Heavy Metals in Fish: Bioaccumulation and Health

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ABSTRACT: *Heavy metals occur during natural processes and are also obtained during anthropogenic activities. Heavy metals include chromium, cadmium, arsenic, lead, zinc, nickel, mercury, selenium and copper hence their presence in the aquatic habitat are highly toxic to fishes and shell fishes. Heavy metals are found in the aquatic environment as a result from contamination by heavy metals from industrial, agricultural waste and by-products and domestic waste and by products. The increasing level of heavy metals in fish is alarming and has spurred scientists to make researches on the dangers caused by the heavy metals resulting to heavy metal accumulation and bioaccumulation of life cells. The aim of this study was to assess the possible sources of heavy metal in the aquatic environment, impact of heavy metals in the aquatic environment, its bioaccumulation in fish and human health impact. Several reports tell of the detrimental effect of heavy metals in fish (some of which include; poisonous effect in the blood such as anemia, eosinophilia, lymphocytosis, renal lesions, convulsions and ataxia, detachment of gills, fusion of secondary gill filaments, acute inflammation in the liver, amongst several others) and in man (some of which include, skin diseases, Irritation of the gastrointestinal mucosa, nephritis, lung cancer, liver and kidney damage, necrosis, neurological and behavioral disorders and death amongst others). In conclusion, the toxic effects of heavy metals in fish and the effect of bioaccumulation and bio-magnification have been reviewed in this paper. It is therefore recommended that the treatment of all forms of wastewaters, agricultural waste, sewage, industrial effluents be carried out before their discharge in to the environment. Also, the enforcement of all laws, legislations regarding the protection of aquatic life and environment should be enforced and sanctions meted out against defaulters.*

KEYWORDS: heavy metals, pollution, bioaccumulation, growth, health, death.

INTRODUCTION

Heavy metals are metals which have a density of above 5mg/cm3 and negatively affect life in any form. They are harmful when they exceed threshold limits. (WHO 2011). Heavy metals occur during natural processes such as erosion, volcanism and weathering. HM are also obtained during anthropogenic activities that takes place in the; industry, mining, metal smelting, oil refining, agriculture and fertilization and drainage (Wei et al., 2018)

These heavy metals are substances that occur naturally in the environment but in trace amounts with no important biological role to play in human existence; causing many toxic effects that lead to malfunctioning of the body systems and disruption of metabolic process. (Yarson and Yipel, 2013).

Heavy metal pollution in rivers, streams and lakes is of severe threat to fisheries and public water supplies. (Auta et al., 2005; Agbugui and Deekae, 2013; Mensor and Said, 2018). Heavy metals are found in the aquatic environment as a result from contamination by heavy metals from industrial, agricultural waste and by-products and domestic waste and by products. When HM become highly concentrated in a medium or niche such as air, water and soil such medium becomes toxic and then accumulate in the environment because they do not degrade. Gradual, persistent and increasing accumulation of these heavy, toxic metals can lead to devastating effects to life and aquatic biomes, fish life, diversity and conservation. (Mensor and Said, 2018; Agbugui et al., 2019). Living organisms especially humans become contaminated by association with aquatic systems polluted by organic and inorganic HM and from the consumption of contaminated fish and other aquatic foods from such environment (Baharom and Ishak, 2015).

Fish is a basic and important food for human nutrition, providing protein, healthy fatty acid with low cholesterol level that is healthy for consumption and capable of reducing the risk of heart diseases and stroke as well as essential minerals and vitamins (Agbugui et al., 2011). The role of Fisheries in the ecosystem serving as food along the food chain, hence their presence and importance cannot be overlooked as the heavy metal accrued in fish results to an impact in human health (Azaman et al., 2015; Agbugui et al., 2019).

In recent years, the increasing level of heavy metals in fish is alarming and has spurred scientist to make researches in the dangers caused by the heavy metals resulting to heavy metal accumulation and bioaccumulation to life cells.

Heavy metals are easily accumulated in fishes because they are readily taken up by body parts of fishes such as body surface, gills, digestive tract, liver and muscles. The highest point of HM levels of concentration in the organs of organisms are often the gills then the liver and then the muscle shows the lowest concentration levels. However, the muscles are the most source of heavy metal intake to the body since the muscles are the largest consumed parts of the body hence the ability to cause negative impact towards health (Mahmood and Alkhafaji 2016). Caution must be taken to assess the levels of heavy metals for consumption (Mensoor and Said 2018, Azaman et al., 2015; WHO 2011)

Heavy metals include Chromiun (Cr) cadmium (Cd), Arsenic (As) lead (Pb), Zinc (Zn), Nickel (Ni), Mercury(Ag), Selenium(Se)and copper (Cu) hence their presence in the aquatic habitat are highly toxic to fishes and shell fishes. Freshwater fishes are more prone to HM pollution because of their higher ability to bioaccumulate thus are easily exposed and vulnerable (Authman et al., 2013a; Authman et al., 2013b)

The aim of this study was to assess the possible sources of heavy metal in the aquatic environment, impact of heavy metals in the aquatic environment, its bioaccumulation in fish and human health impact.

Heavy metals are introduced into the aquatic environment by activities from the use of:

Agricultural sector

Pesticides:

Pesticides are all chemicals and substances that are used to kill or control pest and diseases which includes herbicides (weed), insecticides (insects), rodenticides (rodents), fungicides (fungi), nematocides (nematodes) or in public health programs to protect humans from vectors-borne diseases such as malaria, dengue fever and schistosomiasis. In addition to the aforementioned are; pet shampoos, skin care and tick sprays for live stock and boat bottoms in order to eliminate or prevent the presence and growth of unwanted species (Nicolopoulou- Stamati, 2016).

Pesticides and other forms of HM used in the agricultural sector often find their way in the aquatic environment through run off from the environment. They are however subject to airborne and water borne hazards. An example is the insecticide made from organochlorine such as dichloro-diphenyl- trichloroethane (DDT) and lindane (-HCH), which were widely and popularly used from the 1950s to the 1970s became ubiquitous in the environment due to their high environmental persistence and potential for long-range atmospheric transport (USEPA 1979; Nicolopoulou-Stamati, 2016).

The waterborne hazard is often of derived by precipitation and then irrigation. These processes often wash compounds from the farm lands into waters bodies via runoff or subsurface flow or into the groundwater (Kim et al., 2008; Witczak and Abdel-Gawad 2014; Blaznik et al., 2015).

Pesticides are also organic micro pollutants that have ecological impact when introduced into agriculture to enhance and promote the production of food and produce. These heavy pesticides often get into water bodies and cause adverse effect to the life it inhabits and the environment.

The high rise in pesticides concentration and deposition in the environment causing pollution is often attributed to the rapid urbanization, industrialization, economic growth, development of dynamic agricultural practices, increased human and domestic activities. (Sharma et al., 2019).

Fertilizers:

Streams, lakes and rivers surrounded by farmlands engaged in use of heavy metal enriched fertilizers have shown possible and positive correlation to the rise in heavy metals in from the use of chemical, organic and water soluble fertilizers for a long period. Wei (2020) reported highly positive correlations between TN and ACd, TN and PPb, and TN and PZn. Again, stating that nitrogen fertilizer significantly elevated the levels of Cd, Pb, and Zn availability in source water. Furthermore, it was confirmed that the sources of Cd, Cu, and Zn were related to the sources of

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AP, especially when phosphate fertilizers were used. Furthermore, it is reported that source water from along farms from the application of manure, chemical fertilizer, organic fertilizer, compound fertilizer, and watersoluble fertilizer reveal the availability and accumulation of heavy metals to be significantly influenced by AP, TN, and IN, which are associated with fertilizer application thus posing health risk to biodiversity in habitat (Mortvedt 1995; Guo et al., 2010; Li et al., 2019; Wei et al., 2020)

Industrial Sector

Geo-mining (quarry, blasting, crude oil mining)

The introduction of heavy metal into water bodies can be through natural occurrences such as volcanic eruption, land slide and anthropogenic activities like all forms of mining, crude oil spills, pipe line vandalism, illegal bunkering of crude oil, and untreated waste effluents containing metals. Surface water can easily be polluted by contaminants washed into it through run-off either from far polluted sites as non-point source pollution or through direct introduction into water bodies (dumping sites), as point source pollution (Akinnifesi et al., 2021). Recent reports from researchers in China state that water contamination by Heavy metals (As, Mn, Cr, Ni, Cu, Cd, Pb, and Zn) has evaluated. This was carries out by comparing water from industrial sites as against their concentrations with the guidelines for drinking water and surface water established by the China Environment Protect Agency (EPA) in 2002 and 2006 and it was reported that mining activity has significantly increased the seven Heavy metals in surface sediments. The mean concentrations of the HMs (As, Cr, Ni, Cu, Cd, Pb, and Zn) were significantly higher than the background mean value compared with the mean background sediment metal concentrations in the Heihe River basin (Wei et al., 2018). In Iludun-Ore and Environs in South-West Nigeria, the mining activities of tantalum niobium concentrates showed high level of Pb, Fe, Cr, Sr, Mn and Ni (Oyebamiji et al., 2018). Oyetibo et al. (2021), reported the capacity of characteristic sulphates (313.0 ± 15.9 mg l^{-1}), carbonate (253.0 ± 22.4 mg l^{-1}), and nitrate (86.6 ± 41.0 mg l^{-1}), having extreme tendencies to enrich receiving environments with extremely high pollution load index (3110 ± 942) for toxic metals/metalloid were observed in drains from Onyeama coal mine in Nigeria. The drains contained extreme levels of toxic metals/metalloid contamination and consequent astronomically high ecological risks in the order: Lead > Cadmium > Arsenic > Nickel > Cobalt > Iron > Chromium.

In Jos, Nigeria, high levels of HM associated with mineral ores were found in soils and underground water from Tin mines. The eight HM (CR, Cu, ZN, PB, Co, As, Cd, and Ni) had concentration above the Nigerian referred levels (Olarinoye et al., 2021).

Domestic waste (Waste water).

Processed water from cosmetic industries, detergent industries, textile industries often contain high levels of HM. The release of such waste into surrounding water bodies cause the disruption of the ecological balance of organisms.

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In the study of the Common carp *Cyprinus carpio,* the scheme of accumulation of heavy metals in reported to be at maximum in the gills, liver and then fish flesh. Most absorbed HM are for Cd and Pb respectively. In all heavy metals, the bioaccumulation of lead and cadmium proportions was extensively augmented in tissues of (Ashref et al., 2019).

Effects of Heavy Metal in Fish and Man

Chromium (Cr) In Fish

Chromium is reported to have lesser accumulation on fish muscles compared to fish gills. Chromium shows poisonous effect in the blood such as anemia, eosinophilia and lymphocytosis, branchial and renal lesions. EPA recommendation for possible level are 50 to 100ugCr/L for protection of human health and aquatic life respectively (Ashref et al., 2019)

Chromium in Man.

Workers in the textile and steel industries are often affected by Cr (IV) which is harmful to human health. Tobacco smokers also have higher possibility of disclosure to Cr. Chromium (VI) can cause many health effects. Chromium in leather products can cause skin rash-like allergies. Exposure to Cr can cause nose irritations and nosebleeds. Other health problems caused by Cr (VI) are: Faded immune system, Skin diseases, Irritation of the gastrointestinal mucosa, Nephritis, Lung cancer, liver and kidney damage, Necrosis, death in man (Karadede et al., 2004).

Mercury (Hg) in fish

Mercury is taken up during ingestion and passed on the liver where its action is distributed. In the liver, it binds, stores, and redistributes the mercury through peripheral circulation for bioaccumulation in different tissues, mostly in the kidney, liver and gill tissues. Methyl mercury is one of the most toxic compounds to fish usually generated through methylation of inorganic mercury by anaerobic microorganism as sulfate-reducing bacteria SRB, methagens MPA and iron reducers FeRP (Pack et al., 2014). The lethal concentration of Hg varies according to fish species. Svoboda, (1993) reported a range from 0.3-1mg/l in Salamon fish, while in cyprinid, it reaches 0.2- 4mg/l and 0.20-0.70 mg/l.

The toxicity of Mercury is accompanied by convulsions and ataxia, detachment of gills, fusion of secondary gill filaments, acute inflammation in the liver with degeneration of the blood vessels (Selvanathan et al., 2013 Raihan et al., 2020). Low levels Hg in the reproductive system in Zebra fish affect the survival rate of eggs and fry, degenerative ovary tissue, leads to reduces egg production, also in *Gymnotus carapo,* it affects spermatogenesis and availability of spermatozoa as a result of histopathological alteration in the testes structure, disorganization of seminiferous tubules with a reduction in the germ cells proliferation (Vergilio et al., 2013; Zhang et al., 2016).

Mercury (Hg) in Man

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Inhalation of elemental mercury vapours can cause neurological and behavioural disorders such as tremors, emotional instability, insomnia, memory loss, ulcers and cancers in the thyroid and kidneys. Mercury is poisonous causing mutagenic effects, disturbs the cholesterol levels and high exposures can lead to death (greenfacts.org).

Lead (Pb) in fish

Pb is a hazardous substance commonly characterized as a persistent heavy metal. (Abadi et al., 2014). Pb is a naturally occurring metal however, its concentrations in the environment are largely increased by anthropogenic activities such as base metal mining, battery manufacturing, lead-based paints and lead-gasoline (Abadi et al., 2014; Krishnani et al., 2003; Kennedy 2011). Lead in water may come from industrial and smelter discharges; from the dissolution of old lead plumbing, lead containing pesticides, through precipitation, fallout of lead dust, street runoff, and municipal wastewater. Pb can become toxic to fishes when it is accumulated to a substantially high level (Yildirim, et al., 2009). Pb as a potent environmental pollutant affects the trophic levels in a food chain. Pb from system run offs, industrial and sewage waste and are taken up by fish through ingestion and inhalation from aquatic medium. High doses of Pb in the water can cause metabolic poisoning, generative damage in some aquatic life and cause blood and nervous changes, irritability, anemia and behavioural changes in fish. (MacCoy et al., 1995; Vincent-Akpu and Yanadi, 2014).

Lead (Pb) in Man

Man can be affected by Pb through food ingestion and breathing and then accumulated in the muscles, bones, blood and fat. Leads is reported to affect Newborns and young children even at low levels.(MacCoy et al., 1995).

Pb is known to severely damage to liver, kidneys, brain, nerves and other organs, reproductive disorders osteoporosis (brittle bone disease) heart disease, high bloodpressure, especially in men, anemia, memory problems, behavioral disorders, mental retardation while lesser levels of Pb damage thenerves and brain in fetuses and young children, resulting inlowered IQ and learning deficits (Elder and Collins 1991; Healey 2009).

Arsenic (As) in Fish

Arsenic is a substance used in the agricultural sector for the production of pesticides and defoliants. It is significantly used to kill aquatic plants to reduce the difficulty encountered during hook-and-line fishing of areas overgrown with aquatic vegetation (kinuthia et al., 2020). Just like other HM, Arsenic is able to accumulate in large quantities in the sediments in the beds of water courses and reserviours and in turn aquatic organisms (Suhendrayatna et al., 2002). Suhendrayatna et al., (2002) reported the LC_{50} for *Oryzias laticepes* were 14.6 and 30.3 mg /l, acute exposure to arsenic causing sudden death of fish because of increase in mucus secretion damage to gill epithelium and then suffocation. It is mentioned by Sorensen (1991) also that Arsenic toxicity causes

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histopathological changes and defects in internal organs such as kidneys, liver with focal hepatic necrosism bie duct proliferation with plugs, parenchymal hepatocytosis. Apoptosis of the heart muscles, enlargement of intestinal mucosa and submucosa (Hossain, 2012). Acute exposures can lead to death. Chronic exposures can result in the accumulation of the metalloid to toxic levels and is responsible for several disease conditions (Sorensen (1991; Suhendrayatna et al., 2002; Hossain, 2012).

Arsenic (As) in Man

The ingestion of high levels of inorganic arsenic causes negative effects to the human system. Some of such effects include skin diseases, vascular disease including arteriosclerosis (Peripheral vascular disease and ischemic heart disease (ISHD), renal disease, neurological effects, cardiovascular disease, chronic lung disease, cerebrovascular disease, reproductive effects and cancers of skin, melanosis, keratosis, lungs, liver, kidney and bladder, non insulin dependent diabetes mellitus and visual impairment in children (Singh et al., 2007; Singh et al., 2010).

Cadmium (Cd) in Fish

Increased industrial activities in the 20th, and 21st century has lead to enormous cadmium production, consumption and emissions to the environment due to its uses and consequently lead to contamination of aquatic habitats (Jitar et al., 2014). The use of cadmium for industrial uses such as manufacturing of batteries, electroplating, plastic stabilizers, pigments and fertilizers, agricultural chemicals, pesticides and sewage sludge in farm lands that often runoff into groundwater and surface water, might also contribute to the contamination of aquatic habitat hence fishes through bioaccumulation. Benaduce etal., (2008) and Sassi et al., (2010), have reported morphological and histological alterations in liver of fishes exposed to cadmium stating that higher doses of cadmium caused visible external lesions such as discoloration and necrosis on livers of *Cyprinus carpio, Carassius auratus* and *Corydoras paleatus*.

Cadmium (Cd) in Man.

Cadmium is a deleterious heavy metal and a byproduct of Zinc production. It has an instant destructive impact on humans. Ingestion of significant amount of Cadmium causes immediate poisoning and damage to the liver and kidney. Respiratory tract diseases and kidney problems resulting to kidney failure are the commonest diseases gotten from inhalation of cadmium dust. Compounds containing cadmium are carcinogenic thus easily causing cancer, it also causes weakening and total damage to bones (Rahi zadeh et al., 2017).

Aluminum (Al) in Fish

Aluminum in acid waters is acutely toxic to fish. The gill is the principal target organ mainly disrupting the lamellar epithelial cells and the gill epithelium. These aforementioned dysfunctions results in accelerated cell necrosis, sloughing and death of the fish (Exley et al., 1991). Slaninova et al., (2014), reported that a significant reduction in the growth of fish was observed with

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concentrations as of Al as low as 0.52 mg/l. Physiological and histological alterations are also frequently observed in different fish species exposed to Al. Some of such alterations are mainly related to cardiovascular, respiratory, reproductive and structural gill damage as well as liver and kidney damage (Lappivaara et al., 1999).

Aluminum (Al) in Man

Al is not easily detected in the human body in trace amounts consequently it is believed that aluminium is rapidly excreted within a short time of uptake from the body. Residual aluminium has been detected in organs and tissues in the body-most probably within the skeleton, and brain (Priest, 2004).

Chromium (Cr) in Fish:

Chromium is an essential nutrient metal necessary for metabolism of carbohydrates (WHO, 2011). Chromium will find its way into the aquatic ecosystem through effluents discharged from leather tanneries, textiles, metal fishing, electroplating dyeing, mining, printing industries, ceramics, photographic and pharmaceutical industries (WHO, 2011). Poor treatment of these effluents can lead to the presence of Cr (IV) in the surrounding water bodies, where it is commonly found at potentially harmful levels to fish (Rohasliney et al., 2014). The physicochemical parameters of a given water body especially surface waters determines the stability of chromium. The most stable forms of chromium are the oxidation states trivalent Cr (III) or ($Cr3+$) and the hexavalent Cr(VI) or ($Cr6+$). The hexavalent chromium ($Cr6+$) is considered to be toxic (i.e carcinogenic) because of its powerful oxidative potential and ability to cross call membranes (Ashraf et al., 2010). Fish assimilate Cr by ingestion, gill uptake or by accumulation in the tissues mainly through the liver and kidney. The concentration found in fish and other aquatic organisms are often higher and at lethal doses than those found in the environment (karadede et al., 2010). The overall toxic impact on organs like gill, livers, kidneys, heart may seriously affect the catabolic, anabolic and physiological activities which may deter the optimal growth and behavior of fish (Yilmaz et al., 2010). Common toxic effect of Chromium in fish include: anatomical, histological, hematological and morphological alterations, inhibition and reduction in growth, and impaired immune function (Yilmaz et al., 2007; Weber et al., 2013).

Chromium (Cr) in Man:

Chromium in man causes mucosal irritation, phytotoxic corrosion, irritation f the central nervous system which is followed by depression and in rare cases death (Weber et al., 2013).

Copper (Cu) in Fish:

Copper (Cu) is an essential trace metal. It is a necessary element needed in living organisms for cellular respiration. It is a natural element that occurs in abundance and widely used for many purposes (Coad, 2010). Copper pollution comes from the persistent use of pesticides, fungicides, insecticides, nematocides, molluscides, algaecides and discharge of waste where copper is an

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active ingredient (Balasim et al., 2013). The concentration of copper in these chemical products is extremely toxic to intracellular mechanisms in aquatic animals at high concentrations which are above the world acceptable limits (Zaikov et al., 2017). Copper is easily absorbed by the gills and readily stored in the fish liver. This accumulation is possible through diet or ambient exposure even at low temperatures in the environment (Azaman et al., 2015; Zaikov et al., 2017). Common effects include large amount of mucus on body surface, under the gill covers and in between gill, gill and kidney alterations. At high doses, visible external lesions such as discoloration and necrosis on livers of of *Cyprinus carpio, Carassius auratus* and *Corydoras paleatus*, alterations in gills (edema; vasodilatation of the lamellar vascular axis), alterations in the testes (testicular hemorrhage; pyknosis; disintegration of primary spermatogonia and interstitial tissue), reduced egg production per female, abnormalities in newly hatched-fry, reduced survival of young, induced poor growth, decreased immune response, shortened life span, reproductive problems, low fertility and changes in appearance and behavior (Authman and Abbas 2007; Limbo et al., 2009; Fazio et al., 2014; Dhanakumar et al., 2015; Engwa et al., 2019; Jyothi, 2020).

Copper (Cu) in Man

High and lethal doses of Copper exposed to man can lead to oxidative damage in the brain which causes the Mense disease which is about a fatal disorder (Jyothi 2020). Wilson disease could occur due to accumulated Cu in the brain and eyes in the form of Kayaer-Fleischer ring (Arthri 2006; Sakar 2009). Other negative effects of excessive intake of Cu include abdominal disorders, kidney damage and even death. US dept 2004; Engwa 2019; Jyothi 2020).

Iron (Fe) in Fish

Iron is a prevalent component of industrial and mining effluents that are often discharged into aquatic environments (Andromeda 2021). Ferrous iron (Fe^{2}+) is considered to be more toxic than ferric (Fe^{3}+) form. At normal levels, iron is not deadly to any aquatic animals. At higher levels, iron does not dissolve in water, fish and other living organisms cannot process all the iron they take from the water or their food. The iron then accumulates in the animal's internal organs thus eventually causing harm (Andromeda 2021). Report has shown that excess iron dissolved in the water can cause iron flakes to form in the gills of the fish resulting in their obstruction, causing respiratory disorders (Bury and Grossel 2003). In severe cases, the gill tissues are lost to necrosis. The highest bio concentration of iron in fish tissues was found in the liver and gonads, decreasing in brain, muscle and heart (Omar et al.2014). Report have been given by Andersen et al., (2014) showing iron deposits in the chronically inflamed central nervous system, neuro-degeneration. Gemaque et al. (2019), reported that Fe3+ are more lethal than Fe2+, thus toxicological effects are more conspicuous in the groups contaminated with this pollutant. Again, researchers have shown that the most important effect of iron on fish refers to the ability of this compound to oxidize Hb in the blood, converting it to MeHb thus making it impossible to transport oxygen to tissues and possibly causing the death of the animal through asphyxia (Jensen 2003; Avilez et al. 2013; Anderson et al., 2014; Gemaque 2019; Romano et al., 2021).

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Iron (Fe) in Man

Excess Fe in humans causes the malfunctioning of the general body metabolism. It generates oxidative stress and the production of oxygen radicals. Excess Fe is also related to inflammatory problems such as disorder of the central nervous system, neuronal degradation, Parkinson's and Alzheimer's disease (Chen et al., 2012; Kozlowski et al., 2003; Anderson et al., 2014; Romano et al., 2021).

Nickel (Ni) in Fish

Nickel is a ubiquitous element obtained from natural resources and widely distributed in the environment, air, water, and soil through anthropogenic activity. Environmental pollution from nickel may be obtained from the industry via the use of liquid and solid fuels, as well as municipal and industrial waste. Reports on the adverse effect of lethal and high concentrations of Nickel are reported by Javed 2013. In the study, Fish growth was monitored in terms of wet weight and fork length increments, condition factor, feed intake and feed conversion efficiency (FCE). Fish species showed exploratory behavior such as loss of appetite to cause significant reduction in growth during exposure. (Javad, 2013). Nickel exposure is said to induce some histological changes in the fish structure of Oreochromis niloticus. These changes influenced hyperplasia, hypertrophy, shortening of secondary lamellae and fusion of adjacent lamella, significant rise in the level of blood glucose, liver and pancreatic disorders causing hypercholesterolaemia, hyperproteinanaemia and hyperalbuminanaemia (Yan et al., 2006; Al-Attar, 2007).

Effects of Nickel (Ni) in man

Extreme doses of Ni are reported to primarily cause contact dermatitis. Other include pulmonary fibrosis, respiratory tract cancer, iatrogenic intoxication, liver damage and cardiovascular and kidney diseases (ATSDR, 2006). If inhaled, it is said to be deposited and affect the lungs, heart, diaphragm, bones, brain and spinal cord. High concentration can cause nasal fibroisis, DNA damage (Genchi et al., 2020; Dudek-Adamska et al., 2021)

Effects of Zinc (Zn) in Fish

Zinc is an element occurring naturally in the environment. It is an essential trace element, a micronutrient in ever living organism. Zn is found in almost every cell to be involved in nucleic and acid synthesis (Tabari et al., 2010). The common sources of it are galvanized iron work, zinc chloride used in plumbing and paints containing zinc (Khaled 2009). Zn wastes can have direct toxicity of fish at increased water bone levels. Fisheries are easiest to be affected by either zinc alone or more often together with copper and other metals at high levels. The main target of waterborne Zn toxicity are the gills, leading to hypocalcemia and eventual death (Tabari et al., 2010).At high concentrations it may be toxic to fish. Afshan et al. (2014) observed that Zn accumulates in the gills of fish and creates adverse effects on fish by causing complications in body functions such as the immune system, neurotransmission and cell signaling. Zn also causes

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structural damages that affect growth, development and survival. It also alters fish behaviour, hatchability, hematological parameters, balance, and swimming ability (Eisler 2000; Kalay and Canley 2000). Cicik (2003) studied the effects of Zn on common carp (*Cyprinuscarpio*) and found out that most accumulation took place in gill tissue. Haseen and Mohamed, (2019) reported for the study of *Cyprinus carpio, Lazi abu* and Grass carp, that high concentrations of Zn in the gills might have occurred due to mucus secretion and structural alterations in gill tissue caused by contamination. Furthermore, other target organs in fish include the muscles, kidney, kidney, and skeletal muscle. The clinical symptoms of such damages were growth retardation, respiratory and cardiac changes, inhibition of spawning, and a multitude of additional detrimental effects which threaten survival of fish (Jaryum et al., 2016).

Effects of Zinc (Zn) in man

There are no known negative effets of toxicity of Zn in literature. However one study has it that high doses and exposure of Zn to man may cause lack of muscular coordination (Al-Tae et al., 2021).

DISCUSSION

In Nigeria, most of our water bodies serve as reservoirs for drinking and domestic uses, making the distribution of heavy metals and pesticides in aqueous phase, suspended particles and sediments unavoidable. These accumulation of pesticides in our water bodies is a major public health concern (Wang et al., 2012). In the aquatic environment, organisms are exposed to pesticides through contact with the gills, skin, ingestion or inhalation into the gastrointestinal tract and muscles. Within the fish the HM is either metabolized, excreted, stored, or bio accumulated (Alewu and Nosiri 2011).

Heavy metals are taken up by different fishes in different forms at different rates according to various factors. It could be environmental (water chemistry, salinity, temperature, and levels of contamination) or biological (species, size, gender, sexual maturity, and food source). These HM are transported to human because of their higher uptake mechanism in their tissues towards these elements (Baharon and Ishak 2015; Naeem et al., 2021)

The presence of these heavy metals in the aquatic environment makes the water toxic. The level of toxicity depends on the type of metal, its biological role and the type of organisms that are exposed to it (Ashref et al., 2019). Heavy metals do affect living organisms through bioaccumulation. These heavy metals enters the food chain from the primary producers and affects the whole chain most especially fishes (Lokhande et al., 2011; Naeem et al., 2021). Fishes are often the most vulnerable and are affected directly particularly because they feed and live in the aquatic environment therefore constantly exposed to pesticide and heavy metals. Consequently, the toxic effect of these HM effect the fish through decreasing food sources, food chain is disrupted, leading to lowering aquatic habitat (Haseen and Mohammed 2019; Naeem et al., 2021)

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Studies have shown that the accumulation of heavy metals by fish is mainly dependent on concentrations and exposure period, nature of the water, pH, hardness and alkalinity and dissolved oxygen (Naeem et al., 2021). Heavy metals are taken up primarily from the environment through gills, food, and skin then are carried to organs by carrier proteins via blood path and can reach high concentrations by bonding to metal binding proteins in these tissues (Sönmez et al., 2016). The level of toxic element concentration in fish depends on sex and age of fish, season and habitat. Pollution of water sources by anthropogenic activities leads to aquatic loss and therefore disrupts the balance of food chain (Ashref et al., 2019).

Small fishes are affected more than larger ones (Kim et al., 2008). Again, freshwater fishes are more affected than salt water fishes. Following a comparison in the magnitude of accumulation of heavy metals between marine and fresh water fishes, it can be observed that freshwater fishes tend to accumulate heavy metals in their organs 6 times more than marine fishes (Huseen and Mohammed 2019). The reason for such a difference is that fresh water tends to lose salts and gain water while marine fishes tend to gain salts and loose water. Consequently, freshwater fishes are more exposed and vulnerable to heavy metal pollution (Huseen and Mohammed 2019). Furthermore concentrations of heavy metals are elevated in the wet season in the environment and is fish tissues than in the dry season ($p<0.05$) (Agbugui and Deekae, 2013).

Researchers have suggested that predatory fish (carnivorous), which are at a higher trophic level, accumulate more heavy metals compared with Omnivorous fish and Herbivorous fish. (Kidwell et al. 1995; Voigt 2004; Weber et al. 2013). This is because carnivorous fish, which mainly eat other organisms at the lower trophic levels such as fingerlings, shrimp, crustacean and zooplankton, thus will consume and accumulate high levels of heavy metals in the body unlike the non- predatory and carnivorous fishes with varying diets that includes aquatic insects, shrimps, small fish, crustacean, algae, plankton and detritus This is in agreement with the findings of (Karadede et al. 2004; Bawuro et al., 2018). Thus, the accumulation of HMin fish may have been due to diversity of feeding habit and behaviour.

Uptakes of Heavy Metals by Fish are mostly toxic, can cause severe damage and become lethal for most organisms since they are degradable hence are able to bioaccumulate and biomagnify. The high concentrations of heavy metals affect the growth and development o fish during early life stages such as hatching, laval, fingerlings and juvenile life stages. This is so because the early lif3e stages are more sensitive than during maturing and mature stages. Subsequently, fish form the link for the transfer of toxic heavy metals from water to humans (Ashraf et al. 2010). The harmful effect of trace elements when consumed above the recommended limits can be toxic. (acute, sub-chronic and chronic). Heavy metals can be neurotoxic, carcinogenic teratogenic and mutagenic. The general systems displayed by humans with regards to heavy metal (for instance, Al, As, Cd, Cu, Fe, Hg, Ni, Pb, and Zn,) poisoning include vomiting, convulsions, paralysis, ataxia, hemoglobinuria, gastrointestinal disorder, diarrhoea, stomatitis, tremor, depression and pneumonia (McCluggage 1991;Nyantakyi 2021).

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Bioaccumulation could be defined as an increase in the concentration of a heavy metal in an organism over time compared with heavy metal concentration in the environment Biomagnification means transfer of a heavy metal food sources to an organism, resulting in a higher concentration in the organism that from its source.

CONCLUSION AND RECOMMENDATIONS

In conclusion, the toxic effects of heavy metals in fish and the effect of bioaccumulation and bio-magnification have been demonstrated in the present study. Heavy metals induce early life responses in fish as evidenced by alterations both at structural and functional levels of different organs such of which include enzymatic and genetic effects, thereby affecting the innate immune system of exposed fish and increasing susceptibility to numerous diseases.

It is therefore recommended that the treatment of all forms of wastewaters, agricultural waste, sewage, industrial effluents be carried out before their discharge in to the environment. Also, the enforcement of all laws, legislations regarding the protection of aquatic life ans environment be enforced and sanctions mitted against defaulters.

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