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Original Research Article

Comparative assessment of some heavy metals in water and sediment from the Red Sea coast, Jeddah, Saudi Arabia

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A B S T R A C T

Comparison was made of the [cadmium (Cd), copper (Cu), zinc (Zn), iron (Fe), lead (Pb), manganese (Mn),nickel (Ni) and cobalt (Co)] content of water and sediment from two stations (Al-Kumrah and Al-Shoaibah) in Jeddah, Saudi Arabia Red Sea Coast at summer season 2013,in addition, measurements of some physical properties of seawater such as, temperature, salinity, dissolved oxygen (DO), degree of the acidity or the alkalinity of a solution (pH), total dissolved solids (TDS) and specific conductivity (SpC), also been determination the organic matter in sediments. The higher concentration of Cd, Zn, Pb, Fe, Cu, Co, Ni and Mn in seawater and sediments were recorded in the samples collected from Al-Kumrah site which was considered a contaminated area and this region showed significantly different($p \leq 0.01$) with Al-Shoaibah site. The study showed that there's been a significant different ($p \leq 0.01$) of the concentration of organic matters in the sediments (%), the highest concentration was detected in Al-Kumrah (17.38%), while the lowest concentration was in Al-Shoaibah (2.04%). These results suggest that the fish collected from Al-Kumrah site might be considered relatively polluted with heavy metals. All results were exceeded the maximum limits for sediment and water samples collected from Al-Kumrah site proposed by the World Health Organization (WHO, 2003& 2011) andthe National Oceanic and Atomspheric Administration (NOAA, 2009), therefore, very contaminated area in comparison with non-contaminated area (Al-Shoaibah).Therefore, the continue to discharge untreated sewage into Al-Kumrah site should be limited and water resources should be treated to eliminated the pollutants as well as improving the water quality for improving fisheries in those areas.

Keywords

Heavy metal, Sediment, Concentrations, Red Sea, Jeddah, Assessment

Introduction

Water is such a resource, and recently there has been an unprecedented collective effort by environmentalists, universities, investigative facilities and/or programmers initiated by governments and concerned people to conserve what is left of the usable water and to protect and preserve that environment and save our planet (Turton *et al.*, 2003). The natural water systems (flowing rivers, wetlands, lakes and dams) are the life-blood of our habitat and are undoubtedly the most precious natural resources at humanity's disposal. A pollution and/or depletion of these systems eventually affect all aquatic and terrestrial species dependent on them.

Marine environment provides an important benefit to humans in terms of food resources and ecosystem services. At the same time, human activities may have significant negative impacts on the health of this ecosystem, therefore, it's necessarily to predict and monitor the consequences of human activities on marine environment (Erdoğan, 2009). Since seas and oceans cover a wide space of earth, then they might be exposure to different sources of pollution, which imbalance the marine environments (Forstner and Wittmann, 1981).

Water pollution also results from the discharge of untreated or partially treated human waste and biologically degradable industrial waste into watercourses.The discharge of toxic pollutants into waterways may result in acute or chronic toxicity in fish species. Heavy metals were considered the most serious environmental pollutants because of their high toxicity, abundance and ease of accumulation by various organisms (Malik, 2014).

The sources of pollution in the Red Sea include land- based sources (including urban development, industrial activities, dredging and filling, tourism and agriculture activities), oceanic sources (shipping, fishing, marine traffic and petroleum industries), and atmospheric sources (industries or port activities). Such severe pollution is likely to affect biological life and disturb the Red Sea's natural ecosystems (PERSGA, 2001).

Study on the heavy metal in aquatic ecosystems can give valuable information about the environmental condition of that ecosystem. Water and sediment of the polluted sites contain various levels of heavy metals. Measurement of heavy metals in both water and sediment samples can show the condition of the ecosystem regard to heavy metal pollution. On the other hand, aquatic organisms are the target of heavy metal intoxication, which accumulate a large volume of heavy metals in their tissues (Saghali *et al.*, 2013).

The research was designed to achieve the following objectives:

Determination of some physical properties of seawater in the field [temperature, salinity, DO, pH, TDS and SpC].

Determination of heavy metals concentration[Cd, Cu, Zn, Fe, Pb, Mn,Ni and Co]in each of the water and sediment in two stations (Al-Kumrah and Al-Shoaibah).

Determination of organic matters (OM)concentrationin sediments.

To get information about the threat imposed by these spills and influents to these fish species and know whether it is safe for consumption.

The results obtained from this study would provide information for background levels of metals in water and sediment of the Red Sea and enable the effective monitoring of environmental quality of this ecosystem.

Materials and Methods

Site selection and characterization

Water and sediment were collected and analyzed for various parameters. Sampling sites were selected according to the polluted or unpolluted water concentrations detected during field surveys performed in summer

2012, where the samples were collected between December 2012 and September 2013.

Al-Khumrah is the most important sewage treatment station (STS) in the south of Jeddah, Saudi Arabia lies about 35 km south of Jeddah, it extends between 21°19'26.40"N and 21°19'17.23"N.Al-Shoaibah area, which is the area clean because free from any pollution source close to it and lies about 135 kilometers south of Jeddah, it extends between 20°42'54.25"N and 20°41'44.86"N, as shown in the table (1)sampling locations were identified with a hand-held Garmin-GPSMAP 76S-type global positioning system.

The width of the area is relatively regular and ranges between 500 and 700 m (this part was named inner coastal area). The second part extends seaward (this part was named middle coastal area). Depths vary widely from less than 20 m to more than 200 m (this part was named outer coastal area).

Determination of oceanography properties of water

Temperature, salinity, DO, pH, TDS and SpC were measured in situ using HACH Portable Meters device model HQ 40d

Water sampling and analysis of heavy metals

Twenty-foursample of seawater were collected in clean polythene bottles containers three times with washed it with water in the site prior to collection.After collection, samples of 1 liter were properly covered and stored in ice-packed coolers and transferred cold to the laboratory, the heavy metals in water samples were extracted with cons. HCl and preserved in a refrigeratorat 4^oC to inactivate microbes and thus preserve the integrity of the samples (Radojevic and Bashkin, 1999) until analysis for heavy metals determination. Sea water samples were digested by adding 10 ml nitric acid to 500 ml of the mixed sample in a beaker. Slow boiling and evaporation on a hot plate to reach the lowest volume. Wash down beaker walls with distilled water, then the digested samples were transferred to a 100 ml volumetric flask and completed to the mark as described in APHA (1992).

Sediment sampling and analysis of heavy metals

Sediment samples were collected using core sampler as described in Boyd and Tucker (1992). A total of twenty-four sediments were collected for heavy metals determination. After collection, the sediment samples were kept in cleaned plastic bags and stored in ice-packed coolers to preserve the integrity of the samples. Sediment samples were refrigerated in the laboratory at 4^oC to inactivate microbes.

The samples were dried at 80 ^0C in an oven and grinding to fine particles, 1 gm of fine grinded samples was digested according to Oregioni and Aston (1984) method. The sediments samples were gently washed by distilled water to remove soluble salts, then spread and left to dry in air. Part of the sediment was ground to a powder using an agate mortar, and then it passed through a 63 μ mesh sieve. About 0.2 gram of the prepared ground sample was completely digested in a teflon cup by using a mixture of conc. hydrofluoric acid (HF), nitric acid (HNO_3) and perchloric acid ($HClO_4$) with the ratio 5:3:2.Acids were slowly added to the sample and then heated in sand path at temperature 80 °C between 24–48 hour until it remained in the cup a little amount of the sample like a jelly solution. Finally, the solution was justified to volume 20 ml by hydrochloric acid (HCl) conc. 10 %. The levels of Fe, Mn, Zn, Cu, Cd, Ni, Co and Pb in different digested samples (Water andsediment) were determined using inductively coupled plasma atomic emission spectrometry (ICP/AES), model Perkin Elmer, Optima 2100DV. The formula equation to calculate the concentration in mg/kg was:

mg/kg = Concentration* Dilution / Sample weight

Total organic matter

Weight-Loss-on-ignition technique (LOI) is a common, widely-used method of approximating the organic matter content of sediment samples, following Heiri *et al.* (2001) and Abu-Zied *et al.* (2007). About one gram of sediment was dried in an oven overnight at 105° C and then weighted to determine the total dry weight. After that, they were placed in the oven (Thermolyne-type 47900 furnace) for three hours at 550 °C to determine the total organic matter. After each heat treatment, samples were cooled in a glass desiccators with $CaCl_2$ to absorb all water vapor. Samples were weighed and the percentages of organic matter were calculated from the total dry weight of samples using the following equation:

$$LOI_{550^0 c} = [(DW_{105^0 C} - DW_{550^0 C})/DW_{105^0 C}]X100$$

Where: LOI Loss on ignition, DW dry weight.

Statistical analysis

Average and standard error values were calculated for different measurements. A statistical computer package was used for calculating probability values of Student's t-test or one-way analysis of variance to test the differences between the measurements at the level of 0.05 and 0.01.

Results and Discussion

Oceanographic parameters in sea water

Tables (2 and 3) and figure (3) summarize the oceanographic parameters values of seawater surface at the two locations. From these tables, variations of seawater salinity were of significant differences ($p \leq 0.01$) at the two locations (38.6-39.6 ‰). Similarly, variations of temperature (^{0}C), pH, SpC and TDS were (27.8-32.4), (6.99-8.3), (55.9-57.3mS/cm) and (36.49-38.14 g/l) respectively, and were shown significant differences ($p \leq 0.01$) between the two locations studied.

Temperature and DO: Higher DO (**7.5** mg/l) was found at Al-Shoaibah area due probably to the release of O_2 from the photosynthesis of micro-algae, as well as to high water circulation by local currents.

Salinity: decreases slightly (38.6‰) around the sewage outfall in Al-Kumrah area, indicating a high influx of sewage freshwater into the Red Sea water.

pH: The results showed significant differences in surface water pH degrees where decreased in Al-Kumrah area (6.9) due probably to degradation processes of the dead organic matters by aerobic and anaerobic bacteria, releasing more CO_2 into the water column where increased pH in Al-Shoaibah area (8.3) this is probably related to the photosynthesis of many algae and sea grasses in this area leading to uptake of CO_2 from seawater and consequently pH increases.

TDS: The results showed significant differences in surface water TDS degrees where the high concentration of TDS was in Al-Kumrah area which may occur by sewage discharge (anthropogenic) whereas decreased in Al-Shoaibah area due probably to absence of sources are anthropogenic in nature through point source water pollution, industrial and sewage discharge.

SpC: High total dissolved solids in water Al-Kumraharealed to the increased ability of electrical conductivity (SpC), which showed higher than Al-Shoaibaharea.

Generally, the results showed that in the Al-Kumrah area were salinity, dissolved oxygen the alkalinity pH less thanAl-Shoaibah area while both (SpC), temperature and TDS were higher than the Al-Shoaibah area.

These results have been observed and confirmed by author (Al-Farawati, 2010). Finally, according to the (WHO, 2003) considered waters of Al-Kumrah site of less quality compared to water of Al-Shoaibah site.

The concentrations of heavy metals in seawater

Table (4) shows the concentration of heavy metals in seawater during the year 2013. The highest concentration of Cd was recorded in Al-Kumrah (1.099 mg/l) and the lowest in Al-Shoaibah (0.017 mg/l). Cu concentration varied between (0.128 mg/l) in Al-Kumrah to (0.053 mg/l) in Al-Shoaibah.

Al-Kumrah had the highest concentration of Fe (6.343 mg/l) while Al-Shoaibah had the lowest (2.788 mg/l). Zn was higher in Al-Kumrah (0.678 mg/l) and lower in Al-Shoaibah (0.127 mg/l). Meanwhile, the highest concentration of Pb was detected in Al-Kumrah (0.635 mg/l) while the lower was recorded in Al-Shoaibah (0.179 mg/l).

In Al-Kumrah, were Mn (0.128 mg/l), Ni (1.463 mg/l) and Co (0.002 mg/l) where the higher than Al-Shoaibah and which the values for Mn (0.050 mg/l), Ni (0.866 mg/l) and Co (0.005 mg/l).

Data presented in tables (5) and illustrated in figures (4, 5 and 6) show significant differences($p \leq 0.01$) in the concentrations of heavy metals between the two locations except for Mn and Co which is not a were significant differences($p \leq 0.01$) in the two locations.

These concentrations were increased because a sewage influx of new mouth at the Al-Kumrah area and these concentrations exceeded the recommended values according to (WHO, 2011).

The limits permissible by WHO, 2011 for Cd, Cu, Fe, Zn, Pb, Mn, Ni and Co concentration in sea waters samples were (0.003, 2.00, 0.3, 5.00, 0.01, 0.5, 0.07 and 0.5) respectively and shown in the table (4), and were observation concentrations for waters samples collected from Al-Kumrah site exceeded the recommended permissible limit except for Cu, Zn and Co. And thus is considered as an indicator of poor water quality in Al-Kumrah site, this result have been observed and coincided by several authors (El-Sayed *et al.*, 2004; Ali and Abdel-Satar, 2005 and Bazzi, 2014) and incompatible with several authors (El-Serehy *et al.*, 2012 and Abdel-Baki *et al.*, 2011).

The results of the heavy metal contents of sea water were categorized from the highest concentration metals to the lowest; The rank of the studied elements in Al-Kumrah site can be arranged as follows: Fe>Ni>Cd>Zn>Pb>Mn= Cu>Co., The rank of the examined elements in Al-Shoaibah site can be arranged as follows:

Fe>Ni>Pb>Zn>Cu>Mn>Cd>Co.

Generally, the probabilities sources of heavy metals in Al-Kumrah were by the sewage is discharged near the coast line (instead from the open sea) which causes the pollution in this location, in addition, the South Cornish did not have any restricted areas.

The concentrations of heavy metals in sediments

Table (6) shows the mean concentration of heavy metals in sediments during the year 2013. The highest concentration of Cd was recorded in Al-Kumrah (0.146 mg/l) and the lowest in Al-Shoaibah (0.051 mg/l). Cu concentration varied between (14.383 mg/l) in Al-Kumrah to (0.501 mg/l) in Al-Shoaibah.

Al-Kumrah had the highest concentration of Fe (19.213 mg/l) while Al-Shoaibah had the lowest (6.708 mg/l). Zn was higher in Al-Kumrah (1.010 mg/l) and lower in Al-Shoaibah (0.257 mg/l). Meanwhile, the highest concentration of Pb was detected in Al-Kumrah (39.324 mg/l) while the lower was recorded in Al-Shoaibah (3.069 mg/l). In Al-Kumrah, were Mn (23.875 mg/l), Ni (18.026 mg/l) and Co (23.332 mg/l) where the higher than Al-Shoaibah and which the values for Mn (3.308 mg/l), Ni (16.353 mg/l) and Co (9.080 mg/l).

Data presented in tables (7) and illustrated in figures (7 and 8) show significant differences in the concentrations of heavy metals between the two locations except for Ni which is not a was significant differences at the two locations.

In general, high concentrations of heavy metals (Cd, Cu, Fe, Zn, Pb, Mn, Ni and Co) were recorded in the nearshore sediments of the study area, and these concentrations decreased seaward displaying very low values in the offshore zone. This finding indicates an anthropogenic origin for most of these metals or a rapid precipitation near the shoreline.

These concentrations may be attributed to many common sources: large input of anthropogenic waste into the study area, terrigenous depositionfrom wadies, and land filling by lithogenous materials for coastal zone management.

The limits permissible by the NOAA, 2009 for Cd, Cu, Fe, Zn, Pb, Mn, Ni and Co concentration in sediments samples were (3.35, 2.02, 35.30, 110.00, 0.11, 10.00, 15.9 and -) respectively and shown in the table (6), and were observation concentrations for sediments samples collected from Al-Kumrah site exceeded the recommended permissible limit except for Cd, Zn and Fe. And thus is considered as an indicator of poor water quality in Al-Kumrah site.

This result have been observed and confirmed by several authors (El-Sayed and Niaz, 1999; Basaham, 1998 and El-Sayed*etal.*, 2004) and incompatible with the authors (El-Serehy *et al.*, 2012).

The results of the heavy metal contents of sediments were categorized from the highest concentration metals to the lowest; The rank of the studied elements in Al-Kumrah site can be arranged as follows: Pb>Mn>Co>Fe>Ni>Cu>Zn>Cd., The rank of the examined elements in Al-Shoaibah site can be arranged as follows:

Ni>Co>Fe>Mn>Pb>Cu>Zn>Cd.

Generally, the probabilities sources of heavy metals in Al-Kumrah were by the sewage is discharged near the coast line (instead from the open sea) which causes the pollution in this location, the results were considered a potential health risk to humans and the aquatic life of the ecosystem., in addition, the South Cornish did not have any restricted areas.

Table.1 Shows the sampling locations

Site name	Station No	Latitude Longitude	Site name	Station No	Latitude Longitude
Al-Shoaibah	Inner 1	20°42'54.25''N 39°29'31.32''E	Al- Kumrah	Inner 1	21°19'26.40''N 39° 6'21.00'' E
	Inner 2	20°42'27.43''N 39°29'18.11''E		Inner 2	21°19'26.40''N 39° 6'11.40'' E
	Middle 3	20°42'33.97''N 39°28'50.98''E		Middle 3	21°19'19.58''N 39° 6'7.41'' E
	Middle 4	20°42'11.29''N 39°28'49.38''E		Middle 4	21°19'21.60''N 39° 6'0.00'' E
	Outer 5	20°42'13.35''N 39°28'20.18''E		Outer 5	21°19'13.31''N 39° 5'53.16'' E
	Outer 6	20°41'44.86''N 39°28'9.39'' E		Outer 6	21°19'17.23''N 39° 5'44.75''E

Table.2 The mean values of hydrographic parameter in summer for seawater at different locations (Al-Kumrah and Al-Shoaibah) along Jeddah Coast, Red Sea, during (2013)

Locations	Temperature °C	Salinity ‰	pH	SpC mS/cm	DO mg/l	TDS g/l
Al-Kumrah	32.417 ± 0.394	38.600 ± 0.093	6.996 ±0.117	57.265 ±0.187	2.576 ± 0.085	38.143 ±0.637
Al-Shoaibah	27.797±0.235	39.560 ± 0.262	8.313 ± 0.039	55.838 ± 0.303	7.468 ± 0.070	36.491 ±0.426
WHO, 2003	26-30	36-38	6.5-8.5	0.250	>5	1

Mean value ± SE: Standard Error.

Table.3 One way ANOVA analysis for the hydrographic parameter of seawater at different locations (Al-Kumrah and Al-Shoaibah) along Jeddah Coast, Red Sea

Hydrographic parameter	Source of Variances	Degree of Freedom	Mean Square(MS)
Temperature	Between Groups	1	64.033**
	Within Groups	10	0.634
Salinity	Between Groups	1	2.765**
	Within Groups	10	0.232
pH	Between Groups	1	5.201**
	Within Groups	10	0.046
SpC	Between Groups	1	6.106**
	Within Groups	10	0.381
DO	Between Groups	1	71.785**
	Within Groups	10	0.036
TDS	Between Groups	1	8.184**
	Within Groups	10	1.763

** Significant at $p \leq 0.01$ level

Table.4 The mean concentration of heavy metals (Cd, Zn, Fe, Cu, Pb, Mn, Ni, Co mg/kg dry weight) ± SE in sediments at different locations (Al-Kumrah and Al-Shoaibah) along Jeddah Coast, Red Sea with permissible limits

Locations	Cd	Cu	Fe	Zn	Pb	Mn	Ni	Co
Al-Kumrah	1.099 ± 0.010	0.128 ± 0.008	6.343 ± 0.954	0.678 ± 0.037	0.635 ± 0.053	0.128±0.050	1.463±0.141	0.002±0.001
Al-Shoaibah	0.017 ± 0.006	0.053 ± 0.008	2.788 ± 0.068	0.127 ±0.017	0.179 ± 0.013	0.050±0.002	0.866±0.022	0.005±0.003
WHO (2011)	0.003	2.00	0.3	5.00	0.01	0.5	0.07	0.5

(Mean value ± SE: Standard Error, WHO: World Health Organization)

Table.5 One way ANOVA analysis for the heavy metalsconcentration of seawater at different locations (Al-Kumrah and Al-Shoaibah) along Jeddah Coast, Red Sea

Heavy metals	Source of Variances	Degree of Freedom	Mean Square(MS)
Cd	Between Groups	1	7.031**
	Within Groups	22	0.001
Cu	Between Groups	1	0.028**
	Within Groups	22	0.001
Fe	Between Groups	1	75.828**
	Within Groups	22	5.495
Zn	Between Groups	1	1.826**
	Within Groups	22	0.010
Pb	Between Groups	1	1.247**
	Within Groups	22	0.018
Mn	Between Groups	1	0.036
	Within Groups	22	0.015
Ni	Between Groups	1	2.136**
	Within Groups	22	0.123
Co	Between Groups	1	0.000
	Within Groups	22	0.000

** Significant at $p \leq 0.01$ level

Table.6 The mean concentration of heavy metals (Cd, Zn, Fe, Cu, Pb, Mn, Ni, Co mg/kg dry weight) ± SE in sediments at different locations (Al-Kumrah and Al-Shoaibah) along Jeddah Coast, Red Sea with permissible limits

Locations	Cd	Cu	Fe	Zn	Pb	Mn	Ni	Co
Al-Kumrah	0.146 ± 0.016	14.383 ± 0.547	19.213± 3.900	1.010 ± 0.064	39.324 ±8.722	23.875±1.075	18.026±2.108	23.332±1.187
Al-Shoaibah	0.051± 0.033	0.501 ± 0.144	6.708± 0.603	0.257 ±0.004	3.069 ± 0.719	3.308±0.111	16.353±0.583	9.080±0.082
Guidelines NOAA, 2009	3.35	2.02	35.30	110.00	0.11	10.00	15.9	-

(Mean value ± SE: Standard Error, WHO: World Health Organization)

Table.7 One way ANOVA analysis for the heavy metalsconcentration of sediments at different locations (Al-Kumrah and Al-Shoaibah) along Jeddah Coast, Red Sea

Heavy metals	Source of Variances	Degree of Freedom	Mean Square(MS)
Cd	**Between Groups**	**1**	**0.054****
	Within Groups	**22**	**0.008**
Cu	**Between Groups**	**1**	**1156.343****
	Within Groups	**22**	**1.923**
Fe	**Between Groups**	**1**	**938.250****
	Within Groups	**22**	**93.459**
Zn	**Between Groups**	**1**	**3.405****
	Within Groups	**22**	**0.025**
Pb	**Between Groups**	**1**	**7886.550****
	Within Groups	**22**	**459.612**
Mn	**Between Groups**	**1**	**2537.927****
	Within Groups	**22**	**7.018**
Ni	**Between Groups**	**1**	**16.800**
	Within Groups	**22**	**28.730**
Co	**Between Groups**	**1**	**1218.803****
	Within Groups	22	8.501

** Significant at p≤ 0.01 level

Figure.1 Shows the Al-Kumrah area using geographic information systems program (GIS)

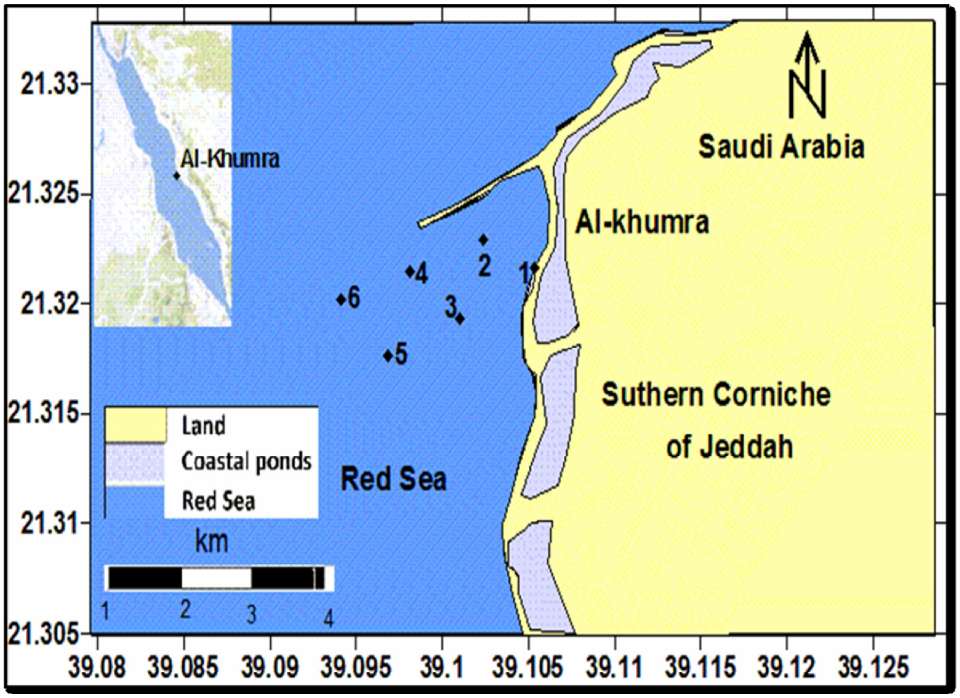


Figure.2 Shows the Al-Shoaibah area using geographic information systems program (GIS)

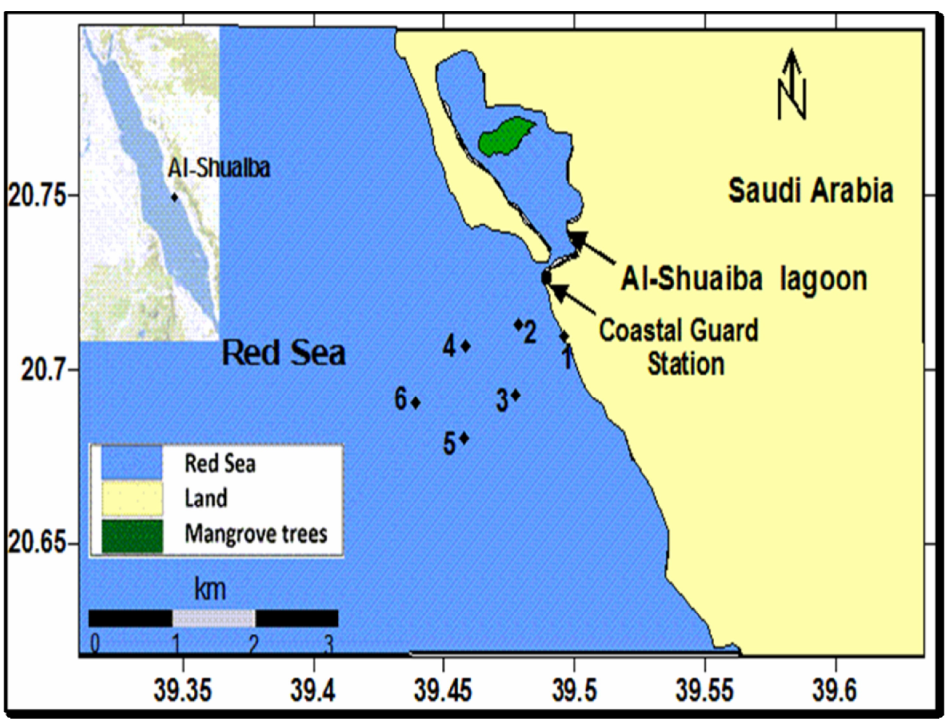


Figure.3 Hydrographic parameter values (Mean value ± SE) in summer for seawater at different locations (Al-Kumrah and Al-Shoaibah) along Jeddah Coast, Red Sea, during (2013)

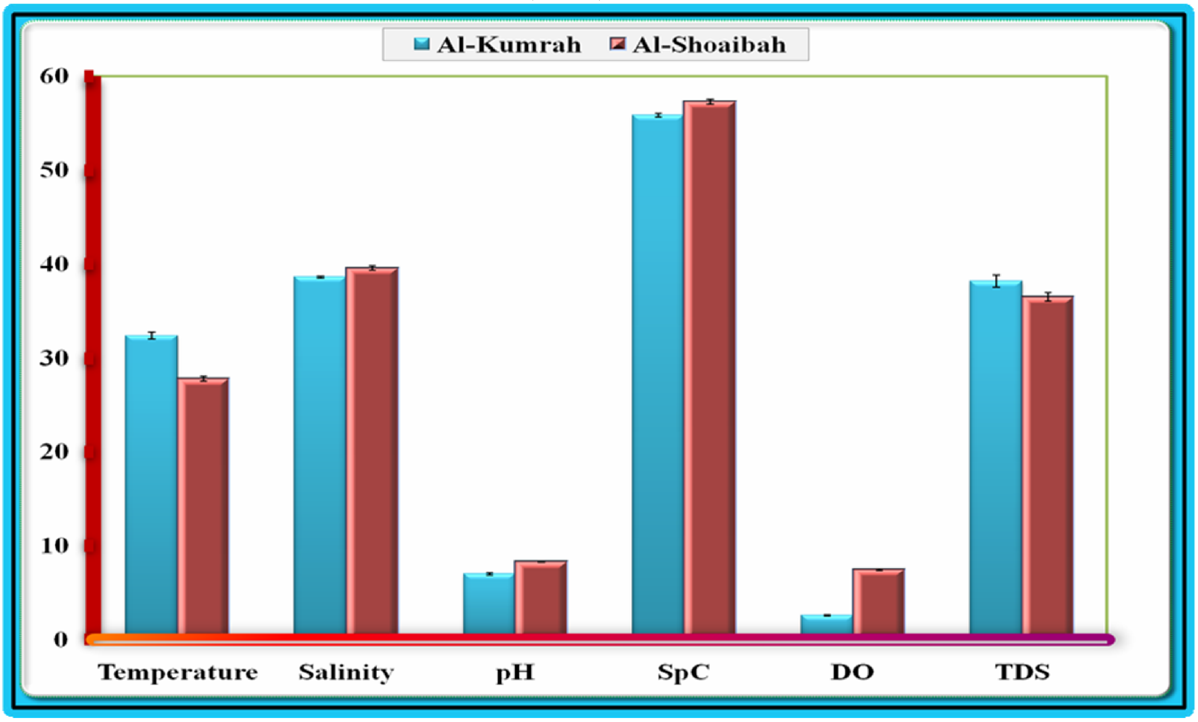


Figure.4 The mean concentrations of some heavy metals in seawater at different locations (Al-Kumrah and Al-Shoaibah)

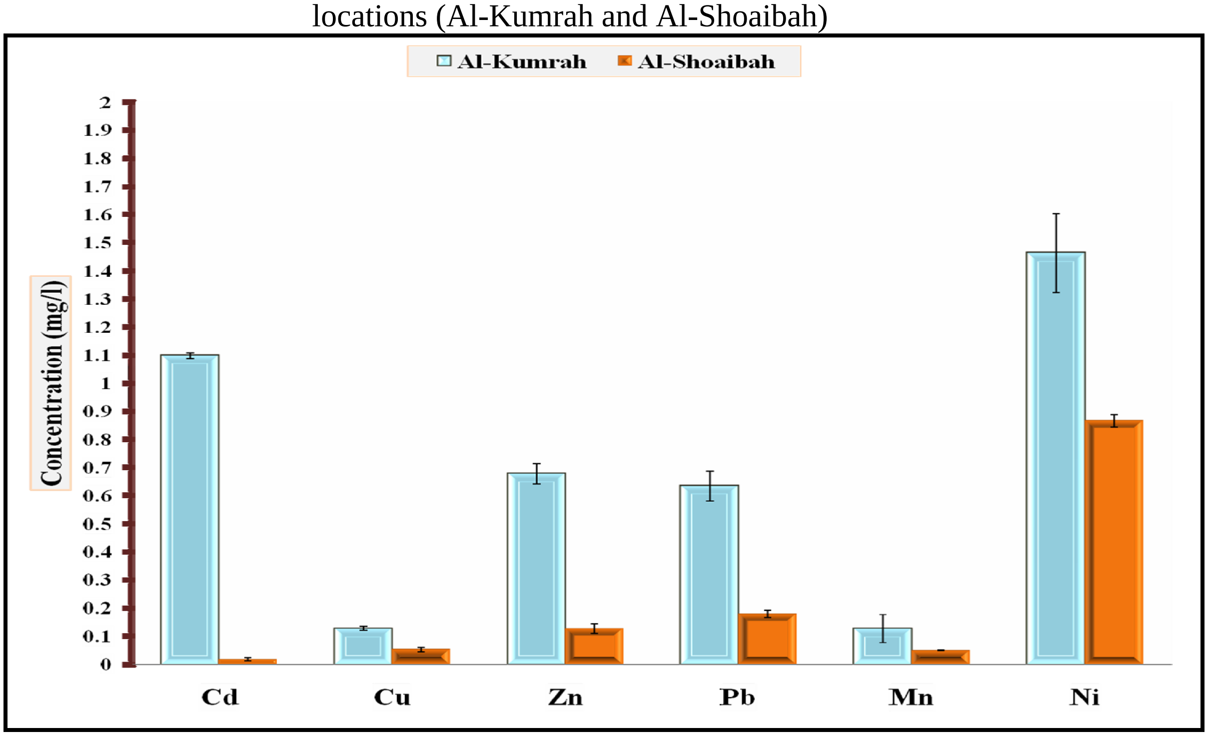


Figure.5 Fe concentration in seawater at different locations (Al-Kumrah and Al-Shoaibah)

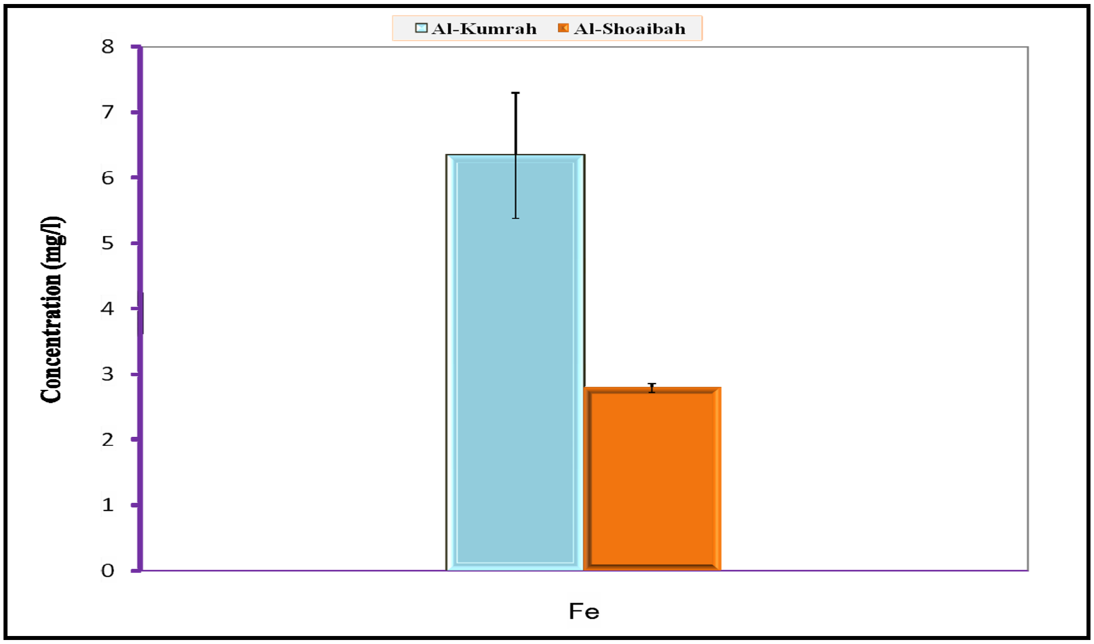


Figure.6 Co concentration in seawater at different locations (Al-Kumrah and Al-Shoaibah)

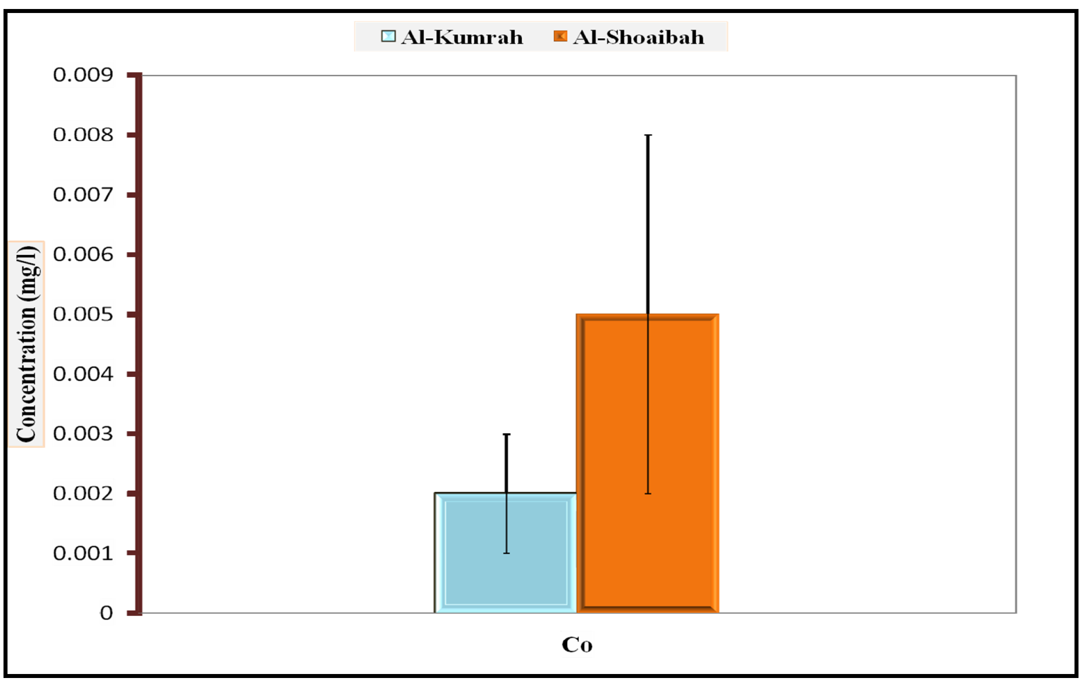


Figure.7 The mean concentrations of some heavy metals in sediment at different locations (Al-Kumrah and Al-Shoaibah)

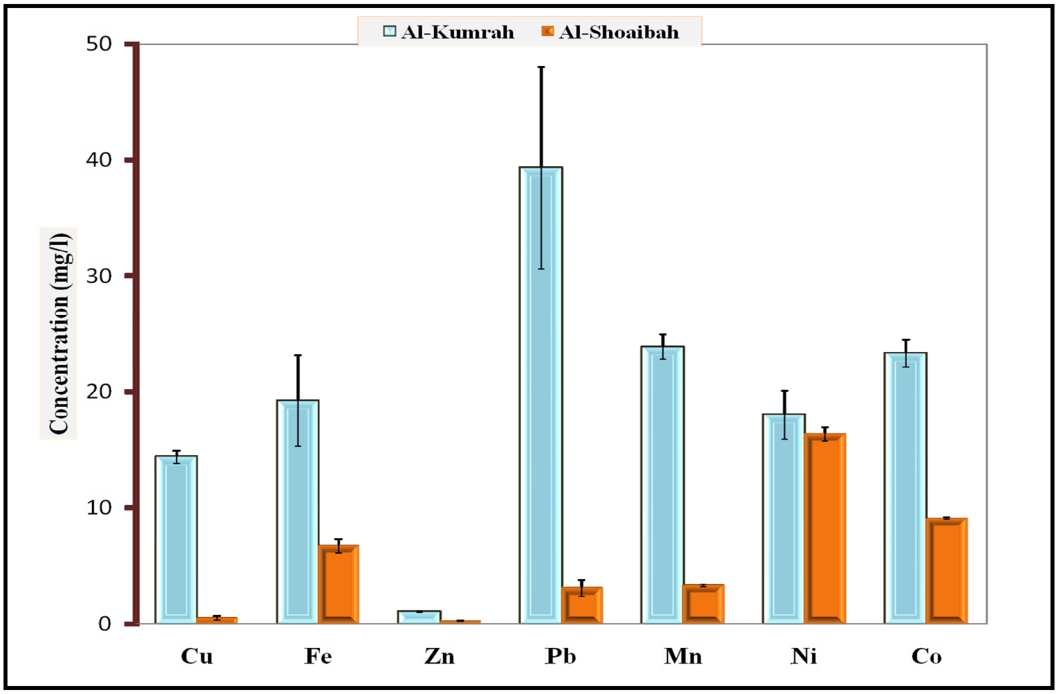


Figure.8 Cd concentration in sediment at different locations (Al-Kumrah and Al-Shoaibah)

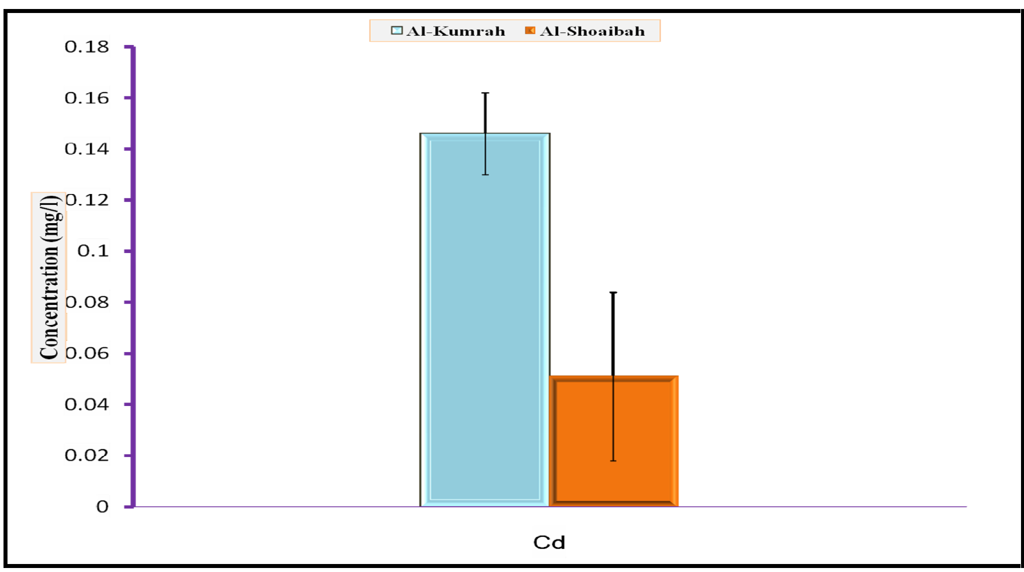
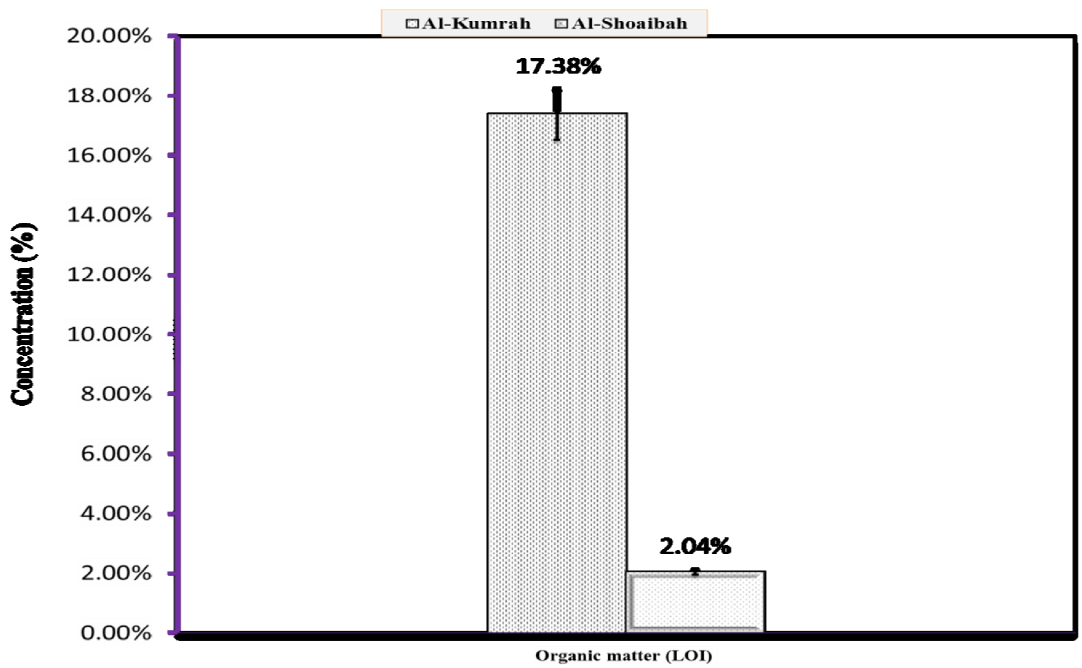


Figure.9 The mean LOI concentration in sediment at different locations (Al-Kumrah and Al-Shoaibah) with standard error



The concentrations of organic matter in sediments.

The LOIat 550 ^{o}C values were relatively high in the studied sediments of the study areas, which is a proxy for total organic matter content, varies between 1.56% to 19.66% with a mean value of 9.71% (Figure. 9). The mean higher of LOI (17.38%) occurs in Al-Kumrah. The mean lower of LOI (2.04%) occurs in Al-Shoaibah area.

In Al-Kumrah site (17.38%), when temperature increases and the solubility of the DO decreases because sewage flows, sedimentation rate for long periods containing chemicals caused the increasing water temperature and thus increase the uptake of oxygen during decomposition of the organic matter by bacteria there is a limited amount of dissolved oxygen available for bacteria and other aquatic organisms to use and this is the reason an excessive amount of organic matter in the sediment becomes a pollutant. In Al-Shoaibah site (2.04%), when temperature decreases and the solubility of the DO increases because the absence of human activities or any source of pollution caused decreases the uptake of oxygen during decomposition of the organic matter by bacteria there is the abundant amount of dissolved oxygen available for bacteria and other aquatic organisms to use and this is the reason a slight amount of organic matter in the sediment becomes less pollution. These results confirmed by Osman et al. (1990).

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