Int. J. MAr. Sci. Eng., 4(1), 47-56, Winter & Spring 2014
ISSN 2251-6743

Heavy Metals in Water, Sediments and Marine Oorganisms (*Saccostrea cucullata)* of the Chabahar Gulf, Oman Sea (Iran)

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Received 22 December 2013; revised 11 March 2014; accepted 25 April 2014

ABSTRACT: Levels of the heavy metals Copper (Cu), Zinc (Zn), Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Iron (Fe) and Manganese (Mn) were determined by graphite furnace atomic absorption spectrophotometer (Model 67OG) in coastal water, sediments and soft tissues of the *Saccostrea cucullata*, from the intertidal zone at five stations in the Gulf of Chabahar on the Iranian coasts along the Oman Sea.The concentrations of heavy metals in water ranged between 3.37–5.74, 18.01–22.62, 4.24–4.52, 0.15–0.19, 20.16–21.46, 16.42–17.14, 15.43–24.76 µg $L^{-1}$and 7.06–8.67 µg L^{-1} for Cu, Zn, Pb, Cd, Cr, Ni, Mn and Fe, respectively. The corresponding concentration values in the sediments were 46.79–54.76, 40.14–43.12, 25.63–28.23, 0.53–0.63, 47.16–51.43, 26.45–28.68, 52.13–53.46 and 84.42–89.14 µg $g^{-1}$for Cu, Zn, Pb, Cd, Cr, Ni, Fe and Mn, respectively. The highest accumulated metals were Zn, Cu and Mn in *S. cucullata* while the lowest one was Cd. The highest concentrations of all metals in water, sediments and Oyster were recorded at Tiss harbour eastern parts of the Gulf, while the lowest concentrations were recorded at Damagheh. Based on this research, land based activities; shipping activity and the sewage disposal from vesseles and residential area close to these harbors are the main source of metal pollution in the Gulf of Chabahar.

Keywords: *Heavy metals; Seawater; Sediment; S. cucullata; Oman Sea; Gulf of Chabahar*

INTRODUCTION

Marine pollution is a global environmental problem; Human activities in the coastal area and marine water contribute to the discharge of various kinds of pollutants such as heavy metals into the marine ecosystems (Censi *et al*., 2006; Pote *et al*., 2008). The main reason for the metal contamination is persistent and toxic properties, could create several problems for different kinds of marine ecosystems and could be accumulated in marine organisms (Wen *et al*., 2007; Wcislo *et al*., 2008). Many marine organisms have the potential to bioconcentrate high levels of metals from their environment (Fowler, 1990; Phillips and Rainbow, 1993; Szeffer *et al*., 1999). Metal bioaccumulation by marine organisms has been the subject of considerable interest in recent years because of serious concern that high levels of metals may have detrimental effects on the marine organisms and may create problems in relation to their suitability as food for humans. The pollution levels of the aquatic environment by heavy metals can be estimated by analyzing water, sediments and marine organisms. The levels of heavy metals in Oysters and other invertebrates are often considerably higher than in other constituents of the marine environment. Compared to sediments, marine organisms exhibit greater spatial sensitivity and therefore, are the most reliable tool for identifying sources of biologically available heavy metal contamination (Goldberg et al., 1978; Koide *et al*., 1982; Thomson *et al*., 1984; Szefer, 1986). As a result, biomonitoring has been widely used to monitor metals in the last two decades (Zelika *et al*., 2003; Nicholson and Lam, 2005; Stanly *et al*., 2008). Different types of organisms may be used for biomonitoring, such as marine algae (Topcuo *et al*., 2003; Besada *et al*., 2009) and filter-feeding mollusks (Mashinchian Moradi, 2001; Zorita *et al*., 2006; Hamed and Emara, 2006). Many studies shows that bivalves do not regulate the level of some metals within their body (Stanly *et al*., 2008) and they can reflect the metals contamination from surrounding area. Thus, bivalves are considered as good biomonitor agents for heavy metal monitoring in aquatic ecosystems (Elfwing and Tedengreen, 2002; Yap *et al*., 2003; Zelika *et al*., 2003; Nicholson *et al*., 2005; Zorita *et al*., 2006; Vlahogianni *et al*., 2007; Maanan, 2008). Gulf of Chabahar on the Iranian coasts along the Oman Sea is a developing area; traditionally this area is used for fisheries and aquaculture activities of the local people. However it

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has developed as an important free zone for Iran import and export, economy, urbanization and industries. This area have also grown parallel to economic development (Amini and Miraki, 2006). Although the area is still growing and especial weather seems to greatly influence on distribution and redistribution of metals in coastal ecosystems, there is a lack of information concerning trace metals contamination in Chabahar. Such information could be used to establish baselines in the area. The Study of De Mora *et al* (2004) in southern coasts of the Oman Sea showed, some metals like the Ni have natural source in this area. Meanwhile, the human activity including shipping, fishing activity and cannery industry can increase the Pb concentration in coastal area. These activity are conducted in Iranian coasts of the Oman Sea. These metals also can be accumulated in tissues of organisms (Gochfeld, 2003; Yi *et al*., 2008). Therefore, for the first time, the concentrations of trace metals (Cd, Pb, Cu, and Zn) in seawater, sediments and its accumulation in the tissues of oysters (*S. cucullata*) have been determined and compared in different marine environmental compartments in the area of the coast of India and Southern coast of Oman sea.

MATERIALS AND METHODS

Study area

The Gulf of Chabahar is located in the south-east of Iran and northern part of the Oman Sea at 25° 17' 28" N 60° 38' 15" E. This Gulf is the largest embayment in the Oman Sea and extends for about 350 km from the Konarak city in the west of Chabahar city in the east (Fig. 1). The width of the Gulf varies between 14 and 17 km, and its depth throughout its axis is fairly constant with a mean of 16 m. Historically due to its antiquity as a port near the Oman Sea, it assumed importance in trade and was the centre of business and navigation. Shahid Kalantary and Shahid–Beheshti ports are two important ports in Gulf of Chabahar. The executive operation of this port was started in 1981 and it became operational with the completion of four jetties in 1983. This area has a subtropical weather with two distinct seasons, dry season in summer and rainy season in winter. It also experience monsoon (seasonal western winds) during summer and winter. The seawater is completely disturbed by huge waves during monsoon period (Zareii, 1995). Therefore considerable amount of sediment is displaced by the power of waves. This condition could result in redistribution of metals in the coastal environment.

Sampling and analytical methods

Samples of seawater (0.5 meters depth from the seawater surface) and sediments (about 5–10 cm) were collected during winter and summer, 2013 from the intertidal zone of five stations in the western side to eastern side of the Gulf of Chabahar (Fig. 1). Sampling location was determined by GPS (model Garmin eTrex 20). The stations were as follows: stationI: infront of the Shahid–Beheshti port, station II: near to the industrial activity of Chabahar free zone and front of the Tiss harbour, station III: front of the old sewage drain, near to the desalination unit and industrial activity, station IV: north of the Konarak port, and station V: in front of the Damaghe area and away from industrial zone. All stations were situated in the proximity of different geochemical, hydrological and human impacts.

Total metals in seawater samples were extracted by the APDC–MIBK procedure (Brewer *et al*., 1969; APHA, 1989). The pH of seawater sample was adjusted to about pH 3–4 by adding 5 ml ammonium pyrrolidine dithiocarbamate (APDC) solution. Then, we added 50 ml methyl isobutyle ketone (MIBK) and shaked vigorously for 30 s. The extracted organic layer was aspirated directly to the graphite furnace atomic absorption spectrophotometer (Model 67OG) to determine the metals concentration. Sediments were dried in the oven at 70 ̊C and kept in polythylene until analysis (Amini Ranjbar, 1998). Sediment samples of 0.5 g were digested in Teflon vessels for 2 h with a mixture of 3: 2:1HNO_3, $HClO_4$ and HF acids, respectively, according to the method described by Origioni and Aston (1984). The most common marine organism (*S. Cucullata)* were examined for trace metals levels in five station in study aera. Samples were stored in plastic bags in a freezer. The soft part of live oysters was dissected to separate the different organs. The metals, Fe, Cr, Ni, Cd, Pb, Cu, Mn and Zn were analyzed by graphite furnace atomic absorption spectrophotometer (Model 67OG). The precision of analysis was checked by replicate measurements of target metals in a marine biota sample.

RESULTS AND DISCUSSION

Heavy metals in seawater

The variations of heavy metals concentrations in seawater samples in summer and winter, 2013 from the five stations the Chabahar Gulf are summarized in Table 1. Concerning the sites variation, the highest concentrations for all metals were recorded at station II (Tiss port) in the eastern part the Chabahar Gulf (Fig. 2). These high concentrations may be attributed to sewage and wastes discharged from the Industrial activities related to Chabahar Free Trade-Industrial Zone, shipping activity(such as: repairing, fueling, greasing and painting of fishing ships) and boats. The remarkably high Cu concentration at station II in the eastern part of the Gulf may be due to corrosion of ships' hulls coatings and anti-fouling paints at Tiss port. Similarly, Zn increased at station II during winter and decreased during summer; this may be due to its consumption by phytoplankton, which increases in spring and summer as stated by El-Samra et al. (1995). On the other hand, Abou-El-Sherbini and Hamed (2000) reported that the removal of zinc from water could be aided by phytoplankton, which increase in spring and summer. Also, the center parts (station III) the Chabahar Gulf could be heavily contaminated by Cr and Ni and high levels of Fe and Mn. This may has the natural origin. The geology of southeastern of Iran (Makoran zone) is rich in ophiolites and metalliferrous sediments of marine origin. The Makoran ophiolites contain chromite and various nickel sulfide minerals (Jacob and Quittmeyer, 1979, Mcall, 1997, Farhoudi and Craig, 1977). Thus, the high metal concentrations are most likely due to the local mineralogy, and are natural, rather than pollution.

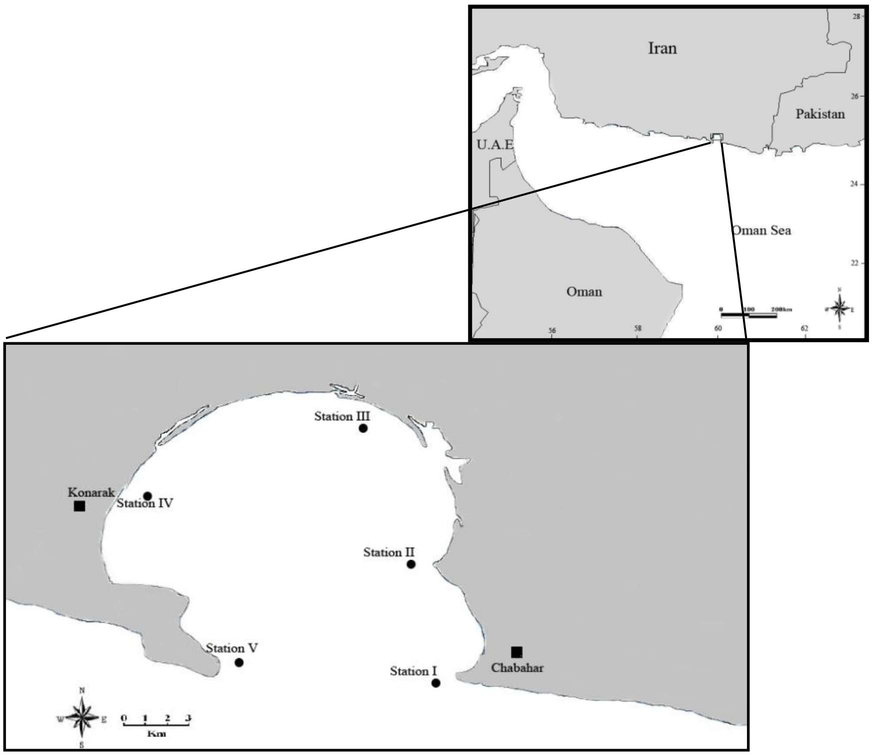

Fig. 1: Map of the Chabahar Gulf, showing the sampling stations.

Table 1: Heavy metal concentrations (µg L^{-1}) in water samples collected from the Gulf of Chabahar during winter and summer, 2013

Station	**Metals**							
	Cu	**Zn**	**Pb**	**Cd**	**Cr**	**Ni**	**Fe**	**Mn**
Winter								
I	3.22	9.76	2.08	0.16	12.76	9.69	22.18	4.75
II	5.74	22.62	4.52	0.19	15.59	10.08	19.70	2.12
III	2.68	8.43	1.91	0.1	21.46	17.14	15.43	7.06
IV	2.90	11.57	1.68	0.13	15.12	10.85	25.36	5.18
V	1.16	6.72	1.16	0.12	9.63	5.63	11.52	3.32
Summer								
I	3.03	8.83	2.75	0.13	9.34	12.96	23.82	4.56
II	3.37	18.01	4.24	0.15	17.67	14.89	16.48	2.45
III	2.42	13.36	0.98	0.1	20.16	16.42	24.76	8.67
IV	2.08	12.58	1.79	0.16	17.34	8.46	19.18	3.29
V	1.06	5.32	1.13	0.1	15.99	3.20	13.82	3.66

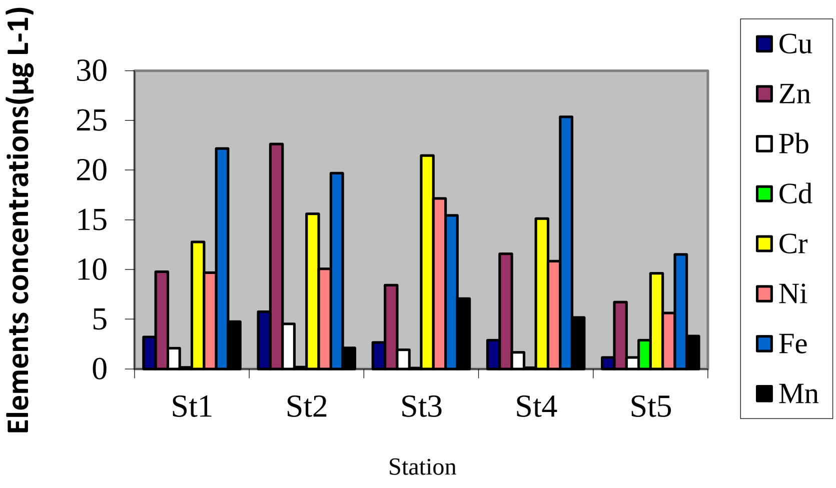

Fig. 2: Concentrations (µg L^{-1}) of heavy metals (Cu, Zn, Pb, Cd, Cr, Ni, Fe and Mn) in water samples collected from the Gulf of Chabahar.

On a seasonal scale, Cu and Zn showed their highest values during winter (5.74 and 22.62 µg L^{-1}) where the lowest values were exhibited during summer (1.08 and 5.32 µg L^{-1}). The levels of Pb and Cd varied from 1.13 and 0.1 µg L^{-1} during summer to 4.52 and 0.19 µg L^{-1} during winter, respectively. The maximum values of Cr and Ni recorded 21.46 and 17.14 µg L^{-1} during winter and their minimum values (9.34 and 3.20 µg L^{-1}) during summer, while maximum and minimum values of Fe (25.36 µg L^{-1}) and (11.52 µg L^{-1}) was recorded during winter. In contrast, Mn recorded its maximum value (8.67 µg L^{-1}) during summer and the minimum value during winter (2.2812 µg L^{-1}). Generally, the highest values of heavy metals were observed during summer and the lowest during winter except for Mn. Moreover, the concentrations of heavy metals in the coastal water of the Gulf of Chabahar could be arranged as the following sequence: Fe>Cr>Zn>Ni>Mn>Cu>Pb>Cd. From these results (Table 1), the local distribution of metals in water at different stations also varied during winter and summer 2013. The maximum value of Cu, Zn, Pb, and Cd were found at station II, Ni at station III and Fe at station IV during winter, while the highest value of Cr and Mn was recorded at station III during summer. The minimum values of Cu, Zn, Pb, Ni and Cd were found at station V but Cr were found at station I during summer, while Fe and Mn recorded the minimum values at station V and II during winter (Fig. 2).

Heavy metals in sediments

Table 2 shows the concentrations of heavy metals (Cu, Zn, Pb, Cd, Cr, Ni, Fe and Mn) in sediment samples collected from the five stations at the Gulf of Chabahar during winter and summer 2013. The highest values for metals in the Gulf of Chabahar were recorded at the easthern part (Tiss port), while the lowest ones were recorded at station V in the westhern part of the Gulf (Fig. 3). This means that anthropogenic contribution to the heavy metal concentrations at the easthern part of the Gulf was clearly noticeable in sediments. The local distribution of metals in sediments gave similar pattern with that of the water, with highest concentrations of Cu, Zn, Pb and Cd levels in station II, while highest Cr, Fe and Mn in station III. This means that the factors affecting the levels of metals in both water and sediments are similar. Although the results indicated that the accumulation of heavy metals is predominant in sediments rather than of seawater. This can be interpreted as sediments act as reservoir for all the contaminants and dead organic matter descending from the ecosystem above. The relatively high concentrations of heavy metals during winter coincide principally with decreasing rate of organic matter decomposition, due to low water temperature. The highest concentrations of Cu, Zn, Pb,Cd and Ni were found at station II (54.76, 43.12, 28.23, 0.63 and 28.68 µg g^{-1}) and their lowest values at station V (10.97, 16.21, 10.72, 0.21 and 8.32 µg g^{-1}), respectively. Cu ranged from 10.97 µg g^{-1} (station V) to 54.76 µg g^{-1} (station I). Also, Ni, Cd, Pb and Zn gave a similar pattern for their lowest and highest concentrations, where their lowest values were found at station V during Summer. The local distribution of Cu in sediment at station II showed higher concentration than the other stations. This may be due to the anti-fouling paints. The seasonal concentration of sedimentary zinc showed higher level at station II (43.12 and 40.14 μg g^{-1}) during winter and summer, respectively, while the lowest levels recorded 16.21 μg g^{-1} during winter and 18.77 μg g^{-1} during summer at station V. This may be due to the high amount of suspended organic matter coming from different industrial wastes that precipitate at the bottom and also the decreased uptake of zinc by phytoplankton at lower temperature. In the present study, Pb content of sediments ranged from 13.88 to 28.23 μg g^{-1} and 18.77 to 40.14 μg g^{-1} at stations V and II during winter and summer, respectively. The high sedimentary Pb content may be due to the precipitation of decomposed organic matter. The maximum value of Mn (89.14 μg g^{-1}) was observed at station III probably due to natural origins at the northern part of the Gulf. Fe and Cr accompanied Mn, which recorded its maximum value (53.46 and 51.43 μg g^{-1}) at the same station (III). This can be explained by Common origin of the ophiolitic rocks, the fact that their hydroxides are precipitated together at the bottom (Price and Calvert, 1973), and the common geochemistry of Fe, Cr and Mn (Beltagy *et al*., 1983).

Table 2: Heavy metal concentrations (μg g^{-1}) in sediment samples collected from the Gulf of Chabahar during winter and summer 2013

Station	Metals							
	Cu	**Zn**	**Pb**	**Cd**	**Cr**	**Ni**	**Fe**	**Mn**
Winter								
I	41.48	28.16	23.97	0.87	22.15	19.61	34.56	73.27
II	46.79	43.12	28.23	0.63	35.56	26.45	37.02	43.16
III	33.77	29.05	20.61	0.4	47.16	11.75	53.46	84.42
IV	21.85	35.16	23.80	0.49	20.42	18.76	23.89	59.36
V	30.42	16.21	13.88	0.36	19.18	13.63	14.22	45.33
Summer								
I	39.54	31.78	21.86	0.5	19.03	14.31	33.28	64.2
II	54.76	40.14	25.63	0.53	37.04	28.68	41.95	53.17
III	23.09	22.66	14.87	0.22	51.43	15.4	52.13	89.14
IV	31.98	30.31	13.86	0.32	27.54	17.24	22.46	52.81
V	10.97	18.77	10.72	0.21	25.96	8.32	12.77	46.93

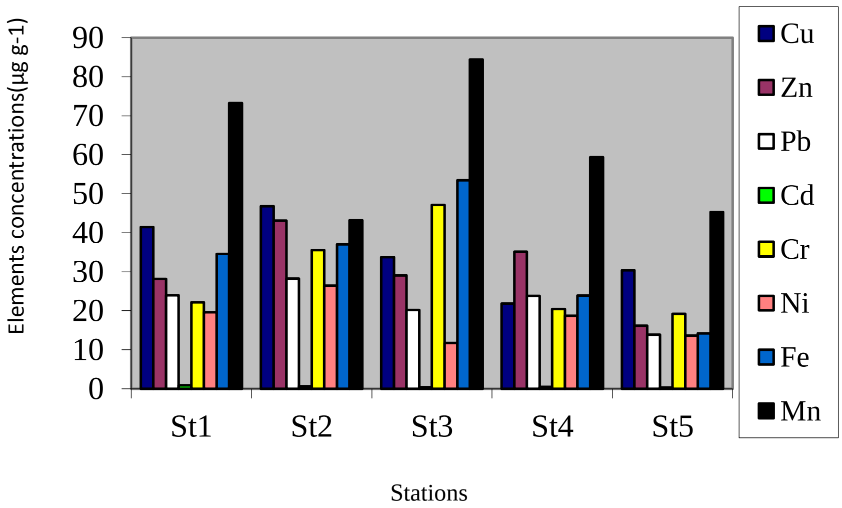

Fig. 3: Concentrations (μg g^{-1}) of heavy metals(Cu, Zn, Pb, Cd, Cr, Ni, Fe and Mn) in sediment samples collected from the Gulf of Chabahar.

Heavy metals in S. cucullata

Table 4 shows the concentrations (µg g^{-1} dry weight) of heavy metals in whole animal of oysters *(S. cucullata)* collected from five stations at the Gulf of Chabahar during winter and summer 2013, respectively. The highest mean values of the heavy metals were found at station II, for Cu (145.07), Zn (191.25), Pb (17.48), Cd (0.45) and Ni (Table 3). This is due to the fact that water of the easthern parts of the Gulf (near to the industrial activity of Chabahar free zone) has higher levels of metals than other parts. In other words, spatial data shows an agreement between the concentration of heavy metals in the water as well as in *S. cucullata* (Fig.4). On the other hand, the lowest mean values of the studied heavy metals were Away from industrial activity and human impacts (stations V). There have been many suggestions that molluscs can be used as monitors of contamination by trace metals in aquatic environments (Shuster and Pringle, 1968; Boyden, 1974; Darracott and Watling, 1975). Comparisons of metal levels in oysters should be made with caution because of variability in the quality of analytical data. In addition, it should be taken into account that differences in the sampling times, size (age) of oysterss, genetic differences, individual variability in metal uptake ability, gonadal maturation of organisms, and induction of metal-binding proteins can also influence the results (Schuhmacher and Domingo, 1996). Although comparison between different stations is open to criticism, the mean concentrations of all studied metals in *S. cucullata* were of the same range with exception for the extreme values. For example, the highest mean value of Pb (17.48 µg g^{-1}) was 7.4 times higher than the lowest mean value (2.36 µg g^{-1}), while other values, which varied between 145.07 and 59.25 µg g^{-1} have non-significant range (Table 3). In the present study, the highest mean value of Zn (191.25 µg g^{-1}) at station II was 2.18 times higher than the lowest ones (87.56 µg g^{-1}) at station V, while other values, varied between 93.67 and 127.53 µg $g^{-1}$with non-significant range (Table 3).

Table 3: Mean concentrations (µg g^{-1}) of Heavy metals in soft tissue of oyster (*S. cucullata*) collected from the Gulf of Chabahar during winter and summer 2013

Station	**Metals**							
	Cu	**Zn**	**Pb**	**Cd**	**Cr**	**Ni**	**Fe***	**Mn**
Winter								
I	129.44	133.09	8.64	0.31	18.76	29.87	3.01	89.21
II	133.59	191.25	17.48	0.4	14.56	38.04	2.56	46.53
III	100.98	97.28	10.83	0.11	23.12	15.42	6.25	49.31
IV	98.95	116.27	6.16	0.15	14.08	22.33	3.78	85.73
V	87.45	87.56	4.37	0.1	15.89	19.48	1.06	64.81
Summer								
I	120.01	129.04	6.57	0.28	17.22	26.85	2.86	63.39
II	145.07	156.17	14.95	0.45	12.66	28.59	3.02	29.75
III	95.71	127.53	9.79	0.08	27.95	16.33	5.81	39.56
IV	75.93	93.67	4.3	0.17	12.74	28.72	4.02	39.56
V	59.25	97.26	2.36	0.13	14.77	17.44	1.57	51.16

* mg g^{-1}

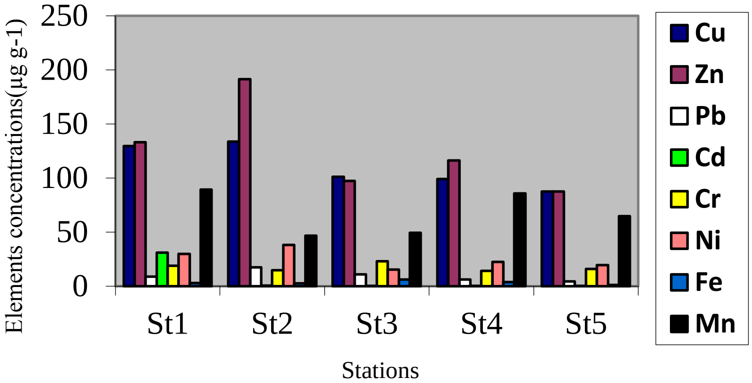

Fig. 4: Concentrations (µg g^{-1}) of heavy metals (Cu, Zn, Pb, Cd, Cr, Ni, Fe and Mn) in tissue of oyster (*S. cucullata*) samples collected from the Gulf of Chabahar.

In this study, the levels of natural and anthropogenic heavy metal contamination metals (Copper (Cu), Zinc (Zn), Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Iron (Fe) and Manganese (Mn)) in seawater, sediments and soft tissues of the *Saccostrea cucullata*, from the intertidal zone at five stations in the Gulf of Chabahar on the Iranian coasts along the Oman Sea were examined and reported for the first time. In summary, the order of Cu, Zn, Pb, Cd, Cr, Ni, Fe and Mn concentrations in seawater, sediments and oysters *(S.cucullata)* from the Gulf of Chabahar was Fe>Cr>Zn>Ni>Mn>Cu>Pb>Cd; Mn>Cu>Fe>Cr>Zn>Pb>Ni>Cd and Zn>Cu>Mn>Ni>Cr>Pb>Fe>Cd , respectively. The local distribution of metals in sediments gave similar pattern with that found in seawater. Although the results indicated that the accumulation of heavy metals is predominant in sediments rather than of seawater. This can be interpreted as sediments act as reservoir for all the contaminants and dead organic matter descending from the ecosystem above. The relatively high concentrations of heavy metals during winter coincide principally with decreasing rate of organic matter decomposition, due to low water temperature.The highest values for metals in the Gulf of Chabahar were recorded at the eastern part, while the lowest ones were recorded at western part of the Gulf. This means that anthropogenic contribution to the heavy metal concentrations at the easthern part of the Gulf was clearly noticed in sediments. Comparison of the heavy metal levels in the present study with background concentrations of heavy metals in seawater and sediments are presented in Table 2. As the table shows, Cu, Pb, Zn, Cr and Ni levels are generally exceeded the background levels in open ocean. While, Zn concentration is only less than the coastal water level but Cu higher than the coastal water concentration. Zn and Cd concentration lies in the range of coastal water concentration (0.30–70.0 and 0.01-0.17 μg/l) reported by Bryan and Langston (1992), UNEP (1993) and Sadiq(1992). Ni levels in sediment samples found in this study are higher than the background levels. Pb, Cd, Cu, Zn and Cr lies in the range of background level of sediment.

The order of heavy metals concentrations in seawater, sediments and Marine Organism *(S. cucullata)* from the Gulf of Chabahar was Marine Organism>sediments>seawater, respectively. It can therefore be concluded that marine organism is a good indicator for essential and toxic metals, Zn and Cu. Ayling (1974) suggested that different mechanisms exist for the uptake of Cu, Cr, Zn and Cd within the oyster *Crassostrea gigas*. These mechanisms may also vary with physiological and environmental factors (Bryan, 1973) or even with the sexual state of the animal (Alexander and Young, 1976). Thus the situation described above could arise as a result of both environmental and physiological factors. So the observed variation in metal levels in *S. cucullata* at different stations may be related to one or both of the following mechanisms: 1) the availability of different metals to the animal varies with different stations, and 2) the animal involves different uptake and retention mechanisms for the same metal at different stations. Therefore, the order of metal accumulation in the animal was: Fe>Zn>Cu>Mn>Ni>Cr>Pb>Cd, where, Fe was the highest followed by Zn, Cu, Mn, Ni and Pb then Cd. This order may be due to variation in the levels of discharged metals at different stations and also the chemical changes of metal before being taken up by the tested limpet.

Table 4: Background concentrations of metals in seawater and sediments of a various environments.

		Concentration	Reference
Seawater(μg/l)	Cd	0.02-0.12(open ocean)	Sadiq, 1992, Bryanand and Langston, 1992.
		0.01-0.17(coastal)	Law et al, 1994.
	Pb	0.02-0.07(open ocean)	Law et al, 1994.
	Cu	0.14-0.90(open ocean)	Law et al, 1994.
		0.35-0.40(coastal)	UNEP, 1993, Bryan and Langston, 1992.
	Zn	<1(open ocean)	UNEP, 1993, Bryan and Langston, 1992.
		0.30-70.0(coastal)	(EPA, 2002)
	Cr	0.05(open ocean)	(EPA, 2002)
	Ni	5.4(open ocean)	Sadiq, 1992.
Sediments (μg/g)	Cd	<1	Salomons and Forstner , 1984.
	Pb	20-30	USPHS, 1997.
	Cu	10-30	UNEP, 1993, Bryan and Langston, 1992.
	Zn	<100	UNEP, 1993, Bryan and Langston, 1992.
	Cr	<52	MacDonal, 1995
	Ni	<5.4	MacDonal, 1995

CONCLUSION

Generally, the land based activities and the shipping activity (such as: repairing, fueling, greasing and painting of fishing ships) and boats in the studied area were the main source of heavy metals in the Gulf of Chabahar. The Level of Cr, Mn and Ni did not significantly change among different station suggesting that these three elements originate from natural sources and is related to the Regional Geology of Makoran zone. The concentration of Pb, Zn and Cu varied among different station with maximum levels in station II (Tiss harbour). Human activities such as shipping, marine transportation and fisheries are might associate in heavy metals enrichment in the sediment. During summer heavy metals concentration in Chabahar sediment increased markedly. It is suggested that increasing of nutrient availability due to upwelling during monsoon season (summer) enhanced phytoplankton growth followed by increasing of suspended organic matter which should be involved in heavy metals enrichment of sediment. This study showed that the pattern of heavy metals accumulation in *S. cucullata* is different in five station. It could be related to the biological role of the metals in the body.

REFERENCES

Abou-El-Sherbini Kh.S. and Hamed M.A. 2000. Pollution assessment in the aquatic ecosystem along the western coast of the Suez Bay, Egypt. J. Aquat. Biol. Fish., 4: 37–59.

Amini-Ranjbar G.H. 1998. Heavy metal concentration in surficial sediments from Anzali Wetland, Iran. Water Air Soil Pollut., 104: 305-312.

Amini-Ranjbar G.H. and Miraki G.H. 2006. Evaluation of quantity and quality of the Chabahar bay, Sistan and Baluchestan University: 7-9.

APHA.1989. AWWA and WPCF Standard Methods for the Examination of Water and Waste water, 17th ed. APHA, Washington Brewer, P.G., Spencer, D.W., Smith, C.L., 1969. Determination of trace metals in seawater by atomic absorption spectroscopy. Am. Soc. Test. Mater. Spec. Tech. Publ., 443: 7 –77.

Ayling G.M. 1974. Uptake of Cd, Zn, Cu, Pb and Cr in the Pacific oyster Crassostrea gigas grown in the Tamar River, Tasmania.Water Res., 8: 729– 738.

Alexander G.V. and Young D.R. 1976. Trace metals in Southern California mussels. Mar. Pollut. Bull., 7 (1): 7– 9.

Beltagy A.I., El-Sayed M.K., El-Sabarouty M. and Halim Y.1983.The distribution of phosphorus, iron and manganese in recent marine sediments of Nile Delta. Acta Adriat, 24: 193– 203.

Besada V., Andrade J.M., Schultze F. and Gonzalez J. 2009. Heavy metals in edible seaweeds commericialised for human consumption. J. of Marine Sys. 75 (1-2): 305-313.

Boyden C.R. 1974. Heavy metal content and body size in molluscs. Nature Lond., 25: 311– 314.

Bryan G.W. (1973) The occurrence and seasonal variation of trace metals in scallops Pecten maximus and Chlayms opercularis. J. Mar. Biol. Assoc., 53: 145–166.

Bryan G.W. and Langston W.J. 1992. Bioavailability, accumulation and effects of heavy metals in sediments with special reference to United Kingdom estuaries: a review. Environ. Pollut., 76: 89– 131.

Censi P., Spoto S.E., Saiano F., Sprovieri M. and Mazzola S. 2006. Heavy metals in costal water system. A case study from the North Western Gulf of Thailand. Chemosphere, 64: 1167-1176.

Coughtrey P.J. and Martin M.H. 1977. The uptake of lead, zinc, cadmium and copper by the pulmonate mollusc, Helix aspersa Muller, and its relevance to the monitoring of heavy metal contamination of the environment. Oecologia., 27: 65– 74.

Darracott A. and Watling H. 1975. The use of molluscs to monitor cadmium levels in estuaries and coastal marine environments.Trans. R. Soc. S. Afr., 41 (4): 325– 338.

Elfwing T. and Tedengreen M. 2002. The effects of Copper on the metabolism of three species of tropical oysters, Saccostrea cucullata, Crassostrea lugubris and Crassostrea belcheri. Aquacul. ,204: 157-166.

El-Samra M.I., Abdallah A.M. and Hamed M.A. 1995. Seasonal variation of some metal in the aquatic system of the Suez Bay. J. Environ. Scince, 9: 81- 95.

E.P.A. 2002. Environmental Protection Agency, United states.

FAO. 1976. Manual of methods in aquatic environment research: Part 3. Sampling and analyses of biological material. FAO Fish. Tech. Pap., 158:124 pp.

Farhoudi G. and Craig D. E. 1977. Makran of Iran and Pakistan as an active arc system. Geol., 5(11): 664-668.

Fowler S.W. 1990.Critical review of selected heavy metal and chlorinated hydrocarbon concentrations in the marine environment. Mar. Environ. Res., 29: 1–64.

Fowler S.W. 1988. Coastal base line studies of pollutants in Bahrain, United Arab Emirates and the Sultanate of Oman. In: Proceedings Symposium on Regional Marine Pollution Monitoring and Research Programmes, ROPME/GC-4/2, ROPME, Kuwait: 155–180.

Gochfeld M.2003. Cases of mercury exposure, bioavailability and absorption. Ecotoxicol. Environ. Saf., 56: 174-179.

Gold berg E.D., Bowen V.T., Farrington J.W., Harvey G., Martin J.H., Parker P. L., Risebrough R.W., Robertson W., Schneider W. And Camble E. 1978. The mussel watch. Environ. Conserv., 5: 101–125.

Hamed A.H. and Emara A.M. 2006. Marine molluscs as biomonitors for heavy metal levels in the Gulf of Suez, Red Sea. Journal of Marine System,60: 220–234.

Howard A.G.1975. The nature of heavy metal complexes in molluscs of California. Ph. D. Thesis, University of Bristol.

Jacob K. H. and Quittmeyer R. C.1979. The makran region of Pakistan and Iran trench-arc system with active plate subduction. Geodynamics of Pakistan: 305-318.

Koide M., Lee D. S. and Gold berg E. D. 1982. Metal and transuranic Records in mussel shells, byssal threads and tissues. Estuar. Coast. Shelf Sci., 15: 679–695.

Law R.J., Waldock M.J., Allchin C.R., Laslett R.E. and Bailey K.J.1994.Contaminants in seawater around England and Wales: results from monitoring surveys, 1990– 1992. Mar. Pollut. Bull. 28: 668–675.

Maanan M. 2008. Heavy metal concentrations in marine mollusks from the Moroccan coastal region. Environ. Pollut., 153: 176-183.

Martin J. H. and Felgal A.R.1975. High Cu concentrations in squid livers in association with elevated levels of Ag, Cd and Zn. Mar.Biol. 30 (1): 51–56.

31.Mashinchian Moradi A.2001. The kinetics of uptake and release of polycyclic aromatic hydrocarbons in the green mussels Perna viridis for biomonitoring of marine pollution. P, 31-42, Univ., Putra Maly.

Mcall G. J. H. 1997. The geotectonic history of the Makran and adjacent areas of southern Iran. Earth Sciences. 15: 517-531.

MacDonald S.L., Long E.R., Smith D.D. and Culder F.D. 1995. Incidence of adverse biological effects within ranges of chemical concentertions in marine and estuarine sediments. Environmental Managment, 19: 81-97.

Nicholson S. and Lam P.K.S. 2005. Pollution monitoring in southeast Asia using biomarkers in the mytilid mussel Perna viridis (Mytilidae: bivalvia). Environ Intern., 31: 121-132.

Origioni B. and Aston S.R. 1984. The determination of selected trace metals in marine sediments by flameless/flame atomic absorption spectrophotometry. IAEA Monaco Laboratory, International Report.

Pote J.L., Haller J.L., Loizeau A.G., Bravo V. and Wildi W. 2008. Effects of sewage treatment planet uolet pipe extention on the distribution of contaminants in the sediments of the bay of Vidy, lake Geneva, Switzerland. Bioresour. Twchnol., 99: 7122-7131.

Phillips D.J.H. and Rainbow P.S. 1993. Biomonitoring of Trace Aquatic Contaminants. Elsevier, London. 371 pp.

Price N.B. and Calvert S.E. 1973. Study of the geochemistry of suspended particulate matter in coastal waters. Mar. Chem., 1: 169–189.

Romeril M.G. 1971. The uptake and distribution of 65 Zn in oyster. Mar. Biol., 9: 347– 354.

40.Sadiq M. 1992. Toxic Metal Chemistry in Marine Environments. Marcel Dekker, New York.

Schuhmacher M. and Domingo J.L. 1996. Concentrations of selected elements in Oysters (*Crassostrea angulata*) from the Spanish coast. Bull. Environ. Contam. Toxicol., 56: 106– 113.

Shuster C.N. and Pringle B.H. 1968. Effect of trace metals on estuarine molluscs. Proc. 1st Mid-Atlantic Ind. Waste Conf., Univ., 5: 285– 304.

Salomons W. and Forstner U. 1984. Metals in the Hydrocycle. Springer-Verlag, Berlin.

Stanly Y.M., Lam K.S., Martin M. and Calwell W. 2008. The use of selected genotoxicity assays in green mussels Perna viridid a validation study in Hong kong coastal water. Marine Pollution Bullten, 83: 1521-1529.

Stephen de Mora, Scott W., Fowler E. W. and Sabine A. 2004. Distribution of heavy metals in marine bivalves, fish and coastal sediments in the Gulf and Gulf of Oman. Marine Pollution Bulletin, 49: 410–424.

Szefer P. 1986. Some metals in benthic invertebrates in Gdansk Bay Marine Pollution Bulletin, 11: 503–507.

Szeffer P., Wolowicz M., Kusak A., Deslous P.J.M., Czarnowski W., Frelek K. and Belzunce M.J. 1999. Distribution of mercury and other trace metals in the cockle Cerastoderma glaucum from the Mediterranean Lagoon Etangde Thau. Arch. Environ. Contam. Toxicol., 36: 56– 63.

Thomson E.A., Luoma S.N., Johansson C.E. and Cain D.J. 1984. Comparison of sediments and organisms in identifying sources of biologically available trace metal contamination. Water Res., 18: 755-765.

Topcuo K.C., Balkis G.N. and Kirbaolu C. 2003. Heavy metal monitoring algae from the Turkish coast of the Black sea, 1998-2000. Chemosphere, 52: 1683-1688.

UNEP. 1993. Preliminary assessment of the state of pollution of the Mediterranean Sea by zinc, copper and their compounds and proposed measures. Mediterranean Action Plan UNEP (OCA)/ MED/WG.66/Inf.3, Athens 3– 7 May 1993.

USPHS. 1997. Toxicological Profile on CD-ROM Agency for Toxic Substances and Disease Registry.

Vlahogianni M., Dassenakis M., Scoullos M.J. and Valavanidis A. 2007. Integrated use of biomarkers (superoxide dismutase, catalase and lipid peroxidation) in mussels Mytilus galloprovincialis for assessing heavy metals' pollution in coastal areas from the Saronikos Gulf of Greece, Marine Pollution Bulletin, 54: 1361-1371.

Wcislo E., Loven D., Kucharski R. and Szdzuj J. 2008. Human health risk assessment, case study: An abandoned metal smalter site in poland, Chemosphere, 96: 223-230.

Wen C., Kao C.M., Chen C.F. and Dong C.D. 2007. Distribution and accumulation of heavy metals in sediments of Caohsiung harbor, Taiwan, Chemosphere, 66: 1431-1440.

Yap C.K., Ismail A., Tan S.G. and Rahim A. 2003. Can the shell of the green-lipped mussel Perna viridis from the west coast of Peninsular Malaysia be a potential biomonitoring material for Cd, Pb and Zn. Estuarine, Coast and Shell Sci., 57: 623-630.

Yi Y., Wang Z., Zhang K., YU G. and Duan X. 2008. Sediment pollution and its effect on fish through food chain in the Yangtze river. Int. J. Sediment Res., 23: 338-347.

Zareii A. 1995. Survey of hydrobiology of main Estuary of Sistan and Baloochestan, Iran. The Central Research of distant water fisheries.

Zelika B., Lukic S. and Pezelj D. 2003. Biomonitoring of heavy metal and arsenic on the east coast of the middle Adriatic Sea using Mytilus galloprivinsialos. Marine Pollution Bulletin, 56: 176-183.

Zorita I., Zarragoitia M., Soto M. and Gajaraville P. 2006. Biomarkers in mussels from a copper site gradient (Visnes, Norway) an integrated biochemical, histochemical and histological study. Aquat Toxic., 78: 109-116.

How to cite this article: (Harvard style)

Bazzi, A., (2014). Heavy Metals in Water, Sediments and Marine Oorganisms(Saccostrea cucullata) of the Chabahar Gulf, Oman Sea (Iran). Int. J. Mar. Sci. Eng., 4 (1), 47-56.