J. Appl. Environ. Biol. Sci., 1(12)630-637, 2011

ISSN: 2090-4215
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Investigation of Heavy Metals Pollution in Water, Sediment and Fish at Red Sea– Jeddah Coast- KSA at Two Different Locations

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ABSTRACT

This study investigate concentrations of heavy metals including, Zinc, Copper, Arsine, Cadmium, Mercury and Lead (Zn, Cu, As, Cd, Hg and Pb) in water, sediments and fish organs (muscle, guts and liver) were investigated in two different locations, Jeddah Islamic Port Coast (JIPC) and northern Coast Side of Jeddah (NCSJ). Large differences in heavy metal concentration mg/g dry weight were observed between different tissue, water and sediments. In sediments, heavy metal concentration was Cd 35.5, Pb, 41.40, Cu 22.5, Zn 32,2, Hg1.85 in (JIPC), where as in (NCSJ) Cd 35.5, Pb, 41.40, Cu 22.5, Zn 32,2, Hg 1.85, water heavy metal concentration in (JIPC) mg/g as follows, As 0.31, Pb 1.20, Cu 0.40, Zn 0.41, Hg was not detected. Generally metal concentration in JIPC was found to be highest than in NCSJ, liver contain the highest concentration in all samples where as in muscles is the lowest, in liver in JIPC Cd 1.09- 3.35, Pb 2.95-7.84, Zn 41.97 – 57.21, Cu 12.23-32.22 in muscles ranged between 0.13- 1.06, Pb 1.03-6.10, Zn 3.98 –9.30, Cu 0.13 – 0.91. Hg not detected in all samples except the sediment in the two location.

Keywords: fish, Heavy metals, sediments, water.

INTRODUCTION

The rapid industrial growth has resulted in an increasing production and usage of toxic chemicals such as trace elements in Jeddah. Some metals are known to be toxic even at low concentrations, including arsenic, cadmium, mercury and lead (Le et al., 2009).Others, such as copper and cobalt, are known to be essential elements and play important roles in biological metabolism at very low concentrations (Le et al., 2009) and either an excess or deficit can disturb biochemical functions in both humans and animals (Gulec et al., 2011). Heavy metals, unlike organic pollutants, cannot be chemically degraded or biodegraded by microorganisms. Thus, their content has steadily increased in soils and subsequently accumulated in plants, animals, and even in humans (Che et al.,2006). The pollutants like heavy metals after entering into aquatic environment accumulate in tissues and organs of aquatic organisms. The amount of absorption and assembling depends on ecological, physical, chemical and biological condition and the kind of element and physiology of organisms (Jaffar et al., 1988). The concentration of any pollutant in any given tissue therefore depends on its rate of absorption and the dynamic processes associated with its elimination by the fish (Al-Kahtani, 2009). Chemicals of industrial effluent and products of ship and boats such as heavy metals which find their way in different water system can produce toxic effect in aquatic organism (Bernet et al, 1999). Petroleum products are one of the most relevant pollutants to aquatic ecotoxicology. Exposure to crude oil derivatives can induce a variety of toxic symptoms in experimental animals Petroleum hydrocarbons can act as amediator in free radical generation in fish Saad and Fahmy (1994) recorded four pollution sources at Jeddah coast: the untreated the untreated domestic sewage waste , oil pollution from oil refinery of factory Petromin, fish waste from the fish market of Bankalah region and probably desalination plant effluents.Heavy metals are well known environment pollutions that cause serious health hazard to human, their effects are not immediate and show up after many years (Jarup 2003, Boguszewsk and Pasternak 2004). Increasing on the need for documentation of both nutrients and contaminant s in fish and sea food, with balance risk assessment (Dahl et al., 2006).Heavy metals discharge into the marine environment can damage both marine species diversity and ecosystems, due to their toxicity and accumulative behavior (Edwards et al 2001 and Sivaperumal et al., 2007). Cadmium, copper, lead and zinc salts are usually found in agricultural and industrial liquid waste (McCrea and Fischer 1986 and Qiao-qiao et al 2007) which discharged into water resources. These metals are toxic to aquatic life at low concentration, particularly in soft water interments. Such metals may be accumulated from water to higher

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level in fish tissue (Sivaperumal et al 2007,Rowayshed et al 2002,Sankar et al., 2006), Liver and gills as main organs for metabolism and respiration are target organs for contaminants accumulation as reported by many authors concerning Structural damage to organs and tissues related to the exposure of fish to petroleum derivatives (Engelhardt et al., 1981, Khan 2003)Evidently these metals accumulated frequently in fish flesh and in internal organs (Turkmen et al 2005,Dural et al., 2007). The excess of heavy metals intake, especially mercury and lead, causes many harmful and neurotoxic effects to the human health. Hg is the most toxic heavy metals that affects the brain causing the syndromes of nerve disturbances and insomnia, in addition to its harmful effects on inhabiting growth activity of some enzymes(Baji et al 1986,FDA, 2001. Hajeb et al 2009)

The Saudi Arabian Standards Organization, SASO (1977), had suggested maximum allowable limits (MALs) for some of the more toxic heavy metals in fish. species, as follows:

Cadmium, Cd 0.5 mg/g
Mercury, Hg 1.0 mg/g
Lead, Pb 2.0 mg/g
Arsene, As 1.0 mg/g
Copper, Cu 20.0 mg/g
Zinc, Zn 50.0 mg/g

So the main objective of this study is to determine the concentration of some heavy metals (Cu, Hg, Cd, Pb, As and Zn) in some local consumed fish captured from Jeddah coast at different location, and know whether it's safe for consumption.

MATERIALS AND METHODS

Water and sediment samples were taken at different places at Jeddah Port by a PVC tube column sampler at depth of half meter from the water surface. The samples were mixed in a plastic bucket and a sample of 1 liter was placed in a polyethylene bottle, kept refrigerated and transferred cold to the laboratory for analysis. Surfacial sediment samples were collected using core sampler as described in (Boyd and Tucker, 1992), then kept in cleaned plastic bags and chilled on ice box for transport to the laboratory for heavy metals determination

Water

Heavy metals in water samples were extracted with conc. HCl and preserved in a refrigerator till analysis for As, Hg, Zn, Cu, Cd and Pb (Parker, 1972).

Sediment

In the laboratory, the sediment samples were dried at 105 ºC, grinding, sieving and about (1.0 gm) of the most fine dried grains were digested with a mixture of conc. H2O2, HCl and HNO3 as the method described in Page et al. (1982) and preserved in a refrigerator till analysis.

Fish Sampling

Four different species of common fish were collected from the shipping area near Jeddah Islamic Port Coast (JIPC) and Northern Coast Side of Jeddah (NCSJ), fish specimens were examined, the samples were weighed, measured, cleaned with deionized-distilled water, stored in pre-cleaned plastic bags, and kept frozen at -18 0C until further analysis. Muscles, liver and guts were taken out and dried in a pre-cleaned glass container at 103 ± 2 0C to a constant weight. Sampling, pretreatment, preparation of subsamples and analysis were made according to FAO Technical Paper No. 212 (1983).. Metals in fish tissue/organs were extracted as described by (AOAC, 1990). Atomic Absorption Spectrophotometer (Model Thermo Electron Corporation, S. Series AA Spectrometer with Gravities furnace, UK,) instrument was used to detect the heavy metals. The concentrations of heavy metals were expressed as mg/l for water and µg/g. dry wt. for sediment samples and fish organs.

RESULTS AND DISCUSSION

This study conducted to determine heavy metals concentration (Cd, Zn, Cu, Pb, As, Hg) in different organs of four fishes, water and sediments collected from Jeddah Islamic Port Coast and Northern Coast, Figure (1) showed the map of Jeddah coast were the samples has been collected. Figure (2)

represents the concentration of heavy metals in sea water from JIC, whereas Figure (3) represents the heavy metal concentration in sea water collected from NCJ. Heavy Metals concentrations in water were found in the following order Pb 1.21. Cu 0.4, Zn,0.31, Cd 0.04, Hg and As not detected in JIPC, whereas water collected from NCJ Pb 0. Cu 0.3, Zn,0.15, Cd 0.02, Hg and As not also detected. The high level of Pb in water of Jeddah Islamic Port could be attributed to the shipping, industrial and agricultural discharge as well as from spill of leaded petrol from fishing boats and dust which holds a huge amount of lead from the combustion of petrol in automobile cars (Hardman et al. 1994). Higher levels of Pb often occur in water bodies near highways and large cities also may be due to high gasoline combustion (Banat et al., 1998). The metals concentrations in bottom sediment of Pb. Zn, Cu, Hg, Cd, As and Pb values collected from JIPC are shown in Figure (4), where as Figure (5) represents values of heavy metals concentrations in sediments collected from JIC. Zn and Pb concentrations among the other metals showed higher concentrations, where as Hg and As are the least concentrations obtained in the sediments of the two locations. The high level of Cd and Pb sediments could be attributed to the industrial and agricultural discharge as well as from spill of leaded petrol from fishing boats which are distributed in the Jeddah Islamic Port. Also, dust which holds a huge amount of lead from the combustion of petrol in automobile cars led to increase Pb content(Hardmanetal.1994)

Figure (1) Jeddah City Coast

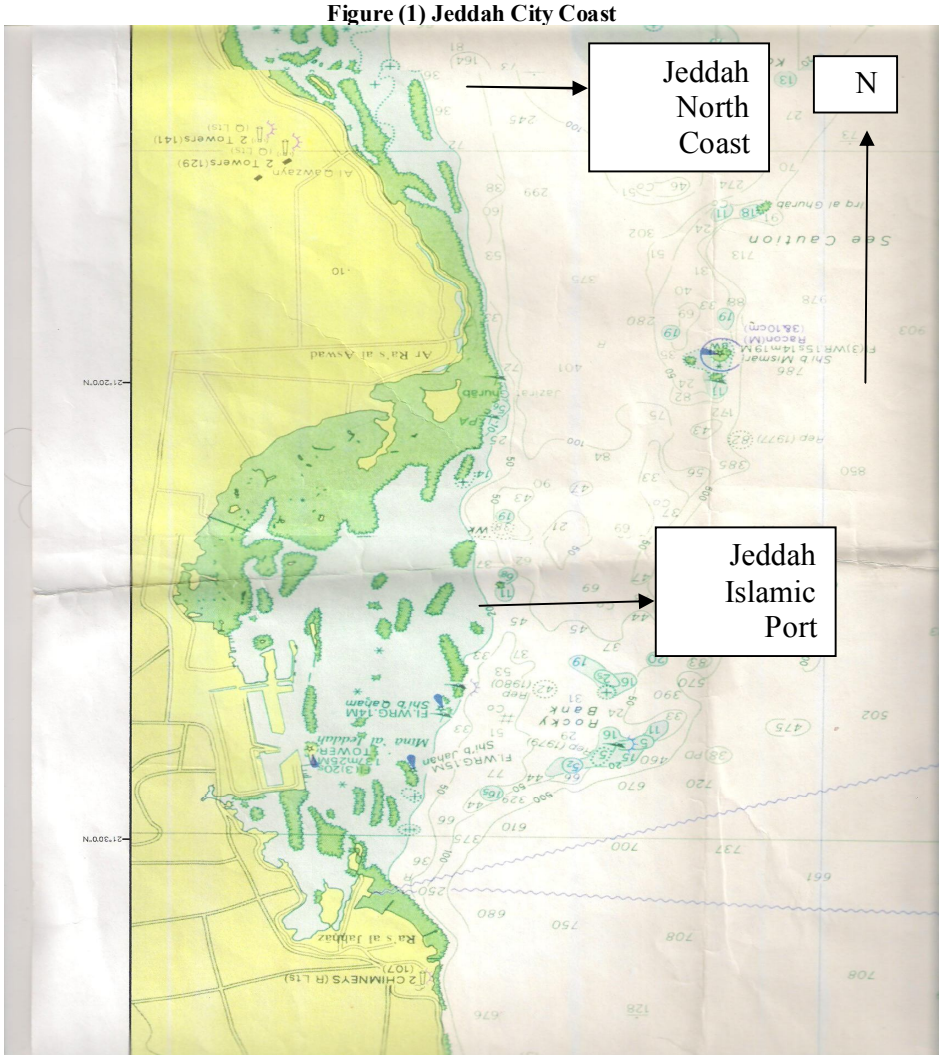
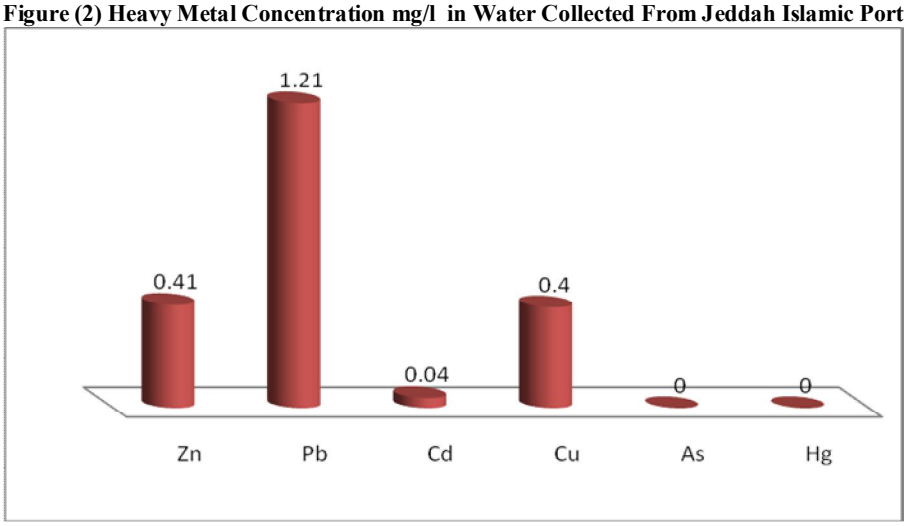


Figure (2) Heavy Metal Concentration mg/l in Water Collected From Jeddah Islamic Port



From the results below Table (1) represent the Concentration (mg\g dry weight) of heavy metals in muscles ,collected from JIPC and JNC where as Table (2) represents the concentration (mg\g dry weight) of heavy metals in guts and Table (3) represents concentration (mg\g dry weight) of heavy metals in liver from the two locations.

Table (1): Concentration (mg\g dry weight) of heavy metals in muscles of four species of common fish collected from Jeddah Coast.

Species (JIPC)	Cu	Zn	As	Pb	Cd	Hg
Lethrinus nebulous	0.13	3.98	2.08	1.03	0.13	ND
Caranx sexfaciatus	0.91	5.33	2.12	0.94	0.9	ND
Carans melampygus	0.63	8.37	4.33	1.41	0.26	ND
Lethrinus mahsena	0.47	9.30	2.98	2.10	1.06	ND
Species (JNC)						
Lethrinus nebulous	0.07	2.40	0.90	ND	ND	ND
Caranx sexfaciatus	0.43	2.33	1.41	0.08	0.02	ND
Carans melampygus	0.32	455	2.04	0.10	ND	ND
Lethrinus mahsena	0.40	2.86	1.80	010	0.06	ND

ND Not Detected

Table (2): Concentration (mg\g dry weight) of heavy metals in the guts of four species of common fish collected from Jeddah coast.

Species (JISPC)	Cu	Zn	As	Pb	Cd	Hg
Lethrinus nebulous	6.09	25.42	4.02	6.80	1.87	ND
Caranx sexfaciatus	3.23	32.03	2.97	9.76	1.96	ND
Carans melampygus	5.49	43.11	4.63	7.66	1.13	ND
Lethrinus mahsena	5.94	24.16	5.45	5.57	0.80	ND
Species (JNC)						
Lethrinus nebulous	5.77	22.71	3.45	3.32	0.50	ND
Caranx sexfaciatus	4.44	33.55	1.42	3.35	0.19	ND
Carans melampygus	2.98	34.83	3.04	5.41	ND	ND
Lethrinus mahsena	4.90	25.64	1.86	2.45	0.66	ND

ND Not Detected

Compared to other heavy elements determined Cd showed relatively low concentration level in the different organs in the fish whereas higher means were found in guts (1.87), livers (3.35) it ranges from 0.13 – 1.06 mg\g dry weight in the muscles, 0.8 -1.87 mg\g dry weight in guts and 1.16 -3.35 mg\g dry in JIC weight as shown in Tables 1, 2 and 3 respectively. Cadmium is accumulated primarily in major organ tissues of fish rather than in muscles (Moore and Ramamurthy, 1984). In general, it can be stated that the concentrations of Cd found in edible part in the present study are still considered as those of uncontaminated fish (< 1.5). Cadmium when detected occurred at fairly low levels, within SASO

limits, in the muscle tissues of fish. The same can be said regarding concentration levels of Zn, Cu, and Pb, which all lie below, or well below, the limits Table (1). Although, the level of Cd in the edible fish muscles showed values within SASO's recommended maximum limit of 0.5 mg/kg, its level in gills and shrimp tissues, only slightly exceeded this limits.

Figure (3) Heavy Metal Concentration mg/l in Water Collected From Jeddah North Coast

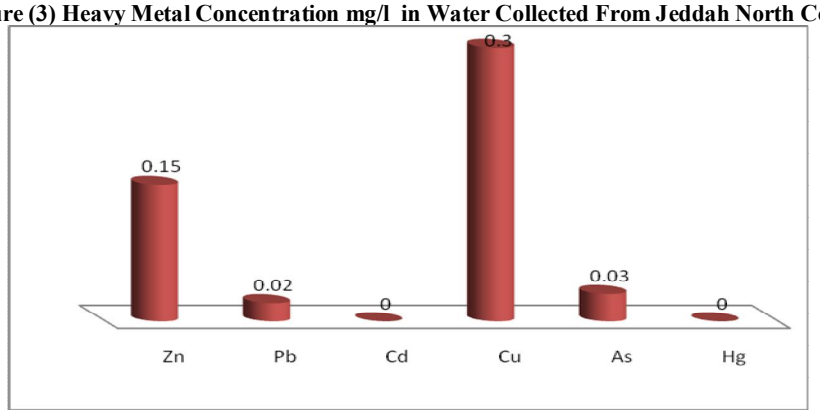
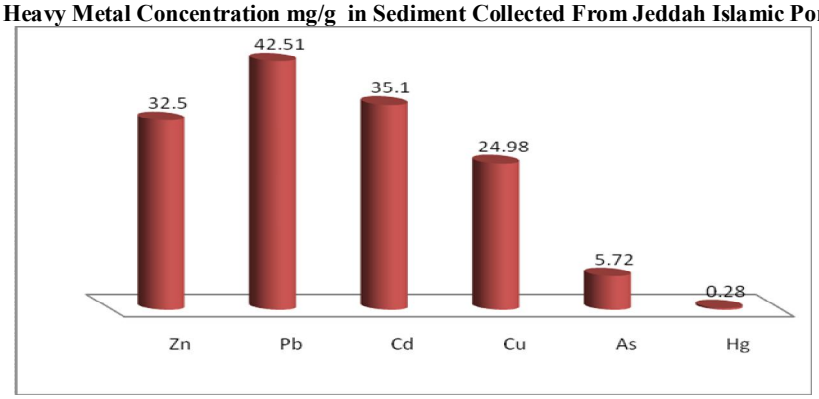


Figure (4) Heavy Metal Concentration mg/g in Sediment Collected From Jeddah Islamic Port



Relatively high mean concentrations of Cu were found in livers (32.22) and guts (6.09) of the fish examined, compared to those found in muscles (0.91). There was also a wide variation in Cu content in livers among species as it ranged from 12.23 for *Lethrinus nebulous* to 32.22for *Carans melampygus*. In muscles, there was a narrower range of concentration (0.13- 0.91) (Ashraf 2006 and Ashraf et al., 2006) found relatively high mean concentration of Cu in liver followed by stomach and lastly muscles. The data indicate that the fish in Jeddah coast compare to other fish worldwide and are not more contaminated with Cu than that at other marine environments (Ahmad H. Abu Hilal, and Naim S. Ismail. 2008). Liver and gill as main organs for metabolism and respiration are target for contaminants accumulation as reported by many authors concerning structural damage to organs and tissue related to the exposure of fish to the petroleum derivatives (Engelhardt et al 1981, Khan 2003).

Table (3): Concentration (mg\g dry weight) of heavy metals in the livers of four species of common fish collected from Jeddah coast.

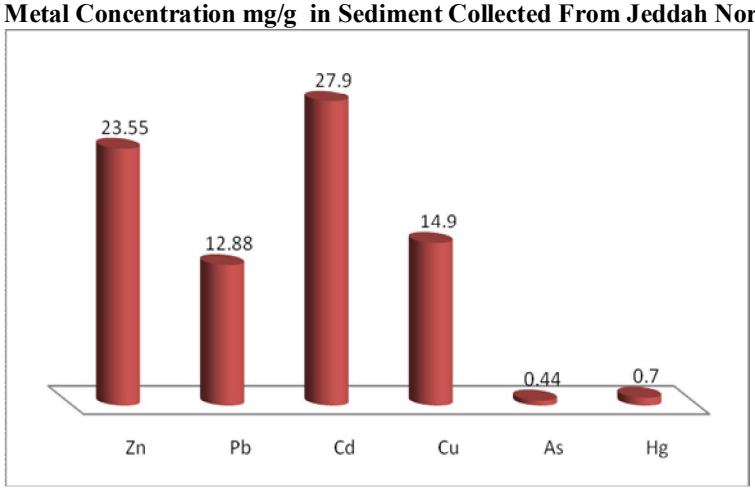
Species(JISPC)	Cu	Zn	As	Pb	Cd	Hg
Lethrinus nebulous	12.23	41.97	3.55	2.95	2.35	ND
Caranx sexfaciatus	22.74	45.48	3.36	7.84	2.97	ND
Carans melampygus	32.22	46.69	2.11	3.71	1.09	ND
Lethrinus mahsena	15.101	57.21	3.31	6.72	1.16	ND
Species (JNC)						
Lethrinus nebulous	6.87	32.54	1.90	0.80	1.90	ND
Caranx sexfaciatus	23.44	42.13	1.41	032	2.02	ND
Carans melampygus	14.32	4058	2.54	0.60	1.99	ND
Lethrinus mahsena	20.40	46.16	1.66	1.10	2.06	ND

ND Not Detected

Zn concentrations were slightly higher compared to e.g. Cd, As, HG & Pb. It occurred in both muscles and guts of some fish species. Similar results of Zn concentration in muscles of several marine fish species, being higher than the above mentioned (and other) trace elements, were also reported [Krenkel, (1975), Abul-Naja**,** W. M., (1996)]. The tendency of Zn to bio-concentrate in muscles may be attributed to its particular tendency to accumulate in the skin layers of fish species [Zhou, et al 1998]. Since muscle samples used in the current study were not intentionally skinned, variability in the Zn content of muscles will be expected to occur in as much as there are skin fractions associated with the muscular tissues. This appears to partly contribute to observed variability of Zn content in muscles of the same species.

Arsenic, As, was detected in low level of concentration compared to Zn, Cu in liver and guts, mercury, Hg, were invariably undetectable in all samples of different organs of fish collected, over the whole study period (Table1). Hg is the most toxic heavy metals that affects the brain causing the syndromes of nerve disturbances and insomnia, in addition to its harmful effects on inhabiting growth activity of some enzymes(Baji et al 1986,FDA, 2001. Hajeb et al 2009).

Figure (5) Heavy Metal Concentration mg/g in Sediment Collected From Jeddah North Coast



The mean concentration of Pb was lowest in the muscles (0.45) and livers (2.95) of the fish examined, while the highest was in the guts (6.80) in JIPC where was not detected in JNC of these fishes this could be due to contamination of water with oil from the shipment area Saad and Fahmy (1994) recorded four pollution sources at Jeddah coast: the untreated the untreated domestic sewage waste oil pollution from oil refinery of factory Petromin, fish waste from the fish market of Bankalah region and probably desalination plant effluents. Recently Badr's group (Badr et al, 2008) confirmed the heavy metals pollutions at sea bed of Jeddah Coast. The concentration of Pb is below the limits in edible part of fish because Pb toxicity in humans include abnormal size and hemoglobin content of erythrocytes, hyper stimulation of erythropoesis inhibition of both haeme synthesis and some enzyme activity in anemia and permanent damage of the brain, liver and central nervous system (Qiao-qiao et al 2007, Ellias 1996)

These results are consistent with what has been reported by Moore and Ramamoorthy (1984) that there is often little accumulation of Pb in the muscles of marine and freshwater fish species. Low concentrations of Pb in the muscles of marine fish were reported from coastal areas of England and Wales (< 1.0 µg g^{-1} wet weight) (Portmann, 1972), West Malaysia (< 0.5 mg kg' wet weight) (Baji et al., 1986),), and Gulf of Aqaba (0.8-2.6 µg g^{-1}) (Wahbeh andMahasneh, 1987). In fishes of the Red Sea Pb ranged between 0.01-0.66 µg g^{-1} in the muscles 0.1-2.4 in the livers, and <0.05-0.14 in the gonads (Hanna, 1989). Our data indicate that the fish in the Gulf contain higher levels of Pb compared to other fish at other marine environments world wide

CONCLUSIONS

Analytical results revealed that very low concentration levels of toxic metals are encountered in Jeddah North Coast compared to Jeddah Islamic Port Coast. Even though no concentration levels that are

abnormally high were observed in the tissues muscles of the test species collected from the two locations. Toxic metal levels analyzed in this study meet the available maximum allowable limits recommended by SASO for fish and shrimp species, so the fish in the coast of Jeddah Port are safe for consumption especially the north side of the city where Pb, AS and Cd where not detected in the water collected from the north side.

Acknowledgement

The authors would like to thanks Taif University for financial support under the research project no 1\432\1135

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