Impact of water pollution with heavy metals on fish health, Updates.

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1. Abstract: -

This review provides a summary of the toxic effects of heavy metals on fish. In the aquatic environment, these metals are important pollutants and are found in all ecosystems and are found in large quantities. Some heavy metals such as Cadmium, iron, copper, zinc and lead have the advantage of accumulating in tissues and poisoning fish. These minerals can effectively affect biological processes, fish reproduction, impair the immune system, and cause pathological changes. Therefore, heavy metals play an important role as a vital predictor of pollutants affecting the health and life of fish environments. These minerals cause organ damage even at low levels of exposure, so they have recently been classified as carcinogens. For all the above-mentioned reasons, this review has been written to contribute to the role of heavy metals in the environment, the toxic mechanism, the toxic effects on fish and the health of the human consumption of fish. Also**,** this article reviews the Histopathological change and biomarkers when exposed to heavy metal contamination.

Key word, fish. Pollutants, heavy metals, health, Histopathological.

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2. Introduction: -

Heavy metals are highly persistent and toxic in trace amounts, and can cause severe oxidative stress in aquatic organisms. Hence, these pollutants are very important in terms of environmental toxins. As it is not subjected to bacterial degradation, and therefore remains permanent in the aquatic environment, it may have devastating effects on the ecological balance **(Ayandiran *et al.*, 2009).** Heavy metal contamination of water creates a serious problem due to the dumping of household and industrial waste into the water. They reach a dangerous level and pose a threat to the health of aquatic organisms, as well as humans. It is important to know the concentration of toxic metals in fish to avoid these problems **(Vardi and Chenji, 2020).**Heavy metals are naturally found in the deep layers of the earth and are found in sediments of high concentrations. In addition, geological weather factors and human emissions from crude oil mines may lead to increased concentrations of heavy metals in the aquatic environment. **(Waheed *et al.*, 2020).** Aquatic animals have the ability to accumulate heavy metals in their tissues through absorption through the layer of gills, liver and intestine to levels higher than those in the environment. Cadmium, mercury and lead have no known essential role in living organisms; however, they exhibit significant toxicity at low exposure levels and are considered fundamental threats to all life forms, especially human health. **(Korkmaz Gorur *et al.*, 2012).**

4. Water Pollution: -

Water pollution is defined as human direct and indirect interference with various substances in the water environment, which leads to harm to human public health, deterioration of fish activities, and damage to water components. Pollution also occurs from human activities that supply some foreign substances in fresh water or sea water **(Clark, 2001).** Agricultural wastewater, industrial effluents, and municipal wastewater are disposed of recklessly into the Nile, gradually making its waters unfit for human consumption. There are many areas in

Cairo that empty into the Nile without treating the water.

5. Water pollution with heavy metals: -

5.1. Identification of heavy metals:-

Heavy metals are defined as mineral elements with a relatively high density compared to water, and human exposure to them has increased dramatically as a result of the massive increase in their use in many industrial, agricultural and technological applications **(Bradl and editor 2002).** The sources of heavy metals are many in different environments, including the industrial and agricultural environment, liquid waste and air sources **(Hezl, *et al.*, 2005).** Heavy metals are considered pollutants due to their toxicity, persistence in the environment, and their ability to integrate and bioaccumulation within food chains **(Armitage *et al.*, 2007).** Heavy metals can accumulate in freshwater and marine systems which pose a potential health concern for consumers and may lead to financial losses if concentrations in the water exceed Maximum Pollutant Levels (MCL). Moreover, the uptake of heavy metal contaminants may lead to concentrations in fish or edible plant tissues that exceed standards, contributing to economic losses, environmental degradation and negative impacts on human health **(Mendiguchia *et al.*, 2006).**

5.2. Classification of heavy metals: -

1. **Essential heavy metals**

Copper, chromium, zinc, nickel, cobalt and iron are essential minerals required for all vital processes within the body at an ideal level. If it exceeds the permissible limits it causes various diseases and high level toxicity (**Sivaperumal *et al*., 2007**).

2. **Non-essential heavy metals**

These have no biological roles and are also called xenobiotics. When it increases in concentrations, it will cause toxoplasmosis effects in the tissues. They include aluminum, mercury, lead, cadmium, and others. **(Salamat *et al.*, 2015).**

5.3. Source of heavy metals in water:-

Heavy metals in surface waters such as rivers and lakes are influenced by soil type and water velocity. So metals on the surface of the soil are derailed and end up in reservoirs and wastewater**.** Rainwater is polluted as it passes through the atmosphere. Water sources are polluted as various industrial liquid wastes flow into them. This industrial and liquid agricultural waste contains many heavy metals,. Groundwater is polluted from landfills, from deep wells, and from industrial waste **(Oyeku and Eludoyin, 2010).**

Heavy metals are natural elements found in the Earth's crust. Pollution with these metals occurs as a result of the activities embodied in the following Mining and industrial production and the use of minerals containing chemical compounds that are used for agricultural and domestic purposes. These sources have been reported by several researchers **(Rahman and Bastola, 2014).**The potential sources of environmental pollution with heavy metals are shown in Figure (2). The toxic properties of heavy metals are characterized by many causes including persistence of the metal in the soil and bioaccumulation **(Manzetti *et al.*, 2014).** Heavy metals in the aquatic ecosystem are a serious pollutant of global concern due to their high bioaccumulation and severity of toxicity, which cause severe damage to organisms present in the aquatic environment **(Xu *et al.*, 2018).**

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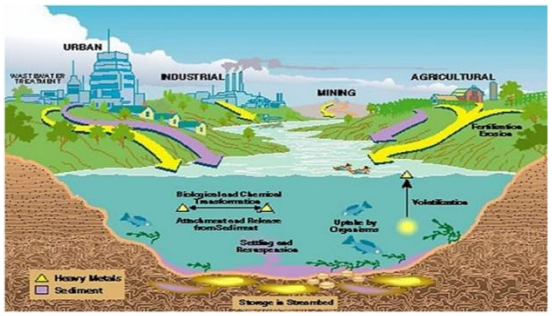


Figure (2). Different sources of heavy metals in surface waters **(Garbarino *et al.*, 1995)**

5.4. Contamination of water with heavy metals: -

Heavy metals are present in the environment in various forms as solids, solutions and free ions that are absorbed by solid colloidal particles. Concentrations in the environment are due to natural sources such as rock weathering, dissolution of water-soluble salts, as well as human sources **(Güven and Akinci, 2008).** The essential and non-essential elements thereof are of particular importance in environmental toxicology because they are of high persistence and are highly persistent and have the potential for virulence **(Storelli *et al.*, 2005).** The presence of metal contaminants in excess of the permissible limits has become a problem of concern. This situation arose as a result of the increase in population and the different activities of human life on earth and the lack of environmental regulations **(Shirkhanloo *et al.*,2011).** Industrialization and urbanization are the biggest reasons for the increase in water pollution with heavy metals, which leads to accumulation in the soil and sediments of water bodies **(Musilova *et al.*, 2016)**. The level of toxicity of heavy metals depends on several factors, including exposure of living organisms such as fish for a long time, their nature, and their biological role. It is may exist naturally in the aquatic environment and cause toxicity and pathological changes in fish tissues when it's permissible restricted concentration increases as a result of agricultural and industrial activities **(Shahbaa *et al.*, 2020).**

6. Hazard of some heavy metals on fish and human health: -

6.1. Iron (Fe):-

Iron is a predominant component of industrial effluents discharged into aqueous environments. Ferrous Fe^{2+} is more toxic to fish than the form of iron $Fe3^{+}$ **(Abbas *et al.*, (2002)** confirmed that the highest iron concentration in fish tissues was in the liver and gonads, and lowest in the brain, muscles and heart. It was found that respiratory disturbance was due to physical obstruction of the gills as a possible mechanism of iron toxicity. Since the surface of the gills of fish tends to be alkaline. Precipitated iron compounds have the dangerous effect of reducing the gill space available for breathing and damaging the respiratory epithelium, leading to fish strangulation and death. Also, iron in tilapia causes secondary platelet enlargement and necrosis through the study **(Baker *et al.*, 1997).** Collapsed nostrils reduce the diffusion distance between water and blood and reduce oxygen consumption. Also, iron compounds can be deposited on the surface of fish eggs, causing non-hatching **(Sepe *et al.*, 2003).** (Fe) is an essential mineral for every living cell, the synthesis of hemoglobin and some enzymes. Iron deficiency leads to weakness and lack of focus, and anemia such as malaria is one of its most common deficiencies.Anemia leads to poor performance in the blood transfusion process and also reduces the supply of oxygen to the muscles, and reduces efficiency due to reduced hemoglobin content and poor endurance **(Erdmann *et al.*, 2012).**

6.2. Lead (Pb): -

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Lead has the potential to bioaccumulation in aquatic ecosystems, due to its persistence in the environment. Lead accumulates in fish tissues such as bones and gills during the gas exchange through the gills into the bloodstream. Some of the effects of lead poisoning include a decrease in cognitive abilities due to the destruction of nerve cells, abdominal pain and weak bones where lead replaces calcium and causes anemia due to reduced enzymes involved in red blood cell synthesis **(Anime *et al.*, 2010).** It is a neurotoxin that causes behavioral deficits in fish and also leads to reduced survival, growth and metabolism rates, as well as increased mucus formation in fish.

Increased levels of lead in water have harmful effects in most aquatic organisms as it leads to changes in the nervous system and blood components of fish and other organisms. It is considered a dangerous environmental pollutant because it has become the subject of many researchers due to its great risks to the health of aquatic organisms and humans **(Afshan *et al.*, 2014).** The effect of lead on Nile tilapia *(Oreochromis niloticus)* has been studied in terms of HSI and GSI; it caused a decrease in the HSI of fish while it had no effect on the GSI. The decrease in HSI was due to the consumption of energy reserves in the liver cells.

6.3. Zinc (Zn): **-**

It is the most abundant element after iron and is an essential element, it is present in almost every cell and participates in the synthesis of nucleic acids and is found in an abundant amount of enzymes. Zinc is involved in more complex functions, such as transmitting nerves, the immune system, and cell signaling. Zinc residue has direct toxicity to fish when water levels are increased **(Niyogi and Wood, 2006).** The primary target of zinc toxicity is the gills, where calcium absorption is disrupted, which leads to hypocalcemia and ultimately death. Also, the fish kidney is a target organ for zinc accumulation **(Farombi *et al.*, 2007).** Zinc is one of the essential elements important to humans and plants. It is considered as a cofactor for most of the enzyme involved in DNA metabolism. It is also important to stabilize a large amount of proteins, when there is an excess of it, it becomes toxic, and as for zinc deficiency can lead to many functional disorders such as poor pregnancy outcomes, the development of chronic diseases, vascular diseases and cancers as well **(Chasapis *et al.*, 2012).** Zinc causes death, respiratory changes, reduced ovulation, and other harmful effects that threaten fish survival, and damage gills, skeletal muscles, and liver **(Gabet-Giraud *et al.*, 2010).**

6.4. Cadmium (Cd): **-**

Cadmium is widely distributed in the environment, and can be found in many food items, including some seafood products. Cadmium is a carcinogen and is toxic to the kidneys. Cadmium is a trace element that tends to bioaccumulate in organisms often at high levels **(Chowdhury *et al.*, 2004).** It has been shown that this mineral accumulates in the kidneys, livers and gills of freshwater fish, but it can also be deposited in the heart and other tissues and cause uneven pathological changes in those organs **(Margot *et al.*, 2013).** The cadmium present in the plasma of the goldfish significantly increased the activities of glutamic acid in the plasma. Cadmium alters carbohydrate metabolism, causing the blood sugar level to rise in some freshwater and marine fish **(Abbas and Ali, 2007).** The high doses of cadmium caused visible external lesions such as discoloration and necrosis of the skin

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(*Cyprinus carpio*, and *Oreochromis mossambicus*). Cadmium inhibits calcium absorption in the gills and may alter the metabolism of essential elements by affecting the normal tissue distribution of trace elements such as zinc and copper **(Žikić *et al.*, 2001).**

6.5. Copper (Cu): -

Copper (Cu) is a micronutrient of cellular metabolism in living organisms due to it being a major component of metabolic enzymes, yet it can be highly toxic to intracellular mechanisms in aquatic animals in concentrations exceeding normal levels **(Jezierska and Witeska, 2006).** Copper accumulates in fish through the diet and the environment. Even at low environmental concentrations, the accumulation of copper in the fish shows significant pathological changes, including the presence of mucus on the surface of the body, under the gill cover, and between the strings of the gills **(Pieters, 2004).** (Cu) is essential for enzymes and essential for hemoglobin synthesis. Poor copper conduction can lead to decreased bone and blood vessel activity, as well as anemia and osteoporosis. Poor copper metabolism can result from two inherited diseases, mine disease and Wilson's disease. Wilson's disease can also be caused by a build-up of copper in the brain and eyes in the form of a Kayaer-Fleischer ring. Excessive copper intake may also damage the kidneys**.** Heavy metals such as copper reduced the respiration rate and metabolism of freshwater fish. Also, the decrease in glycogen number, tissue oxygen consumption and pyruvate level of the whole body of *Cyprinus carpio* due to stress from copper exposure was determined **(Reddy*et al.*, 2008).**

6.6. Mercury: -

The different forms of mercury are symptoms of many different diseases. It causes spontaneous abortion, congenital anomalies, and gastrointestinal disorders such as esophagitis, intoxication, abnormal irritation and allergic reactions characterized by rashes, peeling of hands and feet, gingivitis, stomatitis and neurological disorders **(Duruibe *et al.*, 2007).** Mercury has no known beneficial role in human metabolism, and its ability to influence the distribution and retention of other heavy metals makes it one of the most toxic metals. The relatively high solubility and stability of some mercury salts in water enable them to be easily absorbed and bio-converted to methyl mercury by certain fish. Therefore mercury is found in its highest concentrations in carnivores such as sharks and some tuna. These forms are easily absorbed through the digestive system and have become a major source of human exposure to mercury. Although humans can excrete a small amount of mercury in urine or feces as well as through sweating, they lack a robust, active mechanism for excreting mercury, which allows levels to build up with chronic exposure. When ingested, mercury can spread to many organs, but it may be concentrated in the brain and kidneys. It can also cross the placenta and is found in breast milk. Mercury exerts its toxic effects by competing with and displacing iron and copper from the active site of enzymes involved in energy production. Mercury may also build up in Thyroid gland and increased risk of autoimmune disorders. **(Galanis *et al.*, 2009).**

7. Different methods of detecting heavy metals in the organs of different fish (updates):-

Techniques in determining metals concentration to include the

1. Atomic Absorption Spectrometer (AAS),
2. X-Ray Fluorescence (XRF),

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3. Particle Induced Gamma Ray Emission (PIGE),
4. Instrumental Neutron Activation Analysis (INAA),
5. Particle Induced X-ray Emission (PIXE)
6. The Inductively Coupled Plasma Optical Emission Spectrometry Technique (ICP OES) **(Samson and Asheshi 2017).**

8. Conclusions and future expectations: -

It is extremely important to assess and monitor the concentrations of potentially toxic heavy metals and metals in different environmental sectors as well as in living organisms.

Steps must be taken to minimize the impact of these elements on human health and the environment the following recommendations**: -**

The concentrations of heavy metals present in the water environment must be documented, as they are considered a reference for all researchers in this field.

Levels of potentially toxic heavy metals in water, sediments, soil and living organisms should be assessed and monitored.

Efforts should be made to reduce heavy metal pollution in the aquatic environment which threatens the health of fish and subsequently the health of consumers.

The consumer public should be educated about the harmful effects of toxic heavy metals on human health and the environment.

Industrial wastewater must be effectively analyzed before being discharged into natural water bodies.

Encourage scientific research on environmental assessment of toxic chemicals, including toxic heavy metals, to protect human health and the environment.

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