



IMPACTS OF DESALINATION PLANT DISCHARGES ON THE MARINE ENVIRONMENT

Eman Mohamed Fawzy

Department of Chemistry, Faculty of Science, University of Aswan

ABSTRACT

Desalination of seawater became one of the main alternatives for the substitution of water shortage in Egypt. Although desalinating the seawater is costly, it is still an important option for compensating for the water shortage. We should be aware of the fact that the effluent discharges from the plant back to the sea may have a negative impact on environment. They adversely affect the marine life and the ecology in the plant vicinity. The paper will present the negative impact of the desalination plants and how it can be minimized to keep the marine life and the ecological environment in a good condition.

INTRODUCTION

Desalination of seawater accounts for a worldwide water production of 5000 million m³/year. A "hot spot" of intense desalination activity has always been the Arabian Gulf, but other regional centers of activity emerge and become more prominent, such as the Mediterranean Sea and the Red Sea, or the coastal waters of California, China and Australia. The growth gap between supply and demand for water in the GCC countries can be attributed to limited available surface water, high population growth and urbanization development, deficient institutional arrangements, poor management practices, water depletion and deterioration of quality, especially in shallow groundwater aquifers. Increasing demand for water in the domestic sector has shifted attention to the role of desalination in alleviating water shortages. Experience in the Gulf States demonstrates that desalination technology has developed to a level where it can serve as a reliable source of water at a price comparable to water from conventional sources. Desalination remains in GCC countries the most feasible alternative to augment or meet future water supply requirements. It is considered a strategic option for satisfying current and future domestic water supply requirements, in comparison to the development of other water resources. Despite the many benefits the technology has to offer, concerns rise over potential negative impacts on the environment. Key issues are the concentrate and chemical discharges to the marine environment, the emissions of air pollutants and the energy demand of the processes. To safeguard a sustainable use of desalination technology, the impacts of each major desalination project should be investigated and mitigated by means of a project- and location-specific environmental impact assessment (EIA) study, while the benefits and impacts of different water supply options should be balanced on the scale of regional management plans. In this context, our paper intends to present an overview on present seawater desalination capacities by region, a synopsis of the key environmental concerns of desalination, including ways of mitigating the impacts of desalination on the environment, and of avoiding some of the dangers of the environment to desalination.

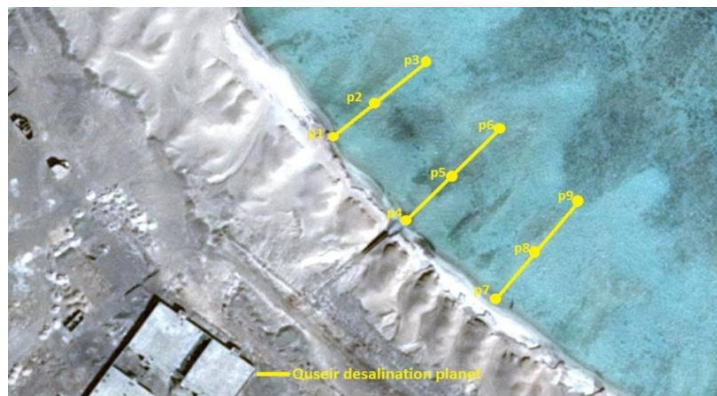
Provision of potable water by seawater desalination is generally considered a benefit despite high construction and operating costs of plants. This is especially true when conventional sources of freshwater are absent or cannot be exploited without severe environmental damage. Whoever is familiar with the situation in arid countries knows that desalination plants are often large industrial facilities, which consume space and emit substantial amounts of combustion gases. It is also known that potable water production means emitting a concentrate into the sea, into the ground or into evaporation ponds. However, a generally less noted fact is that this concentrate contains not only the contents of the seawater taken in, but also additives (or their conversion products) necessary for the desalting process and corrosion by products. Heavy metals are among the most hazardous contaminants that may affect the aquatic environment and they are originated from both natural and anthropogenic sources. Heavy metals are known by their prevalence, bioavailability and severity of their toxicity (Marchand *et al.*, 2011) the rapid growth in industrialization and urbanization may lead to environmental pollution with organic and inorganic pollutants. Heavy metal contamination in aquatic ecosystem may pose a serious threat and causes severe health hazards to humans (Rai, 2009; Boyd, 2010). Sediments act like sink and sources of heavy metals in aquatic systems as they are impacted by the physical and chemical of seawater (Praveena *et al.*, 2007). Lead, mercury and cadmium are ranked as first, second, and sixth toxic wastes in the hazards list of the U.S agency for toxic substance and disease registry (ATSDR) (Praveena *et al.*, 2007). Heavy metals can transport by water or wind to coastal areas, where they can be deposited to sediments. This variability may induce changes in heavy metals distribution between dissolved and particulate phases, and thus changes of their toxicity. As an example, metals in pore-waters are more bioavailable than those absorbed on mineral surfaces, and can be easier uptake by organisms, thus entering food webs (Pan *et al.*, 2001; Idris *et al.*, 2007 & 2008; Marchand *et al.*, 2011). Many researchers believed that the sediments are indicator for water pollution level (Nobi *et al.*, 2010; Harikumar & Nasir, 2010; Yang *et al.*, 2012; Zhu *et al.*, 2012). Metals in seawater and marine sediments can incorporate into the aquatic food webs through sediment water exchanges and then biomagnified in food webs at higher levels (Hosono *et al.*, 2011). This process may cause potential damage to mammals as well as to human health (Chen *et al.*, 2010).

2. Experimental

2.1. Morphology

Figure 1 and 2 show a general layout of the desalination plants in Red sea.

Fig. 1 El Quseir Dilatation Plant



El Quseir Dilatation Plant

Coordinate : N 26°07'32.8" E 34°16'16.6"

Description : is a city in eastern Egypt, located on the Red Sea coast , characterized by phosphate mining and exportation . El Quseir is located 140 kilometers south of Hurghada, 138 km north of Marsa Alam and 73 km north of the Marsa Alam International Airport. The population of El Quseir is around 85,000.

Fig. 2 Hamata Dilatation Plant



Hamata Dilatation Plant:

Coordinate : N 24°17'10.6" E 35°22'42.6"

Description : Hamata is a small village_ located on the Red Sea coast south to Marsa Aam city by 100 Km , Characterized by Four Archipelago islands surrounded by fringing reefs.

The Hamata Islands are most important sites for snorkelers and divers which A tourism operator conducts regular day-trips.

The population of Hamata is around 3000

2.2 Samples Collection and Handling

2.2.1 Sea Water

Water samples (three samples from each sector, three sectors for each location) were collected. The samples were collected from surface water during November 2017 using water sampler, Nansen bottle (Goodwin and Goodard, 1974). For elemental analysis, water samples were filtered immediately using 0.45 μm filter paper mounted on a Pyrex filter holder with the filtrates acidified to pH 2 with A.R. nitric acid in order to prevent adsorption of metals on bottles surface.

2.2.2. Sea Soil

Soil samples (three samples from the points of water samples) were collected from the banks of each sector. The samples were air dried for a weak and sieved through a 2mm to remove the large debris and stones.

2.2.3. Aquatic Algae

Aquatic algae samples were also collected from the same sites of aqueous samples (in al-quser only). All samples were washed with tap and bidistilled water, then dried at 110°C for 48hr, crushed and powdered in an agate mortar. The algae samples were kept in polyethylene bottles till analysis.

2.3 Measurements and Analysis

2.3.1 Water Samples

The chemical and physical parameters of water samples were determined using standard procedures (APHA, 1992).

2.3.2 Soil Samples

Chemical and physical parameters in sediment and soil samples were determined using a textbook of soil analysis (Baruah & Barthakur, 1997).

2.3.3 Algae Samples

Digestion of algae was performed using a chemical analysis of ecological materials (Allen, 1989).

2.4 Analytical Procedures

2.4.1 Water Physico-Chemical Parameters

A) Field Measurements

2.4.1.1 pH values and Temperature

The water pH values were measured, using pH meter (Orion Research, Model SA 520, U.S.A.). Temperature was measured in situ by the aid of standard thermometer (0 – 100°C).

2.4.1.2 Conductivity and Salinity

The conductivity and salinity were measured using conductivity meter (HANNA Instruments, HI 8033, Italy).

2.4.1.3 Dissolved Oxygen

The dissolved oxygen (mg/L) was determined using a Winkler's method. The method is based on the addition of divalent manganese solution, followed by strong alkali – iodide solution to the sample in a glass–stopper bottle in situ immediately after withdrawing the water samples. Dissolved oxygen rapidly oxidizes an equivalent amount of the dispersed divalent manganous hydroxide to hydroxides of higher valence states of manganese. In presence of iodide ions and on acidification, the oxidized manganese reverts to divalent state, with the liberation of iodine equivalent to the original dissolved oxygen content. The iodine is then titrated with a standard solution of sodium thiosulphate in presence of starch as an indicator.

B) Laboratory Measurements

2.4.1.4 Carbonate and Bicarbonate

CO_3^{-2} and HCO_3^- , expressed in mg/L (as CaCO_3), were determined by titration of an aliquot of the filtered water samples using standardized hydrochloric acid in presence of phenolphthalein and methyl orange indicators, respectively.

2.4.1.5 Chloride

The chloride content (mg/L) was estimated according to Mohr's method. In this method the water sample was titrated against 0.019N AgNO_3 silver nitrate in the presence of potassium chromate as indicator.

2.4.1.6. Calcium and Magnesium

Calcium and magnesium were determined by complexometric titration, using standard EDTA solution and buffer solution (pH = 10). In this method, Eriochrome black T. indicator was used for determining Ca and Mg while Calcein indicator was used for determining Ca in presence of buffer solution (pH 12).

2.4.1.7 Total Dissolved Solid

Total dissolved solid (TDS) in mg/L was determined by evaporating one litre filtered water sample at 105°C, the residue was dried at 180 °C for two hours to a constant weight.

2.4.1.8 Biochemical Oxygen Demand

The Biochemical oxygen demand (BOD) was determined by placed water samples bottles in an incubator at 20°C for five days; their dissolved oxygen content were determined, then the difference in the oxygen content after incubation gives the BOD (mg/l).

2.4.1.9 Total Suspended Solid

Total suspended solid (organic and inorganic suspended solids) is the retained material on a standard glass – fiber filter after filtration of a well – mixed sample. The residue was dried at 105°C to a constant weight.

2.4.1.10. Algae Digestion

One gram of each wet sample was digested with 10 ml of acids mixture of conc. HNO_3 / HClO_4 (3:1) in a Teflon reactor under pressure (Allen, 1989). This is to prevent any atmospheric contamination or loss volatile elements during dry ashing technique. After complete digestion, cooling, the solution was diluted with 2% nitric acid solution and then completed to 25 ml with deionised water.

Elemental Analysis and Instrumental Technique

Metal concentrations (Cu, Cd, Pb) in water and extracting solutions of soil and algae samples were determined by atomic absorption.

A flame atomic absorption spectrophotometer (Model Solaar 969, ATI Unicam Comp.) equipped with a digital and direct concentration read out and air – acetylene burner was used. Single element hollow cathode lamps and standard instrumental conditions were used for each element (Table 1).

Table (1): Atomic Absorption Spectra Technique Applicable to the Analysis of Ecological Materials.*

Element	Wave Length (nm)	Flame	Suitable ranges (ppm)	Potential interferences	Control of interferences
Cu	324.8	Air – C ₂ H ₂	0 – 5	None significant	
Pb	217.0	Air – C ₂ H ₂	0 – 10	Cl possible	

In order to validate the method for accuracy and precision certified reference materials were analyzed for each element. Suitable precautions were taken to minimize interferences when necessary. Background absorption can be troublesome so, traditional and simplest method is to monitor the continuum output of a deuterium lamp beam and to correct the analyst signal for any absorption detected.

The detection limit is defined as the concentration corresponding to three times the standard deviation of 10 blanks. Quantification of the metals was based on calibration curve of standard solutions of respective metals.

2.5 Preparation of Standard Reagent Solutions

(Standard method APHA 1992; Merck, 1980)

2.5.1 Metal Solutions

All standard metal solutions for atomic absorption and atomic emission spectroscopy were prepared from certified atomic absorption metal stock solutions (1000 $\mu\text{g ml}^{-1}$) (Spectrosol, BDH chemicals Ltd., Poole, England) by appropriate dilutions.

Quality Control and Assurance

Accurate analysis of metals is dependent upon the prevention of metal contamination. All glass and plastic wares should be soaked in diluted acid, e.g., 10 % (v / v) nitric acid, and rinsed thoroughly with distilled and deionized water before use to ensure that there is no contamination of the laboratory accessories. During sampling and laboratory analysis of heavy metals, care should be devoted to prevent sample contamination and to ensure the reliability and quality of analytical results. First of all, the use of metallic tools should be avoided whenever possible. Sediment samples should be collected using tools made of stainless steel and stored in nonmetallic containers, such as glass bottles or polypropylene bags, at 4°C prior to laboratory treatment.

In order to provide valid and reliable data in a timely manner a quality control system must be implemented throughout the analytical process. Quality control (QC) is defined as a system of procedures and practices that result in an increase in precision and a decrease in bias. The use of duplicate analysis, spiked samples, standard reference materials, and QC check samples are all mechanisms used to demonstrate the control of quality (Klesta & Bartz, 1996). Also the accuracy of the methods was verified by subjecting

standard reference material to the overall analytical procedures. Analysis of reference material yield metals concentrations within acceptable limits. Mean coefficient of variation of metal concentrations, calculated from triplicate analysis of individually digested subsamples of plant or soil.

The working atomic absorption spectroscopic standard solutions (1 mg ml⁻¹) for the elements Cd, Cu, Pb (BDH, England) were prepared by diluting the stock solutions using deionized water. Accuracy of atomic absorption spectrophotometer and validity of the processes were tested with a reference material.

3. Results

Table 1.

Item Sample	DO	TSS	Cond.	pH
Hmatta – Section 1		0.0938	1919	6.90
Hmatta – Section 1		0.1333	1749	6.97
Hmatta – Section 1		0.0769	1920	6.97
Hmatta – Section 2		0.1339	1907	6.94
Hmatta – Section 2		0.1364	1829	6.89
Hmatta – Section 2		0.1425	1558	7.16
Hmatta – Section 3		0.1103	1615	7.14
Hmatta – Section 3		0.0991	1810	7.10
Hmatta – Section 3		0.1226	1561	7.08
Direct - Hamatta		0.1092	1929	6.75
Elquseir - Section 1			1926	7.32
Elquseir - Section 1		0.1308	1631	7.37
Elquseir - Section1		0.134	1735	6.99
Elquseir - Section 2		0.04427	1712	6.30
Elquseir Section 2		0.14491	1771	6.74
Elquseir Section 2		0.1528	1725	6.86
Elquseir - Section 3		0.1089	1735	6.71
Elquseir - Section 3		0.1043	1877	6.29
Elquseir - Section 3		0.098	1618	5.73
Direct – Elquseir		0.1251	1923	5.65
Control		0.9367	1432	7.45

Table 2.

Item Sample	CO ₂	HCO ₃	CO ₃	Cl
Hamata – Section 1	64	1480	Nil	22798.1
Hamata – Section 1	40	1120	Nil	22123.6
Hamata – Section 1	60	1184	Nil	21853.8
Hamata – Section 2	44	1408	Nil	25563.55
Hamata – Section 2	60	1248	Nil	21718.9
Hamata – Section 2	60	1160	Nil	21718.9
Hamata – Section 3	40	1264	Nil	22636.22
Hamata – Section 3	32	1208	Nil	21988.7
Hamata – Section 3	40	1120	Nil	21691.92
Direct Hamata	20	1432	Nil	29745.45
Elqusier Section 1	28	992	Nil	20032.65
Elqusier Section 1	24	872	Nil	17132.3
Elqusier Section 1	20	1040	Nil	16579.21
Elqusier Section 2	60	1200	Nil	26035.7
Elqusier Section 2	28	1120	Nil	29205.85
Elqusier Section 2	28	984	Nil	21044.4
Elqusier Section 3	40	1232	Nil	24889.05
Elqusier Section 3	36	1104	Nil	22258.5
Elqusier Section 3	36	1184	Nil	22609.24
Direct Elqusier	40	1080	Nil	26710.2
Control	48	10744	Nil	21988.7

Table 3.

Item Sample	Cu	Pb	Cd	Ca	Mg
Hmatta – Section 1				500.8	424.32
Hmatta – Section 1				534.4	432.96
Hmatta – Section 1				528	497.28
Hmatta – Section 2				552	539.52
Hmatta – Section 2				464	460.8
Hmatta – Section 2				494.4	483.84
Hmatta – Section 3				464	489.6
Hmatta – Section 3				436.8	494.4
Hmatta – Section 3				488	480
Direct Hamatta				600	432.96
Alqusie Section 1				416	441.6
Alqusie Section 1				372.8	371.52
Alqusie Section 1				400	428.16
Alqusie Section 2				608	720.96
Alqusie Section 2				608	456
Alqusie Section 2				448	388.8
Alqusie Section 3				569.6	474.24
Alqusie Section 3				473.6	479.04
Alqusie Section 3				512	478.08
Direct Alqusie				544	459.84
Control				336	424.32

المشاكل البيئية لحطات التحلية

إيمان محمد فوزي

قسم الكيمياء، كلية العلوم، جامعة أسوان

الملخص :

تعتبر تحلية المياه من المصادر غير التقليدية للمياه العذبة ، وتنتج عملية التحلية مياهًا ذات جودة عالية تكاد تكون خالية من أي شوائب وقد ساهمت تحلية مياه البحر في تلبية العديد من الاحتياجات المتزايدة باستمرار لمختلف القطاعات الاستهلاكية في الكثير من دول العالم ، وهناك تقنيات متنوعة للحصول على المياه العذبة عن طريق التحلية ، وأكثرها شيوعًا هي التحلية عن طريق التقطير .

وأما كانت التكنولوجيا المستخدمة في التحلية ، فإن المدخلات والمخرجات الرئيسية لعملية التحلية تكاد تكون واحدة . حيث تؤخذ مياه البحر المالحة من مأخذ سطحي أو من آبار على الشاطئ ، ويتم إدخالها إلى محطة التحلية ، حيث تخضع هناك لعمليات فيزيائية وتفاعلات كيميائية معقدة مثل الضغط والتبخير وإضافات كيميائية معقدة مثل الضغط والتبخير وإضافات كيميائية لتعديل درجة الحموضة والتطهير ومواد منع التآكل والرواسب وتكون الرغوة وخلافها .

وعلى الرغم من أن تحلية المياه لها الكثير من الآثار البيئية الإيجابية حيث أن إنتاج المياه المحلاة خاصة في المناطق التي تعاني من شح في مواردها المائية التقليدية سهل عمليات التنمية الاقتصادية والاجتماعية إلا أن لمحطات التحلية آثارها السلبية على البيئة البحرية والتي يمكن إجمالها في ما يلي:-

١. تظهر الآثار السلبية لمحطات التحلية منذ بداية عملية تشييد المحطة على الشاطئ وبناء المداخل والمخارج داخل البحر .

٢. إن المياه الراجعة من محطة التحلية تحوي على تراكيز عالية من الأملاح ، والذي يؤدي مع الزمن إلى زيادة ملوحة مياه البحر في منطقة مخرج المحطة والمناطق المحيطة به.

٣. ضخ كميات من المياه الراجعة ذات الحرارة الأعلى من حرارة مياه البحر يعمل على خفض كميات الأكسجين المذاب في ماء البحر واللازم لتنفس الكائنات البحرية .

٤. وجود كميات من المواد الكيماوية العضوية في المياه .

٥. هنالك مركبات ذات أثر سام مثل الكلورين ومشتقاته التي تستخدم في عمليات تطهير المياه وكذلك هناك احتمال لظهور مركبات التراي هالوميثان والتي تتكون نتيجة تفاعل الكلورين مع المواد العضوية وهي ذات أثر مسرطن إذا ما تواجدت بتركيز معينة .

٦. هناك فرصة لأن تحوي المياه الراجعة معادن ثقيلة نتيجة عمليات التآكل في الأجزاء المعدنية لمحطة التحلية .

٧. تستعمل الأحماض الكيماوية عادة لغسل الغلايات وأنابيب التكثيف وإزالة الرواسب التي تتكون نتيجة عملية التقطير.

مما سبق يتبين لنا أهمية إدخال البعد البيئي عند التفكير بإنشاء محطات التحلية وإجراء عملية تقييم الأثر البيئي ابتداءً من عملية التخطيط واختيار التكنولوجيا المناسبة واستخدام المواد الرفيعة بالبيئة وانتهاءً بعملية تشغيل المحطة .

ومن التدابير البديلة التي يُعمل على جعلها مجدية اقتصادياً استخدام مصادر طاقة بديلة مثل الطاقة الشمسية وطاقة الرياح وطاقة جوف الأرض لتشغيل محطات الكهرباء الملحقة بمحطات التحلية. كما يمكن إقامة محطات تحلية عائمة على مسافات بعيدة داخل البحر لتقلل الضوضاء وتوفر الأراضي ذات الأهمية الاقتصادية.