

Impacts of Discharge of Desalination Plants on Marine Environment at the Southern Part of the Egyptian Red Sea Coast (Case Study)

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Abstract: There are many researches illustrated that almost lots mankind is suffering from shortage fresh water supply, both of quality and quantity. Considering water inadequate concerns approximately 80 countries and has caused some dangerous results in many places. The water shortage phenomenon is becoming a serious worldwide problem that impacts people's daily life and obstacle the social development. Because of the population increasing and expansion of industrial and agricultural activities, the governments of many countries get one's way to implement the desalination plants. A desalination plants is an industrial system that would have the potential to have an effect on environmental ecosystem. This study monitored variety of environmental impacts can be caused by desalination plants. It's considers a case study for two of the desalination plants located at Shalateen city at Red sea governorate namely; Marsa Humira and Shalateen desalination plants. The investigation unconcealed that there are distinct impacts of the reject water on the marine ecosystem in the front of the two studied stations. The photographs that has been taken to the biota exist in the marine area around the stations elucidated some of coral reefs affected by the discharge of the saline reject around. Coral reef and sea grass are the most biota affected due to the salty discharges that exceed the safe limits for those to be in a healthy condition.

Keywords: Desalination Plants, Coral Reefs, Heavy Metals

1. Introduction

Freshwater accounts for only 2.5% of the total volume of water on earth [1, 2]. Many regions are suffering from freshwater shortage due to raising water using up and climatic changes that are decrease the reliability of conventional water resources like groundwater sources [3]. For these reasons, water agencies have begun to make to reduce demand for water and to raise water supply by encouraging a new technical method like seawater desalination [4]. The desalination technology is one of recent inventions to produce freshwater from a salt-water solution [5].

Previous studied have reported the potential environmental effects from the discharges of the desalination plants in marine environments [6, 8]. The desalination plants discharge

their reject into the marine environment, and this resulted in impact to marine life [9]. Seawater salinity might not be different in profile from the surface to the bottom while in the ambient area of the discharge reject water it can fluctuate between the surface and to ten meters depth [10].

There is a remarkable relationship between change in the environmental salinity and the impacts on marine life [11]. In the long-term, salinity stress might be impact on the growth and reproduction of coral reef and this leads to mortality [12]. Mobile species such as plankton and fish are the first most likely sort of marine life to be influenced due to changes in the seawater temperature [13].

The present study aimed to illuminate the impacts of the Marsa Humira and Shalateen desalination plants on the marine environment around particularly on coral reef ecosystem.

2. Materials and Methods

2.1. Area of the Study

The two desalination plants studied in the present study have a special geographical characteristic. The study was

carried out at Marsa Humira and Shalateen desalination plants figure 1. The latitude and longitude coordinates of the studied stations were recorded using the survey vessel's Garmin, Global Positioning System (GPS) unit navigation system.

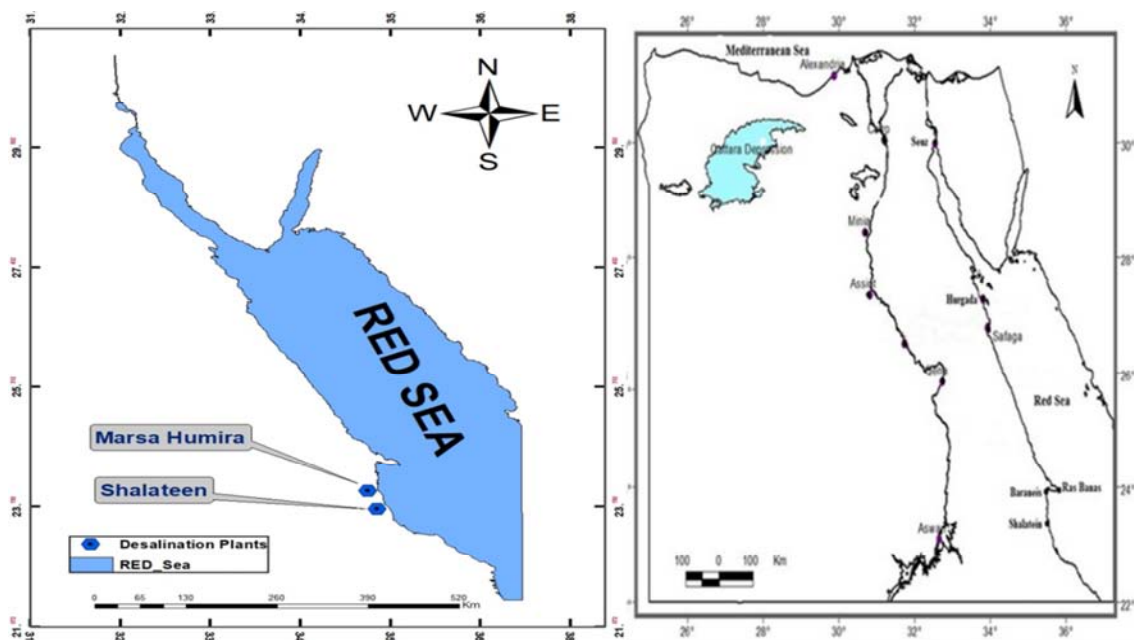


Figure 1. Shows map of Studied areas along the Red Sea coast, Egypt.

2.2. Field Studies

The environmental factors were measured in the feed (sea water) and reject water (the discharge of the desalination plants). These factors include; temperature of water, pH, Total dissolved solids (TDS), Salinity (Sal), Dissolved Oxygen (DO), Turbidity (Turb.) and Oxidation Reduction Potential (ORP). Factors were measured using YSI Pro DSS Multi-Parameter Water Quality Meter. Scopa Diving/ or snorkeling to survey the marine area around the stations studied were used. Photography used to take photos for the marine area include the coral reefs and other aquatic animals present. This was done using digital underwater camera. line transect was used to follow the conditions of the coral reefs in the whole area studied.

2.3. Laboratory Measurements

2.3.1. Determination of Nutrients

Water samples were taken to measure the nutrients includes; ammonium (NH_4), nitrite (NO_2), nitrate (NO_3), phosphate (PO_4) and silicate (SiO_2) using GenWay Spectrophotometer analysis apparatus.

2.3.2. Determination of Heavy Metals

Nine of heavy metals were determined in both feed and reject waters at the two studied stations. The determined heavy metals include; Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Lead (Pb), Nickel (Ni), Cobalt (Co) and Cadmium (Cd). Determination of heavy metals has been done using the Atomic Absorption Spectroscopy (AAS) with

flame methods. All physical and chemical analysis has been done according to according [14].

3. Results and Discussion

3.1. Description of the Sites

Site 1: Marsa Humera station

This site located onshore of Marsa Humera area, at the southern part of Egyptian Red Sea 30 km north Shalateen city figure 1. It impacted by desalination plant which discharge about 300 m^3 / per day of saline water. This site was characterized by low diversity of coral and marine organisms. Sea water around that area may be featured by down swells and waves and characterized by sandy seabed.

Site 2: Shalateen station

This site located offshore of Shalateen area, at the southern part of Egyptian Red Sea, Al Shalateen city, which extends from 15 km north on the Branis road figure 1. There are two desalination plant units in the Shaltin station. The feeding of both units is from seawater. This is by four pipelines extending across the tidal range for about 580 meters to a depth of about 8 meters. Both units discharge about 10000 m^3 / per day of reject water in marine environment around.

3.2. Physicochemical Impact of Reject Water

Table 1 revealed that there is distinct increase in all measured physicochemical parameters concentrations of the reject water of both desalination plants studied compared to

the feed source. RPS stated that the desalination process may increase the temperature of the reject water above the ambient seawater (feed water) [15]. Dawoud *et al* reported that the desalination processes produce large quantities of brine water, which may be increased in temperature [16]. Tularam and Ilahee reported that the reverse osmosis produces reject water with salinity up to twice that of seawater [7]. RPS reported that the de-chlorination process can reduce the pH of the reject water than the seawater [15]. This opposite to the results of pH in the Shalteen desalination plant and this may be due to the shortage in the de-chlorination process. The present study revealed that there is

a reduction in dissolved oxygen values in reject water. Water Consultants International Lattemann and Hopner reported that a shortage in dissolved oxygen can impact marine life [6 and 8]. Lattemann and Hopner stated that the addition of oxygen consuming chemicals can reduce dissolved oxygen in RO plants [8]. The parameters measured in the feed and reject water of the two studied desalination plants were tested for the one-way ANOVA test. The test revealed that there is a significant difference ($p < 0.05$) between all measured physicochemical parameters of the feed and reject water except for TDS and ORP.

Table 1. Show the mean and standard deviation of the physicochemical parameters measured in the feed and reject waters of Marsa Humira and Shalteen desalination plants.

Location	Marsa Humira		Shalteen	
Factors	Feed	Reject	Feed	Reject
Temp	31.403±0.006	31.633±0.058	33.067±0.462	33.36±0.165
pH	7.910±0.010	7.081±0.001	7.823±0.040	7.887±0.085
TDS	40.463±0.006	41.007±0.012	42.547±0.739	43.940±3.247
Sal	42.353±0.006	55.697±0.006	43.210±0.139	54.72±0.49
DO	4.100±0.000	2.700±0.100	4.967±0.808	2.680±0.289
Turb.	2.733±0.544	3.400±0.082	2.433±0.047	4.200±0.082
ORP	245.267±0.252	232.000±1.732	225.900±13.139	221.200±4.158

3.3. Heavy Metals Nutrients Impact

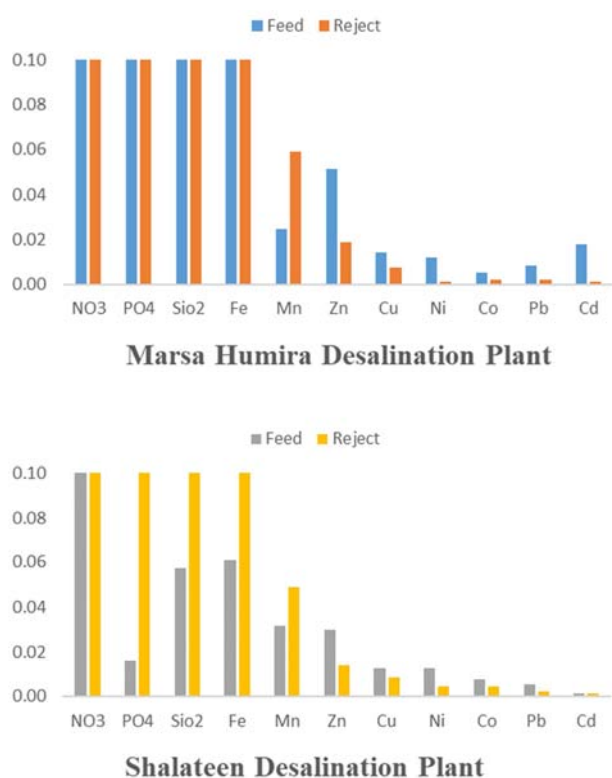


Figure 2. Show the mean heavy metals and nutrients measured in the feed and reject water of Marsa Humira and Shalteen Desalination Plants.

The statistical analysis revealed that there is highly significant difference ($p < 0.05$) between feed and reject water for all measured heavy metals. In contrast, there is a non-significant difference ($p > 0.05$) between feed and reject

water for all measured nutrients measured. Figure 2 illustrate that there are differences between the feed and reject waters in the concentrations of the measured heavy metals and nutrients. Lattemann and Hopner stated that the reversed osmosis and desalination plants produce reject water with heavy metals in relatively low concentrations [8]. Hashim and Hajjaj stated that any heavy metals that naturally occur in sea water are leached through corrosion or added in the pre-treatment process will be concentrated during the RO process after the freshwater is removed [17]. Raventos and Garcia-Rubies reported that the addition of nitrogen and iron during the RO process has potential to affect primary productivity as they are potentially limiting elements in marine system [18]. Roth and Muller-Parker *et al* reported that corals have a mutualistic relationship with dinoflagellates; genus (Symbiodinium) which fused to the coral reef's tissue where they give organic matter to the coral via photosynthesis in return of nutrients [19, 20].

3.4. Impact on Marine Ecosystem (Coral Reef Ecosystem)

The present investigation focused mainly on the impact of reject water discharged from two desalination plants on the marine ecosystem especially on coral reefs figures 3 & 4. The study revealed that there are highly distributed coral reefs, macro algae, sea grass, shellfish, sea urchins at the tidal zone around the discharge of Marsa Humira desalination plant. Birkeland reported that coral reefs considered one of the richest habitats in the marine environments, providing great biodiversity, biomass and productivity [21]. The percentage of coral reef cover around the effluent of the studied desalination plants was computed. The percent cover of alive hard coral reef around the discharge of the desalination plant was 30 % while for alive soft coral was

represented by 5%. The percent cover of dead coral affected by saline rejected water was 65% while for alive massive corals (*ports* sp, *favia* sp, *fungi* sp, and *platigra* sp) was 70%. The percent cover of branching corals of type (*Acropora* sp, *pocillopora* sp, *Millipora* sp) was 30%.

The present investigation recorded increases in salinity values of Marsa Humira and Shalateen station's reject water (55.697 ± 0.006 ppt) and (54.72 ± 0.49 ppt) respectively. Coles reported that a lot of coral species are known to withstand salinities above (50 ppt) in locations such as the Arabian Gulf, Red Sea [22]. The present study recommended that rejected water should be diluted before discharge to the marine environment. salinity play a significant role in the growth of marine species disturbance to keep the coral reef healthy. Birkeland and Graham *et al.* stated that coral reefs are essential for local economies, fisheries and tourism [21 and 23].

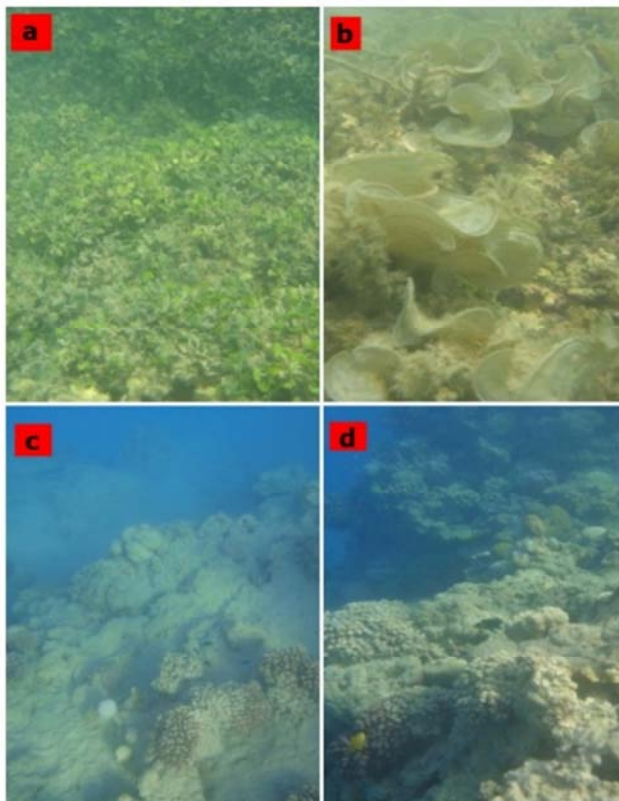


Figure 3. Shows the coral reefs impacted around the discharge of rejected water from Marsa Humira Desalination plant; (a and b) Shows growing green and prawn algae (*Ulva intestinalis* and *Padina boryana*) at tidal flat, (c and d) explained the percent cover of alive hard coral reef 30 % and the percent cover of life soft coral 5%, the percent cover of dead coral 65%, of saline water.

Jones reported that the tolerance limits of marine organisms to variation in salinity degrees is an essential in determine marine disturbance and population [24]. Increase the salinity can be of benefit for some of these organisms such as shellfish and also can have an adverse impact on other species. In the present study there is another problem associated to Shalateen station is it very close to the beach

area and this may cause severe impact. So, the present study recommended that it is necessary to extend the drain pipes into the tide area far from the beach. Einav and Lokiec reported that the vulnerability of marine ecosystem is likely to be influenced by the ecosystem's resilience to change [25]. Lattemann and Hopner reported that many marine ecosystems and species can tolerate or recover from short term changes in temperature, salinity and chemicals beyond normal levels, however, permanent changes are likely to result in mobile species relocating [8]. Lattemann and Hopner stated that the biota, like seagrass, coral and macroalgae are affected directly and it will be decline in health or die [8].

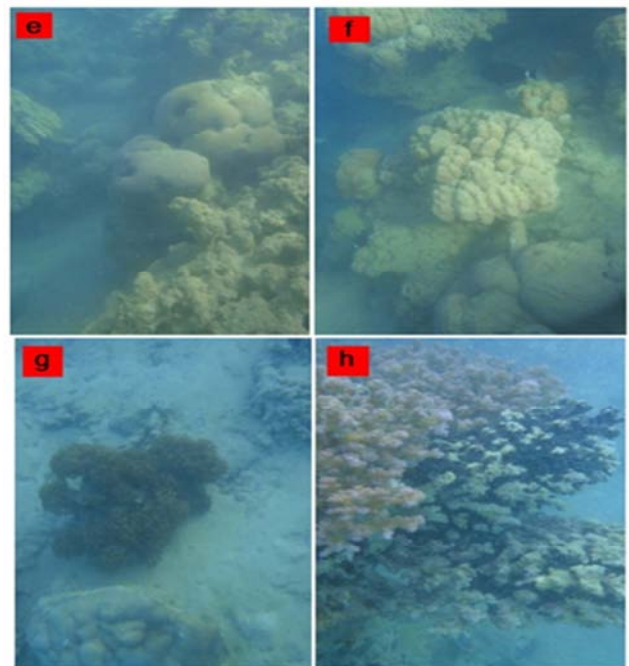


Figure 4. Shows the Shalateen Desalination Plants (e and f) explained the percent cover of alive hard corals (massive corals about 70%), of types (*ports* sp, *favia* sp, *fungi* sp, and *platigra* sp), while the percent cover of branching corals about 30%, of types (*Acropora* sp, *Pocillopora* sp, *Millipora* sp) (g) showed the percent cover of soft coral reached 5% . (h) shows the bleaching of coral impacted.

4. Conclusion and Recommendation

The present study concluded that in spite of the needed to freshwater produced by desalination plants it cannot be neglected its impact on flora and fauna species around. Discharge of desalination plants to the marine environment with high salinity and total dissolved salts (TDS), causing complete destruction of most marine organisms, especially coral reefs. The strong evidence of this in the case study in our hands as a result of the exchange of desalination plants in the study sites of the growth of a dense type of green algae in front of the areas that are disbursed see the desalination plants. So, the study recommended that when the governorates attend to establish desalination plants it should be taken in account the environmental concepts.

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