DESALINATION OPTION WITHIN WATER DEMAND MANAGEMENT AND SUPPLY FOR RED SEA COAST IN EGYPT

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ABSTRACT

The development of non-conventional water resources in Egypt is a must in order to respond to the continuously increasing demand. The present paper presents the results of an investigation undertaken in order to evaluate technically and economically the installed desalination units in Red Sea area. The available water resources are evaluated.

Keywords: Red Sea, Water Resources, Desalination

1. INTRODUCTION

Egypt is facing water scarcity due to over-population, industrialization and agricultural expansion. The Nile valley is overpopulated; the promising areas are Sinai and Red Sea. The Sinai and Red Sea areas are suffering from water shortage. The two areas are identical in geographical conditions. They are away from the Nile with limited underground water resources. Both areas are important to Egypt's economic growth. The present study is focused on Red Sea. A detailed analysis is undertaken dealing with: (1) water resources (including non-conventional) and (2) water use.

Red Sea region is promising for Egypt's economic growth. The only disadvantage for the development of this area is water. The development of this area has been expanded south until Marsa Alam and in the future is expected to reach the southern boarder with Sudan at Shalatin and Halayeb, Fig. 1. For the southern region, the study has shown clearly that water desalination is the most appropriate way to respond to water shortage problem in the future despite that Red Sea is close to the Nile. In some areas the distance is less than 200 km.

2. WATER RESOURCES IN RED SEA GOVERNORATE

The function of water resources management is to:

- assess the present water resources.
- provide reliable information on the availability and quality of surface and groundwater.
- provide scenarios for the development and use of water.

Below are a general description of Red Sea Governorate and the assessment of resources, its availability and quality.

The Red Sea Governorate has an area of 130,000 km^2 (Fig. 1). It includes some plains and highlands (Fig. 2). The weather in the plains is mainly dry and hot. The highlands are not populated. It is colder. In this district, the rainfall is very low (Fig. 3) and is not considered as water resource.

The total population is 122,000 with some Bedouin and the rest are located in small cities as Hurghada and Ras Ghareb. The population growth rate of 2.09% is low compared to Egypt's mean which is 2.24%.

The water resources in Red Sea can be classified into the following categories:

- underground water,
- potable water transported by pipeline, and
- desalinated water.

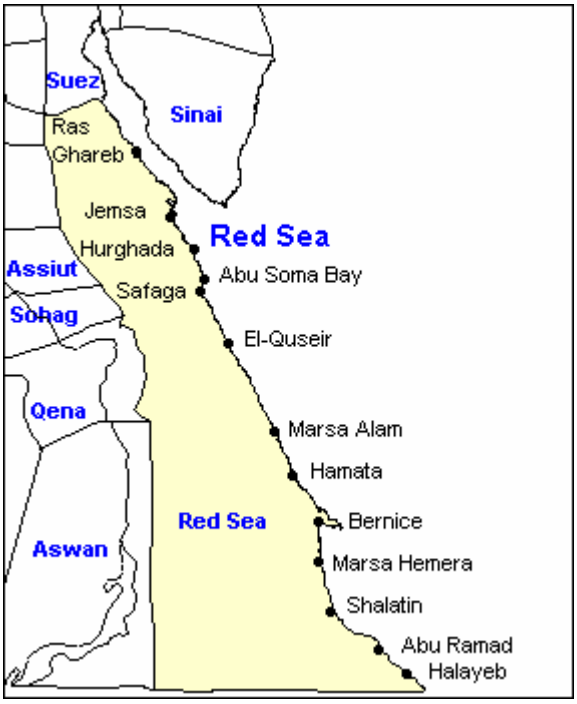

Fig. 1. Red Sea Governorate

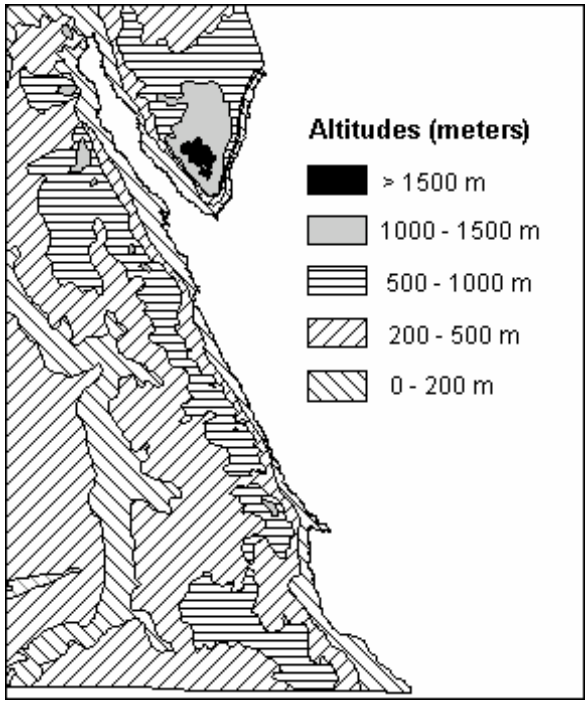

Fig. 2. Topography of Red Sea Governorate

2.1. Underground Water

Underground water (Figs. 4 and 5) is mainly brackish water. There are 87 wells (Fig. 5) but there is no low salinity water springs. The total capacity of desalination units using brackish water is 4230 m^3/d using Reverse Osmosis (RO) technology.

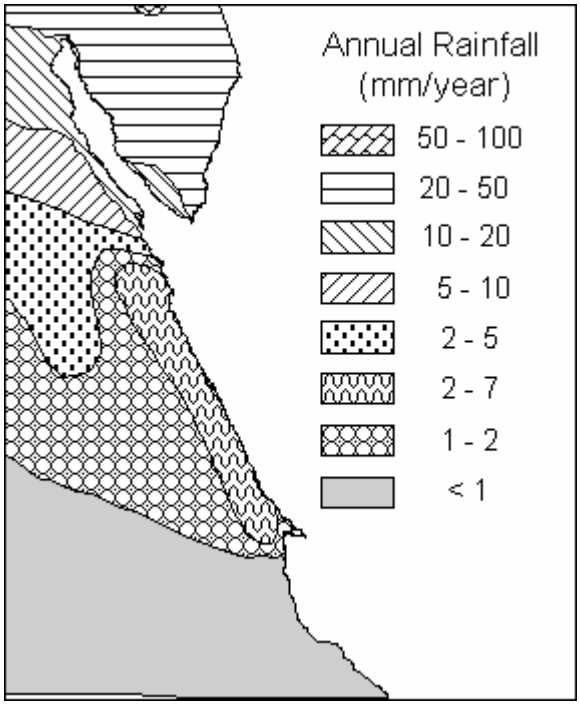

Fig. 3. Annual precipitation in Red Sea Governorate

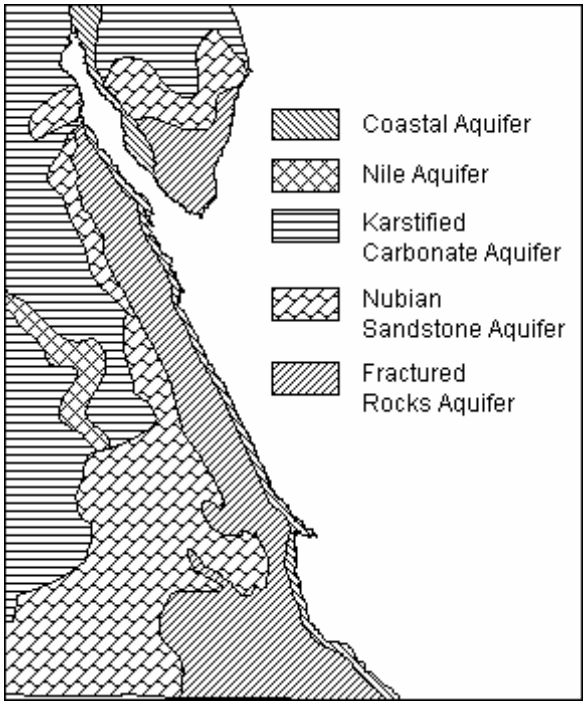

Fig. 4. Main aquifers in Red Sea Governorate

2.2. Nile Water Transported by Pipeline to Red Sea Governorate

There are two main lines (Fig. 6 and Table 1):

The first is Qena-Safaga pipeline with total length of 180 km. There are three parallel lines with different diameters. They have been erected on different periods from 1967 to 2000; the diameters are 200 mm, 300 mm and 400 mm. They are supported by 13 pumping stations distributed on the distance from Qena to Safaga. The total capacity of the lines is 17,000 m^3/d distributed on three cities: Hurghada, Safaga and El-Quseir as 7000 m^3/d, 5000 m^3/d and 5000 m^3/d, respectively, Table 1.

The second line is the Koraimat pipeline, which has been erected recently on 1997 with diameter 1000 mm until Ras Ghareb and 600 mm to Hurghada. The total capacity of the pipeline is 28,000 m^3/d distributed on three cities: Zaafarana, Ras Ghareb and Hurghada as 5500 m^3/d, 5000 m^3/d and 17,500 m^3/d, respectively. There are seven pumping stations on the pipeline. The total cost of this pipeline is 660 millions L.E. which was

equivalent to $US 194 millions. The installation cost per m^3 depreciated on 15 years is 2.15 L.E./m^3 or $US 0.64. The running cost including maintenance cost is 1.5 L.E. The total cost including installation cost is 3.5 L.E. which equivalent approximately to one US$.

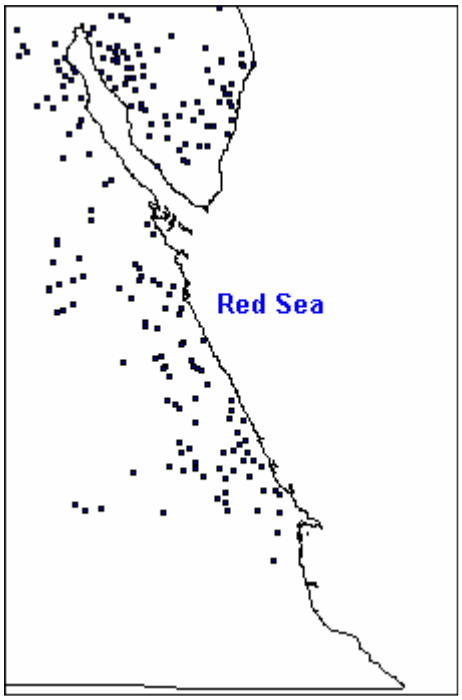

Fig. 5. Location of wells in Red Sea Governorate

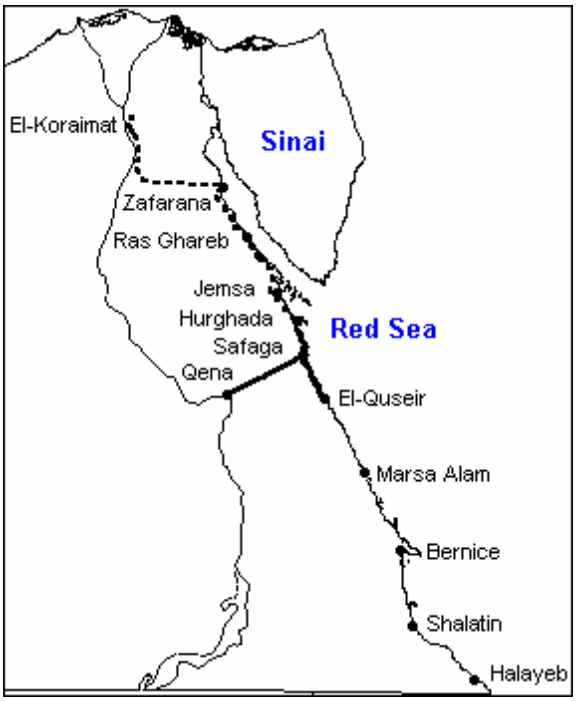

Fig. 6. Water transportation to Red Sea Governorate by pipelines

Table 1 Population and transported potable water of main cities and villages of Red Sea Governorate

Location	Population	Qena-Safaga Pipeline (m^3/d)	Koraimat Pipeline (m^3/d)
Abu Ramad	2,265		
Bernice	1,275		
El Quseir	24,656	5,000	
Halayeb	2,038		
Hamata	0,500		
Hurghada	71,774	7,000	17,500
Marsa Alam	2,121		
Marsa Hemera	1,224		
Ras Ghareb	33,136		5,000
Safaga	28,585	5,000	
Shalatin	7,050		
Zaafarana	1,208		5,500
Total	**175,832**	**17,000**	**28,000**

2.3. Desalinated Water

Most of the Red Sea region uses desalination to respond to water demand requirements. There are two categories of desalination units: first is government-owned units (Ministry of Development); second is the private-sector-owned units.

Table 2 presents the government-owned desalination units and the technology used. Table 3 presents the private-sector-desalination units. The total amount of desalinated water is 34,750 m^3/d or 12.68 Mm^3/y. The units using Reverse Osmosis (RO) technology produce 25,250 m^3/d and the vapor compression (VC) produce 4500 m^3/d.

3. WATER USE

The water use in Red Sea Governorate is classified as following:

3.1. Agriculture

The water for agriculture in Red Sea Governorate is mainly supplied from precipitation and some wells, Figs. 3 and 5. The agriculture is seasonal: 3442 feddans (1 hectare = 2.38 feddans). The cultivated area is very small. There is no plan for expansion in agriculture in this area.

Table 2 Governmental desalination units in Red Sea Governorate

Location	Total Capacity (m^3/day)	Units	Process	Water Quality	User	Operating Year
Abu Ramad	100	1	RO	Brackish	Municipal	1993
	500	1	RO	Brackish	Municipal	1993
Halayeb	100	1	RO	Brackish	Municipal	1993
	500	1	RO	Brackish	Municipal	1993
Hamata	100	1	RO	Sea	Municipal	1995
Hurghada	500	1	RO	Brackish	Municipal	1993
Marsa Alam	100	1	RO	Brackish	Municipal	1993
	500	1	RO	Brackish	Municipal	1993
	500	1	RO	Brackish	Municipal	1995
Marsa Hemera	100	1	RO	Sea	Municipal	1995
Ras Ghareb	1000	2	RO	Sea	Municipal	1994
Shalatin	100	1	RO	Brackish	Municipal	1993
	500	1	RO	Brackish	Municipal	1993
	500	1	RO	Sea	Municipal	1995
Total	**5,100**	**15**				

Table 3 Private-sector-owned units in Red Sea Governorate

Location	Owner	Process	Total Capacity (m^3/day)
Abu Soma Bay	Abu Soma Development Co.	VC	1500
	Abu Soma Development Co.	VC	3000
El Quseir	Utopia Beach Club	RO	1200
Hurghada	Jasmine Village	RO	200
	Warda El Sahara Village	RO	200
	El Samaka Club Hotel	RO	250
	Sofitel Hurghada Hotel	RO	250
	Calimera Golden Beach	RO	300
	Coral Beach Resort	RO	300
	Giftoun Tourist Village	RO	300
	Hilton Hurghada Plaza	RO	300
	Hurghada Marriott Beach Resort	RO	300
	Iberotel Arabella Village	RO	300
	Marlin Inn	RO	300
	Melia Pharaoh Hotel	RO	300
	Mirette Hotel & Beach Resort	RO	300
	Paradise Golden 5 Hotel	RO	300
	Zahbia Village	RO	300
	Hurghada Intercontinental Resort	RO	350
	Sindbad Beach Resort	RO	350
	Grand Resort	RO	500
	Le Meridien Hurghada Hotel	RO	500
	Royal Azur Resort	RO	500
	Arabia Tourist Village	RO	600
	Beach Albatros Hotel	RO	700
	Le Meridien Makadi Bay Hotel	RO	1000
	El-Safa Co. for Water Desalination	RO	1400
	El-Yosr Plant	RO	4000
	El Gouna Movenpick Resort	RO	4200
Marsa Alam	Kahramana Beach Resort	RO	150
	North Marsa Alam City	RO	500
Ras Ghareb	General Co. for Petroleum	ED	5000
	Total Capacity (m^3/day)		**29,650**

* ED (Electrodialysis), RO (Reverse Osmosis), VC (Vapor Compression).

3.2. Domestic

The density of population in Red Sea Governorate is very low. Table 4 presents the population estimates through the year 2017. The supply of water for the domestic use comes from the Nile water transported by pipelines. The discharge of the pipelines is 45,000 m^3/d. It satisfies the needs for the

inhabitants in some cities as Hurghada. The south of Red Sea Governorate relies on desalination. South of El-Quseir City there is no Nile water; practically, half of the total coastal length of the Red Sea Governorate. All these areas rely on desalinated water.

3.3. Tourism

Tourism activities are supplied mainly by desalinated water. The water consumption for tourism is as high as 500 l/d per bed. The expansion of tourism is based on desalination. All the private units' production is devoted to tourism. Table 5 presents the number of hotels and rooms for the year 2001 and Table 6 shows the number of hotels and rooms estimated up to the year 2017.

3.4. Recreational

Recreational areas are irrigated by treated sewage water. Each resort treats its wastewater and uses it in garden irrigation.

Table 4 Population estimates for Red Sea Governorate regions through the year 2017

	Year				
Location	**2000**	**2002**	**2005**	**2010**	**2017**
Ras Ghareb	30,798	34,344	40,443	53,108	77,770
Hurghada	64,363	71,774	84,519	110,988	162,526
Safaga	29,164	32,522	38,297	50,291	73,644
El Quseir	27,655	30,839	36,316	47,688	69,832
Marsa Alam	3,788	4,224	4,974	6,532	9,565
Shalatein	12,900	14,385	16,940	22,245	32,574
Total	**168,668**	**188,088**	**221,489**	**290,852**	**425,911**

Table 5 Classification, number of hotels and rooms in Red Sea Governorate Cities in the year 2001

Location	*****		****		***		**		*		Under Classification		Total	
	No. of Hotels	No. of Rooms	No. of Hotels	No. of Rooms	No. of Hotels	No. of Rooms	No. of Hotels	No. of Rooms	No. of Hotels	No. of Rooms	No. of Hotels	No. of Rooms	No. of Hotels	No. of Rooms
Gouna	3	960	3	622	1	64	1	25	-	-	-	-	8	1671
Hurghada	7	3203	23	6826	24	4515	22	1532	19	677	20	4943	115	21,696
Marsa Alam	-	-	1	150	-	-	-	-	-	-	2	478	3	628
El Quseir	-	-	2	354	-	-	1	48	1	52	2	174	6	628
Safaga	2	598	4	1088	2	435	2	125	1	20	2	69	13	2335
Zaafarana	-	-	-	-	-	-	-	-	-	-	2	273	2	273
Total	**12**	**4761**	**33**	**9040**	**27**	**5014**	**26**	**1730**	**21**	**749**	**28**	**5937**	**147**	**27,231**

Table 6 Number of hotels and rooms in Red Sea Governorate through the year 2017

	Year				
	2000	**2001**	**2002**	**2005**	**2017**
No. of Hotels	134	147	165	-	-
No. of Rooms	24,421	27,231	35,000	50,000	130,000

4. DISCUSSION

From Table 1, it is clear that after the Koraimat pipeline, there is no clear shortage in water in Red Sea Governorate. But, it is important to know that the pipeline reaches only El-Quseir City. So, the northern area has sufficient water supply. In fact, it is even more than the demand because the pipeline is designed to supply water for the future demand until the year 2010. But south El-Quseir City, there are no other sources of water supply; there are no springs or rainfalls. The only source is desalinated sea or brackish water. The development of southern region of Red Sea Governorate must be dependent on desalination. From Table 5, the total number of rooms in Red Sea Governorate is 27,231 which requires 13,615 m^3/d. This demand is covered by the existing units. Table 6 shows the number of hotels and rooms estimated up to the year 2017. The estimated figures up to the year 2005 are based on the actual demand of licenses delivered for construction and from 2005 up to 2017, the figure is predicted based on the rate between 2000 up to 2005 which is 13%. We can notice an increment between the year 2001-2002, the rate is 29% and this is based on actual demand. Most of these hotels will be situated in the southern part and upon these figures an increment of 13% of water demand is required. Only the tourism sector will require 65,000 m^3/d. This amount is double the actual water supply.

The development of tourism is based only on desalination. The installation cost of pipeline is high. Also, it is important to note that desalinated water is a new water resource added to the national water supply. Egypt suffers from water insufficiency problem; water is recycled in order to meet the ever-increasing demand. A new pipeline will increase the demand that is satisfied with difficulties.

Based on available information and forecasting for the future, the expected major activities in the Red Sea will be tourism only. The expansion of tourism in Red Sea Governorate is going south in new areas as Marsa Alam and El-Quseir Cities. The coast from Hurghada to Safaga is saturated. Thus, the demand will be supplied only by desalination.

The data obtained from the desalination units in Red Sea area are shown in Tables 2 and 3. Figure 7 shows the development of desalinated water

production using the Reverse Osmosis with sea water (SWRO) and with brackish water (BWRO), and the vapor compression (VC). It can be observed that the dominating technology is RO. The main VC units are in Abu Soma Bay which produce 4500 m^3/d. This is the largest VC units in Egypt. In general, the cost of the water produced by RO and vapor compression is similar and varies according to the year of starting. The difference does not justify the use of one technology or the other.

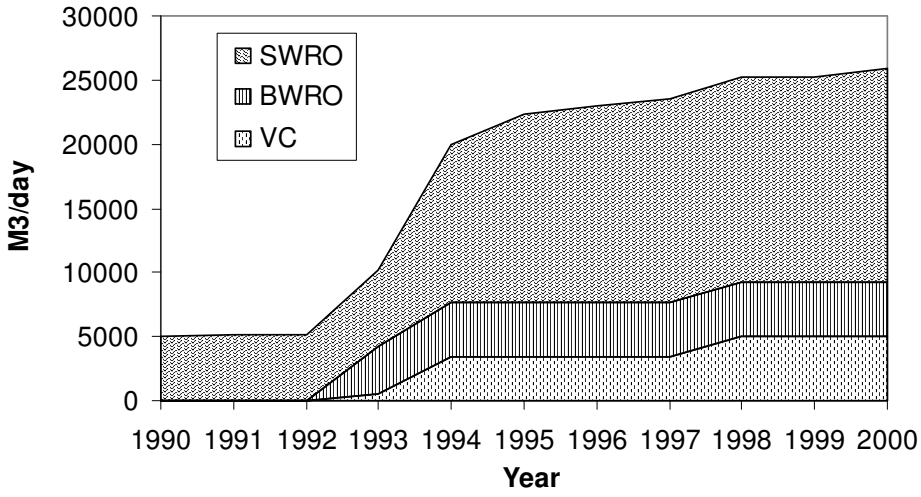

Fig. 7. Development of desalinated water production; SWRO: RO using sea water, BWRO: RO using brackish water

The international tender now for RO units is as low as less than US$1 and reaches $0.6, which is equivalent to less than LE 3.4, approximately half of the actual operating costs in Red Sea. That is why the new unit will be RO and the private sector understands these results.

The advantage of RO is that its maintenance work is less sophisticated than vapor compression. Other advantages of RO units are their reliability and compactness in size.

5. CONCLUSIONS

The Red Sea Governorate has two different parts, the northern part up to El-Quseir City and the southern part up to the boarder with Sudan. The northern part is supplied by two pipelines transporting water from Nile and some desalination plants. According to the available data, this part does not suffer from water problem and has sufficient water up to the year 2020.

The southern part relies only on desalination. There is no other way than desalination to develop this area up to the southern boarder with Sudan

but the rate of development is slow and a heavy development is not expected for the coming years.

In general, the study reveals that RO technology is the predominant technology for this area. Also, solar energy can be used in order to power these units using photovoltaic units instead of diesel generators.

It is not worthy to transport Nile water to this area since the cost of desalinated water is decreased continuously. A careful economic analysis is required before any similar project.

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