PRELIMINARY INVESTIGATIONS OF SOME HEAVY METALS IN WATER, SEDIMENTS AND PLANKTON IN OBHUR CREEK (EASTERN RED SEA)

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ABSTRACT

Levels of some heavy metals in water, sediments and plankton of Obhur creek, north of Jeddah, were measured. The creek receives little fresh water input, and has restricted water exchange with the Red Sea. The range of concentrations of Cu, Cd, Zn, Fe and Mn were 0.5-1.9, 0.44-1.10, 1.0-3.7, 2.3-4.3 and 0.7-1.0 μg/l in the water, 6-16, 1.9-5.0, 2-30, 88-5092 and 10-86 μg/g in the sediments and 17-185, 1.4-3.0, 53-119, 691-1681 and 10-26 μg/g in the plankton. These values, compared to those in other parts of the world show no significant pollution by heavy metals in the study area.

INTRODUCTION

Obhur Creek (Sharm) is one of the several creeks spread along the Saudi Coast on the Red Sea. It is a tidal, narrow and winding creek, located at 35 km north of Jeddah. It corresponds to the end of an old fluvial valley flooded by the Red Sea water.

This creek extends a distance of about 9 km long and has an average width of 0.5 km (Fig. 1). The bottom of the creek is being narrow and deep at the mouth, where a depth of about 50 meter is reached. The water depth decreases gradually landward, reaching about 3 m at the end. The fringing reef patterns of the coast continue into the outer part of the creek, where plentiful and rich populations are observed, while the inner part is inhabited by peculiar biological assemblages (Behairy, 1980). Most of the creek sediments are indigenous carbonates mixed with clastic materials in different proportions.

No study has been carried out in Obhur creek, except that made fy Behairy (1980) on the clay and carbonate mineralogy of its sediments. The creek is a public recreational area for a considerable number of visitors, so it is necessary to know the present base line levels of different chemical elements in its ecosystem. Particular concern should be given to those elements considered by many environment. The purpose of this preliminary study is to estimate the levels of heavy metals (Cu, Cd, Zn, Fe and Mn) in water, sediments and plankton of Obhur creek. The results of this study could be considered as basic elementary information for future detailed investigations on this creek.

MATERIALS AND METHODS

The study area and sampling sites for water, sediments and plankton are shown in Fig. 1. Thirty stations representing different regions were chosen for sampling water and sediments inside and outside the creek and the adjacent near-shore area. Water samples were collected at about 20 cm below the water surface and kept in polyethylene jerry cans. Water temperature was measured by an ordinary thermometer and salinity was determined by a salinometer. The water samples were not filtered for determination of heavy metals, due to the low level of suspended matter and to avoid any contamination during filteration (Alberts *et al,* 1976). The concentrations of heavy metals in the surface water of Obhur creek were determined according to the method described by Riley and Taylor (1968).

The sediment samples were collected, using a stainless steel Ekman grab. From the well mixed sample 200 g was transfered to a self sealed plastic bag. About 10 g of the sample was dried at 80°C in silica basin, then ground in an agate morter. One gram of the dry sediment was digested with 25 ml of 2 $MHNO_3$ (Smith *et al,* 1981) on a hot plate for four hours. The content was collected in a 25 ml measuring flask, using 1 ml of 6 M HNO_3 and metal free water, and then kept in a pre-acid washed 50 ml polyethylene bottle for subsequent analysis of metals.

A phytoplankton net (50 μ mesh size) was used to collect plankton organisms from three different zones (Fig. 1) the first zone (A) is in the Red Sea off Obhur creek, the second (B) from the mouth of this creek to its middle and the third (C) from the middle to the end of the creek. A part of the well mixed plankton sample from each zone was subjected to a microscopic examination for identification of phytoplankton species. The other part was filtered, using pre-weighed 0.45 μm millipore membrane filter and then dried at 80'C to a constant weight. The filter containing the plankton organisms was weighed and subjected to a chemical treatment for determination of heavy metals in the phyto and zooplankton, according to the method described by Riley and Segar (1970).

Heavy metals (Cu, Cd, Zn, Fe and Mn) were determined in the water, sediments and plankton by atomic absorption spectroscopy (Pye Unicam Sp 129), using the recommended standard procedures.

RESULTS

Water

The average concentrations of heavy metals, temperature and salinity of the surface water of Obhur creek recorded in April 1980 are compared to values of metals from other regions (Table 1). The ranges of concentrations for copper, cadmium, zinc, iron and manganese in the unfiltered surface water were 0.5-1.9, 0.44-1.10, 1.0-3.7, 2.3-4.3 and 0.7-1.0 μg/l, respectively. The preliminary results presented here illustrate the general levels found in the waters of the creek. The data indicate that slight variations occurred in the concentrations of heavy metals in the water and most of the values are generally close to the overall means given in Table 1. The highest values of copper (1.6 and 1.9 μg/l) and zinc (3.2 and 3.7 μg/l) were found in the surface samples at the entrance of the creek. Comparison of sea areas in Table

1 confirms the general view that the water at the shoreline north of Jeddah contains levels of heavy metals comparable to those for unpolluted sea and ocean waters.

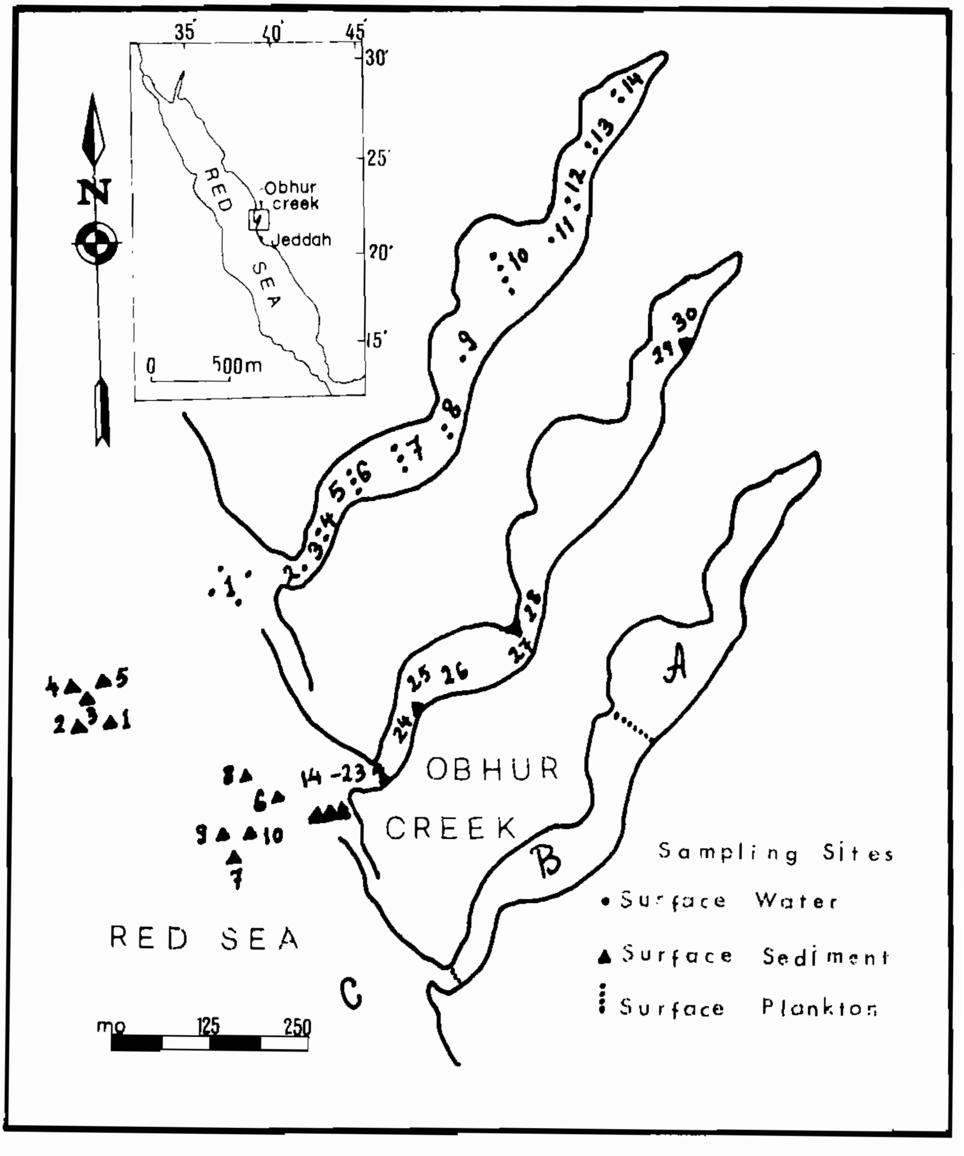

Fig. 1. The study area and sampling stations form waters, sediments and plankton.

Sediments

The heavy metal concentrations in the surface sediments of Obhur creek and the area of the Red Sea off this creek are presented in Table 2. The average values of metals in the surface sediments of Obhur creek and of the Red Sea outside this creek, together with data from other areas are shown in Table 3. The observed ranges of concentrations for copper, cadmium, zinc, iron and manganese were 6-16, 1.9-5.0, 2-30, 88-5092 and 10-86 μg/g, respectively. The sediment samples are mostly composed of carbonates, which constitute over 90% of the sediments. The organic carbon content fluctuated between 0.17 and 0.71%. The highest values of Cu, Zn, Fe and Mn were generally found in the sediments at the entrance of the creek. In general, the concentrations of these four metals in the creek sediments were higher than from outside the creek. Cadmium showed slight variations in concentrations in all sediment samples and most of the values were close to the overall means given in Table 3. Most of the values of heavy metals obtained in this study are comparable to those from other regions in the world.

Plankton

The values of copper, cadmium, zinc, iron and manganese in the plankton organisms collected from the creek and outside this creek are given in Table 4. The phytoplankton species found in Obhur creek are listed in Table 5. The ranges of concentrations of heavy metals 17-185, 1.4-3.0, 53-119, 691-1681 and 10-26 μg/g for Cu, Cd, Zn, Fe and Mn, respectively. Most of the values of metals in the study area are, in general, comparable with values of average composition reported by Turekian (1976). The highest values of the five metals were found in the plankton living in the surface water outside the creek. The metal content in the plankton in the creek decreased towards the land.

DISCUSSION

The hydrography of Obhur creek, based on the present observations on salinity and temperature (Table 1) and those made by (Behairy *et al,* (1981) a,b), indicates that evaporation exceeds precipitation and runoff. The creek has no major source of fresh water, as indicated from the distribution of surface salinity in the creek, (Table 1).

The shallowness and restriction of the water inside the creek obviously increase the rate of evaporation relative to that in the Red Sea outside the creek. According to Behairy (1981, a,b), the rate of evaporation in the neighbouring coastal water of the creek (204 cm) was remarkably higher than that in the water of the open sea in front of Jeddah (144 cm). The surface water from the Red Sea, entering into the creek, extends landward. El-Sheikh (1981) found, from 12 months observations on salinity, temperature and dissolved oxygen along two water columns near the entrance of Obhur creek, that there is a subsurface salinity maximum water layer at a level equal to the bottom depth of the creek at its entrance. This layer originates mostly from the surface Red Sea water invading the creek, which sinks and flows back to the sea, probably under its density gradients. The surface water near the entrance is the most freely exchanged with the Red Sea water outside the creek, compared with the water inside the creek.

The surface water near the entrance of the creek showed elevated levels of copper and zinc ans to some extent of the other metals, compared to those of the inside surface water inside the creek. This could be attributed to the decrease in replinishment of metal in the Red Sea surface water during its proceeding towards the end of the creek by biological or other environmental processes. The effect of evaporation is excluded here, since the salinity is increasing in a reverse order to that of the metals. Also, the geological influence is rather negligable, because the area has a similar geological formation (Behairy, 1980).

Considering the biological factor, the metal contents in the plankton hauled from the surface waters of the Red Sea and of the creek showed a distribution pattern characterized by an increase seawards. This is more or less similar to that in the surface water. Such distribution pattern suggests that the surface water inside the creek has a longer retention time relative to that near the mouth. In the restrictred water inside the creek, the consumption of metals by organisms is not replinished, causing the decrease in metal concentrations, compared with the near mouth water where the metals are replinished more or less continously from the Red Sea. The plankton organisms are able to take up heavy metals from the water against a concentration gradient. According to Bowen (1966), many of the metals (Fe, Mn, Cu and Zn) concentrated by planktonic organisms are essential for their growth, whereas others are probably not essential (Riley and Chester, 1971).

Other essential nutrients (phosphates and silicates) were also studied in the creek surface water (unpublished data). These two nutrients showed a distribution patterns similar to that for the metals, since they were nearly diminished from the surface water inside the creek relative to their concentrations near its entrance. Both observations confirms the important role of the plankton organisms in controlling the distribution of trace elements in the creek surface water.

The elevated levels of the five metals observed in the surface sediments of the creek, particularly at its entrance, compared with the outside sediments from the Red Sea, could reflect the more productivity of the creek and the possible effect of the subsurface maximum salinity water layer flowing from the creek seawards. Such flowing water is expected to be at the lower speed at the entrance of the creek relative to that at the place of sinking of this water from the surface. And therefore, the chance is greater for more precipitation of the fine particles suspended in the bottom maximum salinity water layer at the entrance of the creek. This assumption is confirmed by the presence of more non-consolidated particles at the creek entrance. The low levels of metals in the sediments outside the creek might suggest the open sea current action in decreasing the chance of deposition of the fine particles and probably the relative decrease in productivity of this area. Also it is possible that the observed metal variations in the sediments are caused by the variation in the proportions of the different bioclasts in the sediments. The sediments constitute coral fragments, calcareous green algae, inorganic lime mud, foraminifera in varying proportions (Behairy, 1980).

The correlation matrix for the five metals studied is presented in Table 6. It shows a good Cu-Zu and Fe-Mn associations ($r > + 0.9$). Also, it indicates good inter-relationship between the four metals (Cu, Zn, Fe and Mn). The insignificant correlation of Cd with the other four metals ($r > - 0.42$) indicates that Cd is not associated with the other four phases of the metals studied. This could be either due to its association with the calcium carbonate phases of the sediments, or that cadmium has a great tendency to be in the more soluble Cd-chloro complexes (Dryssen and Wedborg, 1974). The incorporation of cadmium in the carbonate phases has been reported by Goldschmit (1954); Mullin and Riley (1956), and El-Rayis (1977). The good interrelationships between the four metals, especially Cu and Zn confirms that they are of biologically important metals as most of the sediments in the study area are formed from fragments of coral reefs. And cadmium seems to be nonessential metal for those biota. The relative abundance of metals in the sediments of the creek is in the order of Fe > Mn > Zn > Cu > Cd.

TABLE 1

Average concentration (μg/l) of heavy metals as well as temp. and salinity, values in the surface waters along Obhur creek (April 1980), compared with values of heavy metals from other regions

Station	Cu	Cd	Zn	Fe	Mn	Salinity %	Temp. (°C)
1 (4)	1.9+	1.10+	3.7+	4.3	0.9	39.00	28.7 –
2 (2)	1.6	0.67	3.2	3.5	0.8	38.81	28.7 –
3 (1)	1.1	0.62	2.0	—	0.8	39.00	28.8
4 (2)	0.9	1.03	1.8	4.8+	1.0+	38.80 –	28.9
5 (1)	0.5 –	0.48	1.0 –	2.6	0.8	39.02	28.8
6 (3)	1.2	0.47	2.3	3.1	0.7	39.11	28.8
7 (3)	1.3	0.69	2.3	3.9	0.8	39.12	28.9
8 (2)	0.6	0.88	1.5	2.3 –	0.8	39.13	29.4
9 (1)	0.7	0.57	1.3	3.5	0.7	39.05	—
10(4)	1.1	0.53	1.7	2.7	0.8	39.13	29.2
11(1)	1.1	0.77	2.3	3.9	0.7	39.34	29.3
12(2)	0.8	0.44 –	1.9	3.4	0.7 –	39.73	29.6
13(2)	1.4	0.52	1.9	2.8	0.7	40.29+	30.0+
14(2)	1.1	0.47	2.2	3.3	0.7	39.21	29.9
Mean (30)	**1.17**	**0.68**	**2.23**	**3.5**	**0.78**	**39.26**	**29.09**
1) **Jeddah Coast:**							
a) South of the creek	1.0	0.65	—	—	4.4		
b) North of the creek	0.8	0.41	9.5	1.7	0.3		
2) **North West Red Sea:**							
a) Suez	5.7	—	9.1	89.9	3.5		
b) Hurgada	5.7	—	44.9	62.5	2.0		
c) Safaja	41.2	—	80.3	165.8	1.0		
d) Quesir	9.4	—	29.1	49.0	3.0		
3) **Unpolluted sea water**	3.0	0.11	10.0	3.0	2.0		
4) **Liverpool bay U.K.**	1.5	0.88	13.8	2.0	1.7		

5) **Oceanic water**	0.5	0.1	4.9	2.0	0.1

(1) Unpublished data (2) Abdel Salam (1981) (3) Elskens (1971)
(4) Royle (1973) (5) Brewer (1975).

– Numbers in paranthesis in the tables represent numbers of observations used for circulating the average values.

- The maximum vlaues are designated by (+) and the minimum by (–).

TABLE 2

Concentrations of heavy metals (μg/g) and percentage of organic carbon in the surface sediments of Obhur creek and the Red Sea off the Creek.

Stations	Cu	Cd	Zn	Fe	Mn	Organic Carbon %
Outside the Creek						
1	6	3.9	2	246	22	0.42
2	6	2.9	5	122	19	0.28
3	6	2.7	4	109	14	0.28
4	6	3.5	5	158	30	0.34
5	6	2.8	6	170	18	0.32
6	6	2.5	4	90	10	0.25
7	7	4.4	6	469	22	0.25
8	6	3.3	4	98	16	0.17
9	7	2.7	4	223	15	0.28
10	6	2.7	4	88	18	0.26
11	7	2.7	5	189	18	0.29
12	6	2.7	6	390	19	0.30
13	6	2.8	7	822	22	0.27
The Creek entrance						
14	8	3.0	12	2798	51	—
15	10	2.4	14	5092	58	0.62
16	7	2.8	6	864	22	0.36
17	8	2.8	9	1649	35	0.34
18	7	2.5	12	871	21	0.39
19	12	2.3	20	4801	75	0.71
20	7	2.2	7	1031	29	0.35
21	10	5.0	9	626	24	0.34
22	10	2.5	13	1111	21	0.36
23	16	2.0	30	2650	39	0.49
Inside the Creek						
24	12	2.4	20	5021	86 +	0.71
25	7	2.4	6	1925	23	0.33
26	6	3.0	6	1325	18	0.26

27	6	2.5	5	999	13	0.40
28	7	2.8	5	749	15	0.33
29	8	2.6	9	2957	45	0.30
30	10	1.9	16	3337	69	0.46

TABLE. 3

Average heavy metal concentrtions (μg/g dry weight) in the surface sediments of Obhur Creek and from outside of this creek compared with date from other regions.

Area	Cu	Cd	Zn	Fe	Mn
Obhur creek	8.9	2.60	11.7	2224	38.0
Outside the creek	6.2	3.00	4.8	244	18.7
(1) Jeddah coast south of the creek.	19.7	5.2	30.2	338	33.3
(2) Egyptian coast:					
a) El-Max area:	24.1	2.18	35.4	1472	151
b) Abu-Qir bay:	12.0	2.02	102.0	4500	45
(3) Cardigan bay, Wales	11	1.1	36	7309	310
(4) Liverpool day, U.K	7.7	1.57	56	8530	378
(5) Deep sea carbonate	30	—	35	9000	1000

(1) Unpublished data
(2) El-Nady (1981)
(3) Jones (1972)
(4) El-Rayis (1977)
(5) Riley and Chester (1971)

TABLE 4

Concentrations of heavy metals (μg/g dry weight) in the plankton of Obhur Creek and from outside of this Creek compared with average levels.

	Cu	Cd	Zn	Fe	Mn
Area					
A	185	3.0	119	1681	26
B	115	1.7	103	975	16
C	17	1.4	53	691	10
Average	106	2.03	92	1116	17.3
Average composition of plankton, (Turekian, 1976)	11.3	2.00	87	650	9

TABLE 5

List of Phytoplankton Species in Obhur Creek

Diatoms	**Dinoflagellates**
Asterionella japonica Cleve	Amphisolenia bedentata Sch.
Chaetoceros affinis Lauder	*Ceratium belone* Cleve
Chaetoceros brev Schuett	*Ceratium breve* (Ost. & Schm) Sch.
Chaetoceros lorenzianum Grun.	*Ceratium buceros* (Zach.)
Coscinodiscus centralis Ehr.	*Ceratium carriense* Gour.
Coscinodiscus concinnus W. Smith	*Ceratium furca* (Ehr.) Clap. & Lachm.
Guinardia flaccida (Castracane) Perag.	*Ceratium fusus* (Ehr.) Duj.
Lauderia annulata (Cleve)	*Ceratium horridum* Gran.
Leptocylindrus danicus Cleve	*Ceratium incisum* (Karsten) Jorg.
Nitzschia longissima (Berb) Ralfs	*Ceratium pavillard*
Nitzschi seriata Cleve	*Ceratium longirostrum* Gour.
Rhizosolenia alata Brightwell	*Ceratium massiliense* (Gour.) Jorg.
Rhizosolenia bergonii Perag.	*Ceratium platycorne* Daday
Rhizosolenia setigera Brightwell	*Ceratium trichoceros* (Ehr.) konfoid.
Rhizosolenia stolterfothii Perag.	*Ceratium tripos* (Muller) Nitz.
Thalassiothrix longissima Cleve et Grun.	*Dinophysis caudata* Saville-Kent
Triceratium favus Ehr.	*Dinophysis caudata* Saville-Kent
	Van tripos (Gour.)
	Noctiluca miliaris Surinay
	Peridinium abei Paulsen
	Peridinium brochi Kof & Swenzy.
	Peridinium conicum (ran) Ost. & Schm.
	Peridinium depressum Bailey
	Peridinium diabolus Cleve
	Peridinium grande Kof.
	Peridinium leonis Pavillard
	Pyrycystis fusiformis Murray.

TABLE 6

Correlation coefficient matrix among the different heavy metals in the surface sediments of Obhur Creek and from outside of this Creek

	Cu	**Cd**	**Zn**	**Fe**	**Mn**
Cu	1.00				
Cd	-0.27	1.00			
Zn	0.95	-0.41	1.00		
Fe	0.72	-0.42	0.76	1.00	
Mn	0.69	-0.31	0.73	0.92	1.00

The significant values are > 0.449 or less than-0.449.

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فحوصات أولية على بعض الفلزات الثقيلة في مياه ورسوبيات وبلانكتون خليج أبحر – شرق البحر الأحمر

عبد القادر على بحيرى ، عثمان عبد المطلب الريس

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كلية علوم البحار – جامعة الملك عبد العزيز

لقد تم قياس مستويات بعض الفلزات الثقيلة في المياه والرواسب والبلانكتون في خليج أبحر – شمال جدة . ولايستقبل هذا الخليج موارد رئيسية للمياه العذبة وتبادل مياهه مع مياه البحر الأحمر محدودة . يصل تركيز كل من النحاس والكادميوم والزنك والحديد والمنجنيز في المياه الى :

٠ر٥ – ١ر٩ . ٠ر٤٤ – ١ر١٠ ، ٠ر١ – ٣ر٧ ، ٢ر٣ – ٣ر٤ ، ٠ر٧ – ١ر٠ ميكروجرام/لتر في الرواسب الى : ٦ – ١٦ . ١ر٩ – ٠ر٥ ، ٢ ٣٠ . ٨٨ – ٥٠٩٢ . ١٠ – ٨٦ ميكروجرام/جرام وفي البلانكتون الى : ١٧ – ١٨٥ ، ١ر٤ – ٠ر٣ . ٥٣ – ١١٩ . ٦٩١ – ١٦٨١ ، ١٠ – ٢٦ ميكروجرام/جرام على التوالي .

بمقارنة هذه القيم مع مثيلاتها من أماكن أخرى من العالم يتضح عدم وجود تلوث ظاهر بمنطقة الدراسة الحالية بالفلزات الثقيلة .