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Effect of Toxicity and Bioaccumulation of Heavy Metals on *Channa punctatus* fish

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Abstract
The persistent bioaccumulation and magnifying properties of heavy metals make them environmental hazard. Many human activities also due to natural sources heavy metals are continuously released it the environment and keep polluting the environment such as volcanic eruptions and weathering of metal rich rocks while anthopogenic sources include agriculture and industrial activities fossils fuels and gasoline, waste incineration mining etc. In aquatic ecosystem chemical properties of these heavy metals change due to their toxicity which is dangerous and harmful to living being. These heavy metals enters the boby through gills body tissues and digestive system during ingestion of food particles in aquatic animals. Cadmium, Nickel, Chromium, Copper, Mercury, Lead and Zinc are the most dangerous heavy metals pollutants that generally causes harm to the body. This causes stress and stress weakens the immune system causes damage to various organs of the body and stunts growth.

Keywords: Heavy metal, bioaccumulation, toxicity, pollution

Introduction
One of the biggest problems facing human society today is environmental degradation [1].
Environmental contamination is rising daily as a result of the recent several decades' reckless d epletion of natural resources, rapidly expanding businesses, and rising energy consumption [2].
In the soil and aquatic ecosystem, different organic and inorganic hazardous chemicals are con tinuously leaking from a variety of man-made and natural sources.
Because of their toxicity and tendency for bioaccumulation in the food chain, heavy metals are one of the main contributors to environmental contamination [3].
The natural ecosystem is primarily exposed to heavy metals from mining, fossil fuel combustion, industrial waste materials, household and agricultural waste products, and waste water treatment facilities [4]. Heavy metals get accumulated in the body of animals as they are stable in nature. As plants absorb heavy metals from the soil they cause problems the most common on which are chlorosis, growth retardation etc. Heavy metals enter the bodies of aquatic animals and later get transferred to animals along with the food chain. [5]
Many of them have severe toxicity regular exposer to the body can interfere with the immune system and also compromise its immunity and survival. Depending on the number of antibodies and the duration of the disease they can have mutagenic, Teratogenic and carcinogenic effect [10, 11].
Being omnivores human come in contact with harmful heavy metals through various food items like vegetables meat, fish, etc. [9] Causing heavy metals pollution and aggravation in the body of plants and aquatic animals and the metals continue to move forward in the food chain. Human easily became victim of this. They reach the body [6, 7].
Chromium- The Sea's salty water and the surface of earth Chromium has been found in trace amount in the earth's surface and it's found in various valent states like Cr+2, Cr+3 and Cr+6. Among these Cr+6 is most stable state [12, 13, 17].
Cadmium- Cd is a trace element usually present in association with Copper oxides and lead ores. Its concentrations at the earth's surface is 0.1 - 0.5 parts per million less on the surface and in the ground, but in the sea it ranges from 5 to 110 mg/L. Cadmium is present in the form of element in nature [16, 18].
Abiotic variables like water's pH, temperature, and alkalinity, as well as biotic parameters like age, developmental stage, and species type, all affect how hazardous chromium is to aquatic

life. Fish that were first exposed to chromium had a variety of behavioral abnormalities, including irregular swimming, mucus secretion, body color changes, hunger loss, and more [21]. Cyprinus carpio exposed to chromium at concentrations ranging from 2 to 200 µmol/L over an extended period of time shown cytotoxicity, reduced mitogen-induced lymphocyte activation, and impaired phagocyte activities [22]. When exposed to chromium, Tilapia sparrmanii's blood coagulation time reduced, resulting in internal bleeding and an elevation in pH [23]. Chromium buildup in Indian main carp (Labeo rohita) tissue reduces the amount of total protein and fat in the muscle, liver, and gills [24]. When exposed to chromium, a freshwater teleost called Colisa fasciatus showed a decrease in the amount of glycogen in its liver [25]. At pH 7.8 and 6.5, Cr6+ poisoning caused respiratory and osmoregulatory failure in rainbow trout (Salmo gairdneri) [26]. Chinook salmon exposed to chromium over an extended period of time experienced physiological anomalies, microscopic lesions, DNA damage, and a decrease in growth and survival rate [27]. Chromium exposure at a dosage of 2 mg/L had an impact on fish development and embryo hatching in rainbow trout (Salmogairdneri) [28]. Varied fish tissues exhibit varied levels of chromium bioaccumulation (Table 1). Muscle tissue has a very low quantity of chromium, while the gills, liver, and kidney have the highest concentrations [29, 32].

Copper (Cu)

The widespread use of insecticides, fungicides, and algaecides in agricultural fields, followed by the release of waste materials into water bodies, is the cause of copper contamination in freshwater ecosystems. Other sources of copper toxicity include mining, sewage sludge, air deposition, the electroplating, metal refining, and plastic industries [47, 48].

Methodology: The healthy *Channa punctatus* fishes were used as an experimental animal and it was collected from local fish market of vrindavan and acclimatized in the laboratory for 15 days.

Test chemical: The analytical grade of heavy metals with 0.2ppm was taken.

Experiment design: In present investigation experimental fishes were divided in to two groups control and treated group. 10 fishes were kept in control and exposed to normal water and in experimental group 10 fishes were exposed to concentration of heavy metals, in both control and experimental group fishes were exposed to maximum 96 h.

Result: There have been many determination studies of heavy metals in water, sediment, fish and other aquatic organisms. Some of them are presented in Table 1.

Table 1: Heavy metal bioaccumulation in different tissues or organ of fish-ranked in decreasing order.

Heavy metal	Bioaccumulation in tissue or organ	Fish species	Reference
Chromium	Kidney>heart>muscle>gills	Hydrocynusforskahlii	Murtala *et al.*, 2012
	Kidney>gills>muscle>heart	Hydrocynusbebe occidentalis	Murtala *et al.*, 2012
	Kidney>gills>heart>muscle	Clariasgariepinus	Murtala *et al.*, 2012
	Liver>kidney>gills>muscle	Coregonus lavaretus	Gashkina*et al.*, 2020
	Gills>muscle>kidney>liver	Cyprinus carpio	Rajeshkumar*et al.*, 2018
	Liver>kidney>gills>intestine>muscle	Pelteobagrusfulvidraco	Rajeshkumar*et al.*, 2018
Cadmium	Gills>liver>muscle	Pleuronectes platessa	Westernhagen*et al.*, 1978
	Gills>intestine>liver	Pleuronectes platessa	Pentreath., 1977
	Gills>liver>intestine	Raja clavata	Pentreath., 1977
	Gills>muscle>heart>kidney	Hydrocynusforskahlii	Murtala *et al.*, 2012
	Gills>heart>muscle	Hydrocynusbebe occidentalis	Murtala *et al.*, 2012
	Kidney>gills>heart	Clariasgariepinus	Murtala *et al.*, 2012
	Kidney>liver>gills>muscle	Coregonus lavaretus	Gashkina*et al.*, 2020
	Kidney>gills>muscle>intestine>liver	Cyprinus carpio	Rajeshkumar*et al.*, 2018
	Intestine>kidney>muscle>liver>gills	Pelteobagrusfulvidraco	Rajeshkumar*et al.*, 2018
Copper	Kidney>Liver >gills>muscle	Coregonus lavaretus	Gashkina*et al.*, 2020
	Gills>intestine>kidney>liver>muscle	Cyprinus carpio	Rajeshkumar*et al.*, 2018
	Liver>kidney>muscle>gills>intestine	Pelteobagrusfulvidraco	Rajeshkumar*et al.*, 2018
Lead	Gills>muscle>heart>kidney	Hydrocynusforskahlii	Murtala *et al.*, 2012
	Gills>kidney>heart>muscle	Hydrocynusbebe occidentalis	Murtala *et al.*, 2012
	Gills>liver>kidney>muscle	Coregonus lavaretus	Gashkina*et al.*, 2020
	Gills>kidney>muscle>liver>intestine	Cyprinus carpio	Rajeshkumar*et al.*, 2018
	Kidney>liver>gills>intestine>muscle	Pelteobagrusfulvidraco	Rajeshkumar*et al.*, 2018
Nickel	Kidney>gills>muscle>heart	Hydrocynusforskahlii	Murtala *et al.*, 2012
	Gills>heart>kidney	Hydrocynusbebe occidentalis	Murtala *et al.*, 2012
	Kidney>heart>muscle>gills	Clariasgariepinus	Murtala *et al.*, 2012
	Kidney>liver>gills>muscle	Coregonus lavaretus	Gashkina*et al.*, 2020
Arsenic	Liver>gills>blood>muscle>skin>br ain	Clariasbatrachus	Kumar *et al.*, 2012
	Stomach>liver>gills>muscle	Oreochromis niloticus	Oliveira *et al.*, 2017
Mercury	Kidney>liver>muscle>gills	Coregonus lavaretus	Gashkina*et al.*, 2020
	Gills>kidney>muscle>liver>intestine	Cyprinus carpio	Rajeshkumar*et al.*, 2018
	Muscle>liver>kidney>head	Oreochromis niloticus	Bradley *et al.*, 2017
Zinc	Gills>kidney>liver>gut	Pleuronectes platessa	Pentreath 1973
	Liver > kidney> intestine > gill > muscle	*Channa punctatus*	Murugan*et al.*, 2008

Exposure to copper sulfate in *Channa punctatus* resulted in morphological and biochemical alterations in the liver tissue [33, 57]. Following subchronic exposure to copper sulfate, fish liver cells, gill epithelial cells, and blood erythrocytes all developed micronuclei and binuclei. Complex fish behaviors that are essential for life, like social interaction, predator avoidance, and reproductive behavior, were hampered by copper. When combined with other elements like PbS, PbSO4, and PbCO3, lead is one of the most dangerous heavy metals that occurs naturally in the environment.Numerous man-made sources, including metal mining, burning coal, oil, and gasoline, battery production, lead-arsenate insecticides, lead-based paint, pigments, food cans, and more, significantly raise the amount of lead in the environment [55]. Aquatic life is poisoned by lead discharge from a variety of sources, including municipal wastewater, lead dust, street runoff, agricultural fields, and industry [56].

pH, salinity, hardness, and other factors affect how soluble lead is in water: Ni (nickel): In the environment, nickel is a fairly common trace element that is found in association with sulfur or oxygen. Both natural and man-made factors contribute to the discharge of nickel into the environment. When nickel is mined and converted into alloys or nickel compounds, the element is released from industry. Additionally, waste incinerators, coal-burning power plants, and oil-burning power plants emit nickel [37]. Zinc contamination in the environment is increasing because of different anthropogenic sources such as industrial activities, mining, combustion of coal and waste materials, steel processing etc [46].

Zn (Zinc)

Zinc is a ubiquitous trace element and one of the essential micronutrients for living organisms. Zinc is involved in various metabolic pathways such as nucleic acids and protein synthesis,

Zinc accumulates in fish through gills and digestive track, however the role of water as a source of zinc is not fully elucidated [36].

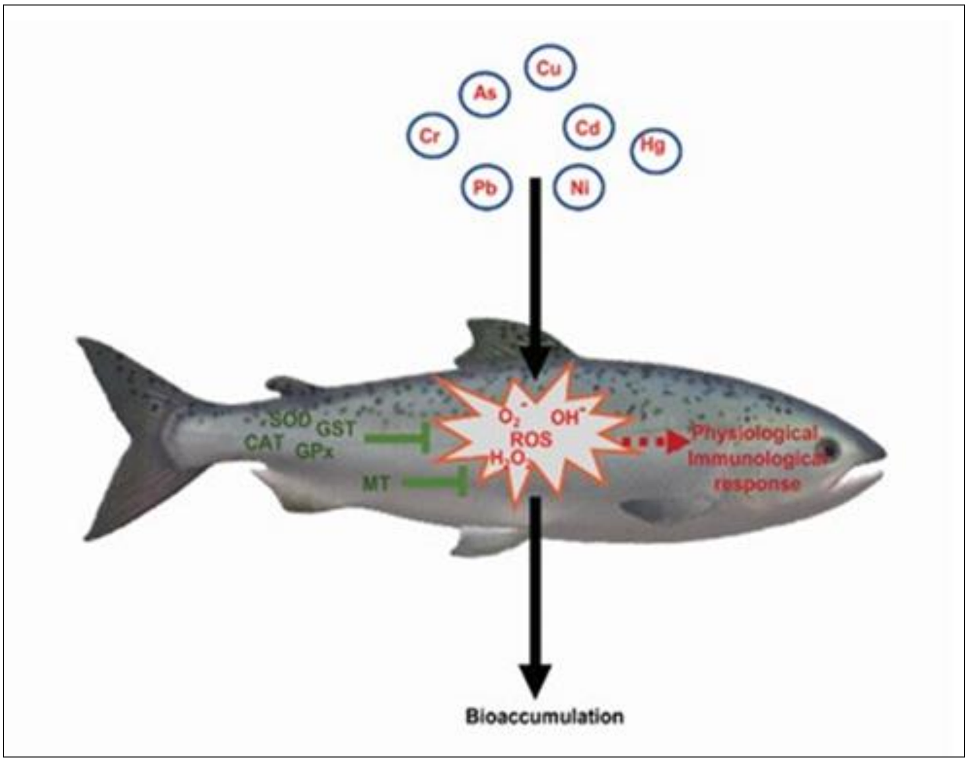

Figure 1: The toxicity of heavy metals on fish. Reactive oxygen species (ROS) are produced by heavy metals, which causes oxidative stress. The detoxification process involves the anti-oxidation defense mechanism, which includes the several enzymes CAT, SOD, GST, GPx, and metal scavenging protein MT. Several physiological and immunological reactions are produced by severe metal toxicity. Metal bioaccumulation takes place in several fish tissues after metal poisoning.

Conclusion

Certain heavy metals are necessary for regular biological functions, and either too little or too much of them can disrupt metabolic pathways and result in severe disease [48]. According to Table 1, essential heavy metals are those with established biological roles [49]. Other heavy metal groups are harmful to tissues at higher concentrations and have no biological function [43,44]. Fish experience an oxidative stress response when metal ions exceed their tolerance threshold because they stimulate the generation of Reactive Oxygen Species (ROS) [36, 41]. Through redox cycling, redox-active metals like copper and chromium produce reactive oxygen species. The defense process is hampered by redox inactive metals, such as mercury, nickel, lead, arsenic, and cadmium, which attach to the Sulfhydryl groups (SH) of proteins involved in antioxidant defenses [34]. Fish with elevated ROS generation have DNA lesions, lipid and protein oxidation, and changes in cellular redox state.

Furthermore, the primary source of the bioaccumulation of heavy metals in various fish tissues is metallothioneins, which detoxify the metals [35]. In addition to having an impact on the fish population in the aquatic ecosystem, the deposited heavy metals also go to the next trophic level through the food chain or web. These materials' trophic transfer from aquatic to terrestrial ecosystems has detrimental effects on human health by fostering a variety of illnesses, such as cancer and neurological diseases Thus, this thorough investigation of the harmful effects of heavy metals on fish health recommends that crucial actions be done to reduce the harmful effects of heavy metals on the environment and human health [45, 46].

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