Reverse osmosis water desalination plants and environmental impacts

Leila Rezaei
islamic azad university, qeshm branch
Vali Alipour
Hormozgan University of Medical Sciences
Mohsen Dehghani (dehghani933@gmail.com)
Islamic Azad University Bandar Abbas
Amir Hesam Hassani
Islamic Azad University, Science and Research Branch

Research Article

Keywords: Ecological risk, heavy metal, desalination, reverse osmosis, marine pollution

Posted Date: May 23rd, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1645047/v1

Reverse osmosis water desalination plants and environmental impacts

Leila Rezaei [1], Vali Alipour[2], Mohsen Dehghani*[3], Amir Hesam Hassani[4]

1-Department of Environmental Sciences, Qeshm Branch, Islamic Azad University, Qeshm, Iran

2-Department of Environmental Health Engineering, School of Health, Hormozgan University of Medical Sciences, Iran

3- Department of Natural Resources and Environmental Sciences, Islamic Azad University, Bandar Abbas Branch, Bandar Abbas, Iran

4 -Department of Environmental Engineering, Science and Research Branch, Islamic Azad University, Tehran, Iran

Corresponding author: *Department of Natural Resources and Environmental Sciences, Islamic Azad University, Bandar Abbas Branch, Bandar Abbas, Iran. dehghani933@gmail.com*

Abstract

This case-control study was conducted to investigate the possibility of pollution caused by reverse osmosis desalination wastewater discharge into the coastal environment from spring 2019 to fall 2020.

Five sites (wastewater receiving) and two sites (checkpoint) were selected in Bandar Abbas coast. Seawater, plant waste, and coastal sediments were sampled 63 times at checkpoints and cases. The physical, chemical, heavy metals and plankton were measured. The environmental pollution indices including pollution coefficient, pollution load, enrichment, toxicity potential were determined.

The EC and heavy metal concentration (Pb, Cu, Ni, Cd, zinc and Fe) values in the checkpoint were significantly higher than the control stations. The plankton counts in the control stations was more than checkpoint. The pollution indices show low to moderate pollution levels of the banks of the desalination plant. Desalination plants have the potential to adversely affect coastal ecosystems; monitoring and management programs need to be implemented more extensively.

Keywords :*Ecological risk, heavy metal, desalination, reverse osmosis, marine pollution*

Introduction

Today, the challenge of the water crisis and its scarcity is evident in most societies; therefore, the use of sustainable water supplies has become necessary. (Berkani, et al.2022; Roberts, Johnston et al. 2010). Among sustainable sources, seawater desalination has found a special importance, especially in among sustainable sources, seawater desalination is of particular importance, especially in areas with open water sources. Depending on the nature of seawater desalination and the technologies used, different environmental challenges have been created, especially for coastal ecosystems.(Alipour, S Baneshi MM et al. 2016, Khan, Lal et al. 2019). Desalination plants use thermal, membrane and ion exchange technologies for desalination, but the most common are thermal systems (MSF and MED) and reverse osmosis (RO) systems (Pazouki et al. 2022). Depending on the salinity of the water, the type of power supply, the level of product quality and the size of the device, special priorities are given when choosing. (Aliewi, El-Sayed et al. 2017) . Recent advances have made membrane technologies such as reverse osmosis (RO) and electro dialysis (ED) more efficient than other methods. For higher salinity energy sources such as sea water (SW) and salt water (BW), modern of these plants. The environmental effects of SWRO can be broadly classified into three technology is used with greater reliability. Sustainable water supply is a good aspect of using desalination facilities, while environmental threats are one of the most important concerns in the use categories; effects of energy consumption, reservoir and wastewater effluent. Most environmental research on the effects of desalination facilities has focused on the effect of saline effluent on the physicochemical properties of the receiving environment (Roberts, Johnston et al. 2010, Petrik, Green et al. 2017); High rate of brine discharge and chemicals added in the chlorination process, regulation of coagulation and flocculation pH, dechlorination, hardness adjustors, cleaning solutions and addition of anti-fouling agents have negative effects on the environment. (E Portillo, Rosa et al. 2014, Shahabi, A et al. 2017, Missimer and Maliva 2018). Based on effluent studies from 21 desalination plants in the Red Sea, it was estimated that 2.7 tone of chlorine, 9.5 tone of anti-scalant agents and 36 kg of copper and are released in the Sea every day (Hoepner and Lattemann 2002). Due to the presence of these different chemicals in varying concentrations, marine wastewater has the potential to alter the alkalinity and temperature of seawater and can cause biological changes in the marine environment. Much of the environmental and economic problems can be traced back to these materials. (Höpner and Windelberg 1997, Karami, Karami et al. 2017, Herrero-Gonzalez, Admon et al. 2020). In addition, desalination wastewater contains large amounts of environmental pollutants such as mercury, lead and cadmium, which are potentially toxic and harmful to the aquatic environment, especially living organisms, as they accumulate, are stable and do not biodegrade. (Fernández-Torquemada, Sánchez-Lizaso et al. 2005, Admon 2011, Herrero-Gonzalez, Admon et al. 2020). Discharge of desalinated wastewater into the marine environment can reduce the number and diversity of marine communities on beaches that receive wastewater (Sola, Zarzo et al. 2020). Studies show that concentrated discharge can have adverse effects on the microbial activity of flora and fauna; phytoplankton, zooplankton and fish larvae (Frank, Fussmann et al. 2019, Sola, Yolanda et al. 2020).

The Persian Gulf is a shallow, semi-enclosed sea, connected to the Indian Ocean only through the Strait of Hormuz and its water exchange is insufficient. The limited circulation of water in this bay has made the bay particularly important from an environmental point of view. Many desalination plants have been concentrated on the shores of the Persian Gulf in the Bandar Abbas industrial zone due to the density of different industries such as oil and gas refineries, aluminum and steel production and shipbuilding in the limited area. This regime. On the one hand, the extremely rapid evaporation and lack of rainfall in the Persian Gulf region and the discharge of wastewater from desalination plants, on the other hand, have created conditions that can lead to increased water salinity and concentration. heavy metals in water, which can reduce the level of dissolved oxygen in the water; This situation therefore increases the likelihood of an increase in ecological stress (Sharifinia, Bahmanbeigloo et al. 2019). Since there are many plans to develop desalination plants in this area, by studying environmental and ecological impacts, more comprehensive information on environmental impacts can be obtained for environmental management, before installation. For this purpose, this study was carried out.

2. Research method

2.1. Study area

This case-control study was carried out in the Persian Gulf coast; in distance of 15 km from south of the Bandar Abbas (BA), the capital of Hormozgan province southern Iran (Figure 1); during the summer 2019 to winter 2020. In the Hormozgan especially in shore line of BA and as an obvious point is west beach of BA, large scale desalination plants have been installed in two purposes: industrial and drinking water supply, this area has become a point of concern for environmentalists. So this location was selected as the case of study area, and an area located on the east coast of Bandar Abbas was also selected as a control for the study. The distance between the case and the control locations was more than 30 km. Case concordance for the case and controlled areas of the study included morphological characteristics, structural features of the area, depth of coast, climatic conditions, absence of maritime traffic, and absence of discharge of other urban and industrial wastewater. The difference between the investigated beaches and the control beaches consisted of discharging desalination wastewater into the area of the study case. The case and control areas, whose geographic coordinates are shown in Table 1, consisted of 5 and 2 stations, respectively (Figure 2).

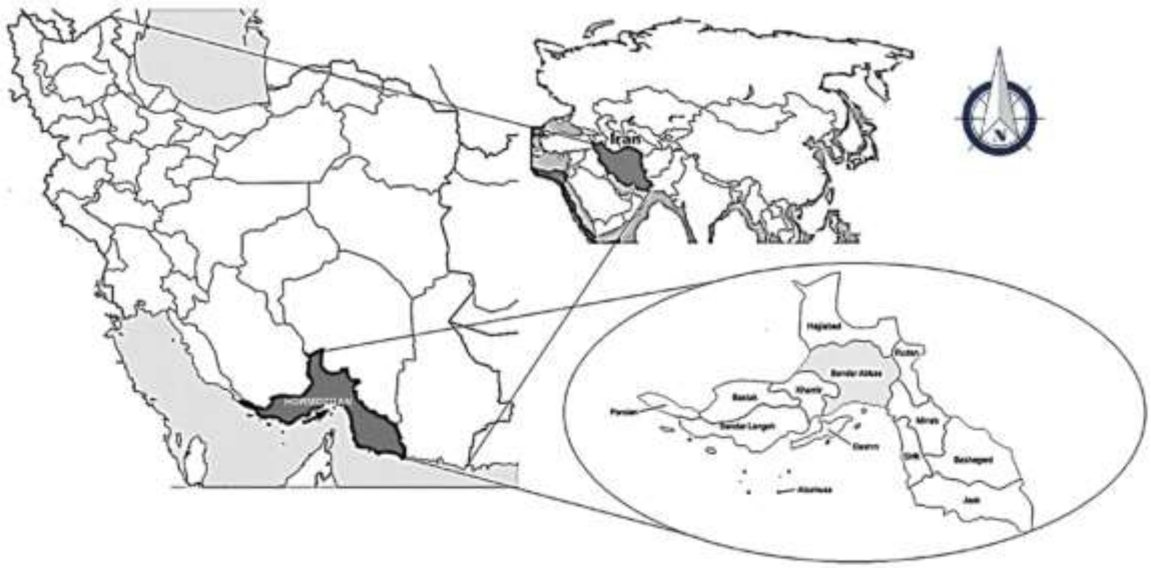

Fig.1: Location of the study area ion.

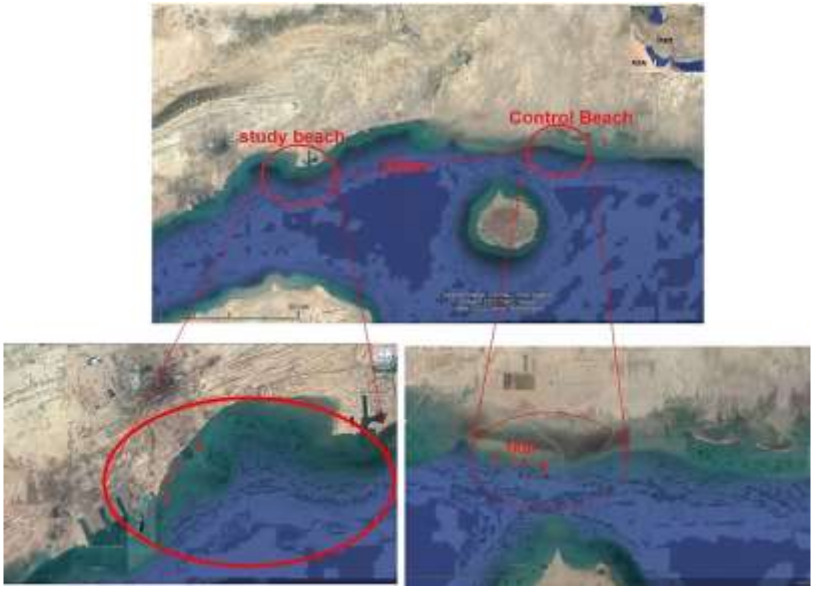

Figure 2: Study and control site on the shores of Bandar Abbas

Table 1. Geographical coordinates of study stations

station	Easting	Northing
Case 1	409961.13	2999595.8
Case 2	410093.8	2999943.92
Case 3	411536.62	3001603.03
Case 4	410282.21	3000185.31
Case 5	409775.12	2998852.4
Control 1	452407.17	3002476.53
Control 2	454887.78	3002059.15

2.2 Sampling and testing

In the selected area as the study area, there are 5 different desalination wastewater evacuation channels, each channel is considered as a station; In addition, two stations were selected in the control area. A total of 84 samples were collected from these 7 stations over 4 seasons in a triplicate pattern. Sampling of seawater, coastal sediments and desalinated wastewater; Seawater samples were taken at a depth of 0.5 to 1 m and sediment samples were taken at a depth of 20 to 30 cm. Samples of coastal sediments, were taken in 2 replications and at depths of 0-5 and 5-10 cm.

Various experiments were performed on the samples to determine the physical, chemical and biological properties of sea water as well as the physical and chemical properties of desalination effluents and coastal sediments. Examinations BOD and COD were performed according to standard reference method; standard numbers of 5210 and 5220, respectively. To measure EC and TDS, TDS meter with accuracy (0.01) was used. Physical and chemical factors of water in the area including: temperature, salinity and pH were recorded by HACH multi-parameter device at the same time as sampling. Alkalinity and hardness of water were measured by titration.

To determination of heavy metals (Cd, Fe, Cu, Ni, Zn and Pb), samples were placed in polytetrafluoroethylene vials containing acidified [HNO3 (5 ml) HClO4 (1 ml) HF (1 ml)]. After digestion and filtration, Fe, Cu and Zn were measured by Flame Atomic Absorption Spectroscopy and Pb, Cd and Ni by Atomic Absorption Spectroscopy in a graphite furnace (Thermo Elemental SOLAR Atomic Absorption Spectroscopy) was done.

For plankton assessment, at each station, 3 times and each time, 3 liters of seawater was collected in 4L containers of polyethylene and 2% formaldehyde was used to stabilize the phytoplankton samples. Samples were transferred to the laboratory for identification and counting. The samples were kept at rest for 11 days to completely precipitated, and after preparation, they were identified and counted by microscopy (APHA, 1998).

Determining the potential of an environmental risk

To investigate whether desalination effluent discharges could pose an ecological threat to coastal ecosystems in regions adjoining to the disposal sites, a number of ecological threat indicators were calculated and analyzed. In this study, the enrichment Factor (EF), potential contamination index (PCI), pollution load index (PLI), ecological toxicity unit (TU) and pollution index (Pi) and modified pollution (MPI) were used to assess the extent of sediment pollution due to heavy metals (Table 2).

Table 2. Formulas used to assess environmental pollution caused by heavy metal concentrations in coastal sediments (Duodu et al., 2016).

Index	Formula	Details	Classification
Contamination factor CF	$C_f = \frac{C_i}{C_b}$	Cf: contamination factor Ci: the metal concentration C_b: background metal concentration	Cf < 1, low contamination; 1 Cf < 3, moderate contamination; 3 Cf < 6, considerable contamination and Cf 6, very high contamination.
Enrichment factor EF	$E_f = \frac{(C_i/C_{ref})_{sa}}{(C_i/C_{ref})_{back}}$	e Ci:the element concentration C_{ref}: the concentration of normalisation element	Enrichment level: Ef < 2: minimum; 2 ≤ Ef < 5, moderate; 5 ≤ Ef < 20, significant; 20 ≤ Ef < 40, very high; Ef > 40, extremely high.
Potential contamination index (PCI)	$PCI = \frac{Cimax}{Cb}$	PCI: Potential contamination index Ci_{max}: maximum metal concentration C_b: background metal concentration	PCI< 1: low contamination. 1< PCI<3: Medium contamination. PCI>3: Severe to very severe contamination
Toxicity Unit	$TU = \frac{Ci}{\text{PELi}}$	Ci: metal concentration PELi: possible effects Level of metal For Cu, Pb, Zn, Cd, Ni and Cr= 108, 112, 271, 4.21, 42.8 and 160(mg / kg), respectively	ΣTU <4:no toxicity ΣTU> 6: acute toxicity.
PI	$PI = \sqrt{\frac{(Cf_{average})}{}}$	here Cf i, $Cf_{average}$, $Ef_{average}$, Cf_{max} and Ef_{max} represent contamination factor for individual element, average of contamination factors, average of enrichment factors,	PI < 0.7 :Unpolluted 0.7 < PI < 1 : Slightly polluted 1 < PI < 2 : Moderately polluted 2 < PI < 3 :Severely polluted PI > 3 :Heavily polluted

MPI	$MPI = \sqrt{\frac{(ECf_{average}}{}}$	maximum contamination factor and maximum enrichment factor, respectively.	MPI < 1 :Unpolluted 1 < MPI< 2 : Slightly polluted 2 < MPI < 3: Moderately polluted 3 < MPI < 5 : Moderately-heavily polluted 5 < MPI < 10 : Severely polluted MPI > 10 : Heavily polluted

3-Results

3.1-Sea water Quality

As stated earlier, extraordinary bodily and chemical parameters have been examined for extraordinary samples in seawater. The results of physicochemical parameters of seawater in the case and control shorelines is shown in Table 3.

Table 3. **Physicochemical** parameters of seawater in coastal water of case and control

station	Alkalinity (mg/l)	TDS (mg/l)	TSS	SO4	Na	K	Ca	Mg (mg/l)	pH	EC (µm/cm)	Turb (NTU)	Temp (ºC)
1	131.49 ±4.72	39643.00 ±991.52	5.99 ±1.06	3733.93 ±93.94	12321.73 ±708.04	276.01 ±14.27	470.00 ±51.86	1412.33 ±70.78	7.60 ±0.11	55617.07 ±223.74	7.50 ±1.12	33.69 ±2.81
2	129.16 ±3.57	39369.00 ±1203.72	5.45 ±0.69	3722.33 ±131.32	12442.87 ±646.89	273.80 ±10.55	449.20 ±32.76	1467.53 ±89.43	7.64 ±0.12	55527.33 ±259.43	7.31 ±0.88	33.79 ±2.78
3	129.20 ±3.23	39944.73 ±1430.78	5.58 ±0.75	3695.20 ±102.56	12311.80 ±668.55	278.87 ±12.58	435.73 ±28.93	1424.33 ±91.85	7.66 ±0.15	55605.47 ±249.38	7.23 ±1.03	33.71 ±2.83
4	130.43 ±2.04	39772.50 ±1262.10	5.37 ±0.52	3694.92 ±111.77	12058.58 ±771.04	275.14 ±9.79	426.67 ±19.99	1401.92 ±98.88	7.65 ±0.21	55484.53 ±143.19	7.26 ±0.92	34.14 ±2.79
5	131.61 ±4.20	39936.33 ±1316.40	5.34 ±0.49	3646.08 ±132.36	12371.33 ±947.22	272.67 ±12.05	441.75 ±21.27	1434.75 ±94.77	7.66 ±0.11	55549.80 ±279.99	7.36 ±0.90	33.89 ±2.87
Control	130.18 ±3.04	63191.00 ±93191.33	5.52 ±1.34	3698.67 ±128.78	12638.33 ±587.62	279.20 ±8.72	436.33 ±39.21	1384.67 ±64.29	7.53 ±0.50	55365.15 ±245.10	7.12 ±1.01	33.79 ±2.72

To evaluate the plankton, a count of them was first performed. The results of the average plankton count in the studied stations as well as the control station are presented in Table 4. Also, the frequency of planktonic species in the studied and control stations in terms of percentage is presented in Table 5.

Table 4 - Average number of plankton in the studied and control beaches (number/cubic meter)

Station	1	2	3	4	5	Control
Number of plankton	149130	154324	138710	145080	158480	183110

Table 5. Abundance (%) of phytoplankton species in case study beaches

Category	**Genus**	**Case**	**Case**	**Case**	**Case**	**Case**	**Cont**
BACILLARIOPHYCE AE	LePtocylindrus	0	0	4.77	0.5	0	20.35
	Chaetoceros	67.33	60.55	63	68	74.1	18.25
	Nitzschia	12.3	4.09	9.83	12.5	6	2.61
	Biddulphia	10.05	16.11	7.25	10.33	8.47	2.11
	Eucampia	0	0	2.3	0	0	2.03
	Rhizsolenia	8.14	13.42	9.11	5.47	7.34	1.54
	Navicula	0	0	0	0	0	1.44
	Amphora	0	0	0	0	0	0.45

	Thallassiothrix	0	0	0.4	0	1.5	1.33
	Pleurosigma	2.18	5.53	2.3	3.2	0	0.47
	Lauderia	0	0	0	0	0	0.3
	Cosinodiscus	0	0	0	0	0	0.25
	Bacteriastrum	0	0	0	0	0	0.03
	Amphiprora	0	0	0	0	0	0.21
	Hemidiscus	0	0.3	1	0	0	0.05
	Hemiaulus	0	0	0.04	0	2.59	0.05
BACILLARIOPHYCEAE	Diploneis	0	0	0	0	0	0.04
	Asterionella	0	0	0	0	0	0.03
	Coconeis	0	0	0	0	0	0.03
	Thalassiosira	0	0	0	0	0	0.02
	Skeletonema	0	0	0	0	0	0.02
	Cerataulina	0	0	0	0	0	0.01
	Gymnodinium	0	0	0	0	0	4.21
	Prorocentrum	0	0	0	0	0	2.35
	Noctiluca	0	0	0	0	0	0.22
	Ceratium	0	0	0	0	0	0.07
DINOPHYCEAE	Scripsiella	0	0	0	0	0	0.2
	Protoperidinium	0	0	0	0	0	37.55
	Phormidium	0	0	0	0	0	1.45
CYANOPHYCEA	Oscillatoria	0	0	0	0	0	2.11
	Phormidium	0	0	0	0	0	0.03
RAPHIDOPHYCEAE	Chattonella	0	0	0	0	0	0.05
Sum		100	100	100	100	100	100

3.2-disalination plant wastewater Quality

To evaluate the quality of effluent from desalination plants, various physicochemical indicators of heavy metals as well as two important indicators of all BOD and COD pollution were evaluated, the results of which are presented in Table 6.

Table 6 – mean value of physical and chemical parameters of desalination plants effluent

Effluent discharged to station	**pH**	**EC** s/cm	**Tyrbidity (NTU)**	**TDS** mg/L	**TSS** mg/L	**BOD mg/l**	**COD mg/l**	**Pb (µg/L)**	**Cu (µg/L)**	**Ni (µg/L)**	**Cd (µg/L)**	**Zn (mg/L)**	**Fe (mg/L)**
1	8.2 ± 0.31	67300 ± 7860	2.84 ± 0.35	47110± 6699	8.91 ± 3.13	10.83 ± 3.75	260.15 ± 21.13	105.12 ± 44.09	1245.31± 339.87	145.06 ± 51.58	75.15± 26.91	4.11 ± 1.22	5.20 ± 2.00
2	7.9± 0.28	67700± 6943	0.74 ± 0.40	46690± 7083	10.23± 4.02	16.12 ± 7.18	267.41 ± 19.95	98.68 ± 34.00	1301.21± 408.46	167.38 ± 60.19	84.54± 29.88	3.1787 ± 1.55	4.74 ± 2.31
3	7.58 ± 0.43	76000± 8031	1.22 ± 0.61	53200± 6121	19.78± 7.35	17.78 ± 7.00	314.65 ± 27.55	84.45 ± 28.31	1197.00± 345.70	163.70 ± 49.22	90.97± 30.20	3.60 ± 1.88	4.16 ± 2.54
4	8.15 ± 0.50	66800± 7300	6.95 ± 3.34	46764± 8110	23.12±	10.1 ± 5.03	248.01 ± 18.07	80.97 ± 26.03	1050.25 ±	143.98 ± 53.17	78.59 ±	4.06 ± 2.03	3.26 ± 2.48

					11.76				412.45		43.15		
5	8.17 ± 0.41	77300± 6295	0.42 ± 0.13	54118± 6965	8.11 ± 2.93	15.32 ± 5.52	281.32 ± 21.28	91.11 ± 19.59	1100.27 ± 306.05	158.83 ± 39.19	90.97± 27.15	4.51 ± 1.76	3.57 ± 1.33

3.3-Coastal sediments Quality

As stated in the study method section, the hearts of heavy metals in coastal sediments have been measured. In this measurement, the studied stations have been as compared with the reference value, in order that the manipulate stations have been decided on because the reference and this assessment became made among the manipulate stations and the look at stations. The outcomes of this evaluation are offered in Table 7.

Table 7: Average concentrations of heavy metals in sediments and reference

Station	Pb	Cu	Ni	Cd	Zn	Fe
1	0.62±0.28	1.52±0.72	2.05±0.81	0.85±0.40	5.04±2.38	9530±2415
2	0.21±0.10	1.16±0.60	2.00±0.69	1.77±0.73	2.77±0.75	6190±1974
3	0.56±0.08	0.65±0.17	0.86±0.28	0.86±0.40	1.17±0.83	3630±1055
4	0.58±0.21	1.14±0.39	1.92±0.66	1.03±0.35	2.91±1.02	6240±2347
5	0.57±0.16	1.03±0.44	1.66±0.30	0.82±0.32	3.72±1.11	3930±987
*Reference	0.57±0.22	0.79±0.28	2.20±0.84	1.06±0.28	2.93±1.43	5200±1365

*Reference values are the average concentrations of heavy metals in sediments in the control station

The results of the Contamination Factor (CF) showed that most of the samples are in the category of low to moderate contamination coefficient. Index (CF) by metal type at all stations Contamination status for heavy metal lead, Ni and Cd (low contamination) (CF> 1) for heavy metals, Fe, Zn and Cu (moderate contamination) (3<CF≥1); table 8.

Table 8: calculated values of pollution indices for heavy metals in coastal sediments

	Zn	**Cd**	**Ni**	**Cu**	**Pb**	**Fe**
EF	1.03	0.95	0.71	1.25	0.89	-
CF	1.13	1.01	0.81	1.39	0.89	1.14
PCI	1.72	1.67	1.14	1.92	1.09	1.83
PI	1.73	1.07	1.33	1.61	1.03	1.41
MPI	1.58	1.37	1.00	1.76	1.34	-
TU	0.028	0.112	0.47	0.024	0.008	-

Discussion

The EC and turbidity of the water in the study area were significantly higher than the control site (P= 0.049 and 0.046), respectively. It means that in areas where desalinated water is discharged into the sea, increasing of salinity and turbidity will occur. Increased salinity and turbidity affect plankton density at survey stations. In desalination plant wastewater, high values of turbidity, conductivity and COD, as well as relatively low values of BOD are the most important parameters, as they do not meet applicable standards. A high COD/BOD ratio indicates that the pollutant is more chemical in nature and has low biodegradability. The mean planktonic concentrations at the control and case studies stations were 183,000 and 148,000 cell /cubic meter, respectively. The T- Student statistical test showed a statistically significant difference between the two means ($p < 0.05$). This means that discharge of wastewater into seawater can cause differences in plankton populations. By comparing the planktonic diversity, it was found that the frequencies were mainly associated with Leptocylindrus, Chaetoceros and Nitzschia, Protoperidinium, Gymnodinium and Oscillatori and the abundance of these plankton in receiving edge was higher than that of the control shore. Because plankton (Chaetoceros and Leptocylindrus) are halophile planktoned, their population has been increasing with increasing sea water salt concentration (Guiry et al., 2011 (Pizarra et al. 1997,). Therefore, it is possible that desalination of wastewater to the receiving shores caused the change in diversity.

According to table 6, the quality of desalination plants effluent not meet the related standards (EPA & national standards). In general, what has been determined in a few stations shows that this factor in time may be the place to begin for pollutants and, of course, the start of concern. These outcomes are absolutely constant with research carried out in different elements of the world (Chesher, 1975, Saeed et al., 2019 ;Sharifinia et al., 2019 Roberts et al., 2010) Drami et al., 2011. so, by a preliminary judgement, it can be expected that the desalination plants effluent may had the potential to pollution of the shore line sites.

The analysis of ecological contamination indices related to heavy metals

Given that, based on the analysis of CF index, the mean pollution limits for the three metals Fe, Zn and Cu were calculated in the moderate contamination class, it is possible that the source of the increase in these metal concentrations is due to desalinated wastewater. This statement is quite consistent with research (Cheshr 1975). The results of a researcher's study of Florida desalination plants show that up to 45 kg of copper is released into seawater every day (Chesher, 1975). However, in a study conducted in the northern Red Sea, it was noted that 36 kg of copper is discharged into the Red Sea daily during desalination operations (Hoepner and Lattemann, 2003). It is therefore likely that these metals can be part of the same chemical compounds that were added to the raw water during the algae pretreatment and coagulation and flocculation stages, and were eventually released into the sea. Along the wastewater stream and accumulate in the sediment.

Ecological Toxicity unit (TU) indicating that no metal toxicity unit ($tu < 4$). The enrichment factor for all metals studied at all stations is less than 2, indicating that there was no abnormal contamination. The metal pollution load index showed that the PLI values were greater than 1, indicating that contaminated with heavy metals is occured. The values of pollution index were adjusted to be proportional to each other and in the order of "minor pollution" for all studied stations. The level of pollution of each of the studied elements based on the average of this index showed that the metals lead, nickel, cadmium, zinc and copper are all in the range of low pollution ($P < 2 < 1$). The highest pollution index is related to copper and zinc metals and then iron. The values obtained from the calculation of potential contamination index (PCI) for different metals in each station indicate the average potential pollution status for all metals, among which copper, iron and zinc have the highest potential pollution index among the metals. The results of this index are highly consistent with the results of the pollution factor in relation to the metal copper, iron and zinc and in fact confirm each other. It should be noted that these three metals are the most widely used metals in desalination plants. So that iron salts are used as coagulants in the form of compounds such as iron chloride and iron sulfide to improve coagulation and sedimentation conditions. Copper compounds in the form of materials such as copper sulfate are also widely used as algaecides in the pre-treatment of water entering the desalination plant. On the other hand, zinc compounds are used in anti-fouling chemicals to prevent clogging of the membranes of desalination plants. Based on this, it is possible that the calculated pollution index is due to the effects of desalination effluents. However, in order to strengthen this possibility, sediment monitoring should be done over a period of several years, which was not possible due to time constraints. Due to the increasing activity of desalination industries in the region, it is necessary to pay more attention to human and industrial activities in the region in order to prevent the accumulation of heavy metals.

Conclusion

In this study, conducted from spring 2019 to autumn 2020, five sites on the west coast and two on the east coast of BA were selected as study and control sites, respectively. As a first step, desalination plants west of BA were visited and their wastewater, as well as coastal waters and sediments sampled and tested for physicochemical parameters and heavy metals. In addition, plankton concentrations were measured in the coastal waters of the case and control areas. Data is collected and analyzed technically and statistically. After analyzing the quality parameters, potential environmental threats are performed by determining the pollution coefficient index, determining the ecological risk assessment index, etc.

The results showed that the EC value and Fe concentration in the saline receiving ranges were significantly higher than that of the control. The difference of average numbers of plankton at the control and receiving shores were statistically significant. Concentrations of some heavy metals in the sediments of the stations were higher than those of the control sites, which indicates the impact of the coastal ecosystem on this pollutant.

The general conclusion is that the discharge of desalinated wastewater on the studied beaches has entered the ecologically destructive stage and therefore requires further monitoring and management plans.

Acknowledgements

The authors are grateful to Special Economic Zone of Persian Gulf Mining and Metal Industries for their cooperation.

Competing interests

The authors have declare that they have no conflicts of interest.

Funding declaration

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Author's contribution

Leila Rezaei and Vali alipour conducted field operations to collection data. Leila Rezaei, Vali alipour and Mohsen Dehghani wrote the main manuscript text and Amir Hessam Hassani has participated in data analysis. All authors reviewed the manuscript

References:

Admon, N. (2011). " Overview of seawater concentrate disposal alternatives." Desalination **273**(1): 205-219.

Aliewi, A., E. El-Sayed, A. A, K. Hadi and M. A.-R. . (2017). " Evaluation of desalination and other strategic management options using multi-criteria decision analysis in Kuwait." Desalination 413: 40-51.

Alipour, V., R. S Baneshi MM, M. Narooie, A. Salimi and R. Khaksefidi (2016). " Are household water purification devices useful to improve the physical chemical and microbial quality of the feed water? case study: Bandar Abbas south of Iran." International Journal of TropicalMedicine 11(6): 251-256.

APHA (1998), Standard Methods for the Examination of Water and Wastewater American Public Health Association, 20th Edition. ISBN. 0-97553-235-7

Berkani , M., Smaali, A., Almomani, F., Vasseghian, Y (2022). "Recent advances in MXene-based nanomaterials for desalination at water interfaces.".Environmental Research. 203: 111845

Duodu, G. O., Goonetilleke, A., & Ayoko, G. A. (2016). Comparison of pollution indices for the assessment of heavy metal in Brisbane River sediment. Environmental pollution, 219, 1077-1091.

E Portillo, M. R. d. l. Rosa, G Louzara, J. Quesada, J. M. Ruiz, H. Mendoza and M. Al-Rashed (2014). " Dispersion of desalination plant brine discharge under varied hydrodynamic conditions in the south of Gran Canaria." Desalin. Water Treat. 52: 164–177.

Fernández-Torquemada, Y., J. Sánchez-Lizaso and J. González-Correa (2005). "Preliminary results of the monitoring of the brine discharge produced by the SWRO desalination plant of Alicante (SE Spain)." Desalination **182**(1-3): 395-402.

Frank, H., K. E. Fussmann, E. Rahav and E. B. Zeev (2019). "Chronic effects of brine discharge from large-scale seawater reverse osmosis desalination facilities on benthic bacteria " Water Res **151**: 478–487.

Herrero-Gonzalez, M., N. Admon, A. Dominguez-Ramos, R. Ibañez, A. Wolfson and A. Irabien (2020). "Environmental sustainability assessment of seawater reverse osmosis brine valorization by means of electrodialysis with bipolar membranes." Environ Sci Pollut Res Int **27**(2): 1256-1266.

Hoepner, T. and S. Lattemann (2002). "Chemical impacts from seawater desalination plants e a case study of the northern Red Sea." Desalination **152**: 133e114.

Höpner, T. and J. Windelberg " .(١٩٩٧) Elements of environmental impact studies on coastal desalination plants." Desalination **108**((1-3): 11-18.

Karami, S., E. Karami and S. Zand-Parsa (2017). " Environmental and economic appraisal of agricultural water desalination use in South Iran: a comparative study of tomato production." Journal of Applied Water Engineering and Research **5**(2): 91-102.

Khan, M. S., B. Lal, K. M. Sabil and I. Ahmed (2019). "Desalination of Seawater through Gas Hydrate Process: An Overview." Advanced Research in Fluid Mechanics and Thermal Sciences **55**(1): 65-73.

Missimer, T. and R. Maliva (2018). " Environmental issues in seawater reverse osmosis desalination: intakes and outfalls " Desalination **434**: 198-215.

Pazouki, p., Sidhu, J.P.S., Ipe, D.S., Pype, M.L., Wohlsen,. T.D., Helfer, F., Bertone, E. Stewart, R.A.(2022)" Seawater dilution desalination with hybrid FO-RO and UF-RO: Characterisation and assessment of pathogen removal efficacy." Desalination. **525:** 115509.

Petrik, L., L. Green, A. Abegunde, M. Zackon, C. Sanusi and J .Barnes (2017). "Desalination and seawater quality at Green Point, Cape Town: A study on the effects of marine sewage outfalls." S Afr J Sci **113**(11/12): 0244-0254.
Roberts, D. A., E. L. Johnston and N. A. Knott (2010). "Impacts of desalination plant discharges on the marine environment: A critical review of published studies." water research **44** 5117 e5128.
Shahabi, M., M. A and H. G. Anda M (2017). " A framework for planning sustainable seawater desalination water supply." Sci Total Environ **575**: 826-835.
Sharifinia, M., Z. A. Bahmanbeigloo, W. O. S. Jr, C. K. Yap and M. Keshavarzifard (2019). "Prevention is better than cure: Persian Gulf biodiversity vulnerability to the impacts of desalination plants." Global Change Biology **25**(12): 4022-4033.
Sola, I., F-.T. Yolanda, F. Aitor, V. Carlos, d. P.-R. Yoana, G.-C. J. e. M. and L. J. e. L. Sanchez- (2020). "Sustainable desalination: Long-term monitoring of brine discharge in the marine environment." Marine Pollution Bulletin **161**
Sola, I., D. Zarzo, A. Carratala, Y. Fernandez-Torquemada, J. A. de-la-Ossa-Carretero, Y. Del-Pilar-Ruso, S´ and J. L. anchez-Lizaso (2020). "Review of the management of brine discharges in Spain." Ocean Coast. Manag **196**: 105301.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- DATAd1.xlsx