Water Resources and Management Issues

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ABSTRACT

The Gaza Strip is located on the extreme edge of the shallow coastal aquifer that borders the eastern Mediterranean Sea. There is little rainfall and no reliable riparian flow; hence water supply for Gaza residents is limited to that available from the part of the coastal aquifer. The exploitation of the coastal aquifer has resulted in continuous lowering of regional water levels and the worsening of water quality. The greatest threats to existing water supplies are seawater intrusions and up coning of deep brine fossil water. There are serious water quality problems in the Gaza Strip's Aquifer. The population of the Gaza Strip will grow to over two million by 2020, and the demands for water will far exceed the sustainable capacity of the aquifer. Continuous urban and industrial growth will place additional stress on the aquifer system, unless appropriate integrated planning and management actions are instituted immediately. It is evident that drastic action must be taken quickly to support its people in the future. This paper presents overall guidelines for the management through year 2020, with associated investment requirements for infrastructure facilities to meet all goals and objectives. It has been estimated that a capital investment program of about US$1.5 billion is needed to finance the implementation of such plan. It has been concluded that seawater desalination as well as brackish water desalination are the main components of the domestic water management plan that will have overall beneficial impacts on the socioeconomic aspects in addition to protecting people lives in Gaza.
Keywords: groundwater**,** water demand, resources management, desalination, water supply.

1. INTRODUCTION

The Gaza Strip is a very small area of land with a total area of only 360 km2. It is underlain by a shallow aquifer, which is contiguous with the Israeli Coastal Aquifer to the north. See fig.1. Gaza is the downstream user of the Coastal Aquifer system, and hence water abstraction in Gaza does not affect Israeli water supplies. The Gaza Aquifer has a natural recharge rate of approximately 65 million cubic metres (MCM) of water per year from rainfall and lateral inflow of water from Israel and Egypt (CAMP, 2000).

This aquifer is essentially the only source of fresh water in the Gaza Strip. By 1967, when Israel occupied Gaza, the sustainable yield of the aquifer was being fully utilized (Nasser, 2003). Since then, as the population has grown, so too has the demand for fresh water. No serious attempt was made at exercising any water management strategy in the Gaza Strip during the Israeli administration, with the number of registered wells increasing from 1200 in 1967 to 2100 in 1993 (Nasser, 2003). Abstraction from the aquifer was approximately 110 MCM per year by 1993, resulting in falling water levels and degrading water quality due to seawater infiltration, caused by the over-pumping that had been taking place. Likewise, there was little investment in maintaining or improving the deteriorating water infrastructures of Palestinian municipalities during this period, despite taxes being paid by Palestinians to the Israeli government (World Bank, 1993).

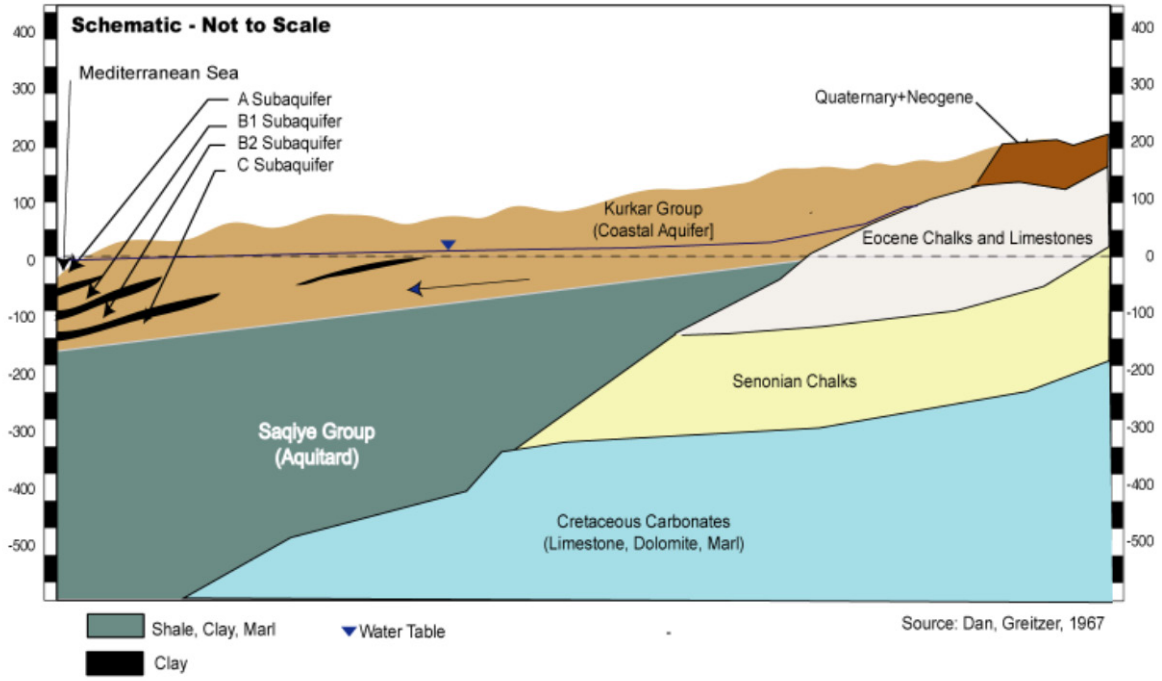

Fig.1: Schematic hydro geological cross section of Gaza aquifer

2. WATER RESOURCES

Gaza has a sub-Aquifer, which is a part of the Coastal Aquifer that lies along the Mediterranean coastline of Israel and the Gaza Strip. Studies of the Palestinian Water Authority (PWA) show the people of Gaza over abstract (over-pump) between 180-190 million cubic meters (MCM) of water from the coastal aquifer per year, but the natural (such as rainwater) and anthropogenic (agricultural return flow and waste water) replenishments between 110 – 140 MCM/yr. These figures reveal that Gaza has a current water deficit of approximately 50-80 MCM/yr.

In addition, population density determines how much water is needed within a geopolitical area, even if the hydro-geological and topographical landscape does not have the natural resource capacity to satisfy the number of people living there. The Gaza Strip is also one of the most densely populated areas in the world and there are approximately 4,300 people per square km.

With a growing population expected to exceed 2.1 million by end-2020, there will be over 5,800 people per square km. As a result of population increases the water deficit will be more exacerbated if more water and resource infrastructure are not in effect within the next years.

3. WATER CONSUMPTION AND DEMAND

The present situation concerning water availability and quality in Gaza is little short of catastrophic. As a result of such concerns the water situation in Gaza has been recognized for some years as a critically important issue, but the situation continues to worsen inexorably over time.

Although the World Health Organization (WHO) calls for minimal water consumption of 100 liters per capita per day (l/c/d) for a quality level of health; PWA shared that Palestinians average 70-80 liters (l/c/d) see fig.2. Moreover, Israeli capita usage averages 400 l/d and Israel settlers in the Palestinian Occupied Territories average 800 l/c/d. Thus, Israelis average almost five times more water consumption than Palestinians.

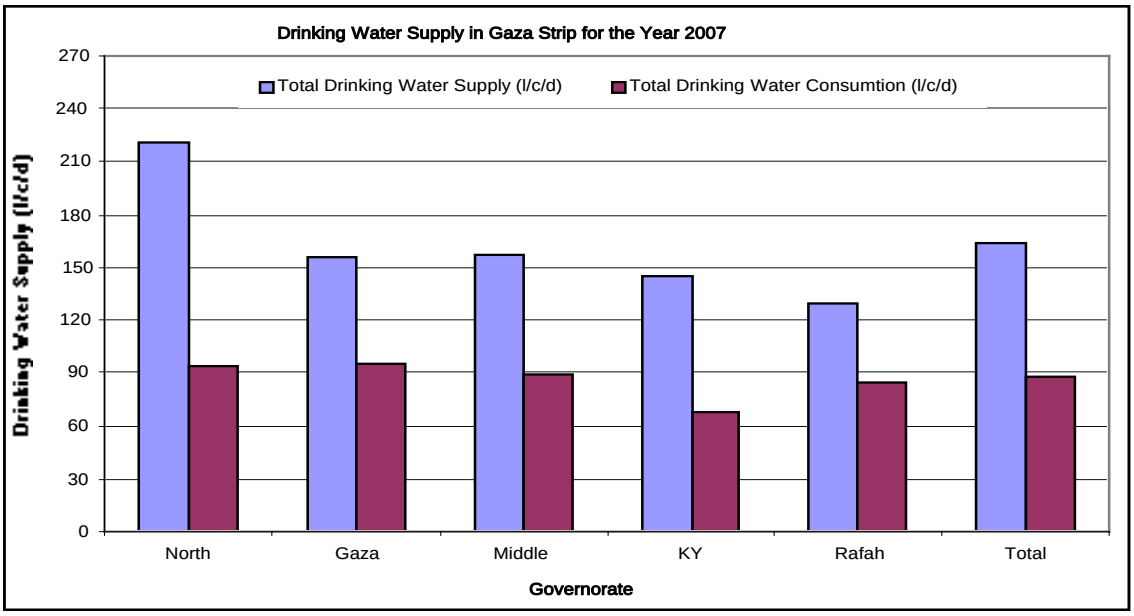

Fig.2: Drinking water supply and consumption in Gaza Strip

For the 1.5 million Palestinians living in Gaza Strip they consume approximately 190 MCM/yr; and this figure includes domestic, agricultural and industrial consumption. However, 6.4 million Israelis have a total water consumption of 2,129 MCM/yr.

A large groundwater aquifer basin underlies the West Bank and supplies high quality water to both Israelis and Palestinians. It is composed of three sub aquifers: the Western, the Eastern and the North-eastern Aquifer Basins. Since Israel controls the water, they allow Palestinians in the West Bank 114 MCM/yr only -- they have to purchase another 30-40 MCM/yr for the West Bankers and 4 MCM/yr for Gazans from Mekorot, the Israeli water company.

In Gaza, Palestinians consume roughly 190 MCM/yr of which around 70 MCM is due to over abstraction of the Gaza Aquifer. The Palestinians are over-pumping the aquifer through around 6,000 wells within the Gaza Strip. Although most of the wells are used for agricultural purposes, there are 4,000 illegal wells. Moreover, illegal wells drains the already stressed aquifer.

4. How is the exploitation of the water table affecting the Coastal Aquifer?

It is increasing the rate at which saline ground water naturally flows from the eastern part of the Coastal Aquifer toward Gaza, which is salinizing the freshwater in the western part of the aquifer at an accelerated pace, see fig.3. Moreover the study concluded: If pumping continues at these unsustainable rates, it will destroy the aquifer's capacity to resist sea water intrusion from the west and saline ground water from the east, thereby making it totally unsuitable for human consumption or for irrigated agriculture with the next few decades.

The exploitation of the aquifer has damaged the water's quality already. One can say that 90 per cent of the aquifer's water is brackish water: saline water due to over-abstraction.

Unfortunately, as there is no alternative, people in Gaza are drinking this water and they are experiencing health problems.

5. WATER QUALITY AND ITS IMPACTS ON HUMAN HEALTH

WHO established international standards for salt levels of chemical compounds in water, such as nitrate and chloride. For safe and healthy human consumption of drinking water these concentrations can not exceed the WHO guidelines. For nitrate, the WHO standard is 50 mg/l and for chloride it is 250 mg/l. The Gaza aquifer has nitrate levels over 100 mg/l and chloride levels averaging 1000 mg/l. Therefore, these unsafe levels are affecting the health of Palestinians, see fig. 5&6.

The health problems are: 50 per cent of Gaza's children have a parasitic infection; children and adults suffer from diarrhea; high chloride levels causes kidney disease; consumption of saline water leads to salt levels in humans that causes kidney

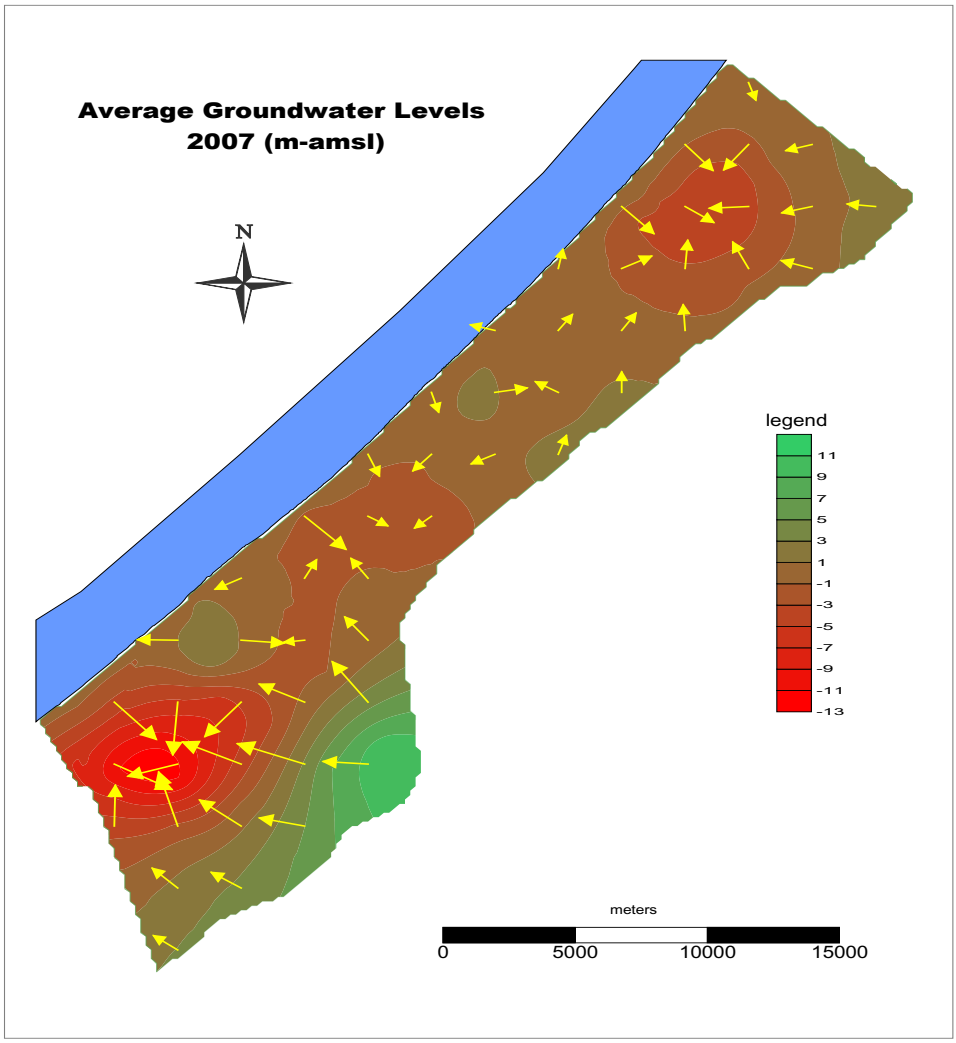

Fig.3: Average groundwater levels in the Gaza Strip

dysfunction, heart failure, neurological symptoms, lethargy, and high blood pressure; excessive levels of fluoride are toxic, causing gastritis, ulcers, kidney failure, bone fluorisis (bone fractures and crippling), and teeth fluorsis (black lines around gums and tooth decay); and high nitrate levels causes "blue baby" syndrome, also know as methaemoglobinaemia and gastric cancer.

6. DRINKING WATER SUPPLY

Around 98% of the Gaza Strip's population has piped water supply systems. The remainder depends mainly on cisterns and springs for their water use. The overall loss of water in the Gaza Strip through

the system is estimated at 45% of which 35% is due to physical losses and 10% is due to unregistered connections.

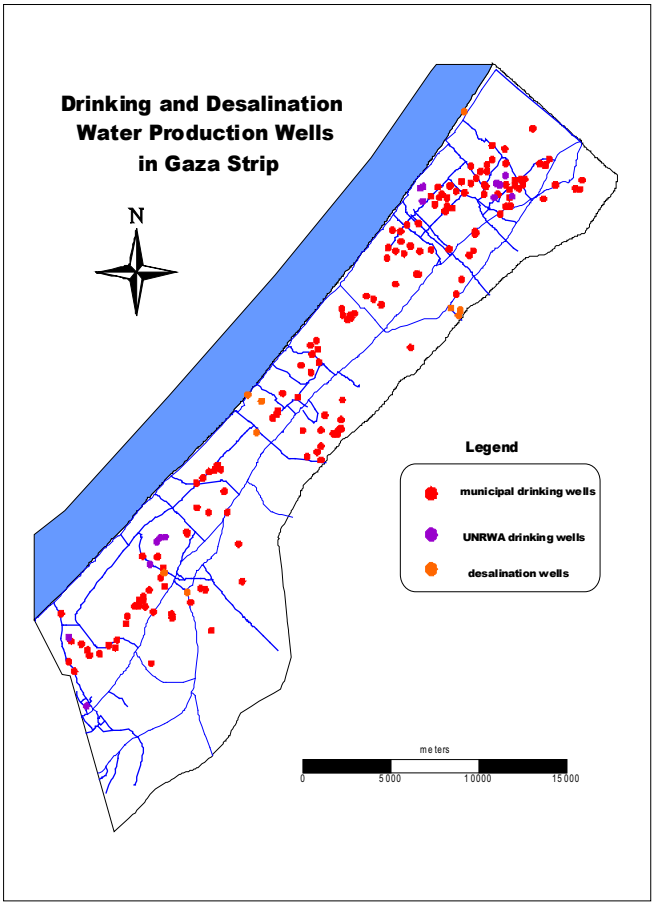

Fig.4: Location of municipal and desalination water wells

Drinking water is mainly supplied by Coastal Municipal Water Utility, which manages and operates about 170 water wells distributed all over the Gaza Strip see fig.4. These wells produce about 85 MCM per year, while the actual water consumed does not exceed 55 percent of this amount. However, UN- water and sanitation department supplied part of the refugee camps with clean water. The total quantity of such water is just 2.5 MCM per year and pumped from 15 wells. In addition to these quantities, another 2 MCM per year is produced by desalination plants. Moreover, the major amount of such water is distributed to consumers by tankers in different areas in Gaza.

7. WATER DESALINATION

The only technology in water desalination applied in Gaza is Reverse Osmosis (RO). The first RO plant in the Gaza Strip was built in 1993 in Deir al balah town by EMS a subsidiary of Mekkorot company. This plant is constructed to desalinate brackish water and has a capacity of 45 m3/h with a

recovery of 75%. After that between 1997- 1998 and through an Italian development cooperation program two RO plants were constructed in Khan younis to desalinate two brackish water wells. Each RO plant has a capacity of 50 m3/h to supply a part of Khan younis town with potable water.

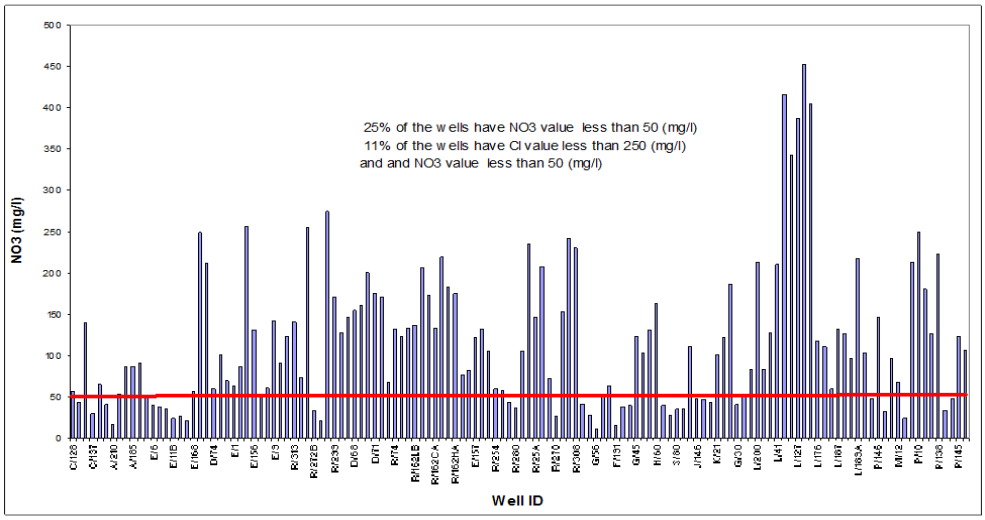

Fig.5: Average NO3 concentration in municipal water wells

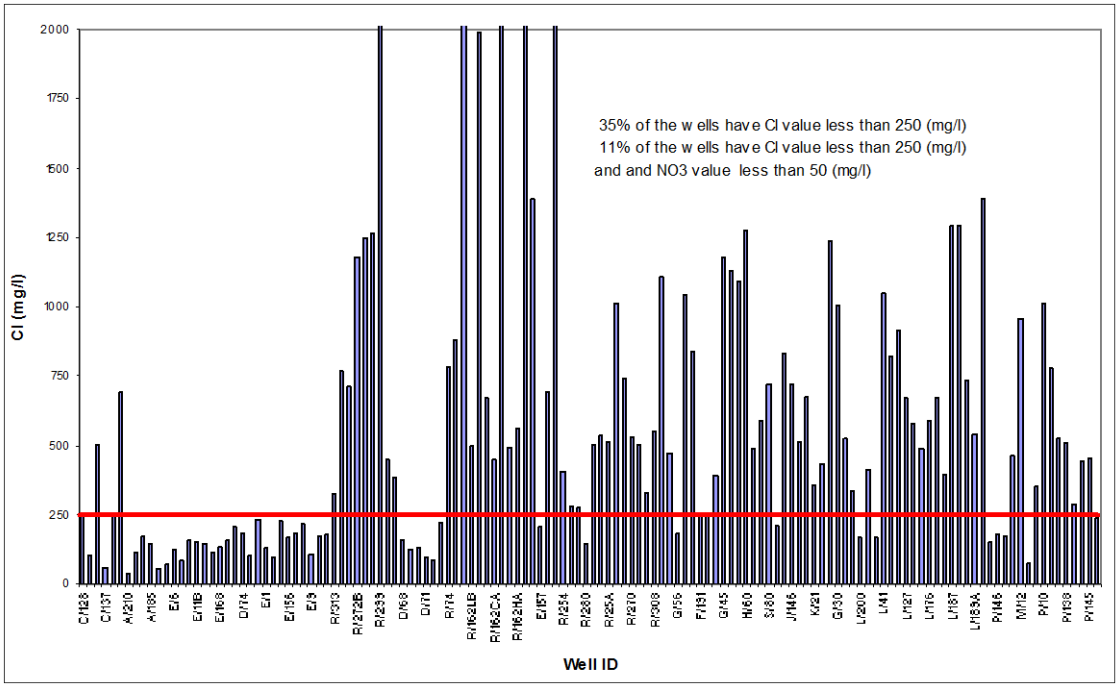

Fig.6: Average Cl concentration in municipal water wells

In 1998, USAID financed a BWRO plant built by an American company Metcalf and Eddy in Gaza Industrial Zone. This plant has a capacity of 40 m3/h and was designed to supply water to

the surrounded industrial complexes and adjacent part of Gaza city. In 1999 the private sector – local companies- started to invest in the desalination field. They installed small scale BWRO plants with different capacities to desalinate low brackish water wells in various areas in Gaza Strip. Such plants have current capacities from 10 to 200 m3/d and recoveries ranging from 40 to 70 percent. The total amount of desalinated water produced by such small plants range from 1 to 1.5 million cubic meter per year where the number of these plants does not exceed 80 units.

CONCLUSION AND RECOMMENDATIONS

- Sustainability of the water, wastewater and agricultural reuse water systems is a primary goal of PWA. To make these systems sustainable, there must be:
  Sufficient funds collected to recover costs: operations and maintenance, administration, depreciation and debt service.
- In term of quality more that 90% of the pumped water is far from the drinking standard and can be used only for domestic purposes.
- The network distribution system efficiency in all Gaza governorates is very low (40-50%) and that affects negatively the actual water per capita consumption.
- CMWU should improve the system efficiency in order to increase the per capita water consumption.
- PWA is not in the favor of drilling new wells for domestic use.
- New resources such as seawater desalination should be considered by the CMWU for fulfilling the domestic water needs.
- Brackish groundwater desalination should not be considered as an option for domestic water supply at least for the short term (5-years).
- Pumping rates from the different wells as well as pumping duration should be minimized to the levels that have been recommended by PWA.
- Wastewater treatment and reuse projects are considered by PWA as very important component in the water resources management and CMWU should consider that in their short and long term demand management plan.
- The operation water distribution system in all the Gaza Strip governorates should be revised taking in consideration the related hydraulic model that was established through the Finland/PWA project, which will improve significantly the network efficiency and the water per capita consumption.
- No new wells should be drilled in the near future in all the Gaza Strip governorates except for Rafah.
- There is no domestic water supply shortage in all of the Gaza Strip Governorates except for Rafah governorate in terms of quantity.
- The illegal domestic municipal water wells should be licensed following the PWA's regulation.

REFERENCES:

1. Palestinian Central Bureau of Statistics,1997, Palestinian Authority, "General Census".
2. Palestinian Water Authority / Palestinian Energy Authority,2000 "Water Desalination Plan", Draft Report.
3. Palestinian Water Authority / USAID, 2000"Coastal Aquifer Management Program (CAMP), Integrated Aquifer Management Plan (Task-3), Gaza.
4. Al-Jamal K., Al-Yaqubi A., (2000) " Prospect of Water Desalination in Gaza", Palestinian WaterAuthority, Gaza.
5. Palestinian Water Authority / USAID,2000 "Coastal Aquifer Management Program (CAMP), Tariff assessment (Task-19), Gaza.
6. Ahmed Mohammed, 2007"Drinking Water Supply through RO Desalination in Gaza Strip".
7. Al Bana Mazen and Ahmed Mohammed,2008 "Current Status of Water Resources in Gaza Strip".