no knowledge about the WWTS, little knowledge or sufficient knowledge. After the display, participants are asked to explain why they are standing where they are.

Introduction of the main concepts of WWTS and discussion about wastewater treatment systems (WWTS)

5. Introduce the importance and the concern for functional WWTS, the conditions important for their proper functioning, especially in small communities (e.g. high fluctuations on a daily, weekly and monthly basis of hydraulic and organic/inorganic loads, and the need for easy management and operation) (slide 8).

6. Wastewater and sewage treatment can be divided into categories as depicted in slide 9.

7. Below are shown some of the most important criteria for long term sustainability of wastewater collection and treatment concepts in suburban and rural areas of the MEDA countries:

- Affordable; especially low construction and operation costs.
- Operable; operation must be easily possible with locally available staff and support.
- Reliable; producing a safe effluent for water reuse.
- Environmentally sound; (e.g. little sludge production and low energy consumption).
- Suitable in the Mediterranean climate (average wastewater temperature e.g. in Istanbul 23°C in July and 15°C in January).

8. Wastewater characteristics as seen in slide 9, which are useful for setting the context for technologies that need to be used to manage the pollutants they contain, include the following:

- Water (more than 95 percent): (often added during flushing to carry the waste down a drain)
- Non-pathogenic bacteria: (more than 100,000/ml for sewage)
- Pathogens: (Bacteria, viruses, parasitic worms)
- Organic particles (ex: faeces, hairs, food, vomit, paper fibres, plant material, humus ...)
- Soluble organic material (ex: urea, fruit sugars, soluble proteins, drugs, pharmaceuticals ...)
- Inorganic particles (sand, grit, metal particles, ceramics ...)
- Soluble inorganic material (ammonia, sea-salt, cyanide, hydrogen sulphide)
- Animals (protozoa, insects, arthropods, small fish ...)
- Macro-solids (sanitary towels, nappies/diapers, condoms, needles, children's toys, dead pets, body parts ...)
- Gases (hydrogen sulphide, carbon dioxide, methane)
- Emulsions (oils in emulsion, paints, adhesives, mayonnaise, hair colorants ...)
- Toxins (pesticides, poisons, herbicides)

This description is not meant to be exhaustive, but to enable the scientific basis of the technologies to be understood.

9. Different categories of waste streams and their differences in composition and concentration of the various components as well as the different type of pollutions they can cause are depicted in slides 10. Each receiving body of water has limits to the amount of pollutants it can receive without degradation. Therefore, each sewage treatment system must hold a sustainable level of BOD5, suspended solids and other pollutants... As an example the Environmental Limit Values (ELV) for Wastewater Pollutants according to Directive 98/15/EC are depicted in slide 11.

10. The session ends with a brief discussion with the participants on the importance of proper wastewater treatment to preserve water bodies and human health, in order to introduce Topic 1.

4. Topic 1:

Small wastewater treatment systems

Topic overview

Time
Session 1: Topic Presentation – 120 min
Session 2: Case Studies – 30 min
Session 3: Exercise – 90 min

Objectives
- To present the characteristics of small wastewater treatment systems (wetlands, stabilisation ponds, tanks, activated sludge systems – decentralised...).
- To explain benefits as well as advantages and disadvantages and the useful application of small wastewater treatment systems.

Participants should be able to
- Understand specifics of different systems.
- Select possible solutions, plan and design the appropriate wastewater treatment system.

Material
- Marker
- Pin board
- Pinpoint Cards
- Pens
- Paper
- Flipchart
- Projector
- Slides
- Self Test

This topic is covered in 3 sessions:

1. Session 1 – Topic Presentation

The purpose of the topic presentation is to present the characteristics of small wastewater treatment systems. Content of this presentation will be repeated throughout the sessions of the present module.

2. Session 2 – Case Studies

The case studies should show the application of the systems described during the topic presentation, using real world examples.

3. Session 3 – Exercise

This session should help the participants to improve their acquired knowledge by applying it in designing a small alternative wastewater treatment system. Furthermore, it should give an overview to the facilitator of the understanding of the lectured topic and of the level of knowledge acquired by the participants.

4.1 Session 1 – Topic Presentation

Small wastewater treatment systems

Session overview

Title Small wastewater treatment systems

Objectives
- Present the characteristics of small wastewater treatment systems.
- To explain the benefits of small wastewater treatment systems and when it is useful to apply them.

Teaching method presentation

Time estimation 120 minutes

Needed material marker, pin board, pinpoint cards, flipchart, projector, slides

Session guide

1. This session is designed to introduce the main characteristics of alternative small wastewater treatment systems and explain their principal usage (slides 2-3). The importance of proper wastewater treatment and the need for new, alternative methods for wastewater treatment (WWT) should be emphasised.

Brainstorming

The participants can brainstorm on the reasons that drive the needs to search for alternatives to conventional WWT systems and the possible alternatives. This can lead to a brief discussion with the participants on their opinions and suggestions and followed by a presentation of the main criteria of alternative WWT (e. g. consider wastewaters as a resource; economically acceptable; treat and make reuse possible; develop practical technologies; close the cycle; encourage sustainable systems) written on cards to pin on the pin board.

2. Explain why it is important to achieve sustainable material flow in relation to wastewater treatment (slides 5–6). Reasons mentioned are based on the needs for alternative, usually small, wastewater treatment systems (WWTS), constructed primarily to respond to the needs of small communities and to a different range of social and environmental conditions. These systems are particularly feasible where coverage with sewerage systems is not possible or desirable for both geographical and/or economical reasons.

3. In slide 7, the main categories of WWTS are depicted (Extensive systems, Intensive systems and Integrated systems) as well as the type of systems that will be explained during the session. Extensive systems are those characterised by lower surface loads than the intensive ones. Usually, these techniques are also intended as processes for treating wastewater through fixed film microbiological cultures on small media or suspended growth cultures using solar energy to produce oxygen by photosynthesis. Consequently, extensive facilities can be operated without (or negligible) power supply (except for some cases, such as aerated lagooning, where mechanical aerators or air blowers are installed). The so-called integrated systems consist of a combination of anaerobic and aerobic biological systems in series.

Exercise

No chemicals, biological treatment, low energy.
The following criteria are written with the marker on the flipchart. The participants have to figure out how these criteria are related to wastewater treatment.
Alternative small WWTS typically rely on natural processes occurring in the natural environment. Wastewater is collected, treated and disposed/reused at or near the point of its origin, preferably using gravity and biological processes for nutrient and pollution removal. There is no need for laying sewers for transportation of sewage as in the traditional treatment systems, which are normally located far from the point of origin, and there is no use of chemicals or high energy equipment. Lesser dilution of sewage than in the conventional system, possibilities to reuse treated wastewater and nutrients (slide 8).

4. Slide 10 shows the extensive WWTS that will be explained to the participants. Suggestion is to cover the enumerated WWTS one by one, but the trainer might decide to cover the topic in more or less detail, according to the participants' prior experience and knowledge, by rearranging or completely excluding some of the slides.

5. Constructed Wetlands (CWs):

CWs can be classified as extensive or lower-intensity techniques, although there are system configurations (Sub-Surface Flow Systems) where higher surface loads can be applied. In any case, if the needed footprint is available, CWs can also be applied for big communities (slide 11).
Constructed Wetlands (CWs) are artificial areas that are inundated or saturated by surface or underground application of wastewater at a frequency and duration sufficient to maintain saturated condi-

tions. The treatment process relies on bacteria for the degradation of organic substances and uptake of nutrients by plants (slide 12). Several plant species are typically used in CW's depending on soil and environmental conditions (slide 13). Adsorption by the media used to construct the wetland is also an important process for removal of nutrients, heavy metals and organic compounds.

If properly designed and operated, effluents of CWs can have characteristics comparable to those of secondary or tertiary effluents, making them suitable for discharging into surface water bodies or for water reuse applications. Efficient pre-treatments (e.g. Imhoff tanks) are needed in order to remove solids and avoid clogging problems in CW media.

CWs are classified into two main types (slide 14):

Free Water Surface (FWS) Systems, typically consisting of basins or channels, with a natural or artificial subsurface barrier to prevent seepage, soil, or another suitable medium to support vegetation, and water at relatively shallow depth flowing over the soil surface. Effective pre-treatments and influent distribution are required to reduce total organic loading and prevent mosquito problems.

Surface (SS) Flow Systems with water flowing through the sand or gravel

According to the flow direction, there are:

- **Horizontal Flow** (SS-HF) Systems (slide 15) typically consisting of a trench or a bed underlain by impermeable material and containing a medium (rock or crushed stone, d = 10-15cm) that supports the growth of emerged vegetation. The wastewater flows through the medium and is purified during the contact with the surfaces of the medium and the root zone of the vegetation. When applied as secondary treatment, nitrification is limited but denitrification is very effective.
- **Vertical Flow** (SS-VF) Systems (slide 16), in which raw wastewater is distributed over the surface, through pumps or siphons, and is thus subjected to physical (filtration), chemical (adsorption, complexing, etc.) and biological (attached biomass) treatment. Oxygen is supplied by convection and diffusion mechanisms.

Discontinuous and uniform distribution has to be provided, thus requiring the filtering surface to be separated into several units to make it possible to establish batch conditions in each one. Filter medium is made by layers of gravel or sand with a variable grading.

According to treatment needs, different configurations of HF and VF in series or parallel can be used (slide 17).

SS-HF systems, with incoming concentrations of 50-200 mgBOD5/l, and sizing for 3-5 m^2/PE, can result in a reduction of 70-90% of BOD5. For incoming wastewater with 300-600 mgBOD5/l, systems sized for 10 m^2/PE can remove approx. 86% of BOD5 and SS, 37% of TKN and 27% of P_{TOT}.

SS-VF systems can produce the following effluent standards: BOD5 $<$ 25 mg/l; COD $<$ 90 mg/l; TKN $<$ 10 mg/l; Pathogens reduction by 10 to 100 fold (slide 18).

Advantages of CW's:

- Site location flexibility
- No noise pollution

- No alteration of natural wetlands
- Process stability under varying conditions
- Simple O&M (no highly qualified personnel needed, limited sludge management)
- Lower construction and operating costs (low energy consumption according to topography)

Disadvantages of CW's:
- High footprint needed
- Risk of mosquito growth
- Possible start-up problems in establishing the desired plant species

6. Waste Stabilisation Ponds (Natural Lagoons):

In waste stabilisation ponds (WSP) (slide 20); wastewater treatment is ensured by long retention times in several watertight basins placed in series. Lagoons are made through a shallow excavation of around 1 to 1.5 m and they are best arranged in series (at least 3). Wastewater then flows from one pond to the next by gravity. The pond base should be impermeable with a soil permeability of 10^{-7} m/s or less, which is achieved with the sediment on the pond bed (after a certain time) or a plastic liner or clay barrier. WSPs are characterised by high daytime dissolved oxygen concentrations, which allow the growth of aerobic species of bacteria, also inducing a rapid die-off of pathogens. Hydraulic retention times basically depend on the temperature, varying from 25-40 days at temperatures higher than 15°C to more than 80 days at temperatures close to 0°C. Consequently, a big footprint is required (about 4-12 m^2/PE), corresponding to a daily surface load of 2.0-4.5 gBOD5/m^2 d. Precipitation and evaporation losses have to be taken into account when designing lagoon performance and sizing. The typical removal efficiency of WSPs is 65-85% with respect to COD, and 75-85% of BOD_5; systems with polishing ponds can reach a nitrogen removal of 65%.

There are three main types of WSPs:

Anaerobic ponds, usually classified as the first treatment stage, removing BOD5 and SS. Water depth (2-5 m) and high organic loads (200 – 400 gBOD5/m^3 d) ensure anaerobic conditions. In temperate climates, septic or Imhoff tanks or UASB reactors can be used for the same function.

Facultative ponds, usually classified as the second treatment stage, with a water depth of 1.5 • 1.8 m, have aerobic conditions in the upper layers (due to the algal population) and anaerobic conditions in the lower layers.

Maturation ponds, usually classified as the *tertiary treatment stage*, typically have aerobic conditions throughout the whole water column, and are usually used to reduce pathogen levels. To be regarded as the final stage downstream of the anaerobic and facultative ponds.

Advantages of waste stabilisation ponds:
- Low cost
- Simple construction
- Good removal of COD and nutrients
- Excellent pathogen removal
- Ability to treat a variety of wastes
- Low O&M requirements
- Low sludge production
- Simple land reclamation

Disadvantages of waste stabilisation ponds:
- High footprint needed
- Hapital costs depend on the type of substratum
- Hischarge quality varies according to the season

7. Lagoons WWTS:

Aerated Lagoons - organic matter digested by aerobic bacteria. Suspended growth aerated lagoons consist of completely mixed and suspended growth activated sludge systems, made of relatively shallow earth basins varying in depth from 2 to 5 m. Oxygen transfer from the atmosphere into lagoons is increased by mechanically agitating the water with mechanical aerators on floats or fixed platforms. Roughly, a surface area of 1.5 to 3 m^2/PE must be planned. Usually, one or more separate settling lagoons are expected (two basins allow one to be by-passed for cleaning). For the settling stage, 0.6-1 m^3/PE and 2-3 m depth can be expected. Aerated lagoons could be placed after the anaerobic stage with recirculation to ensure denitrification, or can be used at the first stage of treatment after screening and grit removal.
Anaerobic Lagoons - oxygen demand of the bacteria exceeds oxygen supply by surface aeration and algal photosynthesis. Biodegradation of organic waste by anaerobic bacteria. Used for high-strength industrial wastewater. Usually reactors have a floating geomembrane cover sealed to the reactor perimeter, thereby allowing for biogas collection and for odour control. These could be applied as a primary treatment option.
Facultative Lagoons - aerobic and anaerobic conditions, organic matter biodegradation by facultative bacteria.

Advantages of Lagoons WWTS:
- Simple O&M with regular overall cleaning

- Very good removal of COD, nutrients and pathogenic organisms
- Low sensitivity to hydraulic and/or organic variations
- Production of stabilised sludge

Disadvantages of Lagoons WWTS:
- High footprint needed
- High energy consumption
- Capital costs depend on the type of ground
- Lower performances than other intensive systems

Exercise

The flipchart shows a schematic combination of a series of lagoons (as shown); the first ones are anaerobic lagoons, the middle ones are facultative lagoons and the last few are aerobic lagoons. The participants are asked why different processes take place in the lagoons and how they become anaerobic, aerobic or facultative.

8. Slide 24 shows the Intensive WWTS that will be explained to the participants. As already stated for Extensive WWTS, the suggestion is to cover the WWTS one by one, but the trainer might decide to cover the topic in less or more detail according to the participants' prior experience and knowledge, by rearranging or completely excluding some of the slides.

9. Imhoff Tanks:

Septic tank-soil absorption systems are conventional WWTS, which are used extensively to treat and dispose of household wastewaters in rural and suburban areas with no connection to main sewerage pipes. Septic tank effluent (STE) is similar to primary treatment sewage effluent. Although extensively used, this system poses several problems, must have well-drained soils with limited slopes and requires regular inspection and periodic pumping.
The Imhoff tank was developed to correct the two main defects of the septic tank:

a) it prevents the solids removed from the sewage from being mixed with it again, but it still provides for the decomposition of these solids in the same unit;
b) it provides an effluent amenable to further treatment (biological secondary treatment).

As a septic tank that provides for sedimentation of solids as well as for treatment through the biological activity of anaerobic or facultative bacteria, Imhoff tanks consist of a two-stage septic system where the sludge is digested in a separate tank. This avoids mixing digested sludge with incoming sewage. The shape of the tank must be designed to maximize the detention time of the wastewater. Wide and shallow tanks, made of concrete, polyethylene or fibreglass, are preferable for the process, and also for tank installation and safe operation.
The tank design must include provisions for adequate storage. Biological treatment efficiency is linked to detention time, ranging from 36 to 48 hours.
To avoid leach field failures, it is recommended that the tank is inspected once a year, providing base pump-outs on these annual inspections (slide 25).

10. Sand Filtration:

Sand filtration (slide 26) is usually combined with septic tank treatment and can be very effective in tertiary wastewater treatment. The mechanisms for water impurities removal are mechanical filtration, enhanced biological activity on surfaces, and adsorption. These features make sand filtration very attractive for advanced treatment of effluents. The typical sand filter is a concrete- or PVC-lined box filled with a specific sand material. The key parameters are the depth of the sand filter and the effective size of the sand. The effective size of the sand is usually 0.15 – 0.4 mm and the depth between 0.6 to 1.0 m. The filter doesn't need to be backwashed regularly, and it is easy to remove the first layer on the surface and to replace it with new material. The material used can be recycled or disposed of. Sand filtration is able to significantly remove bacteria so that the effluent is almost hygienically safe. Types include: single pass, recirculating...

Advantages:
- Produces a high quality effluent with low O&M.
- Wastewater percolates through graded media where biological, physical, chemical treatment occurs.

Disadvantages:
- Can become clogged.

11. Rottenbehaelter (Pre-Composting Tank):

A relatively new technology, retaining solid material and rain water to a certain extent, has been found to be an interesting component for decentralised systems to replace the usual septic tank. It consists of an underground concrete tank with two filter beds at its bottom or two filter bags that are hung side by side and used alternately at an interval of 6-12 months (slide 28).

12. Biofilters:

The operating principle involves running pre-treated wastewater through a bed of porous stone or open plastic material (variable size 10/50 mm – 20/60 mm) which supports micro-organisms and provides biological treatment (slide 29). Biofilters need to be preceded by primary clarifiers equipped with scum and grease collecting devices, or other suitable pre-treatment facilities.

Biofilters can be anaerobic or aerated by means of a blower. Anaerobic Biofilters are efficient in reducing BOD5 up to 75%, especially if there is a settling unit (septic tanks) upstream. For aerated filters, aeration is carried out by natural aspiration or by forced ventilation. Wastewater is fed by rotary distributors or fixed-nozzle systems providing uniform flow distribution over the surface of the entire filter media.

The treatment efficiency depends exclusively on the organic volumetric loading rate and the hydraulic surface loading rate. Since no mechanical devices are installed (except possibly a loading pump), the system is easy to operate. Today several different types of compact high-performance biofilters are available. Trickling filters have a fixed film, or attached growth process where microorganisms become attached to an inert medium. The wastewater is distributed over the surface of the medium where pollutant removal occurs as the waste stream comes into contact with this fixed film of microorganisms. The effluent is then collected at the bottom of the medium through an underdrain system. Trickling filters are known to be efficient nitrifiers, as long as adequate BOD and TSS reduction has occurred (slide 31).

Advantages:
- High removal efficiency for BOD5 (<25 mg/l) and SS (<30 mg/l)
- Surface area needed is much less than natural lagooning

Disadvantages:
- Effective primary settling is required
- High sensitivity to hydraulic variations
- Filter medium has to be carefully defined to avoid clogging problems

13. Sequencing Batch Reactor (SBR):

The sequencing batch reactor (SBR) as shown in slide 32, is a fill-and draw activated sludge system for wastewater treatment. In this system, wastewater is added to a single "batch" reactor, treated to remove undesirable components, and then discharged. Equalization, aeration, and clarification can all be achieved using a single batch reactor, while the steps are performed one after another. Aerobic decomposition, settling, and return take place in the same chamber. Air is bubbled through the liquid during the decomposition cycle. The bubbler shuts off, and the wastewater goes through a settling cycle. Once the bubbler turns back on, the tank re-enters the decomposition cycle, and settled bacteria mixes back into the aerobic environment. At least two reactors in parallel are required in order to divert, alternatively, the continuous incoming flow rate; an equalisation tank should also be expected for easier management of hydraulic loads. No sludge recycling is needed – the excess sludge withdrawal normally takes place near the end of the reaction phase or during the settling phase.
SBRs are highly-equipped electro-mechanical systems, whose functions are: mixing and aeration, effluent and excess sludge withdrawal, scum and foam removal. Sensors and computer-aided control devices are usually installed as well to make the process cycle flexible and full-automation controllable.

Advantages:

- Flexibility and regulation of the cycle duration related to the wastewater characteristics and pollutant load.
- High process reliability with respect to load fluctuations and to non-steady-state conditions.
- Low footprint as all the treatment processes take place in the same reactor.
- No sludge recycling (less energy and O&M costs).
- Higher settling phase efficiency due to static conditions.
- Process automation.

Disadvantages:

- Expert and skilled personnel is required for O&M.
- Specific electro-mechanical equipment.

14. Ecomax Cell:

As depicted in (slide 34) this system is an amended soil cell that can treat or dispose of effluent from a septic tank or AWTS. It is a partially lined cell that uses amended sand and geo-fabric to remove bacteria, organic matter and nutrients, such as nitrates and phosphates, from the effluent. It does not require any pumps or power supply. Effluent from the Ecomax cell can then be collected and used for irrigation.

The material, called an "amended soil", is a waste product of various industrial applications and has the ability to absorb high concentrations of phosphorus and other environmental and health contaminants from effluent.

The system operates as follows:

a) Effluent drains from the source to the pre-treatment tanks, where, after 2-3 days, the partially treated effluent flows out of the septic tank and into the infiltration structure in the Ecomax cells.

b) 50% of the Ecomax cells are used at a time, and rotation is once every 6 months to maintain hydraulic handling capacity by resting and drying one cell at a time.

c) Due to the hydraulic head difference between the standing water level in the infiltration structure and the perimeter bund, wastewater inside the infiltration structure flows radially by gravity into the amended soil and towards the perimeter bund, where it exits the system.

d) In certain weather conditions like in hot, dry periods, evapotranspiration is a dominant process, and depending on hydraulic loading, the Ecomax cells may have zero discharge.

The treatment processes which are applied to the effluent as it is driven by gravity through the amended soil include: filtration, pH adjustment, ion exchange, volatilization, biological water and nutrient uptake, oxidation and reduction, sorption, chemical precipitation, detention, and evaporation or dilution depending on rainfall/evaporation balance. As a result of this treatment, the final effluent produced by Ecomax has a very high quality, with particular reference to phosphorus concentration.

15. Slide 36 shows hybrid systems (package plant) that will be briefly described to the participants. It is considered useful to stress the importance of new technologies in wastewater treatment practices.

Hybrid systems represent a new technology incorporating both biofilm and activated sludge systems. The common reason for using hybrid systems is to enhance treatment efficiency where an individual process (biofilm or activated sludge) is not effective. Such systems are usually applied as packaged plants (slide 37); the most common application includes flock enhancement filter media in the activated sludge process. This is aimed at maintaining a large, stable flock size in the bioreactor to enhance both the biodegradation of organics and settling in secondary clarifiers. Operational parameters of hybrid systems depend on the type of patented technology and they are usually given by the manufacturer. The main drawback of this technology is the additional O&M costs required to deal with the filter media. Example of a new developed hybrid system package plant is the Biomax (slide 38).

16. Biomax WWTP:

The Biomax wastewater treatment plant is divided into five principal chambers;

1. Anaerobic chamber – anaerobic treatment
2. Aerobic chamber – aerobic treatment
3. Clarification chamber – sludge settlement and removal
4. Disinfection chamber – contact time with chlorine
5. Pump out chamber – discharge to disposal system

1. Anaerobic Chamber

Raw wastewater is initially received into the anaerobic chamber. Approximately 30 - 50% of the suspended solids settle out in this chamber, where they undergo anaerobic digestion. The anaerobic digestion process is carried out by microorganisms which have the ability to feed, grow and multiply in the absence of free oxygen. In addition, settled sludge and skimmed material returned from the clarification chamber are further digested in this chamber. The plant is sized to enable these microorganisms to maintain a sufficient population naturally without the need for the addition of proprietary biological products.

2. Aerobic Chamber

The partially treated wastewater, still containing the colloidal and dissolved solids which represent approximately 65% of the pollution loading, flows from the anaerobic chamber to the aerobic chamber. Air is introduced to the liquid in this chamber by means of a compressor and diffusers, maintaining aerobic (free dissolved oxygen) conditions. The oxygen-enriched effluent flows around packs of submerged media which have a large surface area on which bacteria and other microorganisms thrive, forming a biological film.

The process differs from ordinary suspended growth systems in that it is more stable and also allows the growth of sub-surface anaerobic microorganisms beneath the surface film of aerobic microorganisms. This allows anaerobic bacterial action to control the media growth, thereby reducing the biological sludge accumulation. Nevertheless, as the material thickens on the media, some sloughing off will take place.

The multiple compartment design of the aerobic chamber ensures that no short-circuiting can occur, preventing the possibility of partially treated wastewater passing into the clarification chamber. The diffused aeration system allows the air to be introduced below the media packs.
Basically the reaction in the aerobic chamber converts the dissolved and non-settleable (colloidal) solids into carbon dioxide and a biological flock, which, under quiescent conditions, will settle.

3. Clarification Chamber
Following aeration, effluent flows into a circular hopper-bottomed clarification chamber, where the biological flock (or sludge) settles under quiescent conditions. Settled sludge from the bottom of the chamber and also floating material are returned to the anaerobic chamber. From the clarification chamber, the effluent is drawn off below surface level and flows through the chlorinator to the disinfection chamber.
This continuous return of sludge to the anaerobic chamber ensures continuous fluid movement in the plant even with zero inflow and keeps the system "live" during periods of inactivity.

4. Disinfection Chamber
The discharge from the clarification chamber passes through an automatic gravity chlorinator. The chlorinator is calibrated for above normal water usage. Chlorine stocks are provided to cover maximum usage with built in safety factors to cover all foreseeable circumstances between the service periods.
The disinfection chamber is designed to provide a minimum of 30 minutes contact time between the effluent and chlorine to ensure bacterial die-off.

5. Pump out Chamber
After disinfection, the treated effluent enters the pump out chamber.

17. Upflow Anaerobic Sludge Blanket (UASB):

The operating principle of the Upflow Anaerobic Sludge Blanket (UASB) reactor (slide 39) consists of feeding the influent to be treated into the bottom of the reactor, where it comes in contact with the settled sludge blanket. The anaerobic degradation of organic substrates occurs in the granular sludge bed, where biogas is produced. The combined flow of the wastewater and the biogas causes natural mixing, which contributes to wastewater-sludge contact. Effluent recycling can be employed to promote mixing and sludge bed expansion, or with highly concentrated effluents, to dilute incoming substrate concentrations. The sludge bed in UASB reactors can consist of either granular or flocculent sludge. Flocculent no granule sludge will develop in the treatment of domestic sewage with a high

fraction of suspended solids (SS). Only when two-step systems are applied, where the majority of the SS is removed in the first step, can methanogenic granules develop in the second step.
A gas-liquid-solids separator (GLS, three-phase-separator) placed at the top of the reactor causes separation of biogas, water and sludge. Biogas is collected under the gas-collector by means of a baffle; and led out the top of the reactor.
Aerobic/anaerobic characteristics and principle of wastewater treatment will be largely discussed in another session.

18. In the box below is shown an example of the integrated wastewater treatment system (slide 40).

Example

UASB reactor integrated with constructed wetland and UV sterilisation of wastewater.
The operation costs are very limited, consists mainly of pumping costs, no aeration is necessary which usually represents the major financial part. Maintenance is easy and local staff can be trained for this.
As primary treatment, the anaerobic step provides physical as well as biological treatment with very low sludge production – less than 10% of conventional systems with activated sludge. Discharge is only necessary once or twice a year and effluent can be applied to field according to agricultural needs. Depending on the ambient temperature, one or two high rate reactors, e.g. UASB are required.
Constructed wetlands (CW) are the secondary treatment basic unit. CWs act as biofilters combining physical, chemical and biological treatment. As tertiary treatment, UV radiation as an environmentally sound technology is selected for disinfection because most of the reuse standards require a disinfection step for safety reasons.
This treatment cycle is not designed to remove nutrients. For example, for irrigation purposes, nutrients like nitrogen, phosphorus and potassium can additionally fertilise the plants when applying the treated water on the fields. See case study Session 2.

4.2 Session 2 – Case Studies

PPT

Session overview

Title
Case Study 1: UASB reactor-Turkey
Case Study 2: Greywater Treatment with small scale trickling filters
(West Bank, Palestine)

Objectives
• Present already applicable solutions for small wastewater treatment systems.

Teaching method lecture

Time estimation 30 minutes

Needed material flip chart, markers

Session guide

1. Introduce the criteria considered most important for long term sustainability of wastewater treatment and reuse concepts in suburban and rural areas of the MEDA countries:

• Affordable; especially low operation costs.
• Operable; operation must be easily possible with locally available staff and support.
• Reliable; producing a safe effluent for water reuse.
• Environmentally sound; little sludge production and low energy consumption.
• Suitable in Mediterranean climate.

2. UASB reactor-Turkey:

In an experimental project in Turkey (Wendland et al. 2006), a UASB reactor with a total volume of 55 l and a diameter of 0.15 m was built of PVC.
The reactor was operated at the ambient temperature, between 18 and 25°C.
The influent wastewater is a municipal wastewater typical for rural areas of water limited regions like the MEDA-countries.
The biogas produced in the UASB reactor consisted of 80% methane, 16% nitrogen and 4% CO_2, the removal of CODtot varied between 27% and 60%.

The evaluation indicated that high-rate anaerobic treatment like the UASB reactor followed by constructed wetlands and UV radiation is an appropriate and cost efficient method of wastewater treatment for suburban and rural areas of the MEDA-countries. If adapted to ambient temperature, it is an easily operable and sustainable treatment cycle.

3. Greywater Treatment with small scale trickling filters (West Bank, Palestine):

In Palestine, a pilot project to optimise the design of small-scale trickling filters for the treatment of greywater for reuse in home gardens in hilly, low-density peri-urban areas of the West Bank, has shown promising results. The individual or small collective (10-15 homes) systems are built from recycled shampoo containers and use local materials such as wadi gravel or waste such as crushed plastic bottles as filter media. The treated greywater from a properly operating system has been used safely for irrigating any product in home gardens, including raw vegetables.
Following outputs have been achieved:

- Refined greywater treatment design by putting vents on septic tanks to reduce odour and adding an aerobic sand unit downstream for polishing the effluent and ensuring that the trickle irrigators do not clog.
- Septic tank pump-out cost savings are up to a maximum of $400/year.
- Achieved an average of 56% greywater recovery in each home system. This reduces pressure on an overloaded and polluted environment – septic tanks, aquifers and sewerage systems.

4.3 Session 3 – Exercise

Design of a small alternative wastewater treatment system

Session overview

Title Design of a small alternative wastewater treatment system

Objectives
- To apply the acquired knowledge in selection and design of an appropriate, small, alternative wastewater treatment system.

Teaching method exercise in groups, discussion

Time estimation
- 15 min. explanation of the exercise
- 75 min time for preparing the answer
- 20 min presentation on a pin board
- 10 min final discussion and explanation

Needed material pens, paper, pin board, flipchart, assignment paper

Session guide

1. Divide the participants into 2 or 4 groups depending on the size of the course (each group should consist of 3 to 4 members) and distribute the questionnaire explaining the exercise.

2. Give the groups half an hour to answer the requested questions and to design the WWTS's following the instructions.

3. After that, each group will attach their designed solutions on a pin board and one member of each group will explain the chosen WWTS.

4. Discuss the options chosen by each group and explain why some options are preferable over others.

Design of a small alternative wastewater treatment system

Describe and design a small alternative wastewater treatment system (WWTS), explain the reasons for the chosen option and figure out the criteria for suitable sanitation system selection.

Consider the following initial assumption:

a) Village with 2000 inhabitants, abundant water, and soil is poorly dried with clay texture.

b) Individual houses, separated no less than 100 m. one from the other, scarcity of water, soil is sand.

Trainer's notes

In the first case (question a), it is preferable to use extensive systems (Constructed Wetlands), which are adequate for the proposed small community and can effectively remove organic matter, phosphates and nitrates from the treated wastewater.
Usually, these techniques are intended as wastewater treatment processes using fixed film microbiological cultures on small media (Constructed Wetlands, Land Based Treatment Systems) or suspended growth cultures (Waste Stabilisation Ponds, Aerated Lagoons), using solar energy to produce oxygen by photosynthesis and thus operated without (or negligible) power supply.
In the second case (question b), due to the sparsely populated area, the intensive system (Imhoff tank, septic tank) is preferable.

Imhoff tanks:
A septic tank that provides for sedimentation of solids as well as for treatment through the biological activity of anaerobic or facultative bacteria.
Imhoff tanks consist of a two-stage septic system where the sludge is digested in a separate tank. This avoids mixing digested sludge with incoming sewage. The shape of the tank must be designed to maximize the detention time of the wastewater. Wide and shallow tanks, made of concrete, polyethylene or fibreglass, are preferable for the process, for tank installation and safe operation.
The tank design must include provisions for adequate storage. Biological treatment efficiency is linked to detention time, ranging from 36 to 48 hours.
To avoid leach field failures it is recommended to inspect the tank once a year, providing a base pump-outs on these annual inspections.

Septic tank:
Soil absorption system is composed of a septic tank and an absorption field. A septic tank is a structurally sound and watertight concrete, fibreglass, or polyethylene container that is buried in the ground. The tank accepts wastewater from a household and separates the solids, by settling and floating, from the liquid. The soil absorption field receives septic tank effluent (primary quality effluent) and conveys it throughout a dispersal area where it is further treated and lost to evapotranspiration or percolates to groundwater. Microorganisms living in the soil profile feed on organic matter in the septic tank effluent, thus treating and purifying the wastewater. A septic tank–soil absorption system is often used in an area that has well drained soil with medium (loam) and coarse (sand) textured soils.
More sophisticated solutions to be mentioned: Biofilm systems, Activated sludge systems.
Example of criteria for suitable sanitation system selection to be taken into account (EM-Water Draft Policy Guidelines, 2006), and parameters that have to be assessed:

- Population to be treated
- Wastewater quality
- Water supply availability (per capita)
- Type of final wastewater destination
- Effluent standards and country laws and regulations
- Land topography
- Site characteristics and distance from residential and agricultural areas
- Energy availability and requirements
- Local climate
- Sludge production and disposal management

4.4 Self Test

Self test to hand out to the participants at the end of the topic. Participants have to answer each of the possible solutions with yes or no.

1. **Extensive WWTs are:**
    a. Characterised by low needs for energy supply.
    b. Very expensive and complicated.
    c. Technologically outdated.
    d. Characterised by low surface load.

2. **Constructed wetlands are:**
    a. Simple to operate and manage.
    b. Very complicated to operate and manage.

3. **The operating principles of biofilters include:**
    a. Physically removing the organic content from wastewater.
    b. Chemically removing the organic content from wastewater.
    c. Working as a support for micro-organisms providing a biological treatment.

4. **UASB reactor:**
    a. Production of biogas due to aerobic condition.
    b. No contact between sludge and wastewater.
    c. Organic degradation occurs in the sludge.
    d. Allows the collection of methane.

Answers:

1. a and d
2. a
3. c
4. d

4.5 Literature

Brix, H. (1993). Constructed wetlands for water quality improvement. By Moshiri, G.A. CRC Press, Inc. ISBN 0-87371-550-0.

Baetens, T. (2000). The use of horizontal planted filters for decentralised wastewater treatment in Auroville, an overview and description. In Constructed Wetlands for Wastewater Treatment in Tropical and Subtropical Regions, ed. Anna University, Chennai.

Cooper, P.F., Job, G.D., Green, M.B. and *Shutes, R.B.E.* (1996). Reed beds and Constructed Wetlands for Wastewater Treatment. Medmenham, Marlow, UK: WRC publications.

Crites, R., and *Tchobanoglous, G.* (1998). Small and Decentralized Wastewater Management Systems, WCV/Mc Graw-Hill.

DWA (2004). Principles for the Dimensioning, Construction and Operation of Plant Beds for Communal Wastewater with Capacities up to 1000 pe Deutsche Vereinigung für wasser, Abwasser und Abfall. Guideline A 262 draft.

El-Hoz, M. (2004). Wastewater Management in Rural and Suburban Areas. Training Program for Lebanese Officials: Efficient Management of Wastewater, Treatment and Reuse. InWEnt-EMWATER-INSTITUTE FOR WATER STUDIES.

EMWater Draft Policy Guidelines (2006). Part I: Guidelines for Wastewater treatment.

European Commission (2001). Extensive wastewater treatment processes adapted to small and medium sized communities, International Office for Water, Luxembourg.

Lange, J. and Otterpohl, R (2000): Abwasser. Handbuch für eine nachhaltige Wasserwirtschaft. ISBN 3-9803502-1-5.

Masi, F., Wendland, C., Chiarawatchai, N. (2006). Constructed Wetlands for Wastewater Treatment. EMWater computer based training (cd rom).

Reed, S. C., Crites, R. W. E., Middlebrooks, E. J. (1995). Natural systems for waste management and treatment, 2nd edition. McGraw Hill, New York.

Tchobanoglous, G. (1996). Appropriate Technologies for Wastewater Treatment and Reuse, Australian Water & Wastewater Association, Water Journal, Vol. 23, No.4.

UNEP-International Source Book On Environmentally Sound Technologies for Wastewater and Stormwater Management. Web site:
http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub15/main_index.asp

US EPA (2000). Constructed Wetlands Treatment of Municipal Wastewater. EPA/625/R-99/010 Office for Research and Development, Cincinnati Ohio.

Wendland, C. and *Chiarawatchai, N.* (2006). Constructed Wetlands for Wastewater Treatment - Lesson B4. EMWater computer based training (cd rom).

Wendland, C., Behrendt, J., Elmitwalli, T. A., Al Baz, I., Akcin, G., Alp, Ö and *Otterpohl, R.* (2006). UASB reactor followed by constructed wetland and UV radiation as an appropriate technology for municipal wastewater treatment in Mediterranean countries. Proceedings of the 7th Specialised Conference on Small Water and Wastewater Systems in Mexico, March 7-10, 2006.

Pravinjith, K.P. (2005). Training on "Urban Sustainability Management". ASEM GTZ.
http://www.borda-net.org

4.6 Recommended Reading

Cooper, P.F., Job, G.D., Green, M.B. and *Shutes, R.B.E.* (1996). Reed beds and Constructed Wetlands for Wastewater Treatment. Medmenham, Marlow, UK: WRC publications.

DWA (2004). Principles for the Dimensioning, Construction and Operation of Plant Beds for Communal Wastewater with Capacities up to 1000 pe Deutsche Vereinigung für Wasser, Abwasser und Abfall. Guideline A 262 draft.

Forster, C. (2003). Wastewater Treatment and Technology, Thomas Telford.

EMWater computer based training (cd rom).

Gray, N.F. (1999). Water Technology, An Introduction for Environmental Scientists and Engineers, Arnold.

El-Khateeb, M.A. and El-Gohary, F.A. (2003). Combining UASB technology and constructed wetland for domestic wastewater reclamation and reuse. Wat. Supp. 3 (4) pp 201-208.

Henze, M., Harremoes, P., la Cour Jansen, J., Arvin, E. (2002). Wastewater Treatment, Biological and Chemical Processes', Springer Verlag.

Kadlec, R. H., Knight, R. L. (1996). Treatment wetlands. Lewis publishers.

Lens, P., Zeeman, G. and *Lettinga, G.* - Decentralised Sanitation and Reuse, Concepts, systems and implementation (2001). IWA Publishing, London.

Mara, D. (2003). Domestic wastewater treatment in developing countries. ed. Earthscan USA.

Matsuo, T., Hanaki, K., Takizawa, S. and *Satoh, H.* (2001). Advances in water and wastewater treatment technology. Elsevier Ed.

Nuttall, P. M., Boon A. G., and *Rowell, M. R.* (1997). Review of the design and management of constructed wetlands. CIRIA Report 180. CIRIA, London. ISBN: 0-86017-485-9.

Reed, S. C., Crites, R. W., E. Joe Middlebrooks, E. J. (1995). Natural systems for waste management and treatment, 2nd edition. McGraw Hill, New York.

Tchobanoglous G. (1993). Constructed wetlands and aquatic plant systems: research, design, operational, and monitoring issues. In: Moshiri, G. A., Constructed wetland for Water Quality Improvement, Lewis Publishers, ISBN 0-87371-550-0,23-34.

Tchobanoglous, G., and *Burton, F.L.* (1991) Wastewater engineering: treatment, disposal, reuse. McGraw-Hill, Inc., New York.

4.7 Internet Resources

http://www.smallwat.org/inicio1024/index.htm
Small Wastewater Technologies and Management for the Mediterranean Area

www.swamp-eu.org
Data on research project on Sustainable Water Management and Wastewater Purification in Tourism Facilities (SWAMP).

http://ec.europa.eu/environment/water/water-urbanwaste/info/pdf/waterguide_en.pdf
Link of the European Commission, International Office for Water. Guide on Extensive Wastewater Treatment Processes Adapted to Small and Medium Sized Communities

http://www.unep.or.jp/ietc/ws/index.asp
UN Environmental Programme web page with a number of useful background, resources, links on water and sanitation topics.

http://web.idrc.ca/es/ev-6338-201-1-DO_TOPIC.html

http://www.eawag.ch/organisation/abteilungen/sandec/schwerpunkte/index_EN
Link of Eawag, Swiss Federal Institute of Aquatic Science and Technology, provides useful information and links on ecological, economical and socially responsible management of water.

5. Topic 2:

Aerobic and anaerobic wastewater treatment systems

Topic overview

Time
Session 1: Topic Presentation – 60 min
Session 2: Case Study – 30 min

Objectives
- Present an overview of organic presence in wastewater.
- Present differences and scope for use of aerobic and anaerobic wastewater treatment systems.

Participants should be able to
- Comprehend the organic contamination of water.
- Understand and recognize the different treatment processes and what is going on in each process.

Material
- Marker
- Pin board
- Flipchart
- Pinpoint Cards
- Projector
- Slides
- Self Test
- Assignment material

This topic is covered in 3 sessions:

1. Session 1 – Topic Presentation

The topic presentation aims to give an overview of organic material in wastewater and explain the principal usage of aerobic and anaerobic wastewater treatment systems. The slides contain notes with additional information for trainers to facilitate the lecture delivery.

2. Session 2 – Case Study

This case study shows the integrated aerobic – anaerobic treatment system for wastewater and faecal sludge.

5.1 Session 1 – Topic Presentation

Aerobic and anaerobic wastewater treatment systems

Session overview

Title Aerobic and anaerobic wastewater treatment systems

Objectives
- Present an overview of organic materials in wastewater.
- Present differences and scope of use of aerobic and anaerobic wastewater treatment systems.

Teaching method lecture

Time estimation 60 min

Needed material marker, pin board, pinpoint cards, flipchart, projector, slides

Session guide

1. Introduction to the session (slides 2-3).

2. It is advisable to give a brief definition and recapitulation of the meaning of the term sewage as shown in slide 5-6, emphasizing the characteristics and sources of domestic wastewater. Participants can be asked their opinion on the adverse effect on the environment when wastewaters are discharged untreated.

3. As reported in the table below, the main components of wastewater and their adverse effects on the environment can be written on cards and pinned to the pin board. The displayed components and effects can stimulate a brief discussion with the participants on the possible reasons for the unwanted effects.

Component	Of special interest	Environmental effect
Microorganisms	Pathogenic bacteria, virus and worms eggs	Risk when bathing and eating shellfish
Biodegradable organic materials	Oxygen depletion in rivers an lakes	Fish death, odours
other organic materials	Detergents, pesticides, fat, oil and grease, colourings, solvents, phenols, cyanide	Toxic effect, aesthetic inconveniences, bioaccumulation in the food chain
Nutrients	Nitrogen, phosphorus, ammonium	Europhication, oxygen depletion, toxic effect
Metals	Hg, Pb, Cd, Cr, Cu, Ni	Toxic effect, bioaccumulation
Other inorganic materials	Acids, for example hydrogen sulphide, bases	Corrosion, toxic effect
Thermal effects	Hot water	Changing living conditions for flora and fauna
Odour (and taste)	Hydrogen sulphide	aesthetic inconveniences, toxic effect
Radioactivity		Toxic effect, accumulation

(Henze and Ledin, 2001)

4. Definition of chemical and biological composition of wastewater, as described in the table below, can be written on the flipchart.

Wastewaters may contain any material, either dissolved or suspended.
Chemically, wastewater is composed of organic (70%) and inorganic (30%) compounds.
85 to 90% of the total inorganic component is dissolved and about 55 to 60% of the total organic component is dissolved.
Biologically, wastewater contains various microorganisms but the ones that are of concern are those classified as protista, plants, and animals.
The category of protista includes bacteria, fungi, protozoa, and algae.
Plants include ferns, mosses, seed plants and liverworts.
Invertebrates and vertebrates are included in the animal category.

5. It is useful to give a short overview of the main chemical parameters of wastewater utilised to determine the present organic content as enumerated in slide 8.

Dissolved oxygen (DO) is the amount of molecular oxygen dissolved in water. It is required for the respiration of aerobic microorganisms. The actual quantity of oxygen that can be present in solution is governed by:

- the solubility of gas
- the partial pressure of the gas in the atmosphere
- the temperature
- the concentration of the impurities in the water (e.g., salinity, suspended solids, etc.)

DO can be measured using chemicals or with an oximeter.

Biological oxygen demand (BOD) is the amount of O_2 (in milligrams) required by microorganisms to carry out the oxidation of organic carbon in one litre of water. (Oxygen is removed from water when organic matter is consumed by bacteria). Usually applied to determine waste loadings to treatment plants & efficiency of control measures (slide 9).
Organic loading from domestic waste: 55 g/person/day
5 day test: BOD5
20 day test: BOD20
60-90 day test: UBOD
Low BOD, High DO: Clean water
Unpolluted water will have BOD < 2 mg/L
Water receiving wastewaters will have BOD > 10 mg/L
Raw sewage has BOD = 600 mg/L

Treated sewage effluents BOD = 20-100 mg/L
Industrial wastes BOD ≈ 25,000 mg/L
The rate of oxygen consumption is affected by a number of variables**:**

- Temperature
- pH
- presence of certain kinds of microorganisms
- type of organic and inorganic material in the water

BOD5 measurement consists of filling an airtight bottle of specified size to overflow and incubating it at the specified temperature for 5 days. Dissolved oxygen is measured before and after incubation and the BOD is computed from the difference between the initial and the final D.O.

Chemical oxygen demand (COD) is another indirect measurement of organic material. It measures the susceptibility to oxidation of the organic and inorganic materials present in a water body, especially in the effluents from sewage and industrial wastewater
COD measures the oxygen equivalent of the organic material oxidized by dichromate or permanganate during acid digestion. This parameter was developed in order to substitute the more time-consuming BOD test. Values are usually about 1.25 times BOD. Disadvantage is the production of toxic waste in laboratories.
In unpolluted water, COD < 20 mg/L
In water receiving effluents, COD > 200 mg/L
In industrial wastewaters, COD ≈ 60,000 mg/L

Total organic carbon (TOC) is the amount of carbon present in organic molecules contained in the wastewater sample. The TOC test is an indirect measurement of organic material. The test measures the quantity of carbon dioxide liberated during the combustion of the wastewater sample.
TOC is independent of the oxidation state of the organic matter and does not measure H or N
Organic molecules $\rightarrow$ C $\rightarrow$ CO_2.

Total oxygen demand (TOD) is the difference in the oxygen content of a sample before and after combustion. It is an indirect method of measuring organic material concentration. However, it is the most direct measurement of oxygen demand. TOD measures the amount of oxygen required to burn the contaminants in the wastewater sample.

6. Many toxic organic compounds are identifiable only by direct measurement, it is worthy of mentioning existing specialized analytical techniques for detection of organic substances such as infrared spectrophotometry, gas chromatography, gel chromatography and mass spectrometry. Other analytical methods may be required depending upon the substance.

7. A different test exists for the measurement of organic content in the water and their mutual interrelation is worthy of mentioning (slide 10).

For the measurement of BOD, different volumes of wastewater are mixed in special BOD bottles with a liquid called "dilution water". This may be final effluent of a wastewater treatment plant which still contains some microorganisms or primary clarifier effluent diluted with tap water. Blanks are also prepared (bottles containing only dilution water and nitrification inhibitor).
The BOD bottles are completely filled and sealed with a glass stopper in such a way that no more air bubbles are contained in the bottles. With every mixture a duplicate of bottles is prepared. In one bottle of each pair, the concentration of dissolved oxygen is determined (e.g. by means of an oxygen probe) immediately after mixing. The other bottle is stored for n days at 20°C in the dark (to prevent photochemical reactions). At the end of this period, the concentration of dissolved oxygen is also measured in this bottle. The difference in oxygen concentration between a pair of bottles is the oxygen consumption (OC) (mg O_2/l). From the oxygen consumption of a particularly diluted wastewater sample and the oxygen consumption of the blanks (OC_{DW}), the BODn is calculated as follows:
$BOD_n = DF \cdot OC - (DF - 1) \cdot OC_{DW}$
with DF being the dilution factor (V(diluted sample)/V(sample before dilution)).
Cuvette tests for COD and TOC analyses are commercially available.

Interrelationship between BOD, COD and TOC
Typical values for the ratio of BOD/COD for untreated municipal wastewater are in the range from 0.3 to 0.8 (see in table below). If the BOD/COD ratio for untreated wastewater is 0.5 or greater, the waste is considered to be easily treatable by biological means. If the ratio is below about 0.3, either the waste may have some toxic components or acclimated microorganisms may be required in its stabilization. The corresponding BOD/TOC ratio for untreated wastewater varies from 1.2 to 2.0. In using these ratios, it is important to remember that they will change significantly with the degree of treatment the waste has undergone.

Comparison of ratios of various parameters used to characterize wastewater

Type of wastewater	BOD/COD	BOD/TOC
Untreated	0.3 – 0.8	1.2 – 2.0
After primary settling	0.4 – 0.6	0.8 – 1.2
Final effluent	0.1 – 0.3	0.2 – 0.5

8. Slide 11 shows additional organic components present in wastewater. It is advisable to give a short overview of the characteristics of these parameters.

Additional organic parameters:
- Oil and grease
- Phenol
- Adsorbable organic halides (AOX)
- Cyanide
- Surfactants

Oil and grease

Oil and grease in wastewater is usually a characteristic of petroleum• based chemical manufacturing, machining, vehicle maintenance, kitchen and restaurant wastes and, to a lesser degree, domestic wastewater.
Oil and grease is an indirect measurement defined and quantified by an analytical procedure. Oil and grease is an expression of all substances extracted by the organic solvent (Freon) employed in the test procedure.
Oil and grease may include hydrocarbons, fatty acids, soaps, fats, waxes, oils and any other Freon extractable substance that will not volatilize during the test procedure.
Oil and grease, in large quantities, is a dangerous environmental pollutant. Oil and grease is difficult to remove by conventional treatment processes such as anaerobic or aerobic biological processes and interferes in most physical-chemical treatment processes.
Oil and grease treatment usually consists of removal by skimming or flotation and disposal by reuse, incineration, or landfilling.
These substances are determined by extracting them with an organic solvent 1,1,1• trichloroethane. The two immiscible solvents (organic solvent and water) make separate layers. The solvent containing the oil and grease fraction of the wastewater is separated from the aqueous layer. It is dried and evaporated to determine the extractable residue.

Phenol

Phenol is encountered most frequently in the petroleum refining and chemical processing industries, but is present where industrial activities utilize petroleum distillates.
Phenol is very soluble in water, oils, carbon disulfide and numerous organic solvents. The wet chemical analysis of phenol measures directly a variety of phenolic compounds.
Phenol is a toxic and mutagenic substance in high concentrations and may be absorbed through the skin. Phenols are, for the most part, biodegradable.

Adsorbable organic halides (AOX)

Adsorbable organic halides (AOX) is an organic sum parameter comprising such organics that contain chlorine, bromine or iodine (not fluorine!) atoms which are adsorbable to activated carbon. For AOX determination, a wastewater sample is agitated with powdered activated carbon. Subsequently the activated carbon is separated by filtration using a membrane filter. Then the membrane filter is incinerated together with the activated carbon and the halogen atoms contained in the exhaust gas of the incineration furnace can be absorbed e.g. in acetic acid. Finally electrochemical quantification methods are used to analyse chloride, bromide, or iodide, of these acids (bromide and iodide are calculated as chloride equivalents). The result is mg AOX (chloride)/l wastewater.

Cyanide
Cyanide is found in metal plating, petroleum refining, plastics, and chemical manufacturing wastewaters.
The cyanide ion is highly toxic to aquatic life and humans at very low concentrations. Most cyanide appears as a chemical complex with a metallic compound. As a result, toxicity of cyanide depends upon the nature of the complex. Some cyanide compounds are harmless.
Cyanide compounds are usually biodegradable and are otherwise treatable by alternate methods.

Surfactants
Surfactants are found in household and industrial cleaning detergents and many industrial wastewaters. The presence of surfactants is indicated when there are large quantities of foam in the collection or treatment system
Methods for analyzing these organic sum parameters are given in the "Standard Methods" (Greenberg et al. 1985).

9. The marker can be used to draw the table shown below on the flipchart. It introduces aerobic and anaerobic conditions during decomposition of organic compounds. (Source: M. El Hoz)

	End products of decomposition	
Element in org. compound	**Aerobic conditions**	**Anaerobic conditions**
Carbon	CO_2	CH_4
Nitrogen	NO_{3-}	NH_3 and amines
Sulfur	SO_4^{2-}	H_2S
Phosphorus	PO_4^{3-}	PH_3 and other P cmpds

10. A question can be made to the participants on what the differences between aerobic and anaerobic conditions are.

Aerobic processes use bacteria and other organisms that feed on waste products present in the treated water and break them down, using oxygen from their surroundings.
Anaerobic processes use bacteria that obtain the oxygen they require from the materials on which they feed.

11. Slides 13 and 14 show the objectives and some types of biological treatment of wastewater aimed at removing soluble biodegradable organic matter. There is also a brief description of what sludge is.

The removal of soluble biodegradable organic matter from wastewater is performed through **biological degradation**. Such treatment processes can be aerobic or anaerobic or a combination of the two.
Aerobic biological treatment is efficient but presents high capital and running costs and technology requirements. Alternatively, anaerobic treatment has been proven to be an excellent process and is considered the core of sustainable waste management.
Moreover, removing pollutants from wastewater results in the **production of sludge**, which requires treatment (or stabilization) before its disposal.

Sludge production and management
Sludge originates from the process of treatment of wastewater and is separated in the treatment process by sedimentation or flotation. Sewage sludge consists of water and solids that can be divided into mineral and organic solids. The quantity and characteristics of sludge depend very much on the treatment processes. Most of the pollutants that enter the wastewater get adsorbed to the sewage sludge. Therefore, sewage sludge contains pathogens (and heavy metals, many organic pollutants pesticides, hydrocarbons etc. if the sewage has industrial origins).
Sludge treatment aims to stabilise (reduction or inactivation of pathogens) and digest (degradation and mineralisation of organic matter) sludge.
Sludge treatment processes can be classified into complementary treatments (degritting, thickening, conditioning, and dewatering) and stabilisation treatments (chemical stabilisation, composting, aerobic or anaerobic digestion). Dewatering can be accomplished through a wide variety of methods. The most applied in small plants are drying beds, mechanical dewatering (filter press, belt filter press, centrifuges), reed beds and lagoons. Aerobic digestion is commonly used by small communities prior to land application and is performed in open tanks where continuous or intermittent aeration is provided. Wastewater sludge from countries which are not heavily industrialised is characterised

by a lower metal and toxic content and higher microbiological concentrations. Furthermore, sludge production is usually lower than equivalent plants in industrialised countries, and production data are reported in very few cases.
Sludge production depends on the type of treatment applied. Primary and physical-chemical treatments produce greater quantities than biological ones, because the latter provide higher organic matter mineralisation. Wastewater composition, solids conveyed by water runoff and other operating conditions also affect sludge production.
A big advantage of anaerobic wastewater treatment is the production of much less sludge than in aerobic systems because of low growth rates of anaerobic bacteria. If the primary and secondary treatment is replaced by an anaerobic step like a UASB reactor, the sludge production is less than 10% of the aerobic system.

12. Schematic descriptions of the aerobic digestion process are displayed on slide 16.

13. Overview of the main devices used to enhance aerobic biological processes is given in slide 17. The devices mentioned for aerobic digestion as well as the main advantages and disadvantages are briefly explained on slides 18-20.

Aerobic digestion

Aerobic processes use bacteria and other organisms that feed on waste products present in the treated water and break them down, using oxygen from their surroundings.
As the supply of available substrate is depleted, the microorganisms begin to consume their own phytoplasm to obtain energy for cell maintenance reactions. Cell tissue is oxidised aerobically to carbon dioxide, water and ammonia. The ammonia is subsequently oxidised to nitrate as digestion proceeds. In reality only 75 to 80% of the cell tissue can be oxidised, the remaining 20 to 25% is composed of inert components and organic compounds that are not biodegradable.
Increasing the area of contact between wastewater and the air increases the opportunity for oxygen take-up from the air. The most common ways to achieve this are:

- produce activated sludge by using mechanical agitators such as a rotating biological contactor or by blowing air through wastewater; or
- create 'bacteria beds' or trickling filters, by allowing water to trickle through a bed of stones (or another suitable medium) so that it spreads as a fine film and is in contact with both air and the oxidizing organism.

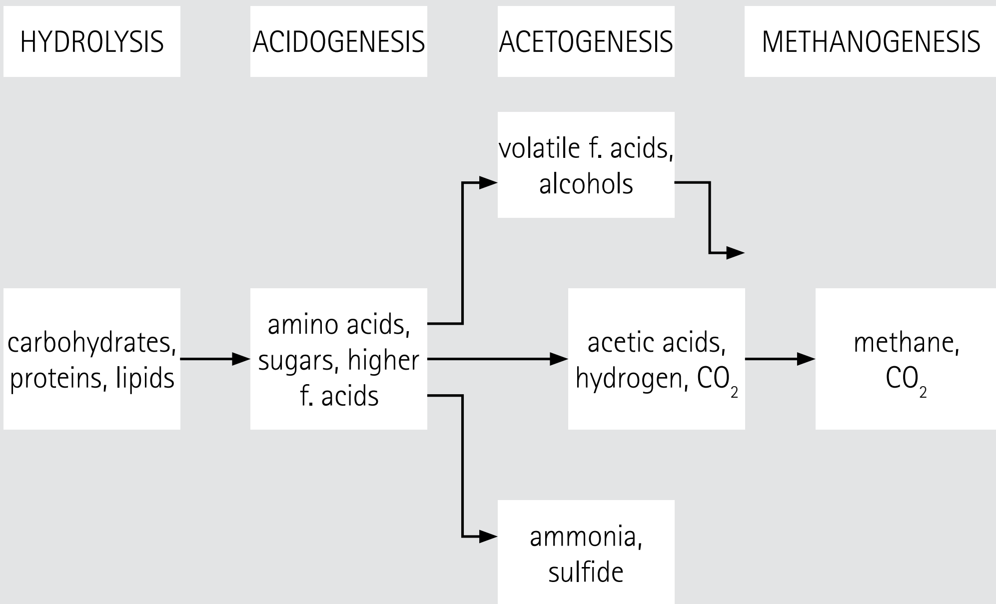
The activated sludge system is a versatile system offering operational flexibility and high reliability. It allows integration of nutrient removal processes, such as nitrification, denitrification and biological phosphorous removal. Rotating biological contactors are frequently used for small wastewater flows, such as from hotels and small compounds.

Although trickling filters are more easily operated and consume less energy than activated sludge processes, they have lower removal efficiency for solids and organic matter, they are more sensitive to low air temperatures, and can become infested with flies and mosquitoes. Trickling filters have no capacity for nutrient removal.

14. The 4 steps of the anaerobic degradation pathway of organic matter are depicted in slide 22.

4 steps of the anaerobic degradation pathway of organic matter

The anaerobic degradation pathway of organic matter is a multi step process of series and parallel reactions. This process of organic matter degradation proceeds in four successive stages, namely (1) Hydrolysis, (2) Acidogenesis, (3) Acetogenesis and (4) Methanogenesis.



Since bacteria are unable to take up particulate organic matter, the first step in anaerobic degradation consists of the hydrolysis of polymers through the action of exoenzymes to produce smaller molecules which can cross the cell barrier. Hydrolysis is in most cases, notably with sewage as substrate, rate-limiting for the overall process of anaerobic degradation of organic matter and is very sensitive to temperature. For that reason, design of the anaerobic reactors for sewage treatment is usually based on the hydrolysis step.

During the acidogenesis, the hydrolysis products which are relatively small, soluble compounds are diffused inside the bacterial cells through the cell membrane and then are either fermented or anaerobically oxidized.
The acidification products consist of a variety of small organic compounds, mainly so-called volatile fatty acids (VFA's) (acetate and higher organic acids (like propionate and butyrate), H_2, CO_2, some lactic acids, ethanol and ammonia. Given that VFA's are the main end products, fermentative organisms are usually designated as acidifying or acidogenic microorganisms. These reactions are thermodynamically unfavourable (positive $\Delta G°'$) unless the hydrogen partial pressure is maintained at an extremely low value.
Methanogenic bacteria utilize molecular hydrogen in the usual anaerobic digester so rapidly that the hydrogen partial pressure can be kept as low as 10-4 atm which is enough to ensure the active performance of the hydrogen producing acetogenic bacteria. This means that the degradation of higher fatty acids depends largely on the activity of methanogenic bacteria. Microbial associations in which a H_2-producing organism can grow only in the presence of H_2-consuming organisms are called syntrophic associations. The coupling of the formation and use of H_2 is called interspecies hydrogen transfer (HTS).
During the fourth and last stage of anaerobic degradation of organic matter, a group of methanogenic bacteria both reduce the carbon dioxide by hydrogen and decarboxylate acetate to form methane (CH_4). The methanogenic bacteria are obligate anaerobes.

15. Schematic description of the anaerobic digestion process and an overview of the main devices used to enhance anaerobic biological processes are described in slide 23-25.

Anaerobic digestion

- Bacterial process in absence of oxygen.
- In these systems, wastewater flows through the anaerobic sludge where purification takes place through complex interrelated bio - physical - chemical processes. Organic matter is converted into biogas and sludge.

- Sludge is:
  Fermented in heated digesters operated at 37°C (mesophilic) or 55°C (thermophilic).
  Thermophilic → biogas with a high proportion of methane (heats tank and runs onsite engines). In large treatment plants, sufficient energy can be generated in this way to produce more electricity than the machines require.

Advantages:
- No electrical power
- Small-size land
- Fairly simple to operate and maintain

Disadvantages:
- High capital and maintenance cost
- Outflow channels get clogged + corrosion
- Filter distribution pipes frequently clog
- Filter requires cleaning and/or replacement
- Methane vented into atmosphere

Anaerobic contact process

Untreated wastewater is mixed with recycled sludge solids and then digested in a sealed reactor. The mixture is separated in a clarifier. The supernatant is discharged as effluent, and settled sludge is recycled.

Advantages:
- Methane recovery
- Small area required
- Volatile solids destruction

Disadvantages:
- Heat required
- Effluent in reduced chemical form requires further treatment
- Requires skilled operation
- Sludge to be disposed of is minimal

Upflow Anaerobic Sludge Blanket (UASB)

Wastewater flows upward through a sludge blanket composed of biological granules that decompose organic matter. Some of the generated gas attaches to granules that rise and strike degassing baffles, releasing the gas. Free gas is collected by special domes. The effluent passes into a settling chamber.

Advantages:
- Low energy demand
- Low land requirement
- Low sludge production
- Less expensive than other anaerobic processes
- High organic removal efficiency

Disadvantages:
- Long start-up period
- Requires sufficient amount of granular seed sludge for faster start-up
- Significant wash out of sludge during initial phase of process
- Lower gas yield than other anaerobic processes

Aerobic digestion compared to anaerobic digestion presents some advantages(+) and disadvantages(–):

+ Lower BOD concentrations in supernatant liquor
+ Recovery of more of the basic fertilizer value in the sludge
+ Operation is relatively easy
+ Lower capital costs

– High power cost for supplying the required oxygen
– Digested solids have poorer mechanical dewatering characteristics
– No useful by-product (methane) is recovered

16. The main mixed (aerobic-anaerobic) digestion processes with a flow chart of the integrated system stream are shown in slides 27-29.

Integrated Systems

Anaerobic systems guarantee fairly good removal of carbonaceous matter, but are markedly inadequate to remove nitrogen and phosphorus compounds. The integrated systems (mixed aerobic-anaerobic digestion) consist of a combination of anaerobic and aerobic biological systems in series.
The first stage involves anaerobic treatment, even for intensive and high-loaded wastewater treatment, aimed at the removal of the biodegradable dissolved organic fraction. The second stage is aimed at removal of nitrogen and phosphorus compounds and usually consists of an aerobic (low-cost) biological treatment system (e.g. RBCs). Natural systems (constructed wetlands, algal ponds) or sand filters offer alternative options to upgrade high-rate anaerobic pre-treatment stages.
The integrated systems developed over the last few years differ according to the various treatment systems used and the substrates that they eliminate. Whatever configuration is applied, integrated systems represent a cost-effective method, also for a decentralised approach, for reclaiming domestic wastewater for agricultural production.

17. For revision of pond treatment processes, the participants can be asked to figure out and describe what kind of treatment systems they already know and in which both aerobic and anaerobic processes are used (slides 30-31). In the following discussion, the sludge disposal systems can be summarised and explained.

Exercise

Participants are asked to write the main characteristics of the aerobic and anaerobic processes on a paper sheet and some of them should read their answers. This short repetition is useful to briefly revise the main differences between the two processes and the different final products obtained at the end of each process (i.e. about ten times less sludge is produced with anaerobic treatment than with aerobic treatment)

Integrated treatment and reuse system for wastewater

Session overview

Title Mexico – Integrated treatment and reuse system for wastewater (SUTRANE)

Objectives
- To present an integrated aerobic-anaerobic system for wastewater and faecal sludge treatment.

Teaching method lecture, discussion

Time estimation 30 min

Needed material projector, marker, flip chart

Session guide

1. It is useful to begin by mentioning that constructed wetlands for the treatment of faecal sludge might be very effective in raising the quality of life of local communities in developing countries. The waste can be treated as a valuable resource since wetlands yield valuable products, as can be seen in the case study from Mexico as reported by AAlbers (1999).

2. This case study shows an integrated treatment and reuse system for wastewater (SUTRANE) developed in Mexico in 1970 (Chavez, 1998; Jank, 1995). The entire system can be constructed using local materials and labour. The English translation for Sutrane is Unit Treatment System for the Reuse of Water, Nutrients and Energy at the domestic level.

3. The primary system includes an anaerobic digester for the treatment of black water, a two stage reactor for the treatment of grey water, and a trickling filter followed by a grease trap. The anaerobic digesters decompose complex organic material, thereby generating methane gas and liberating essential nutrients for plant growth in the secondary treatment system. The methane gas is used as a fuel source for cooking or heating.

4. Pre-treatment, including the pre-oxygenator, provides film flow on the surface of the rock media, absorbing oxygen necessary to counteract the harmful effect of the detergents. This effluent flows to the grease trap where the oil and grease float to the surface. The grease is reused for soap production or placed in the anaerobic digesters to

enhance digester loading and performance. Both primary effluents flow into a channel with aquatic plants. These effluents sub-irrigate a secondary filtration field constructed of stone, gravel, and sand with an impermeable film below the entire bed. Selected plants are grown on the filtration bed. A multi-purpose greenhouse can be used to provide optimal growth for the plants in both stages of secondary treatment.

5. The plants in the secondary process consume the available nutrients and, with the assistance of the soil micro-organisms in the filtration bed, provide a relatively high degree of treatment. For larger systems, the Sutrane system concepts have been incorporated into a design referred to as the Dual Microplant system.

6. Black water combined with the biodegradable organic fraction of solid wastes is treated in a 3 stage anaerobic reactor followed by solid/liquid separation and effluent polishing.

7. The selection of the tertiary treatment technology for effluent polishing is based on the water quality reuse requirements.

8. A SUTRANE system treating the wastewater of 2,000 inhabitants showed the following performance: 92.3 % BOD removal , 99.8 % oil and grease removal, 99.4 % organic N removal and 73.5 % total suspended solids removal (Jank, 1995).

9. Chavez (1994) reported the following removal percentages for Dual Microplant systems: Faecal coliforms 93 %, BOD 90 %, COD 85 % and TSS 86 %. The SUTRANE system has already been used successfully in approximately 10,000 applications in Mexico, Central and South America and the Caribbean (Jank, 1995).

5.3 Self Test

A self test is handed out to the participants to check the level of comprehension of the topic. The questionnaire has to be completed and the answers checked. It is possible to have more than one correct solution. (The explanation in parentheses is only for the moderator's use).

1. **Blackwater: What is blackwater?**
    a. Wastewater from industries
    b. Toilet wastewater
    c. Brownwater and greywater collected together
    d. Urine and faeces collected together

2. **BOD Understanding: Determine a correct measured BOD of 160 mg/L, what can be said about the degradability of that sample?**
    a. It is classified as «not degradable»
    b. A classification about degradability is not possible based on BOD alone
    c. It is classified as «good degradable»
    d. It is classified as «very good degradable»

3. **BOD advanced Understanding: Determine a very small BOD5, what can be possible reasons, if the measurement was applied correctly?**
    a. The time was not enough for further degradation
    b. The sample had a pH lower than 3
    c. The sample includes less biochemical degradable material
    d. The used microorganisms haven't be able for further degradation

4. **COD Analyse: Which is one of the main problems of COD analysis?**
    a. It requires a long digestion period
    b. Production of toxic waste in laboratories
    c. International standards for COD differ too much
    d. The result is not identical to BOD

5. **Anaerobic wastewater treatment 2: Which are the key issues in designing a UASB reactor for sewage treatment?**
    a. Nutrients removal
    b. Sludge retention time
    c. Upflow velocity
    d. Temperature

6. **Activated sludge: Which are basic parameters characterizing an activated sludge process?**
    a. Sludge retention time
    b. TSS, Total suspended solids in mixed liquor
    c. Reactor volume
    d. Recycle ratio of sludge

7. Anaerobic treatment: Which treatment technologies are aerobic treatment technologies?

a. Activated sludge process
b. Extended aeration
c. Sedimentation
d. UASB

8. Anaerobic-aerobic: Which statements are right?

a. With anaerobic treatment, about ten times less sludge is produced than with aerobic treatment
b. Aerobic wastewater treatment is always better than anaerobic treatment
c. Anaerobic wastewater treatment is always better than aerobic treatment
d. Anaerobic treatment of municipal wastewater needs usually a post treatment step

Answers:

1. b and d	2. b
3. a, c and d	4. b
5. b, c and d	6. a, b and d
7. a and b	8. a and d

5.4 Literature

AAlbers, H., 1999, Resource Recovery from Faecal Sludge using Constructed Wetlands, Waste, UWEP working document.

Abbassi, B. (2004). Nature and origin of wastewater. InWEnt Training program on Chemical, Physical, and Biological Methods for Water and Wastewater Analysis. 04.07. – 08.07.2004 Jordan.

Akcin, G., Alp, O., Gulyas, H. and *Büst B.* (2006). Characteristic, analytic and sampling of wastewater. Lesson a1, EMWater E-learning course (cd rom).

Ayoub, G. M. (2006). general considerations in designing a wastewater treatment plant. Training Program for Lebanese Officials: Efficient Management of Wastewater, Treatment and Reuse. InWEnt-EMWATER-INSTITUTE FOR WATER STUDIES.

Chavez, J.A., 1994, Pollutants remission efficiency in effluents from Dual Micro-plants, (unpublished).

Chavez, J.A., 1998, Alternative systems, In: A.. Balkema, H. Aalbers, E. Heijndermans (Eds.), Workshop proceedings Sustainable municipal wastewater treatment systems, ETC/WASTE, Working Document, edition January 1998, WASTE, the Netherlands.

El-Hoz, M. (2006). Water quality parameters in wastewater treatment plants. Training Program for Lebanese Officials: Efficient Management of Wastewater, Treatment and Reuse. InWEnt-EMWATER-INSTITUTE FOR WATER STUDIES.

Henze, M. and *Ledin, A.* (2001). Types, characteristics and quantities of classic, combined domestic of classic, combined domestic. In: Decentralised sanitation and reuse, concepts, systems and implementation (eds. Lens, P., Zeeman,G., Lettinga, G). IWA Publishing.

Jank, B., 1995, Evaluation of the technical and financial viability of the SUTRANE and Dual Microplant integrated systems for the treatment and recovery of resources of domestic/municipal wastewater - Project report, Wastewater Technology Centre, Burlington, Canada

Kallab, F. (2004). Wastewater treatment. Training Program for Lebanese Officials: Efficient Management of Wastewater, Treatment and Reuse. InWEnt-EMWATER-INSTITUTE FOR WATER STUDIES.

Mahmoud, N. (2006). Anaerobic sewage treatment. Lesson b3. EMWater E-learning course (cd rom).

Samwel, M. (2005). Alternatives for Sanitary Systems Ecological Sanitation - A chance for Rural

Romanian Areas, WECF Women in Europe for a Common Future.

Shammas, A. (2005). Management of sewage Treatment and reuse in the Mediterranean Countries. Training Program for Lebanese Officials: Efficient Management of Wastewater, Treatment and Reuse. InWEnt-EMWATER-INSTITUTE FOR WATER STUDIES.

5.5 Recommended Reading

El-Khateeb, M.A. and *El-Gohary, F.A.* (2003). Combining UASB technology and constructed wetland for domestic wastewater reclamation and reuse. Wat. Supp. 3 (4) pp 201-208

Greenberg, A.E., Trussell, R.R., Clesceri, L.S., and *Franson, M.A.H.*, eds. (1985) Standard methods for the examination of water and wastewater, 16th ed. American Public Health Association, Washington, DC.

Henze, M., Harremoes, P., la Cour Jansen, J., Arvin, E. (2002). Wastewater Treatment, Biological and Chemical Processes', Springer Verlag

Tomar, M. (1999). Quality Assessment of Water and Wastewater. Lewis publishers

UNEP-International Source Book On Environmentally Sound Technologies for Wastewater and stormwater Management. Web site:
http://www.unep.or.jp/ietc/Publications/TechPublications/TechPub-15/main_index.asp

Wendland, C., Behrendt, J., Elmitwalli, T. A., Al Baz, I., Akcin, G., Alp, Ö and *Otterpohl, R.* (2006). UASB reactor followed by constructed wetland and UV radiation as an appropriate technology for municipal wastewater treatment in Mediterranean countries. Proceedings of the 7th Specialised Conference on Small Water and Wastewater Systems in Mexico, March 7-10, 2006

Zeeman, G., Lettinga, G., 1999. The role of anaerobic digestion in closing the water and nutrient cycle at community level. Water Sci.Technol., 39 (5), 187-194.

5.6 Internet Resources

http://www.atv-dvwk.de/download/betriebspers-klaeranl.pdf Activated sludge process

www.UASB.org Anaerobic Granular Sludge Bed Technology Pages

http://www.cepis.ops-oms.org/muwww/fulltext/repind54/anadow/anadow.html
Comparison of high-rate anaerobic wastewater treatment reactors

http://www.dep.state.fl.us/water/wastewater/dom/domdefn.htm Link to the Florida department of environmental protection with information and links on water treatment and sanitation

http://www.atv-dvwk.de/download/betriebspers-klaeranl.pdf
Guide for sewage treatment plant staff

http://www.smallwat.org/inicio1024/index.htm
Small Wastewater Technologies and Management for the Mediterranean Area

www.swamp-eu.org Data on the research project on Sustainable Water Management and Wastewater Purification in Tourism Facilities (SWAMP).

http://ec.europa.eu/environment/water/water-urbanwaste/info/pdf/waterguide_en.pdf
Link of the European Commission, International Office for Water. Guide on Extensive Wastewater Treatment Processes Adapted to Small and Medium Sized Communities

http://www.unep.or.jp/ietc/ws/index.asp UN Environmental Programme web page with useful background information, resources, links on water and sanitation topics.

6. Topic 3:

Decentralised options for rural areas vs. centralised urban systems

Topic overview

Time
Session 1: Topic Presentation – 90 min
Session 2: Case Studies – 60 min
Session 3: Exercise – 90 min

Objectives
- Present differences and possible options for wastewater treatment in rural areas compared to big systems.
- Identify and estimate differences in feasibility, operation and maintenance of decentralised wastewater treatment systems.
- Present high-tech urban options.
- Present economical and environmental aspects of wastewater treatment options.

Participants should be able to
- Understand the differences and recognise possible options for wastewater treatment in rural areas compared to big systems.
- Identify and comprehend the operating and maintenance characteristics of decentralised wastewater treatment systems.
- Evaluate and identify environmental and economical aspects of selected wastewater treatment options.

Materials
- Marker
- Pin board
- Pinpoint Cards
- Flipchart
- Projector
- Slides
- Self Test
- Pens
- Paper
- Assignment paper

This topic is covered in 3 sessions:

1. Session 1 – Topic Presentation

The topic presentation is designed to explain the importance and feasibility of decentralised wastewater treatment systems (WWTS), as well as to give an overview of the environmental and economic aspects of selected wastewater treatment options.

2. Session 2 – Case Studies

The examples and case studies presented aim to give an overview of possible alternatives when selecting the most feasible wastewater treatment system as well as to show real applied solutions.

3. Session 3 – Exercise

The exercise should promote discussion and enhance participants' knowledge of the differences between conventional centralised and alternative decentralised wastewater treatment systems.

6.1 Session 1 – Topic Presentation

PPT

Decentralised options for rural areas vs. centralised urban systems

Session overview

Title Decentralised options for rural areas vs. centralised urban systems

Objectives
- Present the differences and possible options for wastewater treatment in rural areas compared to big systems.
- Present high-tech urban options.
- Present economic and environmental aspects of wastewater treatment options.

Teaching method lecture

Time estimation 90 min

Needed material marker, pin board, pinpoint cards, flipchart, projector, slides, assignment paper

Session guide

1. Introduction to the session (slides 2).

2. The importance and the goals of proper wastewater treatment should be emphasised (slides 3-6). In particular, the treatment of wastewater (as part of management of water resources) is strictly connected with the concept of water reuse as a part of an overall water cycle system.

3. Participants should be asked about their knowledge of the water cycle in nature and invited to brainstorm on the problems of, reasons for, and possible alternatives to wastewater treatment in their home places.

4. Slides 7-8 introduce the participants to the main criteria to consider when selecting a proper WWTS, with a diagram showing an example of the components to be considered in municipal wastewater treatment systems.

5. The concept of centralised and decentralised wastewater management is introduced in slides 9-10.

Centralised wastewater management represents the conventional approach in many countries, as it is characterised by the collection of sewage and storm water using sewers, and transport of the wastewater to a specific location. Here the wastewater and sludge are treated and disposed of in a controlled manner in an advanced intensive treatment plant. The advantages of this method are assumed to include lower capital and operating costs of one large treatment plant compared to many small-scale plants serving the same urban area, and more effective control of quality standards and plant operation. Disadvantages include: high construction and maintenance costs of the collection system; long sewer pipes may leak, causing soil and groundwater pollution if they are not adequately maintained; combining all kinds of wastewater and storm water leads to a highly complex variety of pollutants, which fluctuate heavily in composition and concentration, thus making effective treatment very difficult; central treatment systems usually require intensive aeration and, consequently, their operational costs may exceed the financial resources capacity; central municipal treatment plants make wastewater reuse and sludge reclamation very difficult due to components like harmful materials, household chemicals, pharmaceuticals, heavy metals, and pathogenic organisms; effluent reuse in centralized plants is also expected to be centralized, therefore the number of beneficiaries (farmers) will be limited and less than in scattered decentralized systems; consideration of pumping stations in centralized treatment systems is mostly unavoidable.

Decentralised wastewater management (DWM) is already applied in many countries, mostly serving rural areas. By definition, DWM employs collection, treatment and disposal/reuse of wastewater from small communities (from individual homes to portions of existing communities) integrated into village/town development projects. Such models consist of many small wastewater treatment facilities designed and built locally. The basic concept is to maintain both the solid and the liquid fractions of the wastewater near the point of origin and to minimize the wastewater collection network. In development situations, this approach is more flexible, allowing the design to fit into a number of development locations and scenarios. Advantages of decentralised systems: saving money in terms of sewerage investment costs and the cost of operation and maintenance; promoting better watershed management; offering an appropriate solution for low density communities; providing effective solutions for sensitive areas.

Concerns related to the decentralised approach include the risk of low effluent quality (rarely allowing for safe water reuse), inadequate plant operation and groundwater pollution. In order to overcome these problems, new concepts have been introduced in recent years, based on: integration of drinking water and wastewater management systems on a local scale with consideration of long term perspectives; separate collection and treatment of different categories of waste streams; recovery of valuable substances for further and mostly direct private or public reuse. Such an approach can also minimise the demand for fresh water, a very important issue especially in water-scarce areas where local groundwater is not used for drinking water supply.

Exercise

The participants are asked to write their opinions on the main advantages and disadvantages of centralised vs. decentralised WWTS on cards and pin them on the pin board. The answers are discussed with the participants and, if necessary, the factors that have to be considered when making a decision on which kind of system to implement, are summarised.

Consider the following factors in the choice between implementing a centralized or decentralized system:

1. Are lot sizes generally large?
2. Are there less than 50 homes per 1.5km?
3. Is there little expectation of growth in the area?
4. Are soils suitable for onsite systems?
5. Is the area hilly?
6. Is the bedrock in the area shallow?
7. Could an onsite wastewater management district be developed?
8. Will people be responsible for their onsite systems?
9. Is there a means of enforcing violations of onsite wastewater standards?
10. Are centralized systems prohibited by their costs?

Exercise

Write the following terms on the flipchart with the marker:
Conventional wastewater treatment processes: -physical, -chemical, -biological.
Participants are asked to figure out the significance of these terms in wastewater treatment processes, and what they know about the different stages of conventional WWTPs.

6. We suggest showing slide 11 to briefly summarise the conventional WWT stages and to offer answers to questions posed in the exercise above.

7. It is advisable to explain the importance of the sewer systems, and the main cost component in traditional centralised WWTS. Conventional collection systems are typically installed in urban areas or areas of high population density. They require large diameter piping constructed on a design grade with manholes routinely spaced throughout. They are designed to carry fluids and solids by gravity and have to be cleaned by mechanical cleaning equipment. Large pump stations are required to lift the sewage to higher elevations in order to maintain gravity flow with the consequence of high energy cost and expensive O&M (slides 12-13). The choice of sewerage and treatment system for public sewage and rainwater must be made very carefully as there are different system alternatives available, as will be seen later. Task of the treatment process: produce "clean" effluent.

8. The conventional wastewater treatment process involves several stages: preliminary, primary, secondary and tertiary/advanced (disinfection) treatment of wastewater (slide 14). The trainer might decide to cover the topic in more or less detail according to the participants' prior experience and knowledge by rearranging or completely excluding some of the slides.

Preliminary treatment (physical)
The objective of preliminary treatment is to remove coarse solids and other large materials often found in raw wastewater. Removal of these materials is necessary to enhance the operation and maintenance of subsequent treatment units. Flow measurement devices, often standing-wave flumes, are always included at the preliminary treatment stage.

Primary treatment (physical)
The objective of primary treatment is to remove settleable organic and inorganic solids. It removes up

to 40% of wastewater pollutants mechanically. The goal is to produce a homogenous liquid capable of being treated biologically, which is free of course material and oil.

- Grit removal of settleable coarse material, gravel, sand
- Screening of floating plastic, wood ...
- Sedimentation. Wastewater is allowed to stand in large tanks for faecal solids to settle, and oil to float and be skimmed

Removal during primary treatment:

- 25 to 50% of the incoming BOD5
- 50 to 70% of the TSS
- 65% of the oil and grease

Secondary treatment (biological)

The objective is to further treat the effluent from primary treatment to remove the residual organics and suspended solids. It is designed to substantially decompose the organic content of the sewage. Usually biodegradable dissolved and colloidal organic matter are degraded aerobically.

High-rate biological processes are characterized by relatively small reactor volumes and high concentrations of microorganisms compared with low rate processes. Consequently, the growth rate of organisms is much greater in high-rate systems because of the well controlled environment.

The microorganisms must be separated from the treated wastewater by sedimentation (secondary clarifiers) to produce clarified secondary effluent. The biological solids (sludge) removed during secondary sedimentation are normally combined with primary sludge for sludge processing.

- Microorganisms consume dissolved mineral nutrients and fast biodegradable organics, thus synthesizing stable, large-molecule humic substances.
- Degradation of large-molecule organics (cellulose, proteins ...) into stable humic matter -A settling period follows to let stabilized humics settle out, forming the sludge.
- A somewhat clear effluent with low levels of organic matter and suspended solids is left.

Removal after Secondary Treatment:

- Solids 85-95%,
- BOD 80-95%,
- Col. 90-95%

Tertiary and/or advanced treatment (physical, chemical)

Employed to remove specific wastewater constituents which cannot be removed by secondary treatment. Individual treatment processes, including use of filters and chemicals, are employed to remove nitrogen, phosphorus, additional suspended solids, refractory organics, heavy metals and dissolved solids.

Provides a final stage to raise the effluent quality to the standards required before it is discharged to the receiving environment (sea, lakes, rivers, marshes, ground ...

1. Polishing of the effluent by slow sand filtration.
2. Filtration over activated carbon to remove residual toxins.

3. Nutrient removal by alternate aerobic – anaerobic conditions to transform ammonium-N into nitrate and then N; and addition of alum to precipitate phosphorus.
4. Disinfection to substantially reduce the number of living organisms.

Removal of nutrients (N, P) by biological and chemical methods:

- Solids ~100%,
- BOD ~99%,
- Col. ~99%

9. Slide 15 shows the efficiency of several disinfection technologies.

Tertiary treatment – disinfection

Disinfection of Wastewater:

- Intended to reduce microbes in treated effluent.
- Typically used method: chlorination. Alternatives: UV radiation, ozone and chlorine dioxide, granular medium (e.g., sand) filtration, membrane filtration.
- Chlorination remains the most common disinfection method; low cost, long term history of effectiveness. However, some chlorinated hydro-carbons can be generated that are carcinogenic or harmful to the environment. Good enteric bacterial reduction: typically, 99.99+% (meets faecal coliform limits for effluent discharge). Often 200-1,000 per 100 ml geometric mean as permitted discharge limit. Less effective for viruses and parasites: typically, 90-99% reduction. Toxicity of chlorine and its by-products to aquatic life now limits wastewater chlorination; designers may have to:
- Dechlorinate
- Use an alternative, less toxic chemical disinfectant or
- Use an alternative treatment process to reduce enteric microbes

Ultraviolet (UV) disinfection

An ultraviolet (UV) disinfection system transfers energy from a mercury arc lamp to an organism's genetic material. When UV radiation penetrates the cell wall of an organism, it destroys the cell's ability to reproduce. The effectiveness of a UV disinfection system depends on the characteristics of the wastewater, the intensity of UV radiation, the amount of time the microorganisms are exposed to the radiation, and the reactor configuration. For any one treatment plant, disinfection success is directly related to the concentration of colloidal and particulate constituents in the wastewater.

Advantages: no unwanted by-products, good efficiency, easy to combine with other treatment options.

Disadvantages: lack of depository effect, possible growth of pathogens, wastewater must be free of suspended solids, fouling on protection pipes, lack of practicable dosage measurement.

Ozonation

Like chlorine, ozone is a strong oxidizing agent. The ozonation (or ozonization) of compounds in water is a complex process.

Ozonation can be applied as an alternative method of water purification, capable of being used instead of conventional chlorination or in combination with chlorine, hydrogen peroxide and other oxidizing agents, as well as together with ultra-violet irradiation, ultrasound, sand, adsorption and ion-exchange filtration.

Advantages: besides being a disinfectant and able to remove colour, it eliminates odours and bad taste in water and, in general, makes it tastier. Ozone does not change the natural properties of water.

Disadvantages: high electrical power demand, chemical and physical properties of ozone aqueous solution are not sufficiently known yet.

Wastewater disinfection is recommended or required in the following circumstances:

- discharge to surface waters;
- near water supply intakes;
- used for primary contact recreation;
- used for shellfish harvesting;
- used for irrigation of crops and green space;
- other direct and indirect reuse and reclamation purposes.

Factors Influencing disinfection:

- disinfectant concentration and contact time;
- pH and temperature;
- reactor hydraulics;
- type of microorganisms;
- type of disinfectant;
- chemical and physical interference.

10. Brief overviews of some new high-tech treatment systems for urban wastewater depuration are given in slides 16-19. It is suggested to stress the utility of these new technologies.

New technologies in wastewater treatment and disinfection

In wastewater treatment, micro and ultrafiltration is mainly applied for separation of suspended solids or disinfection. A porosity of less than 0.2 Sm (ultrafiltration) is required to totally remove pathogens (ATV 1998). Although viruses may be even smaller, they are also removed because they are attached to particles. Membranes can be used in a separate final step after biological treatment or in an integrated unit in intensive technology applications like activated sludge reactors.

Firstly, filtration can be applied as last process in tertiary treatment. Secondly the membrane bioreactor, which has been developed in recent years, is characterised by a combination of activated sludge processes and membrane filtration. Here, the filtration unit replaces the sedimentation unit. The activated sludge process can be operated with higher biomass concentrations than the conventional activated sludge process. Therefore the space needed for this technology is much smaller.

Advantages of filtration:

- Pure physical treatment
- Chemical agents unnecessary
- No unitended by-products
- Good efficiency
- Can be combined with the activated sludge process (membrane bioreactor)

Disadvantages:

- High investment and running costs, especially energy demand
- Clogging due to fouling and biofouling on the membranes which requires the use of chemicals
- Membranes must be replaced from time to time
- Membranes represent a very promising technology that still needs development to cope with biofouling effects.
- New technologies work with vibrating or rotating membranes to avoid fouling.
- Reverse osmosis is the best technology to produce clean water from wastewater since it even removes salts, heavy metals and pharmaceutical residues.
- A high driving power is needed for reverse osmosis, which is why energy costs are high.

Case study

Torreele, a wastewater treatment plant with ultrafiltration as pre-treatment and reverse osmosis. (Realised in 2002 for aquifer recharge)

Problem: seawater infiltration makes drinking water production difficult in the coastal area of Belgium. To combat this problem, the Belgian Intermunicipal Water Company of the Veurne Region (IWVA) wanted to design a plant that could produce water suitable for aquifer recharge.

Surface water is typically used to recharge the aquifers, but since these water sources tend to experience reduced flows during the summer months, an alternate supply of continuous high quality water was required to protect the aquifers from seawater infiltration and to reduce demand on potable surface water.

Solution: after extensive piloting, IWVA selected a system which included ZENON's ultrafiltration (UF) membranes in December 2000. This system's multi-barrier approach consisted of a ZeeWeed® system, followed by reverse osmosis (RO) and ultraviolet (UV) disinfection.

UF is the method of choice for RO pretreatment. Compared to conventional pretreatment, ZeeWeed® membranes remove suspended solids and colloidal material more reliably with the use of fewer chemicals. The membrane is capable of handling solids spikes, and consistently produces an ideal RO feed typically yielding an SDI < 3. ZeeWeed® enables the RO system to operate with a higher sustainable flux, smaller system size, and lower cleaning frequency, thereby significantly reducing operating and capital costs.

The new IWVA Station Torreele tertiary plant produces treated water equivalent to nearly 40 percent of the annual drinking water requirements for this area. The system also constantly meets the drinking water regulatory limits for parasites and salt.

Process Overview

The secondary effluent first passes through the headworks, consisting of a 1mm (0.04") mechanical screen. Once dosed with chlorine, the water is held in a reservoir, and then flows by gravity into the ZeeWeed® UF tanks. Filtration is achieved by drawing water to the inside of the membrane fibres using suction created by permeate pumps.

Permeate is then sent to an RO system, passes through a UV disinfection unit, and is pumped into the dune area. From there, the water seeps into the groundwater table over an open pond with an area of approximately 2 hectares (20,000 m^2).

The infiltration water is composed of 90 percent RO filtrate and 10 percent ZeeWeed® filtrate. This mixing is to remineralize the RO filtrate, so the salt content matches that of the natural dune water.

11. General considerations and parameters to take into account when designing a wastewater treatment plant are shown in slide 20.

12. It is advisable to mention that although it is widely implemented, conventional wastewater treatment, which use long sewerage systems to convey effluents to a centralised WWTP, is not a universally applicable solution (slide 21).

Many **municipal wastewater treatment plants** (WWTPs) are oversized; i.e., designed to treat a much greater volume of wastewater than they currently do. In general, WWTPs are built with a long time-horizon. Municipal treatment systems are designed to operate for twenty years or more, and must have sufficient capacity for future population growth and additional demands on the treatment system. This is understandable, given the very high cost of constructing new facilities. However, excess treatment capacity usually results in inefficient treatment practices, i.e. using more energy than required to treat the current waste stream.

Advantages:

• lower capital and operating cost of one large treatment plant compared to many small-scale plants serving the same urban area; a more effective control of quality standards and plant operation.

Disadvantages:
- the cost-benefit of central systems diminishes if construction and maintenance costs of the collection system are taken into account;
- long sewer pipes may leak, causing soil and groundwater pollution if they are not adequately maintained;
- combining all kinds of wastewater and stormwater leads to a highly complex variety of pollutants, heavily fluctuating in composition and concentration, thus making effective treatment very difficult;
- central treatment systems usually require intensive aeration and, consequently, their operational cost may exceed the financial resources capacity;
- central municipal treatment plants make wastewater reuse and sludge reclamation very difficult due to components like harmful materials, household chemicals, pharmaceuticals, heavy metals, and pathogenic organisms;
- effluent reuse in centralized plants is also expected to be centralized, therefore the number of beneficiaries (farmers) will be limited and less than in scattered decentralized systems;
- consideration of pumping stations in centralized treatment systems is mostly unavoidable.

13. It is important to clearly explain to the participants that alternatives exist to conventional wastewater treatment systems as already presented in topic 2 and further in the text below. In recent years, increasing attention has been given to decentralised wastewater management (DWM) in which the wastewater is treated near its source (slide 22). These WWTSs are characterised by no need (on site) or limited need for sewerage systems, although it is important to properly decide which kind of sewer system is the most appropriate to convey the wastewater from the point of origin to the final treatment destination.

By definition, DWM employs collection, treatment and disposal/reuse of wastewater from small communities (from individual homes to portions of existing communities) integrated in village/town development projects. Such models consist of many small wastewater treatment facilities designed and built locally, usually applying low-tech solutions (septic tanks) and only rarely adopting advanced technical solutions. They discharge effluent into the next receiving water or infiltrate it into the ground with the risk of groundwater contamination.
The basic concept is to maintain both the solid and the liquid fractions of the wastewater near the point of origin and to minimize the wastewater collection network. In development situations, this approach is more flexible, allowing the design to fit into a number of development locations and scenarios.

Advantages:
- costs: saves money in terms of sewer investment cost and the cost of operation and maintenance, no high long-term investment, small damage in case of failure (risk minimisation);
- flexible (expandable) and adaptable, better adjustment to the individual grade of pollution
- minimises risk of epidemics (separation of pathogens, etc.);
- can be well fitted into landscape;
- preserves resources: water and nutrients;
- promotes better watershed management;
- offers an appropriate solution for low density communities;
- provides effective solutions for sensitive areas.
- etc.

Disadvantages:
- lower treatment efficiency is possible (N, P);
- insufficient control;
- requirements regarding space and climate;
- subjective feelings, acceptance of users;
- inadequate plant operation and groundwater pollution, need for education and correct usage;
- possible effects for groundwater;
- etc.

14. The following part of the topic has the main goal of presenting the opportunities, main advantages and drawbacks of implementing a small decentralised WWTS. In order to achieve this, it is suggested that the trainer explain and present several comparisons between the conventional centralised WWTS and an alternative decentralised WWTS.
Decentralised small treatment systems can be subdivided into:
- On-site systems
- Off-site systems

On-site systems have the main structures and operations on the plot (or in very close vicinity) of the household (HH). For rural areas, on-site systems are preferable from a technical, financial and institutional point of view, if at all possible. For on-site systems, the HHs themselves are responsible for O&M.
Off-site systems are more complicated and require more organised management and operation & maintenance, and are more costly. However, on-site sanitation has its limitations. Soil and water table conditions can make on-site solutions difficult or impossible; population densities can be so high that it might be difficult or an environmental hazard to operate on-site sanitation solutions if water abstraction takes place close to or downstream of the infiltration of wastewater.

15. Small systems are those developed for small scale wastewater flows. Such systems typically rely on biological processes for organic matter removal. Many of the small systems are cost effective because they utilise natural processes that typically occur in the natural environment, rather than mechanical or chemical treatment processes. Technologies intended to be applied in small communities have been described in Topic 2.

16. As already stated, the typical conventional wastewater system involves a collection system, a series of pipes to transport the raw sewage to a treatment plant, and a treatment system to treat the raw sewage so it can be disposed of without harming the environment. The major challenge in constructing any wastewater system is the cost of the collection system, which can represent as much as 80% of the total cost of the project. This includes the main sewer lines which transport the sewage from the household or business to the treatment plant. The huge potential of alternative systems is to save costs in the collection system. Most alternative systems use small diameter flexible pipes buried at a shallow depth, and septic tanks to pre-treat the raw sewage as opposed to large diameter inflexible pipes buried in deep ditches to transport raw sewage by gravity.

17. The main characteristics of sewerage systems are summarized in the table below (slides 23-27).

Type of system	Characteristics
On site system (no sewerage system)	• Sparsely populated and/or difficult conditions for sewerage, • Rainwater infiltration locally • Cost efficient as no central sewerage is required • Operation and maintenance must be done on site e.g. by public service • Public and private rights and obligations to be properly defined
Wastewater sewer	• Rainwater infiltration locally • Surface runoff
Separate sewerage (wastewater and rainwater sewers)	• In principle better than combined sewerage but more costly • Usually a high rate of wrong connections if uncontrolled
Combined sewerage	• During heavy rainfall, sewers can overflow causing pollution

Type of sewerage	Advantages	Disadvantages
Free water level sewerage		• exfiltration possible
Pressurised sewerage	• small diameter • economic dig in	• technically complex • high energy consumption • exfiltration possible
Vacuum sewerage	• small diameter • economic dig in • no exfiltration	• technically most complex • high energy consumption
Simplified sewerage	• minimum pipe length • minimum gradients • smaller diameter • less manholes • less street work	• exfiltration possible
Settled (or solids free / small bore) sewerage	• potential where septic tanks exist • minimum gradients • smaller diameter	• septic tanks need to be emptied

18. If properly designed and managed, small scale decentralised WWTSs can meet the criteria of environmentally sustainable management practices for wastewater and stormwater. The main objective should be to respect natural purification processes and biogeochemical cycles with the possibility to completely reuse the treated effluents (EcoSan concept) as will be explained in more detail in Topic 4 (slide 30).

19. Discharge of wastewater and stormwater at a rate that exceeds the natural purification capacity of the receiving environment will result in the accumulation of organic materials (carbon), nitrogen, phosphorus or other pollutants that cannot be absorbed by the ecosystem. Accumulation of organic materials will result in a high oxygen demand that cannot be met by oxygen transfer from the atmosphere. Undesirable anaerobic conditions are a consequence. Unsustainable practices are those where the wastewater discharge exceeds the natural purification capacity of the receiving river, and where the local biogeochemical cycles are not closed.

20. The following points describe some of the aspects of sustainable sanitation:

- Wastewater considered as a resource.
- Closing and separating the cycles of water and nutrients; avoidance of hygienic problems due to the separation of faeces from the water cycle.
- Reclamation of nutrients (phosphorus and nitrogen) for agricultural use and hence saving of resources and energy (for the production of artificial fertilizer).

- Considerable savings of freshwater through the use of water saving toilet systems (vacuum, separating or dry toilets).
- Energy production (biogas) instead of energy consumption (for carbon degradation in sewage plants).
- Savings of construction, operation and maintenance costs compared to the conventional central sewerage systems.
- Sophisticated modular system, which can be adapted perfectly to local social, economical and environmental conditions.
- Easier operation and maintenance compared to centralized technology; local job creation.

21. The next aspect to study is the comparison and selection of appropriate small wastewater treatment systems. The appropriateness of different wastewater treatment technologies depends on technical considerations but is closely related to many non-technical factors and issues linked to the local context, such as regulatory requirements, economic and environmental factors associated to a sanitation program, social factors that can lead to the acceptance and sustainability of a system in the long term (slide 30).

22. The choice between decentralised and centralised options have implications beyond environmental sustainability because economical aspects and financial sustainability represent one of the most relevant criteria to be considered: in general, to select an appropriate treatment technology, detailed cost-benefit analysis should always be given in terms of capital financing and plant O&M/Tariffs (indeed, this latter aspect is the most common problem affecting treatment plants).

23. Many criteria for suitable selection of proper WWTS can be taken into account, and many parameters have to be assessed (slide 31), such as:

- Population to be treated
- Wastewater quality
- Water supply availability (per capita)
- Type of final wastewater destination
- Effluent standards and country laws and regulations
- Financial aspects: construction and O&M costs
- Tariffs, willingness and capacity to pay
- Land availability and topography
- Site characteristics and distance from residential and agricultural areas
- Energy availability and requirements
- Local climate
- Sludge production and disposal management

- Operator expertise
- Technology simplicity and spare parts availability
- Management model to be applied
- Public and private obligations
- Treated water sold

24. On-site or small systems are chosen due to their cost-effectiveness with larger systems preferred where enough funds and water supply are available.

On-site and small decentralised systems have to be considered appropriate when there is low water availability (also considering methods for self-cleansing) and where medium-low costs can be afforded. If funds are available and the population density is high, connection to a centralised sewerage network can represent a feasible option. For agglomerations with more than 5,000 inhabitants, alternative solutions have to be studied and a phased development for intermediate and long term solutions may be the least cost solution. Indeed, decentralisation allows a reduction of both capital and O&M costs, ensuring good treatment flexibility because the number of units can be increased according to the demand for sanitation. Most decentralised wastewater treatment systems require relatively little maintenance but they rarely receive any. The result is system failure. Operation and maintenance at reasonable cost must be arranged (co-ordinated for a region…). With proper management, decentralized small scale wastewater treatment systems can be environmentally safe and responsible, make water reuse easy and are very cost efficient.
Nevertheless, the quality criteria for water reuse are strict, and costs and management models can become a big constraint for decentralised wastewater management, making these solutions affordable only in specific circumstances. Thus, a detailed assessment of real on-site reuse potentials and benefits has to be performed in advance. This type of management can be carried out centrally on behalf of local (district) or regional government (e. g. decentralised treatment, (local) central management). Thus an appropriate long term management model for wastewater treatment and wastewater reuse should be developed for the authorities responsible to coordinate systems that provide adequate environment protection and efficient and effective water and sludge reuse in agriculture.

25. Referring to criteria from legal regulations (e.g. Italian legislation for treatment plants not exceeding 10,000 PE), the decision about which treatment to adopt has to be made based on the following factors, with the aim of protecting the water bodies and the respect of water quality:

- Population to be treated (PE) according to the projections.
- Type of final destination (ground, underground, rivers, lakes, sea, transition water bodies, reuse).
- Quality level of the final destination.
- The population to be treated allows the choice of which type of final discharge can be considered as suitable and, accordingly, which effluent standards are to be complied with.

26. Once all the possible options are defined, the best solution can be chosen after a detailed analysis of the quality characteristics to be achieved (e.g. groundwater pollution risk analysis, environmental impact analysis for superficial water bodies, etc.) and of the corresponding treatment cycles that can be adopted, including phased development.

27. From the technical point of view, the first requirement is a good understanding of the available and reliable technologies which offer the appropriate treatment. Furthermore, any technology should always be designed according to the local climate, operator expertise, and government and other public utility policies.

Nevertheless, when considering any of the wide range of process options, the two most important preconditions are that the effluent quality requirements are met and the implementation, operation and maintenance costs of the project are covered.

28. Effluent standards (slide 31), with which every plant must comply, always include organic material and suspended solids. Additionally, heavy metals, faecal coliform and helminth eggs are usually included where the effluent is reused in irrigation of edible crops. Where the effluent discharges to a sensitive water course (likely to suffer from eutrophication), nutrients like ammonia, nitrate and phosphate are usually also included.

29. The treatment process will be defined according to a balance between several criteria, including: land availability, capital and operational costs, and sludge production.

30. Land availability represents the main criteria to be considered when selecting an intensive/extensive centralised treatment system (slide 33). Consider the following general rule in practice:

- For a footprint availability of less than 1m2/PE, intensive systems will be chosen;
- if available space is higher (up to 5m2/PE), mixed systems (biological secondary treatment + finishing lagooning, drained vertical sand filters, etc) can be considered;
- if a footprint occupation higher than 6m2/PE is acceptable, extensive systems should be applied;
- as a general rule, the more complex a process becomes (intensive systems), the less land it requires while total costs and sludge production increase.

31. Selection criteria may additionally involve sludge production and management issues and reuse considerations related to water and nutrients.

In many arid and semi-arid areas of the world, large scale effective and efficient reuse of sewage effluents is necessary because of the water shortages that result from increasing population and agricultural demand. In such cases, standards are required to minimise the health risks associated with wastewater reuse. This has resulted in effluent standards for microbiological quality of wastewater.

32. Financial aspects represent, indeed, the most significant constraint in the wastewater treatment system selection process. Capital and O&M costs are clearly situation-specific, thus making an absolute assessment very hard to perform. O&M costs have to be included in the cost-benefit calculation (Net present value!)

Long term sustainability can be reached only if feasibility studies confirm the most economic solution and the phased development foresees the time needed to build up the necessary institutional capacity and to secure the financing of investment and O&M costs.

33. In general, it is important to consider several different criteria when choosing the most suitable wastewater treatment system (slide 34). It is possible to state that extensive systems allow less operational costs, especially those required for energy consumption and for sludge treatment and disposal. Furthermore, these techniques do not require specialised manpower. Taken as a whole, the use of extensive processes should allow, with identical capacities, a saving of 20 to 30% on average on capital costs, and 40 to 50% on O&M costs, compared to intensive purification systems.

6.2 Session 2 – Case Study

Example of a comparison model for wastewater treatment technologies

Session overview

Title Example of a comparison model for wastewater treatment technologies

Objectives

- To present a comparison model to estimate the level of the capital, O&M and total costs required to finance wastewater improvements.
- To understand different unit processes and stages of the wastewater treatment process.

Teaching method: presentation, discussion

Time estimation: 60 min

Needed material: projector, slides, marker, flip chart

Session guide

Case study 1 – Example of a comparison model for wastewater treatment technologies

1. The case study presents a slightly modified comparison model, which was developed by the OECD EAP task force (2007), and has proven to be a useful tool for developing a sound financial strategy (FS) for the WWT sector. The model derives cost functions to estimate the level of the capital, O&M and total costs required to finance water and wastewater improvements using some wastewater treatment technologies. The trainer might decide to exclude some of the following WWT technologies or to rearrange the order of their presentation on the basis of the particular participants' interests and prior experience and knowledge.

Example of a comparison model for wastewater treatment technologies

On Site Septic Tank

Description
Septic tanks are usually used for the treatment of sanitary wastewater from individual households. In principle, septic tanks provide primary treatment with settling of the solid phase and cold anaerobic digestion of settled solids. Sludge must be removed regularly, e.g. once or twice a year, and transported to a wastewater treatment plant for final treatment or otherwise stabilised. Septic tanks can serve several households if designed accordingly.

Experience
Septic tanks and infiltration trenches are used world wide in rural areas.
There are normally three main types of tanks for on-site sewage holding and pre-treatment with 2 to 3 compartments:

- Concrete tanks
- Fibreglass tanks
- Polyethylene/plastic tanks.

Tanks (wet volume) should be designed for a retention time of 3-6 days.
As solids collect in the tank, the water depth decreases, which reduces the time sewage is retained in the tank. Fewer solids settle in the tank, resulting in increased solids in the tank effluent that may have a negative impact on the final treatment process.

Operation and Maintenance
The operation of the septic tank includes emptying the tank, transport and final treatment/disposal of the sludge. The model offers the following options:

- No collection and disposal of the sludge;
- Collection, transport and disposal at a wastewater treatment plant;
- Collection, transport and disposal at a municipal landfill.

It is assumed that the amount of sludge collected in the tank is 0.5 m^3 per year per person (PE).

Expected lifetime
The lifetime of the septic tank is assumed to be 30 years and, say 10-15 years for drainage fields.

Cost

In the table below is shown the estimated capital and recurrent cost of the mentioned technological options.

Cost Components	Capital Cost	Annual O&M Cost	Replacement Cost
Total Cost (in €/year)	4552	148	228
Cost per Capita (in €/year)	759	25	38

Note: Serving 6 people

The capital cost function used for a septic tank for a single household is:
Cost = -98 * log (PE) + 83514 – €/PE
O&M = 8* PE + 100 €/year; where PE is here number of people

Note: The investment expenditure function is actually a replacement value function which is used to estimate three types of expenditure needed 1) the annual reinvestment; expenditure, 2) the renovation need and 3) the investment expenditure in case of service extensions requiring new infrastructure. The cost is at the international price level, 2005. International level means an average price level experienced or estimated to be representative for an international cost level.

Conclusion

Septic tanks are a good option for on-site sanitation in rural and semi-urban areas. It is better if coupled to secondary biological treatment (e. g. sand filter, constructed wetland…).

Sewered Interceptor / Settled Sewerage

Nomenclature

Simplified sewerage: A household's (HH) wastewater is discharged into sewers without prior settling. Simplified sewerage is essentially a conventional sewerage system without any of its conservative design requirements. Sewers are most often laid at shallow depth and in small dimensions.

Description

Settled sewerage is an off-site sanitation option. In settled sewerage, the sewers can be laid following the topography as long as the gravity flow is ensured and backflow in the sewers is prevented so that wastewater cannot enter the inceptor tanks connected to the system. The settled sewerage as mentioned requires an interceptor tank.

This means that the system is particularly applicable for upgrading septic tank systems because the effluent pipe from the septic tank can be connected directly to the sewers. The minimum sewer pipe dimension is typically ø 75mm – ø 100mm.

The settled sewerage system caters for the sullage problem, as far as the sullage is discharged into the system. The collected wastewater has to be treated in a wastewater treatment plant. The cost of settled sewerage is between a third and half that of conventional sewerage. Originally developed in South Australia to overcome problems with failing septic tanks, it has been used widely throughout the world to upgrade septic tank systems.

Operation and Maintenance

The system requires an organisation responsible for the administration and O & M of the system, which includes the sewers and the wastewater treatment plants. Due to the incorporation of inceptor tanks, these tanks have to be emptied frequently, a service which has to be vested with the operating organisation, not the individual HHs, to minimise the risk of clogging of the sewers when HHs do not empty the inceptors. To reduce cost, the wastewater from a group of houses can be connected to one interceptor tank. Just like in a septic tank, the accumulated sludge has to be removed regularly from an interceptor tank.

When intercepting tanks do not exist the cost of septic tanks has to be included, the typical construction costs of settled sewerage and conventional sewerage are about the same;

- Settled sewerage depends on regular and efficient emptying of the septic tanks; and
- Desludging can not be done at the last minute when the interceptor tanks begin to overflow, or on the owner's request. It must be done at fixed intervals to avoid solid materials blocking the sewers.

When selecting settled sewerage as a waterborne sewerage option, due consideration should be given to local suitability, cost etc. when assessing alternatives.

The cost of the settled sewerage is less than that for conventional waterborne sewerage, because excavations are shallow (which then require that the pipe locations are not subject to vehicle loads) and because dimensions of the sewers are smaller.

USA experience shows a cost saving compared to conventional waterborne sewerage of 20-50 %.

Expected Lifetime
Depending on the design and quality of construction – say 30 to 40 years.

Cost
The table below shows the estimated capital and recurrent costs of the mentioned technological options.

Cost Components	Capital Cost (in €)	Annual O&M Cost (in €/year)	Replacement Cost (in €/year)
Total Cost	3,461,675	64,666	86,542
Cost per Capita	692	13	17

Note: Based on 5000 people, one tank per household, 20 km pipes, mechanical and biological treatment...

Conclusion
The system requires septic tanks/inceptor tanks, and if these are not already in place, the cost of construction of these tanks decreases the feasibility of this option. This means that the system would be most ideal for areas where septic tanks already exist, in high income areas with in-house water supply and high water consumption. The system requires effective operations organisation, not the least in ensuring emptying of septic tanks/inceptor tanks.

Simplified Sewerage

Description
Simplified sewerage – also known as condominial sewerage – is an off-site sanitation option. In simplified sewerage, small diameters sewers are laid at shallow depths, typically inside housing blocks, thereby minimising the total length of sewers. Manholes are often constructed as simplified manholes (e.g. smaller than for conventional waterborne sewerage). Hydraulically, the simplified design operates with lower minimum design velocities, which means either smaller dimensions or less slope requirements. The result is that more effort (higher O&M costs) is needed to maintain the sewers (clean and not clogged).
Simplified sewerage is most appropriate in high density lower / middle income areas, where on-site solutions are not possible due to space or soils. The system requires large flows, also typical design practices require 90% initial connection rate. The simplified sewerage system caters for the sullage problem, as far as sullage is discharged into the system. The wastewater has to be treated in a wastewater treatment plant. The same problems as

mentioned for the settled sewerage option also apply for the simplified sanitation option. The cost of construction of simplified sewerage can be 30 to 50 % less than conventional sewerage depending on local conditions.

Experience

It was developed in the early 1980s in Brazil and is mostly used in Brazil and Latin America, in Asia, and in some pilot schemes in southern Africa. In some cases, the simplified sewerage is cheaper than conventional sewerage and has been in use for many years, but in other cases, legal and institutional problems need to be solved with some technical issues such as clogging, increasing depth in very flat areas. In colder climates, the shallow depth of the pipes is not recommendable due to long, cold winter periods.

Operation and Maintenance

The system requires an organisation to be responsible for the administration and O&M of the system, which includes sewers and wastewater treatment plants. Special emphasis should be paid to cleaning of sewers due to the "non-self cleansing" operating conditions of the simplified sewerage system.

Expected Lifetime

Depending on the design and quality of construction – say 20 years.

Costs

The table below shows the estimated capital and recurrent cost of the mentioned technological options.

Cost Components	Capital Cost	Annual O&M Cost	Replacement Cost
Total Cost (in €/year)	3,349,392	37,134	167,470
Cost per Capita (in €/year)	670	7	33

Note: Based on 5000 people, 20 km pipes, mechanical and biological treatment...

Conclusion

Wastewater pumping and treatment will be required, which thus requires an efficient operating organisation.

Conventional Waterborne Sewerage

Description

Conventional waterborne sewerage is an off-site sanitation option. HHs are connected to the conventional waterborne sewerage system through gravity property drains. Sewers (gravity or a combination of gravity and pumped) convey the wastewater to a wastewater treatment plant. The conventional waterborne sewerage is most appropriate in high density areas where the predominant
water supply service level is house connections.
The conventional waterborne sewerage system caters for the sullage problem, as far as sullage is connected to the system. The wastewater has to be treated in a wastewater treatment plant.

Experience

Conventional sewerage either combined or as a single system, is expensive because the sewerage pipes are laid deep beneath the ground. Pumping is generally required at various stages of the sewer pipe network, especially if the landscape is fairly flat. The larger the population served by the sewerage system, and the longer the planning horizon to cope with future population increase, the larger the final pipe diameters become. The costs of the pipes, inspection manholes, pumps and pumping stations and their construction/installation are therefore high.

Operation and Maintenance

The system requires an organisation to be responsible for administration and O&M of the system, which includes sewers and wastewater treatment plants.

Expected lifetime

Depending on the design and quality of construction and O&M - say 50 years.

Cost

The table below shows the estimated capital and recurrent cost of the mentioned technological options.

Cost Components	Capital Cost (in €)	Annual O&M Cost (in €/year)	Replacement Cost (in €/year)
Total Cost	3,844,040	48,235	76,881
Cost per Capita	769	10	15

Note: Based on 5000 people, 20 km pipes, mechanical and biological treatment

Conclusion
The conventional waterborne sewerage system will only be an appropriate sanitation solution if willingness and ability to pay are high enough in the rural area.

Wastewater Treatment

The model gives four options for treatment of wastewater:
1. Conventional mechanical and biological/chemical treatment;
2. Reed bed treatment;
3. Biological sand filters; and
4. Stabilisation ponds.

1. Conventional Treatment Plant

This component includes the wastewater treatment plant and the outfall pipeline. The operational expenditure of wastewater treatment presented is based on the experience of the consultant with advanced treatment plants during the last 10 years.
The following combinations of wastewater treatment plants are considered:

Mechanical (M)	Category 1
Mechanical-Biological/Chemical (MB/C)	Category 2

The investment expenditure of wastewater treatment plants is divided into 2 categories as shown above.
The influent water quality assumed is illustrated in the table below.
Influent quality in mg/L (yearly average):

BOD	N	$NH_4 - N$	P	SS
250	50	30	8	300

Source: Consultant's estimates.

The categories are assumed to provide the effluent quality illustrated.

Effluent quality in mg/L (yearly average):

		Effluent quality in mg/L				
Treatment	Expenditure category	BOD	N	$NH_4 - N$	P	SS
M	1	175	45	35	7	25
MC	2	100	40	35	2	25
MB	2	25	35	30	6	25

Source: Consultant's estimates.

Note: The assessment of effluent quality is based on frequent 24-hour sampling proportional to flow (say, at least 12 samples taken at regular intervals over one year).

Organic pollution is the primary parameter for establishing the expenditure functions for the capital expenditure of new wastewater treatment plants.
The following assumptions have been made:

- The pollution parameter used in the expenditure functions is PE. The number of PE is defined as the total load of BOD per day (including industry) divided by 60 g/day.
- The function assumes a wastewater flow of 200 l/PE/day.
- BODinlet/Ninlet = 4.5
- Peak rainflow/Peak dryflow is equal to 2
- The design temperature of the inlet water is 7°C
- "Medium quality" design. Very fancy and very cheap solutions have not been assumed.

Conventional Wastewater Collection
This component includes the works in relation to a single pipe wastewater collection system from the property lines to the wastewater treatment plant, i.e.:

- Network collection system
- Service connections
- Main/trunk/interceptor sewers

The function for estimation of the total pipe length (L) is:
If population < 50,000 then L= Pop * (-0.00005833 * Pop + 4.92);
where Pop is the population serviced.
Cost of pipe per meter: 0.004235*Dia^1.6811+152.8 - €/m, Diameter in mm.
Total capital cost = Unit price * length of pipe network.
O&M = 2 % of capital cost/year

Sewer Interceptor Tanks and Collection Pipes
One interceptor tank is used per household, and a unit cost per connection. For each of the house connections, a default length of pipe to the tank and to the outfall of the

interceptor tank is used (can be changed by the user).
Capital cost of interceptor tank = 2000 €/each; and Pipe cost = 0.0009*dia.^2+0.2884*dia., €/m, diameter in mm. O&M for tanks are as for septic tanks.
O&M pipes= 1 % of capital cost/year (default value, can be changed by user).

Simplified Sewerage
The prices for pipes are the same as for interceptor pipes, and the length of the network is the same as defined under conventional wastewater collection network.
O&M = 1 % of capital cost/year (default value, can be changed by user).

Pumping Stations
Pumping stations for wastewater collection are only anticipated for conventional wastewater collection. The capital cost function for a pumping station is:
Capital cost = 2*(16570*KW installed^0.559) - €/pump station; KW= total KW installed.
Power installed is calculated according to default values/user defined values for lift and efficiency of pump.
O&M = 3% of capital cost plus energy cost (default value, can be changed by user).

Wastewater Treatment
The expenditure functions are shown in the table below.
New connections are estimated as the number of people, assuming one PE per person, while the effect of industries has to be assessed as part of the pre-model analysis.

Investment expenditure functions for wastewater treatment plants, in €/PE in 1990 prices.

	Load in PE			
Technology	<400	<400–2,000	2,000–100,000	>100,000
M	188.1	=10^(-0.2745*log(PE)+3.8605)/7.44	=10^(-0.2073*log(PE)+3.6385)/7.44	53.8
MB/MBC	403.2	=10^(-0.4735*log(PE)+4.7093)/7.44	=10^(-0.2632*log(PE)+4.0149)/7.44	67.2

Operational Expenditure
The operational expenditure for wastewater treatment is estimated using a percentage of the investment expenditure. This covers all operational expenditure except electricity, which will be specified separately.
Electricity consumption (values are for efficiency of 40%):
Mechanical treatment: 15 kWh/year/PE
Mechanical/biological/chemical: 25 kWh/year/PE
Other operational expenditures: 3% of the total investment expenditure for wastewater treatment (default value can be changed by user).

2. Reed Bed Filter

Description

Normally 2 reed bed filters are used comprising vertical and horizontal filters. Reed bed systems consist of a primary sedimentation tank (septic tank) followed by a shallow soil filter planted with reed. Sanitary wastewater flows through the system and undergoes treatment by means of settling, biological decomposition, filtration and adsorption to humus and clay.

Reed bed filters are often designed to use 4-7 m^2 per person connected. If phosphorus and nitrogen are to be removed, it needs 10-15 m^2 per person.

The treated wastewater flows to the receiving environment. Septic sludge must be removed frequently and transported for final treatment at a wastewater treatment plant or otherwise stabilised.

Experience

In most reed bed treatment plants, the wastewater runs on the surface instead of percolating through the roots. The advantages include relatively cheap operating costs and good reduction of organic matter and bacteria. The disadvantages include a running-in period of 5-8 years, high capital cost, and low ammonia removal.

Using this option for communities bigger than 2000 PE should be avoided.

Operation and Maintenance

Operation and maintenance is low, and consists of cutting down and disposing of reeds, cleaning feeding pipes etc.

Expected lifetime

Varies depending on the construction and maintenance and is not documented - say 20 years.

Cost

The table below shows the estimated capital and recurrent cost of the mentioned technological options.

Cost Components	Capital Cost (in €)	Annual O&M Cost (in €/year)	Replacement Cost (in €/year)
Total Cost	6,009,587	42,750	300,479
Cost per Capita	1,202	8,6	60

Expenditure functions, less than 2,000 p.e.
The replacement value function is:
Cost = 1521 * log(PE) + 6892, €/PE
O & M = 13.5 * PE + 6,750 - €/year
Note: Connection to existing sewer pipes is assumed, i.e. excl. connection to house installations and discharge facilities.
PE is the number of population equivalents calculated based on a total demand assuming e.g. a per capita consumption of 200 litres per day. In this rural context, one PE is assumed to be one person regardless of the amount of water consumed as the BOD content is assumed to be the same.

Conclusion
Reed bed filter are sustainable treatment options for households, groups of households or smaller villages. However, the capital costs are relatively high, though O & M cost is low.

3. Biological Sand Filter

Description
Biological sand filters consist of a primary sedimentation tank (septic tank) followed a ventilated sand filter. Sanitary wastewater flows through the plant and undergoes treatment by means of settling, biological decomposition and filtration. Loading is often 3-7 m2/PE. The treated wastewater flows to the receiving environment. Septic sludge must be removed frequently and transported for final treatment at a wastewater treatment plant or otherwise stabilised.

Experience
The advantages of biological sand filters include relatively cheap operating costs, immediate function, nearly all organic matter is removed and ammonia is reduced, but the treatment effect can be reduced with insufficient oxygen. The main problem is the availability of sand for the filters.

Operation and Maintenance
Maintenance is low and consists of checking possible clogging in the system.

Expected lifetime
Varies depending on the construction and maintenance and is not documented - say 20 years.

Cost

The table below shows the estimated capital and recurrent cost of the mentioned technological options.

Cost Components	Capital Cost (in €)	Annual O&M Cost (in €/year)	Replacement Cost (in €/year)
Total Cost	4,650,547	67,500	232,527
Cost per Capita	930	12,5	46,5

Expenditure functions, less than 2,000 PE
The replacement value function is shown below:
Cost = -777 * log(PE) + 3,872 - €/PE.
O&M = 13.5 * PE + 6,750 - €/year

Conclusion

Biological sand filters are treatment options for households, groups of households or smaller villages. However, the capital costs are relatively high, although O&M cost is low. Availability of sand is required.

4. Stabilisation Pond

Description

A simple pond system consists of a screen, grit removal, a grease chamber and stabilisation ponds. Stabilisation ponds are shallow earth basins with a long detention time. Microorganisms provide biological treatment. The solids and dead microorganisms settle on the bottom, and the treated wastewater overflows to the receiving environment. Settled sludge is removed regularly e.g. once a year and utilised as fertilizer or disposed of to landfill after dewatering. Stabilisation ponds are suitable for hot climates only.

Experience

The number of basins most commonly used is 3. Daily surface load is often 10- 15 m2/PE.

Operation and Maintenance

Operation and maintenance is low, and consists of cutting the dikes, cleaning screens, cleaning feeding pipes etc.

Expected lifetime

Varies depending on the construction and maintenance - say 25 years.

Cost

The table below shows the estimated capital and recurrent cost of the mentioned technological options.

Cost Components	Capital Cost(in €)	Annual O&M Cost (in €/year)	Replacement Cost (in €/year)
Total Cost	1,358,073	569,250	54,323
Cost per Capita	272	114	11

Expenditure functions, less than 2,000 PE.
The replacement value function is shown below assuming that the average temperature in ponds is 18°C.
Cost =-283 * log(PE.) + 1232 - €/PE
O&M = 13.5 * PE + 6,750 - €/year

Conclusion

Stabilisation ponds are suitable treatment options for households, groups of households or smaller villages. The capital cost is relatively high, though the O&M cost is low. However the stabilisation ponds are suited for warm climatic areas.

More examples of comparison models that cover some wastewater treatment technologies:

Table A) French study (Berland and Cooper, 2001) reporting the capital and operational costs including energy (€/PE) of small wastewater treatment plants for 1,000 PE in France (2001).
Table B) and **C)** construction and operational costs (per PE) from an Italian survey for a population varying from 100 to 10,000 PE, considering the lowest cost per unit equal to 100 (Oxidation Pond for 10,000 PE) and expressing other costs relative to that. Reported data include sewer system costs (EMWater, 2006).

Table A) Capital and annual operational costs (€/PE year) of small wastewater treatment plants for 1000 PE in France.

Treatment Process	Capital Costs	Operational Costs
Activated Sludge	230 (± 30%)	11.5
RBCs	220 (± 45%)	7
Imhoff Tank + CW	190 (± 35%)	5.5

Treatment Process	Capital Costs	Operational Costs
Biofilters	180 (± 50%)	7
Aerated Lagoons	130 (± 50%)	6.5
Waste Stabilisation Ponds	120 (± 60%)	4.5

Table B) – Construction costs (per PE) of some wastewater treatment systems.

Type of System	Number of Inhabitants (PE)						
	100	200	500	1000	2000	5000	10 000
Aerated Lagoon	1600	1050	610	400	265	150	100
Primary Settling	1350	1100	810	650	515	380	310
	1250	1030	785	650	525	400	330
Activated Sludge	2025	1600	1230	1000	800	600	490
	1350	1175	970	850	725	600	520
Biofilters	2100	1675	1250	1020	820	615	500
	1150	1015	850	750	640	530	460
Sewer Systems	6300	5350	4300	3650	3120	1030	2130

Table C) – Operational costs (per PE) of some wastewater treatment systems.

Type of System	Number of Inhabitants (PE)						
	100	200	500	1000	2000	5000	10 000
Aerated Lagoon	3680	2700	1900	1400	1050	750	100
Primary Settling	10800	8950	7100	6000	5000	4000	3250
	5300	4800	4100	3550	3200	2800	2400
Activated Sludge	13900	11700	9450	7950	6700	5300	4500
	14000	11950	9550	8100	6900	5500	4700
Biofilters	15300	11900	8600	6700	5250	3800	3000
	15800	12550	9100	7250	5700	4100	3350
Sewer Systems	2100	1850	1500	1350	1200	975	850

In table **D)** the most relevant parameters/criteria to be taken into account during the decision process are evaluated in a qualitative way, due to the need to compare and summarise site-specific information (EMWater, 2006).

Table D – Qualitative evaluation of decision criteria for suitable sanitation system selection

<table>
<tr><th>Treatment system</th><th>Compliance with standards for discharge</th><th>Footprint occupation</th><th>Sludge Production</th><th>Energy requirements</th><th>Construction costs</th><th>O&M costs</th><th>Main Advantages</th><th>Main Drawbacks</th></tr>
<tr><td>Constructed Wetlands</td><td>Good [combination SS-VF + SS-HF]</td><td>Medium to High</td><td>Low</td><td>Low (inlet/outlet pumps)</td><td>Low</td><td>Low</td><td>Natural and simple low-cost system</td><td>High footprint needed</td></tr>
<tr><td>Stabilisation Ponds</td><td>Good [also for nutrient and pathogens removal]</td><td>High</td><td>Low</td><td>Low (inlet/outlet pumps)</td><td>Low (according to topography)</td><td>Low (solids disposal is the more expensive item)</td><td>Simple and low-cost system</td><td>High footprint (and capital costs) needed</td></tr>
<tr><td>Aerated Lagoons</td><td>Good [also for nutrient and pathogens removal]</td><td>Medium</td><td>Low</td><td>Medium (inlet/outlet pumps, aeration)</td><td>Low-Medium (according to topography)</td><td>Medium</td><td>Simple O&M and good efficiency</td><td>High capital costs</td></tr>
<tr><td rowspan="2">Biofilters</td><td rowspan="2">Medium-Good [low denitrification efficiency]</td><td rowspan="2">Low</td><td rowspan="2">Medium</td><td>Medium-High</td><td>Medium-High</td><td>Medium-High</td><td rowspan="2">Low footprint needed</td><td rowspan="2">Effective primary treatments required</td></tr>
<tr><td colspan="3">For high-load biofilters, a backwash system is required</td></tr>
<tr><td>RBCs</td><td>Medium-Good [low denitrification efficiency]</td><td>Low</td><td>Medium</td><td>Medium</td><td>High</td><td>Medium</td><td>Simple O&M and low energy consumptions</td><td>High capital costs</td></tr>
<tr><td>Extended Aeration</td><td>Very Good [with denitrification stage]</td><td>Low</td><td>High</td><td>Very High</td><td>Medium-High</td><td>High</td><td>Good treatment efficiency</td><td>High O&M costs</td></tr>
<tr><td>SBRs</td><td>Very Good</td><td>Low</td><td>High</td><td>Very High</td><td>High</td><td>High</td><td>Low footprint needed, flexibility and automation</td><td>High capital and O&M costs</td></tr>
<tr><td>UASB Systems</td><td>Post-treatment needed</td><td>Low</td><td>Medium</td><td>Low</td><td>Medium</td><td>Low</td><td>Low construction and O&M costs</td><td>Process sensitivity</td></tr>
</table>

6.3 Session 3 – Exercise

Session overview

Title Cost and environmental comparison between conventional and alternative wastewater treatment systems

Objectives
- To promote the discussion and verify the level of acquired knowledge of the conventional centralised and alternative decentralised wastewater treatment systems.
- To discuss different financial and environmental aspects of wastewater treatments.

Teaching method exercise in groups, discussion

Time estimation
- 15 min. explanation of the exercise
- 30-45 min time for preparing the answer
- 30 min presentation
- 15 min final discussion and explanation

Needed material pens, paper, flipchart, assignment paper

Session guide

1. Divide the participants into 2 or 4 groups depending on the size of the course (each group should consist of 3 to 4 members) and distribute the questionnaire explaining the exercise.

2. Give the groups enough time to answer the requested questions and to discuss and decide on the questions posed in point b).

3. After that, each group will explain their assumption about the cost and environmental sustainability of a different WWTS.

4. Discuss the assumptions of each group and explain why some options are preferable in particular situations and what criteria should be used to choose the best WWTS.

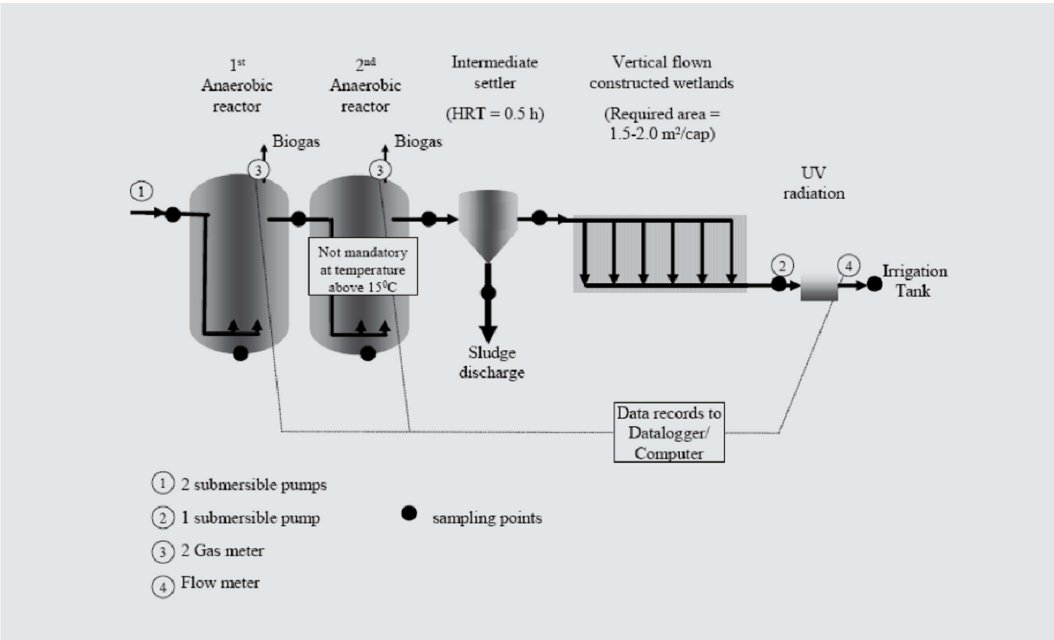
Cost and environmental comparison between conventional and alternative waste-water treatment systems

a. On the basis of the given pictures describe the type and the process involved in each wastewater treatment system (WWTS) and answer to the question.

b. Define the possible cost components for each WWTS and give your opinion of environmental sustainability for each WWTS.

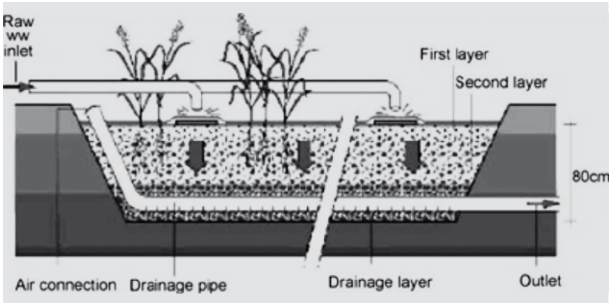
Alternative Wastewater Treatment Systems

Figure a



(Source : Wendland et al., 2006)

Figure b



(Source: Moll et al., 2005)

Questions:

1. What types of WWTS are depicted in fig a & b?

2. Why is biogas produced?

3. What are the possible uses of biogas?

4. What is the main purification process in constructed wetlands?

5. What kind of water sterilization is depicted in the picture?

Conventional Wastewater Treatment System

Figure c

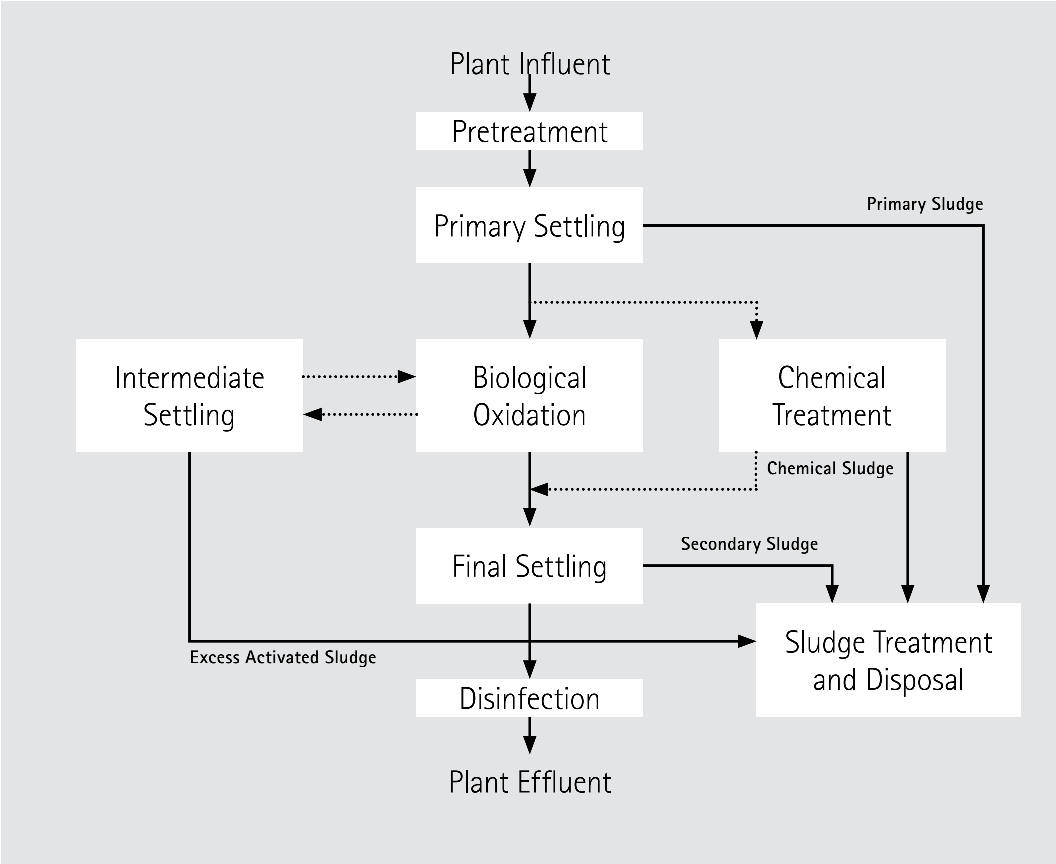
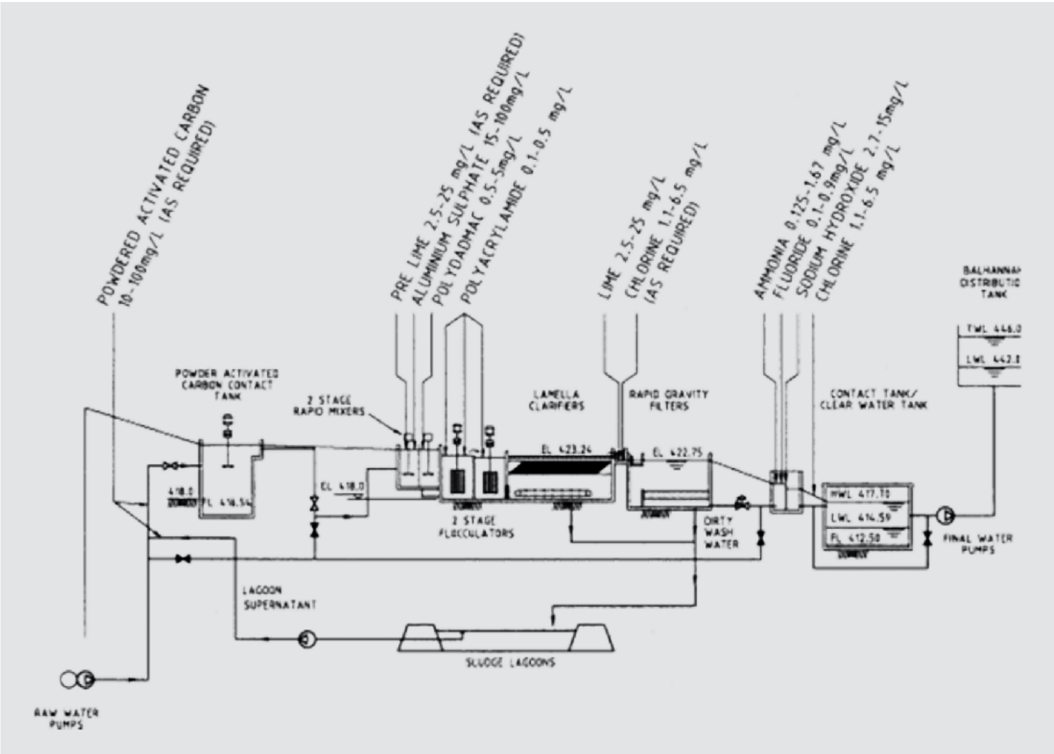


Figure d



(Source: Palmer & de Groot, 1998)

Questions:

Looking at Figures c & d please answer the following questions:

1. What operations are involved in the pre-treatment phase?

2. In what phase is the main part of the organic component of the wastewater removed?

3. What does sludge treatment and disposal involve?

4. What are the possible disinfection options?

Trainer's notes

a1) Conventional WWTS
Centralised WWTS option.
Question answers:

1. Screening, grit removal, oil separation, flow equalization.
2. 2nd
3. Grinding, degritting, blending, thickening, stabilization, conditioning, disinfection, dewatering, heat drying, thermal reduction, ultimate disposal
4. Chlorine compounds, bromine chloride, ozone, UV Radiation, ultrafiltration...

a2) Alternative WWTS
Possibly decentralised WWTS options.
Question answers:

1. UASB treatment system and constructed wetland for wastewater treatment.
2. Anaerobic degradation of organic substrates occurs in the granular sludge bed of the reactors.
3. Biogas is typically used in factory boilers and in engine generator sets to produce electricity and heat.
4. The purification process relies on bacteria for the degradation of organic substances and uptake of nutrients by plants. Adsorption by the media used to construct the wetland is also an important process for the removal of nutrients, heavy metals and organic compounds.
5. UV radiation.

b) The appropriateness of different wastewater treatment technologies depends on technical considerations but is closely related to many non-technical factors and issues linked to the local context, such as regulatory requirements, economic and environmental factors associated to a sanitation program, social factors that can lead to the acceptance and sustainability of a system in the long term.

Many criteria for suitable sanitation system selection can be taken into account, and many parameters have to be assessed, such as:

- Population to be treated
- Wastewater quality
- Water supply availability (per capita)
- Type of final wastewater destination
- Effluent standards and country laws and regulations
- Financial aspects: construction and O&M costs

- Tariffs, willingness and capacity to pay
- Land availability and topography
- Site characteristics and distance from residential and agricultural areas
- Energy availability and requirements
- Local climate
- Sludge production and disposal management
- Operator expertise
- Technology simplicity and spare parts availability
- Management model to be applied
- Public and private obligations
- Treated water sold

The choice between decentralised and centralised options have implications beyond environmental sustainability because economical aspects and financial sustainability represent one of the most relevant criteria to be considered: in general, to select an appropriate treatment technology, detailed cost-benefit analysis should always be given in terms of capital financing and plant O&M/Tariffs (indeed, this latter aspect is the most common problem affecting treatment plants).

On-site or small systems are chosen due to their cost-effectiveness, with larger systems preferred where enough funds and water supply are available. On-site and small decentralised systems have to be considered appropriate when there is low water availability (also considering methods for self-cleansing) and where medium-low costs can be afforded. If funds are available and the population density is high, sewerage network connection to a centralised system can represent a feasible option. For agglomerations with more than 5000 inhabitants, alternative solutions have to be studied and the phased development for intermediate and long term solutions may be the least cost solution.

Indeed, decentralisation allows a reduction of both capital and O&M costs, ensuring good treatment flexibility because the number of units can be increased according to the demand for sanitation. Nevertheless, the quality criteria for water reuse are strict, and costs and management models can become a big constraint for decentralised wastewater management, making these solutions affordable only in specific circumstances. Thus, a detailed assessment of real on-site reuse potentials and benefits has to be performed in advance. Once all the possible options are defined, the best solution can be chosen after a detailed analysis of the quality characteristics to be achieved (e.g. groundwater pollution risk analysis, environmental impact analysis for superficial water bodies, etc.) and of the corresponding treatment cycles that can be adopted, including phased development (EMWater Draft Policy Guidelines, 2006).

6.4 Self Test

A self test is handed out to the participants to check the level of comprehension of the topic.

Answer yes or no to each of the possible solutions.

1. Decentralised WWTS are:

a. Applied in low density communities
b. Very expensive
c. Applied in highly populated areas
d. Technologically outdated

2. Secondary treatments of wastewater are:

a. Biological
b. Physical
c. Chemical

3. Which treatment process requires the highest operation costs?

a. Biofilters
b. Pond
c. Activated sludge process
d. Constructed wetland

4. Disinfection: Which statements are true?

a. Chlorination may produce harmful by-products in the treated water
b. Chlorination is an effective and common disinfection technology for biologically treated wastewater
c. Efficient UV disinfection needs wastewater to be free of suspended solids
d. Reverse osmosis is a new and best technology to produce clean water from wastewater.

Answers:

1. a
2. a and c
3. c
4. b and c

6.5 Literature

ATV (1998): Disinfection of biologically treated wastewater, in German. ISBN 3-927719-75-2

EMWater Draft Policy Guidelines (2006). Part I: Guidelines for Wastewater treatment

EMWater, 2006. EMWater Draft Policy Guidelines Part I: Guidelines for Wastewater Treatment.

M. Berland and *P. Cooper*, 2001. Extensive wastewater treatment process.
http://www.wecf.de/cms/download/2004-2005/waterguide_en.pdf

Moll, P., Liénard, A., Boutin, C., Merlin, G., and *Iwema, A.* (2005). How to treat raw sewage with constructed wetlands: an overview of the French systems. Water Science and Technology, 51(9), 11-21.

OECD EAP task force, 2007. Cost Functions for Rural Water Supply and Sanitation: Technology Overview and Cost Functions, Tenth Meeting Of The Eecca Environmental Finance Network, 22 – 23 February 2007, Paris, France

Palmer, N. and *de Groot P.* (1998). Ten new water treatment plants in South Australia – the riverland project. Proceedings of the 61st Annual Victorian Water Industry Engineers and Operators' Conference

Ridderstolpe, P., 1999. Wastewater Treatment In A Small Village – options for upgrading -, SwedEnviro Report no. 1999:1

Wendland, C., Behrendt, J., Elmitwalli, T. A., Al Baz, I., Akcin, G., Alp, Ö and *Otterpohl, R.* (2006). UASB reactor followed by constructed wetland and UV radiation as an appropriate technology for municipal wastewater treatment in Mediterranean countries. Proceedings of the 7th Specialised Conference on Small Water and Wastewater Systems in Mexico, March 7-10, 2006

6.6 Recommended Reading

Agence de l'Eau Seine-Normandie (1999), Guides des procédés épuratoires intensifs proposés aux petites collectivités, Nanterre.

EMWater computer based training (cd rom).

Henze et al., (1997): *Henze, M. Harremoës, P. Jansen, J. La C. Arvin, E.*: Wastewater treatment: biological and chemical processes; Second Ed. Springer.

Jacangelo, J.G., Trussell, R.R. (2001) International Report Water and Wastewater Disinfection: Trends, Issues and Practices, Preprints 2nd World water congress in Berlin, October 2001.

Mara, D. (2003). Domestic wastewater treatment in developing countries. ed. Earthscan USA.

Wendland, C. (2003): Sanitation concepts for small communities. Contribution to the decision making process for the pilot plants within the EMWater project, presented on the 1st Regional Meeting in Amman, Jordan, EMWater project.

Wendland, C. Al Baz, I, Akcin, G, Kanat, G., Otterpohl, R. (2007) Selection of an appropriate wastewater treatment for further reuse in Mediterranean countries within the EMWater project, Chapter in the book "Wastewater reuse – risk assessment, decision-making and environmental security", Springer publication 2007.

6.7 Internet resources

http://www.iwva.be/docs/torreele_en.pdf.
Info on a high tech WWTP in Belgium.

www.abe.psu.edu/extension/factsheets/f/F170.pdf
Paper on alternative on-site wastewater treatment systems.

http://ec.europa.eu/environment/water/water-urbanwaste/info/pdf/waterguide_en.pdf
Publication of EU on Extensive Wastewater Treatment Processes Adapted to Small and Medium Sized Communities (2001).

http://www.oznet.ksu.edu/olg/programs/enviro_mgmt/
The Office of Local Government, Department of Agricultural Economics Kansas State University provides educational outreach, technical assistance, applied research, and information on natural resource management and land use planning.

http://www.unep.or.jp/ietc/ws/index.asp
UN Environmental Programme web page with useful background information, resources, and links on water and sanitation topics.

7. Topic 4:

Separation, management at the source of wastewater on a household level and the EcoSan concept

Topic overview

Time
Session 1: Topic Presentation – 120 min
Session 2: Case study – 60 min
Session 3: Exercise – 150 min

Objectives
- Present the importance of available technology and management options for wastewater treatment at the household level.
- Explain sustainability principles in household wastewater treatment and the importance of implementing the sustainability concept in the selection of wastewater treatment options – EcoSan concept.

Participants should be able to
- Understand the importance of wastewater treatment "at the source".
- Recognize the available techniques for wastewater separation at the household level.
- Apply sustainability principles in household wastewater treatment.
- Understand the importance and implement the sustainability concept in the selection of wastewater treatment options.

Material
- Flipchart
- Projector
- Slides
- Self Test
- Assignment paper

This topic is covered in 3 sessions:

1. Session 1 – Topic Presentation

This lecture should give a broad theoretical description of the importance of available technology and management options for wastewater treatment at the household level, explain sustainability principles in household wastewater treatment and the importance of implementing the sustainability concept in the selection of wastewater treatment options – EcoSan concept.

2. Session 2 – Case Study

The presented case study gives an example of a technologically advanced EcoSan solution implemented in an urban area.

3. Session 3 – Exercise

The exercise is a combination of individual work and class discussion. Participants are expected to develop a problem-solving skills while trying to find solutions that can improve the poor sanitary conditions that are typical for urban and sub-urban areas of the Third world.

7.1 Session 1 – Topic Presentation

PPT

Separation, management at the source of wastewater on a household level and the EcoSan concept

Session overview

Title Separation, management at the source of wastewater on a household level and the EcoSan concept

Objectives
- Present the importance of available technology and management options for wastewater treatment at the household level; explain sustainability principles in household wastewater treatment and the importance of implementing the sustainability concept in the selection of wastewater treatment options – EcoSan concept.

Teaching method lecture

Time estimation 120 minutes

Needed material flipchart, projector, slides

Session guide

1. In this session, a broad theoretical description of the objectives stated above will be presented to the participants. The aim is to implement all the notions acquired during the previous lessons to emphasise the importance of sustainable management of wastewater treatment processes, and to introduce some new technologies and products for domestic wastewater treatment (slide 2-3). The session will end with a broad exercise aimed at revising the knowledge acquired from this module.

2. Conventional sanitation systems and their limitations. This argument, as well as the next one on conventional decentralised sanitation systems, has already been presented in Topic 3. Here some examples are suggested and a short overview is provided. The trainer can address some questions to the participants and begin a short discussion. In conventional centralised wastewater management systems, household wastewater, together with municipal and industrial wastewater, stormwater, and infiltration/inflow water is collected and transported over a large distance to a central treatment plant where it is treated and disposed of or reused. A huge amount of fresh water is used as a transport medium and a sink to dispose of waste. Huge investments have to be made to treat and

dispose of the wastewater and/or improve the surface water quality in order to use it as drinking water (slides 5-7).

3. Conventional sanitation systems show clear deficiencies in the recovery of nutrients and organic matter, which are valuable fertilisers and soil conditioners respectively. Even the best affordable treatment plants discharge to the aquatic environment, where they are lost forever and cause severe problems. Moreover, most of the wastewater is discharged without any treatment, mostly in developing countries (slides 8-9). While wastewater management has reached a high standard in many industrialised countries, the situation in developing countries is in many respects still similar to that of the currently industrialised countries in the 19th century. About 95 % of wastewater in developing countries is discharged without any treatment into the aquatic environment (WIR, 1992). This contributes largely to the fact that about 1.2 billion people worldwide still do not have access to clean drinking water. Almost 80 % of diseases throughout the world are water related. Water-borne diseases account for more than 4 million infant and child deaths per year in developing countries (Lubis, A.-R., 1999). For example in New Delhi, India, more than 50 % of the raw wastewater is still discharged into the river Yamuna, from where the city draws its water supply (Narain, 2002) as shown in slide 10.

4. Even with the high inputs of money for construction, maintenance and operation, the conventional end-of-pipe concept is producing linear mass flows (slide 11). It shows clear deficiencies in recovery of nutrients and organic matter, which are valuable fertilisers and soil conditioners.

5. Conventional decentralised sanitation systems – benefits and limitations. In decentralised systems, wastewater from individual houses is collected, treated and disposed of or reused at or near the point of its origin. The most important benefits of this system compared to the centralised system are:

- there is no need to lay sewers for the transportation of sewage as in the centralised treatment plant, which is normally located far from the point of the origin of the sewage; construction, maintenance and operation of sewers are very costly parts of sanitation systems;
- there is far lower dilution of sewage than in the centralised system, which creates possibilities to reuse treated wastewater and nutrients.

Therefore, decentralised wastewater treatment technologies will play a significant role if they are low-cost and allow reuse.

6. There are many existing decentralised wastewater treatment systems which have been widely used throughout the world. However, a great number of them cause pollution through seepage of nutrients and pathogens into the groundwater and nearby surface water. These systems cannot destroy pathogens and deprive agriculture of valuable nutrients and soil conditioner from human excreta. Moreover, some systems require expensive tanker-trucks to pump and transport the sludge deposited at the bottom of the system over long distances. Transportation of relatively small faecal sludge volumes (5 – 10 m^3 per truck) through congested roads over long distances in large urban agglomerations is not suitable, from both an economical and an ecological point of view (Montangero and Strauss, 2002).

7. Most of the people in urban and peri-urban areas of Asia, Africa and Latin America and peri-urban areas of industrialised countries use conventional decentralised sanitation systems (on-site sanitation systems), notably septic tank systems (slide 13).

Example

According to the EPA, states of the USA reported septic tanks as a source of groundwater contamination more than any other source, with 46 states citing septic systems as sources of groundwater pollution, and nine of them to be the primary source of groundwater contamination in their state. It has to be noted that there are occasional problems with broken septic tanks, leading to infiltration of nearly untreated wastewater. Another problem is home chemicals with hazardous constituents, which are discharged to toilets and contribute to severe groundwater contamination in sanitation systems using septic tanks.

8. Household (domestic) wastewater management. The trainer can introduce this argument with a brief discussion with the participants on their knowledge and their good habits in domestic wastewater management. Based on participants' knowledge, the trainer may decide to cover the topic in more or less detail by rearranging or completely excluding some of the proposed slides. However, it is suggested that the trainer stress the importance of source control and proper household wastewater management.

In households, the nutrients that are brought in the form of food are converted into human excreta and kitchen waste. High levels of nutrient recovery are possible with the concept of source control in households (slide 15). Source control technologies have already been developed (Esrey et al., 1998).

9. Different sources. Domestic or household wastewater is made up of different wastewater streams (slide 16). The wastewater originating from toilets is called black water and

can be further divided into yellow water (urine with or without flush water) and brown water (toilet wastewater without urine). Additionally, grey water is the part of domestic wastewater which originates from the kitchen, shower, wash basin and laundry.

10. Characteristics of different streams. In conventional sanitation systems, a huge amount of fresh water is used as a transport medium and a sink to dispose of these wastes. In this process, a small amount of human faeces is diluted with a huge amount of water.

11. The typical characteristics of the streams of domestic wastewater (slide 17) clearly demonstrate that yellow and brown water contains most of the nutrients discharged to sewers in conventional sanitation systems. This means that they are generally wasted instead of being used as fertilizer (except the small portion of nutrients contained in sludge which is sometimes used as fertilizer after sanitisation).

12. Due to pathogens, brown water poses a high health risk, but it represents a very small volume flow in domestic wastewaters (only 50 litres are excreted per person per year). In conventional systems, this small volume is mixed with other streams of domestic wastewater with higher volume flows: yellow water (tenfold volume flow compared to faeces) and grey water. Grey water volume flows depend on habits, which is why a wide range is given for grey water volume flow: 25,000 to 100,000 litres per person per year. Slide 18 is related to Central European patterns. Of course, much smaller grey water volume flows per person can also be found, especially in regions with water scarcity. Additionally toilet flush water has to be taken into consideration (which might be up to 10 litres per toilet use).

13. Because of its low contribution to the mass flow of nitrogen and phosphorus in domestic wastewater and its high volume flow, grey water turns out to be a significant component of the water cycle and represents a splendid source for wastewater reuse. Since grey water contains nearly half of the organic load of domestic wastewater, organics are the main pollutants to be removed before grey water can be reused. Therefore, the treatment of grey water is far cheaper than the treatment of total domestic wastewater as there is no need for costly nitrification and denitrification processes, which are mostly employed in modern municipal wastewater treatment plants. Moreover, the greatest part of the nutrients (nitrogen, phosphorus and potassium) in domestic wastewater is contained in the comparably small volume flow of yellow water. Urine also contains trace metals required for plant growth. Only about 10 % of the organics of domestic wastewater are urine borne. For these reasons, yellow water has to be taken into consideration as fertilizer, and is thus related to the food cycle rather than to the water cycle. Brown water contributes greatly to the phosphorus load of domestic wastewater and can thus also be considered for potential use as fertilizer. Furthermore, the organic solids make brown wa-

ter a splendid candidate for a soil conditioner after suitable treatment. Therefore, brown water also belongs to the food cycle.

14. Minimizing wastewater flows and pollutants. Minimizing wastewater flows and pollutants involves techniques and facilities to a) reduce water use and the resulting wastewater flows and b) decrease the quantity of pollutants discharged to the waste stream. Minimizing wastewater volumes and pollutant concentrations can improve the efficiency of onsite treatment and lessen the risk of hydraulic or treatment failure.

15. Minimizing residential wastewater volumes. Reducing water use in a household can decrease hydraulic loading to the treatment system and generally improve system performance. Several different devices are available to reduce water consumption and wastewater generation (slide 19).

16. Household water use and the resulting wastewater flows can be attributed mainly to toilet flushing, bathing, and washing of clothes. Toilet use usually accounts for 25 to 30 percent of indoor water use in residences, and the use of non conventional low/no diluting toilets can greatly reduce this water consumption; showers and faucets in combination can represent more than 70 percent of all indoor use. By addressing the reduction of these primary uses, a huge reduction of wastewater flow can be achieved.

17. Elimination of extraneous flows:

- Improved water-use habits
- Improved plumbing and appliance maintenance and monitoring
- Elimination of excessive water supply pressure
- Therefore, it is important to modify water use habits and maintain the plumbing system appropriately to reduce water consumption

18. Examples of methods to reduce water use include:

- Using toilets to dispose of sanitary waste only (not kitty litter, diapers, ash tray contents, and other materials.)
- Reducing time in the shower
- Turning off faucets while brushing teeth or shaving
- Operating dishwashers only when they are full
- Adjusting water levels in washing machines to match loads; using the machine only when full
- Making sure that all faucets are completely turned off when not in use
- Maintaining the plumbing system to eliminate leaks

These practices generally involve changes in water use behaviour and do not require modifications to plumbing or fixtures.

Example

In the USA, experience shows that significant water losses result from leaking plumbing fixtures. The easiest ways to reduce wastewater flows from indoor water use are to properly maintain plumbing fixtures and repair leaks when they occur. Leaks that appear to be insignificant, such as leaking toilets or dripping faucets, can generate large volumes of wastewater. For example, a 1/32-inch (0.8 millimetres) opening at 40 pounds per square inch (207 mm of mercury) of pressure can waste from 3,000 to 6,000 gallons (11,550 to 22,700 litres) of water per month. Even apparently very slow leaks, such as a slowly dripping faucet, can generate 15 to 20 gallons (57 to 76 litres) of wastewater per day. Installing indoor plumbing fixtures that reduce water use and replacing existing plumbing fixtures or appliances with units that use less water are successful practices that reduce wastewater flows (slide 20) (USEPA, 1995).

19. Several toilet designs that use reduced volumes of water for proper operation have been developed; mainly they are divided in water carriage toilets and systems and non-water- carriage toilets.

20. Devices that reduce water flows can decrease the volume of water used for bathing (showering with common showerheads using 3.0 to 5.0 gallons/minute (0.19 to 0.32 litres/second) amounts to a water use of 10 to 12.5 gallons/person/day (37.9 to 47.3 litres/person/day), low-flow showerheads can reduce water flow through the shower by 2 or 3 gallons/minute (0.13 to 0.19 litres/second).

21. Indoor water use can also be reduced by installing flow reduction devices or faucet aerators in sinks and basins. More efficient faucets can reduce water use from 3 to 5 gallons/minute (0.19 to 0.32 litres/second) to 2 gallons/minute (0.13 litres/second), and aerators can reduce water use at faucets by as much as 60 percent while still maintaining a strong flow.

22. Reducing water pressure. Reducing water pressure is another method for reducing wastewater flows. The flow rate at faucets and showers is directly related to the water pressure in the water supply line. For example, a reduction in pressure from 80 pounds per square inch (psi) (414 cm Hg) to 40 psi (207 cm Hg) can reduce the flow rate through a fully opened faucet by about 40 percent. Reduced pressure has little effect on the volume of water used by fixtures that operate on a fixed volume of water, such as toilets and washing machines, but it can reduce wastewater flows from sources controlled by the user (e.g., faucets, showerheads).

23. Reducing mass pollutant loads in wastewater. Pollutant mass loading modifications reduce the amount of pollutants that require removal or treatment in the WWTS. Methods that may be applied for reducing pollutant mass loads include modifying product selection, improving user habits, and eliminating or modifying certain fixtures. Household products containing toxic compounds, commonly referred to as "household hazardous waste," should be disposed of properly to minimize threats to human health and the environment.

24. Selecting cleaning agents and household chemicals. Toilet flushing, bathing, laundering, washing dishes, operating garbage disposals, and general cleaning are all activities that can include the use of chemicals that are present in products like disinfectants and soaps. Some of these products contribute significant quantities of pollutants to wastewater flows.

25. For example, bathing, clothes washing, and dish washing contribute large amounts of sodium to wastewater. Through careful selection of cleaning agents and chemicals, pollution impacts on public health and the environment associated with their use can be reduced.

26. Improving user habits. Everyday household activities generate numerous pollutants. Almost every commonly used domestic product (cleaners, cosmetics, deodorizers, disinfectants, pesticides, laundry products, photographic products, paints, preservatives, soaps, and medicines) contains pollutants that can contaminate ground water and surface waters and upset biological treatment processes in WWTS. Some household hazardous waste (HHW) can be eliminated from the wastewater stream by taking hazardous products to HHW recycling/reuse centres, dropping them off at HHW collection sites, or disposing of them in a solid waste form (i.e., pouring liquid products like paint, cleaners, or polishes on newspapers, allowing them to dry in a well-ventilated area, and enclosing them in several plastic bags for landfilling) rather than dumping them down the sink or flushing them down the toilet. Improper disposal of HHW can best be reduced by implementing public education and HHW collection programs. A collection program is usually a 1-day event at a specific site. Establishing HHW collection programs can significantly reduce the amount of hazardous chemicals in the wastewater stream, thereby reducing impacts on the treatment system and on ground water and surface waters. Stopping the practice of flushing household wastes (e.g., facial tissue, cigarette butts, vegetable peelings, oil, grease, other cooking wastes) down the toilet can also reduce mass pollutant loads and decrease plumbing and WWTS failure risks. Homeowner education is necessary to bring about these changes in behaviour.

27. Eliminating use of garbage disposals. Eliminating the use of garbage disposals can significantly reduce the amount of grease, suspended solids, and BOD in wastewater (slide 21). Reducing the amount of vegetable and food matter entering wastewater from garbage disposals can also result in a slight reduction in nitrogen and phosphorus loads. Eliminating garbage disposal use also reduces the rate of sludge and scum accumulation in the septic tank, thus reducing the frequency of required pumping.

28. Wastewater reuse and recycling systems. Decentralized wastewater management programs that include onsite wastewater reuse/recycling systems are a viable option for addressing water supply shortages and wastewater discharge restrictions. Wastewater reuse is the collection and treatment of wastewater for other uses (e.g. irrigation, ornamental ponds, and cooling systems). Wastewater recycling is the collection and treatment of wastewater and its reuse in the same water-use scheme, such as toilet and urinal flushing (Tchobanoglous and Burton, 1991). Wastewater reuse/recycling systems can be used in individual homes, clustered communities, and larger institutional facilities such as office parks and recreational facilities. Wastewater reuse/recycling systems reduce potable water use by reusing or recycling water that has already been used at the site for non potable purposes, thereby minimizing wastewater discharges. The intended use of wastewater dictates the degree of treatment necessary before reuse.

29. A number of different onsite wastewater reuse/recycling systems and applications are available (slide 22). Some systems, called combined systems, treat and reuse or recycle both blackwater and greywater (NAPHCC, 1992). Separating greywater (yellow and brown) and blackwater is a common practice to reduce pollutant loadings to wastewater treatment systems (Tchobanoglous and Burton, 1991) and one of the main issues of the EcoSan concept.

Example

The Grand Canyon National Park has reused treated wastewater for toilet flushing, landscape irrigation, cooling water, and boiler feedstock since 1926, and other reuse systems are gaining acceptance (Tchobanoglous and Burton, 1991). Office buildings, schools, and recreational facilities using wastewater reuse/recycling systems have reported a 90 percent reduction in water use and up to a 95 percent reduction in wastewater discharges (Burks and Minnis, 1994).)

30. Source separation as a key issue in resource management sanitation. Human faeces contain most of the pathogens with the potential to cause diseases. Therefore, source control of faeces from household wastewater prevents these disease-causing pathogens from gaining access to water bodies where they survive longer than on land and pose a long-

term threat to human health. The best approach involves separating the flows at the source, avoiding dilution of faeces. The separated solid fractions, which are easily biodegradable, can be treated biologically. When organic matter is decomposed oxidatively, heat is produced due to self heating capacity. This self produced heat will hygienize the matter.

31. The sanitation methods most often applied to separated faecal waste are composting and dehydration. Factors such as heat, a high pH, competition for food, antibiotic action and the toxic by-products of decomposing organisms play a significant role in eliminating or reducing pathogens. In summary, the die-off rate of pathogens depends on the environmental conditions of the place where they reside.

The following factors are lethal to most pathogens:

- High pH (> 9)
- Low moisture content (< 25%)
- High temperature (> 55 OC) over more than 10 hours
- Long retention time (> 6 months)
- Ammonia and high salt content
- Limited nutrients (competition for food), predator-prey relationships, antagonism

32. In practice, complete elimination of pathogens may not be possible in any kind of sanitation. Therefore, secondary barriers such as personal, food and domestic hygiene must be used to destroy the pathogens completely. Therefore, hygiene awareness and proper education are the crucial points for on-site faecal waste management.

33. The aforementioned aims can be achieved by source control in sanitation! Source separation of different streams of domestic wastewater helps to prevent pathogens in faecal matter from spreading to the environment, enables nutrients in yellow water to be utilised, and prevents grey water from being further contaminated with nutrients, faecal pathogens, and hazardous substances from industrial wastewaters, making it a suitable source for reuse – even for high quality demand like groundwater recharge. Source control requires some special pre-requisites: separate pipes for yellow, brown and grey water, no-mix toilets for separate collection of yellow and brown water and low volumes for toilet flushing. Generally, there are different options for source separation (slide 23).

34. A simple scheme would be the separation of grey water from black water, requiring two separate pipe systems in the home (one for grey water, one for black water). Low volumes of toilet flush water are helpful in further treatment of black water solids. For certain sanitation techniques (dehydration, composting), the black water solids have to be

separated from the liquid phase. One possibility for sanitisation of the entire black water is anaerobic digestion, which also offers the opportunity of harvesting biogas.

The second option is to collect all three sources of domestic wastewater separately: grey water, yellow water, and brown water. This option requires three different types of pipes in the home (for grey water, yellow water, and brown water). In such a scheme, the excellent fertilizer "yellow water"is collected very purely. Source separation of different particular domestic wastewater flows (related to both the nutrient and the water cycle) facilitates sanitation of human excreta as well as nutrient recovery from excreta – and also purification of the grey water stream.

35. One innovative option is the closed loop system for toilet wastewater (slide 24). In such a system, toilet wastewater is not wasted but treated for reuse as toilet flush water. Treatment with MBR plus ozonisation including nitrification assures high quality (pharmaceutical residues and hormones are eliminated). The closed loop produces a clear liquid with about the same volume and nutrient concentrations as what is put into the toilet (GTZ, 2003). For example this system can solve the hygienic and pollution risk from hospital effluents (they usually discharge to the sewerage system, which is open to the environment through stormwater overflows and inadequate treatment in conventional plants). Sizes start from some 100 people/hotel beds. With new construction and complete reconstruction, this system can be significantly cheaper than conventional systems and reduce freshwater demand to 10 litres per person per day.

36. Resource Management Sanitation – Ecological Sanitation (EcoSan) concept. While presenting the concept of EcoSan, it is up to the trainer to review one or more of the arguments presented during Module 3 according to his/her judgement of any weaknesses in the participants' acquired knowledge.

It is apparent from the points presented above that the need for resource management sanitation is strong. New criteria need to be developed and applied to sanitary systems, such as resource efficiency, the system energy demand, recovery rate, the hygienic risk (not only of ecosan-systems, but also for conventional systems, with regard to: in-house hygiene, hygiene of local areas and water bodies, hygienic aspects of the handling, processing and reuse of the products, etc.), environmental risks, lifecycle analysis, self-help criteria, factors regarding job creation, full cost and benefit analysis, etc. The EcoSan principle, aims to close the loop between sanitation and sustainable environmental management, enabling reuse and recycling rather than disposal (slide 25). EcoSan solutions aim to reduce water consumption of sanitation, integrate rainwater harvesting systems along with grey water treatment and reuse, and, ideally close the material flow cycles at the minimum practical level (i.e. reuse close to the wastewater source). This in turn should minimise transport requirements and avoid simply transferring the problems to another area. The aim is to avoid pollution through the productive reuse of excreta and wastewater.

37. Sustainable Sanitation. Ecological sanitation (EcoSan) (slide 26), which fulfils social and ecological requirements, is called "sustainable sanitation".

38. Some further aspects of sustainable sanitation are (slide 27):

- Closure and separation of the water and nutrient cycles; avoidance of hygienic problems due to the separation of faeces from the water cycle.
- Reclamation of nutrients (phosphorus and nitrogen) for agricultural use and thus reduction of resource and energy use (for the production of artificial fertilizer); considerable savings of freshwater through the use of water saving toilet systems (vacuum, separating or dry toilets).
- Energy production (biogas) instead of energy consumption (for carbon degradation in sewage plants).
- Savings of construction, operation and maintenance costs compared to the conventional central sewerage systems.
- Sophisticated modular system, which can be adapted perfectly to local social, economical and environmental conditions.
- Easier operation and maintenance compared to centralized technology.
- Local job creation.

39. As already stated, conventional wastewater treatment systems usually deprive agriculture, and hence food production, of the valuable nutrients contained in human excreta, since the design of these systems is based on the concept of disposal. In households, resources are converted into wastes. When the systems we have designed fail to reconvert the waste back into resources, they don't meet the important criteria of sustainable sanitation (Esrey, 2000). Thus, future sanitation designs must aim to produce fertiliser and soil conditioner for agriculture rather than waste for disposal (Otterpohl et al., 1999).

40. Nutrients and organic matter in human excreta are considered resources, food for a healthy ecology of beneficial soil organisms that eventually produce food or other benefits for people. One person can produce as much fertiliser as necessary for the food needed for one person (Niemcynowicz, 1997). Therefore, the new approach should be designed in such a way that it can reconvert the waste we produce into resources that are free of pathogens at a reasonable cost without polluting the aquatic environment.

41. There are numerous advantages of resource management sanitation compared to conventional sanitation. The major advantages are:

- reuse of human excreta as fertiliser and soil conditioner, water and energy;
- preservation of fresh water from pollution as well as low water consumption;
- preference for modular, decentralised partial-flow systems;
- design according to the place, environment and economical condition of the people;
- hygienically safe;
- preservation of soil fertility;
- secure food supply;
- low cost (ecological, economical and health cost);
- reliable.

42. This scenario can be achieved by applying resource management sanitation, based on the concept of source control. The technologies for source control have already been developed (slide 28).

43. Several treatment systems are available for yellow, brown and black water (slides 30-31) as well as for grey water.

44. Treatment systems for yellow water. In conventional wastewater treatment systems, the yellow water is wasted instead of being used for plant nutrition. In modern municipal wastewater treatment plants, nitrogen compounds (most of them originating from yellow water) are removed using costly nitrification and denitrification processes. Even with high inputs of money, a substantial quantity of nitrogen compounds (especially nitrate) escapes in the effluent of treatment plants and causes eutrophication of water bodies. In high-tech treatment plants, most of the nitrogen compounds are converted to N_2, which is itself a raw material for the high-energy consuming synthesis of nitrogen fertilizer (e.g. in natural gas based ammonia plants). For these reasons, the practice of wasting of yellow water is not sustainable. Therefore, we should use the human resource "Anthropogenic Nutrient Solution" (ANS; Larsen and Gujer, 1996) i.e. yellow water as fertiliser which contains reasonable amounts of these nutrients. Separate collection of yellow water is possible with a sorting toilet.

45. The sorting toilet (slide 32) is a suitable technology to separate urine and faeces at the source. Usually, the toilet has two bowls, the front one for urine and the rear one for faeces. Each bowl has its own outlet from where the respective flow is piped out. The flush for the urine bowl needs only a small amount of water (0.2 l per flush) or no water at all. A mechanical device closes the urine pipe when users stand up whereas flushing water for the faeces bowl can be adjusted to the required amount (about 4 to 6 l per flush).

There is a variety of processes used in liquid-solid separation. These processes are usually based on two principal modes of separation: 1) filtration (gravity, vacuum, pressure and centrifugal), in which the solid-liquid mixture is directed towards a filter medium (screen, woven cloth, membrane etc.). The liquid phase flows through the filter medium while solids are retained, either on the surface or within the medium and 2) sedimentation or settling in a force field (gravitational and centrifugal) which takes advantage of differences in the densities between the solid and liquid phases. The solids are allowed to sink in the fluid under controlled conditions. In the reverse process, flotation, the particles rise through the liquid due to natural or induced low solids densities. However, in the present system, separate collection is efficient only when men sit down to urinate. Recently, there has been a new development in Norway for separating urine even when men stand up while urinating.

46. Treatment systems for brown and black water. There are two types of treatment systems, namely dry and wet systems for the treatment of brown and black water. Dry systems use no flush water whereas wet systems use flush water, but only very small amounts, just enough to transport faecal matter to the treatment plant located close to the origin of faecal matter. The undiluted or slightly diluted faecal matter has to be sanitised before reuse in agriculture. This can be done with composting, dehydration, vermicomposting and anaerobic fermentation/digestion.

47. Sanitation systems based on composting are an effective method to deal with human excreta because they keep faeces that contain disease causing pathogens at a small volume in a closed environment for a long time fro sanitation before reuse. They also produce compost that is rich in nutrients and is a good soil conditioner (slide 33). Some composting toilet systems divert urine, others do not.

48. The Clivus Multrum composting toilet shown in slide 34 is a continuous system and features a single chamber for combined processing of urine, faeces and organic household waste (Del Porto and Steinfeld, 1999). The composting chamber has a slanting floor, through which the air flows/circulates, before exiting through a vent pipe and, at the lower end, a storage space. A tube connects the toilet seat riser with the receptacle. There is a constant draught due to natural convection from an air intake in a vault, through which the air flows, before exiting through a vent pipe. This system has a separate chute for the household organic waste. Because of the sloping floor, the content of the vault slowly slides down from the fresh deposits at the upper end to the storage part of the vault.

49. Another type of the composting toilet called twin-bin net composting toilet (slide 35) was used for the first time on the Pacific Islands (Del Porto and Steinfeld, 1999). It

consists of two chambers constructed above the ground with a fishing net suspended inside each chamber using hooks on the sides of the chambers. A mat woven from coconut palm fronds is placed on the fishing net in order to separate the solid from the liquids. The net also allows air to enter into the composting materials from all sides. In the chamber, coconut husks, small wood chips, leaves or vegetable food scraps are periodically added through the seat riser or drop hole. The liquid that accumulates on the floor of the composting chamber is evaporated by air flow and a wick made from old clothing, or is drained to an evapo-transpiration bed next to the composting chamber. Air flow inside the chamber is provided with a large diameter vent pipe that draws air up through the pile from an intake opening located below the net along the rear wall of the vault.

50. The Vietnamese type double-vault composting toilet with urine diversion as shown in slide 36 has been applied in Kerala, India. Since most of the Indian people are washers, water used for anal cleaning is diverted along with urine to the evapotranspiration bed. Over each vault there is a drop hole for faeces and a funnel for urine. Between the two vaults there is a trough over which anal cleaning is performed. Straw, leafy material and paper scraps are added to enhance composting. A handful of ash is sprinkled over the faeces after each use.

51. The Dryloo composting system as shown in slide 37 consists of a rotating PVC frame upon which six woven polyethylene bags are hung. These bags are used alternately and serve as faecal matter composters. A bag is placed in a watertight container just below the toilet stool. The system also contains a fan and a vent pipe. There are also other types of composting toilet systems, either batch or continuous systems, such as Minimus, Weelie Batch, Nature-loo and Rota-loo. They are increasingly used in Australia (Pollard et al., 1997).

52. Urine diversion is crucial for the dehydration toilet system. The undiluted faecal materials (faeces and toilet paper if used) drop into the dehydrating vault located just below the toilet and are dehydrated using heat (Solar radiation), ventilation and the addition of dry materials. Sanitation based on dehydration prevents pollution, destroys pathogens and recycles human excreta as fertiliser. Different forms of dehydration toilets have been in used in many parts of the world. However, all use the same basic principle of dehydration. Dehydration toilets are mostly used in Vietnam, Mexico, China, El Salvador, Ecuador, Yemen, South Africa and India.

53. Double-Vault dehydrating toilets as shown in slide 38, consist of two alternately used vaults constructed above the ground. They have been widely used in Northern Vietnam since 1954, and adapted models were implemented in Mexico, Central America and Sweden (Esrey et al., 1998). In this toilet, urine is diverted to a collection tank or soak pit under

the toilet vault or outside the toilet and faeces drop into one of the two vaults located below the toilet seat. When one vault is full, it is sealed and another vault is used. Dry materials like ash or soil or a mixture of sawdust/lime or soil/lime are added after defecation. The added dry material assists the desiccation process and raises the pH, which aids in pathogen reduction.

54. The single-vault dehydrating toilet uses a passive solar panel to increase the chamber temperature and rate of dehydration. The addition of dry materials after defecation is required as in the double-vault dehydrating toilet. In this system, the faecal materials that accumulate below the toilet seat are shifted to the rear of the chamber with a hoe or rake. There are also systems, which have been equipped with a pusher to shift the faecal materials to the rear of the vault as depicted in slide 39. After a few months, the dry materials at the rear of the chamber are shovelled into a sack and stored outside the toilet until reuse. The German Technical Co-operation (GTZ), together with the company Otterwasser, has implemented some dehydrating toilets in Mali, West Africa (slide 40).

55. The dehydration toilet is very beneficial for regions with a warm climate. However, there have also been a number of dehydration toilets on the market in Sweden for many years (Del Porto and Steinfeld, 1999). The WM Ekologen system, for example, is based on urine diversion and dehydration. This system has been used in indoor bathrooms. By now tens of thousands of urine diversion ecosan toilets have been built in China (Xianghong and Jiang, 2003). Ash, soil and lime are added after toilet use. The urine-diversion squatting pan and mechanical ash dispensers are provided in the systems (slide 41). Many of the toilets are built inside the dwelling, and often upstairs.

56. The main principles for good functioning of dehydration toilets are:

- they should be built above the ground to prevent groundwater entering or becoming contaminated;
- urine diversion is beneficial;
- two vault systems with alternate usage is advantageous;
- vaults should be heated with solar energy by covering each chamber with a black lid;
- wash water has to be kept out;
- post-composting after collecting the dehydrated faecal materials may be required.

57. Some toilets use earthworms to decompose faecal matter and kitchen organic waste. The Dowmus system (slide 32) in Australia is partially filled with active compost at the time of installation and inoculated with beneficial soil organisms, in particular, tiger and red composting worms (Ho and Mathew, 1998). There is no heating element and the system is not intended to operate above 35 °C to protect the worms. The process depends

more on soil organisms and worms rather than on the thermophilic microorganisms for composting. It can also take other household organic matter provided it is cut into small pieces. A Vermi-processing toilet was field tested for 8 years in India and was found to be a novel low water-use toilet for safe processing of human excreta without odour and fly problems. In the USA, Redworm (Eisenia and Lumbricus rubellus) has been added in the Clivus Multrum composting toilet (Rockefeller, 1995).

58. Vacuum toilets, as depicted in slide 43, produce slightly diluted black water which is transported by the vacuum system to a bio-gas reactor where the black water is treated anaerobically together with bio-waste from kitchens. A well managed anaerobic digester should produce 1 m^3 gas / m^3. The biogas mixture is about 70 % methane and 30 % carbon dioxide (Doelle, 1998). The methane can be used as a source of renewable energy and can be used to produce electricity as well as for cooking and lighting. The sludge, which is rich in nutrients and organic matter, can be used after sanitisation in agriculture as a fertiliser.

59. Treatment systems for grey water. Biological treatment methods are required to remove organic contamination from grey water. The most widely used methods are constructed wetlands, sequence batch reactors, membrane bioreactors and biological aerated filters.

Example

Grey water treatment with vertical flow constructed wetlands with sizes of 2 m^2 per inhabitant in the Flintenbreite settlement, Luebeck has shown good performance (slide 44).

60. Physical methods used for grey water treatment are sand filtration, ultrafiltration, microfiltration, and reverse osmosis.

61. Grey water treated using a combination of constructed wetlands and chemical processes (TiO_2–based photocatalytic oxidation) have achieved effluent that meets the European bathing water quality standard (Li et al., 2000).

62. Bellagio statement. In February 2000, there was an expert consultation arranged by the Water Supply and Sanitation Collaborative Council (WSSCC) which resulted in the formulation of the "Bellagio Statement" ("Clean, healthy and productive living: a new approach to environmental sanitation"), which gives some insight into the philosophy and principles of resource management sanitation (slide 45). The statement contains the following principles (EAWAG/SANDEC, 2000):

1st: "Human dignity, quality of life and environmental security at household level should be at the centre of the new approach, which should be responsive and accountable to needs and demands in the local and national setting."

2nd: "In line with good governance principles, decision-making should involve participation of all stakeholders, especially the consumers and providers of services. "

3rd: "Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flows and waste management processes."

- Inputs should be reduced so as to promote efficiency and water and environmental security.
- Exports of waste should be minimised to promote efficiency and reduce the spread of pollution.
- Wastewater should be recycled and added to the water budget.

4th: "The domain in which environmental sanitation problems are resolved should be kept to the minimum practicable size (household, community, town, district, catchments, and city) and wastes diluted as little as possible. "

By adhering to these principles, resource management sanitation systems help to solve some of society's most pressing problems – infectious diseases, environmental degradation, water scarcity and the need to recover and recycle nutrients for plant growth. In doing so, it also helps to restore soil fertility, conserve fresh water and protect marine environments. Moreover it takes an ecosystems approach to the problem of human excreta. Urine and faeces are considered valuable resources, with distinct qualities, that are needed to restore soil fertility and increase food production. Prior to recycling nutrients, urine and/or faeces may need to be processed. Many of the plant nutrients in urine are readily available to be taken up by plants, while most of the pathogens causing illness are in the faeces. Thus, it makes sense to divert urine from faeces to keep urine relatively sterile, while making it easy to process and treat faeces to render them harmless. Faeces, which contain most of the carbon in excreta, can be rendered harmless by several processes and returned to the land as a soil conditioner as well as returning other valuable nutrients."

Excreta must be handled safely and chemical contaminants from domestic wastewater must be contained in compartments as small as possible (again: "dilution is no solution"), water scarcity has to be overcome by reusing the reclaimed part of domestic wastewater related to the water cycle (i.e. greywater), nutrients from human excreta should be recycled for increasing agricultural yields, and saving money (not only by avoiding high investment for sewers, but also needing less synthetic fertilizers because of the use of nutrients from human excreta).

63. Ecosan schemes (slide 47).

Source separation

The aforementioned aims can be achieved by source control in sanitation! Source separation of different streams of domestic wastewater helps to prevent pathogens in faecal matter from spreading to the environment, enables nutrients in yellow water to be utilised, and prevents grey water from being further contaminated with nutrients, faecal pathogens, and hazardous substances from industrial wastewaters, making it a suitable source for reuse – even for high quality demand like groundwater recharge. Source control requires some special pre-requisites: separate pipes for yellow, brown and grey water, no-mix toilets for separate collection of yellow and brown water and low volumes for toilet flushing.

Generally, there are different options for source separation. A simple scheme would be the separation of grey water from black water, requiring two separate pipe systems in the home (one for grey water, one for black water The second option is to collect all three sources of domestic wastewater separately:

grey water, yellow water, and brown water.

Source separation of different particular domestic wastewater flows (related to the nutrient as well as to the water cycle) facilitates sanitation of human excreta as well as nutrient recovery from excreta – and also purification of the grey water stream.

EcoSan combats hygienic risks

The highest concentrations of pathogenic microorganisms are contained in brown water. As sanitation of small volumes is easier than of the highly diluted entire wastewater streams, and source control sanitation leads to catchments of brown water with a far lower water content than in domestic wastewater in conventional sanitation, resource management sanitation is a good means to reduce sickness and deaths from diarrhoea because of the safe containment and hygienization of brown (or black) water (solids). This is a clear advantage. Separately collected faeces can be hygienized by dehydration (when there is no water available for pathogenic organisms, they will die). A good way to take the water away is by using solar heat. For this purpose, the solids of brown water are stored in a chamber which is covered with a black lid. This way is more feasible for warm regions. It has to be noted that faeces have to be safely kept away from stormwater (special care is required e.g. in regions with monsoons). Another possibility to kill pathogens in faeces is composting.

EcoSan helps to overcome malnutrition
The safe nutrients obtained from Ecological sanitation can be reused in agriculture and thus help to increase harvest yields and to combat malnutrition.

The nutrient cycle – closed
The food cycle can be closed leading to less environmental degradation and also to socio-economic advantages.

Wastewater reuse
Wastewater reuse is facilitated because the less contaminated greywater, which belongs to the water cycle, is used (this can help to combat water scarcity). For example, in constructed wetlands, the separately collected greywater can be purified in a relatively simple way to a high quality.

Reduced pollution of the aqueous environment
Pollution of the aqueous environment is reduced as excreta flows do not come into contact with surface waters. Moreover, pharmaceuticals are not discharged to the water cycle-related greywater and can thus not enter surface waters. Groundwater contamination by pharmaceuticals due to the agricultural use of yellow water (and of hygienized brown water solids) will have to be investigated more intensively in future.

Socio-economic benefits
EcoSan may also contribute to some improvement in socio-economic aspects:
Jobs can be created (e.g. caretakers for resource management sanitation facilities, yellow and processed brown water transportation firms).
There will be financial benefits (no sewers needed, energy necessary in wastewater treatment plants in conventional sanitation schemes is saved, a great deal of energy for fertilizer production can be saved).

64. EcoSan project implementation. It is possible to broadly identify four basic types of EcoSan projects (slide 48), and give a general description of the stakeholders involved, their degree of participation in the process, and the activities to be undertaken. This allows an identification of the tools and instruments that may be necessary, and who may need them, at different stages throughout the project.

Project type A (rural upgrade) corresponds to what could be considered as the "classic" EcoSan-project. Farming households, in rural areas, receive support to establish ecological sanitation systems either on their compounds or in their houses.

Project type B (peri-urban and urban upgrade) corresponds to EcoSan projects implemented in all existing urban or peri-urban areas of cities and towns, where more or less well functioning existing sanitation systems are converted to closed loop systems. This therefore applies to all areas, from informal settlements to luxury multi-storey apartment or office blocks, where the existing infrastructure is to be upgraded to EcoSan systems.

Project type C (new urban development) is to be found when new dwellings or development areas are being constructed either by the authorities (national, regional or local government) or by private developers (these are normally private businesses, but may sometimes also include citizens groups who wish to build their own homes in an ecological way). The dwellings come equipped with EcoSan systems, and these systems are therefore considered from early on in the planning stage, facilitating considerably the consideration of all relevant aspects of town planning, land use, (urban) agriculture, water management etc. as well as their rapid and comprehensive introduction.

Project type D (non-residential) is a regrouping of all EcoSan applications in buildings and areas that are not intended for normal residential purposes (schools, hospitals, banks, offices, hotels or holiday lodges situated in sensitive areas (e.g. in national parks, on islands etc.)), or in regions that are not served by the public sewer network. Projects of this type may address the upgrading of an existing conventional sanitation system to EcoSan or the construction of a new building with a closed loop sanitation system.

65. Steps of EcoSan projects. There are certain key tasks and moments in the course of an EcoSan project that can determine whether and how the programme will continue. Although there are possibly a lot of different tools for the implementation of an EcoSan project, the reported 10 Step criteria flowchart (slide 49) is useful to show how to transforms the theoretical steps into an idealised practical example.

Step 0 – Raising awareness
Activities: advocacy; lobbying; information provision; demand creation.
Output: increased awareness of the EcoSan philosophy and systems, demand for EcoSan.
Awareness raising activities should concentrate on subjects such as: the water, sanitation and soil crisis, the closed loop approach to sanitation, the shortcomings of conventional sanitation, the advantages of EcoSan, EcoSan technologies and operating systems, aspects of hygiene, health and user comfort, costs, technical information etc.

Step 1 – Request for assistance
Activities: formulation of request.
Output: request formulated and submitted to relevant party.
The request for assistance has to be formulated by the relevant stakeholders (e.g. the users of the sanitation facility or of the recyclates) possibly with the feedback of the supporting institution (e.g. an NGO) and be passed on to the to the body that is in a position to respond to the demand (e.g. the local authorities or a supporting organisation like an NGO or international development organisation). A positive response to this demand should lead to "Step 2".

Step 2 – Launch of planning and consultative process
Activities: facilitation including identification of all relevant stakeholders; information on planning process and EcoSan; active participation in workshop.
Output: start-up workshop report; agreement among stakeholders on the working procedure, their tasks, roles and means, and the project boundaries.
In this step a "start-up" or advocacy-workshop can help inform all stakeholders about the process itself. Apart from obtaining agreement to use the participatory approach, the "start-up workshop" can also be used to further inform stakeholders of EcoSan and to start the participatory development of the terms of reference (TORs) for the investigation of the status quo. As in all phases of the project, the expectations of the stakeholders should not be raised beyond the project's ability to deliver.

Step 3 – Assessment of current status
Activities: participatory development of terms of reference; investigation of status quo; elaboration of reports; present findings of investigation; correct possible factual errors.
Output: report on status quo.
The participatory developments of the TORs are used to investigate the current situation. In the EcoSan approach this covers not only an assessment of the current level of urban environmental sanitation services (UESS), but also considers water supply, social-cultural and legal aspects, aspects of reuse, urban planning, agricultural practices, fertiliser needs, energy needs, social acceptability, environmental pollution, etc. These investigations are used as a basis for writing the report on the current status quo.

Step 4 – Assessment of (user) priorities
Activities: establish ground rules for step 5 (priorities, levels of service, institutional arrangements, cultural acceptability etc.).
Output: ground rules for the identification of options.
After presenting the "status quo report" to the stakeholders and incorporating their feedback into it, the "ground rules" for the identification of EcoSan options (Step 5) are formulated, based on the assessment of user priorities. This will take place in dialogue with the stakeholders. They should include

information on user priorities (for both the users of the sanitary facilities and the recyclates), as well as the priorities of the service providers, the municipality and sector agencies, the willingness and capability of each of these to pay for or otherwise contribute to the implementation or operation of the project, minimum acceptable levels of service, institutional arrangements, cultural acceptability, etc.

Step 5 – Identification of options

Activities: elaboration of adequate EcoSan solutions; elaboration of reports.

Output: report on suitable EcoSan options. Based on the ground rules established in step 4, a variety of EcoSan solutions, including their technical, institutional and management aspects should be elaborated and described in the report. These solutions should comprise sanitation and corresponding reuse options and respond to the priorities of the different stakeholders and provide them with the possibility of making an informed choice. The range of solutions developed should not be limited to EcoSan systems. Where appropriate, characteristic conventional solutions should also be elaborated which should serve as a comparison for the technical, institutional, ecological, economical, public health and other implications of the different approaches. This report should include all adequate possibilities according to the results of step 4 in order to provide the user with the widest possible choice.

Step 6 – Evaluation of feasible service and reuse options

Activities: participatory determination of feasible service and reuse combinations; elaboration of reports; decision making workshop.

Output: decision on continuation and service / reuse combinations

While in step 5, a wide variety of available options that fulfil the ground rules are identified and presented in a report, step 6 involves the participatory determination of the options that are likely to be feasible and most suited to the needs identified. This will require a participatory evaluation of the options identified, with respect to the technical, economic, social, institutional, public health and other relevant aspects. This may require an iterative approach to steps 3, 4, 5 and 6 before a range of solutions are developed that are acceptable to all stakeholders. This range of options may be necessary due to differences in the social structure of the project area, with corresponding differences in the financial means and expected service levels among the users of the sanitary facilities.

Step 7 – Consolidated EcoSan plans for project area

Activities: assemble / integrate the service and reuse combinations into a broader water supply, sanitation and reuse framework.

Output: Consolidated EcoSan plan for the entire project area.

In this step the technical, institutional and management plans for the project area are elaborated. This is achieved by fitting together the accepted service and reuse combinations from step 6 in order to appropriately cover the needs of the entire project area.

An example of how such a range of sanitation and reuse solutions could fit together would be:

- Communal toilets for a market place with anaerobic treatment of faeces, producing biogas used for baking in a local bakery, and with sludge from the biogas reactor and urine being used by local farmers;
- Urine separating dehydrating toilets installed in a poorer neighbourhood with the collection and reuse of the urine and faeces being organised by a local CBO;
- A biogas installation operated by a local farmer that treats and reuses the black water of surrounding houses together with animal manure from the farm; and
- A constructed wetland in the centre of a main street, used to treat grey water, which is subsequently reused to irrigate a local park or other green area.

Step 8 – Finalising consolidated EcoSan plans for the study area

Activities: presentation of assembled plans; approval of assembled plans.

Output: approved EcoSan plans.

The process and plans developed in "Step 7" should be "officially" presented to, and approved by, all stakeholders. This may best take place during a workshop or official meeting. Again it may be necessary to repeat steps 7 and 8 several times to adequately address the concerns of the stakeholders allowing them to approve of the assembled plans.

Step 9 – Implementation

Activities: elaboration of technical plans; elaboration of implementation plans; decision on infrastructure; tendering; granting of financial support / subsidies; hardware investment; provision of equipment; construction; training / advice to users and service providers; use of sanitary system; maintenance; collection, treatment; storage, transport; reuse of recyclates; marketing of recyclates.

Output: sustainable, user oriented closed-loop sanitary system.

This step includes all aspects of implementation of the project according to the process and plans developed in the preceding steps. In many projects, full implementation of EcoSan systems may have to be introduced in a stepwise process, as the systems may not yet be sufficiently developed or well known to decision makers and users, and they may therefore lack the confidence to apply an EcoSan system to cover the entire project area.

66. Monitoring, evaluation and feedback – a continuous activity. Ongoing monitoring, evaluation and feedback (MEF) activities are extremely important in an EcoSan programme. These should be performed throughout the entire process, beginning in the awareness raising phase, with the activities and results being monitored and evaluated. The results of this should be used to make necessary adjustments in the activities to ensure that the process continues as desired. Recognised methods such as interviews, statistical evaluation, questionnaires or observations, should be used to collect the necessary information within reasonable and appropriate limits.

67. Conventional planning and implementation instruments vs. EcoSan (slide 50). Currently the most frequently applied instruments used in the planning and implementation of infrastructure projects are pre-feasibility and feasibility studies, followed by the elaboration of detailed technical plans and tendering documentation; the tendering procedure; construction; and finally the operation of the system. These instruments should also be appropriately applied in the planning and implementation of EcoSan-projects. They should, however, be adapted to address the specific needs of the EcoSan approach and to allow thorough consideration of the "EcoSan-project steps" as described above.

68. Stakeholders. In general stakeholders are those groups of individuals or organisations who have an interest in the outcome of a particular process. They can range from households and community based organisations to local, regional and national government, and can also include private sector institutions, social services, such as health and education, national and international donor institutions and civil society at all levels. Relevant stakeholders are those who should be involved in a particular process, as well as those who are mainly affected by it or involved in the related decision making process. The relevant stakeholders in EcoSan projects (slide 51) are:

- Users of sanitation facilities
- Users of the recyclates:
- User-groups (CBOs and self-help groups)
- NGOs
- Local authorities and governmental institutions
- Service providers
- Developers and investors
- Financial institutions

69. Presenting a flowchart for the early planning process of the feasibility of implementing the Ecological sanitation in new settlements, depicted in slide 52, the trainer can propose a discussion and ask for feedback from the participants on the concepts presented during this Topic.

70. The session ends with a questionnaire handed out to the participants. They are asked to answer the questions with a short essay (20 min. time).

7.2 Session 2 – Case Study

Vacuum-biogas system – Lübeck Flintenbreite, Germany

Session overview

Title Vacuum-biogas system – Lübeck Flintenbreite, Germany

Objectives
- To present an advanced EcoSan solution.

Teaching method lecture

Time estimation 60 minutes

Needed material projector

Session guide

1. With presenting this case study the trainer can stress on the existence of feasible solution for wastewater treatment in urban and semi-urban areas capable to realize resources and energy recovery.

2. A vacuum-biogas system that was built in Lübeck Flintenbreite, Germany, is a pilot project of a semicentral system for more densely populated areas of house-blocks of up to 5.000 people (slides 2-4). For larger populations additional systems are necessary because of limitations in the length of the vacuum pipes.

3. In this system water-saving vacuum toilets are used (slide 5). Faeces are collected and treated central together with bio-wastes in an anaerobic digester (slide 6). The biogas is converted in a cogeneration unit into heat and electrical energy (slide 7). The produced sludge can be recycled into the nutrient cycle by agricultural utilization. Greywater is treated in constructed wetlands and thereafter infiltrated or supplied to a pond system (slide 8). Rain water can be infiltrated on-site (Otterpohl et al. 1999). The partially higher investment (e.g. vacuum toilets) is balanced by savings due to the facts that there needs to be no connection to the public sewer system, and from low operating costs.

7.3 Session 3 – Exercise

EcoSan – wastewater treatment solutions

Session overview

Title EcoSan – wastewater treatment solutions exercise

Objectives
- To develop problem-solving skills.
- To get a feeling for the difficult problems faced by anyone put in a position to try to improve sanitary conditions under which the majority people in cities in the Third World are living.
- To find technically, financially and environmentally appropriate solutions for wastewater treatment.

Teaching method class work and discussion

Time estimation
- 15 minutes to explain the exercise
- 60 minutes for group work
- 75 minutes of solution presentations and class discussion

Needed material flipchart, assignment paper

Session guide

1. With this exercise, the trainer has the opportunity to check and review the knowledge acquired by the participants throughout the lessons presented in Module 3.

2. General Features of the Project Area:

A poor housing area with 4000 inhabitants is situated along a river bank. There is no sewerage system, and existing septic tanks discharge basically treated liquid waste into open drains that discharge into the river. The households have small fields planted with vegetables and some cattle or poultry. Both the river and the water supply canal are becoming increasingly polluted from human waste and wastewater. The ground water is very close to the surface and faecal coliform counts are high in most wells.

3. It is suggested that the participants create 4-5 groups of 3-4 persons.

4. The time for completing the exercise is suggested to be divided up into parts as follows:

60 minutes
Think about the problems and their interrelationships, but come up with a few key themes you want to address. You should ensure these are well defined. Themes will have a heading and a question you wish to answer. Here are some examples (but please think for yourselves what you want to focus your attention on!):

- Improving the Quality of Water Supply: What short and long term options are available for protecting the water supply? How realistic might we expect the different options to be in terms of cost and implementation?
- Domestic Sanitation: What, technically, financially and environmentally, can be done about improving sanitation for those living in the area? What are the chances of implementing an EcoSan approach: what would this mean technically and how would it be carried out in practice?

Work systematically through the chosen themes and write your solutions schematically either on an slide or in Power Point. Please keep good time – (it is suggested that each theme be completed in 15 minutes, and if not, then go on to the next theme anyway)!

75 minutes
Reports should be no longer than 7 minutes to give time for discussion and final commentary by the facilitators.

Trainer's notes

The exercise aims at putting the participants in the difficult situation of suggesting how the problems can at least be reduced. Many things are technically possible and several different solutions may be appropriate. Knowledge acquired throughout the presentations held during Module 3 should be used to find the most appropriate solutions to the proposed questions.

EcoSan – wastewater treatment solutions exercise

General Features of the Project Area:
A poor housing area with 4000 inhabitants is situated along a river bank. There is no sewerage system, and existing septic tanks discharge basically treated liquid waste into open drains that discharge into the river. The households have small fields planted with vegetables and some cattle or poultry. Both the river and the water supply canal are becoming increasingly polluted from human waste and wastewater. The ground water is very close to the surface and faecal coliform counts are high in most wells.

- Improving the Quality of Water Supply:

- What short and long term options are available for protecting the water supply?

- How realistic might we expect the different options to be in terms of cost and implementation?

- Domestic Sanitation:

- What, technically, financially and environmentally, can be done about improving sanitation for those living in the area?

- What are the chances of implementing an EcoSan approach: what would this mean technically and how would it be carried out in practice?

7.4 Self Test

1. Do you agree with the statement that conventional sanitation is not sustainable? Please explain shortly.

2. Are EcoSan concepts acceptable in your country? If not, what can be done to make them acceptable?

7.5 Literature and recommended reading

Burks, B.D., and *M.M. Minnis.* 1994. Onsite Wastewater Treatment Systems. Hogarth House, Madison, WI.

Del Porto, D. and *Steinfeld, C.* (1999). The Composting Toilet System Book. Centre for Ecological Pollution Prevention, Massachusetts. ISBN 0-9666783-0-3

Doelle, H.W. (1998). Socioeconomic microbial process strategies for a sustainable Development using environmentally clean technologies www.ias.usu.edu/proceedings/icibs

EAWAG/SANDEC (2000) Summary report of Bellagio expert consultation on environmental sanitation in the 21st century, 1-4 February 2000. EAWAG (Swiss Federal Institute for Environmental Science and Technology), SANDEC (Water & Sanitation in Developing Countries), Duebendorf, Switzerland.

Esrey, S. (2000). Closing the loop. In proceeding of first international symposium on ecosan- closing the loop in wastewater management and sanitation, 30-31 October, Bonn c/o GTZ, Germany

Esrey, S.A., Gough, J., Rapaport, D., Sawyer, R., Simpson-Hébert, M., Vargas, J., and *Winblad, U.* (1998) Ecological sanitation. Swedish International Development Cooperation Agency, Stockholm. www.ecosanres.org/PDF%20files/Ecological %20Sanitation.pdf;

GTZ (2003). Ecosan – Introduction of closed-loop approaches in wastewater management and sanitation – a new supra-regional GTZ – project. GTZ, Eschborn.

Ho, G.E and *Mathew, K.* (1998). Household Systems for Wastewater Treatment. In Caribbean Environment Programme Technical Report #43 1998, UNEP

Larsen, T.A., and *Gujer, W.* (1996) Separate management of anthropogenic nutrient solutions (human urine). Wat. Sci. Tech. 34(3-4), 87-94.

Li, Z., Gulyas, H., Jahn, M., Gajurel, D.R., Otterpohl, R. (2000): Grey water treatment and reuse by constructed wetlands with TiO2-based photocatalytic oxidation and infiltration for suburban and rural areas with sewer system. In: proceedings vol 1 of international water association 5th specialised conference on small water and wastewater systems, 24.-25.09.02, Istanbul. ISBN 975-561-225-4

Lubis, A.-R. (1999) Water watch: a Community action guide. Asia-Pacific People's Environmental Network. ISBN: 9839941607 WIR (1992). World Resources. Oxford university press, New York

Moe et al. (2003). The impact of ecological sanitation on parasitic infections in rural El Salvador. In proceeding of the 2nd international symposium on esosan, Luebeck, Germany 7-11 April.

Montangero, A. and *Strauss, M.*(2000). Faecal sludge treatment: Strategic Aspects and Treatment Options. Paper submitted to the International Workshop on Biosolids Management and Utilization at Nanjing and to the Forum on Biosolids Management and Utilization at Hong Kong, September 2000. Swiss Federal Institute for Environmental Science and technology(EAWAG) P.O. Box 611, CH-Duebendorf, Switzerland

Narain, S. (2002). The flush toilet is ecologically mindless. Down to earth, P.29-37 Feb28, 2002. Centre for science and environment , New Delhi, India

National Association of Plumbing-Heating-Cooling Contractors (NAPHCC). 1992. Assessment of On-Site Graywater and Combined Wastewater Treatment and Recycling Systems. NAPHCC, Falls Church, VA.

Niemczynowicz, J. (1997). The Water Profession and Agenda 21. Water Quality International March/April 1997, pp 9-11.

Otterpohl, R.; Albold, A, Olderburg, M. (1999). Source Control in Urban Sanitation and Waste Management: 10 Systems with Reuse of Resource. Wat. Sci. Tech. Vol. 39 (5) pp.153-160

Otterpohl, R. (2001) Black, brown, yellow, grey – the new colours of sanitation. Water 21, October 2001, 37-41.

Pollard, R., Kohlenberg, A. and *Davison, L.* (1997). Effectiveness and User Acceptance Of Composting Toilet Technology in Lismore NSW. In Environmental Technologies for Wastewater Management, Proceedings of Conference. Murdoch University, December 4-5, 1997.

Rockefeller, A. (1995). Clivus Multrum loves worms. Worm Digest. Nr.8, Oregon, USA http://www.wormdigest.org/

Tchobanoglous, G., and *F.L. Burton.* 1991. Wastewater Engineering: Treatment, Disposal, Reuse, 3rd ed. McGraw-Hill, Inc., New York, NY.

U.S. Environmental Protection Agency (USEPA). 1995. Clean Water Through Conservation. EPA 841- -95-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.<http://www.epa.gov/OW/you/intro.html>.

Xianghong, L. and *Jian, L.* (2003). Comparison of sanitation latrines used in China. In Proceeding of second international symposium on "ecosan- closing the loop" 7- 11 April, Luebeck, Germany. http://www.gtz.de/ecosan/english/symposium2-proceedings-eng.htm

7.6 Internet Resources

Information on both residential and non-residential water use reduction
http://www.epa.gov/OW/you/intro.html

Information on Dowmus composting toilets, http://www.maleny.net.au/dowmus.html

Information on disposal options and related issues, web site of USEPA Office of Solid Waste's Household Hazardous Waste
http://www.epa.gov/epaoswer/non-hw/muncpl/hhw.htm

Information on user habits improvement in order to reduce pollutant loads in wastewater, web site of National Small Flows Clearinghouse.
http://www.estd.wvu.edu/nsfc/NSFC_septic_news.html.

"Ecological Sanitation", revised and enlarged edition of the book can be downloaded from
http://www.ecosanres.org/PDF%20files/Ecological%20Sanitation%202004.pdf

Definitions of "sustainable development"
http://www.gdrc.org/sustdev/definitions.html)

Overview of toilet systems for source control sanitation
www.gdrc.org/uem/waste/oldenburg.html

Module 4
Wastewater Reuse

2007

1. Introduction

The module on alternative solutions of wastewater treatment covers four topics:
1. Wastewater reuse basics
2. Legal frameworks to prevent health risks related to reuse in agriculture
3. Planning and economic evaluation of reuse projects
4. Importance of awareness raising for reuse

with the following objectives:
- Raise awareness on potentials of wastewater reuse
- Introduce main reuse applications and related benefits and risks
- Explain health risks related with reuse in agriculture and how to avoid them
- Introduce international quality standards and regulations for wastewater reuse
- Give an overview on economic cost benefit analysis of reuse in agriculture

After completing the course participants should be able to:
- Be familiar with potential reuse applications
- Know main water quality requirements for wastewater reuse
- Understand the health risks related to reuse and preventive measures
- Know main international regulations and guidelines
- Be able to assess the overall economic and environmental risks and benefits of reuse in agriculture

For each module 1 - 4 materials are provided in the Trainer`s Toolkit which allow for a 3 day training, 6 training hours per day. While the Trainer`s Toolkit includes a suggested training schedule, the trainers are strongly encouraged to alter this schedule according to their own preferences and especially according to the training needs of the target group. The EMWater Trainer`s Toolkit which is designed for a very wide target group, can of course not fulfill the needs of each specific target group.

2. Suggested timetable for training

Wastewater Reuse

Training module 4

Day 1

9:00 – 10:30	Introductory Session
10:30 – 11:00	Coffee Break

Topic 1: Wastewater reuse – basics

11:00 – 12:30	Session 1 – Brainstorming
	Session 2 – Topic Presentation I
12:30 – 14:00	Lunch
14:00 – 15:30	Session 3 – Topic Presentation II
15:30 – 16:00	Coffee Break
16:00 – 17:30	Session 3 – Topic Presentation II (Continuation)
	Session 4 – Case Study

Training module 4

Day 2

Topic 1: Wastewater reuse – basics

9:00 – 9:30	Session 5 – Topic Presentation III
9:30 – 10:30	Session 6 – Group Exercise
10:30 – 11:00	Coffee Break

Topic 2: Legal frameworks to prevent health risks related with reuse in agriculture

11:00 – 12:30	Session 1 – Topic Presentation
12:30 – 14:00	Lunch

Topic 3: Planning and economic evaluation of reuse projects

14:00 – 15:30	Session 1 – Topic Presentation
15:30 – 16:00	Coffee Break
16:00 – 17:30	Session 2 – Case Study Exercise

Training module 4

Day 3

Topic 3: Planning and economic evaluation of reuse projects

9:00 – 10:30	Session 2 – Case Study Exercise (Continuation)
10:30 – 11:00	Coffee Break

Topic 4: Importance of awareness raising for reuse

11:00 – 12:30	Session 1 – Topic Presentation
12:30 – 14:00	Lunch
14:00 – 15:30	Session 2 – Role Play
15:30 – 16:00	Coffee Break
16:00 – 17:30	Final/feedback Session

3. Introductory Session

Time: 90 min - see modules 1, 2 or 5 for suggestions

4. Topic 1:

Wastewater reuse basics

Topic overview

Time

Session 1: Brainstorming – 15 - 30 min
Session 2: Topic Presentation I – 60 - 75 min
Session 3: Topic Presentation II – 90 - 120 min
Session 4: Case Study – 60 - 90 min
Session 5: Topic Presentation III – 45 - 60 min
Session 6: Group Exercise – 60 - 90 min

Objectives

- Introduce the general concept and stress the benefits of wastewater reuse.
- Overview of reuse applications: benefits, risks.
- Explore in more detail the potentials and requirements for reuse in agriculture, as well as groundwater recharge and industry.

Participants should be able to

- Be aware of the benefits of wastewater reuse.
- Know about different reuse applications and related benefits and risks.
- Be familiar with benefits and risks, water quality and technical requirements for reuse in agriculture.

Material

- Marker
- Pin board
- Flipchart
- Projector
- Assignment material

This topic is covered in 6 sessions:

1. Session 1 – Brainstorming

The suggestion is that you start this topic with a brainstorming session. This session serves to get an insight into the level of knowledge of the participants, and how aware they are of potentials and risks of wastewater reuse. This will allow you to adapt your teaching in the course of the module. Furthermore, this exercise is meant to create more relaxed atmosphere and better group coherence at the beginning of this module.

2. Session 2 – Topic Presentation I

The topic presentation can be covered in 60-100 minutes depending on the level of knowledge and experience of participants. Furthermore, the content of this presentation in the part describing the constituents of wastewater and potential health impacts is covered in some aspects within the Wastewater Management module. Hence, some slides are made optional with respect to the overall organization of the course.

3. Session 3 – Topic Presentation II

This session will cover in detail the potentials and problems of wastewater reuse for irrigation, especially in agriculture. It can be covered in 90-120 min, depending on how many examples and calculations are given and discussed.

4. Session 4 – Case Study

This session will present participants with a real world example of wastewater reuse in agriculture: A case study of the Reuse project in Drarga, Morocco.

5. Session 5 – Topic presentation III

Very briefly this session will present potentials, benefits and risks of Wastewater Reuse in sectors other than agriculture.

6. Session 6 – Group Exercise

This exercise will revisit the different physico-chemical parameters important for use of reclaimed water in irrigation. It will allow participants to compare the quality of surface and reclaimed water.

4.1 Session 1 – Brainstorming

Session overview

Title Wastewater Reuse: applications, benefits, risks

Objectives
- To collect information on reuse applications, benefits, risks.
- To explore the level of knowledge of participants.

Teaching method interactive participation, di scussion

Time estimation
- 5 min exercise explanation
- 20 min for brainstorming and short discussion

Needed material markers, pin board with paper (or cards)

Session guide

1. Ask participants what reclaimed water could be used for or what applications they personally know of. Write the question down on a board or flipchart so it is visible to everybody. Write a list of uses on the middle of the board. Explain that this brainstorming exercise is mainly to get an overview of how much the group already knows about reuse in order for you to adapt your lectures.

2. In a second step ask participants about benefits of wastewater reuse, either in general or in specific applications. Write theses benefits in a column on the right of the uses. For specific benefits, draw a line between the respective application and its benefits.

3. Finally, ask participants for potential risks of reuse of reclaimed water and write them on the left of the uses. For application specific risks, again draw lines between the use and its respective risks. Point out to the participants that applications, benefits and risks will be discussed in more detail within the following sessions and therefore they shouldn't be discussed in detail now. Also you can complete the list within the course of the following sessions.

4. Point out, from the table that you have just prepared, what aspects of reuse will be covered in detail in the following sessions and which applications will not.

You can also prepare the blank table in advance:

Risks	Reuse for	Benefits

PPT

4.2 Session 2 – Topic Presentation I

Wastewater reuse basics

Session overview

Title Wastewater reuse basics

Objectives
- To stress the potential of and need for wastewater reclamation.
- To arrive at a common understanding of wastewater reuse and related terms.
- To shed light on the importance of wastewater reuse in the MENA region.
- To present an overview of the wastewater reuse applications as well as related benefits and constraints.

Teaching method lecture

Time estimation 60 -100 min

Needed material projector

Session guide

The trainer might decide to cover the topic in less or more detail according to the participants' prior experience and knowledge by rearranging or completely excluding some of the slides. To facilitate the lecture, notes providing additional content information for trainers are included within the presentation itself.

1. Rational – Why is reuse an important component of an integrated water resource management. Increasing freshwater scarcity and the need for safe wastewater disposal call for integrated solutions, especially in the MENA region (slides 5-10).

2. What is wastewater reuse – Some definitions are given in slides 12-15. In the course of this Module we will mainly consider reuse of treated municipal wastewater.

3. Reuse applications – an overview of categories and typical applications are given in slides 17-19, followed by general benefits and risks related with reuse (slides 20-21).

4. The current situation of wastewater reuse in the MENA region. Different sources give different numbers, but generally it can be said that even though the need for reuse in MENA is obvious, it is still not too common (slides 23-27).

5. Major limitations are based in capacity limitations (institutional, financial, and human). Religious impediments are often named as a constraint, but actually several Fatwas have permitted reuse of treated wastewater (slides 28-29).

6. Some of the typical constituents of municipal wastewater pose problems for some re-use applications - foremost, pathogenic microorganisms, which can cause illnesses (slides 31-35).

7. Physico-chemical wastewater parameters can also cause problems (slides 36-38).

8. Therefore, all wastewater must generally be treated before reuse according to its planned application (slides 39-40). Sometimes the reclaimed water quality can also limit the range of potential uses (slide 41).

4.3 Session 3 – Topic presentation II

Reuse in agriculture and landscape irrigation

Session overview

Title Reuse in agriculture and landscape irrigation

Objectives
- To explore in more detail the benefits of reuse in agriculture.
- To point out management strategies to prevent health and environmental risks of reclaimed water use in irrigation.
- To point out important aspects for crop health.

Teaching method lecture

Time estimation 90 -120 min

Needed material projector, marker, flip chart or white board

Session guide

1. Agriculture is the most important wastewater reuse application in the Mediterranean countries. The main advantages are that reclaimed water presents a source for additional irrigation water and nutrients for plants (slides 5-6).

2. The fertilisation potential can either be simply demonstrated by showing slide 7, or – to make the lecture more entertaining – by doing the following calculation together with the participants on a whiteboard. You can also ask participants to provide you with typical numbers from their region and use those instead of the ones given in the example:

Agronomic and economic benefits of wastewater use in irrigation

As an example, a city with a population of 500,000 and water consumption of 200 L/d per person would produce approximately 85,000 m^3/d (30 Mm^3/year) of wastewater, assuming 85% inflow to the public sewerage system. If treated wastewater effluent is used in carefully controlled irrigation at an application rate of 5,000 m^3/ha.year, an area of some 6,000 ha could be irrigated. In addition to the economic benefit of the water, the fertilizer value of the effluent is of importance. With typical concentrations of nutrients in treated wastewater effluent from conventional sewage treatment processes as follows:

Nitrogen (N) - 50 mg/l
Phosphorus (P) - 10 mg/l
Potassium (K) - 30 mg/l

and assuming an application rate of 5,000 m^3/ha.year, the fertilizer contribution of the effluent would be:

N - 250 kg/ha. year
P - 50 kg/ha. year
K - 150 kg/ha. year

Thus, all of the nitrogen and much of the phosphorus and potassium normally required for agricultural crop production would be supplied by the effluent. In addition, other valuable micronutrients and the organic matter contained in the effluent will provide additional benefits.

Source
Pescod, M. B. 1992: Wastewater treatment and use in agriculture. FAO Irrigation and Drainage Paper 47. Rome FAO, http://www.fao.org/docrep/T0551E/t0551e00.htm

3. Slides 9 and 10 list disadvantages and potential technical problems that can be linked with using reclaimed water.

4. In addition, if irrigation with reclaimed water is not managed properly, risks for human health, the environment and crop yields can arise (slides 11-12). Therefore it is important to increase knowledge and experience in wastewater reuse and to inform farmers about required management practices (slide 13). Ways and agricultural management practices to control such risks will be explained in the following slides.

5. The main pathogens and diseases posing health risks in agricultural reuse are given in slides 15 and 16.

6. Ways to control health risks are mainly: wastewater treatment, crop restriction, adapted irrigation technique, and human exposure control. These will be explained in detail in slides 17-23.

Wastewater treatment

The most obvious approach to reduce risks of infection from wastewater is the removal or inactivation of pathogens through wastewater treatment. Conventional treatment technologies, however, focus mainly on the removal of suspended solids, organic matter, and nitrate – and not on the removal of pathogens. Hence, water reclaimed through conventional treatment may require further treatment, such as filtration or disinfection, in order to reduce the concentration of pathogens to an acceptable level.

Conversely, some alternative wastewater treatment technologies have shown to be more effective in removal of pathogens. An example is the chemically enhanced primary treatment that uses specific chemicals to facilitate particle coagulation and flocculation and, thus, increases the removal of suspended solids, organic matter and intestinal nematode eggs. Another alternative solution is wastewater stabilisation ponds: If designed and operated properly, this treatment process is highly effective in removing pathogens and can be operated at low costs where inexpensive land is available. Where effective treatment is not available, storage reservoirs can improve wastewater quality through simple sedimentation.

(Information on technologies suitable to produce microbiologically safe effluents for wastewater reuse in the Middle East and North Africa has been compiled by Duncan Mara (2000)).

Crop restriction

Health risks can also be reduced by restricting irrigation with reclaimed water to crops that are processed or cooked before consumption (e.g. wheat, potatoes etc.) or to non-food crops (e.g. fodder crops, energy crops, cotton etc.). Crop restriction is often adopted in order to allow for use of lower quality effluents for irrigation. This approach enables wastewater reuse associated with less costly wastewater treatment and may be favoured for this particular reason. Crop restriction may, nevertheless, discourage wastewater reuse where demand is low or lacking for crops that can be irrigated using wastewater.

Furthermore, crop restrictions are often difficult to enforce in practice. Effective control and law enforcement by public authorities is essential to avoid health risks. Moreover, while consumers and handlers of crops can be protected by crop restriction, this does not provide protection for farm workers and their families. Hence, crop restriction needs to be combined with further protective measures, such as appropriate irrigation system management and human exposure control.

Irrigation techniques

The issue of which irrigation technique to use has a major impact on the actual health risk situation: In general, health risks are greatest with spray/sprinkler irrigation, as this would contaminate large parts of the crops and may also expose the off-site population to aerosols. Application of this technique should, therefore, be avoided where possible, and if used, more stringent microbial standards for reclaimed water have to be observed. Conversely, flood and furrow irrigation exposes on-site workers to the greatest health risk, especially if work is done by hand and without taking special protective measures. Localized irrigation (including drip and trickle irrigation) present the lowest health risks.

Regulations establishing a time-limit for irrigation before the harvest (usually of about one or two weeks) can allow die-off of bacteria and viruses. Time limits for irrigation prior to harvest are more practicable with crops that do not need to be harvested at their freshest, as with, e.g., fodder crops. Replacing wastewater with fresh irrigation water before harvest does not remove the risks of biological contamination of crops, since re-contamination of crops from the soil may occur. From the facts already mentioned above as to crop restrictions, such time-limits need to be effectively controlled and enforced.

Human exposure control

Farm workers and their families face the highest potential health risks from wastewater reuse in agriculture, especially through parasitic infections. Protection can be achieved by applying low-contamination irrigation techniques, along with wearing protective clothing (e.g. footwear and gloves for farmers and gloves for crop handlers) and improved levels of hygiene. Provision of adequate freshwater supplies for consumption (to avoid consumption of reclaimed water) and for hygiene purposes (e.g. for hand washing) is also important. Moreover, all reclaimed water channels, pipes, and outlets should be clearly marked (preferably painted in a characteristic colour scheme). The design of outlet fittings should be such to prevent misuse.

Where reclaimed water is used in spray/sprinkler irrigation, people living nearby can be protected by establishing a buffer zone of, e.g., 50 to 100 m from houses and roads. Local residents should be informed of the location of all fields under wastewater irrigation, so they can avoid these sites and prevent their children from entering them. Warning notices (using simple universal pictograms) should be posted along wastewater irrigated fields and at water tap sites.
Consumers themselves can contribute to mitigate risks, for instance, by complying with sanitary standards when preparing and consuming their food. Health education campaigns that focus on improving personal and domestic hygiene should address produce consumers, farm workers, produce handlers and vendors. Potential sources of crop contamination other than irrigation to be considered include crop handling, transportation and the sale of products in unhygienic market facilities. The best efforts to supply healthy crops according to health regulations are thwarted if the produce is 'freshened' afterwards with contaminated water in the market.

7. Chemical parameters that should be monitored in order to prevent crop damage and environmental risks are listed in slide 25. Their special importance in arid regions is explained in slide 26, and slide 27 gives an overview of available strategies to prevent negative impacts from these parameters. Each parameter and respective risk control measures are given in the following slides.

8. Salinity is covered in slides 29-35.

9. Sodium is covered in slides 37-40.

10. Boron is covered in slides 42-43.

11. Nutrients are covered in slides 45-47.

12. Heavy Metals are covered in slides 49-56.

4.4 Session 4 – Case Study

Reuse for agricultural irrigation in Drarga, Morocco

Session overview

Title Reuse for agricultural irrigation in Drarga, Morocco

Objectives
- To give a real world example of the potential of reuse in agriculture
- To study lessons learned from a real world project

Teaching method lecture

Time estimation 60 min

Needed material projector

Session guide

This case study presents a reuse project in Drarga, Morocco, that was implemented as part of the Morocco Water Resources Sustainability (WRS) Activity from July 1996 to September 2003. WRS was financed by USAID and implemented under the supervision of the Moroccan Department of Environment.

1. Slides 2-4 give an overview of the case study, why it was chosen as a best practice example and who the responsible institutions were

2. The background situation in Morocco is given in slides 5-6.

3. The WWTP in Drarga was selected according to several parameters. Slides 7-11 present the main features of the Drarga project and the course of its selection.

4. The technology of the WWTP is presented in slides 12 and 13, and slide 14 gives an overview of the treatment efficiency.

5. Slides 15 and 16 include information on how and where the effluent of the WWTP is reused.

6. Economic considerations of the project, i.e. the project costs and ways for their recovery are given in slides 17-18.

7. The results of the wastewater reuse for the environment, crops and farmers are given in slides 19-24.

8. Slides 25-26 summarise the lessons learned from the Drarga case.

4.5 Session 5 – Topic presentation III

PPT

Reuse for groundwater recharge and industry

Session overview

Title Reuse for groundwater recharge and industry

Objectives
- To explore the potentials and risks of reuse of wastewater for groundwater recharge.
- To explore in brief the benefits and constraints for reusing wastewater in industry.

Teaching method presentation

Time estimation 45 min

Needed material projector

Session guide

1. The main purposes of groundwater recharge, be it with reclaimed or with other waters, are given in slide 5. In addition, there are some advantages of groundwater recharge for wastewater reuse in particular (slides 6 and 7).

2. The potential risks in recharging groundwater with reclaimed water are given in slide 8.

3. There are mainly three methods to recharge groundwater, irrespective of what type of water is used for recharge: surface spreading, riverbank or dune filtration, and direct injection. These are explained in more detail in the next slides (slides 9-11).

4. As a real life example, a project in Belgium is presented in slides 13-20 where groundwater is recharged with tertiary effluent through dune filtration.

5. Slide 22 lists typical applications for reclaimed water in industrial processes. There are mainly two options: either recycling water within a plant or using reclaimed municipal wastewater (slides 23-24).

6. The development of the concept of water recycling and reuse has gone through several phases. While at first wastewater treatment was only meant to protect receiving waters, the concept of recycling and reuse developed with higher environmental standards and decreasing availability of freshwater. Today, water reuse is quite common in some industries around the world (slides 25-26).

7. Some industries have more potential for water recycling than others, the main factors and industries are listed in slides 27 and 28.

8. Nevertheless, there are also some constraints to using reclaimed water in industrial processes which are named in slide 29.

Scaling refers to the formation of hard deposits, usually on surfaces, which can e.g. reduce the efficiency of heat transfer. Due to repetitive recycling of water, evaporation leads to increased concentrations of impurities such as calcium, magnesium, sodium, chloride, and silica, which eventually lead to scale formation. Scale forming constituents can be eliminated through precipitation techniques, ion exchange or reverse osmosis.

Corrosion is accelerated by many contaminants present in the wastewater. Ammonia, which may be present in significant concentrations in the reclaimed municipal wastewater, may be one of the prime causes of corrosion in many industrial water reuse installations. Dissolved solids increase the electrical conductivity of the solution and thereby accelerate corrosion. Dissolved oxygen and certain metals (manganese, iron, and aluminium) promote corrosion because of their relatively high oxidation potential. Corrosion can be controlled by adding chemical corrosion inhibitors (especially in case of excess dissolved solids).

Slime and algal growth are common problems in reclaimed water due to high nutrient content, which promotes biological growth. Biological slime settles and binds other debris present in the reclaimed water, thus inhibiting e.g. effective heat transfer. At the same time, certain microorganisms also create corrosive by-products during their growth. This growth can be controlled or eliminated by addition of biocides during the internal treatment process.

Fouling refers to the process of attachment and growth of deposits of various kinds in the recirculation system. These consist of biological growths, suspended solids, silt, corrosive products and organic scales. Fouling is usually controlled by the addition of chemical dispersants, which prevent particles from forming flocs, so that they can be kept in suspension.

Suitability and effects of various irrigation waters

Session overview

Title Suitability and effects of various irrigation waters

Objectives
- To become more familiar with quality requirements for irrigation water by applying what was just learned to real world water qualities.
- To repeat and thus deepen what was learned the day before.

Teaching method exercise in small groups

Time estimation
- 5 min to form groups
- 10 min to explain exercise
- 40-90 min to do the exercise
- 30-60 min to present and discuss results

Needed material Assignment material, blank answer sheet on projector or whiteboard to present results

Session guide

1. Ask participants to form 4 groups.

2. Hand the assignment paper to each participant and ask each group to assess the suitability for irrigation of one of the four given water sources (relatively unpolluted Sacramento River, a moderately saline groundwater in San Joaquin County, and reclaimed municipal wastewaters from the cities of Fresno and Bakersfield respectively).

3. Explain that they should assess the waters according to the guidelines and tables given in the assignment paper. These are taken from the FAO reference document. If available and found appropriate, other irrigation water guidelines could also be used to assess the various waters, e.g. the national policies.

4. Give the groups 40-90 min to complete the tasks, and fill one column in the blank table, indicating for each parameter and irrigation situation whether problems are expected when using the respective water for a long period of time (N= no problem, S-M = slight to moderate problem, and SV = severe problems expected).

5. Provide individual help if necessary.

6. Ask each group to read their results and write them into a prepared blank table on the projector or on a white board.

7. Discuss with participants the potential problems that could be related with each of the parameters as well as some potential prevention measures (to repeat what was presented in the lecture earlier).

8. Ask participants if they know of other irrigation water guidelines and whether they find the FAO guidelines appropriate.

Suitability and effects of various irrigation waters

Analyses of four representative waters in California are presented in the following data table. The waters are:

1) Relatively unpolluted Sacramento River.
2) A moderately saline groundwater in San Joaquin County.
3) Two reclaimed municipal wastewaters from the cities of Fresno and Bakersfield.

Assuming that the following conditions are applicable, determine the suitability of these waters for irrigation:

1. Daily crop water demand varies during the growing season and among crop types. Water demand may range from a low of 2,0 mm/d to a high of 7,6 to 10,1 mm/d.

2. On-farm management of reclaimed wastewater must take crop water demand into account, and the irrigation objective should be to use the reclaimed wastewater efficiently to produce a crop.

3. Evaluation for the suitability of various irrigation waters is made based on the information given in the tables above. The results of the analysis are presented in the following table.

Constituents	Sacramento River	San Joaquin County groundwater	Fresno wastewater effluent	Bakersfield wastewater effluent
EC (dS/m)	0.11	1.25	0.69	0.77
pH	7.1	7.1	8.6	7.0
Ca (me/l)	10	100	24.0	47
Mg (me/l)	5	33	12.8	5
Na (me/l)	6	92	80	109
K (mg/l)	1.5	3.9	1.8	26
SAR	0.4	2.0	3.3	4.1
HCO_3 (me/l)	42	190	236	218
SO_4 (me/l)	7.3	110	-	62
Cl (me/l)	2.2	200	70	107
NO_3-N + NH_3-N (mg/l)	0.08	5.9	14	0.5
B (mg/l)	-	1.5	0.43	0.38
TDS (mg/l)	72	800	442	477
As (mg/l)			<0.002	
Cd (mg/l)			<0.002	

For units see Table 2 below

Please fill the answer sheet indicating whether N= no problem, S-M= slight to moderate problem, and SV= severe problems are expected when using respective water for a long period of time.

	Degree of Problem			
Problem area	Sacramento River	San Joaquin County groundwater	Fresno waste-water effluent	Bakersfield waste-water effluent
Salinity				
Infiltration				
Toxicity (sensitive crops only)				
Na Surface irrigation Sprinkler irrigation				
Cl Surface irrigation Sprinkler irrigation				
B				
Miscellaneous (susceptible crops only)				
N HCO_3				

N = no problem, S-M = slight to moderate problem, and SV = severe problems are expected when using respective water for a long period of time.

Material

Source:
Ayers, R.S. and D. W. Westcot 1985: Water quality for agriculture. FAO Irrigation and Drainage Paper 29 Rev.1. Rome: FAO. http://www.fao.org/DOCREP/003/T0234E/T0234E00.htm

Water Quality Guidelines

Guidelines for evaluation of water quality for irrigation are given in Table 1. They emphasize the long-term influence of water quality on crop production, soil conditions and farm management, and are presented in the same format as in the 1976 edition but are updated to include recent research results. This format is similar to that of the 1974 University of California Committee of Consultant's Water Quality Guidelines which were prepared in cooperation with staff of the United States Salinity Laboratory.

The guidelines are practical and have been used successfully in general irrigated agriculture for evaluation of the common constituents in surface water, groundwater, drainage water, sewage effluent and wastewater. They are based on certain assumptions which are given immediately following the table. These assumptions must be clearly understood but should not become rigid prerequisites. A modified set of alternative guidelines can be prepared if actual conditions of use differ greatly from those assumed.

Ordinarily, no soil or cropping problems are experienced or recognized when using water with values less than those shown for 'no restriction on use'. With restrictions in the slight to moderate range, gradually increasing care in selection of crop and management alternatives is required if full yield potential is to be achieved. On the other hand, if water is used which equals or exceeds the values shown for severe restrictions, the water user should experience soil and cropping problems or reduced yields, but even with cropping management designed especially to cope with poor quality water, a high level of management skill is essential for acceptable production. If water quality values are found which approach or exceed those given for the severe restriction category, it is recommended that before initiating the use of the water in a large project, a series of pilot farming studies be conducted to determine the economics of the farming and cropping techniques that need to be implemented.

Table 1 is a management tool. As with many such interpretative tools in agriculture, it is developed to help users such as water agencies, project planners, agriculturalists, scientists and trained field people to understand better the effect of water quality on soil conditions and crop production. With this understanding, the user should be able to adjust management to utilize poor quality water better. However, the user of Table 1 must guard against drawing unwarranted conclusions based only on the laboratory results and the guideline interpretations as these must be related to field conditions and must be checked, confirmed and tested by field trials or experience.

The guidelines are a first step in pointing out the quality limitations of a water supply, but this alone is not enough; methods to overcome or adapt to them are also needed. Therefore, in subsequent sections, management alternatives are presented and several examples are given to illustrate how the guidelines can be used.

The guidelines do not evaluate the effect of unusual or special water constituents sometimes found in wastewater, such as pesticides and organics. However, suggested limits of trace element concentrations for normal irrigation water are given in Table 2.

Table 1 Guidelines for Interpretations of Water Quality for Irrigation[1]

Potential Irrigation Problem				Units	Degree of Restriction on Use		
					None	Slight to Moderate	Severe
Salinity (affects crop water availability)[2]							
	EC_w			dS/m	< 0.7	0.7 – 3.0	> 3.0
	(or)						
	TDS			mg/l	<450	450 – 2000	>2000
Infiltration (affects infiltration rate of water into the soil. Evaluate using EC_w and SAR together)[3]							
SAR	= 0 – 3	**and EC_w**	=		> 0.7	0.7 – 0.2	< 0.2
	= 3 – 6		=		> 1.2	1.2 – 0.3	< 0.3
	= 6 – 12		=		> 1.9	1.9 – 0.5	< 0.5
	= 12 – 20		=		> 2.9	2.9 – 1.3	< 1.3
	= 20 – 40		=		> 5.0	5.0 – 2.9	< 2.9
Specific Ion Toxicity (affects sensitive crops)							
	Sodium (Na)[4]						
	surface irrigation			SAR	< 3	3 – 9	> 9
	sprinkler irrigation			me/l	< 3	> 3	
	Chloride (Cl)[4]						
	surface irrigation			me/l	< 4	4 – 10	> 10
	sprinkler irrigation			me/l	< 3	> 3	
	Boron (B)[5]			mg/l	< 0.7	0.7 – 3.0	> 3.0
	Trace Elements (see Table 3)						
Miscellaneous Effects (affects susceptible crops)							
	Nitrogen (NO_3 – N)[6]			mg/l	< 5	5 – 30	> 30
	Bicarbonate (HCO_3)						
	(sprinkling only)			me/l	< 1.5	1.5 – 8.5	> 8.5
	pH				**Normal Range 6.5 – 8.4**		

[1]) Adapted from University of California Committee of Consultants 1974.
[2]) ECw means electrical conductivity, a measure of the water salinity, reported in deciSiemens per metre at 25°C (dS/m) or in units millimhos per centimetre (mmho/cm). Both are equiva-lent. TDS means total dissolved solids, reported in milligrams per litre (mg/l).
[3]) SAR means sodium adsorption ratio. SAR is sometimes reported by the symbol RNa. See Figure1 for the SAR calculation procedure. At a given SAR, infiltration rate increases as watersalinity increases. Evaluate the potential infiltration problem by SAR as modified by ECw.
[4]) For surface irrigation, most tree crops and woody plants are sensitive to sodium and chloride; use the values shown. Most annual crops are not sensitive; use salinity tolerance tables for those. For chloride tolerance of selected fruit crops, see separate Tables. With sprinkler irrigation and low humidity (< 30 percent), sodium and chloride may be absorbed through the leaves of sensitive crops. For crop sensitivity to absorption, see specific Tables.
[5]) For boron tolerances of specific crops, see specific Tables.
[6]) NO_3 -N means nitrate nitrogen reported in terms of elemental nitrogen (NH_4 -N and Organic-N should be included when wastewater is being tested).

Assumptions in the Guidelines

The water quality guidelines in Table 1 are intended to cover the wide range of conditions encountered in irrigated agriculture. Several basic assumptions have been used to define their range of usability. If the water is used under greatly different conditions, the guidelines may need to be adjusted. Wide deviations from the assumptions might result in wrong judgements on the usability of a particular water supply, especially if it is a borderline case. Where sufficient experience, field trials, research or observations are available, the guidelines may be modified to fit local conditions more closely.

The basic assumptions in the guidelines are:

Yield Potential: Full production capability of all crops, without the use of special practices, is assumed when the guidelines indicate no restrictions on use. A "restriction on use" indicates that there may be a limitation in choice of crop, or special management may be needed to maintain full production capability. A "restriction on use" does **not** indicate that the water is unsuitable for use.

Site Conditions

Soil texture ranges from sandy-loam to clay-loam with good internal drainage. The climate is semi-arid to arid and rainfall is low. Rainfall does not play a significant role in meeting crop water demand or leaching requirement. (In a monsoon climate or areas where precipitation is high for part or all of the year, the guideline restrictions are too severe. Under the higher rainfall situations, infiltrated water from rainfall is effective in meeting all or part of the leaching requirement.) Drainage is assumed to be good, with no uncontrolled shallow water table present within 2 metres of the surface.

Methods and Timing of Irrigations

Normal surface or sprinkler irrigation methods are used. Water is applied infrequently, as needed, and the crop utilizes a considerable portion of the available stored soil-water (50 percent or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF]≥15 percent). The guidelines are too restrictive for specialized irrigation methods, such as localized drip irrigation, which results in near daily or frequent irrigations, but are applicable for subsurface irrigation if surface applied leaching satisfies the leaching requirements.

Water Uptake by Crops

Different crops have different water uptake patterns, but all take water from wherever it is most readily available within the rooting depth. On average about 40 percent is assumed to be taken from the upper quarter of the rooting depth, 30 percent from the second quarter, 20 percent from the third quarter, and 10 percent from the lowest quarter. Each irrigation leaches the upper root zone and maintains it at a relatively low salinity.

Salinity increases with depth and is greatest in the lower part of the root zone. The average salinity of the soil-water is three times that of the applied water and is representative of the average root zone salinity to which the crop responds. These conditions result from a leaching fraction of 15–20 percent and irrigations that are timed to keep the crop adequately watered at all times.
Salts leached from the upper root zone accumulate to some extent in the lower part but a salt balance is achieved as salts are moved below the root zone by sufficient leaching. The higher salinity in the lower root zone becomes less important if adequate moisture is maintained in the upper, "more active" part of the root zone and long-term leaching is accomplished.

Restriction on Use

The "Restriction on Use" shown in Table 1 is divided into three degree of severity: none, slight to moderate, and severe. The divisions are somewhat arbitrary since change occurs gradually and there is no clearcut breaking point. A change of 10 to 20 percent above or below a guideline value has little significance if considered in proper perspective with other factors affecting yield. Field studies, research trials and observations have led to these divisions, but management skill of the water user can alter them. Values shown are applicable under normal field conditions prevailing in most irrigated areas in the arid and semi-arid regions of the world.
Laboratory determinations and calculations needed to use the guidelines are given in Table 2 and Figure 1, along with the symbols used.

Table 2 Laboratory Determinations Needed to Evaluate Common Irrigation Water Quality Problems

Water parameter	Symbol	Unit[1]	Usual range in irrigation water	
SALINITY				
Salt Content				
Electrical Conductivity	EC_w	dS/m	0 – 3	dS/m
(or)				
Total Dissolved Solids	TDS	mg/l	0 – 2000	mg/l
Cations and Anions				
Calcium	Ca^{++}	me/l	0 – 20	me/l
Magnesium	Mg^{++}	me/l	0 – 5	me/l
Sodium	Na^{+}	me/l	0 – 40	me/l
Carbonate	CO^{--}_3	me/l	0 – .1	me/l
Bicarbonate	HCO_3^-	me/l	0 – 10	me/l
Chloride	Cl^-	me/l	0 – 30	me/l
Sulphate	SO_4^{--}	me/l	0 – 20	me/l
NUTRIENTS[2]				
Nitrate-Nitrogen	NO_3-N	mg/l	0 – 10	mg/l
Ammonium-Nitrogen	NH_4-N	mg/l	0 – 5	mg/l
Phosphate-Phosphorus	PO_4-P	mg/l	0 – 2	mg/l
Potassium	K^+	mg/l	0 – 2	mg/l
MISCELLANEOUS				
Boron	B	mg/l	0 – 2	mg/l
Acid/Basicity	pH	1–14	6.0 – 8.5	
Sodium Adsorption Ratio[3]	SAR	$(me/l)^{1,2}$	0 – 15	

¹) dS/m = deciSiemen/metre in S.I. units (equivalent to 1 mmho/cm = 1 millimmho/centi-metre)
mg/l = milligram per litre ≃ parts per million (ppm).
me/l = milliequivalent per litre (mg/l ÷ equivalent weight = me/l); in SI units, 1 me/l= 1 millimol/litre adjusted for electron charge.

²) NO_3 -N means the laboratory will analyse for NO_3 but will report the NO_3 in terms of chemically equivalent nitrogen. Similarly, for NH_4-N, the laboratory will analyse for NH_4 but report in terms of chemically equivalent elemental nitrogen. The total nitrogen available to the plant will be the sum of the equivalent elemental nitrogen. The same reporting method is used for phosphorus.

³) SAR is calculated from the Na, Ca and Mg reported in me/l (see Figure 1).

Figure 1

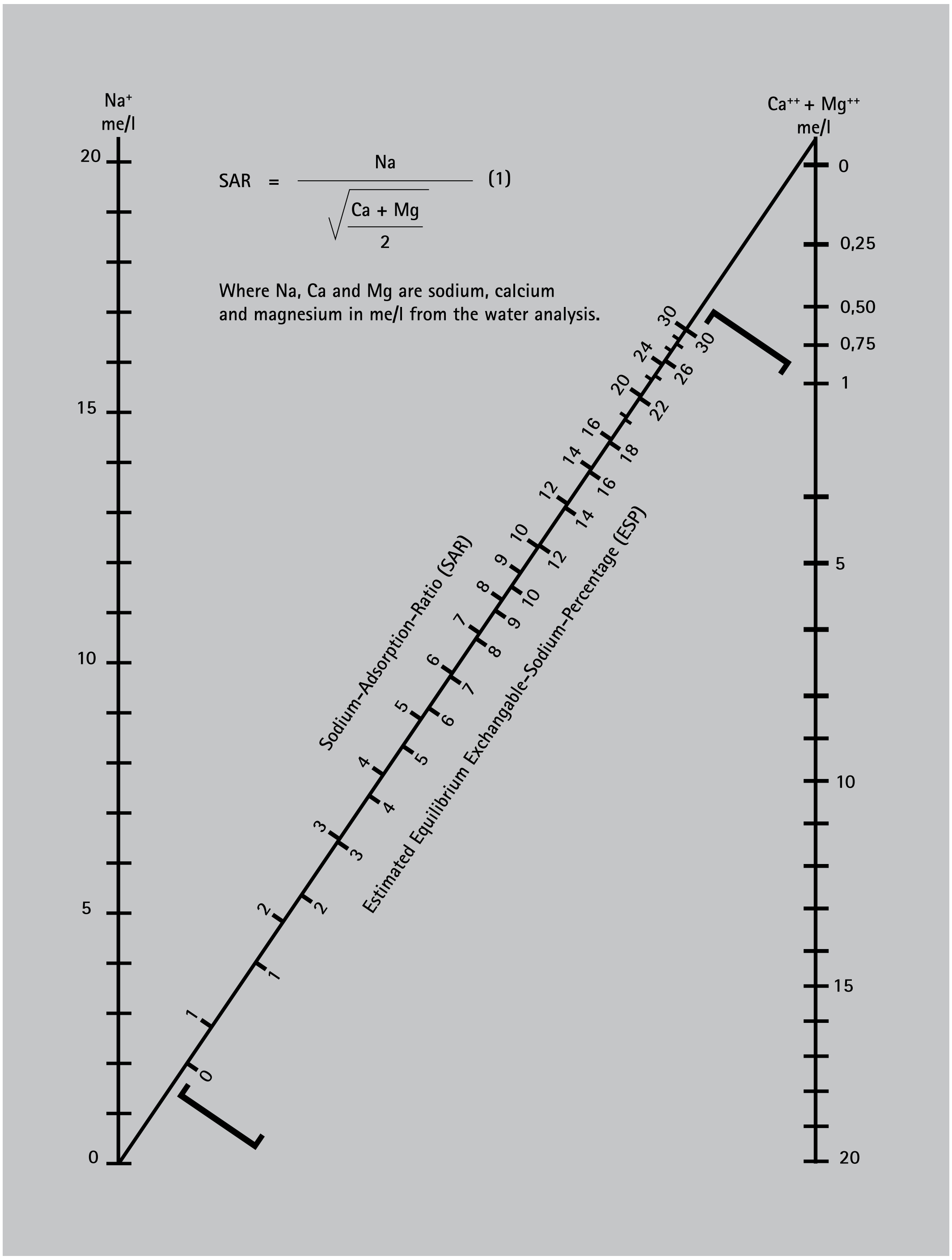

Na+ me/l
Ca++ + Mg++ me/l
SAR = Na / √((Ca + Mg)/2) (1)
Where Na, Ca and Mg are sodium, calcium and magnesium in me/l from the water analysis.
Sodium-Adsorption-Ratio (SAR)
Estimated Equilibrium Exchangable-Sodium-Percentage (ESP)
0
5
10
15
20
0
0,25
0,50
0,75
1
5
10
15
20

Table 3 Recommended Maximum Concentrations of Trace Elements in Irrigation Water[1]

Element	Recommended Maximum Concentration[2] (mg/l)	Remarks
Al (aluminium)	5.0	Can cause non-productivity in acid soils (pH < 5.5), but more alkaline soils at pH > 7.0 will precipitate the ion and eliminate any toxicity.
As (arsenic)	0.10	Toxicity to plants varies widely, ranging from 12 mg/l for Sudan grass to less than 0.05 mg/l for rice.
Be (beryllium)	0.10	Toxicity to plants varies widely, ranging from 5 mg/l for kale to 0.5 mg/l for bush beans.
Cd (cadmium)	0.01	Toxic to beans, beets and turnips at concentrations as low as 0.1 mg/l in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Co (cobalt)	0.05	Toxic to tomato plants at 0.1 mg/l in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Cr (chromium)	0.10	Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on its toxicity to plants.
Cu (copper)	0.20	Toxic to a number of plants at 0.1 to 1.0 mg/l in nutrient solutions.
F (fluoride)	1.0	Inactivated by neutral and alkaline soils.
Fe (iron)	5.0	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. sprinkling may result in unsightly deposits on plants, equipment and buildings.
Li (lithium)	2.5	Tolerated by most crops up to 5 mg/l; mobile in soil. Toxic to citrus at low concentrations (<0.075 mg/l). Acts similarly to boron.
Mn (manganese)	0.20	Toxic to a number of crops at a few-tenths to a few mg/l, but usually only in acid soils.
Mo (molybdenum)	0.01	Not toxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high concentrations of available molybdenum.
Ni (nickel)	0.20	Toxic to a number of plants at 0.5 mg/l to 1.0 mg/l; reduced toxicity at neutral or alkaline pH.
Pd (lead)	5.0	Can inhibit plant cell growth at very high concentrations.

Element	Recommended Maximum Concentration[2] (mg/l)	Remarks
Se (selenium)	0.02	Toxic to plants at concentrations as low as 0.025 mg/l and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. An essential element to animals but in very low concentrations.
Ti (titanium)	----	Effectively excluded by plants; specific tolerance unknown.
V (vanadium)	0.10	Toxic to many plants at relatively low concentrations.
Zn (zinc)	2.0	Toxic to many plants at widely varying concentrations; reduced toxicity at pH > 6.0 and in fine textured or organic soils.

[1]) Adapted from National Academy of Sciences (1972) and Pratt (1972).

[2]) The maximum concentration is based on a water application rate which is consistent with goodirrigation practices (10 000 m^3 per hectare per year). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates less than 10 000 m^3 per hectare per year. The values given are for water used on a continuous basis at one site.

Trainer's notes

	Degree of Problem			
Problem area	**Sacramento River**	**San Joaquin County groundwater**	**Fresno wastewater effluent**	**Bakersfield wastewater effluent**
Salinity	N	S-M	N	S-M
Infiltration	SV	N	S-M	S-M
Toxicity (sensitive crops only)				
Na				
Surface irrigation	N	N	S-M	S-M
Sprinkler irrigation	N	S-M	S-M	S-M
Cl				
Surface irrigation	N	S-M	N	N
Sprinkler irrigation	N	S-M	N	S-M
B	-	S-M	N	N
Miscellaneous (susceptible crops only)				
N	N	S-M	S-M	N
HCO_3	N	S-M	S-M	S-M

N = no problem, S-M = slight to moderate problem, and SV = severe problems are expected when using respective water for a long period of time.

4.7 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in the class, depending on the time availability.

1. Name four categories of wastewater reuse applications.

2. What are the main benefits of wastewater reuse?

3. Name three risks for the environment that can arise from wastewater reuse in agriculture.

4. Name three ways to reduce human health risks from wastewater reuse in agriculture.

5. Name three chemical criteria that should be monitored in reclaimed water when it is reused in agriculture.

6. What are purposes of groundwater recharge? Name at least two.

7. Name three potential wastewater reuse applications in industry.

Answers:

1. Possible answers are: Agricultural irrigation, Landscape irrigation, Industrial recycling and reuse, Groundwater recharge, Aquaculture, Recreational/environmental uses, Non-potable urban uses, Potable reuse.

2. Reduces the demand on conventional water resources, diminishes the volume of wastewater discharged, and allows recovery of wastewater constituents.

3. Pollution and salinisation of soils, Reduction of soil permeability and aeration by clogging pores through grease in wastewater, Contamination of shallow aquifers with microbial pathogens and nitrates from wastewater. Impacts on crop health.

4. Wastewater treatment, Crop restriction, Irrigation technique, Human exposure control.

5. Salinity, sodium, boron, nutrients (nitrogen, phosphorus, potassium, zinc, boron and sulphur).

6. Establishment of saltwater intrusion barriers in coastal aquifers, augmentation of potable or non-potable aquifers, storage of reclaimed water for future reuse, and control or prevention of ground subsidence.

7. Cooling water, boiler feed water, process water, dust control on construction sites and quarries, landscaping and maintenance of industrial grounds.

4.8 Literature

Post, Julika and *Mikael Henzler* 2005: Water Reuse – Basics. Presentation at the EMWAter Regional Training in Lebanon, November 2005.

World Bank 2007: Making the most of scarcity: accountability for better water management results in the Middle East and North Africa. MENA development report. Washington DC: The World Bank.

Roudi-Fahimi, Farzaneh: Liz Creel, and *Roger-Mark De Souza* 2002: Finding the Balance: Population and Water Scarcity in the Middle East and North Africa. Policy brief. Washington, DC: Population Reference Bureau.
http://www.prb.org/Publications/PolicyBriefs.aspx

Abassi, Bassim 2005: Wastewater Reuse. Presentation held at the EMWater Local Training Course in Jordan, 2005.

EMWater Guide 2007

WHO-CEHA 2005: A regional overview of wastewater management and reuse in the Eastern Mediterranean Region. World Health Organization, Regional Office for the Eastern Mediterranean, Regional Centre for Environmental Health Activities.
http://www.emro.who.int/ceha/pdf/A%20regional%20overview%20of%20wastewater%202005.pdf

Scott, C. A.; J. A. Zarazúa and *G. Levine* 2000: Urban-wastewater reuse for crop production in the water-short Guanajuato river basin, Mexico. Colombo, Sri Lanka. Research Report 41. Colombo, Sri Lanka: International Water Management Institute.
http://www.iwmi.cgiar.org/pubs/PUB041/Report41.pdf

Otterpohl, Ralf and *Martina Hammer* 2005: Impact of Wastewater Reuse on Plants. Presentation prepared for the EMWater Webbased Training 2005.

Maas E.V. 1984 Salt tolerance of plants. In: The Handbook of Plant Science in Agriculture. B.R. Christie (ed). CRC Press, Boca Raton, Florida.

Richards L.A. 1954 Diagnosis and improvement of saline and alkali soils. USDA Agricultural Handbook No. 60, US Department of Agriculture, Washington DC. 160 p.

Ayers, R.S. and *D. W. Westcot* 1985: Water quality for agriculture. FAO Irrigation and Drainage Paper 29 Rev.1. Rome: FAO.
http://www.fao.org/DOCREP/003/T0234E/T0234E00.htm

Asano, T. and *C. Visvanathan*, 2001: Industries and water recycling and reuse. In: Business and Industry - A Driving or Braking Force on the Road towards Water Security, 2001 Founders Seminar, organized by Stockholm International Water Institute, Stockholm, Sweden. SIWI Report 14 pp.13-24.
http://www.siwi.org/downloads/Reports/Report%2014%20Founders%20Seminar%202001.pdf

Aomi, Jemali; Abdelmajid, Kefati (2002): Wastewater Reuse in Morocco. Water Demand Management Forum on Wastewater Reuse, 26–27 March 2002, Rabat, Morocco. http://www.idrc.ca/uploads/user-S/10637267421Morocco_Waste.doc

Kerby, Mario (2003): The Drarga Wastewater Treatment and Reuse Project: A Model for Small Communities.
http://213.186.164.75:2000/downloads/pdf/papers/2003_12_16.pdf

Mountadar, Mohammed; Assobhei, Omar (2004): Wastewater Reuse in Morocco, Task 5 of MEDAWARE Project.
http://www.uest.gr/medaware/

Project PREM (2004): Final Report of the Morocco Water Resources Sustainability Project. Kingdom of Morocco, Ministry of Environment, Project financed by USAID/Morocco.
http://pdf.usaid.gov/pdf_docs/PDABZ561.pdf

Palestinian National Authority Environmental Quality Authority (EQA) 2005: A detailed description of the Reuse Schemes applied in Palestine. MEDAWARE Project, Task 5
http://www.uest.gr/medaware/

4.9 Recommended Reading

Asano, T. (ed.) 1998: Wastewater Reclamation and Reuse: Water Quality Management Library Vol. 10. U.S.A.: CRC Press LLC.

Faruqui, N. I.; A. K. Biswas and *M. J. Bino* (eds.) 2001: Water Management in Islam.
Tokyo: UNU Press. http://www.idrc.ca/en/ev-9425-201-1-DO_TOPIC.html

Metcalf & Eddy, Inc. 2003: Wastewater Engineering - Treatment and Reuse, 4th Edition. New York: McGraw-Hill.

Davis, R. and *R. Hirji* (eds.) 2003: Wastewater Reuse. Water Resources and Environment Technical Note F.3. Water Conservation and Demand Management Series. Report No. 26325, Washington D.C.: The World Bank.
http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2003/08/02/000094946_03071804010223/Rendered/PDF/multi0page.pdf

Lahlou, A. A. 2005: Wastewater Reuse. In: E. Baroudy, A. A. Lahlou and B. Attia (eds.): Managing Water Demand - Policies, Practices and Lessons from the Middle East and North Africa. IDRC and IWA Publishing.
http://www.idrc.ca/en/ev-85521-201-1-DO_TOPIC.html

Ayers, R. S. and *D. W. Westcot* 1985: Water Quality for Agriculture. Irrigation and Drainage Paper no. 29, Rev. 1. Rome: Food and Agriculture Organization.
http://www.fao.org/DOCREP/003/T0234E/T0234E00.htm

Pescod, M. B. 1992: Wastewater treatment and use in agriculture. FAO Irrigation and Drainage Paper 47. Rome FAO.
http://www.fao.org/docrep/T0551E/t0551e00.htm

Lens, Piet; Griethe Zeeman and *Gatze Lettinga* (eds.) 2001: Decentralised Sanitation and Reuse. Concepts, systems and implementation. London: IWA Publishing.

4.10 Internet resources

MED-REUNET Mediterranean Network on Wastewater Reclamation and Reuse
Med-Reunet.com is the online platform of the Mediterranean Network, offering a member forum section (with restricted access) for experience and expertise exchange as well as an open information section with links to institutions and programmes, classified by topic.
http://www.med-reunet.com/home.asp

International Water Management Institute (IWMI) – Wastewater Resource Page
On its resource page on the reuse of wastewater for agriculture, IWMI has compiled a number of brief case studies as well as a list of its own research publications on the topic.
http://www.iwmi.cgiar.org/respages/Wastewater/index.htm

EAWAG Department of Water and Sanitation in Developing Countries (SANDEC)
While the SANDEC project section is still under construction, the online platform already covers a range of topics in water and sanitation infrastructure development, ranging from strategic environmental sanitation planning to rural and peri-urban wastewater management. Contents available at the moment are downloadable publications and a link list on environmental sanitation sites.
http://www.sandec.ch/

IDRC Regional Water Demand Initiative (WaDimena)
While the WaDimena programme website spans the whole range of water management issues in MENA countries, the focus area on wastewater reuse provides ample literature references. A description of WaDimena's research and field-level pilot projects offers information on wastewater reuse case studies in the MENA region.
http://network.idrc.ca/en/ev-57064-201-1-DO_TOPIC.html

ZERO-M is a project under the Euro-Mediterranean Regional Programme on Local Water Management of the European Commission. Zer0-M aims at concepts and technologies to achieve optimised closed-loop usage of all water flows in small municipalities or settlements (e.g. tourism facilities) not connected to a central wastewater treatment system– the Zero Outflow Municipality (Zer0-M).
http://www.zer0-m.org

Publications of the GTZ Reclaimed Water Project in Jordan
http://gtz.jo/cms/node/69

5. Topic 2:

Legal frameworks to prevent health risks related to reuse in agriculture

Topic overview

Time
Session 1: Topic Presentation – 90 min

Objectives
- Present an overview of health risks related to reuse in agriculture.
- Give an overview of existing laws, regulations and guidelines.
- Introduce the new WHO approach.
- Introduce a broad range of measures for the prevention of health risks.

Participants should be able to
- Recognise the health risks related to wastewater reuse.
- Understand the principle means for health protection in wastewater reuse.
- Have basic knowledge of existing regulations and quality standards for reuse mainly in agriculture.

Material
- Projector
- Assignment material

This topic is covered in 1 session:

1. Session 1 – Topic Presentation

The topic presentation should introduce participants to different approaches of regulating wastewater reuse to prevent risks mainly to human health. Starting from a general introduction on why legal frameworks for wastewater reuse are helpful, the session will present the main approaches in regulating reuse together with their advantages and disadvantages. At the end, some examples of laws regulating reuse in specific countries are given as well as an introduction to the approach that is followed by the World Health Organisation.

5.1 Session 1 – Topic Presentation

Legal frameworks to prevent health risks related to reuse in agriculture

Session overview

Title Legal frameworks to prevent health risks related to reuse in agriculture

Objectives
- Present an overview of health risks related to reuse in agriculture.
- Give an overview of existing laws, regulations and guidelines.
- Introduce the new WHO approach.
- Introduce a broad range of measures for the prevention of health risks.

Teaching method lecture and class discussion

Time estimation 90 min

Needed material projector, assignment paper

Session guide

1. Slides 5-6 introduce the session with explanations on why legal frameworks are helpful in controlling health risks and thus promoting wastewater reuse.

2. Any laws and regulations should however be adapted to the local situation (slides 7-9).

3. Parameters that are typically regulated include microbiological and physico-chemical parameters as well as restrictions relating to crops and irrigation (slides 11-14).

4. The various general approaches that have been taken mainly in the USA, some developing countries and by the WHO are explained in slides 16-17.

5. However, it should also be considered that several factors determine whether a potential or a real risk for human health exists (slides 19-20).

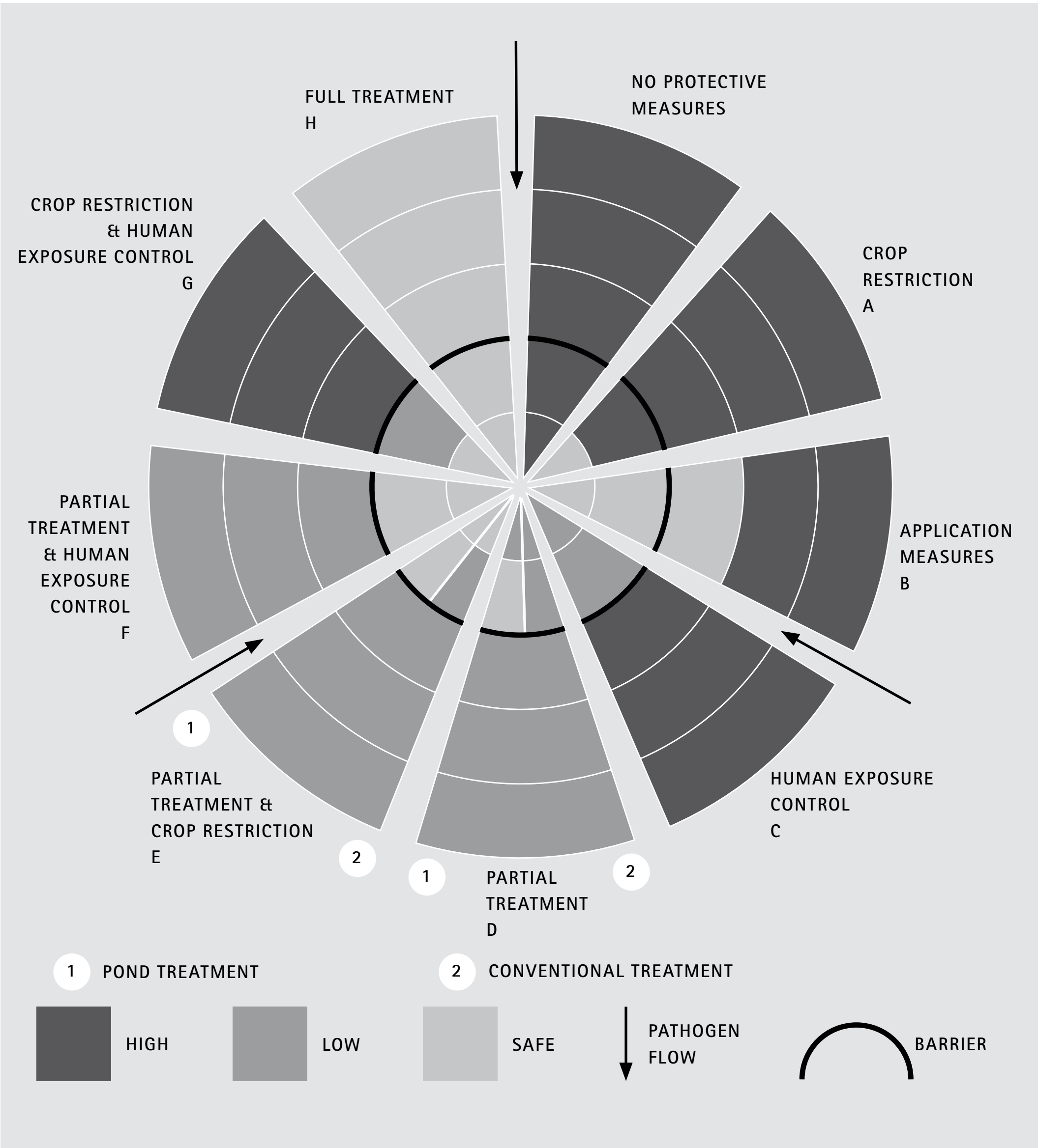
6. Slide 21 illustrates the level of risk to human health associated with different combinations of control measures for the use of wastewater or excreta in agriculture. The concentric circles (bands) represent the various "media" on the path of human pathogens from the point of wastewater effluent disposal to the potential consumer of contaminated

foods. The effect of different remedial techniques (interventions A to H) in protecting agriculture workers and consumers is shown and compared to the high contamination risk associated with the (non-recommended) practice of reusing untreated wastewater for irrigation. Source Blumenthal 1988.

7. This figure is rather complex. It is therefore suggested to print the discussion paper for the participants and discuss the various risks and control measures in class.

Different combinations of control measures

The figure shows a generalized model of the level of risk to human health associated with different combinations of control measures for the use of wastewater or excreta in agriculture or aquaculture. The concentric circles (bands) represent the various "media" on the path of human pathogens from the point of wastewater effluent disposal to the potential consumer of contaminated foods. The effect of different remedial techniques (interventions A to H) in protecting agriculture workers and consumers is shown and compared to the high contamination risk associated with the (non-recommended) practice of reusing untreated wastewater for irrigation. (Source: Blumenthal 1988)



8. After the discussion, some examples are given of how the discussed approaches have been put into legal practice, namely in the form of the 1989 WHO guidelines, the Mexican Standard, and the Jordanian Standard (slides 23-33).

WHO (1989)

The World Health Organisation (WHO) has recognised both the potential benefits and risks of wastewater reuse and, consequently, has developed guidelines to assist policy makers to legislate permission for the safe use of wastewater. Acknowledging the fact that previous health standards were unnecessarily high and did not reflect prevailing conditions of wastewater use in developing countries, the 1989 WHO guidelines (see Slide 23) were developed with the objective of protecting against excess infection in exposed populations. Faecal coliforms and intestinal nematode eggs are used as pathogen indicators. The recommended quality standards are combined with best practice guidelines for reuse management (crop restrictions, irrigation techniques, good personal hygiene, and use of protective clothing).

Many countries have welcomed the guidance from the 1989 WHO standards and guidelines. France, for example, used a similar approach in setting guidelines, which were published in 1991. These guidelines adopt analogous water categories (called A, B and C in the WHO guidelines) and microbiological limits, but stipulate additional rules for wastewater application: For example, for category A, the quality requirement must be extended to include the use of irrigation techniques that avoid wetting fruit and vegetables. Furthermore, spray irrigation of golf courses and open landscaped areas is only allowed outside public opening hours (Blumenthal et al. 2000a).

While the 1989 WHO guidelines were sometimes criticised for not guaranteeing health protection, its recommendations were still difficult to meet for some developing countries. Mexico and some other countries have modified the microbiological criteria to suit local epidemiological and economic circumstances.

The WHO has subsequently revised their guidelines on wastewater reuse and the third edition was published under the title "Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture" in 2006.

The revised guidelines can be downloaded at: http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html

Mexico (1996)

In Mexico, microbiological and chemical standards governing wastewater reuse in agriculture have developed considerably over the last 15 years. Existing guidelines were reviewed in 1991, 1993, and again in 1996. Particular attention was paid to (1) the cultivation of vegetables and other crops eaten raw, (2) the importance of wastewater reuse in agriculture as a form of wastewater treatment and disposal, and (3) the diversity of treatment processes available to achieve the guidelines. (Peasey et al. 2000)

The final revision of the microbiological standards was introduced in 1996. The adopted standard NOM-001-ECOL-1996 "establishes the maximum permissible limits of contaminants in wastewater to be discharged into national waters and onto national soil". As in the WHO guidelines, faecal coliforms are used as the indicator for pathogenic contamination. The maximum limit concentration of faecal coliforms imposed for wastewater to be discharged into national water or property and for wastewater application to soils is a monthly mean of 1,000 MPN (most probable number) per 100 ml and a daily mean of 2,000 MPN per 100 ml. Helminth eggs are used as the indicator for parasitic contamination. The maximum value for wastewater application to soils (for agricultural irrigation) is one helminth egg per litre for restricted irrigation and five helminth eggs per litre for unrestricted irrigation. In the annex of the Mexican regulations, suitable irrigation techniques are defined (Mexican Official Regulation as cited in Scott et al. 2000).

The revised standards impose the same limit values regardless of the discharge source. The standards were designed to be accomplishable with the technology and resources available at present and in the near future in Mexico and to be easily enforced requiring only limited monitoring. The standard was further designed to sufficiently protect "at-risk" groups according to the actual state of research. The proposed microbiological standards take into account all possible treatment processes. A stricter helminth standard would have required additional use of filters in conventional treatment plants which would add significant extra costs.

The Mexican reuse standard also stipulates limit concentrations for basic contaminants, heavy metals and cyanides in wastewater to be discharged into national water or property. The allowable range for pH is 5 to 10 units.

Jordan (2002)

The key policy objectives of the Jordan water reuse management plan are to use reclaimed water wherever this is practical in exchange for present and future use of freshwater and to maximise the returns from reclaimed water resources. Therefore, the Government of Jordan has stipulated that all new wastewater treatment projects must include feasibility aspects for wastewater reuse and has set standards for treated domestic wastewater effluent (Jordanian Standards JS 893/1995 revised in 2002). The Jordanian standards for wastewater reuse are based on reuse categories according to the type of crops and areas to be irrigated. The standard prohibits the use of reclaimed water for irrigating vegetables to be eaten raw. Furthermore, it is prohibited to employ sprinkler irrigation for applying reused water, except for irrigating golf courses. In this case, irrigation should take place at night and sprinklers must be movable and not accessible for day use. When using reclaimed water for irrigating fruit trees, irrigation must be stopped two weeks prior to fruit harvest and all fallen fruits must be discarded.

In addition, the Jordanian standards provide guide values for a range of chemical wastewater components for the purpose of guidance. If these values are exceeded, "the end user must carry out scientific studies to verify the effect of that water on public health and the environment and suggest ways and means to prevent damage to either". (http://www.mwi.gov.jo/mwi/JS-893.aspx)

The new WHO approach:

The new WHO approach of tolerable disease burden and how to estimate it is rather complex and this lecture does not aim to explain it in detail. Therefore, some questions might come up during the lecture. You can refer students to the WHO guidelines and prepare yourself by studying it.

1. The 1989 World Health Organization (WHO) guidelines on the "Safe Use of Wastewater in Agriculture" have long been the standard reference for regulating wastewater reuse. Latest research and results from practice, however, have stressed the fact that the 1989 WHO guidelines needed to be broadened to better accommodate local conditions and, therefore, should be complemented with other health measures, such as hygiene promotion, provision of adequate drinking water and sanitation. The revised WHO (2006) guidelines now consider wastewater treatment as only one component of an integrated risk management strategy (slide 35).

2. The revised WHO guidelines for wastewater quality now include health-based targets, which correspond to the maximum 'tolerable' burden of disease that would result from wastewater use in agriculture (slide 36).

3. For the development of the WHO guidelines, the median infection risk resulting from wastewater reuse in agriculture was determined by use of realistic human exposure scenarios (slide 37).

4. Based on these scenarios and infection risks, the required pathogen reduction was determined that needs to be achieved through wastewater treatment and other health protection measures (slide 38).

5. Slide 39 shows various post-treatment health-protection control measures and corresponding pathogen reductions achieved.

6. Examples of options for the reduction of pathogens by different combinations of health protection measures that achieve the WHO health based target are illustrated in slide 40.

5.2 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. Which microbiological parameters are usually used as indicators in health guidelines for reuse?

2. Why do guidelines have to be adapted to the specific local situation?

3. Why are strict microbiological quality standards not always the best solution to control health risks from reuse?

4. What is the difference between a potential health risk from wastewater reuse and the actual health risk?

Answers:

1. Faecal coliforms (or total coliforms or E.coli) and helminth eggs (or nematode eggs).

2. Because they need to be need to be realistic in relation to local conditions (epidemiological, socio-cultural, technical, environmental factors), affordable and enforceable.

3. Because they may only be achievable with advanced treatment technology, which is very costly and not always available in developing countries.

4. An actual risk only exists, when all of these conditions are fulfilled: (1) Either an infectious dose exists or pathogens multiply to this dose; (2) The infective dose reaches the human host. (3) The host becomes infected. (4) The infection causes disease or further transmission. Otherwise, only a potential risk exists.

5.3 Literature

Blumenthal, U.J.; D.D. Mara, A. Peasy, G. Ruiz-Palacios and *R. Stott* 2000a: Guidelines for the microbiological quality of treated wastewater used in agriculture: recommendations for revising WHO guidelines. Bulletin of the World Health Organisation (WHO) 78, 9. http://www.who.int/docstore/bulletin/pdf/2000/issue9/bu0741.pdf

Scott, C. A.; J. A. Zarazúa and *G. Levine* 2000: Urban-wastewater reuse for crop production in the water-short Guanajuato river basin, Mexico. Colombo, Sri Lanka. Research Report 41. Colombo, Sri Lanka: International Water Management Institute. http://www.iwmi.cgiar.org/pubs/PUB041/Report41.pdf

WHO 1989: Health Guidelines for Use of Wastewater in Agriculture and Aquaculture. World Health Organization, Technical Report Series 778, Geneva: World Health Organisation.

WHO 2006: Guidelines for the safe use of wastewater, excreta, and greywater. Volume 2: Wastewater use in agriculture. Geneva: World Health Organisation.
http://www.who.int/water_sanitation_health/wastewater/gsuweg2/en/index.html

Mara, Duncan and *Annika Kramer* 2007: The 2006 WHO Guidelines for Wastewater and Greywater Use in Agriculture: A Practical Interpretation. In: EMWater Book reference to be confirmed

5.4 Recommended Reading

U.S. Environmental Protection Agency (U.S. EPA) 2004: Guidelines for Water Reuse. EPA/625/R-04/108 September 2004. http://www.epa.gov/ord/NRMRL/pubs/625r04108/625r04108.htm

Blumenthal, U.J.; A. Peasy, G. Ruiz-Palacios and *D.D. Mara* 2000b: Guidelines for wastewater reuse in agriculture and aquaculture: recommended revisions based on new research evidence. WELL Study No. 68 part 1. http://www.lboro.ac.uk/well/resources/well-studies/full-reports-pdf/task0068i.pdf

International Water Management Institute (IWMI) 2006: Recycling Realities: Managing health risks to make wastewater an asset. Water Policy Briefing, Issue 17.
http://www.gwpforum.org/gwp/library/IWMI-GWP%20Wastewater%20brief.pdf

Sperling, M. von and *B. Fattal* 2001: Implementation of guidelines: some practical aspects. In: L. Fewtrell and J. Bartram (eds.): Water Quality: Guidelines, Standards and Health; Assessment of Risk and Risk Management for Water-related Infectious Disease. London, UK: International Water Association (IWA) on behalf of the World Health Organization, pp. 361–376.
http://www.who.int/water_sanitation_health/dwq/iwachap16.pdf

WHO-CEHA 2006: A compendium of standards for wastewater reuse in the Eastern Mediterranean Region. World Health Organization.
http://www.emro.who.int/ceha/pdf/Compendium%20wastewater%20standards.pdf

5.5 Internet Resources

U.S. Environmental Protection Agency (EPA) – Office of Wastewater Management's online section
EPA's Office of Wastewater Management supplies information on a wide range of wastewater management issues in the U.S., including texts of relevant U.S. laws, EPA wastewater programmes, wastewater standards, treatment and reuse.
http://www.epa.gov/owm/

World Health Organisation (WHO) – Water, Sanitation and Health section
The Water, Sanitation and Health service offers WHO's guidelines for the safe use of wastewater as well as a number of further publications in the field for download. More information can be found on a wider range of water and sanitation issues, and interested readers can subscribe to the WHO water and sanitation mailing list.
http://www.who.int/water_sanitation_health/wastewater/en/index.html

WHO Regional Centre for Environmental Health Activities (CEHA)
CEHA is a specialised centre established in Amman, Jordan, by the World Health Organisation's Regional Office for the Eastern Mediterranean (EMRO). CEHA's mandate is to promote environmental health through technical support for national capabilities and programmes in the Member Countries of the Region.
http://www.emro.who.int/ceha/

6. Topic 3:

Planning and economic evaluation of reuse projects

Topic overview

Time:
Session 1: Topic Presentation – 70 - 90 min
Session 2: Case Study Exercise – 180 min

Objectives
- Introduce main steps in planning a reuse project with a focus on reuse in agriculture.
- Introduce economic aspects related to reuse.
- Stress the importance of economic and financial analysis.

Participants should be able to
- Take into consideration all important aspects when planning a reuse project.

Material
- Marker
- Flipchart
- Projector
- Assignment material
- Calculator

This topic is covered in 2 sessions:

1. Session 1 – Topic Presentation

The topic presentation covers the content of the EMWater Guide for decision makers and explains the process of planning a reuse project. Several aspects have to be considered. The selection process suggested here leads from an overall assessment of potential supply and demand for wastewater to a more detailed evaluation of related benefits and risks as well as an assessment of the costs involved.

2. Session 2 – Case Study Exercise

The case study (see the assignment paper) presents the situation in the Gaza Strip in general and in the Gaza governorate and its WWTP in particular. Quantity and quality of the WWTP effluent are given as well as existing crops and their water demands. The participants are asked to discuss the various steps of the planning process in groups and to present results where the information available allows for it.

6.1 Session 1 – Topic Presentation

PPT

Planning and economic evaluation of reuse projects

Session overview

Title Planning and economic evaluation of reuse projects

Objectives
- Introduce main steps in planning a reuse project with a focus on reuse in agriculture
- Introduce economic aspects related to reuse
- Stress the importance of economic and financial analysis

Teaching method lecture

Time estimation 70 - 100 min

Needed material projector, flip-chart

Session guide

1. The slides 3 and 4 give the background for planning a reuse project: What is the overall goal, and what should feed into the planning process?

2. The following slides focus on presenting the planning process as illustrated in the flow chart below.

1. Inventory of potential supply and demand for reclaimed water

Provide an overview of quantity, quality and location of potential sources and users of reclaimed water in a given project area.

Objective: identify a broad range of potential reuse applications

Stop / Go decision point

Is there a potential source of reclaimed water in vicinity of a potential user?
Does the quantity and quality of reclaimed water supply meet the demand of the application?
If yes, proceed to the analysis of legal requirements.
If not, you might have to consider additional treatment or storage

2. Assess legal and institutional framework

Analyse legal an institutional requirements

Objective: assess whether the selected potential reuse applications are legal and what requirements have to be met.

Stop / Go decision point

Do laws and regulations allow the potential reuse application? If yes, continue to a more detailed assessment of the application. If not, you may have to consider additional wastewater treatment or adaptation of the reuse application.

3. Detailed analysis of reuse alternatives

For each selected reuse application assess

- Related environmental and health risks and identify respective requirements.
- Needs for additional infrastructure
- Public acceptance of reuse application

Objective: select most viable reuse applications based on the related risks and accordant counter measures.

Stop / Go decision point

Does the selected reuse application seem viable and does it not entail unpredictable risks?
If yes, continue to the economic evaluation of the most favourable reuse applications.

4. Economic evaluation:

assess direct and indirect costs and benefits related to the selected reuse application and compare with a non-reuse scenario.

Objective: determine the reuse application with the highest net benefit to society

Stop / Go decision point

Does the selected reuse application have an overall economic benefit?
If yes, take the most favourable application through a financial feasibility check.

5. Check financial feasibility

prepare preliminary designs for the selected reuse systems and estimate

- all costs related to distribution and storage infrastructure, monitoring, etc.
- the marketability of goods produced with reclaimed water

Objective: assess whether the selected reuse application is financially feasible for a specific user of reclaimed water or participant in a reuse project

Stop/ Go decision point

Is the selected reuse application financially beneficial? If yes, you can continue to prepare a business plan for the selected reuse application.

3. Generally, the planning process will begin with an inventory of existing sources of wastewater in a given project area. Based on this, potential uses of reclaimed water can be identified and quantified. The objective is to find the least effort path between a given wastewater source and the desired wastewater application. Although it is essential to be open and receptive to the possibility of additional treatment and storage options, reuse applications should be given priority where these are not necessary in order to save costs and resources. (Slides 7-9)

4. Another element important to the decision-making process is the detailed analysis of the existing legal and institutional framework (specific legislation on wastewater reuse, regulations on environmental and groundwater protection, irrigation water quality standards, occupational health standards, etc.). Furthermore, the inventory should include all agencies and authorities that have jurisdiction: Which ministries / authorities are involved in controlling and licensing the use of reclaimed water? Which ministries / authorities monitor compliance with regulations? Which organisations are charged with safeguarding public health? (Slides 11-13)

5. Given that – according to the preliminary assessment– the quantity, quality and availability of effluents do meet the demand requirements of a potential reuse application and the legal framework is positive towards it, a more detailed assessment should be started which involves ranking the potential applications according to the potential risks they may entail. The assessment of the viability and sustainability of a proposed reuse project should address the following elements (slides 15-21):

- Suitability of soils and crops
- Potential environmental risks and required counter-measures
- Health-related requirements
- Requirements of infrastructure amendments
- Acceptance of wastewater reuse

6. Based on the detailed analysis of selected reuse options in the previous step, an economic evaluation should be performed with the objective of identifying the reuse options with highest net benefit to society. A comprehensive economical assessment should also include external costs and benefits that arise from positive and negative impacts on health, environment, etc. However, such costs are often difficult to determine in monetary terms. (Slides 23-27) The table below provides a (non-exhaustive) list of potential costs and benefits to be addressed in an economic evaluation of reuse projects.

Potential costs related to	Potential benefits
External effects	
Negative external effects: • Health-related impacts • Environmental impacts (groundwater contamination, soils) • Impact on adjacent lands, nuisances (bad odours, insects)	Positive external effects: • Preservation of freshwater resources, reduced investment in extending water supply systems and/or developing new water resources, sustained or increased availability of water for other uses • Positive health effects (where wastewater was previously discharged untreated) • Positive environmental effects (no discharge of [un]treated wastewater into the sea or inland waters)
Sewerage system	
• Separate conveyance and distribution network for reclaimed water • Additional treatment to meet quality requirements for reuse • Administrative costs associated with reclaimed water supply services (customer billing etc.)	• Less treatment required than for discharge into the sea or inland waters (e.g. no advanced treatment for nutrient removal needed) • No conveyance or transport of effluents to discharge location • Savings in discharge fees / taxes
Project site	
• Adaptation of water application infrastructure to fit usage of reclaimed water • O&M costs (more frequent cleaning of water distribution system, monitoring of water quality) • Storage (investment in, and O&M of, storage facility) • Additional on-site treatment • Decreased income from crops (where water reuse in irrigation is only allowed for less profitable crops)	• Saving on costs for fresh water • Additional water availability • Savings in fertiliser costs • Higher crop yields (through the fertiliser effect of reused wastewater); shift to more profitable crops (where wastewater can provide additional irrigation)

7. In order to obtain a clearer view of the economic benefits, the costs of a reuse project should also be compared with a “baseline scenario without wastewater reuse”. (Slide 28.)

8. You could discuss various baseline scenarios with the participants. The World Bank Guide for Planners for Reuse of Wastewater in Agriculture (Khouri et al. 1994) suggests the following baseline scenarios for evaluation of wastewater reuse for irrigation:

1. No existing irrigation: Where there is no existing agriculture or the only irrigation is from rainfall, benefits would be the introduction of agricultural production or more production from existing farms. Costs would include those for (a) setting up the irrigation system, and (b) transporting and treating the wastewater (but only the cost in excess of that required to discharge it into receiving waters). Where sound environmental disposal is enforced, the cost of treatment for reuse may be less than that for direct discharge, in which case the value for (b) would be negative--a benefit.

2. Existing irrigation: Where wastewater can provide supplemental irrigation, it might permit a shift to more profitable crops (for example, from grains to vegetables) or longer growing seasons. The additional revenues of this expansion minus its cost would be the benefit. Wastewater-associated costs would be the same as those in (1).

3. Existing irrigation: Where wastewater can substitute for scarce freshwater sources, a no-action scenario would imply (in the medium or long term) reducing or abandoning irrigated areas to increase the drinking water supply for domestic consumers; the crop production saved would be the benefit. Wastewater-associated costs would be the same as those in (1).

4. Existing, uncontrolled wastewater irrigation: This is a situation quite often encountered in developing countries. Shifting to controlled operation using treated wastewater would result in public health and environmental improvements. These improvements should have a major weight in project development, even if they are difficult to quantify. Two situations might further increase the overall feasibility of the controlled-reuse option. First, land application of treated effluent might be part of the least-cost wastewater treatment alternative. Second, irrigating with treated wastewater might lead to the production of more profitable crops.

5. Existing or new freshwater irrigation of public parks or greenbelts: Where this is the case, shifting to wastewater irrigation would be justified if it would cost less than wastewater discharge to surface water and/or if it would provide environmental benefits equal to the cost of reclamation and irrigation investments. These could be quantified or at least described qualitatively. Another benefit would be the value of the potable water saved, which could be substantial in cities where water is scarce.

6. No existing irrigation, wastewater application as land treatment: In this situation, there is no existing need or demand for irrigation water. The least-cost wastewater treatment alternative, however, would include the disposal of treated wastewater on land. The cost of the entire system, including irrigation, should be included in wastewater-associated costs. Benefits from irrigation could enhance the feasibility of wastewater treatment.

(Khouri et al. 1994)

9. Slides 29-32 present an example for economic evaluation of two reuse alternatives. The example is also given in the handout paper that you might want to print for participants to help them follow the presentation.

10. Slides 35-39 present the assessment of financial feasibility as the final step in planning a reuse project. This includes market assessments for products and reclaimed water as well as mechanisms to recover costs of a reuse project.

11. The following example can be given to participants as an individual home-work assignment and then latter discussed in class, depending on time constraints.

Economic Evaluation of alternative reuse options

Based on:
Haruvy, N. 1996: Wastewater Reuse –Regional considerations. Paper presented at the 36th European Congress of the Regional Science Association, ETH Zurich, Switzerland, 26-30 August 1996. http://www.ersa.org/ersaconfs/ersa96/SESSION.D/d4.pdf

The following situation is assessed:

- Wastewater is produced in Area 1 (central area), a densely populated area, where hence land is expensive and a lot of wastewater is produced.
- Wastewater treatment in Area 1 consists of secondary treatment with activated sludge, a technology with low land requirements but high capital and energy costs.
- Two alternative locations for reuse of treated wastewater:
  1. In the area where wastewater is produced, Area 1 (central), densely populated and located over the main aquifer used for drinking water supply.
  2. Conveyance of reclaimed water to Area 2 (south) with low density population and no aquifer, thus lower human health and environmental risks.
- Specific crop patterns exist in each of the area.
- Additional tertiary treatment for N-removal is also considered as a further option.

Net costs and benefits of agricultural wastewater reuse in cents per m^3

External effects	Area 1 Secondary wwt	Area 1 Tertiary wwt	Area 2 Secondary wwt	Area 2 Tertiary wwt
Negative impact on aquifer [a)]	-10	0	0	0
Negative health impacts [b)]	-4	0	-4	0
Aquifer recharge through irrigation [c)]	7	7	0	0
Total external effects	-7	+7	-4	0

Sewerage system costs	Area 1 Secondary wwt	Area 1 Tertiary wwt	Area 2 Secondary wwt	Area 2 Tertiary wwt
Secondary treatment	-27	-27	-27	-27
Tertiary treatment	0	-17	0	-17
conveyance	0	0	-13	-13
Total sewerage system costs	-27	-44	-40	-57

Agricultural costs and benefits	Area 1 Secondary wwt	Area 1 Tertiary wwt	Area 2 Secondary wwt	Area 2 Tertiary wwt
Fertiliser saving [d)]	+5	0	+5	0
freshwater dilution [e)]	-1	-1	-1	-1
Agricultural output [f)]	36	36	29	29
Crop changes [g)]	-5	0	-5	0
Decreased yield due to excess N [h)]	0	0	-2	0
Decreased yield due to excess salinity [i)]	-4	-4	-2	-2
Total agricultural benefits	31	31	24	26

Total	Area 1 Secondary wwt	Area 1 Tertiary wwt	Area 2 Secondary wwt	Area 2 Tertiary wwt
Total external effects	-7	+7	-4	0
Total sewerage system costs	-27	-44	-40	-57
Total agricultural benefits	31	31	24	26
Balance	-3	-6	-20	-31
Compared to discharge [j)]	+41	+38	+24	+13

[a)] Contamination of aquifer from nitrogen leaching.
[b)] Health effects due to increased risks from secondary water.
[c)] Calculated from percolation of irrigation water into aquifer.
[d)] Decrease in fertiliser costs due to nutrient content in secondary wastewater.
[e)] Additional freshwater needs to dilute salinity in reclaimed water.
[f)] Agricultural output calculated from marginal value of water in agriculture in the specific location.
[g)] Loss of income due to need for change to crops not eaten raw (restricted irrigation with secondary effluent).
[h)] Decrease in crop yields due to excess nutrient content in secondary effluent (only applies to type of crops grown in Area 2).
[i)] Decrease in crop yields due to salinity of reclaimed water (depending on types of crops grown).
[j)] Costs of discharge into river, tertiary treatment required (44 cents/m^3).

6.2 Session 2 – Case Study Exercise

Present situation of wastewater and the possible prospect for its reuse in the Gaza Strip

Session overview

Title Present Situation of Wastewater and the Possible Prospect for its Reuse in the Gaza Strip

Objectives
- To understand and practise the main steps to consider in planning a reuse project in agriculture.

Teaching method group work, discussion

Time estimation:
- 5 min to divide into groups
- 10 min to explain the exercise
- 60 min for groups to discuss the planning process and results for the case given
- 60 min for presentation of results and discussion

Needed material group assignment paper, markers, pin boards, flip charts, calculator

Session guide

1. Divide participants into 2-3 groups and give them the exercise materials.

2. Each group will discuss the planning steps, benefits and costs of wastewater reuse in the case of Gaza according to the assignment paper and write their results on flip charts.

3. Give groups time to discuss the process and results according to the tasks given below. Provide them with help if necessary.

4. After the groups have had enough time to discuss each point within the group, ask them to come together in class and discuss the results together. For each of the questions given below, ask one group to present their results. Discuss the results with the whole group.

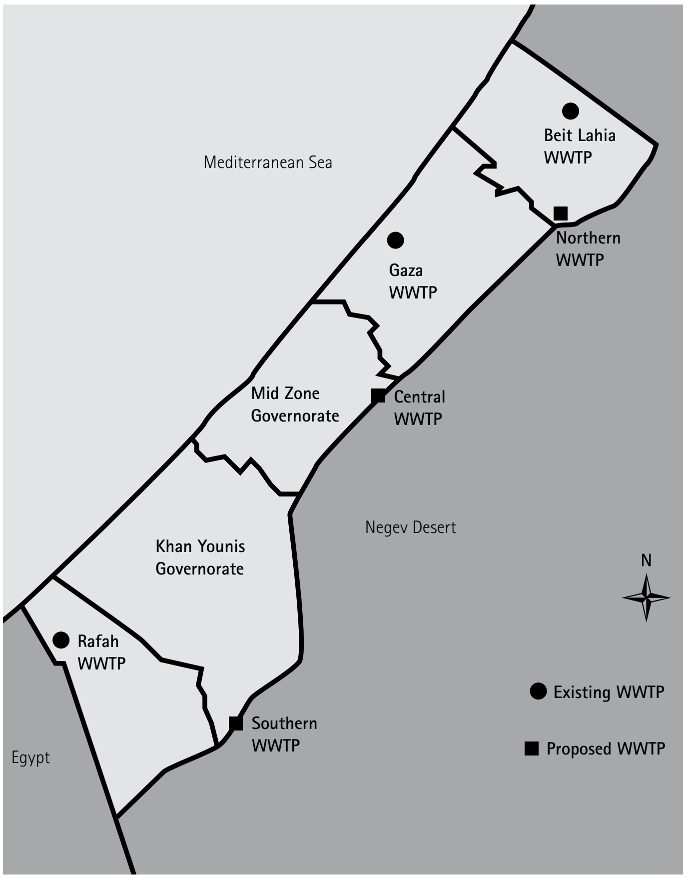


Fig. 1: Map of the Gaza Strip showing locations of existing and proposed wastewater treatment

Present Situation of Wastewater and the Possible Prospect for its Reuse in the Gaza Strip

Reuse of treated wastewater from the Gaza WWTP

The following Case Study is based on an an article by Khalil M. Tubail, Jamal Y. Al-Dadah and Maged M. Yassin (Gaza/Palestine) that was published in the journal KA – Abwasser, Abfall 2004 (51) Nr. 8.

Background

The Gaza Strip is a plain coastal strip located in a semi-arid area (360 km^2). The annual average rainfall varies from 400 mm in the north to about 200 mm in the south of the strip. The entire population depends totally upon groundwater. The total abstraction of groundwater in Gaza Governorates is estimated to be 135 Mm^3/year. Crop cultivation consumes around two thirds of the total water withdrawal; the reminder is used for industrial and domestic water supplies.

The aquifer is continuously being over-exploited. The gap between water demand and water supply is increasing with time as a result of rapid population growth in this small area. The water balance record reveals a deficit of about 45 Mm^3/year. Reconciliation relies in the strategy of ensuring additional water supply and wastewater reuse schemes.

All the existing three wastewater treatment plants (WWTPs) in the Gaza strip are overloaded. As the actual flow far exceeds the design flow, blocked pipes and flooded manholes have become routine events in Gaza Strip. The WWTP in the Gaza Governorate is the biggest one in the Gaza Strip. The Gaza WWTP recharges the aquifer with approximately 3.6 Mm^3 of treated wastewater annually through infiltration in sandy basins and the remaining quantity (11.7 Mm^3) is disposed into the Mediterranean Sea. Its main features are:

Governorate	Gaza
Name of WWTP	Gaza
Year of establishment	1977
Population connected to sewer network	78 %
Processes	Two anaerobic ponds, one aerated lagoon and two trickling filters
Inflow (Mm^3/year)	11.7 (designed flow) 15.3 (actual flow)
Outflow	Mediterranean Sea, infiltration

Some biological and chemical properties of influent and effluent wastewater of the Gaza WWTP monitored at a monthly basis during the years 2001 and 2002 are given in Table 1. Further details on the Gaza WWTP effluent quality are given in Table 2.

Table 1 Some Biological and Chemical Properties of Influent and Effluent of Gaza WWTP

Year	Gaza					
	Influent [mg/l]			Effluent [mg/l]		
	BOD	COD	SS	BOD	COD	SS
2001	688 ± 195	1 375 ± 344	644 ± 182	31 ± 8	100 ± 21	31 ± 8
2002	518 ± 94	984 ± 180	522 ± 118	26 ± 3	91 ± 8	32 ± 8

Table 2 Current Effluent Quality (Chemical and Biological) of The Gaza WWTP

Parameter	Value
pH	7.7
total Kjeldahl nitrogen as N	57 mg/l
ammonia-nitrogen	18 mg/l
nitrate-nitrogen	27 mg/l
phosphate	26 mg/l
chloride	418 mg/l
faecal coliform	40 x 106CFU/100 ml*)

Opinion of 79 farmers was sought for using treated wastewater by interviewing farmers through a questionnaire. The outcome is summarized in Table 3. The majority of interviewed farmers (86.1 %) firmly agreed to use the treated wastewater for irrigation of 285.6 hectare (80.7 %) of the total targeted area. Only eight farmers (10.1 %) rejected the idea. Although most of the farmers (71; 89.9 %) wanted infrastructural and other support like irrigation network, extension, fertilizers and protective gear, the majority of them (71; 89.9 %) also answered that they were willing to pay for wastewater. This attitude of farmers appears to be very encouraging in launching a move towards developing strategy for wastewater reuse in agriculture.

Table 3 Attitude of Farmers (N = 79) Toward Wastewater Reuse for a Agricultural Area Of 353.8 ha in Beit Hanoun

Attitude	Number of farmers	Percentage (of the number)	Area [ha]	Percentage (of the area)
Farmers agreed completely	68	86.1	285.6	80.7
Farmers agreed partially	3	3.8	23.9	6.8
Farmers rejected	8	10.1	44.3	12.5
Farmers accepted to pay	71	89.9		
Farmers seeking subsidy	71	89.9		

In an effort to promote reuse of wastewater, citrus, olives and almonds have been selected for future irrigation with treated wastewater. The existing pattern of these crops and their irrigation demand in the Gaza Governorate is illustrated in Table 4.

Table 3 Existing Pattern of Selected Crops and Irrigation Demand in the Gaza Governorate

Crop	Cultivated area [ha]	Crop water demand [m3/ha/y]	Total annual demand [Mm3/y]
Citrus	1 500	9 000	13.5
Olives	1 530	3 000	4.59
Almonds	120	4 000	0.48
Total	3 150	16 000	18.57

Task

Your group has been selected as the planning committee for a reuse project in Gaza. Using the information given above, start the planning process according to the scheme discussed in the lecture.

1. What are the first assessments you would undertake? And what are the results?

2. What measures do you suggest to control health risks related with reuse of the Gaza effluent?

3. What could be environmental risks related with the reuse of the Gaza effluent?

4. What further assessments would be necessary? What information is missing to fulfil a complete assessment of the planned project?

5. List all factors that should be included in an economic evaluation of the planned project? Please fill the table below.

Potential costs related to	Potential benefits
External effects	
Negative external effects:	Positive external effects:
Sewerage system	
Project site	

6.3 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. What potential sources of wastewater for reuse can you think of? Name three.

2. In which aspects does the supply of wastewater ideally have to meet the demands of the reuse application?

3. What additional infrastructure might be required for reuse projects?

4. What are the five steps suggested for selecting a reuse project?

5. What assessments should the detailed analysis of a wastewater reuse project in agriculture cover?

Answers:

1. Possible answers are: Municipal wastewater, Commerce, Agro-industry, Manufacturing industry, Agriculture, Aquaculture, Power plants, Stormwater.

2. Location of the wastewater source, Quantity of effluents from a given source, Seasonal variation of flow (e.g., monthly flow rates could be identified for each month of the year), Effluent quality.

3. Infrastructure amendments for distribution, Additional on-site treatment, Water storage system may be required to balance supply and demand fluctuations.

4. The process suggested covers:
   i. Potential sources and users of reclaimed water
   ii. Legal requirements and responsible institutions
   iii. Detailed analysis of reuse alternatives
   iv. Economic evaluation
   v. Financial feasibility

5. The detailed analysis should cover:
   i. Suitability of soils and crops
   ii. Potential environmental risks and required counter-measures
   iii. Health-related requirements
   iv. Requirements of infrastructure amendments
   v. Acceptance of wastewater reuse

6.4 Literature

EMWater Guide

Haruvy, N. 1996: Wastewater Reuse –Regional considerations. Paper presented at the 36th European Congress of the Regional Science Association, ETH Zurich, Switzerland, 26-30 August 1996.
http://www.ersa.org/ersaconfs/ersa96/SESSION.D/d4.pdf

Khouri, N.; J. M. Kalbermatten and *C. R. Bartone* 1994: Reuse of Wastewater in Agriculture: A Guide for Planners. Water and Sanitation Report 6. UNDP-World Bank Water and Sanitation Program. Washington, DC: The World Bank.
http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000009265_3961006165519

Florida Reuse Coordinating Committee 1996: Guidelines for Preparation of Reuse Feasibility Studies for Consumptive Use Permit Applicants.
http://www.dep.state.fl.us/water/reuse/docs/feasibility.pdf

Tubail, Khalil M., Jamal Y. Al-Dadah and *Maged M. Yassin* 2004: Present Situation of Wastewater and the Possible Prospect for its Reuse in the Gaza Strip. KA – Abwasser, Abfall 2004 (51) Nr. 8.

6.5 Recommended Reading

Hussain, I.; L. Raschid; M. A. Hanjra; F. Marikar and *W. van der Hoek* 2002: Wastewater use in agriculture: Review of impacts and methodological issues in valuing impacts. (With an extended list of bibliographical references). Working Paper 37. Colombo, Sri Lanka: International Water Management Institute.
http://www.iwmi.cgiar.org/pubs/working/WOR37.pdf

Hussain, I.; L. Raschid; M. A. Hanjra; F. Marikar and *W. van der Hoek* 2001: A framework for analyzing socioeconomic, health and environmental impacts of wastewater use in agriculture in developing countries: Working Paper 26. Colombo, Sri Lanka: International Water Management Institute.
http://www.iwmi.cgiar.org/pubs/working/WOR26.pdf

Darwish, M. R.; F. A. El-Awar; M. Sharara and *B. Hamdar* 1999: Economic-environmental approach for optimum wastewater utilization in irrigation: A case study in Lebanon. Applied Engineering in Agriculture. Jan.15(1): 41-48.

6.6 Internet Resources

Water Guide: http://www.members.optusnet.com.au/~tloetscher/tools.htm
Decision support programmes that can help in identification of potential applications.

Water and Wastewater Treatment Technologies for Appropriate Reuse (WAWWTAR)
WAWWTAR is a Windows-based predictive computer programme designed to support planners in the choice of water conditioning and wastewater treatment technologies appropriate to any given setting. Its website serves as a means of distribution and marketing, as a user's forum and as a source for updates.
http://firehole.humboldt.edu/wawttar/wawttar.html#introduction

7. Topic 4:

Importance of awareness raising for reuse

Topic overview

Time
Session 1: Topic Presentation – 70 - 100 min
Session 2: Role Play – 90 min

Objectives
- Reinforce the importance of awareness raising for successful introduction of reuse
- Give an overview of means for raising awareness

Participants should be able to
- Know the common caveats and objections against wastewater reuse
- Be able to draw an awareness raising campaign plan

Material*:*
- Projector
- Assignment material
- Marker
- Flipchart

This topic is covered in 2 sessions:

1. Session 1 – Topic Presentation

The presentation stresses the importance of awareness raising and public participation for the success of reuse projects. Moreover it presents concepts for development of awareness campaigns and the structure of participative processes. Finally it provides examples of awareness materials.

2. Session 2 – Role Play

The Role Play will make the various viewpoints on wastewater clearer. This will help participants to internalise the different stakeholder perspectives – a prerequisite to address different stakeholders with a target group oriented awareness raising campaign. Moreover the Role Play points out the necessity to include stakeholders in the planning process and how they can shape the project.

3. Additional case studies

The small case studies in Jordan and Palestine can be introduced to the participants, depending on time constraints.

7.1 Session 1 – Topic Presentation

PPT

Importance of awareness raising for reuse

Session overview

Title Importance of awareness raising for reuse

Objectives
- Reinforce the importance of awareness raising for successful introduction of reuse
- Give an overview of means for raising awareness

Teaching method lecture

Time estimation 70 - 90 min

Needed material projector

Session guide

1. Slides 5 and 6 introduce the session by giving reasons why public awareness and acceptance is important for the success of wastewater reuse projects.

2. The public's acceptance of recycled water varies with its potential use. Normally, acceptance levels decrease as proximity to human contact increases (slides 7-8). However, several issues may influence the public acceptance of wastewater reuse (slide 9).

3. In the MENA region, there is a persistent notion that wastewater reuse is against Islam. However, according to religious authorities, wastewater reuse is permissible for all purposes, provided that the wastewater is treated to the required level of purity for its intended use and does not result in any adverse public health effect. For Example: Saudi Arabia is currently reusing about 20 % of its treated wastewater in refineries and for irrigating forage and landscape crops, with the accordance of religious authorities (slide 10).

4. You might also want to use the slides of the Reuse Basics lecture showing the text of some reuse permitting Fatwas.

5. Awareness strategies have to take the target group's priorities, knowledge, specific behaviours and inhibiting factors into consideration. Behaviour change with respect to wastewater management and reuse involves changes of a broad range of current practices at the community level. (Slides 12-13)

6. Public awareness and acceptance is only one element in a wider continuum of a communication process that includes advocacy, social mobilisation and program/project communication. (Slides 14-17)

Advocacy consists of the organisation of information that has to be communicated through various interpersonal and media channels with a view to gain political and social leadership acceptance and to prepare a community for a particular program. Advocacy may be carried out by key people in (international) agencies, as well as special ambassadors, but is gradually taken over by people in national and local leadership positions and the print and electronic media. Advocacy leads directly to social mobilisation.

Social mobilisation is the process of bringing together all feasible and practical intersectoral social allies to raise people's awareness of and demand for a particular development program, to assist in the delivery of resources and services and to strengthen community participation for sustainability and self-reliance.

Program/project communication is the process of identifying, segmenting and targeting specific groups and audiences with particular strategies, messages or training programs through various mass media and interpersonal channels. Communication is an instrument based on a two-way dialogue, where senders and receivers of information interact on an equal footing, leading to interchange and mutual discovery. Planners, experts and field workers must learn to listen to people about their concerns, needs and possibilities (Wegelin-Schuringa, 2001). The program and project communication might be the most important issue within this continuum.

7. A host of methods and tools for implementing awareness raising programmes has been developed or modified for application in the field of sanitation and wastewater reuse. The following slides will present one of them: UNICEF's process-oriented modified Triple A Framework (slides 19-28).

8. The first phase includes establishing a working group, reviewing ongoing activities, and identifying missing information (slide 20).

9. The second phase involves the communication analyses (slide 21); the findings of the stakeholder and communication analyses form the basis for the segmentation of audiences (slide 22).

10. Slides 23 and 24 give examples of possible perspectives of farmers and consumers respectively.

11. The third phase of the modified Triple A framework covers the programme design. Potential building blocks of a programme could be written materials, community outreach, media liaison, and special activities (slides 25-27).

12. The final phase covers the actual performance of the activities, controlling the activities, and monitoring the results (slide 28).

13. Experience from a World Bank study shows that wastewater reuse projects obtain the best results when communities are actively involved early in project planning and implementation (slide 30). As such, community involvement is one aspect in creating an enabling environment for wastewater reuse (slide 31).

14. The Guide to Effective Participation, developed by the Joseph Rowntree Foundation, outlines 10 key issues of community participation (slide 32).

10 Key issues of community participation

1. **Level of participation** – participation should be context-sensitive and meet the expectations of different interests, remaining negotiable if needed to build consensus.
2. **Initiation and process** – a participatory process needs careful preparation and a flexible management.
3. **Control** – the project initiator needs to decide consciously on how much control to confer to others.
4. **Power and purpose** – participation is a matter of power, which has to be well-balanced in order to create synergy and benefits for all participants.
   Role of the practitioner – practitioners have to be particularly conscious of the various roles they play.
5. **Stakeholders and community** – communities typically consist of different stakeholders with varying (perhaps competing) interests, and it is necessary to consider who has most influence.
6. **Partnership** – true partnerships require time to build up trust and develop common commitment.
7. **Commitment** – participant commitment correlates to their problem consciousness and their sense of being able to achieve something.
8. **Ownership of ideas** – to foster identification with the underlying rationale of an intervention, initiators should give people a chance to feel that the idea could have been their own.
9. **Confidence and capacity** – enabling people to take complex decisions entails promoting confidence and may require additional capacity building.

Source: Rowntree Foundation; for further details see http://www.jrf.org.uk/knowledge/findings/housing/H4.asp

15. Moreover, the same guide proposes a five-rung ladder of participation which relates to the stance an organisation promoting participation may take. This ladder ranges from providing mere information to stakeholders, over deciding and acting together, to actively supporting independent stakeholder interests (slides 33-34).

16. The participation process needs to start with proper initiation. Then it leads from Initiation to Preparation, Participation, and last but not least, Continuation (slide 35).

17. Implementation of an awareness campaign requires an implementation plan to establish who is going to do what, and when (slides 37-38). Potential activities to enhance public acceptance are given in slide 39).

18. The action phase as recommended by UNICEF (1999) involves seven elements that range from training and capacity-building measures to budget control (slide 40).

19. Slides 42-44 present some examples of awareness material for wastewater reuse from the region and around the world.

20. If time permits, you might want to show the video on greywater reuse that is presented in slide 43. It is freely available for download from the internet at
http://rana.lilypadresources.com/greywater/

21. The presentation concludes with some summarising remarks on the importance of awareness raising (slide 46).

7.2 Session 2 – Role play

Different stakeholder perspectives in wastewater reuse

Session overview

Title Different stakeholder perspectives in wastewater reuse

Objectives
- To understand the various views and objections against wastewater reuse – and how to balance them.

Teaching method role play, discussion

Time estimation 90 min
- 10 min to explain the exercise
- 5 min to divide into groups
- 15 min for role groups to prepare their play
- 2 x 20 min to play
- 20 min for discussion

Needed material assignment paper, 2 x 4 separate role cards, markers, flip chart

Session guide

1. Explain the purpose of the activity, the different views on reuse that need to be taken into account and the need to include stakeholders in planning a reuse project in order to ensure its success.

2. Explain the role play and its various roles; see background sheet and role sheets below.

3. Depending on the size of the group, assign 2-3 participants to each of the 8 roles. The remaining participants will act as observers. In case there are not enough participants, you can act as the observer. Always try to have at least 2 participants per role.

4. The roles existing in one group should not be disclosed to players of other roles in the group? Or should be disclosed in order to allow them to prepare strategies

5. Give participants 15 min to prepare their role play. Couples should prepare their role together.

6. Let each group play for about 15 min. Tell them that they should actually come to a consensus.

7. Ask the observers what they noted in the two plays, and who they would think has the better chance of receiving the funding.

8. Discuss the play with all participants and note the main findings on the flip chart.

Different stakeholder perspectives in wastewater reuse. Agreeing on a wastewater project

Background

The national ministry responsible for wastewater management has offered your municipality to fund a wastewater treatment plant. However, as you are living in a water scarce region and your country wants to start a more integrated management of the existing water resources, the national ministry conditioned funding to a wastewater management that includes reuse of the WWTP's effluent. Because the national ministry is also aware of the importance that stakeholder participation has for the success of a reuse project, they ask your community to come up with a plan for wastewater reuse that is supported by all stakeholders.

Various opinions about wastewater reuse exist among the members of your community, and you will be assigned to play one of the possible roles. During the discussion in the role play you will have to defend your position, but in the end, your community will also have to come up with a project and flanking measures that are agreed upon by all groups. You can try to convince your opponents by offering e.g.:

- to apply control and counter measures,
- to share costs or benefits,
- alternative sources of funds or resources.

Group A - role cards

Role of the farmer in favour of reuse
You see the following advantages in reusing wastewater:

- Lower-cost, reliable, additional source of water for irrigation.
- Effective use of residual nutrients in wastewater (nitrogen, phosphorous, potassium).
- Humus accumulation in soils due to input of additional organic substances in wastewater; protection against erosion.
- Any other you can think of.

✂---

Consumers against reuse
You see the following disadvantages / risks / costs related to wastewater reuse:

- Possible health risk from consumption of plants / fruit / produce irrigated with wastewater).
- Health risk due to creation of breeding places for disease carriers.
- Risk of increased disturbance by odorous substances (should more treatment plants be based on anaerobic processing to meet the nutrient needs of farmers for reuse).
- Any other you can think of.

✂---

Operators against reuse
You see the following disadvantages/ risks/ costs related to wastewater reuse:

- Need for investment to reliably comply with hygiene standards (disinfection).
- Costs for additional training / qualification of plant personnel.
- Costs for increased control needs / quality management.
- Costs for construction and maintenance of systematic treatment systems (developing economies).
- Effort and expense needed to sensitize the public and train personnel with a view to conveying the needed know-how and preventing image problems.
- Any other you can think of.

✂---

Public in favour of reuse
You see the following advantages in reusing wastewater:

- Availability of freshwater for domestic use/ other uses.
- Rise in productivity per unit volume of water, and thus enhanced efficiency of water use. Saving funds for "supply" investments.
- Attractive possibility to beneficially eliminate growing quantities of wastewater.
- Less wastewater in receiving bodies and surface water.
- Reduced extraction of groundwater.
- Lower energy use due to substitution of fertilizer production.
- Any other you can think of.

✂---

Group B - role cards

Environmental groups in favour of reuse
You see the following advantages in reusing wastewater:

- Rise in productivity per unit volume of water, and thus enhanced efficiency of water use. Saving funds for "supply" investments.
- Attractive possibility to beneficially eliminate growing quantities of wastewater.
- Less wastewater in receiving bodies and surface water.
- Reduced extraction of groundwater.
- Lower energy use due to substitution of fertilizer production.
- Any other you can think of.

✂---

Municipality / operators in favour of reuse
You see the following advantages in reusing wastewater:

- Possible cost advantages because denitrification treatment stages are unnecessary: nutrients remain in wastewater (nitrogen / phosphate).
- Possibility to generate income from selling reclained water to re-users.
- Lower effluent standards than for discharge into environment.
- Any other you can think of.

✂---

Role of the farmer against of reuse
You see the following disadvantages/ risks/ costs related to wastewater reuse:

- Need for investment in irrigation systems (separate duct systems) as well as in new equipment, transportation costs, storage infrastructure.
- Dirty work, e.g. removing wastes from canals etc.
- Possibly lower yields, plant intoxication, clogging of microsprinklers and soil capillaries due to inputs of organic substances.
- More effort required handling different water qualities; rising management needs.
- Risk of negative impacts on chances of marketing of produce (esp. export).
- Any other you can think of.

✂- -

Public against reuse
You see the following disadvantages/ risks/ costs related to wastewater reuse:

- Possible health risk from consumption of plants / fruit / produce irrigated with wastewater).
- Health risk due to creation of breeding places for disease carriers.
- Risk to groundwater: contamination with nitrates, nitrites, and other toxic substances.
- Risk to soil: salinization, contamination with toxic substances (heavy metals).
- Investments in treatment technology, infrastructure and transportation costs.
- Investments in institution-building, regulatory and control mechanisms.
- Any other you can think of.

✂- -

7.3 Additional case studies

The small case studies in Jordan and Palestine can be introduced to the participants, depending on time constraints.

7.4 Self Test

The self test on the topic can be given to participants as a homework assignment or it can be done in class, depending on time availability.

1. What issues influence the public acceptance of wastewater reuse? Name at least 5.

2. What are the three components of a communication process?

3. What are the four steps of the modified Triple A Framework?

4. Put the following levels of participation in order from low level to high level: Deciding together – Supporting independent community interests – Consultation – Information – Acting together.

Answers:

1. Possible answers are: Degree of human contact; Protection of public health; Protection of environment; Promotion of water conservation; Cost of treatment and distribution technologies and systems; Perceptions of wastewater as the source of recycled water; Awareness of water supply problems; Perception of the role of recycled water in overall water supply; Quality of recycled wastewater; Confidence in local management of public utilities and technologies.

2. Advocacy, Social mobilisation, Programme/ project communication.

3. Assessment, Communication Analysis, Programme design, Action.

4. From low to high: Information, Consultation, Deciding together, Acting together, Supporting independent community interests.

7.5 Literature

Wegelin-Schuringa, Mandeleen 2001: Public awareness and mobilisation for sanitation, in: Piet Lens et al.; *Zeeman Grietje* and *Gatze Lettinga* (eds.): Decentralised Sanitation and Reuse. Concepts, systems and implementation, London: IWA Publishing, 534-551.

UNICEF - United Nations Children's Fund 1999: Towards better programming. A Manual on Communication for Water Supply and Environmental Sanitation Programmes. Water, Environment and Sanitation Technical Guidelines Series - No. 7. New York: UNICEF.

Hartley, Troy W. 2002: Framework for Public Perception and Participation in Non-Potable and Potable Water Reuse Initiatives: Guidance on Establishing and Maintaining Public Confidence (00-PUM-1). Draft Report sponsored by Water Environment Research Foundation. Washington D.C.

7.6 Recommended Reading

Khateeb, N., 2001: Sociocultural Acceptability of Wastewater Reuse in Palestine. In: N. I. Faruqi, A. K. Biswas and M. J. Bino (eds.): Water Management in Islam. Tokyo: UNU Press.
www.idrc.ca/en/ev-93955-201-1-DO_TOPIC.html

WSSCC/ WHO 2005: Sanitation and hygiene promotion: programming guidance. Water Supply and Sanitation Collaborative Council and World Health Organization
http://www.wsscc.org/pdf/publication/Sani_Hygiene_Promo.pdf

Khan, S.J and *Gerrard, L.B.* (2006) "Stakeholder communications for successful water reuse operations", Desalination 187:. 191–202 .
http://www.desline.com/proceedings/58-tc.shtml

7.7 Internet Resources

Community participation and empowerment: putting theory into practice. A new Guide to Effective Participation offers a comprehensive framework for thinking about involvement, empowerment and partnership. It also provides an A to Z of key issues and practical techniques for effective participation.
http://www.jrf.org.uk/knowledge/findings/housing/H4.asp

Poster on Greywater Use for Poverty Reduction in Jordan by the Inter-Islamic Network on Water Resources Development and Management funded by IDRC in Amman, Jordan
available at http://www.idrc.ca/uploads/user-S/11780964871Greywater-poster-INWRDAM-IDRC.JPG

From Waste To Water Greywater Reuse. In The Middle East Video produced with the support of UPE and WaDImena, coordinated by IDRC, with support from CIDA and IFAD. 20 min available at
http://rana.lilypadresources.com/greywater/

Water and Sanitation Project (WSP). Online platform of the Water and Sanitation Project, a joint initiative by several development agencies under the aegis of the World Bank. The publications section on waste and wastewater management and reuse lists relevant WSP projects, and partly offers more detailed downloadable information. The rich water links section contains not only references to further online resources, but also videos, country fact sheets, WSS statistics and a compilation of major water and sanitation-related events. http://www.wsp.org

GTZ ecosan. The aim of this project is to establish ecological sanitation concepts as an internationally recognised alternative approach to sanitation and to contribute to improved sustainability of water and sanitation projects in developing countries. www.gtz.de/ecosan

Module 5
Methodology

2007

1. Introduction

While modules 1 - 4 are all designed to provide training content for a three day training course, module 5 has a different objective.

The module aims directly at the trainers and provides them with a resource for altering the way they implement their training courses. The module has the following objectives:

- Introduce the background to didactic aspects of training, especially interactive and participatory training approaches.
- To familiarise trainers with recommendations for presentation techniques.
- Provide practical examples for feedback and evaluation.
- Familiarise trainers with the basic tools of project management.

In addition to being a resource book, some chapters, like those on communication and basic project management tools, provide training content which the trainers can use at their liking.

After completing the course, trainers should be able to:

- Apply tools for interactive and participative training units.
- Guide a participant group through a moderated feedback process.
- Be familiar with basic tools for project management and how to introduce them in a professional training course.

2. Topic 1:

Training design

Objectives
- Target group focussed training design using the TTK materials
- Basic training needs-assessment
- Time planning and organisational issues

Trainers should be able to
- Do a basic training needs-assessment with their potential target group
- Use the materials provided in the TTK to design a target group-specific training outline
- Organise a training course

For modules 1 – 4, materials are provided in the TTK which allow for 3 days of training with 6 training hours per day. While the TTK includes a suggested training schedule, the trainers are strongly encouraged to alter this schedule according to their own preferences and especially according to the training needs of the target group. The EMWater TTK is designed for a very wide target group and cannot cover all the specific needs of each target group.

Therefore it is recommended to adopt the training design with each set of participants. The training design consists of 4 steps:

1. Training needs-assessment

2. Formation of learning objectives

3. Designing the training schedule

4. Adjusting the training materials

1. Training needs-assessment

It is suggested to go through a two step process to make a basic training needs-assessment. In a full training needs-assessment, a full gap analysis would be necessary. This would involve defining the difference between the status quo and the desired target status of the participants, and then designing the training schedule accordingly. Since this needs quite a lot of resources and active participation of the participants it is proposed to do a more simple analysis.

To do a basic training needs-assessment, the target group should firstly be clearly defined

In addition to the trainers' own experience, it is advisable to have telephone interviews with 2 - 3 of the participants or their employers/university lecturers. This should give a clearer picture of what the participants expect from the training.

2. Formation of learning objectives

In a second step, the perceived needs of the target group are actively formulated as overall learning objectives. Which needs will be addressed during the training course? To make this more transparent to the participants, you should clearly spell out what the participants will have learned after completing the training course. An example for this module is given in on the next page.

3. Designing the training schedule

According to the learning objectives, a detailed schedule is designed showing the topics and training methods that are used during the training course. It can be used as timeline for the course as well.

4. Adjusting the training materials

According to the training schedule, it might be necessary to adjust the training materials provided in the TTK. To facilitate this, all materials incl. the ppt slides have been designed so that they can be restructured, e.g. all exercises are clearly marked and can be used whenever needed; the notes on the ppt slides are directly attached to each slide, hence the order of the slides can be readjusted without losing these notes.

Own training materials and documents should also be added to the TTK materials where deemed necessary.

Example

The training course addresses the following target group:
- Trainers for water management in Mediterranean countries

The training course has the following overall course objectives:
- Introduce the background to didactic aspects of training, especially interactive and participatory training approaches
- Familiarise trainers with recommendations for presentation techniques
- Provide practical examples for feedback, evaluation and skill tests
- Familiarise trainers with the basic tools of project management

After completing the course, participants should be able to:
- Apply tools for interactive and participative training units
- Guide a participant group through a moderated feedback process
- Apply and design basic skill tests for professional training
- Be familiar with basic tools for project management and how to introduce them in a professional training course

2.1 Organisational issues

The successful implementation of a training course requires a series of steps. The following checklist is not exhaustive, but tries to point out several pitfalls.

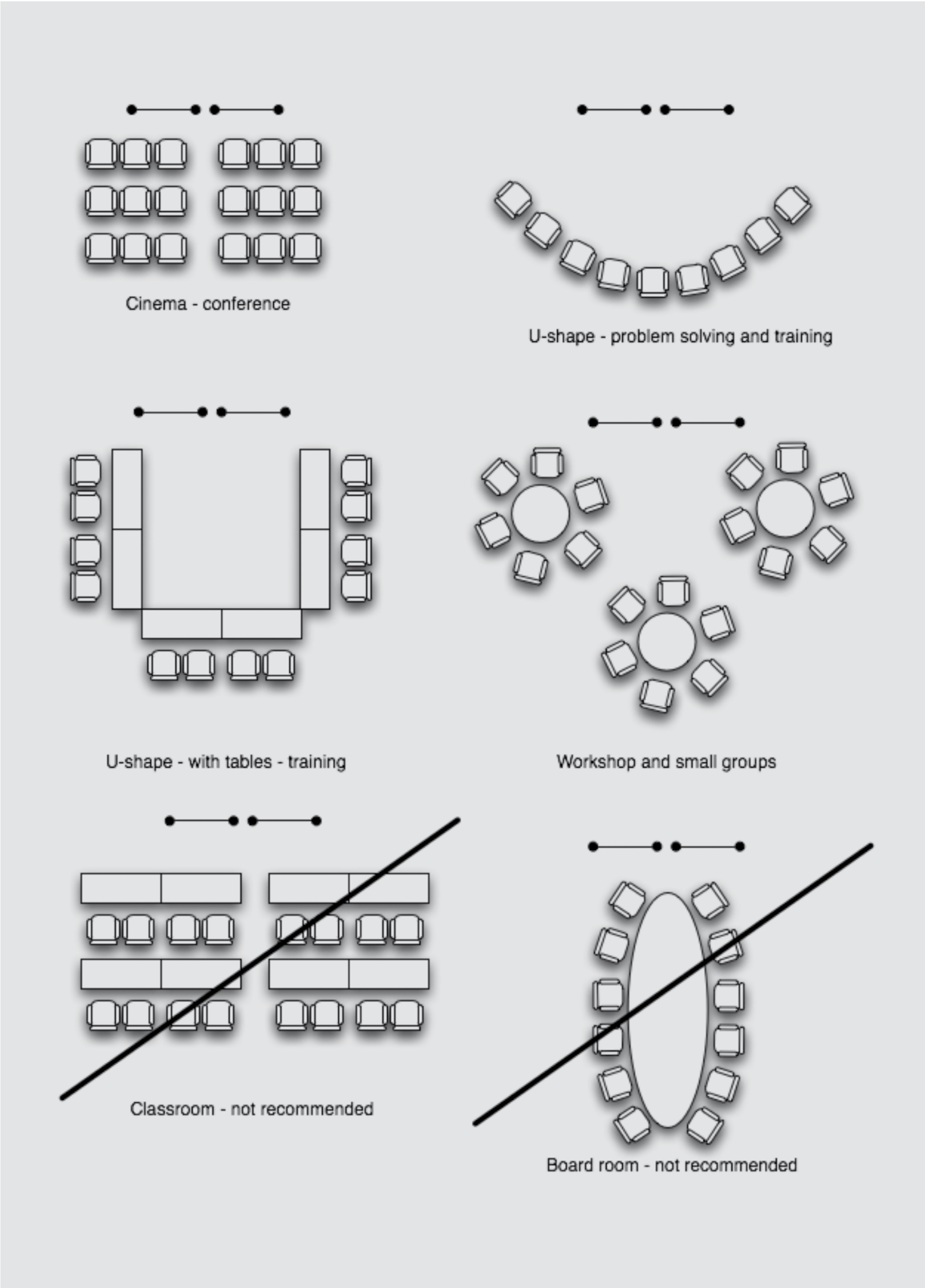
Issue	Explanation
Venue	In the selection of a venue, price, equipment and location are suggested as factors to consider. It is not necessary to have sophisticated equipment like a sound system etc. but rather to allow for a flexible training set-up with sufficient space.
Invitation	The invitation to participate in a training course should be sent to the participants well in advance. Depending on the cultural context, this could range from 2 weeks to 2 months ahead of the training start.
Programme	The invitation should be accompanied by detailed programme, which needs to be ready at the date when the invitations are sent out.
Breaks	Ideally there is a separate space for breaks, where the participants receive refreshments or can purchase them. For lunch there is either catering provided by the organisers or the participants are informed where they can purchase lunch.
Room	As soon as the course dates are known, the rooms need to be booked and the layout needs to be specified. Ideally at least one of the trainers should visit the training room to ensure the training room set-up is in accordance with the proposed training techniques. See also room set-up.
Sign posting	Mark the information on how to get to the venue and the training room well using sign posts at the venue to make it easy for the participants.
Name tags	Name tags should be prepared for all participants. If tables are used, name boards can be used on all the tables.
Agenda	All participants should receive an updated agenda at the start of the course plus additional materials deemed necessary. However, too much material at the start might distract the participants from the first session of the training.

Issue	Explanation
Equipment	Make a detailed list of equipment you will need and tick it off: • Projector • Computer • Extension cable with multiple plugs • Moderation materials • Metaplan board • Flip chart / white board • Pens for flip chart / white board
In the morning	It is suggested you test all technical equipment on the day of training before the participants come to make sure everything works. In particular, the beamer and the laptop sometimes cause problems, resulting in disturbing breaks.
Participant list	Provide for a participant list and sign-up sheet where every participant can add or correct their contact details. All participants should receive this list at the end of the training.
	Add additional information where necessary

2.2 Training room set-up

Physical arrangement of furnishings:
We would like to mention one more important factor which influences the effectiveness of group work and the level of participation. This is the physical arrangement of the work room. Just as there is no one right way to facilitate meetings, there is no one right way to arrange a room which works for all meetings. However, experts have suggested room arrangement models which have positive effects on participation. The examples are shown on the graph on the next page.

Some room arrangements foster participation like U-shapes and round tables, while others block participation like a cinema, classroom and boardroom. Ideal is a situation in which the room can be changed. Small tables which are readily moveable are ideal. This allows the trainer to adjust the training room to the current training needs.


Cinema - conference
U-shape - problem solving and training
U-shape - with tables - training
Workshop and small groups
Classroom - not recommended
Board room - not recommended

3. Topic 2:

Interactive and participative training

Objectives
- To introduce various forms and techniques of participative training (group work, role-play, guided discussions, open space etc.)
- Provide tips and recommendations on how to design interactive and participative training
- Give examples of the concept of energisers to refocus the attention of participants
- Present tools such as mindmap and metaplan

Trainers should be able to
- Apply all exercises and case studies introduced in the TTK
- Feel confident in developing new exercises to adjust their training programme to the target group
- Use tools and materials such as mindmap, metaplan, flipcharts in a training context

This topic covers examples and tips for various situations during the training course, specifically the following:

- Opening
    - Introduction matrix
    - Me, myself and I

- Moderation methods
    - Classic moderation method
    - Discussion leading

- Visualisation
    - Dots
    - Quadrant analysis

- Creativity
    - Brainstorming
    - Mind maps

3.1 Opening

To a certain degree the opening phase of a workshop sets the tone for the rest of the workshop. Also the time during this orientation phase can be used to make everyone feel comfortable with each other.

3.1.1 Introduction Matrix

The trainer has prepared a matrix on a moderation board, or a flipchart paper in landscape format with a table. The table headings are “name”, “function/job”, “I am here because”, “it is typical for me that”.
All participants fill in the matrix for themselves before the workshop starts. Alternatively the participants can do this during an introductory session. The trainer fills in the data as well. This provides for a relaxed opening atmosphere in which everybody can get to know each other.

Name	Occupation	I am here because ...	It is typical for me to ...
Harry	Civil Engineer waterworks	I want more knowledge about sludge treatment	drive fast with the car
Ron	Municipal Politician	water reuse is important	to drink coffee all day

3.1.2 Me, myself and I

Another option to do the introduction round is using ”me, myself and I” questionnaires. The trainer sends a questionnaire to each person in advance of the training course and asks the participants to fill this file in and return it to the trainer. The filled in questionnaire is then posted on a wall or pin board at the beginning of the training course. All participants gather around the questionnaires and look at those of the other participants. This usually provides a good platform for further conversation. the example on the next page shows sucha questionnaire.
The trainer also fills in such a questionnaire. In addition, this might be a good chance to ask the participants about the expectations in advance.

Template

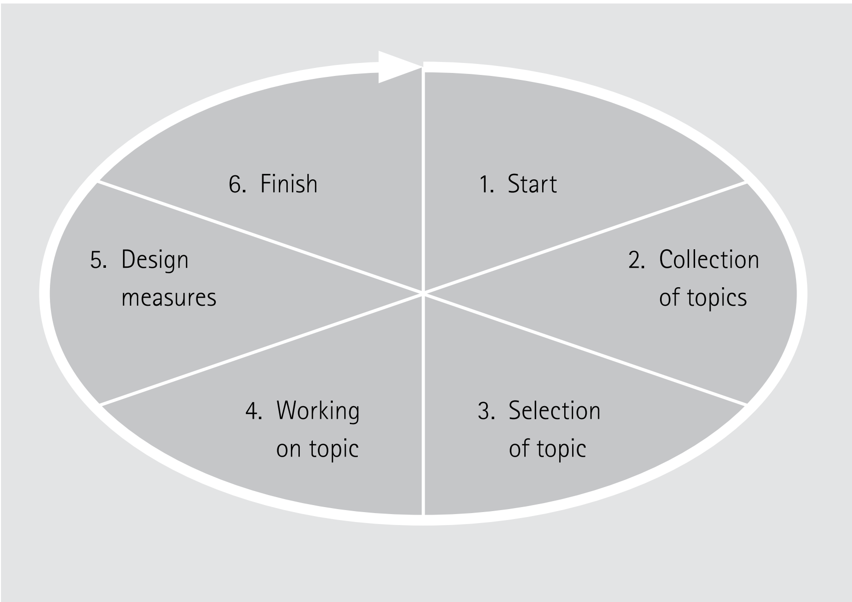
- Name:
- Profession:
- My main interest in the chosen module:
- Children: (age)
- Favourite past time:
- Favourite food:
- Sports, hobbies:
- I like to read:
- I like to listen to (music):
- Favourite animal:
- I get annoyed about:
- My slogan for life:
- Comments:

3.2 Moderation methods

3.2.1 Classic moderation method
The moderation method is a process in which a group goes through various steps, discussing and designing.
The moderator, or in our case the trainer, is the leader of the group. The trainer provides assistance, enabling the group to reach their goal. It is very important that he or she does not tell the group what is right or wrong, but rather assists the group in finding their own way and forming their decisions.
In a training environment it is always difficult for the trainer and the group to accept this shift of the paradigm, that is, that the trainer switches to the role of moderator.
In a moderation situation the moderator:

- Does not have an opinion on the topic, even if he or she has knowledge about the topic
- Seeks the approval of the participants before each moderation step
- Visualises all questions and the discussion results
- Seeks to actively involve all participants in the process

Generally the moderation process consists of six steps:



1. Start

Objective: The participants should get to know each other, feel comfortable with the room and the situation. The objective of the moderation, methods and timetable for the moderation have been set.

In a training situation where the moderation is only part of the training, this step is not necessary since the objective of this step should already have been achieved. Therefore it should be sufficient to shortly introduce the timetable and the proposed aim of the moderation.

2. Collection of topics

Objective: All topics and issues with relevance to the aim are collected by using an aim oriented question.

A precise and concrete question is formulated and used to focus the thoughts of the participants; all results are documented using a flip chart or a pin board. It is suggested to give each participant moderation cards and to ask them to write down their issues and topics referring to the question. (See visualisation)

3. Selection of topic

Objective: Selection of one topic to work further on this topic.

The issues and topics are clustered according to an agreed selection system. It is important to actively involve the participants in clustering; even so it might seem to be more time efficient if the moderator does it.

The participants select one topic, which they would like to jointly discuss further in more detail. An active question is formulated e.g. "How do we overcome administrative difficulties to re-use water in agriculture?"

4. Working on topic

Objective: Collection of information on the selected topic, in-depth problem analysis and development of decision aids and finally decision on how to tackle the problem.

All information available on the topic among the participants is gathered; various techniques are available for visualisation. As a next step the potential problems are discussed in an open discussion round. After a while, the general discussion should create suggestions on different alternative strategies on how to address the topic. The participants should finally decide on one approach to deal with the topic.

5. Design measures

Objective: Design of concrete measures on how to work on the topic further, and how to solve the problem.

Summarises the ideas collected earlier and puts them in an operational form. This leads to a concrete action plan of how to proceed further with the given topic or problem.

6. Finish

Objective: Get and give feedback on the process and the achieved results.
This is basically a feedback round; see information on feedback in the feedback and evaluation chapter.

3.2.2 Discussion Leading

Advantages of discussion leading:

- Gets participants involved in their own learning.
- Lets an instructor know what participants know about a subject and how they feel about it.
- Taps into the knowledge and experience of a learning group, thus making good use of the group as a resource.
- Helps an instructor avoid lecturing participants on subjects they already know about.
- Helps participants retain knowledge better than in a lecture.

Disadvantages of discussion leading:

- Requires more skill from an instructor than straight lecturing.
- Takes more time than a lecture to cover the same amount of material.

What an instructor must do before the discussion:

- Set the stage for a good discussion.
- The discussion group should consist of no more than 25. If it is larger, consider establishing sub-groups for discussion.
- Participants should be seated in a manner that will promote discussion. Ideally, they should all see one another easily. Avoid having people sitting in rows if possible.
- Consider the level of knowledge of the group. In order to discuss, members of the group need to have some knowledge of the topic.
- Consider when this discussion period occurs. Is it early in the morning or late in the afternoon? This may affect the participants' energy level.
- Consider the previous experience of this group. If this is the first time they are asked to discuss something, they may need some prompting. If they have participated in many discussions very recently, they may have become bored with the technique and not wish to participate.
- Consider how comfortable the members are with the group. If the group is new, members will need some time to get used to one another and may feel uncomfortable discussing certain sensitive topics. If the group is well established and cohesive, discussing any topic should not be a problem.
- Know what training objective you are trying to accomplish.

- Plan your discussion session by preparing questions to cover key points you want participants to consider during the discussion period.

What an instructor must do during the discussion:
Begin the discussion by stating your objective and expectations and explaining how you wish the discussion process to occur. Include the time frame if time is tight.

Use questioning techniques effectively:
- Open the discussion with a well phrased, clear, open-ended question.
- Allow silence following a question. Participants need time to think, to decide to answer, to formulate their answer, to get up the courage to give it. Take a drink of water or simply smile and look around the room to show you're willing to wait them out. If the silence goes on too long, reformulate your question.
- Avoid answering your own question either before anyone else does or after (to give the "correct" answer).

Use a variety of questions to involve participants:
- Open-ended: To redirect the discussion to a new topic when needed, make participants think of another aspect, keep things moving along.
- Closed: To clarify a point, solicit particular information, remind participants of an important point (use very few closed questions since they don't promote discussion).
- Overhead: To involve everyone in the group. This should be the most often used question in leading discussions.
- Directed: To involve a quiet participant, seek out a point of view from someone with particular experience.
- Reversed: If any participants try to draw you into the discussion by asking you a question, reverse their question to them by asking what they think.
- Relayed: Again, if a participant tries to draw you into the discussion, you may relay the question to the group by asking the group in general what they think of the issue.
- Restricted: If one or a few participants monopolise the discussion, you may give others a chance to speak by restricting a question to another part of the group or room.

Guide the discussion:
- Generate multiple responses. Don't simply accept the first correct answer and move on. Encourage other responses ("Good, what else?" "Good, another example?" "How about this side of the room?").
- Be flexible. Use only those prepared questions that you need to move the discussion to each key topic. You may not need them all if the discussion moves in that direction naturally. Accept that the order in which they come up may be different from the sequence you had envisaged.

- Observe participants' non-verbals. When you see confusion, disagreement or attempts to break in, use a directed question ("John, do you have a question?") or an observation ("Mary, I think you disagree") to give that person the opportunity to intervene.
- Use paraphrases to ensure you and participants understand a long statement, to encourage shy participants to continue.
- Use recaps to close off discussion of one topic or from one individual, follow it immediately with a question on another topic or to another participant (directed) or part of the group (restricted: "We haven't heard much from this side of the room. I'd like to hear your opinions about…").
- Avoid expressing your opinion or asking leading questions that might bias opinions or make participants feel manipulated. Remember, if they don't bring out every point, you can add it later.
- Be prepared to intervene with thought-provoking questions or take a challenging position, however, to stimulate thinking.
- If one participant interrupts others frequently or interrupts someone who has been very quiet up until then, interrupt the interrupter to allow the first speaker to continue ("Excuse me, Joe, I don't think Susan had finished.").
- During the discussion, try to sit down. This position will allow greater discussion amongst the participants.

Manage time effectively:
- Anticipate how long the discussion should last and determine whether you have enough time to meet the objective.
- If the discussion seems to be going off on a tangent, ask the speaker to relate what she or he is saying to the objective.
- Announce to the group that there is five to ten minutes left until the end of the discussion period. Be sure to leave yourself enough time for the conclusion.

What an instructor should do after the discussion:
In your conclusion, recap the main points of the discussion. Add additional important points that they may have missed ("Other aspects we should consider are…"), link the discussion to the objective and to their job environment.

Checklist on discussion leading

Discussion leader:

____

During the discussion, the leader:	Yes	Somewhat	No
Set the stage by explaining the objective of the discussion and the time limit.			
Opened with a well phrased, clear, open-ended question.			
Allowed silent reflection time.			
Used a variety of questioning techniques (overhead, directed, reversed, relayed, restricted).			
Encouraged multiple responses to questions.			
Acknowledged and accepted responses.			
Showed awareness of participants' body language.			
Used paraphrases to encourage responses.			
Used recaps to close off discussion and summarize.			
Avoided expressing his/her opinion until the conclusion.			
Ensured that everyone had a chance to participate.			
Kept the discussion on topic.			
Used body language to make participants feel comfortable.			
Controlled time effectively.			
Recapped the discussion at the end.			
The hand-out distributed:	**Yes**	**Somewhat**	**No**
is clearly written.			
is well organized.			
will be useful to me in the future.			

Note: You can find other useful methods, like Six Thinking Hats, force field analyses, Pareto Analysis, etc. at http://www.mindtools.com/

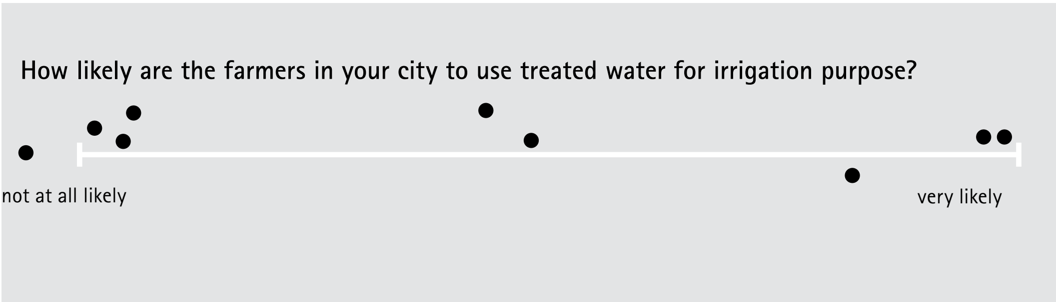
3.3 Visualisation

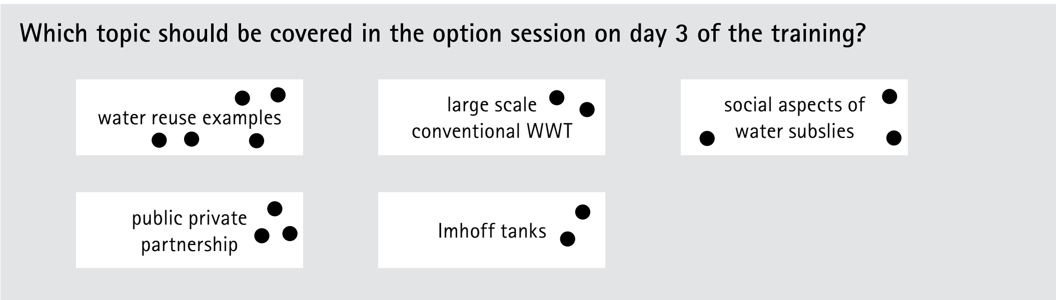
From time to time the trainer might be interested in the current situation within the group, or might want the group to make a selection between various options. The “dots” technique is rather useful for this.

3.3.1 Dots

The “dots” technique is used to make the situation either more transparent or to make a decision between various options. Additionally the result is quite clearly visualized. Generally each participant has one dot - one vote to cast. If one option is to be chosen from a selection of options, it is suggested to give each participant n/2 dots - votes, with a max of two dots to be cast on one option.

Two examples of the application of the “dots” technique are shown below.





3.3.2 Quadrant analysis

This method can be used to analyse a topic further in small groups. The trainer prepares the board with the four fields accordingly, e.g. in the previous example the participants of the group selected "water reuse examples" and "social aspects of water subsidies" as their preferred topics. The participants are now split into two smaller groups and each group tries to answer the questions in the quadrants, which have been written down by the trainer.

Social aspects of water subsidies

Who benefits from water subsidies? • poor citizens • rich citizens • Industry • agriculture	**Which social Implications do water subsidies have?** • rich people use more water and benefit more from subsidies than poor people • water watse is encouraged
Which ways exist to susidies water? • subsidies the water price • provide water for free	**Which criteria should a socially "fair" system fulfill?** • •

3.4 Creativity

3.4.1 Brainstorming

One of the most popular techniques used in training is brainstorming. There are dozens of different brainstorming techniques for groups. A couple of examples are given here.
Apart from being a method by itself, brainstorming is also very important for other methods e.g. quadrant analysis.
The idea of brainstorming is to collect as many ideas as possible on a given topic in a short time. All participants are encouraged to "storm" their brains and to share their ideas with others. To make this work, some important ingredients are necessary:

- The trainer writes down a clear and open question beforehand
- The four core rules are observed by all the participants:

- Rule 1: nobody judges any of the ideas, all ideas are valid
- Rule 2: all ideas are welcome, even if they seem wild and unconventional
- Rule 3: quantity is the objective, the more the better
- Rule 4: already existing ideas can be the seed for new ideas

- The participants visualize the question and the results right away, hence the trainer writes down the question and all the ideas on the board
- The trainer acts as facilitator and tries to rephrase the question to trigger more ideas
- The trainer makes sure the rules are observed, especially that there is no criticism
- Moments of silence or breaks do not mean the brainstorming is over, the trainer should be patient
- Questions to clarify ideas are welcome but should not lead to discussions

The 2nd step after collecting ideas is to evaluate the results. Techniques such as clustering similar ideas, or the selection of preferences with dots could be used.

3.4.2 Mind Maps

A Powerful Approach to Note Taking

Mindmapping can be useful to structure the results of a brainstorming session or to document a discussion on a topic. This method creates a structure with the ideas generated.

At the start, an idea or concept is written in the centre of a sheet. Then all related issues and relevant information is written outward from the centre in all directions. The concepts are connected with lines. The mindmap can grow in every direction at the same time. Visual aids such as colours or symbols can be used to make the concepts more clear.

How to Use the Tool

Mind Maps (mindmaps) are very important techniques for improving the way you take notes. By using Mind Maps you show the structure of the subject and linkages between points, as well as the raw facts contained in normal notes. Mind Maps hold information in a format that your mind will find easy to remember and quick to review.

Popularised by Tony Buzan, Mind Maps abandon the list format of conventional note taking. They do this in favour of a two-dimensional structure. A good Mind Map shows the 'shape' of the subject, the relative importance of individual points and the way in which

one fact relates to the others.
Mind Maps are more compact than conventional notes, often taking up one sheet of paper. This helps you to make associations easily. If you find out more information after you have drawn the main Mind Map, then you can easily integrate it with little disruption.

Drawing Basic Mind Maps
This manual was planned using Mind Maps. They are too large to publish here, however part of one is shown below.

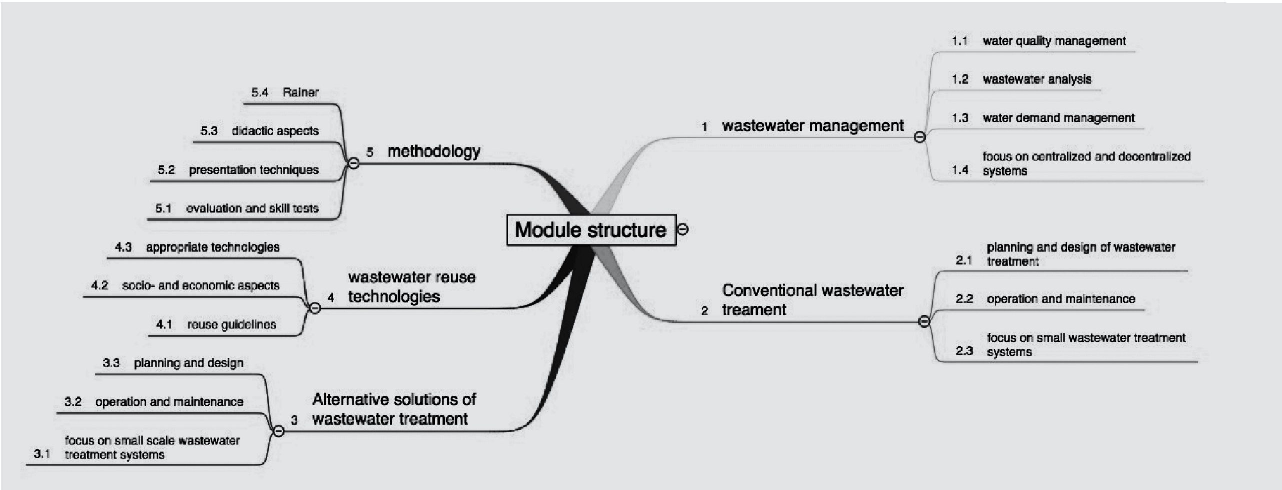


Figure 1: Part of an Example Mind Map

To make notes on a subject using a Mind Map, draw it in the following way:

- Write the title of the subject in the centre of the page, and draw a circle around it.
- For the major subject subheadings, draw lines out from this circle. Label these lines with the subheadings.
- If you have another level of information belonging to the subheadings above, draw these and link them to the subheading lines.
- Finally, for individual facts or ideas, draw lines out from the appropriate heading line and label them.
- As you come across new information, link it in to the Mind Map appropriately.

The following suggestions may help to increase the effectiveness of Mind Maps:

Use single words or simple phrases - key points for information. Print words - joined up or indistinct writing can be more difficult to read. Use colour to separate different ideas. Use symbols and images. Use cross-linkages - information in one part of the Mind Map may relate to another part. Here you can draw in lines to show the cross-linkages. This helps you to see how one part of the subject affects another.
If you do any form of research or note taking, try experimenting with Mind Maps. You will find them surprisingly effective.

Software solutions:
Using a flip chart is one option; there are also software solutions available.

3.5 References

Groups that Work - by Gerard M Blair (Department of Electrical Engineering, The University of Edinburgh)

The IAF Handbook of Group Facilitation – Edited by Sandy Schuman

Robert J. Garmston - Journal of Staff Development, Winter 2002 (Vol. 23, No. 1)

Amason, A., Thompson, K., Hochwater, W., & Harrison, A. (1995). Conflict: An important dimension in successful management teams. Organizational Dynamics, 24(2), 20-35.

Garmston, R. & Wellman, B. (1999). The adaptive school: A sourcebook for developing collaborative groups. Norwood, MA: Christopher Gordon.

Higgins, J.M. 101 Creative Problem Solving Techniques - the handbook of new ideas

Useful links
http://www.mindtools.com/
http://www.thebrain.com/LPS/PBMM/ - mind mapping tool
http://www.rcmp-learning.org/docs/ecdd0011.htm

4. Topic 3:

Presentation techniques

Objectives
• Application of presentation techniques (ppt, flipchart, lecture etc.)
• Basic suggestions for presentation techniques with the TTK

Trainers should be able to
• Decide on when to use which technique
• Get useful suggestions on how to apply basic presentation techniques

4.1 Four Basic Steps

4.1.1 The First Step

Formulate a strategy for the specific audience:

- Understand your purpose and role: It is critical to be clear about your purpose in the communication. This involves knowing your audience, the occasion, and the expectations of your audience. Knowing the audience will be a critical determinant in what information is presented and how it is presented.
- Tailor your message to the audience - understand their needs, desires, knowledge level, and attitude toward your topic.
- Be concrete, specific, practical and relevant
- Clarify your objectives - is it to motivate? ... inform? ... persuade? ... teach? - each calls for a different approach
- Clarify what role you will be performing - coach? advocate? teacher?

4.1.2 The Second Step

Develop a flexible, flowing structure:

Once you know what you want to say, you need to consolidate the materials into a meaningful message. You can't assume that the information will speak for itself. Your audience is capable of hearing your information in very different ways based on your organisation and presentation.
The audience needs to have these basic questions answered.

1. Why should I pay attention to you when I can think about more interesting things?
2. Now that I am listening, why should I care about this issue?
3. I agree with the significance of the topic, but how are you justifying your ideas?
4. So, now that I am convinced, what do you want from me?

Basically, the structure of presentation considers three main parts:

1. Introduction
Purpose: The purpose of the introduction is to define the objective of your presentation, motivate your audience and outline what is to be covered.

O = Objective (State what you hope to achieve in your presentation)
M = Motivate (Get people involved at the outset)
O = Outline (What is to be covered)

2. Body
Purpose: The body is the most important part of the presentation. The body should cover the essential information, provide examples, and allow for discussion and clarification. What should the body include?

- Teaching points
- Examples
- Exercises, if appropriate
- Periodic reviews
- Opportunities for discussion or questions for discussion

3. Conclusion
Purpose: To summarise the body in light of the objective, make a concluding statement and stimulate further thought and action.
In a typical case the specific amount of time that should be allocated to each of the presentation sections is as shown below:

- Introduction lasts around 20%
- Main body of the presentation lasts around 70%
- Conclusion / Summary lasts around 10%

The following lists some points to think about when organizing your ideas:

- Begin by placing your topic in context; you might want to provide an outline or a road map
- Provide the intended, expected benefits, organisation of the presentation, and ground rules
- Organise the body of the presentation logically - make it easy to follow - go from the simple to the complex
- When appropriate, plan ways to encourage audience participation

- Maintain credibility: discuss the pros and cons
- Conclude on a "high note" - include an overall summary and proposed actions or options
- Incorporate visual aids effectively - don't let the mechanics of the presentation interfere with your message
- Prepare for contingencies - practice your presentation and prepare for contingencies - rehearse
- Think about what might happen and prepare: what if the overhead bulb blows out, what if the audience is more prepared than you expected, what if there is an unexpected question... If a disruption is particularly obtrusive, you might relieve the tension with a joke or humorous comment

4.1.3 The Third Step

Combine prepared material with an enhancing, not distracting, presentation style; it is important to remember that how you present is as important as what you present.
Effective presenters recognise that communication is both intellectual and emotional. Organising your ideas is part of the task. The other is to gain and maintain attention. The following lists some basic techniques to maintain attention:

- Convey "controlled enthusiasm" for your subject - the audience will forgive a lot if the speaker is enthusiastic - pay attention to posture, tone...
- Don't confuse enthusiasm with loudness; try to convey a range of emotions from concern, anticipation, excitement, dismay...
- Where appropriate, candidly discuss pros and cons; explain advantages first; present risks or challenges

4.1.4 The Fourth Step

Supplement the presentation with confident, informed responses to questions and challenges.

Use of questions

- Ask "friendly" questions - don't use questions to embarrass or badger; avoid known "sore spots".
- Make the interchange a mutually satisfying experience; give respondents time to think and phrase their answer; help people save face by summarizing what they have said so far and asking if anyone else has something to add.
- Don't let the respondent wander or attempt to take control of the presentation; a polite "thank you, that's what I was looking for" can get you back on track.

- If extensive audience discussion is desired, avoid isolated one-on-one dialogues with specific individuals.
- When challenged, be candid and firm but avoid over responding.
- Maintain control of the session.
- Be firm and assertive without being aggressive or defensive.
- Don't let interruptions disrupt your composure.
- Avoid circumstances that require an apology.
- Anticipate questions and prepare responses; rehearse answers to difficult questions.
- If necessary, offer to obtain additional information and follow up.
- Use questions to strengthen your main arguments – answer questions candidly but positively link objections to attractive features.
- Avoid rhetorical questions - ask interesting questions that are thought provoking but not too difficult to answer.
- Ask some open ended question with no right or wrong answers - encourage sharing experiences, feelings, and opinions.
- Put "you" elements into questions - make them relevant to the audience's personal experience.
- Prepare key questions prior to the presentation; it is difficult to think of good questions on your feet.

Guideline for Answering Questions

- Anticipate questions: think of the ten most likely questions and plan out your answer
- Understand the question: paraphrase it if necessary; repeat it if needed
- Plan the answer: particularly if you anticipated the question
- Do not digress
- Be honest: if you can't answer the question, say so
- Reinterpret loaded questions: if attacked try to show the similarity to other situations
- Control interchanges: if a questioner becomes a heckler try to enlist the audience; if a questioner digresses, try to remind the audience of the goal of the presentation

4.2 Visual Aids

The central purpose of any presentation, written, oral or visual, is communication. To communicate effectively, you must state your facts in a simple, concise and interesting manner.

It is proven that people learn more readily and retain more information when learning is reinforced by visualization. You can entertain, inform, excite and even shock an audience using the proper integration of visual images into virtually any exchange of information.

Meetings which might normally be considered dull, or a chore to be avoided, can be transformed into exciting productions that grab the attention of the viewers.

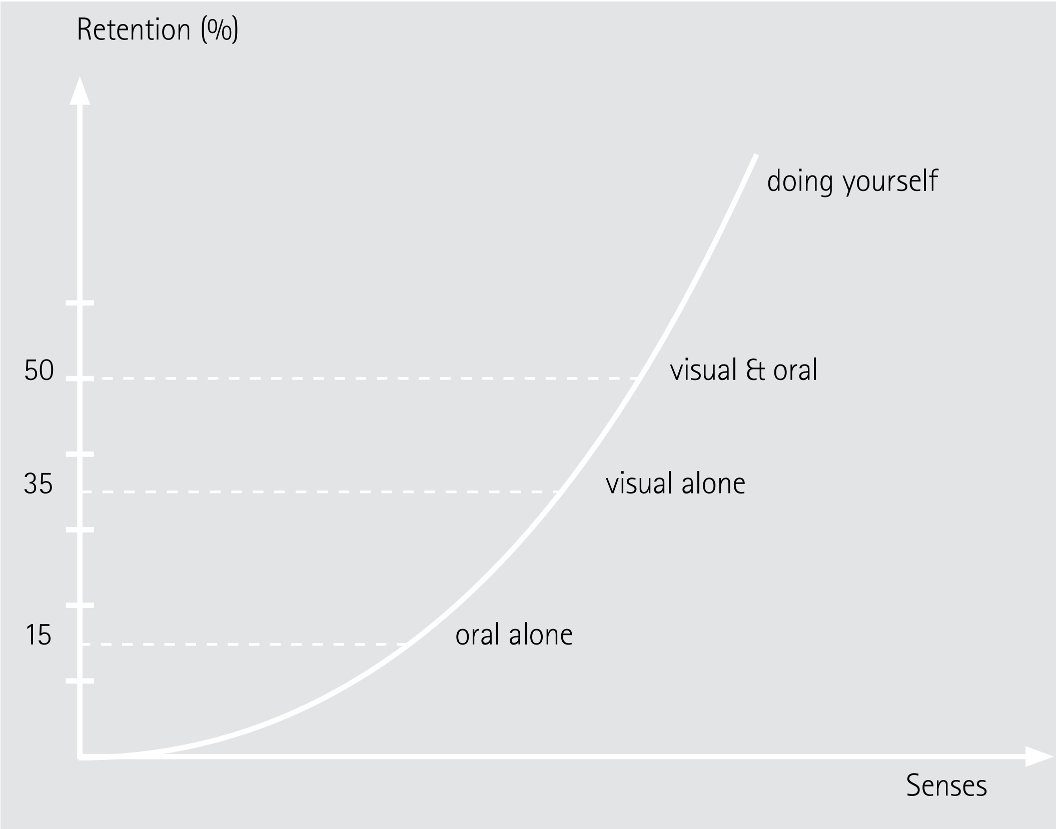
Simple, clear, concise visual images, briskly paced and sprinkled with attention-grabbing graphics will lend support to your spoken words. This leaves your audience with a positive attitude toward you and your product, service or proposal.

Visuals should be used in support of the spoken or written word, and not in lieu of it. A well-developed concept and effective script are the essential elements of any presentation. Regardless of their form, they should be the first and most important phase of its development. When the concept begins to take final form, the visuals are developed around it.

Finally, your presentation should be entertaining. Leave the audience feeling better and more relaxed when they leave and that impression will carry over to both your subject matter and yourself. There is no logical reason that the presentation of routine sales figures and financial reports should not be as exciting as the unveiling of a new product or a first rate service proposal.

4.2.1 Using Visual Aids

Visual aids add impact and interest to a presentation. They enable you to appeal to more than one sense at the same time, thereby increasing the audience's understanding and retention level. With pictures, the concepts or ideas you present are no longer simply words - but words plus images. The chart below cites the effectiveness of visual aids on audience retention.



People tend to be eye-minded, and the impacts visual aids bring to a presentation are, indeed, significant. The studies below reveal interesting statistics that support these findings:

- In many studies, experimental psychologists and educators have found that retention of information three days after a meeting or other event is six times greater when information is presented by visual and oral means than when the information is presented by the spoken word alone.

- Studies by educational researchers suggest that approximately 83% of human learning occurs visually, and the remaining 17% through the other senses - 11% through hearing, 3.5% through smell, 1% through taste, and 1.5% through touch.
- The studies suggest that three days after an event, people retain 10% of what they heard from an oral presentation, 35% from a visual presentation, and 65% from a visual and oral presentation.

The use of visual aids, then, is essential to all presentations. Without them, the impact of your presentation may leave the audience shortly after the audience leaves you. By preparing a presentation with visual aids that reinforce your main ideas, you will reach your audience far more effectively, and, perhaps, continue to "touch" them long after the presentation ends.

4.2.2 Tips on Preparing Visual Aids

- Start with at least a rough outline of the goal and major points of the presentation before selecting the visual aid(s).

- Each element of an audio-visual product - a single slide or a page of a flip chart presentation, for example, - must be simple and contain only one message. Placing more than one message on a single image confuses the audience and diminishes the potential impact of visual media.

- Determine the difference between what you will say and what the visual aid will show. Do not read straight from your visuals.

- Ask the audience to read or listen, not both; visual aids should not provide reading material while you talk. Rather, use them to illustrate or highlight your points.

- Give participants paper copies of various graphic aids used in your presentation. They will be able to write on the paper copies and have them for future reference.

- Use charts and graphs to support the presentation of numerical information.

- Develop sketches and drawings to convey various designs and plans.

- When preparing graphics, make sure they are not too crowded in detail. Do not overuse colour. See that line detail, letters, and symbols are bold enough to be seen from the back of the room.

- Do not use visual aids for persuasive statements, qualifying remarks, emotional appeals, or any type of rhetorical statement.

- If you have handouts, don't let them become a distraction during the presentation. They should provide reinforcement following your address. Consider giving them out after the presentation, unless the audience will use them during the presentation or will need to review them in advance of the presentation.

- Practice presenting the full program using graphic materials so you are familiar with their use and order. If you use audio-visual materials, practice working with them and the equipment to get the timing down right.

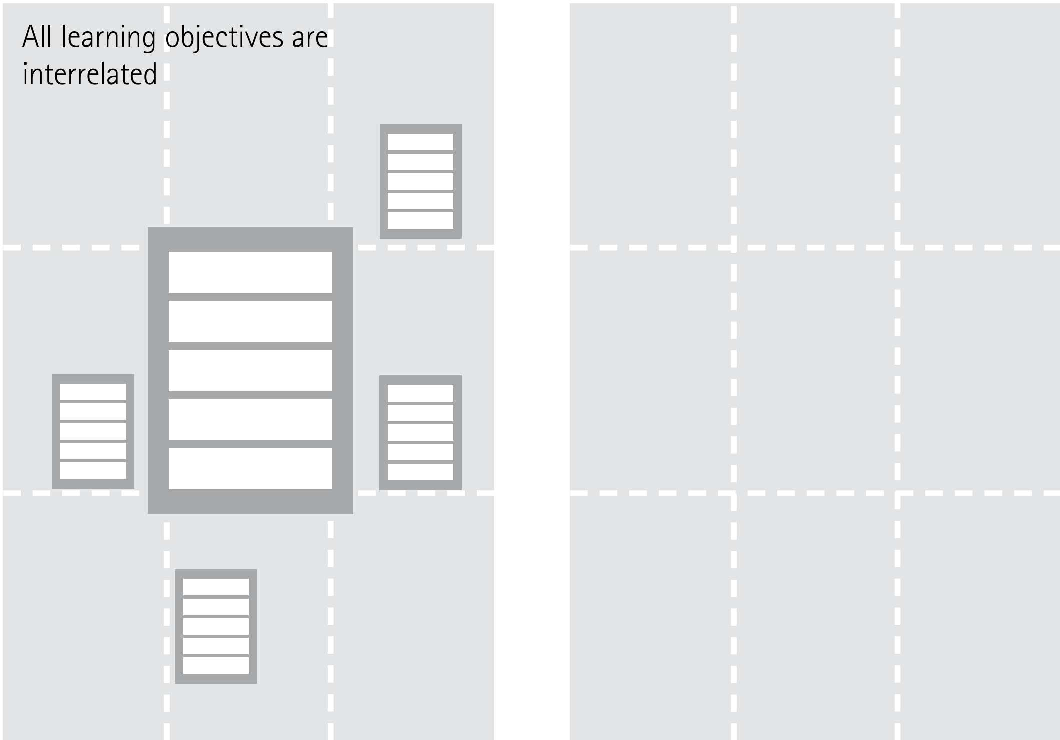
- Seek feedback on the clarity of your visuals and do so early enough to allow yourself time to make needed adjustments.

The question of what to use and how to choose is an excellent one. The next several pages will help you answer this question by identifying the advantages and limitations of each type of visual, as well as the development techniques required in preparing each. By looking at these pros and cons, you can more easily decide what will work best for your presentation.

Flip Charts
Flip charts are quick, inexpensive visual aids for briefing small groups. The charts, felt-tip markers and graphic materials are readily available, and with a modest ability at lettering, the presenters can compose the desired visual aid in-house.

- Help the speaker proceed through the material
- Convey information
- Provide the audience with something to look at in addition to the speaker
- Can be prepared prior to, as well as during, the presentation
- Demonstrate that the speaker has given thought to his or her remarks
- Can be used to record audience questions and comments
- Can be converted to slides

Especially for flip charts and pin boards it is extremely helpful to divide the space into 4 or nine 9 rectangles, this makes it easier to position the information well.



Limitations:
- May require the use of graphics talent
- Are not suitable for use in a large audience setting
- May be difficult to transport

When Developing Flip Charts:
- Each sheet of paper should contain one idea, sketch, or theme.
- Words, charts, diagrams, and other symbols must be penned in a large enough size to be seen by people farthest from the speaker.
- Use block lettering, since it is easiest to read. Use all capital letters, and do not slant or italicise letters.
- Use and vary the colour. Also, check from a distance to make sure the colour works well and is not distracting.

PPT Presentation

The following points are important in the arrangement of the text, diagrams and images on the oral presentation slides:

- Keep sentences short and simple, as the amount of space available on the slide will be at a premium.
- When paragraphs are needed, ensure that these are short and are made up of no more than 4 or 5 sentences if possible.
- Leave a whole line between each paragraph as this will make the slide much easier for the audience to read.
- Ensure that clear space is present between text and any diagrams or images.
- Highlight the most important text on the slide to make it stand out from the rest of the material in the presentation. This can be achieved in many ways such as using bold face, underlining, italicising or by drawing different types of boxes around the important area.
- Try to place any important diagrams, graphs, charts, schemes and images at the centre of the slide because this will have a greater visual impact.

Good slides and bad slides:

The good slide below has several key features:

- The diagrams are large enough to be easily visible.
- There is plenty of white space between images.
- There is enough information so that the slide can be discussed for 2-3 minutes.
- The important text is highlighted so that it stands out.

Selection of font styles and sizes:

It is important that the font size used in the slides is large enough to enable all the audience to view it clearly. A list of recommended font sizes is given below:

- Titles in 48 point
- Other headings in 32 point
- Main text in 18 point

It is important to ensure that the font style that is selected is present on both the computer on which the presentation is created and on the computer on which the presentation is to be shown. Arial and Times are good choices for the font style as these are widely accessible.

Colour schemes for oral presentations:
When choosing the colours for your text and background the following points may help to create an eye-catching presentation slide:

- Ensure that the font colour and the background colour contrast against each other so that the font stands out against the background colour. Black text on white paper is always a good contrast and makes it on top easy to print the slides.
- Avoid using bold primary colours together such as red on a yellow background or vice versa.
- Use a different colour for the font to highlight and emphasise very important points.

4.3 References

Proven techniques for creating presentations that get results. by *Daria Price Bowman*

Northeastern University, College of Business Administration. 2001. Making Effective Oral Presentations. Retrieved August 16, 2005 from http://web.cba.neu.edu/~ewertheim/skills/oral.htm

(*Buzan, Tony* and *Barry Buzan*. The Mind-Map; How to Use Radiant Thinking to Maximize Your Brain's Untapped Potential. New York: Penguin Group, 1996.)

Hunter College Guide to Writing

The Key Steps to an Effective Presentation - General Guidelines and Visual Presentation

Presentation Planning Checklist - By Kellie Fowler, Mind Tools Contributor,

Construction Safety and Health - Outreach Program; U.S. Department of Labor
OSHA Office of Training and Education; May 1996

Useful links:
http://www.businesstown.com/presentations/present-types.asp
http://www.rcmp-learning.org/docs/ecdd0011.htm
http://www2.umist.ac.uk/chemistry/communication/oralpresentation.html

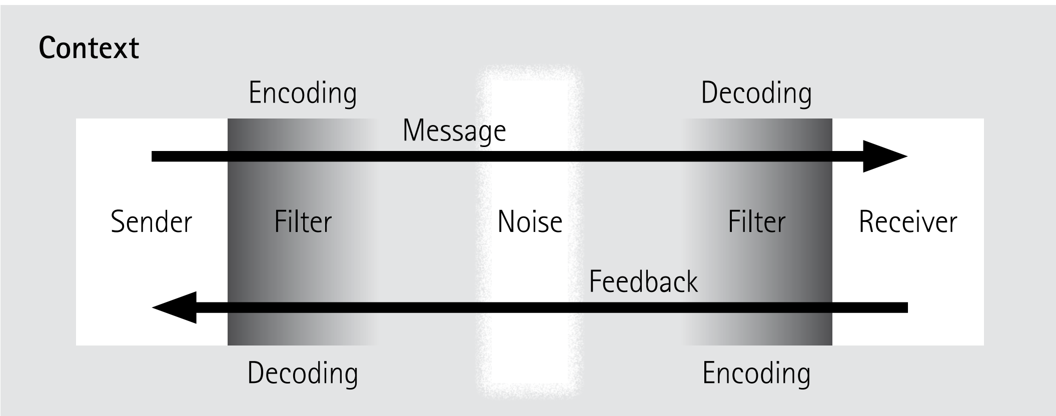
5. Topic 4: Feedback and evaluation

Objectives
- Introduce different kinds of feedback and evaluation techniques and their practical application

Trainers should be able to
- Apply feedback in a training context and choose the right time for the right methods
- Be sensitive to the importance of feedback processes

5.1 What is feedback?

Feedback is communication with a person (group) that gives that person information about how he or she affects others. Feedback helps an individual stay "on target" and thus better achieve a goal or purpose. Feedback helps another person to consider changing their behaviour or altering a message.
The receiver may use the same channel for feedback as the sender used for the original message or the receiver may use a different channel. Using the same channel is usually the case in face-to-face conversation. In face-to-face conversation, feedback is more easily understood than in group conversation.
Effective feedback is usually descriptive rather than judgmental. Feedback can come through a formal critique or from informal reactions. Feedback can come from a colleague, mentor, or just a listener in interpersonal communication. The ideal source of feedback is a person with good communication skills who is close to the intended audience.
As the following figure indicates, feedback is the process by which the listener becomes the source by encoding the information he/she has just received from the source, then giving a message back to the sender that reflects the degree of his/her understanding.



1. Feedback can help the listener to improve the accuracy of the message transmission. We must always ask ourselves, "Has the listener truly understood what I have said, or have noise and the hazards of decoding robbed my message of its fidelity?" Feedback lets you know if the listener has heard you say what you meant him/her to hear.

2. Feedback can help you to keep the conversation personally relevant to the listener. It helps you determine the listener's receptivity to the message.

Thus, according to the logic discussed above, source has become listener, and listener has become source. In a very real sense, we become listener and source simultaneously. As we deliver the message, we are tuned in to the listener's feedback to evaluate how the person has understood our message.

5.2 Types of feedback

- **Positive feedback**: is designed to encourage a response and is formulated in a positive way.
- **Negative feedback**: is designed to discourage a response. (Example: an annoying buzzer).
- **Neutral feedback**: neither encourages or discourages responses. It designed to show the person that we understand him or her.
- **Informative feedback**: displays the correct answer and is most useful for getting information about the topic of interest.
- **Cumulative feedback**: sums individual performances.

Feedback has its typical outcomes: behaviour repetition (for example positive feedback, informative feedback, cumulative feedback), behaviour change (negative feedback, informative feedback), little response (for example neutral feedback) and contempt (negative feedback).

5.3 Informal and formal feedback

Ideally feedback should be given both informally and formally. Informal feedback should be frequent and occur in situations where specific behaviours or skills can be discussed in small doses either at the time or shortly after. Formal feedback will be most commonly given at an appraisal interview, but on occasions an additional planned feedback session may be required. When providing formal feedback, you should:

- ensure the trainee knows they are to receive feedback
- collect relevant information from others

- make notes prior to the meeting
- reinforce good practice with specific examples

The effectiveness of feedback is influenced by:
- the credibility of the person giving the feedback
- the message itself
- the recipient's readiness to respond

The last two often link back to the source i.e. negative feedback is more readily accepted if the source is respected, there is a rapport between the source and the recipient, and the feedback is discussed in a helpful way. Whether the feedback is seen as important depends on the way you do it and your relationship with the trainees.

5.4 Tips for providing feedback

- Feedback must be specific rather than general. Specific feedback objectively describes another person's message, behaviour, or situation and addresses specific actions not generalisations. For example, don't say 'Your analysis of the data is not always good" but rather 'What was your reasoning behind that particular decision?"

- Feedback must describe the person's own feelings. Feedback must describe how the other person's behaviour, message, or situation specifically affects a person's life. Feedback must be directed toward something the receiver can do to change the situation. For example: "I feel as though you are unsure of yourself when you read".

- Feedback must avoid evaluative language, such as 'you are wrong or you are lying'

- Feedback must be focused on actions rather than personality, e.g. "you lost eye contact with the patient etc'" rather than "You're far too shy with patients".

- Feedback must take into account the needs of both the giver and the receiver.

- Feedback must be based on first-hand information, i.e. the person who observes the performance. Second or third-hand feedback, e.g. "Dr X says that you are …" often passes as feedback but it is never as powerful as first-hand information.

- Positive feedback must be given first followed by the negative feedback e.g. 'your plan has some positive aspects … but this aspect needs more …'

5.5 Examples of Feedback

Statement	Effects	Examples
I want "I want you to do this."	Helps clarify what you really want for yourself and for others.	**Example 1:** "I would like some encouragement on my work." Or "I would like some help teaching your child proper habits of cleanliness." **Example 2:** "I would like clarification for that point."
I feel "I feel X when you do Y."	Helps express feelings without attacking the self-esteem of another person.	**Example 1:** "I need some help solving a problem. The problem involves getting a response to the notes I sent to you concerning our team project. I am frustrated about how to solve this problem. Will you help me?" **Example 2:** "When you act like that, I feel as if my statements are not being heard."
Mixed feeling statement	Express positive and negative feelings at the same time. They allow time for an individual to respond after you express the first feeling. Express positive feelings first, give an individual time to respond, and then express negative feelings.	**Example 1:** "I was really pleased with your attitude toward our plans for working more constructively with the children." **Listener's response followed by:** "I also need to share with you my concern for your lack of follow-up. I felt like you were just giving me lip service and not really planning to follow up. I need to work this issue out with you."
Empathic feeling statement	Do more than just express your wants and feelings by conveying sensitivity toward others. Avoid using the statement, "I know how you feel" as it denies the other person his or her feelings.	**Example 1:** "I am anxious about how you might interpret what I am going to say. I realize you are as concerned about your child as I am and I want to make sure there are no misunderstandings. I do want to be considerate about your feelings, but it is very important for you, your child, and me to take a few minutes at the end of each afternoon to talk about what has happened during the day."

Statement	Effects	Examples
Confrontational statement	Is appropriate when there are discrepancies. For instance, when another person's words contradict what he or she does. Another example would be when there is a conflict between a job description and what is being asked of someone in a job.	**Example 1:** Objectively describe what the other person said would be done. Describe what the other person actually did. By doing this, you point out the discrepancy rather than confront the person. This allows separating the person from the behaviour. Express what it is that you want, or what you think should happen?

5.6 References

Knapp. M and *Daly* (2002). Handbook of Interpersonal Communication. London: Sage

Carnett. J. (1992). Communicating for Results in Government : a Strategic Approach for Public Managers. Josey-Bass Publishers.

www.informedia.cs.cmu.edu

E A Hesketh and *J M Laidlaw*, Feedback Designed and produced by the Education Development Unit Scottish Council or Postgraduate Medical and Dental Education

6. Topic 5:

Project Management

Objectives
- Introduce practical project management tools and techniques for everyday work

Trainers should be able to
- Facilitate the daily work planning and the design of the overall set-up of a project

6.1 Projects

A project is a series of linked activities with set objectives, designed to produce a specific output or result, within a clearly defined period of time, using limited resources and meeting pre-defined success and quality indicators. The main elements of a project are the following:

Information

A project is a temporary endeavor undertaken to create a unique product, service, or result.

PMI, A Guide to Project Management Body of Knowledge

- It addresses a particular need identified through a thorough analysis of the situation.
- All the activities are carefully thought out in advance and implemented according to a detailed plan.
- The plan consists of a series of activities or tasks leading to a result. It has clear starting and ending dates. The intended end-result is clearly defined in terms of quantity and quality.
- A team of people, materials and funds are specifically assigned to carry out the activities.

6.2 Projects vs. Operational Work

Organizations perform work to achieve a set of objectives. Generally, work can be categorized as either a project or an operation, although the two sometimes overlap. They share many of the following characteristics:

- Performed by people
- Constrained by limited resources
- Planned, executed, and controlled

Projects and operations differ primarily in that operations are ongoing and repetitive, while projects are temporary and unique. The objectives of projects and operations are fundamentally different. The purpose of a project is to attain its objective before its end. Conversely, the objective of an ongoing operation is to sustain the business. Projects are different because the project concludes when its specific objectives have been attained, while operations adopt a new set of objectives and the work continues.

Projects are undertaken at all levels of the organization and they can involve a single person or many thousands. Their duration ranges from a few weeks to several years. Projects can involve one or many organizational units, such as joint ventures and partnerships. Examples of projects include, but are not limited to:

- Developing a new product
- Implementing a change in structure, staffing, or style of an organization
- Designing a new vehicle
- Developing or acquiring a new or modified information system
- Constructing a building or facility
- Building a water system for a community
- Running a campaign for political office
- Implementing a new business procedure or process
- Responding to a contract tender

6.3 What is Project Management?

Project management is accomplished through the application and integration of the project management processes of identification, development / planning, implementation, monitoring and controlling, closing and evaluation. The project manager is the person responsible for accomplishing the project objectives. Managing a project includes:

Information

Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements.

PMI, A Guide to Project Management Body of Knowledge

- Identifying requirements
- Establishing clear and achievable objectives
- Balancing the competing demands for quality, scope, time and cost
- Adapting the specifications, plan, and approach to the different concerns and expectations of the various stakeholders

Project managers often talk of a "triple constraint" – project scope, time and cost – in managing competing project requirements. Project quality is affected by balancing these three factors. High quality projects deliver the required product, service or result within scope, on time, and within budget. The relationship between these factors is such that if any one of the three factors changes, at least one other factor is likely to be affected. Project managers also manage projects in response to uncertainty. Project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective. The project management team has a professional responsibility to its stakeholders including customers, the performing organization and the public.

6.4 Project Cycle

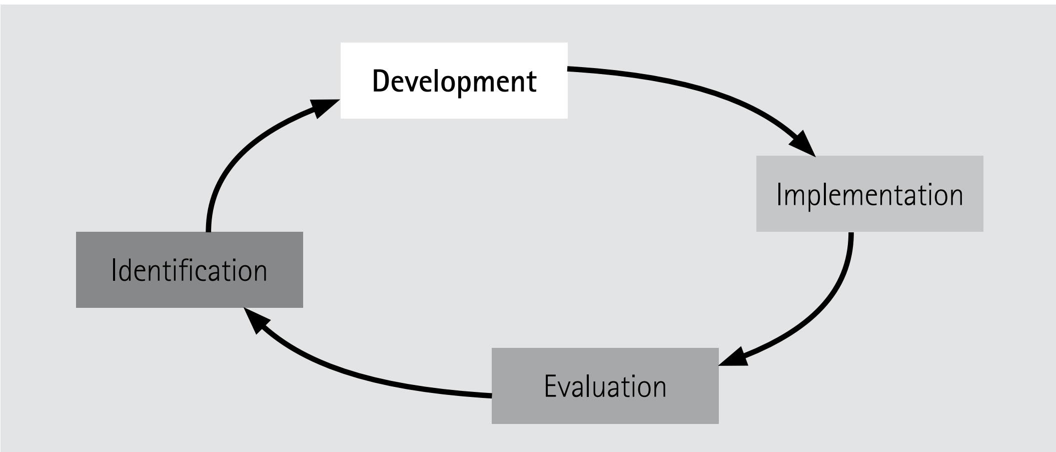
Project managers or the organization can divide projects into phases to provide better management control with appropriate links to the ongoing operations of the performing organization. Collectively, these phases are known as the project life cycle. Many organizations identify a specific set of life cycles for use on all of their projects.

Characteristics of the Project Life Cycle:
The project life cycle defines the phases that connect the beginning of a project to its end. For example, when an organization identifies an opportunity to which it would like to respond, it will often authorize a feasibility study to decide whether it should undertake the project. The project life cycle definition can help the project manager clarify whether to treat the feasibility study as the first project phase or as a separate, stand-alone project. Where the outcome of such a preliminary effort is not clearly identifiable, it is best to treat such efforts as a separate project. The transition from one phase to another within a project's life cycle generally involves, and is usually defined by, some form of technical transfer or handoff. Deliverables from one phase are usually reviewed for completeness and accuracy and approved before work starts on the next phase. However, it is not uncommon for a phase to begin prior to the approval of the previous phase's deliverables, when the risks involved are deemed acceptable. This practice of overlapping phases, normally done in sequence, is an example of the application of the schedule compression technique called fast tracking.
There is no single best way to define an ideal project life cycle. Some organizations have

established policies that standardize all projects with a single life cycle, while others allow the project management team to choose the most appropriate life cycle for the team's project. Further, industry common practices will often lead to the use of a preferred life cycle within that industry.
Project life cycles generally define:

- What technical work to do in each phase (for example, in which phase should the architect's work be performed)?
- When the deliverables are to be generated in each phase and how each deliverable is reviewed, verified, and validated.
- Who is involved in each phase (for example, concurrent engineering requires that the implementers be involved with requirements and design).
- How to control and approve each phase.

Project life cycle descriptions can be very general or very detailed. Highly detailed descriptions of life cycles can include forms, charts, and checklists to provide structure and control.
Most project life cycles share a number of common characteristics: phases are generally sequential and usually defined by some form of technical information transfer or technical component handoff.
Cost and staffing levels are low at the start, peak during the intermediate phases, and drop rapidly as the project draws to a conclusion.
The project life cycle consists of identification, development, implementation and evaluation phases:



6.5 Why Projects? (Project drivers)

The organizational response to the changing environment cannot take the form of an instantaneous transformation from the old system to a new one. To be successful, the transition must be systematic, but it tends to be slow and torturous for most organizations. Therefore many organizations have set up projects to implement their goals for strategic and tactical change.
The Project Management Institute (PMI) distinguishes five strategic considerations resulting in project authorization:

Information

Because of the ever-changing business environment, traditional organizational structures and management systems are simply not adequate to the reality.

PMI, A Guide to Project Management Body of Knowledge

- A market demand (e.g. an oil company authorizes a project to build a new refinery in response to chronic gasoline shortages)
- An organizational need (e.g. a training company authorizes a project to create a new course in order to increase its revenues)
- A customer request (e.g. an electricity utility company authorizes a project to build a new substation to serve a new industrial park)
- A technological advance (e.g. a software firm authorizes a new project to develop a new generation of video games after the introduction of new game playing equipment by electronics companies)
- A legal requirement (e.g. a paint manufacturer authorizes a project to establish guidelines for the handling of a new toxic material)

6.6 Project Identification

Project identification is the first phase in the project. In this phase a need, problem or opportunity is identified and the case which provides various solutions or options is defined.

What is a needs assessment? How to conduct a needs assessment?
A need is a condition, a specific kind of goods or services, which are perceived to be basic requirements by the beneficiary groups. A needs assessment is a systematic exploration of the way things are and the way they should be.

- Current situation: This analysis should examine our goals, climate, and internal and external constraints.
- Desired or necessary situation: This identifies the desired or necessary conditions for organizational and personal success.

The difference between the current and the necessary situation will identify our needs, purposes, and objectives.
The easiest way of obtaining needs assessment information is to interview people, but interviews have limitations. The ideal procedure is to "triangulate" the information you need by collecting it via two or more ways.
There are several basic needs assessment techniques. Use a combination of some of these, as appropriate:

- direct observation
- questionnaires
- consultation with persons in key positions, and / or with specific knowledge
- review of relevant literature
- interviews
- focus groups
- tests
- records & report studies
- work samples

Participation Analysis Matrix
The benefits of carrying out a formal participation analysis are that the stakeholders are identified before finalizing project objectives. This means that the relationships between different stakeholders are kept central to project design. Further, by carrying out the analysis systematically, it becomes possible to involve a wider range of interested parties in the analysis.

This approach helps you analyze how the different stakeholders can contribute to the project, which problems they are facing in doing so, and what actions you have to undertake in order to solve these problems.

Stakeholders	What can they contribute?	The problems they meet	Actions
Stakeholder 1			
Stakeholder 2			
Stakeholder 3			
Stakeholder 4			

- Column 1: brainstorm stakeholders. (Group similar stakeholders in one row)
- Column 2: resources that the stakeholders can provide to the project. What is it that they can contribute to the project? (E.g. data or information; human resources (personnel, expertise); a network; financial resources; materials; facilities and/or equipment that might be used in the project; mandate; policies)
- Column 3: problems faced (by stakeholders) that hinder the successful outcome of the project. (e.g. lack of involvement in planning, lack of funds or materials, lack of information or orientation to the project, etc.)
- Column 4: required actions. Given what we know about the stakeholders, what actions should project implementers take?

6.7 Meeting with people / Meeting Agenda

Whoever organizes and runs the meeting needs to know what he or she doing. The reason why many meetings are boring for 90% of the people attending is that the goals are in conflict with the meeting's structure and size. There are three kinds of meeting, each with different constraints and applications. Always consider what kind of meeting will best serve the problem that needs to be solved.

- **Highly interactive discussion:** Everyone in the meeting is expected to participate. The focus is on resolving specific issues of seeking out alternative ideas. Size: small to medium (2-8). Examples: design discussion, brainstorming, crisis management, and triage.
- **Reporting or moderate discussion**: One person has content to cover, and he or she needs people to respond to or understand that content. The goal is to get high-level feedback or share the knowledge. Several different people may take the floor during the meeting, changing the roles of who is driving and who is responding. Size: medium to large (5-15). Examples: Spec reviews, management review and small presentation.

- **Status and project review:** The objective is to summarize the status of a team or an entire project. Gives leaders a chance to make course corrections and present new directives from management to the entire group at once. When these meetings simply involve finding out the statuses of teams or individuals, and everyone has to listen, they can be particularly dull. Size: Medium to large (10-100). Examples: status review, project review, and large presentation.

Meetings run well when someone facilitates them. Start the meeting by introducing people, clarifying the agenda, and beginning the discussion.
Main features of a good agenda:

- Why has the meeting been organized?
- What is the objective?
- How will the objective be achieved?
- Who will speak?
- Timing (date, hours)
- Location
- Other issues (registration, ID, dress code, etc)

6.8 Project Vision

One of the challenges in leading teams is keeping people focused on the same goals for long periods of time. All leaders fear that decisions they make will not be remembered. It is possible that the reasons people had for listening to them today will be forgotten or ignored tomorrow. Perhaps worse, managers themselves may forget which direction they are supposed to be leading the project in. So the challenge of project management is not only to get things in the right direction, but also to keep it headed that way. This is why Project Vision is essential.
The term 'Project Vision' describes a project manager's preliminary ideas regarding what a project could serve to resolve or change. The project vision is the ground on which a project manager decides to start the process of developing and implementing a project.
Several stages are commonly identified in the process of Project Vision formulation:

- Identifying a need for change
- Meeting with key team members
- Defining what the project should ideally change
- Assessing the common ideal vision
- Producing a feasible vision statement

Ideally, good Project Vision should contain the following items:

- **Project Purpose**: indicates the specific objective(s) the project aims to achieve
- **Link to the goal(s) of the organization**: project should be in line with the overall goals of the organization
- **Project Results**: describes what the project must deliver
- **Constraints**: any possible constraints the project might face
- **Assumptions**: the external factors that could affect the project but over which we do not have direct control

6.9 Problem Analysis and Problem Tree

A problem analysis focuses on clear identification of the causes of the problem. The objectives of the project will depend on the problems you have identified. Thus you must have a very clear idea of what these are and how they relate to each other. The process of identifying problems and organizing them according to their relation to each other is known as developing a problem tree.
Forking principle:

- We have a solution
- We identify other causes
- We generate alternative solutions
- We make an informed choice

A problem is a description of a poor state or of a negative situation. Five major steps are identified in the process of Problem Tree development:

1. Use the feedback obtained during the assessment process as a starting point. Ask your team to brainstorm for problems and write them down in the form of short and concise statements.

2. Paraphrase the short statements as negative conditions and write them on Post-its. Stick the Post-its on a flipchart or a board.

3. Ask your team to help you group the problems according to subject, geographical proximity, rearrange the Post-its on the board as necessary.

4. Analyze the problems and organize them to reflect the way they relate to each other: Is each one the cause or the effect of another one? Does it contribute to the creation of another problem? Rearrange the Post-its once again to reflect those relationships, representing cause and effects in a logical sequence. Each group of problems will become a branch and your problem tree will start to emerge.

5. The issue at the very top of the tree constitutes the central issue or the core problem. The core problem incorporates and summarizes all the other problems stated along the branches.

6.10 Priority Setting

The next step after finalizing the problem tree is to think about priorities. No organization can deal with all existing problems, so prioritization is vital.
Project ideas should be prioritized against:
- Significance of the problem (Is the problem significant enough to be worth project development?)
- Organizational goals (Will addressing the chosen problems be in line with the goals of the organization?)
- Availability of resources (Have you sufficient resources to develop and implement a project addressing certain problem(s)?)
- Operational timelines (Is there enough time available to effectively and efficiently solve the problem by project implementation?)
- Sustainability of the results (Will the results of the project be sustainable?)

6.11 Setting up Objectives

The primary purpose of project planning/development is to establish a set of directions in sufficient detail to tell the project team exactly what must be done, when it must be done, and what resources to use in order to produce the deliverables of the project successfully.

Information

The purpose of planning is to facilitate later accomplishment.

Project Management, Jack R. Meredith, Samuel J. Mantel, Jr.

The process of developing the project plan varies from organization to organization, but any project plan must contain the following elements:

- Objectives: contains a detailed statement of the general goals
- Schedules: outlines the various schedules and lists all milestone events
- Resources: human, material, financial
- Risk Management Plans: covers potential problems as well as potential lucky breaks that could affect the project

To set up objectives, you must rephrase the statements from the problem tree to indicate the condition that the project aims to bring about or the envisaged improvement. Note that, as a result, goals and means for achieving those goals will replace the causes and effects indicated in the problem tree.

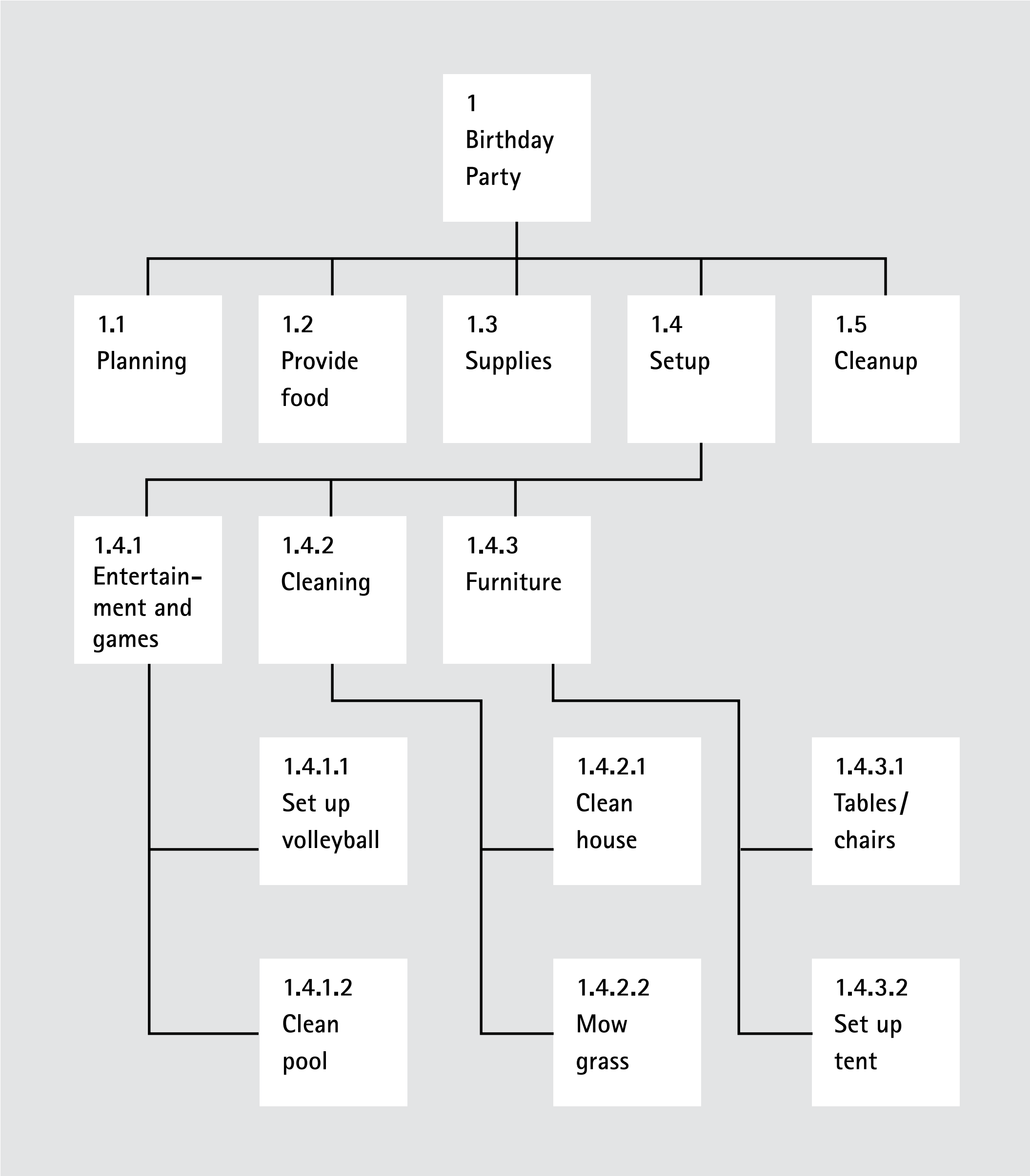
6.12 Preparation of an Activity Plan

Identifying and breaking down the work to be done is the logical starting point in the entire planning process. Once you have identified all of the activities required to fulfil the project, you have to create a complete project plan. You will be able to estimate activity durations and prepare your schedule, estimate activity costs and prepare your project budget, assign responsibility, and carry out many more planning steps.
There are several good reasons why a good Work Breakdown Structure (WBS) should be prepared:

- The WBS provides an easy to read graphical representation of the work, allowing stakeholders to review it thoroughly for missing elements of work.
- People often underestimate the effort required to execute a project. A fully developed WBS underscores how much work there really is.
- The WBS provides a convenient and logical structure for estimating the duration and the cost of each activity, as well as for assigning responsibilities and resources to activities.
- The WBS provides an excellent source for examining the risks associated with the project.

6.13 Work Breakdown Structure

In developing your WBS you must thoroughly identify all work necessary to execute the project. Issues such as duration, cost, and resources will be addressed later in the planning process.



For each of the activities, you will need to consider the following dimensions:

- Time (the number of days / weeks that will be spent working on the activity)
- Cost (how much will be spent on labour and materials)
- Scope (the work that will be done, how it will be done, and what will be produced)

- Responsibility (the person accountable for its successful completion)
- Resources (supporting labour, materials, or supplies needed)
- Quality (how well the work should be done, how well any outputs should perform)

Resources:
- Human resources
- Equipment
- Material
- Services

Budget:
A budget is a quantitative assessment of the likely costs of the resources required to complete the project activities. Budget formats mainly depend on the donors' requirements. It can be presented in either a summary form or in detail. Costs are estimated for all resources that are applied to activity cost estimates. This includes, but is not limited to labour, materials, equipment, services, facilities, information technology, and special categories. Use different formats of the budget. The budget must be complemented with explanatory notes.

Example: Budget line – Travel cost – €1500

Explanatory note: Ticket (Amman-Berlin-Amman) - €500

Visa - € 45
Taxi (to and from airport) - €10
Accommodation (€50 @12 days) - €600
Daily pay (€10@ 30 days) -€300
Local transportation - €45

Total travel cost – €1500

Sources of Financing:
The implementation of the project depends completely on financing sources. Financing sources might be a donor organization, state budget, an organization's own resources, or income generated by project activities. Sometimes financing sources are identified well in advance of the project identification.

6.14 Personal Time Management

What is the point of personal time management tips? Changing time management habits takes time and effort, and it is always much easier when you have a simple system of practical rules and hints that are easy to keep in mind.

Know what you want from your time
The proven way to do it is to set goals, and to set them SMART.

- Specific
- Measurable
- Attainable
- Rewarding
- Timely

The rest of the time management tips below will help you be effective in achieving your goals and making time management decisions.

Learn to see the difference between urgent and important
The important tasks are those that lead you to your goals, and give you most of the long term progress and reward. Those tasks are very often not urgent. Many urgent tasks are not really important.

Plan your actions for achieving your goals
Convert your goals into a system of specific actions to be done. The first significant point of planning is the planning process itself. Planning will help you to identify potential conflicts and crises, minimizing the number of urgent tasks. Planning can also significantly lower the time spent on routine maintenance tasks, leaving you more time on what you like to do or for what you think is important for your long term success.

Schedule time for your tasks
Your concentration can be easily lost in a sea of many boring or less important things waiting to be done. Uncompleted tasks circulating in your mind are also a big drain of mental energy. Most often, there is no way to get those things out of your mind except by either doing them or scheduling them in a organised system, convincing yourself that they will be done in due time.

Know how you spend your time
Keep a time log during some time period, such as a week, and then analyze it to see where your time goes. For example, how long do you spend on urgent or important activities? Which people do you devote most time to?

6.15 Critical Path and PERT

In project management, a critical path is the sequence of project network terminal elements with the longest overall duration, determining the shortest time required to complete the project.
The duration of the critical path determines the duration of the entire project. Any delay of a terminal element on the critical path directly impacts the planned project completion date.
A project can have several, parallel critical paths. An additional parallel path through the network with the total durations just shorter than the critical path is called a sub-critical path.

The Critical Path Method
The critical path method (CPM) was invented by the DuPont Corporation during the 1950's. As with Gantt Charts, Critical Path Method (CPM) helps you to plan all tasks that must be completed as part of a project. The tasks act as the basis both for preparation of a schedule, and for resource planning. During management of a project, they allow you to monitor achievement of project goals. They help you to see where remedial action needs to be taken to get a project back on course.
The benefit of using CPM over Gantt Charts is that Critical Path Analysis formally identifies tasks which must be completed on time for the whole project to be completed on time, and also identifies which tasks can be delayed for a while if resources need to be reallocated to catch up on missed tasks. The disadvantage of CPM is that the relation of tasks to time is not as immediately obvious as with Gantt Charts. This can make them more difficult to understand for someone who is not familiar with the technique.
A further benefit of the Critical Path Method is that it helps you to identify the minimum length of time needed to complete a project. Where you need to run an accelerated project, it helps you to identify which project steps you should accelerate to complete the project within the available time. This helps you to minimize cost while still achieving your objective.

6.16 Team Building

“Teamwork is a lot of people doing what I say”.
There are various models that describe how teams evolve throughout the life of the project. One of the most popular ones suggests that teams pass through four distinct stages.

- **Forming**: In this state, people are gathering information about the project. They are concerned with what they will have to do, who is on the team, how they will fit in with the others, how your leadership style will affect them, and many other issues related to starting a project.
- **Storming**: In this stage, team members react to what they have learned during the forming stage. They decide how much they like the project objectives, their roles and responsibilities, and the demands you have placed on them. Incidentally, they are also deciding how much they like you and your leadership style.
- **Norming**: If any conflicts that arise during the storming stage are handled properly, the team will advance to the norming stage. Here, team members become familiar with the project and their role within it. They begin to focus much more on the work to be done. Behavioural norms are developed and team members begin to know what they can expect from others.
- **Performing** In this stage, working routine becomes established. Team members work well together and produce high-quality results. All members understand one another’s task responsibilities and behavioural patterns. They solve problems, make decisions and communicate relatively smoothly.

As the team evolves and matures, they will tend to become more and more self-sufficient, requiring less direct involvement on your part. You should adjust your leadership style over the course of the project according to their rate of growth.

Information

Motivation of the workforce is a constant challenge to the project manager.

How do you motivate the team?

- Praise and recognition
- Openness
- Information
- Delegation
- Getting the management to set a positive example
- Get across your vision, not only quantity targets
- Joint activities outside the company
- Offer training
- Thoroughly planned and regular meetings
- Knowing and addressing the wishes / needs of your co-workers
- Addressing private problems

6.17 Terms of Reference (TOR)

The Project Manager gives authority to a person or group to carry out specific tasks on behalf of the project through Terms of Reference (ToR). Without such authority, there is no sanction and individuals are working without legal protection. Terms of Reference clarify what the PM expects to be done, and how and when he or she expects this will be accomplished.

There are different types of TOR – Project TOR and individual TOR.

Example

Terms of Reference:

Name of the Organization:

This is to agree on the involvement of experts in the Feasibility Study for Distributed Generation (DG) and Renewable Energy Portfolio of a Distribution Utility: A Case Study in the Philippines, in the following referred to as the 'Action'.

Member company	
Status	
Address	
Phone	
Fax	
Email	
Internet	

Expert 1	
Phone	
Fax	
Email	
Expert's duties	• • • • •
N° of working days	1. 2. 3.

Fee	**Total N° of working days**	
	Daily rate for work	
	Gross fee	
	Own contribution	
	Net fee	
Daily expenses	**Daily allowances are eligible only for abroad missions.**	
	Daily rates	Official EU rates up to the maximum of the EU contract rates
	Own contributions	
Travel	**Only travel costs for trips over 200 km are reimbursed**	
	International flights	Economy class – 100 % of actual costs (including booking, airport taxes, insurance and visa costs)
	Up to 5 international flights	Will be decided finally according to project progress and as appropriate.
Payment	**Upon receipt of invoices including own contributions, where requested, and supporting documents**	
	Honoraria	Time sheets and mission/activity reports
	Per diems	Time sheets and travel documents
	Travel	Tickets, boarding passports, invoices and receipts
Financial identification	**Payments will be in Euros only to the following bank account; other currencies have to be converted according to the monthly updated exchange rates of the EU.**	
	Name of bank	
	Address of bank	
	Account holder	
	Account number	
	IBAN	
	BIC/SWIFT	
Final conditions		

Date, Signature

6.18 Procurement Management

Project Procurement Management (PPM) includes the processes to purchase or acquire the products, services, or results needed from outside the project team to perform the work. There are two perspectives of procurement. The organization can be either the buyer or seller of the product, service, or results under a contract.

PPM includes the contract management and change control processes required to administer contracts or purchase orders issued by authorized project team members. PPM processes include the following:

- **Plan Purchases and Acquisitions:** determining what to purchase or acquire and determining when and how
- **Plan Contracting:** documenting products, services and results requirements and identifying potential sellers
- **Requesting Seller Responses:** obtaining information, quotations, bids, offers, or proposals as appropriate
- **Selecting Sellers:** reviewing offers, choosing among potential sellers, and negotiating a written contract with each seller
- **Contract Administration:** managing the contract and relationship between the buyer and seller, reviewing and documenting how a seller is performing or has performed to establish required corrective actions and provide a basis for future relationships with the seller, managing contract-related changes and, when appropriate, managing the contractual relationship with the outside buyer of the project
- **Contract Closure**: completing and settling each contract, including the resolution of any open items, and closing each contract applicable to the project or a project phase.

Each process can involve effort from one or more persons or groups of persons, based on the requirements of the project. Each process occurs at least once in every project and occurs in one or more project phases if the project is divided into phases. PPM processes involve contracts that are legal documents between a buyer and a seller. Some organizations maintain lists of files with information on prospective and preciously qualified sellers, sometimes called bidders, who can be asked to bid, propose, or provide a quote for work. These lists will generally have information on relevant past experience and other characteristics of the prospective sellers. Some organizations maintain preferred sellers lists that include only sellers already selected through some qualification methodology. Qualified sellers lists can be developed from the organizational assets if such lists or information are readily available. Whether or not that data is available, the project team can also develop its own sources. General information is widely available though the Internet, library directories, relevant local associations, trade catalogs, and similar sources.

Detailed information on specific sources can require more extensive effort, such as site visits or contact with previous customers. Procurement documents can also be sent to determine if some or all of the prospective sellers have an interest in becoming a qualified potential seller.

6.19 Quality Management

Project Quality Management processes include all the activities of the performing organization that determine quality policies, objectives, and responsibilities so that the project will satisfy the needs for which it was undertaken. It implements the quality management system through the policy, procedures, and processes of quality planning, quality assurance and quality control, with continuous process improvement activities conducted throughout, as appropriate. The Project Quality Management processes include the following:

1. Quality Planning: identifying which quality standards are relevant to the project and determining how to meet them;
2. Perform Quality Assurance: applying the planned, systematic quality activities to ensure that the project employs all processes needed to meet requirements;
3. Perform Quality Control: monitoring specific project results to determine whether they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.

A critical element of quality management in the project context is to turn stakeholder needs, wants, and expectations into requirements. Stated and implied needs are the inputs to developing project requirements.
Modern quality management complements project management. For example, both disciplines recognize the importance of:

- **Stakeholder satisfaction**: Understanding, evaluating, defining, and managing expectations so that stakeholder requirements are met. This requires a combination of conformance to requirements (the project must produce what it said it would produce) and fitness for use (the product or service must satisfy real needs).
- **Prevention over inspection**: The cost of preventing mistakes is generally much less than the cost of correcting them, as revealed by inspections.
- **Management responsibility**: Success requires the participation of all members of the team, but it remains the responsibility of management to provide the resources needed to succeed.

- **Continuous improvement**: The plan-do-check-act cycle is the basis for quality improvement. In addition, quality improvement initiatives undertaken by the performing organization, such as TQM and Six Sigma, can improve the quality of the project's management as well the quality of the project's product.

Quality Planning Tools

Cost–benefit analyses:
Quality planning must consider cost-benefit tradeoffs. The primary benefit of meeting quality requirements is less rework, which means higher productivity, lower costs, and increased stakeholder satisfaction.

Benchmarking:
Benchmarking involves comparing actual or planned project practices to those of other projects to generate ideas for improvement and to provide a basis by which to measure performance. These other organizations can be within the performing organization or outside of it, and can be within the same or another application area.

Quality Assurance Tools

Quality Planning Tools:
Quality Planning Tools can also be used for Quality Assurance activities.

Quality Audits:
A quality audit is a structured, independent review to determine whether project activities comply with organizational and project policies, processes, and procedures. The objective of a quality audit is to identify inefficient and ineffective policies, processes, and procedures in use on the project.

Process Analyses:
Process analysis includes identification of needed improvements from an organizational and technical standpoint. This analysis also examines problems experienced and constraints experienced during process operation. Process analyses include root cause analyses, a specific technique to analyse a problem/situation, determine the underlying causes that lead to it, and to create preventive actions for similar problems.

6.20 Project Cost Management

Project Cost Management includes the processes involved in planning, estimating, budgeting, and controlling costs so that the project can be completed within the approved budget.

- **Cost Estimating**: development of an approximation of the costs of the resources needed to complete project activities.

- **Cost Budgeting**: aggregating the estimated costs of individual activities or work packages to establish to the project budget.

- **Cost Control**: influencing the factors that create cost variances and controlling changes to the project budget.

These processes interact with each other and with processes in the other knowledge areas as well. Each process can involve effort from one or more persons or groups of persons based upon the needs of the project. Project Management is primarily concerned with the cost of the resources needed to complete schedule activities. However, cost management should also consider the effect of project decisions on the cost of using, maintaining, and supporting the product, service, or result of the project. For example, limiting the number of design reviews can reduce the cost of the project at the expense of an increase in the customer's operating costs. This broader view of Project Cost Management is often called life-cycle costing. Life-cycle costing can improve the quality and performance of the project deliverable.

6.21 Monitoring & Controlling

Monitoring and controlling is performed to monitor project processes associated with initiating, planning, implementing, and closing. Corrective and preventive measures are taken to control the project performance. Monitoring is an aspect of project management performed throughout the project. Monitoring includes collecting, measuring, and disseminating performance information, and assessing measurements and trends to effect process improvements. Continuous monitoring gives the project management team insights into the health of the project, and identifies any areas that may require special attention. According to PMI, the Monitoring and Controlling process is concerned with:

- Comparing actual project performance against the project plan
- Assessing performance to determine whether any corrective or preventive actions are indicated and then recommending those actions as necessary
- Analysing, tracking, and monitoring project risks to make sure the risks are identified, their status is reported, and that appropriate risk response plans are being executed
- Maintaining an accurate, timely information base concerning the project's product(s) and their associated documentation through project completion
- Providing information to support status reporting, progress measurement, and forecasting
- Providing forecasts to update cost and current schedule information
- Monitoring implementation of approved changes as and when they occur

The difference between Monitoring and Controlling is that monitoring is performed to track project progress, while controlling is performed to take corrective actions.
Monitoring and Controlling consist of four major steps:

- Collecting data
- Analysis of performance
- Managing change
- Reporting

What information do you need for Monitoring and Controlling?

Schedule-related:
- Date that each completed activity was scheduled to start and finish
- Date that each completed activity actually started and finished
- Anticipated start date of each activity currently under way
- Actual start date of each activity currently under way
- Originally scheduled completion date of each activity currently under way
- Estimated completion date of each activity currently under way
- Description of the progress made on each activity currently under way

Cost-related:
- Estimated expenditure for all activities
- Actual expenditure for each completed activity
- Amount spent to date on each activity currently under way
- Estimated cost to complete for each activity currently under way

Functionality-related:
- Estimated capabilities of final deliverables
- Current prediction of what capabilities will actually be

Quality-related:
- Original estimation of how well final deliverables will function
- Current prediction of how well they actually will function

How to gather information?

- Team meetings
- Forms and templates
- Management by Walking Around (MBWA)
- Software support (e.g. MS Project)

Questions to ask during the meetings

- Interim results:
    - Which steps have already been completed?
    - Which success indicators have been met?

- Unexpected changes:
    - Have important assumptions changed? If so, how and why?
    - What modifications have been introduced to the plan accordingly?

- Problems in implementation:
    - Have we failed to complete any tasks on time? If so, why? What have we done to complete the pending work?
    - Are there any issues that remain unresolved? What are we doing to overcome such problems?
    - Can we anticipate any difficulties in follow-up? How should we address them?
    - Have we observed any unintended and possibly unwanted effects of our project? If so, what can we do about it?

Monitoring tool – Monitoring Matrix (Commitment Matrix)

Activity	Person Responsible	Start Date		End Date		Comments
		Planned	Actual	Planned	Actual	
Activity 1						
Activity 2						
Activity 3						

Monitoring tool – Timetable (Progress Gantt chart)

Activities	Date						
	January	February	March	April	May	June	July
Activity 1							
Activity 2							
Activity 3							
Activity 4							

6.22 Reporting

Reporting involves making information available to project stakeholders in a timely manner. Information distribution includes implementing the communications management plan, as well as responding to unexpected requests for information. Generally reporting includes information on scope, schedule, cost, and quality. Many projects also require information on risk and procurement. Reports may be prepared on a regular basis or in exceptional circumstances.

Types of reports:
- Exception reports
- Progress reports
- Narrative reports
- Budget reports
- Performance reports
- Costs reports
- Schedule reports
- Final reports
- Evaluation reports

Progress report:
- Reviews what has happened during the performance period
- Describes problems and relevant corrective actions needed
- Previews what is planned for the next period

Progress report contents:
- Performance highlights
- Performance details
- Problems and issues
- Approved changes to the plan
- Risk management status
- Plans for the next period

Progress report tips:
- Tailor the report to the audience
- Prepare the most detailed one first
- Produce it on a monthly basis
- Always compare actual vs. planned
- Include no surprises

What should be included in the final report?
- Performance indicators
- Resource utilization
- Strengths and weaknesses
- Success factors

6.23 Project Closure and Evaluation

Project closure consists of:
- Finishing all substantive work
- Performing required administrative tasks
- Announcing the closure of the project
- Preparing the final report

Project closure tips:
- Start laying the groundwork for project closure when developing the project plan
- Include project closure as one of the activities in your project plan

Why is project closure announcement needed?
- To alert people that the planned results of your project are now available
- To inform the project team, part-time team members and other project supporters that their efforts led to a successful result

Post-project evaluation

Projects are an excellent opportunity to learn from experience. Monitoring your project allows you to keep track of events. However, you should also explore why or how certain developments (positive or negative) took place.

Evaluation is an opportunity to learn, not to blame others for what did not go well in the project!

Project evaluation usually takes place at the end of project or, in multi-year projects, after the completion of a major project phase.

Evaluating the design of the project

Check, together with the project team, how accurate the logical framework matrix and the plan of operations were. Consider the following questions:
- Relevance of the project: did the project address real needs?
- Success rate: did the project achieve its intended results and objectives?
- Efficient use of resources: how accurately did the team identify and use the human resources, materials and funds allocated to this project? How accurate was the plan of operations? Did events occur when planned?
- Sustainability of the project: what long-term difference has the project made? What follow-up is required?

Evaluating project results

A thorough analysis of results comprises:

- Naming two or more achievements in the following areas:
  - The project's ability to produce the intended results
  - Positive influence on the environment, community or target group
  - Partnership and cooperation with others
  - Management of the project and teamwork
- Identifying an indicator for each achievement listed so as to substantiate statements
- Stating which achievements helped to reach that result
- Indicating at least one consequence deriving from each achievement
- Making recommendations for future activities or projects
- Assessing the sustainability of results, including follow-up activities and handover

Identifying Lessons learnt

With time, the experience gained in the project may be lost if it is not documented properly. When identifying lessons learnt with your project team, ask yourself the following questions:

- What will you remember from your involvement in this project?
- What would you do differently if you had to implement a similar project in the future?

As a rule, ask the members of the project team to judge what went well throughout the entire project cycle and what they would have liked to see done differently. Encourage the members of the project team to point out where they could have made improvements and how.

6.24 References / Recommended Reading

Project Management Institute (2003). A Guide To The Project Management Body Of Knowledge, 3rd ed., Project Management Institute. ISBN 193069945X.

Jack R. Meredith, Samuel J. Mantel (2002). Project Management: A Managerial Approach, 5th ed., Wiley. ISBN 0471073237.

Lewis, James (2002). Fundamentals of Project Management, 2nd ed., American Management Association. ISBN 0814471323.

Scott Berkun (2005). Art of Project Management, Cambridge, MA: O'Reilly Media. ISBN 0596007868.

Heerkens, Gary (2001). Project Management (The Briefcase Book Series), McGraw-Hill. ISBN 0071379525.

Alan Lawton (1998). Ethical Management for the Public Services (Managing the Public Services, Open University Press, ISBN 0335199194

James L. Garnett, Dwight Waldo (1994). Communicating for Results in Government: A Strategic Approach for Public Managers, Jossey-Bass, ISBN: 0787900001

Steven Cohen, William Eimicke (2002). The Effective Public Manager, 3rd ed., Jossey-Bass ISBN: 0787959383

6.25 Internet Resources

Here's a little collection of useful websites – mostly portals, i.e. starting points for further browsing. Many offer free downloading of relevant materials and many networks and organizations offer free subscription to e-newsletters and the like. There are of course many more valuable sites – remember to bookmark sites that you come across and possibly share them with other trainers and participants.

http://en.wikipedia.org/wiki/Project_Management:
The wikipedia entries on "project management"– useful background, resources, links.

http://www.pmi.org/info/default.asp
The Project Management Institute website brings an overview to advanced project management techniques. It is also quite informative to browse the collection of books, electronically available information and templates. Nevertheless, the whole approach very much centres around the Project Management Body of Knowledge.

http://www.pmibookstore.org

http://www.managers-gestionnaires.gc.ca/reading_room/menu_e.shtml
A Canadian page for public managers. In the reading room a whole series of books, articles and presentations are available. „In June 2000, a group of managers from across the country, most of them associated with Federal Councils, met to discuss issues of common interest. In August 2000, these same managers met again and invited managers from the National Capital Area to join them. Together, they identified the need for a national body to represent, support and promote all federal public service (PS) managers in areas of concern to them. With support from Mike Nurse (National Managers' Champion) and the Secretariat for the Managers' Community, they formed the National Managers Council."

http://www.unido.org/doc/6397
Publications page of the United Nations Industrial Development Organization with a range of publications also of relevance to the public sector.

http://www.ogc.gov.uk/
Office of Government Commerce is an independent office of the Treasury and works with public sector organisations to help them improve their efficiency, gain better value for money from their commercial activities and deliver improved success from programmes and projects. The pages contain information on procurement and especially programs & projects in the public sector area.

http://www.laatuk.com/resources.html
A portal page with many links to project management related sites.

http://europa.eu.int/comm/europeaid/qsm/project_en.htm
The standard tool of the European Commission External Aid departments for project and programme planning. A very useful tool to structure bigger projects and programmes.

Funding insitutions

ONE WORLD German Development Policy

MEDA Water

inWEnt Internationale Weiterbildung und Entwicklung gGmbH Capacity Building International, Germany

EMWATER EFFICIENT MANAGEMENT OF WASTEWATER

ENEA

BIRZEIT UNIVERSITY

TUHH Technische Universität Hamburg-Harburg

adelphi research