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Review: Bioaccumulation of heavy metals in fish and other aquatic organisms from Karachi Coast, Pakistan

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Abstract. *Yousif RA, Choudhary MI, Ahmed S, Ahmed Q. 2021. Review: Bioaccumulation of heavy metals in fish and other aquatic organisms from Karachi Coast, Pakistan. Nusantara Bioscience 13: 73-84.* Heavy metals are being utilized in a variety of ways in industries, agriculture, food processing and household in many forms. Metals are unique environmental and industrial pollutants in the sense that they are neither created nor destroyed by human beings but are only transported and transformed into various products. The present study deals with the findings of various investigators on the effect of heavy metals on fish and other aquatic organisms on Karachi coasts of Pakistan. The polluted areas (Rivers and Karachi coasts) receiving effluents from industrial, agricultural, municipal and domestic wastes. The order of abundance of the metals were as fellow; Fe > Zn > Cu > Mn > Cd > Pb > Cr > Ni > Hg > As. Most studies showed that essential metals (Fe, Zn, Cu, and Mn) in aquatic organisms are much high, but the quantities of non-essential metals are found to be less. This review has shown that fish and other aquatic organisms are used as bio-monitoring species in heavy metal pollution. It is suggested that such investigations should be continuous in terms of both human health and determination of metal pollution in aquatic environment.

Keywords: Aquatic organisms, fish, heavy metals, Karachi Coast

INTRODUCTION

Heavy metals are essential components of aquatic environment, usually found in really low concentrations. The many parts of the heavy metals released into the earth discover their way into the freshwater and marine environment as by many ways as input of direct air deposition, climatic, and disintegration due to rainwater. The levels of heavy metals are too high, in the area where domestic activities, mining activities, mechanical and cultivating activities are across the natural areas (Langston 1990; Bryan and Langston 1992; Sulieman and Suliman 2019).

Heavy metals accumulated in the fish and other aquatic organisms in two ways direct and indirect accumulation, consumption of contaminated water and food through the digestive system considered as direct exposure or indirectly through the permeable membranes such as skin and gills. The level of heavy metals concentration in fish and other aquatic organisms' organs indicate their levels also in their surrounding environment. The accumulation of heavy metals in aquatic organism organs sometimes can exceed the environmental levels. The toxic effect usually occurs when the rate of uptake is exceeding the mechanism of metabolism, storage, and detoxification (Ali et al. 2011; Baki et al. 2018; Rajeshkumar and Li 2018).

Contamination of the freshwater and marine environment by heavy metals has been reported by many authors such as Rashed (2001), Rahman et al. (2012), Yousif et al. (2016) and Rajeshkumar and Li (2018), have reported that zinc, chromium, mercury, lead, copper, cadmium and arsenic are the important metals which contaminate the water and harmful to aquatic organisms. Many marine organisms (fish, shrimp, and crab) at the highest point of the natural feeding ground items and aggregates high levels of metals from the water and sediment (Lambert et al. 2000; Tüzen 2003; Arulkumar et al. 2017; Daellenbach et al. 2017; Narsimha and Wang 2018). Heavy metals accumulated in aquatic organisms and their effect can move to the human after using contaminated fish and other aquatic organisms and the consequences can deteriorate the human health (Raja et al. 2009; Alinnor and Obiji 2010; Abarshi et al. 2017).

The levels of dangerous contaminants in aquatic organisms are a critical factor in view of their potential effects on the organisms themselves and the health status of humans that utilize them. Health organizations and institutions, for example, Food and Drug Administration (FDA), have started late raised stresses over the security of fisheries obtained from business sources (Burger et al. 2004).

THE MAIN SOURCES OF HEAVY METALS

Contaminations of heavy metals in water also lead to changes in the chemical components of the aquatic environment, usually influences the behavioral, physiological, and bloodstream patterns, cell structures ionic balance (Oikari and Soivio 1976), liver function, and carbohydrate metabolism (Oikari and Soivio 1976; Oikari and Nakari 1982) of fishes. Earlier studies, showed that anthropogenic activities and domestic effluent constitute huge sources of heavy metal which contribute to the steadily increasing metallic pollutant in aquatic environment in most part of the world (Jibiri and Adewuyi 2008; Ates et al. 2015).

Recent development and advancements in the agricultural sector, industrialization, and urbanization have contributed substantially to elevated heavy metal pollution in freshwater and marine environments. Anthropogenic activities such as mining and smelting (Chen et al. 2015), combustion of fossil fuel refining (Muradoglu et al. 2015), discharge and disposal of domestic and municipal wastes (Khan et al. 2016), using pesticides in agricultural sector (Ogunlade and Agbeniyi 2011), sewage irrigation in some countries (Sun et al. 2013), fertilizer and urea application (Atafar et al. 2010), dust (Chen et al. 2011) contribute to spread the levels and concentrations of dangerous heavy metals in the aquatic environments. The major sources of heavy metals are summarized in Table 1.

Generally, metals can be categorized as biologically essential and nonessential. The nonessential metals (e.g., lead (Pb), mercury (Hg), cadmium (Cd), aluminum (Al), and tin (Sn)) no study has proven their biological function (also called xenobiotics elements or foreign elements), and their effects and toxicity rise with increasing the levels and concentration of these metals, on the other hand essential metals (e.g., zinc (Zn), iron (Fe) copper (Cu), cobalt (Co), nickel (Ni), chromium (Cr) and molybdenum (Mo)), have a known their biological role, and their effects and toxicity occur either at metabolic deficiencies or at high levels and concentrations of these metals (Sfakianakis et al. 2015). The deficiency of an essential metal can lead to adverse health effects, whereas the high levels of essential elements can also lead to negative effects which are equivalent to or worse than those effects caused by non-essential metals (Kennedy 2011; Sfakianakis et al. 2015). The most commonly investigated and found heavy metals in fish and other aquatic organisms in many studies are Zn, Cu, Pb, Cr, Cd, Ni, Hg, Co, Sn, and Mo. Amongst them, the most frequently studied, with respect to fish and aquatic organisms' deformities, include Zn, Pb, Cu, Cr, Cd, and Hg.

ACCUMULATION OF HEAVY METALS AND THE ECOLOGICAL STATUS OF AQUATIC ORGANISMS

The rapid development of industry and agriculture has resulted in an increase in the pollution of coastal areas with heavy metals, which have been identified as a significant environmental hazard for invertebrates, fish, and humans (Yousif et al. 2016; Khan and Strand 2018) Significant quantities of heavy metals in waster water are discharged into aquatic environments. These metals can be strongly accumulated and biomagnified along water, sediment, and aquatic food chains, thus resulting in sublethal effects or death in local fish populations and other aquatic animals (Yi and Zhangc 2012). Heavy metals like copper and zinc are essential for fish metabolism, while others such as mercury, cadmium, and lead have no known role in biological systems (Yi and Zhangc 2012; Ates et al. 2015). Therefore, it is important to better understand the relationships between ecological status of aquatic organisms and the concentrations of both essential and non-essential metals. Heavy metal pollution of water and sediment in the Karachi Coast has attracted much attention from researchers (Ahmed et al. 2017b).

HEAVY METAL AND HUMAN HEALTH

Consumption of contaminated food is the main source of exposure of humans to the risks of heavy metals (Liu et al. 2010). The presence of heavy metal in commercial fish can pose potential health risks to humans (Cid et al. 2001; Castro-gonzález and Méndez-armenta 2008; Saeedi et al. 2012; Ullah et al. 2017). Hence, it is important to know the level and concentration of heavy metal contents in aquatic organisms in order to ensure that it does not expose any hazard to the human and maintain concentration under permissible level (Sivaperumal et al. 2007; Uysal et al. 2008; Palaniappan and Karthikeyan 2009; Dehghani et al. 2017; Pal et al. 2018). Heavy metal pollution is increasingly recognized as a serious, environmental issue by environmentalists, high levels of toxicity, persistence, and potential for accumulation inside human body pose a serious health threat to the residents of urban areas (Karim et al. 2015; Mohmad et al. 2015; Hwang et al. 2016; Gope et al. 2017; Khan and Strand 2018; You et al. 2018; Liu et al. 2019; Men et al. 2019; Tian et al. 2019).

Many organizations and institutions such as the Food and Agriculture Organization (FAO), World Health Organization (WHO) and European Union (EU) from different countries have been established about the maximum permitted concentration of heavy metals in foodstuffs including fish and other seafood (Chary et al. 2008; Xue et al. 2012). For example, European Union (2006) reported that the maximum tolerable limit (MTL) of lead (Pb) in the edible tissues of fish is 0.3 mg/kg where Cd and Hg were about 0.05-0.30 and 0.5-1.00 mg/kg wet weight respectively depends on the type of fish. Heavy metals such as Pb, Cd and Hg are categorized as non-essential elements and they are very toxic and harmful to individuals and aquatic organisms, even at small levels (Thomas et al. 2009; Zheng et al. 2011; Bourliva et al. 2018). While, Zn, Mn, Cu, and Ni are essential elements due to their important function in biological systems (Stern et al. 2007; Fernandes et al. 2008). The dose-response curve for essential metals is U-shaped due to those metals that have both deficiency and copper excess which produce adverse health (Stern et al. 2007).

Table 1. Sources of heavy metal contaminations in the aquatic environment (Lone et al. 2008; Changfeng et al. 2019)

Heavy metals	Sources
Zn	Electroplating industry, smelting and refining, mining, biosolids
Fe	Iron alloys are processed to containers, cars, laundry machines, bridges, buildings, and also the other sources of iron as pharmaceutics, chemicals, iron fertilizers, and pesticides.
Cu	Electroplating industry, mining, biosolids, smelting, and refining
Pb	Mining and smelting of metalliferous ores, burning of leaded gasoline, municipal sewage, industrial wastes enriched in Pb, paints
Cd	Geogenic sources, anthropogenic activities, metal smelting and refining, fossil fuel burning, application of phosphate fertilizers, sewage sludge.
Hg	Volcano eruptions, forest fire, emissions from industries producing caustic soda, coal, peat, and wood burning
As	Semiconductors, wood preservatives, mining and smelting, coal power plants, herbicides, volcanoes, petroleum refining, animal feed additives
Cr	Electroplating industry, sludge, solid waste, tanneries
Mn	Municipal wastewater discharges, sewage sludge, mining and mineral processing, emissions from alloy, steel, and iron production, combustion of fossil fuels and to a much lesser extent.
Ni	Volcanic eruptions, landfill, forest fire, bubble bursting and gas exchange in ocean, weathering of soils and geological materials, industrial effluents, kitchen appliances, surgical instruments, steel alloys, automobile batteries

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Zn is a ubiquitous trace element and one of the essential elements that important to humans and plants. Zn is known as a cofactor to more than 300 enzymes that involved in RNA and DNA metabolism, and it is also important in the structural stabilization of a large amount of proteins (Song et al. 2010; Chasapis et al. 2012). When exceeding amounts are present, Zn becomes toxic (Krishna et al. 2014; Kastury et al. 2017) but a deficiency of Zn can lead to several disorders (Scherz and Kirchhoff 2006). such as results in poor pregnancy outcomes (King 2000; Uriu-adams and Keen 2010) and development of chronic diseases, including cardiovascular disease (Messner et al. 2009; Afridi et al. 2011) and also cause cancer (Kazi et al. 2010).

Fe is essential element for every living cell and necessary for the synthesis of many enzymes, myoglobin, and hemoglobin in the blood. The result deficiency of iron can lead to weakness, susceptibility, and inability to concentrate and other symptoms (Akoto et al. 2014). Anderson and Fitzgerald (2010) reported that one of the most common nutrient deficiencies in the world is Fe deficiency in anemia such as malaria. Anaemia disease gives poor performance in circulatory transport and also reduces oxygen supply to muscle, less efficiency due to the decreasing of myoglobin content and impairing endurance capacity (Erdman et al. 2012).

Cu is an essential metal of enzymes and necessary for hemoglobin synthesis (Sivaperumal et al. 2007). Impaired delivery of Cu can result in decreased cuproenzyme activity, the skeletal and vascular systems Failla et al. (2001), and also cause anemia, neutropenia, and osteoporosis (Angelova et al. 2011). Impaired metabolism of Cu could cause two genetic diseases which are Mense disease and Wilson disease. Accumulation of Cu can expose to the Mense disease which is a fatal disorder (Gu et al. 2002; Ameh and Sayes 2019). Wilson disease also could occur due to Cu accumulates in the brain and eyes in the form of Kayaer-Fleischer ring (Sarkar 1999; Attri et al. 2006). Excessive intake of Cu also could cause kidney damage and even death (U.S. Department of Health and Human Services 2004).

Mn has a biological significance due to its ability to prevent heart attack, stroke, and cardiac arrest, which is also an element of low toxicity. Deficiency of manganese can lead to poor growth performance, congenital malformations in offspring, and low efficiency of the reproductive system (Goldhaber 2003). However, it's become dangerous and toxic at high concentrations and usually may lead to neurologic and psychologic disorders (Perl and Olanow 2007; Saha and Zaman 2013). Normally, nickel (Ni) is an essential metal and occurs at very low levels in the environment. However, a deficiency of Ni in humans has not yet been reported and documented (Barceloux 1999). Ni is known to be carcinogenic (Salnikow and Kasprzak, 2005). Moreover, fibrosis, tumors, lung inflammation, and emphysema occur also caused by Ni (Forti et al. 2011).

Cr is an essential trace element in some aquatic animals and humans. Cr may reduce body fat and also improve lean body mass. However, their effects are small compared to those of a well-balanced diet and exercise (Roussel et al. 2007; Tulasi and Rao 2014). But it could have an undesirable fatal effect in excess amount. Lack of Cr can affect the growth and disturbances in glucose, lipid, and protein metabolism (Akoto et al. 2014). According to Stipanuk and Caudill (2012), they found that 12 out of 15 studies showed a positive effect on the relationship between Cr and impaired glucose tolerance based on a meta-analysis.

Besides, Hg is a non-essential element. The levels of Hg increase due to the increases in fish size (Burger and Gochfeld 2011). Toxicity of Hg can damage the organ in fish (Sary and Mohammadi 2011; Krishna et al. 2014; Abu-Dieyeh et al. 2018). While, in humans, Hg can cause the development of fetus destroyed due to their toxicity and also considered as a carcinogen (Ikem and Egilla 2008). While, Vettori et al. (2003) studied that neuronal loss in the cerebellum granule layer and damage of discrete visual cortex area occurs in adult brain due to Hg poisoning. Emami-Khansari et al. (2005) also stated that Hg is a human toxicant and become primary source of human by eating fish.

Food consumption is the main source of exposure cadmium (Cd) in the human body. Cd is known as an endocrine disturbing substance and it is well documented that Cd can cause to develop breast cancer and prostate cancer in humans (Saha and Zaman 2013). Cd also causes damage in kidney, hypertension, tumors, poor reproductive performance, and hepatic dysfunction (Rahman and Islam 2010; Al-Busaidi et al. 2011; Hao et al. 2013).

In addition, lead (Pb) is a naturally-occurring and industrially-produced element that is very toxic to the human, especially children (Koyashiki et al. 2010; Kastury et al. 2019). Children are the most vulnerable to Pb because having less effective renal excretion and greater absorption of gastrointestinal. The fetal brain presents a greater sensitivity to the toxic effects of Pb compared to the mature brain (Schnaas et al. 2006). Umar et al. (2001) stated that symptoms of intestinal cramps, anemic condition and fatigue caused by poisoning of Pb. Lead also can cause nephrotoxicity and neurotoxicity (García-lestón et al. 2010).

Nowadays, Arsenic (As) is widely spread in the environment due to both natural and anthropogenic processes (Rahman et al. 2012). As is a carcinogen and potent toxicant. As also has potential to destroy communities of ecological systems (Sadiq et al. 2003). Toxicity of as depends on the speciation (Devesa et al. 2008) and trivalent as (III) has the greatest toxicity. According to ATSDR (2000), mono and dimethyl arsenic have low toxicity.

STUDIES ON HEAVY METALS IN FISH AND OTHER AQUATIC ORGANISMS IN KARACHI COAST

Pakistan has geologically and ecologically diverse coastline dissected by harbors, estuaries, bays, and creeks exhibiting wide characteristics in the marine species. Unfortunately, the littoral state of Pakistan is facing many environmental issues as increasing pollution and human-induced environmental changes particularly fishing, coastal aquaculture, waste disposal, industrial activity, agriculture, domestic effluents, salt making, unplanned tourism, etc. Contaminated ecosystem destroys the life of aquatic animals and decreases the market value of seafood products and increase in bacterial diseases (Kamal et al. 2015b; Shahab et al. 2016; Ahmed et al. 2017a; Chandio et al. 2018; Ahmed et al. 2019).

Karachi coast is a very important coast for its dimensions and economic activity. There are over 11000 industrial units (CDGK 2012) present, more than 2000 units in Federal-B-Area, 2571 units in Korangi zone, 2000 units in North Karachi, 1200 units in Landhi zone, and 4000 units in Mangopir zone in Karachi (Aziz and Khan 2014; Ahmed et al. 2018c; Mujeeb et al. 2020) Figure 1. By the Karachi coastline ever-growing pollution level, which is linked to the increase of the shipping industry through the Karachi port, is severely contaminating the mangrove, forests, and marine life (Ahmed et al. 2018c; Ali et al. 2019). The dumping of wastes on the coast provides a major source of heavy metal input (Khattak et al. 2012; Mukhtar and Hannan 2012; Chaudhary et al. 2013; Ahmed et al. 2018c). The important sources of heavy metals pollution are industrial activities and dumping of land-based wastes into the river and coasts of the sea. Especially in Pakistan and other countries such as India and Bangladesh most industries are converged on the riverbanks of big cities (Khan et al. 2011; Hasan et al. 2013; Jilani 2015; Hossain and Islam 2019). Not only these countries but all the coastal countries are exposed to heavy metal pollution. In the coastal areas, heavy metal contamination is found in seawater, sediment and aquatic organisms, causing a health risk (Kazmi and Zubair 2014; Elahi et al. 2015; Devault et al. 2017; Ahmed et al. 2018c).

The investigation of heavy metals (Zn, Fe, Cu, Cd, Hg, As, Cr, Ma and Ni) in different aquatic organisms on Karachi coast has been reported in numerous earlier studies such as *Thunnus* spp. (Yousuf and Ahmed 2010; Ahmed et al. 2012; Ahmed et al. 2015a), *Pongamia pinnata* (Shafiq et al. 2012), *Fenneropenaeus penicillatus* (Kamal et al. 2015a), *Rastrelliger* kanagurta (Yousuf and Ahmed 2011; Ahmed et al. 2014a; Ahmed and Bat 2015; Ahmed et al. 2016b), *Holothurians* spp. (Ahmed et al. 2017b; Ahmed et al. 2018b), *Ohshimella ehrenbergii* and *Stolus buccalis* (Ahmed et al. 2019) (Table 2, Figure 2). Heavy metals are being utilized in a variety of ways in industries, agriculture, food processing and household in many forms. The present study deals with the findings of various investigators on the effect of heavy metals on fish and other aquatic organisms in Karachi. The polluted areas (rivers and Karachi coast) receive effluents from industrial, agricultural, municipal and domestic sources (Ali et al. 2014; Iftikhar et al. 2018). The order of abundance of the metals were as fellow; Fe > Zn > Cu > Mn > Cd > Pb > Cr > Ni > Hg > As. Pb is a neurotoxic metal that causes many behavioral defects in biotic samples, as a result of which decrease in survival growth rates and metabolism occur. The main source of Pb in the present geographical locale could be the contamination from Ibrahim Hyderi coast. The discharge of industrial waste of Korangi industrial trading estate (KITE) and Gizri Creek causes the increase Pb concentration along with the littoral states of Ibrahim Hyderi (Khwaja et al. 2012; Kamal et al. 2015a).

Figure 1. Map of the study area in Karachi Coast, Pakistan

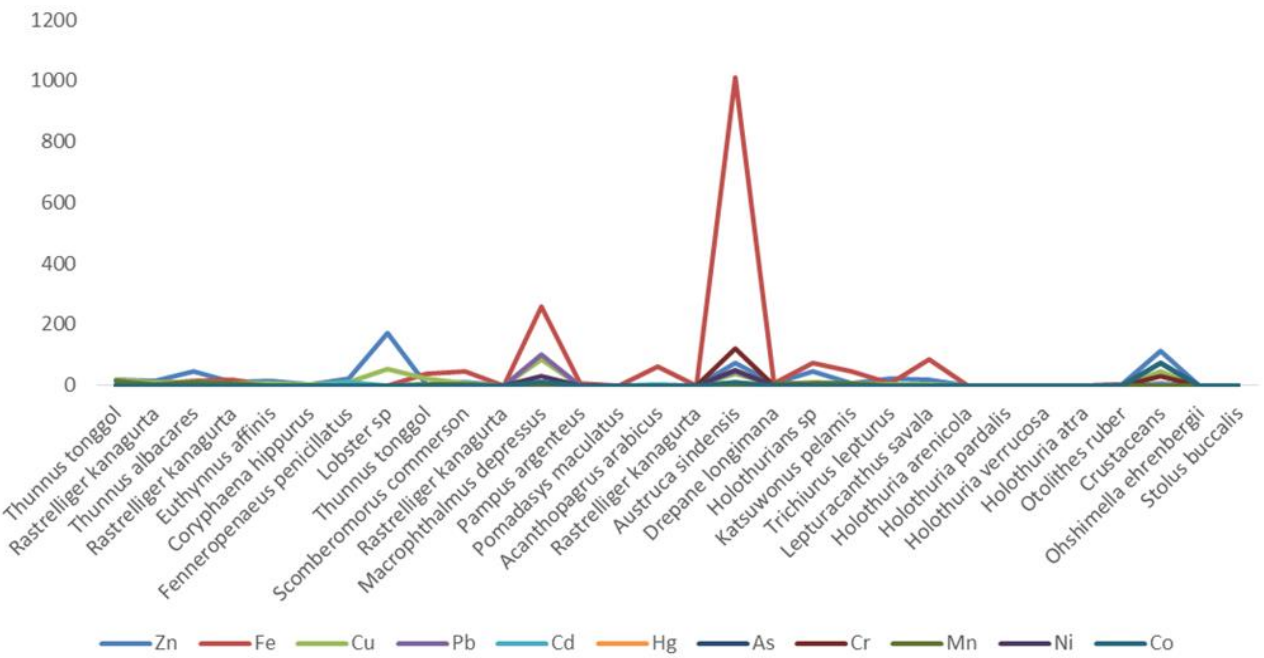

Figure 2. Accumulation of heavy metals (mg/kg) in fish and other aquatic organisms, Karachi Coast, Pakistan

Heavy metal loaded aquatic systems may affect the food chain of inhabitant fish species. It is reported by many researchers that heavy metal pollution in aquatic ecosystems is often more reflected by high metal levels in sediments, macrophytes, and benthic animals than by elevated concentrations in water (Van Hassel et al. 1980; Ashraf et al. 2019). Heavy metal accumulation and its effects on fish are very much complex to elucidate because of dynamic nature of aquatic ecosystems.

Aquatic animals mainly the phyla crustacean species are the bio-indicators of toxic materials because invertebrates have more tendencies to accumulate contaminants as compare to fishes (Balfour et al. 2012; Kamal et al. 2015b; Ahmed et al. 2017a). Hazardous material from the surrounding continuously enter in fresh and marine environment and deposit in biota from where it subsequently transferred in to human through the food chain and when the concentration of these substances reaches to a certain level, it becomes toxic (Gokoglu et al. 2008; Copat et al. 2013; Goretti et al. 2016).

Table 2. Levels of heavy metal in edible tissue of fish and other aquatic organisms from Karachi Coast, Pakistan

Species	Determination techniques	Unit	Metals											References
			Zn	Fe	Cu	Pb	Cd	Hg	As	Cr	Mn	Ni	Co	
Thunnus tonggol	AAS	µg g^{-1}	0.43±0.28 17.47±7.56	0.98±0.49 1.81±0.712	8.27±5.79 10.29±3.33						0.05±0.02 12.57±7.86			Yousuf and Ahmed 2010
Rastrelliger kanagurta	AAS	µg g^{-1}	4.53-12.71	5.89-12.74	1.94 -9.81						0.17-3.67			Yousuf and Ahmed 2011
Thunnus albacares	AAS	µg g^{-1}	12.64-44.50	13.36-2.78	1.68-9.82	0.21-0.80	0.02-0.75				2.10-9.98			Ahmed et al. 2012
Rastrelliger kanagurta	AAS	µg g^{-1}	9.41±3.14 2.96±1.22	18.92±13.12 56.17±24.23	8.21±3.37 2.03±2.23						6.15±4.44 1.42±1.20			Ahmed et al. 2014a
Euthynnus affinis	AAS	µg g^{-1}	16.33± 2.26 6.56± 1.06		6.63± 1.65 2.36± 1.78	0.54± 0.15 0.06± 0.05	0.50 ±0.17 0.14 ±0.12							Ahmed et al. 2014b
Coryphaena hippurus	AAS	µg g^{-1}	4.13		2.92		0.18					0.40		Ahmed and Benzer 2015
Fenneropenaeus penicillatus	AAS	µg g^{-1}	6.83-23.83		4.94-10.08	0.05-0.07	3.57-10.79							Kamal et al. 2015a
Lobster sp	AAS	µg g^{-1}	7.96-173.61		4.65-55.56									Kamal et al. 2015b
Thunnus tonggol	AAS, Aanalyst 700	µg g^{-1}	3.89±2.23	36.43±11.41	23.35±11.47	0.27±0.12	0.71±0.3			0.35±0.20	1.29±1.08	0.35±0.12		Ahmed et al. 2015a
Scomberomorus commerson	AAS	µg g^{-1}	3.17-9.43	23.71-44.40	2.78-6.83	0.14-0.57	0.19-0.68			0.14-0.51	1.30-2.20			Ahmed et al. 2015b
Rastrelliger kanagurta	AAS	mg kg^{-1}						0.01-0.09 0.042±0.023						Ahmed and Bat 2015
Macrophthalmus depressus	AAS	mg kg^{-1}	88.38	259.9	86.5	102.64	2.04			11.94		31.17	9.72	Siddiqui and Saher 2015
Pampus argenteus	AAS	mg kg^{-1}		4.952	0.189	0.569	0.041							Yasmeen et al. 2016
Pomadasys maculatus	AAS	mg/kg				0.54 ± 0.05	0.59 ± 0.05							Ahmed and Bat 2016
Acanthopagrus arabicus	AAS	mg/kg		20.16-63.52		0.1-0.52	0.23-0.88							Ahmed et al. 2016a
Rastrelliger kanagurta	AAS	µg g^{-1}				0.32±0.26	0.31±0.29			0.37±0.26				Ahmed et al. 2016b
Austruca sindensis	AAS	µg g^{-1}	71.86	1009.9	36.33	44.08	1.39			121.6		50.89	11.52	Saher and Siddiqui 2017
Drepane longimana	AAS Aanalys 700	mg/kg	7	5.6	3.5	0.007	0.07				2-5			Ahmed and Bat 2017
Holothurians sp	AAS Aanalys 700	µg g^{-1}	11-46	14-73	0.43-8.93	0.52-3.02	0.11-2.67				0.76-7.12			Ahmed et al. 2017b
Katsuwonus pelamis	AAS	µg g^{-1}	2±1 7±2	16±6 46±17	3±1 7±2						4±1 6±2			Ahmed et al. 2017c
Trichiurus lepturus	AAS	µg g^{-1}	20.34±8.49	7.72±47.84	2.23±1.16	0.20±0.16	0.42±0.19				0.57±0.36			Ahmed et al. 2018a
Lepturacanthus savala	AAS	µg g^{-1}	16.63±9.25	85.11±57.64	2.53±1.90	0.23±0.18	0.47±0.20				0.47±0.27			Ahmed et al. 2018a
Holothuria arenicola	AAS	mg/kg						0.018						Ahmed et al. 2018b
Holothuria pardalis	AAS	mg/kg						0.026						Ahmed et al. 2018b
Holothuria verrucosa	AAS	mg/kg						0.024						Ahmed et al. 2018b
Holothuria atra	AAS	mg/kg						0.036						Ahmed et al. 2018b
Otolithes ruber	AAS	µg g^{-1}	3.34±1.19	4.23±1.38	0.33±1.14	0.02±0.01	0.46±0.06				0.28±0.18			Baloch et al. 2018
Crustaceans	AAS	mg/kg	113.71		45.92	4.78	0.66			30.89		72.71	72.8	Saher and Kanwal 2018
Ohshimella ehrenbergii	AAS Aanalys 700	mg/kg						0.0176						Ahmed et al. 2019
Stolus buccalis	AAS Aanalys 700	mg/kg						0.0155						Ahmed et al. 2019

International limits												
WHO	40	100	30	2	0.5	-	-	-	-	-	WHO 1989
FAO	30	-	30	0.5-6	1	-	-	5	-	-	FAO 1983
USA	75	11	6	1	1	-	-	-	-	6	Cohen et al. 2001
European Community	-	-	-	0.2	0.05	-	-	-	-	-	EC 2005
England	50	-	20	2	0.2	-	-	-	-	-	MAFF 2000
EU lmits	-	-	10	0.1	0.1	-	-	-	-	-	EU 2001

Previous investigations have shown declined condition of aquatic environment on Karachi coast, due to heavy metals contamination which is one of the most critical environmental issues in Pakistan and worldwide (Shaheen et al. 2016). The main source of Cu and Zn metals in the present geographical location could be the effluents of Bin Qasim thermal power plants, seaport activities, industrial effluents of SITE (Sindh Industrial Trade Estate) through Layari River, and unloading of raw materials for Pakistan steel mill; which is further fractionated into water, seaweed and sediments. Industrial effluents coming through Malir River, sewage water and oil refinery situated in the coastal region are the other sources of Cu and Zn contamination (Kamal et al. 2015a; Shahid et al. 2016).

Major source of copper contamination in marine organisms is via food chain rather seawater. Thus increasing ambient pollution levels in water do not directly affects the marine life. Copper is considered highly toxic metal after mercury and silver for marine life because of the existence of a number of detoxifying and storage systems for Cu (Mitra et al. 2012).

Cadmium is mainly concerned pollutant because it is very much toxic metal to aquatic organisms. Cadmium is absorbed in excess by human being through seafood and tends to accumulate mainly in liver and kidneys (Kamal et al. 2015; Ahmed et al. 2018a). The main source of cadmium contamination along the coastal areas is electroplating and industrial waste because it is an important metal with industrial applications.

This review was carried out to provide information on heavy metal concentrations in fish and other aquatic organisms on Karachi coast, Pakistan. The findings of various investigators on the effect of heavy metals on fish and other aquatic organism in Karachi were as follow; Fe > Zn > Cu > Mn > Cd > Pb > Cr > Ni > Hg > As. Fish and other aquatic organisms are used as a bio-indicator to evaluate the health of aquatic ecosystems since heavy metals accumulate in food, that it would be useful to carry out in detailed, extensive observations to monitor this situation in the future in (Rivers and Karachi coast) especially around the industrial, agricultural, municipal and domestic and polluted areas and their impact on the environment.

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