EFFECT OF DESALINATION PLANTS ON THE MARINE ENVIRONMENT ALONG THE RED SEA, EGYPT. (CASE STUDY)

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ABSTRACT

Most coastal areas of the Red Sea have a rapid touristic and urban growth; this development is sustained by an increasing number of seawater desalination plants in the regions which satisfy the growing demand for fresh water. Al Yosr desalination plant was situated at Hurghada and considered a one of the main sources of Hurghada’s growing demand for fresh water. This desalination plant depends on sea water with salinity value varies between 40‰ and 41‰ to produce potable water with total dissolved salts between 300-500ppm, which means that the reject water has salinity rate from 50‰ to 68‰.

The reject water is characterized by increased salinity and high temperature. It additionally contains substantial amounts of chemical pollutants, such as chlorine (which is used for biofouling control in the plants), antiscalants (which are used for scale inhibition) and heavy metals (which are present due to corrosion). So, the heavy metals tend to enrich in sea water than in the sediments, also the carbonate content decreases with increase organic matter. It is estimated that the reject water resulting from this plant will cause an increase of up to 1.5% in mortality for planktonic larvae in an area extending as far away as discharge pipelines. The severity of these effects differs in different areas according to: a) the hydrogeological nature of the marine body (bathymetry, depth, tides, waves, currents); b) the biological sensitivity of the marine habitat; c) the type of desalination plant, its size, the required secondary structures and infrastructure.

The effluent from desalination plant is a multi-component waste, with multiple effects on water, sediment and marine organisms. The discharge point must be extends to the end of the back reef zone and below the reef slope (water depth will reaches more than 20m), away from the navigation paths, and away from any benthic communities. It is necessary that all relevant issues, including the seawater intakes, the concentrate and chemical discharges should be continuously monitoring in order to investigate and minimize negative impacts.

Key words: Desalination plants, Brine water, Marine organisms, Environmental impact, Red Sea.

RESUMEN (Efecto de plantas de desalinización sobre el ambiente marino a lo largo del Mar Rojo, Egipto -estudio de caso-)

La mayor parte de las zonas costeras del Mar Rojo presentan rápido crecimiento urbano y desarrollo turístico, lo que hace necesario un número creciente de plantas de desalinización de agua de mar en esta región para satisfacer la creciente demanda de agua dulce. La planta desalinizadora Yosr se ubicó en Hurghada, siendo una de las principales fuentes para satisfacer la creciente demanda de agua dulce de esta zona.

Este planta de desalinización se surte de agua de mar cuya salinidad varía entre el 40 ‰ y 41 ‰ para producir agua potable agua con sales disueltas entre 300-500ppm, lo que significa que el agua de desecho tiene tasas de salinidad entre 50 ‰ y 68 ‰. El agua de desecho se caracteriza por aumento de la salinidad y alta temperatura. Además contiene cantidades sustanciales de contaminantes químicos como el cloro (Que se utiliza para control de biofouling en las plantas), antincrustantes (que se utilizan para la inhibición de la incrustación) y metales pesados (que están presentes debido a la corrosión). Así, los metales pesados tienden a enriquecerse en el agua de mar más que en los sedimentos, también disminuye el contenido de carbonato con aumento de la materia orgánica. Se estima que el agua de desecho resultante de esta planta causará un aumento de hasta el 1.5% en la mortalidad de larvas planctónicas en una zona que se extiende tan lejos como las tuberías de descarga. La gravedad de estos efectos difiere en diferentes áreas de acuerdo a: a) la naturaleza hidrogeológica de los cuerpos de agua (batimetría, profundidad, mareas, olas, corrientes), b) la sensibilidad biológica del hábitat marino; c) el tipo de la planta desalinizadora, su tamaño, las estructuras secundarias necesarias y la infraestructura.

El efluente de la planta desalinizadora es un desecho con múltiples componentes, con múltiples efectos sobre el agua, los sedimentos y los organismos marinos. El punto de descarga debe extenderse hasta el extremo de la zona de arrecife posterior y por debajo de la pendiente del arrecife (la profundidad del agua llega a más de 20m), lejos de las rutas de navegación, y lejos de cualquier comunidad bentónica. Es necesario que toda la información pertinente a estas cuestiones, incluyendo las tomas de agua de mar, el concentrado y las descargas de compuestos químicos deben ser objeto de continua vigilancia con el fin de conocer y minimizar los impactos negativos.

Palabras clave: Planta desalinizadora, agua salada, organismos marinos, impacto medioambiental, Mar Rojo.
INTRODUCTION

Getting access to drinking water is a daily challenge for more than one billion people in the world; there are more than 7,000 desalination plants worldwide. The Egyptian Red Sea coast extends to about 2025 Km, of this, 1080 Km is Red Sea coast and 945 Km is the coastline of the gulfs of Suez and Aqaba. Most of cities and tourist resorts on the coasts of the Red Sea owned desalination plants discharge their effluent into the sea, which lead to considerable local damage to marine life. At the present time, the Red Sea governorate has 207 hotels and resorts. It is estimated that the discharge of all desalination plants in the Red Sea coast amounts to a waste water flow of about 1,000 m3 per second (Information bank of Red Sea Governorate). Water desalination processes offer various environmental benefits (related to sanitation, water softening, quality of sewage effluents), but the process is also accompanied by adverse environmental effects on the most biologically diverse and productive habitats.

Al Yosr desalination plant was set up as a solution to Hurghada’s growing demand for fresh water. It is one of the largest plant in the Red Sea, and the largest in the Hurghada city. Hurghada city is depending on this desalination plant, which provides about 1/3 of the fresh water requirements for Hurghada.

The impact on the marine environment takes place mainly in the vicinity of the concentrated brine discharge pipelines. Even though the concentrated brine contains natural marine ingredients, its high specific weight causes it to sink to the sea floor without prior mixing. In addition, chemicals, which are administered to the water in the pre-treatment stages of the desalination process, may harm the marine life in the vicinity of the pipe’s outlet. The actual placement of the discharge pipelines may also damage sensitive marine communities.

Recently research studies on the Red Sea environment, and tourism projects and their impact on coastal zone are based on the ecological analysis were done by several
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This paper throws light on the effects of brine on the marine organisms inhabiting the sandy substratum in the marine area off the desalination plant and discusses the potential impacts of seawater desalination activity on the marine environment.

MATERIALS AND METHODS

The present study was carried out in the marine area off Al Yosr desalination plant in Hurghada City during July 2006. This is the largest seawater desalination facility in the Red Sea, producing 5000 m³/day of potable water. Ten surface sediment samples were collected by Scuba diving, while five sea water samples were collected using water sampler. Also, data on physico-chemical and biological aspects were measured and collected during field survey using Hydrolab Instrument (Surveyor 4).

In the laboratory; the sediment samples were washed with fresh water several time to remove any soluble salts and then dried in the sunlight to avoid any change in their physical and chemical properties. The grain size analysis was done using sieves arrange at 1Φ interval according to (Folk and Ward, 1957).

Ten grams of each sample were ground using agate mortar, passed through a 80 mesh sieve to determinate total carbonate content, (Basaham and El-Sayed 1998) and total organic matter, (Bernner and Binford 1988). Also, about 1.5 liters of each water sample were filtrated using 0.45 μm Millipore filter to determine the trace metal contents in the seawater.

The heavy metals (Cu, Pb, Zn, Cd, Mn & Fe) in sediment and sea water samples were determined using the AAS technique by GBC-932 Ver 1.1. In the sediment samples; the concentrations of the different cations have been determined after the complete digestion of 0.5gm of the powdered samples in a 10ml of hot HF:HNO₃:HOCI acid mixture (Chester et al. 1994). While in sea water samples the heavy metals were determined according to Martin (1972), where this technique depends on catching the cations within ammonium pyrrolidine dithiocarbamate (APDC) and methyl isobutyl ketone (MIBK) complex and then extracted using 6N HNO₃ acid. The extracted solution is digested on hot plate to volatilize the acid and then solved in about 10 ml of de-ionized water for the heavy metal measurements. The measurements accuracy was checked by applying three replicates in each one and the digestion procedures were tested with the reference materials.

RESULTS AND DISCUSSION

General conditions

Al Yosr desalination plant is considered a one of the vital projects for the human settlements and tourist industry in Hurghada City. Therefore, it was built since 1986 on the land belong to Red Sea Governorate between the Hurghada shipyard from the north and new touristic harbour from the south at Sakkala area, (Fig. 1). The desalination plant depends on sea water with salinity value varies between 40‰ and 41 ‰ and produce potable water with total dissolved salts between 300-500ppm, which means that the reject water has salinity rate from 50% to 68‰.

The desalination plant consists of 4 osmosis units; each of them includes 6 element membranes. Each membrane contains 20 glass tubes. So, the feed zone is supplying sea water throughout 4 pipelines with 4 inches diameter, which extend through the back reef zone of the

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Depth in m.</th>
<th>Sediment Types (%)</th>
<th>Carbonates %</th>
<th>Total organic matter %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>gravel sand mud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>5.00 95.00 0.0</td>
<td>12.74</td>
<td>10.56</td>
</tr>
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<td>10</td>
<td>10.73 89.26 0.012</td>
<td>10.97</td>
<td>7.69</td>
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<tr>
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<td>15</td>
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<td>22.31</td>
<td>11.36</td>
</tr>
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<td>20</td>
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<td>35.00</td>
<td>5.36</td>
</tr>
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<td>25</td>
<td>0.01 95.04 4.951</td>
<td>33.23</td>
<td>3.60</td>
</tr>
<tr>
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<td>30</td>
<td>3.17 93.01 3.816</td>
<td>65.32</td>
<td>4.06</td>
</tr>
<tr>
<td>7</td>
<td>35</td>
<td>0.75 96.17 3.072</td>
<td>66.56</td>
<td>3.09</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>0.13 93.38 6.488</td>
<td>76.43</td>
<td>4.83</td>
</tr>
<tr>
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<td>45</td>
<td>0.31 91.08 8.613</td>
<td>69.35</td>
<td>4.86</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>0.25 92.52 7.235</td>
<td>70.25</td>
<td>3.90</td>
</tr>
<tr>
<td>Avg.</td>
<td></td>
<td>3.93 91.56 4.51</td>
<td>46.22</td>
<td>5.93</td>
</tr>
</tbody>
</table>

Table 1: Grain size analysis, carbonate content and total organic matter of samples collected from marine area off Al Yosr desalination plant.

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Sea to about 10m depth. The feed water is pumping by three suction pumps with 70 bar pressure. Each pump has suction capacity 156 m³/h. The brine water was discharged throughout 5 pipelines at the beach face.

**Geological setting**

The beach has inclination angle about 3° with about 4m width, followed by muddy sand tidal flat with gently slope, (Pl. 1), then wide back reef zone covered with biogenic sand. Ten sediment samples were collected and analyzed to give an idea about their texture, conditions of deposition, the nature of the sediments constituents and the main forces controlling the sedimentation processes in the site, (Table 1). However, the area is mainly muddy sand bottom with grain size of the sand grades from mud in deeper part to very fine sand near the shoreline.

**Biological issue**

The marine area off Al Yosr desalination plant can be biologically divided into three zones according to the density and diversity of fauna and flora, (Fig. 2). The first zone lies directly next to the shore and extends for about 25m seaward. It is a very shallow area with the depth ranging from 0.3m to 1.5m and sometimes exposed during the low tide. Its bottom is mostly very fine sand and completely covered with green algae (Enteromorpha). This species covers this entire zone and forms condensed layer over the bottom, (Pl. 2). The fauna are represented with few types of dead gastropods; also this zone is characterized by presence of the five outflow pipelines with diameters 6 inches, (Pl. 3).

The second zone extends to about 150m towards the sea and its depth increase from 1.5m to 15m. Seagrass spots were recorded in this zone in addition to some patches of soft corals.

The third zone is the large extending to about 500m, with max. depth 50m and rich with different fishes type, and soft coral (Sarcophyton hrenbergi and S. elealegans) and hard one (Acropora eurystoma). Also, several types of invertebrates such as dead mollusks (Tridacna squamosa), echinoderms (Diadema setosum & Holothuria atra) and sponge (black spongy). The marine flora in this zone is mainly represented by brown and blue green algae and some seagrass spots. Algae is mainly e.g. Chlorophyceae, Digenea simplex and Padina pavonia which cover wide area. Generally, the scarcity of the living corals in the area may be attributed to high sedimentation rate and high percentage cover of filamentous algae due to the high temperature, (Pls. 4-6). It is estimated that the plant will cause an increase of up to 1.5% in mortality for planktonic larvae in an area extending as far away as desalination plant, (VDP, 2008).

**Physico-chemical features**

**Temperature**

In front of Hurghada, the water temperature was ranging between 18.9° C (during January) and 28.9° C (during July), affecting by heating effect of the Sun (El Sman 2000). In extreme shallow areas, higher values were recorded due to solar radiation (Morcos, 1970). Temperature of seawater at the feeding zone off the plant showed moderate fluctuations, whereas surface water temperature was 29° C and bottom water temperature at 50m depth was 26.2° C (Table 2). The area being relatively shallow, the difference between the surface and bottom water temperatures was less than 3° C and the water body was unhomogenous throughout the day because of the continuous movement of water towards the sea.

**Salinity**

Salinity is increased in the brine stream of all processes, but elevated temperature values are characteristic of desalination plant effluents only. The RO brine has a higher density than seawater as a result of its increased salinity and will mostly affect benthic communities, while desalination plant discharges tend to float on the surface and interfere with productivity in the pelagic community. The positive buoyancy of desalination plant discharges is mostly due to the discharge of large volumes of cooling water, which are blended with the brine. The salinity value around the discharge point recorded 60.0‰ at 5m depth and 50.5‰ at 50m depth (Table 2), while in the open sea the average salinity reaches 40.31‰, 40.06 ‰, 40.58 ‰ and 40.24 ‰ in winter, spring, summer and autumn respectively, (Maine Waters, Red Sea Studied, Report III, 1981).

**Specific conductivity**

The specific conductivity values in the feeding zone showed narrow fluctuations, its variation over marine area was ranged from 62.0 ms/cm to 62.9 ms/cm, in that the values were the highest at 50m depth and the lowest at 5m depth (Table 2), while the specific conductivity values in Safaga bay fluctuates from 61.5 to 61.73 ms/cm, (Helal & Abd El Wahab, 2004). The conductivity values observed now were converted to salinity. Generally, surface salinity is generally high in shallow areas because of excess evaporation in relation to precipitation, and poor rainfall.
The pH of seawater in the feeding zone remained always alkaline, whereas it ranged from 8.0 to 8.8 (Table 2), while in the open sea it varies from 8.08 to 8.37 (El-Mamony, 1986).

**Dissolved Oxygen**

The dissolved oxygen concentration in the feeding zone seawater varies between 5.6 and 6.8 mg/L (Table 2). In the open sea, the dissolved oxygen is fluctuated between 6.36 mg/L in winter and 5.28 mg/L in summer (El-Mamony, 1986). With increasing temperature and salinity, oxygen becomes less soluble in seawater. However, oxygen levels are deliberately reduced in desalination plants by physical deaeration and addition of oxygen scavengers like sodium bisulfite to inhibit corrosion. Oxygen depletion is also a problem of the RO brine, as sodium bisulfite is commonly used as a neutralizing agent for chlorine. The lack of dissolved oxygen could be toxic to marine organisms and aeration is recommended prior to oceanic discharge.

**Total Dissolved Salts (TDS)**

TDS value in feed water of the Al Yosr plant was lowest (39.7 g/L) at 5m depth and highest 40.1 g/L at 50m depth (Table 2). High TDS value is considered as an index of water pollution and it is one of the important water quality criterions for which environmental limits are prescribed by regulatory agencies in many countries. Reason for this elevation can be attributed to the shallow area conditions, the re-suspension of fine grained particles by wave action and the uprooting of seagrass due to consequent turbulence in the sea.

The suspended particle load in the area off the plant greatly influenced by accumulation of garbage and fine particles coming from both the shipyard at the north ward and touristic harbour from the south ward. Also, the most important contribution to TDS comes from marine organisms as decomposable organic matter which is continually coming from the navigation of touristic boats. Therefore, sheltered coastal areas off the plant collect organic matter in the form of detritus which in return decomposes and releases nutrients which subsequently become available to the plankton. There is a strong relationship between suspended particles and marine food chain. The coarse particles in seawater are colonized by fungi, because of larger surface area offered by them, while the finer particles are colonized by bacteria, (Smith, 1985). Macro algae have been cited as an important source of detritus suspended solids in the area, as well as heaps of seagrass were observed in the feeding area during periods of survey.

**Carbonates**

Carbonate sediments are usually concentrated in warm tropical or subtropical seawater carbonate secreting plants and animals are dominant (El-Mamony, 1986). The total carbonate content in the investigated sediments varies between 10.97% and 76.43% averaging 46.22% (Table 2). Distribution of the carbonate content through the studied sediments show a lesser value of carbonate concentrations relative to the other locations. Strong relation is detected between the carbonate content and organic matter of the sediments in the investigated area, whereas the carbonate content decreases with increase organic matter (Table 2).

**Total Organic Matter**

Organic matter affects the aquatic ecosystem by interacting with inorganic matter to form complex compounds, which include in its structure several elements. Free carbon dioxide and hydrogen sulfide may be released and affect the composition of the sediments even more.

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**Table 2: Physical parameters of water masses off Al Yosr desalination plant, Hurghada.**

<table>
<thead>
<tr>
<th>S. N</th>
<th>Depth (m)</th>
<th>Temp. °C</th>
<th>DO mg/L</th>
<th>Sal. ‰</th>
<th>pH</th>
<th>SP.C. m/cm</th>
<th>TDS g/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>28.4</td>
<td>5.7</td>
<td>68.0</td>
<td>8.8</td>
<td>62.0</td>
<td>39.8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>27.9</td>
<td>5.8</td>
<td>58.6</td>
<td>8.5</td>
<td>62.1</td>
<td>39.7</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>26.8</td>
<td>5.6</td>
<td>56.9</td>
<td>8.4</td>
<td>62.3</td>
<td>39.9</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>25.6</td>
<td>6.5</td>
<td>54.8</td>
<td>8.4</td>
<td>62.4</td>
<td>40.0</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>25.3</td>
<td>6.6</td>
<td>53.1</td>
<td>8.3</td>
<td>62.4</td>
<td>40.0</td>
</tr>
<tr>
<td>6</td>
<td>30</td>
<td>24.7</td>
<td>6.7</td>
<td>52.7</td>
<td>8.3</td>
<td>62.5</td>
<td>40.1</td>
</tr>
<tr>
<td>7</td>
<td>35</td>
<td>24.5</td>
<td>6.7</td>
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<td>8.2</td>
<td>62.6</td>
<td>40.1</td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>24.3</td>
<td>6.7</td>
<td>51.7</td>
<td>8.0</td>
<td>62.7</td>
<td>40.1</td>
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<tr>
<td>9</td>
<td>45</td>
<td>23.8</td>
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<td>51.1</td>
<td>8.0</td>
<td>62.8</td>
<td>40.1</td>
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<td>50</td>
<td>23.2</td>
<td>6.8</td>
<td>50.5</td>
<td>8.0</td>
<td>62.9</td>
<td>40.1</td>
</tr>
</tbody>
</table>

°C = Temperature, Do = Dissolved oxygen, Sal. ‰ = Salinity, pH = Hydrogen ion concentration, Sp. C. = Specific conductivity, TDS = Total dissolved salts.
Organic matter is initially produced by the fixation of inorganic carbon dioxide by marine phytoplankton in the euphotic zone, and released into the water column by the decomposition of dead cells or actively excreted by such diverse organisms as benthic algae and planktonic species (Kenneth, 1988). The organic matter content in collected sediments ranges between 3.09% and 11.36% with an average of 5.93% (Table 2). The high abundance of organic matter in the studied area compared with other locations is probably due to the abundance of organic productivity of seagrass and algae.

Chlorine

One major pollutant of distillation processes is chlorine, which is added to the desalination plant feed water to prevent biofouling on heat exchanger surfaces. Neutralization is typically required before the feed water enters the RO unit and it can be assumed that the brine is free from chlorine, too. Chlorine is a strong oxidant and highly effective biocide. Residual levels in the discharge may therefore be toxic to marine life in the discharge site. The use of chlorine also leads to the formation of oxidation by-products such as halogenated organics, (Ali and Moch, 1996). These compounds are usually rather persistent in the marine environment and sufficient evidence exists that some of them are carcinogenic to animals.

Heavy metals

Vollenweider (1992) reported that, the heavy metals pollution is one of the water quality problems. It is derived from industrial sewage, oil spill and industrial effluents, discharges and thermal effluents, from acid precipitations and litters.

Often the waste brine contains low amounts of heavy metals that pass into solution when the plant’s interior surfaces corrode. Brine metal composition depends on the use of different construction materials in desalination and reverses osmosis plants: Copper contamination is a major problem of desalination plants, as copper-nickel alloys are common materials for heat exchanger surfaces.

The RO brine may therefore contain traces of iron, nickel, chromium and molybdenum, but contamination levels are generally low. The heavy metals in the sediment and sea water samples may be come from nearby new touristic harbour and among the brine water from Al Yosr desalination plant. Also, the heavy metals are essential in the chemical compounds of the anti-fouling and anticorrosive paints used to protect ships in the nearby shipyard and other urban activities. Here, the heavy metals tend to enrich in sea water than in the sediments.

### Table 3: Heavy metals contents in sea water off Al Yosr desalination plant.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Dist. From beach</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
<th>Cd</th>
<th>Mn</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>0.80</td>
<td>2.24</td>
<td>5.43</td>
<td>0.74</td>
<td>1.26</td>
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<td>2</td>
<td>40</td>
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<td>0.94</td>
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<tr>
<td>3</td>
<td>60</td>
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<td>0.71</td>
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<td>0.14</td>
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<tr>
<td>4</td>
<td>80</td>
<td>0.15</td>
<td>0.66</td>
<td>1.77</td>
<td>0.13</td>
<td>0.65</td>
<td>41.63</td>
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<td>5</td>
<td>100</td>
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<td>0.24</td>
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<td>0.11</td>
<td>0.48</td>
<td>36.24</td>
</tr>
</tbody>
</table>

NT: All values in ug/L & Dist means the distance from shoreline toward the sea in meter.

### Table 4: Heavy metals contents in sediments off Al Yosr desalination plant.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Dist. From beach</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
<th>Cd</th>
<th>Mn</th>
<th>Fe</th>
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<tbody>
<tr>
<td>1</td>
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<td>1.513</td>
<td>0.368</td>
<td>8.090</td>
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<td>0.015</td>
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<td>60</td>
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<td>0.0107</td>
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<tr>
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<td>1.358</td>
<td>0.205</td>
<td>6.084</td>
<td>0.041</td>
<td>0.008</td>
<td>9.231</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>1.018</td>
<td>0.164</td>
<td>4.983</td>
<td>0.038</td>
<td>0.006</td>
<td>6.154</td>
</tr>
</tbody>
</table>

NT: All values in ug/g & Dist means the distance from shoreline toward the sea in meter.
So, the areas of restricted water exchange and soft bottom habitats could be affected by heavy metal accumulation. Many benthic shells are usually affected by metal accumulations in polluted areas and consequently are important food source (Abd El Wahab, 2003), with the risk that metals are enriched in their bodies and passed on to higher trophic levels.

**Antiscalants**

Scaling on heat exchanger surfaces, inside tubes, or on RO membranes impairs plant performance. Antiscalants are commonly added to the feed water in both desalination and RO plants to prevent scale formation. The main representatives of antiscalants are organic, carboxylic-rich polymers such as polyacrylic acid and polymaleic acid. Acids and polyphosphates are still in use at a limited scale but on the retreat, (Abdul Azis, et al. 2000). As antiscalants have a low toxicity, the acute environmental risk associated with their release into the marine environment is relatively low.

**Coagulants and coagulant aids**

Coagulants like ferric or aluminum chloride are used to improve filtration of suspended material from the RO feed water. Coagulant aids (organic substances with high molecular masses that bridge particles further together) and pH control are supplementary methods to enhance coagulation. The filter backwash can be discharged to the sea, as toxic effects are not expected by coagulants and coagulant aids, (Abdul Azis, et al. 2000). However, possible impacts such as reduced primary production or burial of sessile organisms by increased turbidity in the discharge should be anticipated.

**Antifoaming agents**

To reduce foaming in desalination plants, antifoaming agents like polyglycols are added to the feed water, which are not toxic but poorly biodegradable, (Winters, 1997 and Jamaluddin, et al. 1999). Adverse effects are not to be expected with regard to a low dosage level and sufficient dilution following discharge.

**Cleaning chemicals**

Cleaning intervals have to be established for each desalination plant individually and are typically three to six months depending on the quality of the plant’s feed water. In RO plants, alkaline cleaning solutions (pH 11-12) are used for removal of silt deposits and biofilms, whereas acidified solutions (pH 2-3) remove metal oxides and scales. Further chemicals are often added to improve the cleaning process of RO membranes, such as detergents, oxidants, complexing agents or biocides for membrane
Plate (1). Beach profile off Al Yosr desalination plant.
Plate (2). Dense filamentous algae in the intertidal zone off plant.
Plate (3). Five outlets pipelines on the beach off Al Yosr plant.
Plate (4). Polluted filamentous algae in the end of intertidal zone.
Plate (5). Unhealthy soft corals in the marine area off the desalination plant.
Plate (6). High turbidity at the end of back reef zone.
disinfection. In desalination plants, cleaning is typically very simple: Copper-nickel heat exchanger surfaces are washed with acidified warm seawater to remove alkaline scales, (Abdul Azis, et al. 2000). The acidic solution often contains a chemical inhibitor which is added to protect the plant from corrosion. Most of the named cleaning and disinfection chemicals may be hazardous to aquatic life.

**POTENTIAL IMPACTS OF SEAWATER DESALINATION (PROBLEM SEVERITY)**

The sea as a source of drinking water seems to be unlimited, but pollution by land-based activity often impairs the quality of coastal water bodies that serve as feed water for desalination plants. Hot spots of marine pollution are typically near coastal areas of intense human activity such as hotels, resorts, and harbours, which are also the areas where desalinated water is most needed for tourism activities.

The process of desalination is not preserve environmentally friendly and seawater desalination plants also contribute to the wastewater discharges that affect coastal water quality. This is mostly due to the highly saline brine that is emitted into the sea, which may be increased in temperature, contain residual chemicals from the pretreatment process, heavy metals from corrosion or intermittently used cleaning agents. The effluent from desalination plants is a multi-component waste, with multiple effects on water, sediment and marine organisms. The severity of these effects differs in different areas according to: a) the hydrogeological nature of the marine body (bathymetry, depth, tides, waves, currents); b) the biological sensitivity of the marine habitat; c) the type of desalination plant, its size, the required secondary structures and infrastructure.

**PROBLEM RESOLUTION**

For impact mitigation, some aspects should be taken in consideration:

1. Alternative biocides include for example ozone and monochloramine, while disinfection with ultraviolet light may be used instead of biocides to eliminate micro-organisms.
2. Several alternative pretreatment methods have been considered to replace chlorine in desalination plants to avoid environmental and health problems.
3. The disposal brine to the sea should be strictly regulated using neutralization of alkaline or acidic solutions and treatment of additional cleaning agents is recommended before discharge to the sea to remove any potential toxicity.
4. The backwash could be diluted, e.g. by continuous blending with the brine, or alternatively it could be removed from the filters and transported to a landfill.
5. The discharge point must be extends to the end of the back reef zone and below the reef slope (water depth will reaches more than 20m), away from the navigation paths, and away from any benthic communities. Therefore, this zone is wavy in all conditions that allow continuous mixing occur and disperses before reaching the marine communities.
6. Use the diffusers at the end of reject pipelines, which provide good mixing with the seawater and dispersing immediately by the waves and currents before reaching the nearest marine communities.
7. It is necessary that all relevant issues, including the seawater intakes, the concentrate and chemical discharges should be continuously monitoring in order to investigate and minimize negative impacts.
8. In contrast, non-metal equipment and stainless steels are typically used in RO plants.
9. Furthermore, we believe that desalination activity needs to become an integrated part of regional and national water management plans in order to identify the best water supply option under environmental, socio-economic, energy and human health criteria.
10. Environmental awareness and preliminary planning can minimize the adverse effects of the desalination process on the environment.

**REFERENCES**


