Acta Scientific AGRICULTURE (ISSN: 2581-365X)

Volume 6 Issue 12 December 2022

Review Article

Ecological Impacts of Heavy Metals on Aquatic Organisms and Human Health

Khushbu*, Rachna Gulati, Sushma, Amit Kour, Deepak Verma and Pankaj Sharma Poonam Devi

Department of Zoology and Aquaculture, Chaudhary Charan Singh Haryana Agriculture University, Hisar Haryana, India

***Corresponding Author:** Khushbu, Department of Zoology and Aquaculture, Chaudhary Charan Singh Haryana Agriculture University, Hisar Haryana, India.

Received: August 01, 2022

Published: November 08, 2022

Abstract

Heavy metals have high density that is harmful even in low quantity. These metals enter aquatic habitats through a variety of sources, home effluents, including industrial waste, atmospheric sources, and other metal-based businesses, as well as e-waste. Heavy metal pollution is responsible for the degeneration of aquatic species, creating physical abnormalities in creatures and contaminating the aquatic environment. These poisonous heavy metals cause a variety of fish ailments like decrease hatching rate, teratogenesis and bioaccumulation in the tissues etc. The contamination of heavy metals into aquatic bodies and aquatic ecosystems has a significant influence on the food chain. Because fish are consumed by people, it has an indirect impact on them. These heavy metals also have a higher impact on the environment because they remain for longer periods and have bio-accumulative capabilities, leading water health to deteriorate. This study offers insight into the disruption of fish physiology by heavy metals and aims to increase sensitivity to the prevention and management of aquatic environmental pollution, particularly heavy metal contamination.

Keywords: Heavy Metal; Bio-Accumulative; Aquatic Environmental Pollution; Fish Physiology

Introduction

Heavy metal contamination is a major problem for aquatic ecosystems because it imparts a wide spectrum of toxicities that have substantial consequences for aquatic organisms. The majority of these heavy metals found in are the result of uncontrolled population expansion that leads to anthropogenic activities such as agricultural cultivation, docking, landfill erosion, and embarking operations, sewage from industry and home waste, and certain natural processes that produce a variety of contaminants causing major repercussions for aquatic ecosystems. Trace amounts of heavy metals integrate at a certain concentration in abiotic components and pass to aquatic creatures via food chains where they accumulate in their body tissues posing major problems in them [40]. Increasing industrialization leads to the emission of harmful metal contaminated effluents such as iron (Fe), nickel (Ni), copper (Cu), chromium (Cr), lead (Pb), and zinc (Zn). Metals can be categorized in two classes: physiologically essential and non-essential. Metals like tin (Sn), aluminum (Al), cadmium (Cd), mercury (Hg), and lead (Pb) have no records of specialized biological roles; hence their toxicity increases with increasing concentration [2]. Essential metals are generally responsible for growth and feed utilization in fish but when their maximum limit is exceeded, they disrupt the normal physiological and ecological systems in the aquatic environment [7]. The majority of these metals are carcinogenic, and they may also cause significant health complications such as cardiovascular problems, liver illnesses, renal dysfunctions, and, in extreme situations, death [3]. Heavy metal contamination has a significant impact on the physiology of various aquatic creatures, particularly fish. Heavy metal poisoning significantly altered the hemato-biochemical parameter of fish, resulting in many abnormalities (cellular and nuclear) in various blood cells [25]. Heavy metal toxicity has also been linked to genetic abnormalities and drastically impairs fish reproductive performance. Previous studies revealed that there are many reproductive compromises such as decreased fecundity or Gonadosomatic Index (GSI), hatching rate, fertilization, aberrant form of reproductive organs, ultimately reduce the reproductive performance of fish [11]. Furthermore, heavy metals had a negative impact on fish embryonic and larval development, causing a variety of complications such as increased mortality rate, deformed shape, decreased cardiac activity, increased heart rate, vertebral column deformities in developmental stages of the embryo [48]. The current study focuses on gathering up-to-date knowledge on the effects of heavy metals on embryonic and larval development, growth, and reproductive performance, with a focus on the most economically relevant aquaculture species.

Sources of heavy metals

Heavy metals in water bodies can arise from both natural and man-made sources. Volcanic eruptions, weathering of metal-containing rocks, sea-salt sprays, forest fires, and natural weathering processes can all lead to the release of metals from their native skies into various environmental sections. Heavy metals can be found in a variety of forms, including hydroxides, oxides, sulfides, sulfates, phosphates, silicates, and organic compounds.

Volcanic activity

Volcanic ash is the consequence of explosive volcanic eruptions, and ash falls can reach places hundreds of kilometers away from an erupting volcano. Even trace amounts of ash can cause havoc in the water system. Volcanic ash spills into the water system, contaminating it with turbidity, acidity, and low pH. Surface coatings on fresh volcanic ash are very acidic due to the action of aerosols containing the strong mineral acids H2SO4, HCl, and HF in the plume [8]. As a result, when freshly erupted ash comes into contact with water, it can reduce the pH beyond safe levels for aquatic life preservation [13]. Global industrialization and urbanization have resulted in an increase in the anthropogenic component of heavy metals in the atmosphere. Mining, smelting, power plant waste and industrial and agricultural operations are all common anthropogenic sources of heavy metals. Certain metals are released into the environment through mining and the extraction of certain elements from their ores. Heavy metals released into the atmosphere by mining, smelting, and other industrial activities are caused by dry and wet deposition. Heavy metals are added to the environment via wastewater discharges such as industry effluents and residential feces [37]. Elements commonly found in wind-blown dust come from industrialized areas. Vehicle exhaust, which emits lead; smelting, which liberates arsenic, copper, and zinc; pesticides, which emit arsenic; and the combustion of fossil fuels, which emit nickel, vanadium, mercury, selenium, and tin, are all substantial contributors to heavy metal pollution in the environment [10]. Individual actions contribute to environmental degradation owing to the everyday creation of assets to meet the needs of consumers [33].

Effluents from industry

Some of the biggest sources of pollution include municipal trash, home sewage, and industrial waste that are directly released into the natural water system. Untreated garbage discharge contaminates water. The discharge of industrial effluents into bodies of water without treatment is the most significant source of pollution of surface and groundwater water [17]. Wastewater, which contains microbes, heavy metals, nutrients, radionuclides, pharmaceuticals, and personal care items, all finds its way to surface water resources, inflicting irreparable damage to the aquatic ecology and humans by lowering the aesthetic value of such water [22]. These contaminants reduce the availability of usable water, raise the cost of purification, pollute aquatic resources, and have an impact on food supplies. Water pollution is caused by pollutants such as acid, a poisonous metal, agrochemicals, dyes, and other untreated waste discharged by factories. Discharged materials create pollution, also result in a loss of biodiversity in the aquatic ecosystem and may pose health hazards to human [28].

Agriculture-related activities

In response to the ever-increasing demand for food, agricultural systems have expanded and intensified. Overuse and misuse of agrochemicals, water, animal feeds, and pharmaceuticals aimed at increasing production have resulted in increased pollution burdens in the environment, including rivers, lakes, aquifers, and coastal waterways. Agricultural pollution influences aquatic ecosystems as well; for example, eutrophication produced by nutrient buildup in lakes and coastal waterways has an impact on biodiversity and fisheries. In response to the ever-increasing need for food, agricultural systems have expanded and intensified. Farms dump significant amounts of agrochemicals, organic debris, drug residues, sediments, and salty drainage into bodies of water [24]. Water contamination as a result has been shown to endanger aquatic ecosystems, human health, and productive activity. Agricultural waste dumped into aquatic ecosystems has several negative impacts on aquatic animals, including fish, by concentrating toxins directly from dirty water and moving them up the food chain [8].

Mining

The extraction of minerals and other geological materials from earth's deposits is known as mining. The mining sector extracts metals and minerals that modern civilization needs for agriculture, housing, music, telecommunications, the environment, building, space exploration, and medications [15]. Water contamination is a serious issue for mining operations. Because of the large volumes of water produced by mine drainage, mine cooling, aqueous extraction, and other mining activities, these compounds have the potential to pollute ground and surface water. Surface water is mostly deteriorated by a variety of events such as an unintentional spill of hazardous chemicals, waste material erosion, or discharge.

Electroplating

It is a plating process that employs electrical flow to extract desired substance cations from a solution and coat a conductive device with a thin layer of the material, such as metal. It is most commonly used to apply a layer of metal beneath the desired component (e.g., abrasion and wear resistance, corrosion protection, lubricity, aesthetic qualities, and so on) to a surface that would otherwise be deficient in that quality [38]. Electroplating industry effluent pollutes the air, water, and land [13].

E-waste/electronic waste

Uncontrolled disposal and improper recycling of e-waste pose substantial risks to human health and the environment. Toxic chemicals found in e-waste include heavy metals like lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), and nickel (Ni), as well as persistent organic compounds like brominated flame retardants (BFRs) and phthalates [6]. Polychlorinated biphenyls (PCBs), nonylphenol (NP), and triphenylphosphate (TPPs) are among the other substances found in e-waste [18]. Heavy metals, toxic compounds, and carcinogens are known to be abundant in e-waste. Certain disorders of the skin, respiratory, digestive, immunological, endocrine, and neurological systems, including cancer, can be avoided by properly managing and disposing of e-waste [31]. To close the digital gap, there is an exponential increase in the usage of Electrical and Electronic Equipment (EEE), which has a worrisome effect on the environment and human health when information and communication technology [ICT] waste is not disposed of correctly. There is a growing need to align existing rules and guidelines with international standards and best practices for a healthy E-waste management system.

Power plants

Thermal pollution from nuclear and fossil fuel facilities is substantial in bodies of water. The worsening of water quality caused by a change in ambient water temperature is known as thermal water pollution [48]. The Environmental Protection Agency (EPA) estimates that thermoelectric power stations alone generate 50 to 60 percent of all harmful pollutants emitted to surface waterways by all industrial categories under the Clean Water Act (CWA). Coal-fired power stations are the most harmful polluters among the numerous types of thermoelectric generating units. Approximately half of the 1,100 steam-electric facilities now in operation in the United States are coal-fired power plants [15]. Every year, these facilities release millions of tons of harmful heavy metals into the environment, including arsenic, selenium, lead, mercury, boron, and cadmium. When heated water is released into an aquatic ecosystem, it causes many problems. The most noticeable difference is a decrease in dissolved oxygen levels and an increase in pH. Warm water cannot store as much dissolved oxygen as cold water, thus organic matter decomposes more quickly in warm water [25]. Eutrophication is caused by an increase in decomposed aqueous nutrient concentrations, which is most commonly manifested as algae blooms that block sunlight for underlying aquatic plants. The abundance of algae is a simple food supply for aerobic microorganisms that surge in the population and further deplete the dissolved oxygen. Low oxygen levels create hypoxic dead zones, which are inhospitable to most aquatic organisms. Furthermore, rapidly heated water stimulates the metabolism of cold-blooded aquatic creatures such as fish, resulting in malnutrition owing to a lack of food sources. Many species flee as the environment becomes more unsuitable to the area's aquatic wildlife, while more sensitive species may perish, altering the biodiversity of both the original and invaded places. These impacts are most noticeable around coral reefs, which are home to over 2 million aquatic species and approximately 25% of all marine life [8].

The impact of heavy metals on the aquatic environment and aquatic health: Unlike organic substances, the bulk of metals cannot simply be converted into less hazardous molecules. Metals are dispersed throughout the water column, deposited in sediments, or consumed by aggregation once introduced into the aquatic environment. The sediments constitute a semi-permanent offer of contamination to the natural phenomena due to the activity and remobilization processes of metals. Metal residues in polluted settings have the ability to bioaccumulation in aquatic ecosystems (aquatic flora and fauna) which may then enter the natural human phenomena and cause health concerns [25]. Metal accumulation in sediments occurs as a result of processes such as positive compound precipitation, fine solid particle binding, association with organic molecules, co-precipitation with metal or Mn oxides, or species delimited as carbonates all depending on the physical and chemical conditions that exist between the sediment and the associated water column. Metal bioavailability is defined as the proportion of the metal's total concentration that has the potential to accumulate at various points in the body. Metal bioavailability is controlled by the following factors: metal natural science (distribution in water sediment, suspended materials, and metal speciation); physical and chemical parameters (temperature, salinity, pH, ionic strength, dissolved organic carbon content). Metal bioavailability governs the buildup of metals in aquatic organisms [8]. Metals are taken up in two ways: through the receptive stratum if they are dissolved, or by food intake, if they are particulate. The presence of organic or inorganic complexes, pH, temperature, salinity, and reaction conditions are the primary variables that modify metal toxicity. Intake uptake is affected by comparable parameters, including feeding speed, enteral transit duration, and digestive efficiency. Many studies have demonstrated that free hydrated metallic particles are the most accessible form of metal, Cd, Zn, and elements, however, there are notable exceptions. As a result, the significance of various chemical types of dissolved metals and complexes built with appropriate organic ligands with low relative molecular mass should not be neglected. Organic binders have been reported to boost Cd bioavailability in mussels and fish by enabling the migration of the hydrophobic molecule at intervals in the lipid membrane. Metal-organic compounds are also more bioavailable than metal ionic forms [8]. Mercurial organic chemicals are macromolecule-soluble and easily permeate lipid membranes, increasing toxicity when compared to corrosive sublimate, which is not lipid-soluble. The action on suspended particles affects the overall concentration of metals in water. The interaction of solid particles and metals is also significant for metal absorption into organisms via food consumption. The insoluble metal compounds build in the suspended particulates, but under positive circumstances, the metal reaches the gap water being dissolved. Because significant metal concentrations from sediments or suspended solids are loads of over in the water, a little low proportion of them is also a truly essential offer for bioaccumulation in organisms and benthic species. Because the dynamics of various metals at different points in the aquatic environment are not fully known, further studies are needed to investigate the many accumulation/bioaccumulation routes supported by dissolved or suspended metal forms [34]. Because of their filter-feeding activity, the bioavailability of metals in bivalve mollusks is dependent on sediment particle size, according to several studies. The bioavailability of Cd, Zn, and Ag was dramatically increased when the particles were covered with living organisms, polymers, or fulvic acids. Overall, metal binding decreased the bioavailability of metals from sediment. Heavy metal breakdown in water sources is a significant environmental hazard that negatively affects plants, animals, and human health. Freshwater fish are exposed to a variety of hazardous heavy metals dumped into bodies of water from numerous sources [7]. Heavy metal pollution of aquaculture has reached a global crisis since it endangers fish and poses health hazards to seafood customers (Figure 1).

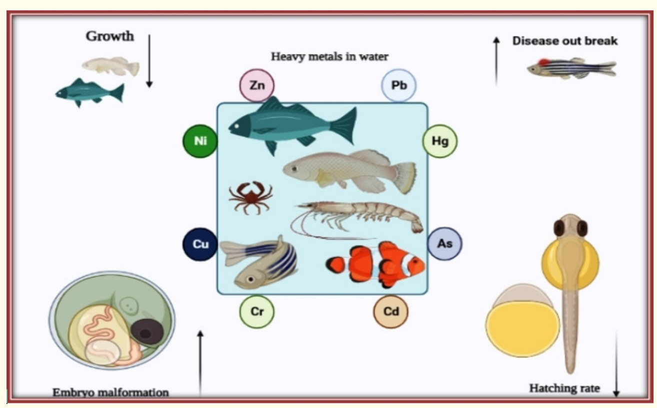

Figure 1: Impact of heavy metals on the aquatic health.

Heavy metal intake via the food chain

To a lesser extent, these heavy metals enter our systems through nutrition, drink, and air (Figure 2). Some of these heavy metals, such as zinc, copper, and selenium, are essential for metabolism. However, at higher concentrations, they can cause poisoning. Heavy metal poisoning might occur as a result of tainted drinking water (lead pipes), high ambient air concentrations near emanation sources, or food chain consumption [18]. Heavy metals bioaccumulate in the body and are hence dangerous to humans. Bioaccumulation refers to an increase in the absorption of a chemical in an organism that is proportional to the concentration of the chemical in the environment. Indeed, the buildup of metals in food crops and their implications on human health is a topic of great concern across the world. However, knowledge on geophysical patterns may assist us in determining the extent to which they affect human health. Difficulties may differ among nations, as may the origin of metallic pollution, which has been poorly explained [48]. Heavy metals are toxicants that cause acute illnesses in aquatic creatures. Absorption of heavy metals in the food chain in aquatic creatures may result in occasional fever, cramps, kidney impairment, and hypertension in humans. Fish play an important role in metal biomagnification since they are at the top of the food pyramid and act as permitted transfer media to humans. Heavy metals may be extremely harmful to humans, causing toxic and carcinogenic effects as well as oxidative degradation of biological macromolecules.

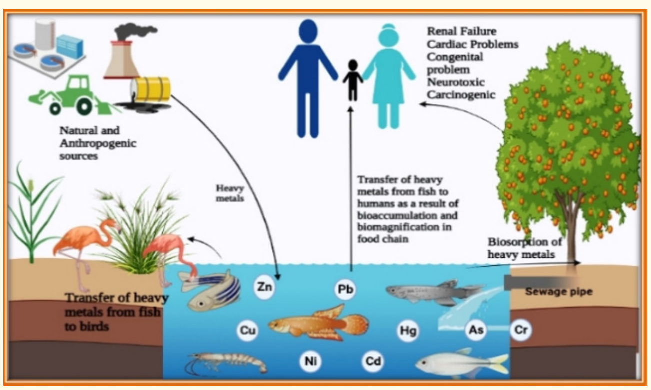

Figure 2: Heavy metal intake via the food chain.

Lead

It is commonly found in wastewater from electroplating, electrical, steel, and explosive makers. The primary reason for the presence of lead (Pb) in industrial waste is lead-acid battery discharge. It occurs as sulfide, cerussite (PbCl2), and galena, all of which are heavy and soft metals [48]. Lead is typically found in aquatic systems as a result of electrical waste. Excessive ROS generation from lead accumulation in fish tissues induces oxidative damage in fish [18]. Furthermore, as an immuno-toxicant, Pb exposure alters immune responses in fish (Table 1). In humans, lead causes memory loss, hearing problems, digestive issues and cancer. Lead is a dangerous metal that easily accumulates in the human body. When lead is ingested, it can cause permanent harm to the Central Nervous System (CNS), Brain, and Excretory System.

No.	Scientific name	Common name	Days of exposure and dose	Deformities recorded in fish	References
1	*Clarias gariepinus*	African sharptooth catfish	48-168h and 0.1-0.5 mg/L	Irregular head Notochord defects	[11]
2	*Chanos chanos*	Milkfish	40 days and 85.2 mg/L	Weight gain decrease Length gain decrease Specific growth rate decrease Feed conversion ratio declined	[48]
3	*Catla catla*	Katla	60 days and 1/3rd of LC50	Weight gain decrease Length gain decrease Specific growth rate decrease Feed conversion ratio declined	[18]
4	*Labeo rohita*	Rohu			
5	*Cirrhina mrigala*	Mrigal			

Table 1: Impacts of Lead on growth performance of larval and adult fish.

Arsenic (As)

Arsenic is released into the environment during lead, copper, and zinc smelting. Furthermore, the mix of chemicals and glassware is responsible for the production of arsenic. Arsine gas is produced during the manufacturing of arsenic-containing insecticides [42]. Arsenic comes from a variety of sources, including industrial waste, metallic trash, and so on. Arsenic exposure in the water bodies causes bioaccumulation in fish/aquatic organisms and can cause physiological and biochemical disorders [9] (Table 2). It is also extremely hazardous to human health since it has a detrimental impact on the neurological system, weakens muscles, and causes protein coagulation. It can start cancer and also has an impact on the endocrine, hepatic, and reproductive systems.

No.	Scientific name	Common name	Days of exposure and dose	Deformities recorded in fish	References
1	*Anguilla japonica*	Japanese eel	15 days and 0.1, 100 µM	Spermatogenesis via Steroidogenesis suppression	[5]
2	*Oncorhynchus mykiss*	Rainbow trout	30 days and 26-77 µg/kg	Growth reduced Slower feeding Reduced Feed Conversion Ratio	[9]

Table 2: Impacts of Arsenic on growth performance of larval and adult fish.

Mercury (Hg)

Bioaccumulation of mercury in marine affect the physiological and ecological properties of fish. When mercury is flashed in large quantities can cause neurotoxicity and reproductive damage. These impacts can then disrupt cells, tissues, ultimately threatening marine fish survival [34] (Table 3). Long-term exposure to mercury has been linked to unsteady walking, poor focus, tremulous speech, clouded eyesight, and decreased psychomotor function [29]. Involuntary Abortion is common in pregnant women when mercury concentrations are high [27]. When mercury is consumed, it has been shown to cause cardiovascular and gastrointestinal consequences.

Cadmium

It is also the most hazardous heavy metal found in industrial waste. It is used extensively in sectors such as plating, cadmium nickel batteries, phosphate fertilizers, stabilizers, and alloys [39]. Even at low concentrations, cadmium compounds are very toxic and accumulate in the environment. It is a trace element that is extremely harmful to fish. It is frequently found in surface waters that have been polluted with industrial effluents. When dissolved in water, Cd can quickly cause physiological alterations in freshwater fish gills and kidneys. Cadmium accumulation can cause "Itai-Itai" illness. Human suffer from bone tempering and fractures as a result of it. When consumed in large quantities, cadmium causes kidney toxicity [41]. It has been linked to kidney damage and bone weakening after long-term or high-dose exposure, and increased levels of Cd have been linked to prostate cancer. Cadmium is to responsible for the high risk of lung cancer.

No.	Scientific name	Common name	Days of exposure and dose	Deformities recorded in fish	References
1	*Danio rerio*	Zebra danio	20 and 30 mg/L	Abnormal fin	[34]

Table 3: Impacts of Mercury on growth performance of fish.

Nickel (Ni)

Sources of nickel in the atmosphere are volcanic dust particles, alloy production plant, weathering of rocks, welding, electroplating, grinding, and cutting processes [32]. Nickel exposure caused certain histological abnormalities in the structure of fish gills. These modifications included hyperplasia, hypertrophy, secondary lamellae shortening, and fusing of neighboring lamellae (Table 5). It also has a number of pathologic consequences and is known to be carcinogenic in humans. Nickel ingestion causes a considerable decrease in body weight. Hair loss is a common side effect of nickel overdose. People who have inhaled nickel have experienced the most serious adverse health effects, including chronic bronchitis, reduced lung function, and lung and nasal sinus cancer [14].

Copper

Copper (Cu) is required by all species, including fish. It plays a crucial function in metabolism. It is one of the most hazardous metals to fish, affecting enzyme function, blood parameters, behavior, growth, and reproduction [20] (Table 6). Metals are non-biodegradable and are key environmental contaminants that cause cytotoxicity, mutagenesis, and carcinogenesis in animals. The fish exposed to copper appeared to have changed the structure of their

No.	Scientific name	Common name	Days of exposure and dose	Deformities recorded in fish	References
1	*Catla catla*	Katla	8 weeks and 70.40g, 71.99g and 79.11g	Growth reduced Slower feeding Reduced FCR Hepatoxicity Loss of appetite Growth reduced Slower feeding Reduced Feed Conversion Ratio Total protein decreased	[19]
2	*Labeo rohita*	Rohu			
3	*Cirrhina mrigala*	Mrigal			

Table 5: Impacts of Nickel on growth performance of larval and adult fish.

No.	Scientific name	Common name	Days of exposure and dose	Deformities recorded in fish	References
1	*Danio rerio*	Zebra danio	120 haf and 0.068-0.244mg/L	Deformities in Lateral line	[20]
2	*Cyprinus carpio*	Common carp	20 day and 0.2 mg/L	Curve in spine C-shape larva Deformed yolk sac, Shortened body	[45]
3	*Danio rerio*	Zebra danio	3 dpf and 50-1000 µg/L	Hatching Rate decreased High heart rate Large yolk sac	[20]
4	*Cyprinus carpio*	Common carp	30 days and 0.2 mg/L	Growth retardation	[35]
5	*Clarias gariepinus*	African sharp-tooth catfish	5 days and 0.15-2.5 mg/L	Reduced pigmentation	[30]
6	*Cyprinus carpio*	Common carp	0.2 mg/L	Development Retardation	[23]
7	*Oncorhynchus mykiss*	Rainbow trout	4 days and 0.22 mg/L	Increased mortality	[9]
8	*Oryzias melastigma*	Marine medaka	7 days and 0.32 mg/L	Abnormalities in skeletal and vascular system	[43]
9	*Fundulus heteroclitus*	Mummichog	50 days and 0.0005-0.004 mg/L	Deformities in Vertebral column	[26]
10	*Odontesthes bonariensis*	Silver catfish bagre	10 days and 22, 220 µg/L	Reduced survivability	[11]
11	*Leuciscus idus*	Ide	21 days and 0.1 mg/L	Vertebral Curvatures Yolk sac deformities and in swim bladder Shorten body length	[46]
12	*Carassius auratu*	Goldfish	24 hah and 0.1-1 mg/L	Scoliosis Tail curvature	[22]
13	*Oryzias latipes*	Japanese rice fish	6.95-23.1 µg/L and 10 days	Spinal cord deformities Abnormal cardiovascular System	[1]

Table 6: Impacts of Copper on growth performance of larval and adult fish.

gills, with an increased number of mucous cells, chloride cells, and respiratory epithelium thickness detected. The fish exposed to copper appeared to have changed the structure of their gills, with an increased number of mucous cells, chloride cells, and respiratory epithelium thickness detected [35].

Chromium (Cr)

This metal is contaminating natural water as a result of anthropogenic activities. Various studies have shown that chromium accumulation can increase the risk of lung cancer. Chromium can quickly cause physiological alterations when dissolved in water in fish gills and kidneys (Table 7) [2]. Damage to the circulatory system and nervous tissue also recorded in the system due to chromium toxicity. The presence of Cr in the presence of other metals has been shown to increase glycogen levels in numerous organs that are stressed as a result of metal exposure.

Zinc

Zinc can be derived through rock weathering, industrial and household wastewater outflows where it plays important functions in preserving cellular integrity. At low concentrations it may kills fish by destroying gills. But at large concentrations it may induce stress resulting in death (Table 8). The role of zinc differs at different concentrations and varies with life history of organism [44]. Zinc also increases the risk of cardiovascular disease. It has the potential to induce hypertension, nausea, and stomach damage. It is also responsible for neurotoxic effects on human health (Figure 3). When used in excess, zinc might induce psychical disorder. The injection of zinc into the body also causes other neurological alterations.

No.	Scientific name	Common name	Days of exposure and dose	Deformities recorded in fish	References
1	*Danio rerio*	Zebra danio	4 days and 50, 500 mg/L	Embryo mortality Increase heart rate	[2]
2	*Clarias gariepinus*	African sharptooth catfish	5 days and 11-114 mg/L	Body axis become abnormal, Survivability become reduced	[11]
3	*Odontesthes bonariensis*	Silver catfish bagre	10 days and 4, 40 µg/L	Morphological alteration	[30]

Table 7: Impacts of Chromium on growth performance of larval and adult fish.

No.	Scientific name	Common name	Dose and days of exposure	Deformities recorded in fish	References
1	*Danio rerio*	Zebra danio	4 days and 50, 500 mg/l	High mortality Increase heart rate	[2]
2	*Melanotaenia fluviatilis*	Murray River rainbow fish	2 h and 0.33-33.3 mg/ L	Deformities in spinal cord	[44]
3	*Pagrus major*	Red seabream	10 days and 0.1, 0.3, 0.5, 0.7, 1.0, 1.5, 2.0, 2.5mg/L	Visceral hemorrhage High mortality Abnormal pigmentation	[16]
4	*Odontesthes bonariensis*	Silver catfish bagre	10 days and 211, 2110 µg/ L	Less survival	[11]

Table 8: Impacts of Zinc on growth performance of larval and adult fish.

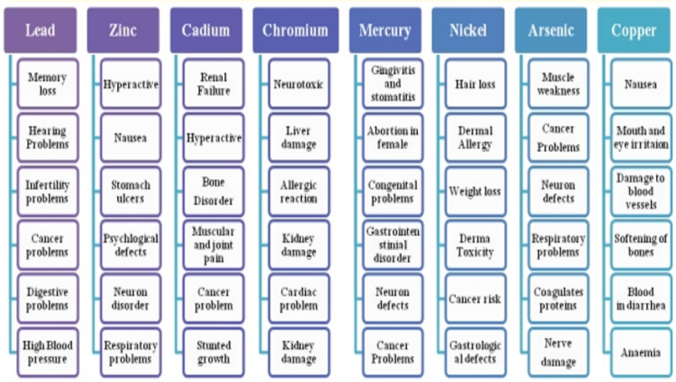

Figure 3: Effects of Heavy metals on human health.

Discussion

Heavy metals are crucial components required for the body's optimal growth and development. Human population growth has resulted in a rise in medical waste, industrial waste, and pollution. This discharge from various sources pollute the water and harms aquaculture. All garbage containing dangerous heavy metals is deposited in water bodies, either directly or indirectly [2]. Usage of industrial effluents, fertilizers, and medical waste has a direct impact on groundwater sources that are linked to neighboring water sources. Excessive heavy metals can cause breeding issues, and physical abnormalities, and even jeopardize survival capacity. People who live near seashores and water bodies fish is major source of food for them [16]. Consumption of heavy metal-enriched fish may have an impact not only on human health but also affect entire food chain. Humans may experience serious complications such as organ failure, bodily deformities, and even mental health problems.

Conclusion

Excessive concentrations of heavy metals in aquaculture are a big problem. Prioritizing heavy metal removal from wastewaters is required. Before release into freshwater or water sources, wastewater must be treated to decrease toxins, pollutants, and unwanted components. The detection technologies for heavy metals must be employed in industries prior to dumping waste into water bodies. To detect the heavy metals in wastewater, a variety of chemical procedures and equipment must be utilized. These industries must be guided under World Health Organization standards [41]. Medical waste should be disposed of in safe areas that are away from drainage systems so that it could not enter the source of contamination. Prior to discharging any effluents into bodies of water, water treatment plants must be established and utilized appropriately. Industrial employees, hospital cleaning personnel, cleaners, and sweepers, among others, should be aware. These individuals will aid in the reduction of garbage from diverse sources. Special awareness initiatives for farmers must be developed to demonstrate the adverse impacts of excessive pesticide use in farming. People should be advised to test their fish for the presence of heavy metals before consuming them. Water sources must be tested regularly by competent authorities using newer and more modern procedures. Academic education must include methods for informing future generations about heavy metals and their hazardous effects.

Bibliography

1. Barjhoux I., *et al.* "Effects of copper and cadmium spiked-sediments on embryonic development of Japanese medaka (*Oryzias latipes*)". *Ecotoxicology and Environmental Safety* 79 (2012): 272-282.

2. Benaduce APS., *et al.* "Toxicity of cadmium for silver catfish Rhamdia quelen (Heptapteridae) embryos and larvae at different alkalinities". *Archives of Environmental Contamination and Toxicology* 54.2 (2008): 274-282.

3. Calta M. "Effects of aqueous cadmium on embryos and larvae of mirror carp". *The Indian Journal of Animal Sciences* 71.9 (2001).

4. Cao L., *et al.* "Cadmium toxicity to embryonic-larval development and survival in red sea bream Pagrus major". *Ecotoxicology and Environmental Safety* 72.7 (2009): 1966-1974.

5. Celino FT., *et al.* "Arsenic inhibits *in vitro* spermatogenesis and induces germ cell apoptosis in Japanese eel (*Anguilla japonica*)". *Reproduction* 138.2 (2009): 279-287.

6. Chen A., *et al.* "Developmental neurotoxicants in e-waste: an emerging health concern". *Environmental Health Perspectives* 119.4 (2011): 431-438.

7. Ediagbonya TF., *et al.* "Bioaccumulation of Elemental Concentrations in Sediment and Frog (Pyxicephalus edulis) in Igbeebo River, Ondo State, Nigeria". *Chemistry Africa* (2022): 1-13.

8. El-Greisy ZA and El-Gamal AHA. "Experimental studies on the effect of cadmium chloride, zinc acetate, their mixture and the mitigation with vitamin C supplementation on hatchability, size and quality of newly hatched larvae of common carp, *Cyprinus carpio*". *The Egyptian Journal of Aquatic Research* 41.2 (2015): 219-226.

9. Erickson RJ., *et al.* "Effects of copper, cadmium, lead, and arsenic in a live diet on juvenile fish growth". *Canadian Journal of Fisheries and Aquatic Sciences* 67.11 (2010): 1816-1826.

10. Fraysse B., *et al.* "Development of a zebrafish 4-day embryo-larval bioassay to assess toxicity of chemicals". *Ecotoxicology and Environmental Safety* 63.2 (2006): 253-267.

11. Gárriz Á and Miranda LA. "Effects of metals on sperm quality, fertilization and hatching rates, and embryo and larval survival of pejerrey fish (*Odontesthes bonariensis*)". *Ecotoxicology* 29.7 (2020): 1072-1082.

12. Green AJ., *et al.* "Cadmium Disrupts Vestibular Function by Interfering with Otolith Formation". *BioRxiv* (2017): 162347.

13. Guffanti M and Tupper A. "Volcanic ash hazards and aviation risk". In Volcanic hazards, risks and disasters (2015): 87-108.

14. Haddad L., *et al.* "A systematic review of effects of waterpipe smoking on cardiovascular and respiratory health outcomes". *Tobacco Use Insights* 9 (2016): TUI-S39873.

15. He S., *et al.* "Current State-of-the-Art in the Interface/Surface Modification of Thermoelectric Materials". *Advanced Energy Materials* 11.37 (2021): 2101877.

16. Huang W., *et al.* "Toxic effects of zinc on the development, growth, and survival of red sea bream Pagrus major embryos and larvae". *Archives of Environmental Contamination and Toxicology* 58.1 (2010): 140-150.

17. Ilyas M., *et al.* "Environmental and health impacts of industrial wastewater effluents in Pakistan: a review". *Reviews on Environmental Health* 34.2 (2019): 171-186.

18. Javed M. "Effects of zinc and lead toxicity on the growth and their bioaccumulation in fish". *Pakistan Veterinary Journal* 32.3 (2012): 357-362.

19. Javed M. "Chronic effects of nickel and cobalt on fish growth". *International Journal of Agriculture and Biology* 15.3 (2013).

20. Johnson A., *et al.* "The effects of copper on the morphological and functional development of zebrafish embryos". *Aquatic Toxicology* 84.4 (2007): 431-438.

21. Jurgelėnė Ž., *et al.* "Toxicological potential of cadmium impact on rainbow trout (Oncorhynchus mykiss) in early development". *Bulletin of Environmental Contamination and Toxicology* 103.4 (2019): 544-550.

22. Kong X., *et al.* "Effects of copper exposure on the hatching status and antioxidant defense at different developmental stages of embryos and larvae of goldfish Carassius auratus". *Chemosphere* 92.11 (2013): 1458-1464.

23. Ługowska K. "The effect of cadmium and cadmium/copper mixture during the embryonic development on deformation of common carp larvae". *Electron J Ichthyol* 2 (2007): 46-60.

24. Mishenin Y., *et al.* "Ecologically harmonized agricultural management for global food security. "In Ecological Intensification of Natural Resources for Sustainable Agriculture" Springer, Singapore (2021): 29-76.

25. Mishra S., *et al.* "Heavy metal contamination: an alarming threat to environment and human health". In Environmental biotechnology: For sustainable future, Springer, Singapore (2019): 103-125.

26. Mochida K., *et al.* "Early life-stage toxicity test for copper pyrithione and induction of skeletal anomaly in a teleost, the mummichog (Fundulus heteroclitus)". *Environmental Toxicology and Chemistry: An International Journal* 27.2 (2008): 367-374.

27. Mukherjee S. "Handbook on Present Environmental challenges: An overview (2022).

28. Mushtaq N., *et al.* "Freshwater contamination: sources and hazards to aquatic biota". In Fresh Water Pollution Dynamics and Remediation, Springer, Singapore (2020): 27-50.

29. Nail AN., *et al.* "Circulating miRNAs as Biomarkers of Toxic Heavy Metal Exposure". Genomic and Epigenomic Biomarkers of Toxicology and Disease: Clinical and Therapeutic Actions (2022): 63-87.

30. Nguyen LT and Janssen CR. "Embryo-larval toxicity tests with the African catfish (*Clarias gariepinus*): comparative sensitivity of endpoints". *Archives of Environmental Contamination and Toxicology* 42.2 (2002): 256-262.

31. Ouabo RE., *et al.* "Ecological risk and human health implications of heavy metals contamination of surface soil in e-waste recycling sites in Douala, Cameroun". *Journal of Health and Pollution* 9.21 (2019).

32. Poonkothai MVBS and Vijayavathi BS. "Nickel as an essential element and a toxicant". *International Journal of Environmental Sciences* 1.4 (2012): 285-288.

33. Purves D. "Trace-element Contamination of the Environment". Elsevier (2012).

34. Samson JC and Shenker J. "The teratogenic effects of methylmercury on early development of the zebrafish, Danio rerio". *Aquatic Toxicology* 48.2-3 (2000): 343-354.

35. Sarnowski P. "The effect of metals on yolk sac resorption and growth of starved and fed common carp [*Cyprinus carpio* L.] larvae". *Acta Scientiarum Polonorum. Piscaria* 2.1 (2003).

36. Sassi A., *et al.* "Influence of high temperature on cadmium-induced skeletal deformities in juvenile mosquitofish (*Gambusia affinis*)". *Fish Physiology and Biochemistry* 36.3 (2010): 403-409.

37. Sharma RK and Agrawal M. "Biological effects of heavy metals: an overview". *Journal of environmental Biology* 26.2 (2005): 301-313.

38. Sierka CE. "Industrial zinc plating processes". Indiana University of Pennsylvania (2015).

39. Singh A., *et al.* "Integrated approaches to mitigate threats from emerging potentially toxic elements: A way forward for sustainable environmental management". *Environmental Research* 209 (2022): 112844.

40. Sonone SS., *et al.* "Water contamination by heavy metals and their toxic effect on aquaculture and human health through food Chain". *Letters in Applied NanoBioScience*10.2 (2020): 2148-2166.

41. Upadhyay R. "Heavy Metals in our Ecosystem. In "Heavy Metals in Plants Physiological to Molecular Approach". CRC Press (2022): 1-15.

42. Wang P., *et al.* "A review on completing arsenic biogeochemical cycle: microbial volatilization of arsines in environment". *Journal of Environmental Sciences* 26.2 (2014): 371-381.

43. Wang RF., *et al.* "Developmental toxicity of copper in marine medaka (*Oryzias melastigma*) embryos and larvae". *Chemosphere* 247 (2020): 125923.

44. Williams ND and Holdway DA. "The effects of pulse-exposed cadmium and zinc on embryo hatchability, larval development, and survival of Australian crimson spotted rainbow fish (*Melanotaenia fluviatilis*)". *Environmental Toxicology* 15.3 (2000): 165-173.

45. Witeska M and Lugowska K. "The effect of copper exposure during embryonic development on deformations of newly hatched common carp larvae, and further consequences". Electronic Journal of Polish Agricultural Universities. *Series Fisheries* 2.07 (2004).

46. Witeska M., *et al.* "The effects of cadmium and copper on embryonic and larval development of ide *Leuciscus idus* L". *Fish Physiology and Biochemistry* 40.1 (2014): 151-163.

47. Zhang H., *et al.* "The toxicity of cadmium (Cd2+) towards embryos and pro-larva of soldatov's catfish (*Silurus soldatovi*)". *Ecotoxicology and Environmental Safety* 80 (2012): 258-265.

48. Zulfahmi I., *et al.* "Development, growth and reproduction of fish-a review". *Toxicology Reports*.