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HEAVY METALS CONTAMINATION OF WATER AND FISH- A REVIEW

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ABSTRACT

Water is a vital resource for all kinds of lives. Heavy metals (HM) generally enter the aquatic environment through natural (atmospheric deposition, erosion of geological matrix) or anthropogenic activities caused by industrial effluent, domestic sewage, mining and agricultural wastes. Tanning generally requires using a heavy chemical that contains chromium, cadmium etc. It was observed that these industrial wastes are discharged, without proper treatment, into small waterways, which subsequently adjoin the rivers and dams. Using agricultural chemicals and fertilizers also contributes to the chemical contamination of the aquatic environment. Discharging untreated sewage into the waterways introduce pathogenic microorganism into the marine environment, among other reasons, which has drawn the attention of researchers to the possibility of having the aquatic organism edible by humans (mostly fish) be contaminated by heavy metals and microorganisms, which have been confirmed to cause short- and long-term health hazards. Fish, one of the primary aquatic organisms in the food chain, may often accumulate large amounts of metals, which can later intoxicate humans after consumption. Humans can also be intoxicated by directly consuming untreated water contaminated with heavy metals. This review focused on the aquatic contamination of different heavy metals in water and fish and also suggested some recommendations to minimize the marine environment's toxicity.

Keywords: Heavy metals, contamination, bioaccumulation, marine ecosystem, health risk

INTRODUCTION

Among the pollutants generated by industry and urbanization, heavy metals and various pathogenic bacteria are the most dangerous because they can cause serious health problems for the human population. Because of natural and anthropogenic activities, heavy metals are present in the environment, so people meet them mainly through the consumption of foods (Hărmănescu *et. al*., 2011). The primary sources of heavy metal contamination are growing and are represented by pesticides, fertilizers, industrial processes, and exhaust gases from automobiles (Albu, 2010). The main threats to human health are contamination with heavy metals, especially lead, cadmium and mercury. Heavy metals become toxic when the body does not metabolize them and accumulate in tissues (WHO, 2011). The contamination is habitually occurring through anthropogenic activities such as discharge of contaminated solid and liquid wastes, mining, abuse of agricultural chemicals, air pollution, and industrial processes such as tanning, dying, and energy and chemical plant operations. Soil and water are the primary victims for the contamination, food crops are in most cases secondary victims, except for the atmospheric deposit, (Abdullahi N, *et al.,* 2021).

Fish are widely consumed, firstly because they are part of the local diet and also because of their high protein, low saturated fat and omega fatty acids content, which are known to contribute to good health (Kennedy *et al.,* 2009). Fish absorb heavy metals from the surrounding environment (Ginsberg and Toal, 2009) depending on a variety of factors such as the characteristics of the species under consideration, the exposure period, the concentration of the element, as well as abiotic factors such as temperature, salinity, pH and seasonal changes. Hence, harmful substances like heavy metals released by anthropogenic activities will accumulate in marine organisms through the food chain; as a result, human health can be at risk because of consuming fish contaminated by toxic chemicals. Pollution of the aquatic environment is a severe and growing problem Alinnor and Obiji (2010), which is usually brought about by increasing man's domestic, agricultural, commercial and industrial activities (Vander *et al.,* 2003).

However, heavy metals are considered the most hazardous environmental pollutants due to their bioaccumulation and toxicity tendencies (Al- attar, 2005). Heavy metals may precipitate, get absorbed on sediment particles, remain soluble or suspended in water and may be taken up by aquatic fauna upon their entry into water bodies (Puttaiah and Kiran, 2008; Mohamed, 2008)). Metals are then absorbed through gills and skin or ingested through food to cause bio-accumulative toxicity in fish, where the intensity of the toxicity is influenced by the temperature, oxygen concentration, pH and hardness of the water (Ayodele and Abubakar, 2001). Many marine lives are being destroyed due to the impact of human activities that discharge their waste, such as heavy metals, into the marine ecosystems. In 2014, East coast areas in Malaysia were heavily impacted by significant discharges from industrial outflows and municipal, especially at the Paka River after the flooding season and affected aquatic organisms, especially fish (Amad *et al.,* 2015).

An Overview of Heavy Metals Pollution

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The indiscriminate discharge of industrial effluents, raw sewage wastes and other waste pollute most of the environments and affects the survival and physiological activities of target organisms. Metals tend to accumulate and undergo food chain magnification. Heavy metals affect all groups of organisms and ecosystem processes, including microbial activities. The bioaccumulation of trace elements in living organisms and biomagnification in them describes the methods and pathways of these pollutants from one trophic level to another, exhibiting the higher bioaccumulation ability in the organisms concerned. Some of these organisms, like fish, are consumed by human beings. They could also cause catastrophic diseases like *Minamata* and *Itai-Itai*. Remediation approaches such as excavation and landfill, thermal treatment, electro-reclamation and soil capping have been proposed depending on the extension, depth and kind of contamination, but all are expensive and environmentally destructive. Hence, reducing toxic elements in an aquatic environment can be progressively monitored by currently accepted and updated methods (Baby *et al*., 2010).

Rajeshkumar and Li (2018) determined the bioaccumulation of heavy metals (Cr, Cu, Cd, Pb) content in freshwater edible fishes *Cyprinus carpio Linnaeus and Pelteobagrus fluvidraco*, which were caught from the Meiliang Bay, Taihu Lake, a large, shallow and eutrophic lake of China. The results showed that the Cr, Cu, Cd and Pb content in the edible parts of the two fish species was much lower than the Chinese Food Health Criterion (1994). However, the results showed marked differences in the four analysed metal content between the two species and different tissues and significant variations. Pb content was the highest in the liver of fishes, and Cd contents were almost the same in all organs of fishes, Cr contents were mainly enriched in the kidney and liver, and Cu contents were the highest in gills. However, the total metal bioaccumulation was most significant in the liver, gills and the lowest in the muscle. However, the total accumulations were highest in *P. fluvidraco* compared to *C. carpio*. This investigation indicated that fish products in Meiliang Bay and Taihu Lake were still safe for human consumption, but the amount consumed should be controlled under the Chinese Food Health Criterion to avoid excessive intake of Pb. Further, this is the first report on the seasonal distribution of heavy metals and proximate compositions of commercialized important edible fishes from Meiliang Bay, Taihu Lake, China.

Abdullahi *et al*. (2015) reported that the Wase Dam in the Minjibir Local Government Area of Kano State is not suitable for human consumption but can be used for rearing animals and other domestic uses. Ali *et al.* (2014) researched the effect of different heavy metal pollution on fish like cadmium (Cd), nickel (Ni), chromium (Cr) and lead (Pb) were tested in various organs like gills, livers, kidneys and flesh tissues of the control fish enduring in the natural water system. And most of the metals are present in the edible portion of fish. Eating fish also affects humans and can cause health problems. The levels of toxic elements in different fishes depend on the fish's sex, age, season and place. The pollution of waterways with anthropogenic activities is the primary cause of aquatic loss and an imbalanced food chain.

Obasohan and Eguavoen (2021) investigated the Seasonal variations of bioaccumulation of heavy metals in a freshwater fish *(Erpetoichthys calabaricus)* from Ogba River, Benin City, Nigeria. Their investigation showed that heavy metal concentrations in water and fish (*Erpetoichthys calabaricus)* of Ogba River were affected by seasons. The dry season concentrations were significantly higher than the rainy season concentrations. It was further shown that heavy metals distribution in the river (water and fish) followed the same pattern, indicating a close correlation between water and fish levels.

Ambedkar and Muniyan (2011) researched the bioaccumulation of some heavy metals in the selected five freshwater fish from the Kollidam River, Tamilnadu, India. The fish organs like the liver, gill, intestine, kidney and muscle from the five freshwater fish were carefully dissected to determine heavy metals like copper, zinc, cadmium, lead and chromium. The levels of heavy metals were determined using ELICO's SL-176 double beam Atomic Absorption Spectrophotometer (AAS). The result shows the copper concentration was the maximum level, followed by Cd > Pb > Cr > Zn. The highest level of copper was observed in the liver tissue of *Saurida undosquamis*. The lowest zinc level was observed in the muscle tissue of *Saurida undosquamis*. These levels of heavy metals accumulated by the five freshwater fish species might be due to the increase in agricultural influx waters and some anthropogenic activities.

Rapid industrialization and advanced agricultural activities led to the contamination of the aquatic environment with heavy metals. Heavy metals ultimately pass into the human body through marine animals like fish, prawns and crabs (Salam *et al.,* 2019). Heavy metals in an aquatic ecosystem are considered essential pollutants since they are present throughout the ecosystem and are detectable in necessary amounts. Heavy metals, such as mercury, cadmium, copper, lead and zinc, are the essential pollutants affecting the aquatic environment and fish. They are extremely dangerous for the health of fish. Most of these metals are characterized by being accumulated in tissues and lead to the poisoning of fish. These metals can effectively influence fish's vital operations and reproduction, weaken the immune system and induce pathological changes. As such, fish are used as bio-indictors, playing an important role in monitoring heavy metals pollution (Authman *et al.,* 2015).

The heavy metals generally enter the aquatic environment through atmospheric deposition, erosion of geological matrix or due to anthropogenic activities caused by industrial effluents, domestic sewage and mining wastes. The metal contaminants in aquatic systems usually remain either in soluble or suspension form and finally tend to settle down at the bottom or are taken up by the organisms.

The progressive and irreversible accumulation of these metals in various organs of marine creatures leads to metal-related diseases in the long run because of their toxicity, thereby endangering the aquatic biota and other organisms. Fishes, one of the main aquatic organisms in the food chain, may often accumulate large amounts of certain metals. Directly acting or synergistically acting metals like Fe, Zn, Pb, Cd, Cu and Mn are common toxic pollutants for fish. The bioaccumulation of trace elements in living organisms and biomagnification in them describes the processes and pathways of these (possible) pollutants from one trophic level to another, exhibiting the higher bioaccumulation ability in the organisms concerned. Increasing concentration through the food chain caused a higher retention time of toxic substances than other typical food components. "Toxic metals, including "heavy metals," are individual metals and metal compounds that have been shown to affect people's health negatively. In minimal amounts, many of these metals are necessary to support life (Baby *et al.,* 2010).

In recent years, world fish consumption has increased simultaneously with the growing concern about their nutritional and therapeutic benefits. In addition to its important source of protein, fish typically have rich contents of essential minerals, vitamins and unsaturated fatty acids (Mederos *et al.,* 2012). The American Heart Association recommends eating fish at least twice per week to reach the daily intake of omega-3 fatty acids (Kris-Etherton *et al.,* 2002). Two main ways heavy metals enter the aquatic food chain are directly consuming water and food through the digestive tract and non-dietary routes across permeable membranes such as the muscle and gills (Ribeiro *et al.,* 2005). Therefore, levels in fish usually reflect levels found in sediment and water of the aquatic environment from which they are sourced (Nhiwatiwa *et al.,* 2011) and exposure time (Annabi *et al.,* 2013).

Bat *et al*., (2017) reported that the concentrations of heavy metal contaminations are an essential factor because of their hazardous effects on the coastal marine ecosystem. These heavy metals are tolerable at even low levels, and above specific concentrations, they become toxic for marine species, especially fish. The significant risk to the consumer is especially nonessential metals such as mercury, arsenic, cadmium and lead.

Heavy metal contamination of coastal marine ecosystems is associated with a wide range of sources like the dumping of industrial and domestic waste, untreated sewage, spills of toxic chemicals, agricultural chemicals and others, which can impact the health of marine life. It should not be forgotten that fish are natural water inhabitants and cannot escape the harmful effects of heavy metals. Fish are exposed to heavy metals in polluted and contaminated waters. Heavy metals from human activities and sources are continually released into aquatic ecosystems. They are serious health risks due to their toxicity, long persistence, bioaccumulation and biomagnifications in the food chain (Bat *et al*., 2017).

Khayatzadeh, and Abbasi (2010) researched The Effects of Heavy Metals on Aquatic Animals. They discovered that Heavy metals consist of less than one per cent of living mass organisms, and their different densities cause some disorders. Surface waters and acidic rains can transfer these metals to oceans via a polluted washing environment. Heavy metals naturally exist in minimal amounts in damp places. Metals pollution of the sea is less than other types of water pollution, but its effects on marine ecosystems and humans are extensive. Industrial wastes in aquiculture cause toxic effects on aquatic organisms, especially fish. Aquatic organisms absorb the pollutants directly from water and indirectly from food chains. Some poisonous effects of heavy metals on fishes and marine invertebrates are a reduction of developmental growth, an increase in developmental anomalies, a decrease in fish's survival- especially at the beginning of exogenous feeding or even cause the extinction of entire fish's population in polluted reservoirs. These consequences can affect geological, hydrological and, finally on, biological cycles. Thus, it seems that more consideration of bio conservation protocols is essential.

Fish can accumulate heavy metals in their tissues by absorption along the gill, surface and kidney, liver and gut tract wall to higher levels than the environmental concentration (Annabi *et al.,* 2013). Accumulating heavy metals by organisms may be passive or selective; differences in the accumulation of heavy metals by organisms could result from differences in assimilation, egestion or both (Egila *et al.,* 2011).

Nonessential heavy metals such as Cadmium (Cd), Mercury (Hg), and Lead (Pb) have no known essential role in living organisms, exhibit extreme toxicity even at deficient (metal) exposure levels and have been regarded as the main threats to all forms of life especially human health (Eisler, 1985). Toxic effects occur when excretory, metabolic, storage and detoxification mechanisms can no longer counter uptake, eventually resulting in physiological and histopathological changes (Obasohan *et al.,* 2008; Vinodhini *et al.,* 2009).

Biomarkers can offer additional biologically and ecologically relevant information and valuable tool for establishing guidelines for effective environmental management. So, it can be stated that fish biomarkers are necessary for monitoring environmentally induced alterations to assess the impact of xenobiotic compounds (i.e., heavy metals) on fish. Also, it is recommended that all kinds of wastewater, sewage and agricultural wastes be treated before discharge into the aquatic systems. Also, enforcement of all articles of laws and legislation regarding protecting marine environments must be considered (Authman *et al.*, 2015).

The heavy metal concentration in fish is essential concerning nature management and human consumption. Heavy metals, such as mercury, cadmium, copper, lead and zinc, are the most critical pollutants affecting the aquatic environment and fish. They are extremely dangerous for the health of fish. Most of these metals are accumulated in tissues, leading to the poisoning of fish and humans through the food chain (Authman *et al.,* 2015).

Le Saux *et al.,* (2020) reported that Toxic metals remain a current substantial threat to aquatic ecosystems, despite regulatory efforts to reduce their release. Several toxic metals already appear in the list of priority substances polluting surface waters. At the same time, concerns arise from the increasing use of technology-critical metals such as metallic nanoparticles, rare-earth, and platinum group metals. In aquatic environments, various chemical, biological and physical processes determine the impact of metals on the biota.

Hamed *et al.,* (2013) conducted research to assess Heavy Metals Pollution and Microbial Contamination in Water, Sediments and Fish of Lake Manzala, Egypt and studied the direct and indirect effects of disposal of wastewater, industrial and agricultural drainage water into the lake on the environmental situation. Samples were collected from four sites in the lake and one in the drain. The selected sites are exposed to direct and indirect industrial, municipal wastewater and agricultural drainage disposals. Water, sediment and fish samples were analysed for the concentration of five primary heavy metals (Mn, Cd, Zn, Pb and Cu), and two groups of bacteria (Total viable bacteria TVB - faecal coliform bacteria FCB). Results show that all the water and sediment samples collected from five sites contain different concentrations of the five tested heavy metals. Due to the industrial disposal, the highly polluted site with Zn, Pb, and Cu in sediment was found in the drain. The highly contaminated site with Zn and Cu in water and Cd in deposit was located near the industrial area due to the direct disposal of factories nearby. All five sites were contaminated with a high rate of TVB and FCB in water, an indicator of untreated wastewater spilt directly or indirectly into the lake. The most alarming result was when analysing fish; all the fish samples were contaminated on the surface and internally with very high amounts of TVB and FCB at the gill and intestine. Fish samples also had high concentrations of analysed heavy metals in their flesh (Hamed *et al.,* 2013).

Escalating human populations and economic development have significantly contributed to the current worldwide deterioration in water quality, including seasonal accumulation of heavy metals such as Cu, Cr, Cd and Pb from Meiliang Bay, Taihu Lake (Varol 2013; Zhang *et al.,* 2015); Rajiskumar *et al.,* 2018). Essential and nonessential metals have been demonstrated to accumulate along the trophic chain in freshwater ecosystems (Wang *et al.,* 2002; Uysal *et al*., 2008). Nonessential metals are not known to play any metabolic function although, therefore to their bioaccumulation in fish, these metals can be toxic for humans, even at very low concentrations as reported by Anwar *et al*. (2009).

Even in the current era of growing technology, the concentration of heavy metals in drinking water is still not within the recommended limits set by the regulatory authorities in different countries. Drinking water contaminated with heavy metals, namely arsenic, cadmium, nickel, mercury, chromium, zinc, and lead, is becoming a significant health concern for the public and health care professionals. Occupational exposure to heavy metals is known to occur through the utilization of these metals in various industrial processes and/or contents, including colour pigments and alloys. However, the predominant source resulting in measurable human exposure to heavy metals is the consumption of contaminated drinking water. The resulting health issues may include cardiovascular disorders, neuronal damage, renal injuries, and risk of cancer and diabetes. The general mechanism involved in heavy metal-induced toxicity is recognized to be the production of reactive oxygen species resulting in oxidative damage and health-related adverse effects. Thus, the utilization of heavy metal-contaminated water is resulting in high morbidity and mortality rates worldwide (Rehman *et al.,* 2018).

Bioaccumulation of Heavy Metals in Biota

Bioaccumulation of heavy metals in biota is essential from an environmental, ecological, and human health point of view and has important implications for wildlife and human health. Different animal species have been suggested as bioindicators of heavy metal pollution. For example, the date mussel (*Lithophaga lithophaga*) has been suggested as a valid bioindicator of marine pollution (Miedico *et al.,* 2016). Contamination of aquatic and terrestrial food chains with potentially toxic heavy metals threatens consumer organisms' health, including humans. In aquatic ecosystems, organisms are simultaneously exposed to different metals, which may have additive, synergistic, or antagonistic interactions (D˙Ir˙Ilgen *et al.,* 2001).

The topic of bioaccumulation of heavy metals in biota is vast. Here, the discussion will be limited to the bioaccumulation of heavy metals in fish, which serve as the primary dietary sources of heavy metal exposure for the general human population. Bioaccumulation of Heavy Metals in Freshwater Fish Aquatic biota is exposed to heavy metals through different routes such as water, sediments and food (Youssef and Tayel, 2004). Freshwater fish are exposed to various toxic heavy metals released to freshwater bodies from natural and anthropogenic sources. Contamination of fish by heavy metals has become an important global issue because it poses a threat to fish and health risks to fish consumers (Rahman *et al.,* 2012). Assessment of heavy metal bioaccumulation in fish species of different aquatic habitats is critical (Yousafzai *et al.,* 2017).

Assessment of heavy metal levels in fish tissues is essential for aquatic ecosystem management and human consumption of fish (Ariyaee *et al.,* 2015). Fish have high levels of unsaturated fatty acids and low levels of cholesterol. They are an essential source of proteins (Malakootian *et al.,* 2016). Using an edible fish in the human diet is beneficial and therefore recommended in a balanced diet. However, contamination of fish by toxic heavy metals is considered a risk to human health. It has raised concerns about their consumption, especially in more sensitive human populations such as women, children, and people at risk of diseases from other causes.

Metals and Their Essentiality for Life

Ali *et al.* (2019) reported that, Chemically, metals are defined as "elements, which conduct electricity, have a metallic luster, are malleable and ductile, form cations, and have basic oxides". Terms usually used for metals in biological and environmental studies are metal, metalloid, semimetal, light metal, heavy metal, an essential metal, beneficial metal, toxic metal, abundant metal, available metal, trace metal, and micronutrient, Duffus (2002). Metals have diverse applications and play an essential role in industry-dominated human society. Some metals have critically important physiological and biochemical functions in biological systems, and either their deficiency or excess can lead to disturbance of metabolism and various diseases. Some metals and metalloids are essential for (biological) life.

They play important physiological and biochemical roles in the body as they may be part of biomolecules such as enzymes, which catalyse biochemical reactions in the body, therefore need to be regulated due to their toxicity, (Duffus, 2002).

Table 1: Values of permissible limits of heavy metals in fish recommended by FAO

Recommended organization	Name of Metal	Value ($mgkg^{-1}$)
FAO (1983)	Cr	0.15-1.0
	Zn	30.0
	Mn	1.0
	Fe	100
	Co	0.04-0.26
	Cu	30.0
	Se	1.0
	Rb	-
	Hg	0.5
	Ni	80.0

	As	1.0
FAO (2003)	Cd	0.0.5
	Pb	0.20

Heavy Metals Effects and Toxicity

According to Csuros and Csuros (2002), heavy metal is defined as "a metal with a density greater than 5 g/cm^3 (i.e., specific gravity greater than 5)." According to Duffus (2002), "the term "heavy metals" is often used as a group name for metals and semimetals (metalloids) that have been associated with contamination and potential toxicity or ecotoxicity." We have recently proposed a broader definition for the term. Heavy metals have been defined as "naturally occurring metals having an atomic number greater than 20 and an elemental density greater than 5gcm^{-3} Ali and Khan (2018).

Environmentally Most Hazardous HMs and Metalloids

Heavy metals are among the most investigated environmental pollutants. Almost any heavy metal and metalloid may be potentially toxic to the biota, depending upon the dose and duration of exposure. Many elements are classified into heavy metals, but some are relevant in the environmental context. List of the environmentally pertinent most toxic heavy metals and metalloids contain Cr, Ni, Cu, Zn, Cd, Pb, Hg, and As (Fu *et al.,* 2017). Heavy metal pollutants most common in the environment are Cr, Mn, Ni, Cu, Zn, Cd, and Pb (Baraka, 2011). In 2009, China suggested four metals, i.e., Cr, Cd, Pb, Hg, and the metalloid As, as the highest priority pollutants for control in the "12th 5-year plan for comprehensive prevention and control of heavy metal pollution" Fu *et al.* (2017). Some other heavy metals are also hazardous to live organisms depending upon the dose and duration of exposure. For example, Mansouri *et al.* (2012) found Ag more toxic than Hg to freshwater fish.

Heavy Metal Toxicity

Csuros and Csuros (2016) reported that although some heavy metals, called essential heavy metals, play important roles in biological systems, they are generally toxic to living organisms depending on dose and duration of exposure. In toxicology, it is a well-known fact that "excess of everything is bad." Nonessential heavy metals (Cd, Pb, and Hg) and metalloids (As, etc.) may be toxic even at quite low concentrations. Essential heavy metals are required in trace quantities in the body but become toxic beyond certain limits or threshold concentrations. For some elements, the window of essentiality and toxicity is narrow. Heavy metals have been reported to be carcinogenic, mutagenic, and teratogenic. They cause the generation of reactive oxygenic species (ROS) and thus induce oxidative stress. Oxidative stress in organisms leads to various diseases and abnormal conditions. Heavy metals also act as metabolic poisons. Heavy metal toxicity is primarily due to their reaction with sulfhydryl (SH) enzyme systems and their subsequent inhibition, e.g., those enzymes involved in cellular energy production (Csuros and Csuros, 2016).

Human Exposure to Heavy Metals

Humans are exposed to toxic heavy metals in the environment through different routes, including ingestion, inhalation, and dermal absorption. People are more exposed to toxic metals in developing countries, Eqani (2016). Generally, people have no awareness or knowledge about exposure to heavy metals and their consequences for human health, especially in developing countries, Afrin (2015). People may be exposed to heavy metals in the workplace and the environment. Human exposure to toxic chemicals in the workplace is called occupational exposure, while exposure to such chemicals in the general environment is called nonoccupational or environmental exposure. Workers are exposed to heavy metals in mining and industrial operations, where they may inhale dust and particulate matter containing metal particles. People extracting gold through the amalgamation process are exposed to Hg vapours. It has been reported that welders with prolonged occupational exposure to welding fumes had significantly higher levels of the heavy metals Cr, Ni, Cd, and Pb in their blood than the control and showed increased oxidative stress (Mahmood, 2015).

Cigarette smoking is also a principal source of human exposure to Cd (Jarup, 2003) and other toxic heavy metals in tobacco leaves. Ingestion of heavy metals through food and drinking water is a major exposure source for the general human population. Industrialization, urbanization, and rapid economic development around the globe have led to intensification in industrial and agricultural activities. Such activities may cause contamination of water, air, and soils with toxic heavy metals. Growing human foods in heavy metal-contaminated media leads to bioaccumulation of these elements in the human food chains from where these elements ultimately reach the human body (Ali *et al.,* 2019).

Effects of Toxic Heavy Metals on Human Health

The heavy metals Cadmium (Cd), Lead (Pb), Mercury (Hg), and Arsenic (As) deplete the major antioxidants of cells, particularly antioxidants and enzymes having the thiol group (—SH). Such metals may increase the generation of reactive oxygen species (ROS) like hydroxyl radical, superoxide radical and hydrogen peroxide. Increased generation of ROS can devastate the inherent antioxidant defences of cells and lead to a condition called "oxidative stress" (Ercal, 2001). Heavy metals, including Cd, Pb, and Hg, are nephrotoxic, especially in the renal cortex (Wilk *et al.,* 2017). The chemical form of heavy metals is important in toxicity. Mercury toxicity largely depends on Hg speciation (Ebrahim pour, 2010). Relatively higher concentrations of toxic heavy metals, i.e., Cr, Cd, and Pb, and relatively lower concentrations of the antioxidant element Se have been found in patients of cancer and diabetes compared to those in the normal subjects in Lahore city (Rehman *et al.,* 2011).

Fish

Fish is one of the most important foods in the human diet because of its high nutritional quality. They are the well-known source of a group of polyunsaturated fatty acids (PUFAs), especially omega-3 and omega-6, which can prevent atherosclerosis and thrombosis. These fatty acids have preventive effects on coronary heart diseases, autoimmune disorders, arrhythmias, and lowering plasma triglyceride levels and blood pressure. Almost all the minerals present in fish which is required by our body are found in fish. The minerals present in fish are Iron (Fe), Calcium (Ca), Zinc (Zn), Phosphorus (P), Selenium (Se), Fluorine (F) and Iodine (I). These minerals have high bioavailability; they can easily be absorbed by the body (Pal *et al.,* 2018).

Proximate Composition

The proximate composition is a term usually used in food or feed, including moisture, ash, lipid, protein, and carbohydrate content, expressed as the content percentage. Different authors have studied the proximate composition of almost all the food fishes. However, variation in design based on their nutritional quality depends mainly on their feeding habits, seasons, adaptation temperature, age, sex, state of spawning, availability of feed etc. The Proximate composition of several marines, freshwater and brackish water fish has been reported (Gopakumar, 1997). Proximate constituents together form about 95-98% of the total weight of the tissue. Others, including carbohydrates, vitamins, free amino acids and non-protein nitrogenous compounds, are also in small quantities. These food components may interest the food industry for product development, quality control or regulatory purposes (Pal *et al.,* 2018).

Vitamins

All the vitamins are necessary for the good health of humans, and they are present in good amounts in fish, but they vary widely from species to species and throughout the year. Fish is an excellent source of vitamins that hold very important body functions. Oily fish is a rich source of vitamins A and D, which are important in the growth and development of children. Whitefish is a good source of B vitamins. Vitamin A is necessary for normal growth, formation of bones and teeth, and cell building; it prevents poor eyesight and helps treat many eye diseases. Vitamin D helps correctly use calcium and phosphorus, which are necessary for strong bones and teeth. Combined with vitamins A and C, it helps prevent colds. Vitamin B is essential for enzyme functioning, accelerating chemical processes in the body. Vitamin K helps prevent internal bleeding and stimulates the correct coagulation of blood. Fatty seafood such as mackerel, herring, salmon and trout are all rich in vitamins A and D. Fish oil, taken with vitamin E, reduces inflammation, joint swelling, pain and tenderness characteristic of rheumatoid arthritis. Vitamin K present in fish is responsible for the anti-haemorrhage factor (Anon 2017).

Minerals

Fish is a good source of almost all the minerals in seawater, and the value ranges from 0.4 to 1.5% (wet basis). The mineral in fish includes iron, calcium, zinc (from marine fish), phosphorus, selenium fluorine, and iodine. These minerals have high 'bioavailability', meaning that the body quickly absorbs them (Balachandan, 2002). The availability of iodine and selenium in marine fish is of particular significance from a nutritional point of view. Iodine is important for the hormones thyroxin that regulate body metabolism, and in children, it is required for growth and mental development. Selenium is an essential antioxidant trace element. Iron is important in synthesizing haemoglobin in red blood cells for transporting oxygen to all body parts. Calcium is required for solid bones (formation and mineralization) and the normal functioning of muscles and the nervous system. The intake of calcium, phosphorus and fluorine is higher when small fish are eaten with their bones instead of discarding fish bones (Balachandan, 2002).

Essential Fatty Acid

Fatty acids are natural components of fats and oils. They are classified based on their chemical structure into three groups: saturated, mono-unsaturated and polyunsaturated fatty acids. Saturated fatty acids are mainly found in animal foods, such as meat, lard, sausage, butter and cheese, but even in palm kernel and coconut oil, which are used for frying. Unsaturated fatty acids are mainly of fatty fish origin. Polyunsaturated fatty acids (PUFAs) are two different groups: 'omega-3-fatty acids 'and 'omega-6-fatty acids' Both are essential fatty acids because humans cannot synthesize them; therefore, they must be obtained from diet or supplementation (Kris-Etherton *et al.,* 2002). Omega-3s are a family of long-chain polyunsaturated fatty acids that are essential nutrients for health and development. Research indicates that the two most beneficial omega-3s are EPA (Eicosapentaenoic acid) and DHA (docosahexaenoic acid). They have several beneficial impacts on human health. These include decreasing the risk of myocardial infarction (Bucher *et al.,* 2002), lowering blood pressure and triglyceride concentration in blood (Harris *et al.,* 1997), enhancing the immune system (Damsgaard *et al.,* 2007) and sustaining proper brain function in the human body. They also protect against various psychological disorders, depression, attention deficit hyperactivity disorder, and cancer (Sinn, 2007).

CONCLUSIONS AND RECOMMENDATIONS

In recent years, responses to toxic metals in aquatic animals were studied in various experimental conditions, which helped to confirm that they trigger common toxicity pathways. Many investigations showed variable toxicity of Arsenic (As), Nickel (Ni), copper (Cu), Chromium (Cr), Lead (Pb), Mercury (Hg) and Zinc (Zn) for fish. Humans are also affected by eating fish which can cause different health problems. The levels of toxic elements in other fishes depend on the fish's sex, age, season and place. The pollution of waterways with anthropogenic activities is the primary cause of aquatic loss and an imbalanced food chain. There is a need to employ advanced technologies, generate less heavy metal pollution to the environment, adhere to the regulatory guidelines in treating industrial effluents before discharging them to waterways and ensure proper sewage handling and treatments to prevent or eliminate the loss of aquatic life and prevent heavy metals toxicity.

CONFLICT OF INTEREST

The authors declare there is no conflict of interest

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