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Water Status in the Gaza Strip and Future Plans

April 2010

1.0 Background and Introduction

Gaza Strip is one of the semi-arid area where rainfall is falling in the winter season from September to April, the rate of rainfall is varying in the Gaza Strip and ranges between 200mm/year in the south to about 400mm/year in the north, while the long term average rainfall rate in all over the Gaza Strip is about 317mm/year.

Groundwater aquifer is considered the main and only water supply source for all kind of human usage in the Gaza Strip (domestic, agricultural and industrial). This source has been faced a deterioration in both quality and quantity for many reasons, e.g. low rainfall, increased in the urban areas which led to a decrease in the recharge quantity of the aquifer, also increasing the population will depleting the groundwater aquifer and led to seawater intrusion in some areas as a result in pressure differences between the groundwater elevation and sea water level.

Gaza Strip is one of the highest population intensity in the world where the population has reached more than 1.5 Million inhabitants living within 378Km^2, and it is expected to reach more than 3.7 Million inhabitants by year 2035.

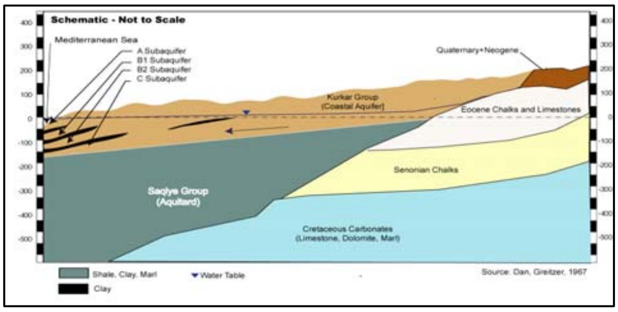
The aquifer is being recharged by different components such as rainfall, water networks leakage, wastewater collection system leakage, agricultural return flow and from recharge storm water ponds. The quantities of all those different components estimated to be as an average around 100 to 120MCM yearly.

2.0 Groundwater Aquifer

The main and only source of water in the Gaza Strip is from the Groundwater aquifer. While the groundwater underneath the Gaza Strip is limited to the Gaza Strip area, while the coastal aquifer is extended from Haifa in the north to Sinai desert in the south, Hebron Mountain in the east and the Mediterranean Sea in the west and as a result of Israeli occupation practices, the groundwater underneath the Gaza Strip becomes limited due to construction of trapped wells along the eastern part of the Gaza Strip to catch the natural flow from east to west, also building dams along the wadi Gaza to collect the rainwater flow in the wadi and recharge it outside the Gaza Strip for Israeli usages.

The thickness of the saturated groundwater aquifer underneath the Gaza Strip ranges from few meters in the eastern and south east of the Gaza Strip to about 120-150m in the west and along the Mediterranean Sea. The aquifer is mainly composed of unconsolidated sand stone known as Kurkar formation, which overlaying the impermissible layer called Saqiya formation which is considered as the bottom of the Gaza Coastal Aquifer with thickness varies from 800-1000m.

The thickness of the unsaturated aquifer which is the overlaying part of the saturated groundwater aquifer ranges from 70–80m in the eastern and south-eastern part of the Gaza Strip to about few meters in the western and along the coast.

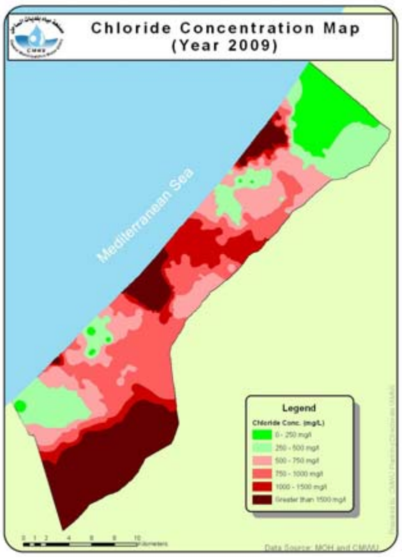


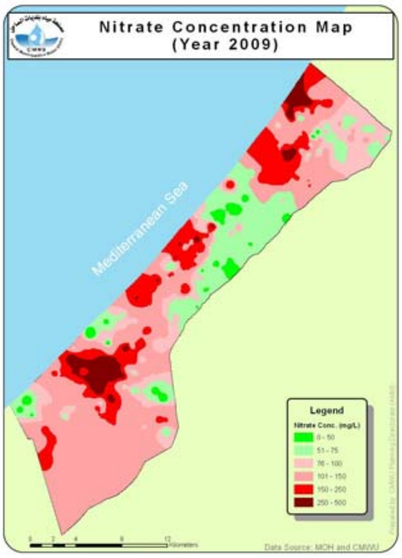
3.0 Groundwater Quality

The groundwater quality is monitored through all municipal wells and some agricultural wells distributed all over the Gaza Strip. The chloride ion concentration varies from less than 250mg/L in the sand dune areas as the northern and south-western area of the Gaza Strip to about more than 10,000mg/L where the seawater intrusion has occurred. The chloride concentration is used as a reflection of water salinity which can be tasted when drinking.

The source of the nitrate ion in the groundwater chemical components has resulted from different sources i.e. intensive use of agricultural pesticides beside the existence of septic tanks to dispose the domestic wastewater in the areas where there is no wastewater collection system. The nitrate ion concentration reaches a very high range in different areas of the Gaza Strip, while the WHO standard recommended nitrate concentration less than 50mg/L.

The overall Chloride and Nitrate concentration maps for Gaza Strip are illustrated in the following maps (CMWU 2010).





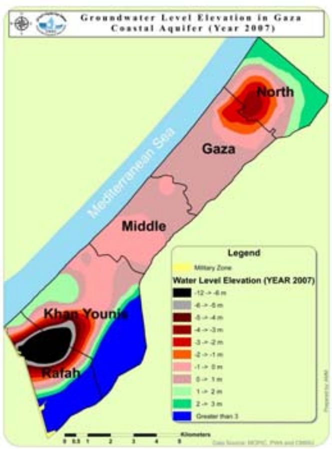
4.0 Groundwater Quantity

The available groundwater quantity could be identified if the saturated aquifer reservoir thickness is known in addition to the hydrological parameters of the aquifer such as effective porosity. The area of the groundwater reservoir is limited to the area of the political border of the Gaza Strip. The area where the groundwater quantity less than 250mg/L is about 33.4Km^2 where it has been recorded in year 2008 to be about 44.8Km^2, which is a shrinkage of about 10Km^2. Based on arithmetic calculation for the stored fresh groundwater (Cl<=250mg/L) will be ranged from 70MCM to around 350MCM by taking an average effective porosity of about 20% with a saturated groundwater ranging from 10 to 50m. In previous studies in year 2000, the same calculation has been performed where the groundwater quantity was ranging from 450MCM to 600MCM, which led to a depletion of about 315MCM from freshwater since year 2000.

In year 2009, the recorded water abstracted from groundwater was around 86.7MCM "Including UN wells", while agricultural water abstraction is assumed to be around 80MCM. The following table illustrates the overall groundwater abstraction for each governorate in year 2009.

Governorate	**Water Supply (m^3)**
North	22,030,009
Gaza	33,226,214
Middle	12,524,944
Khan Younis	13,677,696
Rafah	7,866,840
Total (m^3)	89,325,703
Mekorot Water (m^3)	**4,864,880**
Water Abstracted from Groundwater (m^3)	**84,460,823**
UNRWA wells Abstractions (m^3)	**2,269,361**
Agricultural wells Abstractions (m^3)	**80,000,000**
Total Groundwater Abstracted (Year 2009) in MCM	**~166.7**

Reference: CMWU 2010



The groundwater elevation map shows two sensitive areas for groundwater depression, the north and the south areas, where the groundwater level elevation drops more than 4m in the north and more than 12m in the south below mean sea level. This drop in the groundwater will led to lateral invasion of seawater due to pressure difference and direct contact with the aquifer, and also vertical invasion from deep saline water. This invasion laterally and vertically will affect the overall groundwater quality in the system. This has become from yearly deficit which occurs as a result of un-balance between what is being recharged and abstracted from the groundwater. Yearly average groundwater deficit is ranged from 40 to 60 MCM.

5.0 Population Forecasting

At the end of year 2007, the PCBS finished their population distribution and counting all over the Gaza Strip, and founded that the population in the Gaza Strip is around 1,416,543 inhabitants. By year 2020 the population will be around 2.3 Million inhabitants and by year 2030, the population will be more than double the current populations. Knowing that the forecasting is based on natural growth rate only which is estimated about 3.5%. The following table illustrates the forecasting population till year 2035,

		Year								
		2007	2008	2009	2010	2015	2020	2025	2030	2035
Governorate	North	270,246	279,705	289,494	299,627	355,862	422,653	501,979	596,194	708,091
	Gaza	496,411	513,785	531,768	550,380	653,678	776,365	922,078	1,095,139	1,300,682
	Middle	205,535	212,729	220,174	227,880	270,650	321,448	381,779	453,434	538,537
	Khan Younis	270,979	280,463	290,279	300,439	356,828	423,799	503,341	597,811	710,012
	Rafah	173,372	179,440	185,720	192,221	228,298	271,146	322,037	382,478	454,264
Total		1,416,543	1,466,122	1,517,436	1,570,547	1,865,317	2,215,411	2,631,213	3,125,056	3,711,586

6.0 Water Demand Forecasting

The calculated future water volume required based on two important factors, which are the improvement of the water distribution system and fairness distribution all over the Gaza Strip to reach 150L/C/D by year 2035. Those factors were calculated based on the current situation and expected future development to reach 80% water distribution efficiency by year 2035. The following table showed the water volume required for each governorate till year 2035,

Planned Water Volume Required (MCM)				
Year	North Gov.	Gaza & Middle Gov.	South Gov.	Total (MCM)
2009	18.6	44.9	19.0	82.5
2010	20.4	48.4	22.1	90.9
2015	24.1	59.2	31.2	114.5
2020	29.9	72.1	43.3	145.3
2025	34.9	87.5	56.1	178.5
2030	40.8	106.0	67.1	213.9
2035	48.5	125.9	79.7	254.0

The required volume by year 2035 is around 254MCM which is more than triple current volume abstracted from the groundwater, added to these quantities the agricultural abstraction quantities. Imagine these quantities are abstracted from the groundwater without any other source of water supply, what will be the case at that time of the groundwater. If the current average deficit ranges from 40 to 60MCM and with a shrinkage of fresh groundwater on a rate of $10Km^2$ every two years, hence by year 2016 you will have no more fresh groundwater (Cl<=250mg/L) if same trend is being behaved.

NOW THE ACTION TIME IS REQUIRED TO SAVE SOME FRESH GROUNDWATER FOR OUR CHILDREN…

7.0 Future Plans

The only solution to stabilize the current groundwater deterioration is to have a new water resource merged into the system. The following ideas can be share in solving the deterioration of groundwater,

- Construct Large RO Seawater Desalination Plants
- Importing Water
- Apply Fog and Dew Harvesting in Agricultural and Free Lands
- Apply Storm Water Harvesting
- Use Recovery Treated Wastewater for Irrigation
- Apply Modern Process for Irrigation
- Minimize Wells Abstractions

These solutions are a MUST to stabilize the current groundwater deterioration which will be starting of aquifer healing and recovery. In this article we will point out to the needs of new water resources components, other solutions may discuss later in other articles.

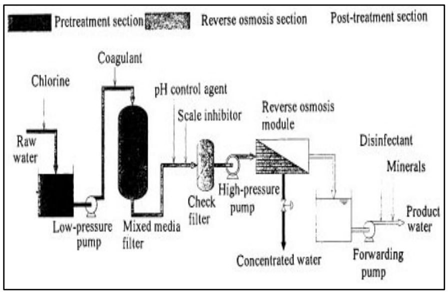
8.0 New Water Resources

8.1 RO Seawater Desalination Plants

As planned before, to construct large RO desalination plant to overcome the yearly groundwater deficit. The first phase suppose to start producing water was planned to be in year 2004 with a starting quantity of $60,000m^3/d$. But due to political constrains, this plant did not see the light. Now it is the most significant time to re-think about this option and have some force to construct this plant which will save freshwater and decrease the stress on the groundwater.

Raw water from sea intake and/or beach wells with chloride concentration around 21,000 mg/L, pumped through multimedia filter. Chemical pre-treatment of raw water to control the raw water PH shall be applied by fully controlled hydraulic acid 33% dosing system linked with PH monitoring meter.

Consequently, the water shall be pumped through the skid RO membranes to generate the permeate water, where the brine water shall be rejected to the purposely and environmentally prepared drainage system which will be finally drained to the sea via the existing channel and drainage piping. The whole process is described in the figure.



The permeate water produced from the RO membranes shall be collected in water tanks with booster pump, where blending quantity of other brackish water may added to the system before distribution. The final Chloride concentration will not be greater than 250mg/L. Post treatment to control PH and chlorine water disinfection shall be maintained before sending the water to the distribution network by the booster pump

The capacity of each skid mountain RO unit is 2,000m^3/d. A series of RO Skid Mountain units may apply based on the final quantity required.

8.2 Importing Water

This option is an urgent option until having the other solution on the ground. Construction of any Large RO desalination will take at least 3 years where at the construction time we need to have other solution is implementing rather than groundwater which is water importing. Two alternatives can be considered at this time either to increase the amount of Mekorot water and enlarge our network to contains the new amount, while at the same time we should look at the price of these water, whether it is affordable or not. The second alternative which is importing water from Turkey as water bag convey, in which we need large water tanks reservoirs close to the shore line to contains the new imported water for drinking.

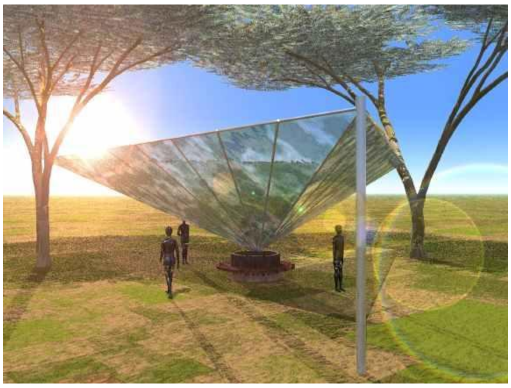
All the solutions, needs a new infrastructure to enable the system handling the new quantities.

8.3 Fog and Dew Harvesting

This option was never taking into account at the time of planning for water strategies. But due to recent researches, they found that "The atmosphere is a river full of water, even in the desert. It won't work absolutely everywhere, but it works virtually everywhere". And based on these researches they found that dew-collection on tree leaves can collect as a minimum of 48 liters of freshwater from the air each day on an area of about 315ft^2. Based on the number of collectors the amount of collected water can be increased.

The following figures illustrate the fog and dew-collection schematic layout drawing.

Ref.: Dew-harvesting 'web' conjures water out of thin air "http://www.newscientist.com"



Ref.: Making Water From Thin Air "http://www.sciencedaily.com"

9.0 Conclusion and Recommendation

This article shows the current status of water supply and the necessary of decision to be taken to have a new water resource merged into the system. The paper presents the possible solution to the current situation and discusses three options out the list. The discussed options illustrate an urgent solution such as water importing as well as extracting water from air and this solution can be used in agricultural areas added to that this technology is cheap based on other water production technologies. Large investment and infrastructure required for constructing the Large RO Desalination Plant which needs the commercial borders to be open to access the materials for such plants.

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