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Environmental Impact Assessment of Brine Discharge from Desalination Facilities via Bioindicators

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ABSTRACT

This study investigates the environmental impacts of brine discharge on the biota. Physicochemical parameters, including faunal composition, percentage cover, abundance and biodiversity, were assessed. Seawater temperature, pH and turbidity showed a spatial variation and recorded the highest at the mixing zone (Z3). Salinity, total dissolved solids (TDS) and conductivity showed seasonal and spatial fluctuations and were the highest at the discharge zone (Z2) and showed lower values at the standard zone (Z1) throughout both seasons. This study recorded a total of 48 species, comprising 251 individuals. Among these, 24 were fish species (50%), and 13 belonged to the phylum Cnidaria (27.08%), including 7 species of soft corals and 6 species of Madriporaria (stony corals). Mollusca represented by 5 species (10.42%) dominated by Gastropoda (4 species) and only one species of Bivalvia. Echinodermata and Porifera were represented by only 3 species (6.25%) for each. Notably, it was observed that 13 species were completely absent in winter, compared to only 3 species that were not recorded in summer. The non-living sand-muddy substrate components were dominant at all studied zones. Seagrass meadows of *Halophila stipulacea* were found only in the standard area (Z1), located north of the discharge pipe, covering 26% of the substrate. These seagrasses meadows were completely absent in the other zones during the study period. The live corals were observed only at Z1 and Z3 as scattered, very small colonies. The percentage of dead corals was higher in Z3 than in Z1 (3 and 1%), respectively. Shannon -Wiener diversity index recorded its lowest (3.02) in winter and highest (3.13) in summer with an average of 3.07. In conclusion, this study shows that the brine discharged from desalination plants has adverse effects on marine biota.

INTRODUCTION

Water covers almost 71% of the earth's surface **(Nybakken, 1993; Karleskint *et al.*, 2010)**. Saline or brackish water bodies account for more than 97.2% of all available water resources. Ice caps, glaciers, the atmosphere, and soil moisture account for more than 2.1% of the remaining 2.8% of freshwater that is accessible. Therefore, the remaining 0.7% of the freshwater supply from lakes, rivers, and groundwater is necessary for human survival as well as a variety of agricultural methods and activities **(Peavy *et al.*, 1985)**.

With the limited water supplies of the Nile River and the impending drought brought on by climate change and upstream dam development, desalination plants offer the most practical way to meet the enormous demand for water in desert regions, particularly in Egypt.

The primary ecological obstacle confronting the saltwater desalination process is its brine disposal effluents and their adverse effects. Large volumes of brine, which are typically returned to seawater, are produced as a byproduct of the Reverse Osmosis (RO) process and have a salt concentration more than twice that of the input water **(Ahmad *et al.*, 2014)**. Brine is often dumped straight into the seas and oceans, where it creates a high-density, hypersaline water plume that diffuses along benthos and damages benthic habitats. The distribution of marine habitats is influenced by salinity; the majority of these habitats can tolerate variations in salinity up to 45 PSU, but prolonged exposure to high salinity may diminish the diversity of marine habitats **(Lattemann *et al.*, 2008)**. Additionally, different species have different distributions of marine organisms at the discharge areas of desalination plants **(Roberts *et al.*, 2010; Nassar *et al.*, 2025)**. Compared to other species, motile organisms—like fish, echinoderms, and plankton—are better able to adapt to high salinity. According to **Al-Hammady (2011)**, coral reefs are extremely vulnerable to high salinity. The ideal salinity range for coral growth is 32–34 ‰ **(Vine, 1986)**. Increased salinity can cause coral bleaching and slow growth, which can impact the dispersion of coral reefs **(Glynn, 1993)**. According to **Ammar and Nawar (1998)**, both hard and soft corals suffered from stressed salinity.

Therefore, this work aims to study the environmental impacts of the brine discharge on biota at Dahab Desalination Plant, Gulf of Aqaba, South Sinai, Egypt

MATERIALS AND METHODS

1. Study sites

Dahab Desalination Plant (DDP) is located south of Dahab City (South Sinai governorate – Egypt) just alongside Dahab Lagoon (28.477908°N and 34.489273°E). It has a capacity of up to 15000m^3/ day and discharges the brine through a submerged diffuser system at the Dahab Lagoon (Gulf of Aqaba). The length of the discharge pipe is 109 meters from the shoreline, equipped with seven diffusers oriented to the west (Fig. 1). The study area depth increases from the mean sea level at the shoreline to 10m west-south. The brine discharges at depths varied between 4 and 6m, and mixes with the normal seawater at the mixing zone (Z3) to the west between 6 and 10m depth. In contrast, the eastern northern side considers the standard zone (Z1).

2. Physicochemical seawater characteristics

Water samples were collected by NISKIN bottle from the three zones (Z1-Z3). Salinity and temperature were measured in the field using a portable (Multi 3510 IDS) and were re-evaluated in the lab within 24 hours using a benchtop meter called inoLab Cond 7310. Other parameters (pH, conductivity, TDS and turbidity) were measured in the laboratory, according to **Rice *et al*. (2017)**.

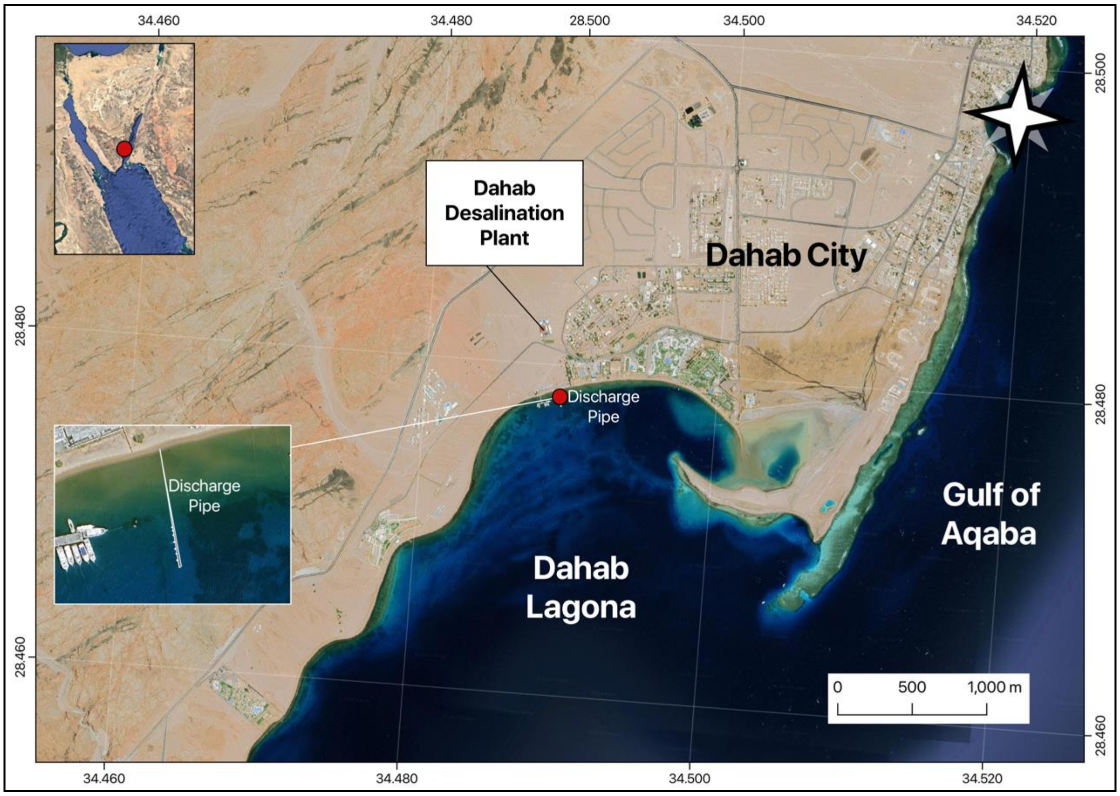

Fig. 1. A map showing the study area at Dahab Desalination Plant

3. Cover percentages and biodiversity

Cover percentages and biodiversity were investigated using Line Intercept Transect (LIT), visual, and sampling techniques according to **English *et al*. (1997)**. SCUBA diving and snorkeling were used to assess, sample and collect data. All collected and surveyed biota were identified based on standard references and textbooks, particularly **Randall (1986)** for fishes, **Veron (2000)** for corals, **Rumore-Villaume (2008)** for mollusks and **El-Shafai (2011)** for seagrasses, as well as other available literatures and textbooks.

4. Diversity

A. Species richness: Species richness is represented by counting the total number of species present in a community.

B. **The Shannon-Wiener index (H')**: the formula described by **Shannon and Weaver (1963)** and **Pielou (1977)**, which is called the "general diversity" or Shannon - Weaver index (H) as follows: $H = -\sum p_i \ln p_i$

Where, pi = the proportion of the total count arising from the species.

C- Equitability or Pielou's evenness (E): calculated according to **Pielou (1966)** according to this formula: $E = H \backslash \log S$

Where, E= evenness, H'= the value of Shannon Wiener index and S= total number of species.

5. Quality control

For accuracy and precision, calibration of all instruments for each variable was constructed of blank and standard solutions according to the calibration manual for each instrument **(Rice *et al*., 2017)**.

6. Data analysis, mapping, and graphs

Data were stored in Microsoft Excel and analyzed using R Studio and SPSS. All maps were created using QGIS (V 3.32.2) and all graphs were illustrated using GraphPad Prism (V.8.0).

RESULTS

1. Seawater physicochemical characteristics

The results in Tables (1, 2) exhibit seasonal values of physicochemical parameters recorded at two depths during this study at Dahab Desalination Plant. The recorded values of water temperature were seasonally varied, averaged 29.14±0.71°C and 23.27 ± 0.38°C during summer and winter, respectively, with an annual average of 26.21±4.15°C. These results showed spatial variations and recorded the highest values at the mixing zone (Z3) (Tables 1, 2).

The values of salinity, TDS and conductivity also showed seasonal and spatial fluctuations. The highest values of these parameters were recorded at the discharge zone (Z2) but declined to the lowest values at standard zones (Z1) during both seasons. The seasonal values of both salinity and conductivity were higher during summer and lower during winter, while TDS had higher values in winter compared to its average in summer. In contrast, the values of pH and turbidity recorded the higher averages in summer at the mixing zone (Z3) and lower values at discharge and mixing zones (Z2 and Z3), respectively, in winter (Tables 1, 2).

2. Cover percentages

The results in Table (3) show remarkable seasonal and spatial differences in substrate components during this study. The non-living sand-muddy substrate components were the dominant at all studied zones and represented by the highest percentage (100%) during both summer and winter at discharge zones (Z2). However, the values of these components declined slightly during the same seasons to 95% at Z3, and showed further decline to 78 and 63% at Z1 (the standard zone) during summer and winter, respectively. These components had an average of 91.0 ± 9.41% in summer and 86.00 ± 16.39% in winter and a total average of 88.50 ± 2.5%.

The seagrasses meadows comprised *Halophila stipulacea* came in the second order and appeared only in the standard area (Z1) and were represented by 26% of the substrate. Its values were higher in winter than in summer. However, it was completely disappeared in other zones during this study and was represented by a total average percentage of 8.67±1.99 (Table 3).

For coral cover percentages, the live corals (soft and stony) were represented with very low values, averaging 1.33±0.94% during summer and 1.67±1.24 % in winter, with a total average of 1.50±0.17 %. The dead corals were also represented with very low values, averaging 1.34±0.33 %. All live and dead corals were recorded only at Z1&3 (Table 3).

However, it was noticed that, several artificial substrates occupied with new growths of stony corals were recorded at the standard zone (Z1) at about 300m east of the discharge pipe. Moreover, quite few growths of filamentous benthic algae were observed on the constructed fixing blocks of both discharge and intake pipes.

ANOVA revealed significant differences in substrate components between zones ($P<0.05$), but no significant differences were detected between seasons ($P>0.05$).

Table 1. Average values of physicochemical parameters of seawater recorded at different depths at DDP, Gulf of Aqaba, Egypt (DDP = Dahab Desalination Plant, D= depth at 6m, S= Surface<2m, Z1= standard zone, Z2= Discharge zone, Z3= After-discharge)

Season	Zone	Temp. (°C)	Salinity (PPT)	TDS (g/l)	Cond. (mS/cm)	pH	Turb. (NTU)
Summer	Z1-D	28.71	40.29	38.55	59.17	8.28	0.55
	Z1-S	28.76	40.41	38.48	58.99	8.34	0.57
	Z2-D	28.64	49.86	47.49	72.80	8.55	0.56
	Z2-S	28.83	48.50	46.19	70.81	8.52	0.65
	Z3-D	29.94	46.46	44.25	67.84	8.57	0.64
	Z3-S	29.98	47.07	44.83	68.72	8.55	0.70
$\bar{X}$+SD		28.98 ±0.64	45.10 ±4.11	43.30 ±3.87	66.39 ±5.92	8.55 ±0.13	0.61 ±0.06
Winter	Z1-D	23.00	39.50	41.28	58.09	8.31	0.35
	Z1-S	23.20	39.20	40.96	57.65	8.39	0.39
	Z2-D	23.12	46.25	48.33	68.01	8.53	0.43
	Z2-S	23.30	46.00	48.07	67.65	8.51	0.41
	Z3-D	23.50	42.20	44.10	62.06	8.48	0.50
	Z3-S	24.10	43.20	45.14	63.53	8.49	0.56
$\bar{X}$+SD		23.28 ±0.39	42.73 ±3.05	44.65 ±3.19	62.83 ±4.48	8.45 ±0.08	0.44 ±0.08
Range (minimum ~ maximum)		6.98	10.66	9.85	15.15	0.29	0.35
Average ($\bar{X}$±SD)		26.26 ±3.06	44.08 ±3.73	43.97 ±3.60	64.61 ±5.34	8.46 ±0.102	0.53 ±0.111

Table 2. Average values of seasonal and spatial physicochemical parameters of seawater recorded at different zones at DDP, Gulf of Aqaba, Egypt, during this study (Z1= standard zone, Z2= Discharge zone, Z3= After-discharge).

Season	Zone	Temp. (°C)	Salinity (PPT)	TDS (g/l)	Cond. (mS/cm)	pH	Turb. (NTU)
Summer	Z1	28.73	40.35	38.52	59.08	8.31	0.56
	Z2	28.74	49.18	46.84	71.81	8.54	0.61
	Z3	29.96	46.77	44.54	68.28	8.56	0.67
	$\bar{X}$+SD	29.14 ±0.71	45.43 ±4.56	43.3 ±4.30	66.39 ±6.57	8.47 ±0.14	0.613 ±0.055
Winter	Z1	23.10	39.35	41.12	57.87	8.35	0.37
	Z2	23.21	46.13	48.20	67.83	8.52	0.42
	Z3	23.80	42.70	44.62	62.79	8.49	0.53
	$\bar{X}$+SD	23.27 ±0.38	42.73 ±3.39	46.41 ±3.54	62.83 ±4.98	8.43 ±0.113	0.44 ±0.0082
Average ($\bar{X}$+SD)		26.21 ± 4.15	44.08 ± 1.91	44.86 ± 2.20	64.61 ± 2.52	8.45 ± 0.03	0.53 ± 0.12

Table 3. Cover percentages of living and non-living components during summer (2023) and winter (2024) at Dahab Desalination Plant, Dahab, Gulf of Aqaba, South Sinai, Egypt (Z1= standard zone, Z2= Discharge zone, Z3= After-discharge).

Items & seasons / Zone	Seagrasses		Sand-muddy		Live corals		Dead corals	
	Sum.	Win.	Sum.	Win.	Sum.	Win.	Sum.	Win.
Z1	20	32	78	63	2	3	0	2
Z2	0	0	100	100	0	0	0	0
Z3	0	0	95	95	2	2	3	3
Seasonal average ($\bar{X}$±SD)	6.67 ± 9.42	10.67 ± 15.08	91.00 ± 9.41	86.00 ± 16.39	1.33 ± 0.94	1.67 ± 1.24	1.00 ± 1.41	1.67 ± 1.24
Total average ($\bar{X}$±SD)	8.67 ± 1.99		88.50 ± 2.5		1.50 ± 0.17		1.34 ± 0.33	

3. Faunal composition

Approximately 48 species were recorded at all transects at Dahab Desalination Plant (Tables 4, 5). They belong to different phyla of animals. Fishes came in the first order and were represented by 24 species amounting 50% of all recorded species comprising fish larvae. The other faunal components comprised 13 species of phylum Cnidaria (27.08 %), which included 7 species of soft corals and 6 species of Madriporaria (stony corals). It was followed by phylum Mollusca represented by 5 species (10.42%) dominated by Gastropoda (4 species) and only one species of Bivalvia. However, both phyla of Echinodermata and Porifera were represented by only 3 species (6.25%) for each. All echinoderms belong to Class Holothuria, comprised *Holothuria edulis*, *Holothuria atra* and *Holothuria argus* (Table 5).

Table 4. Faunal groups during summer (2023) and winter (2024) at Dahab Desalination Plant, Dahab, Gulf of Aqaba, South Sinai, Egypt

Taxa (Phyla)	Winter	Summer	Total no. species	Relative importance (%)
Vertebrata: Fishes	11	21	24	50
Cnidaria	13	13	13	27.08
Mollusca	5	5	5	10.42
Echinodermata	3	3	3	6.25
Porifera	3	3	3	6.25
Total	35	45	48	100

4. Abundance of recorded species

A total of 251 individuals were counted covering summer 2023 and winter 2024 during this study (Table 5). Fishes were dominant in the study area. Species of the family Pomacentridae (damsel fishes) dominated other species and were represented by 88 individuals (36.98 % of all), out of them, *Dascyllus trimaculatus* was represented by the largest number of individuals (43 individuals, 18.07%), followed by *Gerres oyna* with 32 individuals (13.45 %), then *Atherinomores* sp. with 13 individuals (5.46%). The other fish species were represented by a low number of individuals, ranging from only one (11 species) to 5 individuals (3 species). On the other hand, the benthic sedentary animals comprised 13 species of corals and 3 species of sponges, most of them were represented by restricted number of colonies (only one or two colonies), except for *Acropora* sp. and *Pocillopora* sp., which were represented by a higher number of colonies. In contrast, the creeping animals comprised 3 species from Echinodermata and 5 species from Mollusca. The echinoderms (sea cucumber) included *Holothuria edulis*, *Holothuria atra* and *Holothuria argus*, and represented by 26 individuals (10.92% of all), distributed between species as 12, 8 and 6 individuals, respectively; while mollusks exhibited a low number of individuals (Table 5).

Seasonal and spatial variations in abundance

The results in Tables (4, 5) indicate obvious seasonal and spatial fluctuations in the number of recorded individuals, particularly fishes, but no fluctuations were observed for benthic sedentary or creeping animals. The total number of individuals reached the highest (149) in summer and declined to the lowest (102) in winter. Eminently, 13 species were observed to completely disappear in winter compared to only 3 species that were not recorded in summer.

5. Pattern of distribution of faunal elements

The field observations showed mollusks and sea cucumbers were observed in high abundance below the discharge pipe, just on the right side, before brine discharge. There is a great amount of broken shell fragments of gastropods belonging to *Lambis truncatus*, in addition to fragments of broken *Conus* sp., *Terebera* sp. *Cerithium adansonii* and bivalves (*Anadara antiquata)* and other unknown mollusks species (Table 3 & Fig. 2). The recorded seagrasses belong to *Halophila stipulacea*, and was recorded only at the standard zone 1 at the eastern northern side of the discharge pipe (Fig. 3)

Both soft and stony corals were represented by a few colonies comprising 13 different species (Table 5). All occurred at the dead corals or hard substrates, particularly at the eastern sides of the discharge pipe and among the seagrasses meadows, in addition to a few colonies at the western sides.

The recorded fish species occurred at all zones as well as around the discharge pipe, just before brine discharge. They were dominated by damselfishes (Pomacentridae), comprised *Dascyllus trimaculatus*, *Amphiprion bicinctus*, and *Abudefduf sexfasciatus* in addition to surgeon fishes (*Ctenochaeteus striatus*, *Ananthurus nigricans*) and Pomacanthidae (*Pomacanthus imperator*) and other species as *Anthias squamipinnis* and *Atherinomorus* sp.

However, all species of recorded sea cucumbers (*Holothuria edulis*, *H. atra* and *H. argus*) were in high abundance under the discharge pipe. (Tables 4, 5).

Fig. 2. Mollusks below the discharge pipe

Fig. 3. Seagrasses meadows (*Halophila stipulacea*) with spotted snake eel (*Myrichthys maculosus*) at the standard zone

6. Biodiversity of recorded species at Dahab Desalination Plant

Results in Table (5) show seasonal and annual values of Shannon-Wiener index, evenness, species richness and similarity index IN the study area. The calculated values of Shannon-Wiener index recorded the lowest (3.02) in winter and the highest (3.13) in summer, with an average value of 3.07.

The values of equitability or Plielou's evenness were high during both seasons. These values ranged from 0.85 in winter to 0.823 in summer, with an average value of 0.836 (Table 5).

The values of species richness were high and showed slightly seasonal fluctuations (Table 5). The value of seasonal similarity was calculated and recorded 80 % of the recorded species that occurred during the two seasons (Table 5).

7. Effect of brine water on biota

During the field survey, it was noticed that, at Z3, almost no evidence for healthy colonies of both soft and stony corals were detected. Additionally, all seagrasses meadows were concentrated at the east-northern side of the discharge pipe (Z1) only. In addition, the high percentages of dead corals were calculated at the mixing zone due effect of brine water (Table 3). However, only nektonic fishes and holothurians were recorded in high numbers at the discharge pipe.

Table 5. The species numbers seasonally and diversity indexes in the study area during summer (2023) and winter (2024) at Dahab Desalination Plant, Dahab, Gulf of Aqaba, South Sinai, Egypt

Taxa (Phyla)	**Seasons**	**Winter**	**Summer**	**Total No.**	**Relative abundance (%)**
Fishes	Species				
	Pomacanthus imperator	2	3	5	2.10
	Amphiprion bicinctus	2	2	4	1.68
	Dascyllus trimaculatus	19	24	43	18.07
	Amphiprion bicinctus.	2	2	4	1.68
	Abudefduf sexfasciatus	1	2	3	1.26
	Pseudoanthias marcia	3	2	5	2.10
	Acanthurus nigricans	0	2	2	0.84
	Gymnothorax grieseus	0	1	1	0.42
	Myrichthys colubrinus	1	0	1	0.42
	Myrichthys macullosus	0	1	1	0.42
	Synodus sp.	0	1	1	0.42
	Gerres oyna	10	22	32	13.45
	Lethrinuus harak	0	1	1	0.42

	Parupenus forskalli	0	1	1	0.42
	Chaetodon grandieri	0	1	1	0.42
	Chromis pellaura	0	1	1	0.42
	Labroides didmatus	0	1	1	0.42
	Thalasoma rueppelli	0	1	1	0.42
	Acanathurus gabban	0	1	1	0.42
	Ctenchaetuus striatus	0	5	5	2.10
	Atherinomores sp.	0	13	13	5.46
	Odonus niger	1	0	1	0.42
	Mulloidichtbys flavolineatus	2	0	2	0.84
	Fish larvae	5	7	12	5.04
Corals	*Sarcophyton glaucum*	1	1	2	0.84
	Sinularia leptoclades	1	1	2	0.84
	Sinuularia poly actyla	1	1	2	0.84
	Litophyton arboreum	1	1	2	0.84
	Heteractic crispa	2	2	4	1.68
	Xinia sp	1	1	2	0.84
	Heteroxinia sp.	1	1	2	0.84
	Echinoporsa lamellosa	1	1	2	0.84
	Acroropora sp	4	4	8	3.36
	Stylophora sp.	2	2	4	1.68
	Porites sp.	2	2	4	1.68
	Pocillopora sp.	14	14	28	11.67
	Favites sp.	2	2	4	1.68
Mollusca	*Conus* sp.	1	2	3	1.26
	Terebra sp.	1	1	2	0.84
	Lambis truncates (broken)	1	1	2	0.84
	Cerithium adansonii	1	1	2	0.84
	Anadara antiquata	1	1	2	0.84
Sponges	*Halicone* sp	1	1	2	0.84
	Callyspongia crassa	1	1	2	0.84
	Callyspongia viridis	1	1	2	0.84
Echinodermata	*Holothuria edulis*	6	6	12	5.04
	Holothuria atra	4	4	8	3.36
	Holothuria argus	3	3	6	2.52
Total number of individuals		102	149	251	100

Total No. species	35	45	48	
Shannon-Wiener index	3.02	3.13	3.07	
Evenness (E)	0.850	0.823	0.836	
Species richness	7.35	8.794	8.072	
Similarity index			0.8	

DISCUSSION

This study investigated the effect of the brine discharge from the Dahab Desalination Plant on the marine environment of the Gulf of Aqaba, South Sinai, Egypt. The Gulf of Aqaba is a 200-kilometer stretch of coastline that borders Egypt and is the northeastern extension of the Red Sea. The Straits of Tiran divide this semi-enclosed region from the Red Sea. The Gulf of Aqaba contains 138 hard coral species on its fringe reefs. Live hard coral cover varies from 13% at an industrial site to 22% in the marine reserve, according to quick assessments conducted in five locations in the Gulf. In addition to coral reefs, the Gulf of Aqaba has diverse coastal habitats, including mangroves and seagrasses. These coastal ecosystems provide essential food and a shelter for 362 fish species **(Wilkinson 2002)**.

The results of this study showed a spatial and seasonal variation in physiochemical parameters. Seawater temperature varied among seasons with an average of 29.14±0.71°C and 23.27± 0.38°C during summer and winter, respectively, with a total average of 26.21±4.15°C. In addition, the mixing zone (Z3) recorded the highest seawater temperature. However, salinity, TDS and conductivity also showed seasonal and spatial fluctuations, but the values of these parameters were the highest at the discharge zone (Z2) and lowest at standard zone (Z1). In contrast, the values of pH and turbidity recorded higher averages in summer at the mixing zone (Z3) and lowest values at discharge zone (Z2). These parameters had slightly hazard effects on marine biota, particularly at the discharge and mixing zones, represented by disappearance of some common marine groups as corals and seagrasses.

Roberts *et al*. (2010) examined the effects of desalination plant effluent on the environment. Field and lab experiments showed that exposure to high concentrations of salt that are probably present close to the discharge site could result in both acute and chronic toxicity as well as small-scale changes to community structure. According **Kleypas *et al.* (1999)**, physicochemical conditions affect the physiological performance of the coral holobiont and determine the limits of coral reef distribution on a global scale. Temperature also plays a critical role in shaping coral habitats. Within ambient temperature ranges, higher temperatures enhance metabolic rates **(Pörtner 2002)** and coral calcification **(Marshall & Clode 2004)**, but temperature extremes may exceed the thermal limits of a coral species and lead to destabilization of the coral holobiont and to coral bleaching, as recently reported from the Red Sea in 2010 and 2015 **(Furby *et al.*,**

2013; Roik *et al.*, 2015; Monroe *et al.*, 2018; Osman *et al.*, 2018). Additionally, salinity influences coral holobiont functioning and distribution **(Kleypas *et al.*, 1999)**.

The results showed that, the live and dead corals appeared only in the standard area and scattered with very small unhealthy colonies at the mixing zone. The percentages of dead corals were higher in the mixing area than in the standard area, representing 3 and 1%, respectively.

According to **Al-Hammady (2011)**, coral reefs are extremely vulnerable to high salinity. In addition, **Mabrook (1994)** found the desalination discharge has been attributed to the huge decline of coral, and plankton in the Red Sea's Hurghada region.

The results of this study also showed the seagrasses meadows comprised *Halophila stipulacea* appeared only in the standard area lies northwards of the discharge and were represented by 26% of the substrate. The seagrasses disappeared completely in other zones during this study.

According to **Salo *et al.* (2014)**, salinity is a significant environmental factor that can affect the growth, function, structure, and distribution of seagrasses. Shifting salinities can also affect the composition and dynamics of seagrass communities, resulting in the loss of seagrass meadows **(Zieman *et al.*, 1999; Rudnick *et al*., 2005)**. According to **Roberts *et al.* (2010)** and **Van der Merwe *et al.* (2014)**, the brine discharge may have a wide range of impacts on seagrasses community, invertebrates and corals, varying from negligible changes in plankton to significant ecological disruption.

Sea cucumbers (*Holothuria edulis*, *H. atra* and *H. argus*) occurred in high abundance below the discharge pipe, just on the right side before brine discharge. Sea cucumber growth may be impeded, or intestinal discharge and mortality may result from drastic changes in salinity, which can also affect the amount of feed consumed and the energy utilized for osmoregulation **(Fankbonerb, 2002)**. The growth, metabolism, and survival of sea cucumbers were all altered by salinity **(Fankboner, 2002a; Zacharias *et al*., 2002)**. Growth was at its best when the salinity was 30 ± 2 ppt **(Setiawati *et al*., 2023)**.

A great amount of broken shell fragments of gastropods, *Lambis truncatus*, *Conus* sp., *Terebera* sp. *Cerithium adansonii*, the bivalves (*Anadara antiquata)* and other unknown mollusks species were observed below the discharge pipe.

According to **McFarland *et al*. (2013)**, when bivalves are exposed to salt conditions that are near their limits and the surrounding water column is not being filtered as well, their initial response is to seal their valves. In another study, after 72 hours, clam growth and survival rates significantly decreased in hyperosmotic conditions (40–60 ppt) **(Cao *et al*., 2015)**. In addition, **Guzmán-Agüero *et al*. (2013)** investigated the growth and oxygen consumption of *Crassostrea corteziensis* at different salinities (20, 30, 40, and 50 ppt) after two weeks. They found that oyster growth rate and oxygen consumption tended to decline with increasing salinity. Given this relationship, marine bivalves usually grow at a significantly slower rate when salinity varies.

In this study, the fish occurred in all zones; however, they were highly abundant around the discharge pipe, just before brine discharge. In contrast, according to **Whitmarsh *et al.* (2021)**, the brine discharge may not have significant effects on certain fish assemblages, indicating a potential resilience in some marine communities.

CONCLUSION

This study emphasizes the importance of conducting thorough environmental assessments and developing effective mitigation strategies to minimize the adverse effects of brine discharge on marine biota. Specifically, it investigated the environmental impacts of brine discharge from the Dahab Desalination Plant in the Gulf of Aqaba, Egypt, on local marine organisms. The results indicate that brine discharge can lead to various ecological effects on marine biota. Moreover, the findings can assist decision-makers in selecting the most suitable discharge locations and practices to mitigate ecological impacts on the coral reef environment.

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الملخص العربي

تقييم التأثيرات البيئية لتصريف المياه المالحة على الكائنات الحية من محطة تحلية مياه البحر في دهب، خليج العقبة، جنوب سيناء، مصر

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يمكن أن يكون لتصريف المياه المالحة الناتجة عن عمليات التحلية آثار ضارة على بيئة الكائنات البحرية، ولذا تهدف هذه الدراسة إلى تقييم التأثيرات البيئية لتصريف المياه المالحة على الكائنات الحية البحرية في محطة تحلية مياه البحر بمدينة دهب، الواقعة على خليج العقبة .شملت الدراسة قياس عدد من الخصائص الفيزيائية والكيميائية لمياه البحر، تضمنت: الملوحة، درجة الحرارة، المواد الصلبة الذائبة، التوصيلية الكهربائية، وقيم الأس الهيدروجيني(pH) ، ودرجة العكارة. كما تم تقييم نسب الغطاء القاعي، والوفرة، والتنوع البيولوجي، ونمط توزيع العناصر الحيوانية. ولقد أظهرت النتائج أن درجة حرارة مياه البحر وقيم الأس الهيدروجيني والعكارة تباينًا مكانيًا وسجلت أعلى مستوياتها في منطقة الخلط. كما أظهرت الملوحة والمواد الصلبة الذائبة والتوصيلية تقلبات موسمية ومكانية، وكانت أعلى في مناطق التصريف وأقل في المناطق القياسية خلال موسمي الدراسة. كما تم تسجيل 48 نوعًا في هذه الدراسة، شملت 24 نوعًا من الأسماك (50%)، و13 نوعًا من شعبة اللاسعات (27.08 %) تشمل 7 أنواع من الشعاب المرجانية اللينة و6 أنواع المرجانيات الصلبة. أما الرخويات فمثلت بـ 5 أنواع (10.42%)، شملت 4 أنواع من الحلزونيات بطنيات القدم ونوعا واحدا فقط من ذوات المصارعين، كما مثلت شوكيات الجلد والإسفنجيات بـ 3 أنواع فقط بنسبة 6.25%. لكل منها. وتنتمي جميع شوكيات الجلد طائفة خيار البحر "هولوثوريا" وتضم 3 أنواع تم تسجيل معظمها في منطقه مسار أنبوب التصريف. ولقد بلغ العدد الإجمالي للأفراد 251 فردا، سجل منها 149فردا في الصيف مقابل 102فردا في الشتاء. ولقد لوحظ اختفاء 13 نوعًا في الشتاء مقارنة بـاختتفاء 3 أنواع فقط في الصيف. كما سجل وجود اختلاف موسمي في عدد الأفراد خاصة الأسماك، ولكن لم يُلاحظ وجود اختلافات بالنسبة للحيوانات القاعية الساكنة أو الزاحفة. ولقد أظهرتت النتائج أيضا ارتفاع نسبة مكونات القاع الرملية الطينية غير الحية في جميع المناطق وتواجد الحشائش البحرية من نوع هالوفيلا ستيبولاسيا فقط في المنطقة القياسية (المنطقة 1) التي تقع شمال شرق أنبوبي التصريف والسحب، وكانت تمثل 26% فقط من نسب الغطاء النسبي الحي واختفت تمامًا في المناطق الأخرى خلال مدة هذه الدراسة. أما الشعاب المرجانية الحية والميتة فسجلت فقط في المنطقتين 1 و3 ككتل صغيرة متفرقة مع ارتفاع نسب الشعاب المرجانية الميتة في المنطقة رقم 3 مقارنة بالمنطقة القياسية (المنطقة 1)، حيث كانت تمثل 3% و1% على التوالي. وعلى العكس من ذلك، سجلت الشعاب المرجانية الحية 2.5% و2% في المنطقتين 1&3 على التوالي. ومع ذلك، كما سجل تواجد العديد من مستعمرات الشعاب المرجانية الحية (صلبة ولينة) على عدة هياكل صناعية وضعت في المنطقة القياسية 1 على بعد حوالي 300 متر شرق أنبوب التصريف. كما تم تسجيل أنواع الأسماك في جميع المناطق وكذلك حول أنبوب التصريف قبل تصريف المياه المالحة. وكذلك جميع أنواع خيار البحر من منطقة التصريف تحت أنبوب التصريف. سجل مؤشر شانون وينر أدنى مستوى له (3.02) في الشتاء وأعلى مستوى له (3.13) في الصيف. خلصت الدراسة الحالية إلى أن تصريف المياه المالحة الناتجة من محطات التحلية الي البيئة البحرية يؤثر سلبًا على الكائنات البحرية ظهر جليا باختفاء الحشائش البحرية وأنواع اللاسعات تماما في منطقتي الصرف والخلط وارتفاع نسبة المراجين الميتة نسبيا مقارنة بالمنطقة الأولى.