DRINKING WATER SUPPLY THROUGH RO DESALINATION PLANTS IN THE GAZA STRIP

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ABSTRACT

The population in Gaza Strip, Palestine faces potable water scarcity throughout the year in general and acute drinking water problems in lean periods of the year. To mitigate this problem, various capacities of BWRO desalination plants were installed in various locations of Gaza characterized with high salinity of groundwater. General performance of these plants was undertaken to focus attention on the physio-chemical quality of water at various stages of treatment, present status with respect to operation and management (O & M) financial implications and overall management in a current situation.

INTRODUCTION

Gaza Strip has about 1.3 million people living in a coastal area of about 365 km^2. This Strip has a big water problem in terms of water quantity and water quality.

Due to over abstraction of ground water from Gaza aquifer and seawater intrusion, most of water pumped from water wells have high salinity and do not meet the WHO standards.

PWA reviewed various desalination technologies as membrane processes and thermal evaporation and distillation processes for brackish and seawater treatment as a new water resource. Each process was evaluated on cost and ability to meet the water quality standards. As a result, the Water Authority considered desalination of brackish/sea waters a vital option to face water deficit reasonably and to provide people with safe drinking water in Gaza.

WATER RESOURCE

In the Gaza Strip, the main source of groundwater comes from the coastal aquifer (shallow aquifer), which consists mainly of sandstone, sand and gravel. The aquifer is an extension of the coastal plain aquifer in Israel. The aquifer is highly permeable with transmissivity of about 1000 m^2/day and an average porosity of 25%. The depth to

water ranges between 70 meters in the highly elevated area in the east and 5 meters in the low land area. The total annual recharge of the aquifer is estimated at 55 MCM. A deficit with an average of 70 MCM/year is observed in the water balance due to over pumping. Therefore, the aquifer is replenished from brackish or seawater, which results in a deterioration of quality.

An average of 160 MCM/year is pumped from the groundwater aquifer and is distributed over domestic and agricultural water wells.

A water balance was developed to determine the impact of all the integrated aquifer management program activities. New water resources account for nearly 25 percent of the balance. New resources include additional water purchase from mekorot, small SWRO desalination plants and regional SWRO plants.

WATER QUALITY

The main quality problem is the increase in salinity and nitrate content. Nitrate concentration reaches more than 200 mg/l in the northern part of the Gaza Strip and salinity reaches more than 1600 mg/l in the middle and southern parts of the Strip. This deterioration in the quality of water could be related to the unregulated disposal of various forms of waste including domestic industrial solid and liquid and agricultural waste (fertilizers and pesticides) in addition to seawater intrusion in the case of Gaza. PWA reports mentioned that 70% of the Gaza Strip population obtains water with a high salinity and a chloride average of more than 500 mg/l to reach 2500 mg/l. While a large number of drinking water wells contain an average nitrate level of more than 100 mg/l. Moreover, the average water supply per capita in the Strip reaches 80 liters per day, however, most of this water contains high salinity.

EXISTING DRINKING WATER SOURCES

There are five sources of drinking water as follows:
- 130 Domestic water wells produce 70 Mm^3/y
- More than 4000 agricultural water wells produce 90 Mm^3/y
- Water is purchased from an Israeli company "Mekkorot" (5 Mm^3/y)
- Four BWRO plants produce 0.4 Mm^3/y
- The Middle Area SWRO plant produces 0.2 Mm^3/y

HISTORY OF BW & SW RO DESALINATION IN GAZA

- The first RO plant in the Gaza Strip was built in 1991 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 45m^3/h with a recovery of 75%.

- In 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 m^3/h to supply a part of Khan Younis town with potable water.

- 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 m^3/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 m^3/d and recoveries ranging from 40 to 70 percent.

SEAWATER RO DESALINATION

The Palestinian Water Authority has begun with the first SWRO plant since 1999. This plant is designed to have a capacity of 1250 m^3/d in the first phase and was built by Degremont through a grant from the government of France. The plant has not yet begun operation. The second SWRO plant was financed by Austria and built by GWT (Austrian Company). This plant has a capacity of 600 m^3/d in the first stage and could be expanded to produce 2400 m^3/d at the final stage. It is now in operation just for a few hours due to incapability.

NORTH AND MIDDLE AREA SWRO PLANTS

The government of French and Austria financed two Seawater RO plants with a capacity of 1250 m^3/d and 600 m^3/d, respectively. The French-sponsored plant is located in Northern Gaza "Northern RO plant". The Austrian-sponsored plant is located in the middle area "Middle RO plant".

The North RO plant is fed by raw sea water from two beach wells. It includes chlorination and coagulation systems, sand filters, dosing of acid and antiscalent, dechlorination and cartridge filters. Post-treatment unit includes addition of lime and sodium hypochlorite.

The Middle SWRO plant is supplied with feed water by two beach wells operating alternatively. This plant consists of pre-treatment unit, which includes dosing of chemicals as sulpheric acid, sodium hypochlorite, flocculent and antiscalent. The water passes through multi-media filter and 5 micron cartridge filter prior to entering membranes at a high pressure (60 bar). Finally, desalinated water is post treated by adjusting pH and disinfected before it is pumped to the consumers.

The North RO plant has not been completed regarding installing electromechanical works.

The Middle RO plant is now working and produces 600 m^3/d. Part of produced water is directly pumped to the consumers through a network in Deir al Balah and Al Zawaida, while the remaining part is transferred and sold by tankers in the middle area. Seawater is desalinated through two passes in order to have good desalinated quality with a TDS of about 100 ppm.

REGIONAL SWRO DESALINATION PLANT

PWA launched an agreement with USAID to build a regional seawater RO plant with a capacity of about 60,000 m^3/d as a first stage in the middle of Gaza Strip, expandable to150,000 m^3/d. This plant will be supplied with feed water by an open seawater intake located about 800 m from the shore.

The SWRO plant consists of pre-treatment unit including addition of chemicals, ultra filtration, multi-media filters and cartridge filters. It also includes high pressure pumps and membrane units. A post-treatment system includes pH adjustment and addition of limestone. The desalinated water will finally be pumped into the North-South National Water Carrier and will be mixed with other well water in the municipal network.

PRIVATE BWRO DESALINATION

Although public institutions, such as the Palestinian Water Authority (PWA) and Gaza Municipalities, own some BWRO desalination plants, local investors in the private sector have already begun a desalination business, constructing various small BWRO plants since 1999 in Gaza. Such plants have to be licensed by PWA and Ministry of Health according to certain conditions, so that they are monitored in terms for compliance of the product water to the Palestinian water guidelines. The private sector has now about 40 private BWRO plants. These could reasonably satisfy some of Gaza's drinking water needs.

However, these plants are considered small units having operational capacities from 20–150 m^3/d.

DRINKING WATER SUPPLY

Around 98% of the Gaza Strip 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.

However, there are two main systems to distribute the desalinated water from RO plants.

1. Domestic water network

The municipalities of Khan Younis and Deir al Balah are responsible on pumping the desalinated water into the network, where the consumers can get their fresh water. This is to be managed through several hours since the people are aware about the schedule of pumping such water.

2. Water tankers

The private sector- local contractors- has a big rule in transporting the desalinated water from the sites of RO plants to the consumers and water shops where they are not connected to the networks of the plants. Customers have to fill their Jeri cans directly from the tankers or the tanks owned by supermarkets. A provision for direct connections shall be allowed for high rise buildings and hotels. Desalinated water from the regional plant will be distributed in the municipal distribution networks and will be paid as part of the water bill.

TECHNICAL APPRAISAL

In evaluating the competing RO brackish water desalination processes, many factors need to be taken into consideration. The main points are discussed below.

1- State of development

BWRO plants are now in a mature phase of technical development, and they seem unlikely that there will be significant further technological advances in the process and particularly in membrane technology, pretreatment and detail engineering. Development of chlorine tolerant membranes or alternatively the adoption of biocides that are non aggressive to membrane materials would be a significant advance. Membrane replacement, however, is still a considerable factor in O&M if we could estimate the life period of such brackish water membranes of 5–7 years under good operation conditions.

2- Energy consumption

It will be seen that BWRO plants have a lower energy consumption than SWRO plants making this option attractive in high energy cost conditions. Energy consumption forms about 25 to 50% of the total cost required to produce desalinated water by BWRO plants taking in consideration the cost of energy US$ 0.09/kWh.

3- Operational state

Most of the BWRO plants have still not reached a full daily operational status (24 h). This is due to many challenges, such as:

- Low maintenance level for the system.
- Lack of chemicals, such as antiscalants or acids imported to run the units.
- Inefficient distribution in networks to the whole area where the plants are located.
- Dependence of operational hours on the limited quantities of desalinated water marketed in some areas in Gaza.

CONCLUSION

The study indicated that performance of these RO plants was satisfactory in removing high TDS, though the efficiency deteriorated with time. The average utilization of these RO plants since their installation was about 50% as compared to the design capacity, mainly due to non continuous availability of power in some areas; time lapsed in repairs of pumps, and non-availability of spares. The average capital cost/m^3 and O & M cost/m^3 of product water from these plants works out to $0.29 and $0.10 respectively; when plants are utilized as per the design capacity. These costs are high and not affordable by the rural population. The RO plants were socially acceptable since the population was satisfied with the treated water quality.

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