Chromium and their Derivatives Causes Physiological and Biochemical Modifications in Diverse Fish Models: A Review

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The current literature survey reviews the physiological and biochemical impact of chromium and their derivative across various fish species in aquatic ecosystem around the globe. Chromium and its derivatives such as sulphates, oxides, chlorides, nanoparticles etc have been found to have a deleterious effect on neurology, ionoregulatory, physiology, biochemistry, metabolism and histological parameters in fish. Different species of fish like Labeorohita, Channa punctatus, Danio rerio, Catlacatla, Carassiusauratus and their reaction to Chromium toxicity has been chiefly discussed in the review. In conclusion centered on studies accomplished by various research groups, we can infer that chromium and their derivatives pose an alarming threat not only to fish, but also to ecology and environment.

Keywords: Chromium, Ecology, Environment, Fish, Nanoparticles.

In this day and age, pollution is becoming the major issue around the world. Aquatic ecosystem in particular is more susceptible to heavy metal contamination by extensive industrialization and rapid urbanization. Control and alleviation of the same has become a challenging issue to environmentalists. These lead to adverse effect on water quality of all the water bodies over the world¹. The aquatic ecosystem receives anthropogenic wastes and become ultimate depository of heavy metals. Heavy metals are identified as metallic element that have a relatively higher density in contrast to water². Once the heavy metals enter to living organisms through food chain, it becomes irreversible³. The chief sources of heavy metals are agriculture wastes (pesticides, insecticides etc.) industrial waste. Bio-accumulation of these pollutants in aquatic organisms such as fish from different water bodies depends on the intensity of pollution⁴. Nanoparticles also contribute to a significant impact on polluting the environmental health. Metallic nanoparticles are a flexible class of materials ⁵. Fish physiology, metabolism, genomics and behavior may reflect the purity of aquatic environment and its resistance to contamination by heavy metals and nanoparticles ⁶. Elemental chromium is not habitually found in pure form. But it naturally exists as an ore. It has different oxidation states ranging from Cr²⁺, Cr³⁺, Cr⁴⁺, Cr⁵⁺, Cr⁶⁺. But trivalent Cr³⁺ and hexavalent Cr⁶⁺ oxidation states are frequently available in environment and are the most stable forms of...
chromium. In the present literature survey we shall discuss the effects of chromium and their derivatives including nanoparticles on different types of fish models.

**Review**

**Labeorohita (Rohu)**

*L. rohita* is a fresh water fish of the carp family. The fish is one of the top edible fish in Asia. The studies conducted revealed that *L. rohita* when exposed to different concentrations of chromium, the fish body balance were impaired at the dosage of 28.99 mg/L concentration. LC$_{50}$ was reported to be 30.36 mg/L. In another study *L. rohita* were exposed to chromium oxide nanoparticles at 25 mg/L concentration. There results obtained demonstrated decline in red blood cell count and total leucocyte count. The studies also revealed pathological changes in different organs of treated fish compared to untreated fish. Exposure of fish to the sublethal concentration of chromium 6 mg/L for 30 days resulted into mild histopathological conditions. *L. rohita* were exposed to 10% sub lethal concentration for 96 h. They observed histopathological alterations in gills upon 10 days of exposure. And after 30 days of exposure, fusion of gill lamellae, hypertrophy, degeneration of liver cells and liver lesions were recorded. *L. rohita* were treated with organic and inorganic form of chromium separately. Inorganic chromium in the form chromium chloride hexahydrate was treated at the concentration of 0.3, 0.5 and 0.6 mg/kg and organic chromium in the form of chromium picolinate at the concentration of 0.3, 0.5 and 0.6 mg/kg. Other fish were genetically damaged.

**Channa punctatus (Bloch)**

*C. punctatus* is a fresh water fish. It is the species of spotted snakehead. The report showed that fish were exposed to chromium concentration of 20 mg/L and 40 mg/L for the study of behavior changes upon treatment and LC$_{50}$ was found to be 41.75 mg/L. Later the fish were treated with glucose in the concentration range 10 mM, 1 mM, 0.1 mM, 0.01 mM, 0.001 mM. The rate of glucose absorption was higher when the concentration is 0.001 mM in the presence of chromium. The enzymes like lactate dehydrogenase, pyruvate dehydrogenase, succinate dehydrogenase were suppressed upon exposure of chromium in the concentration 2.6 mg/L for 60-120 days. Exposure of hexavalent chromium to *Channa punctatus* for 96 h LC$_{50}$ was found to be 41.75 mg/L. This resulted in irregular swimming, damage of gill cells, renal destruction and hepatocytic abnormalities.

**Danio rerio (zebrafish)**

The Zebrafish is the freshwater fish belonging to family Minnow. It is a popular aquarium fish and is native of south Asia. Zebrafish is one of the major model organism. The report showed that the LC$_{50}$ for 96 hours of chromium trivalent and chromium hexavalent was found to be 105.279 mg/L and 26.03 mg/L. Fishes were exposed to different concentrations of chromium and it was determined that the concentration equal to 0.7 mg/L will effect on swimming speed and turning times. To assess the reproductive ability upon treatment, male and female fishes were exposed for 96 hours LC$_{50}$ of chromium concentration with 37.96 mg/L for three months, and were allowed to breed. There was reduction in fertility to 47%. Moreover, there was a reduction of 45% hatchability. Survival of larvae after seven days of treatment, reduced to 57%. These studies concluded that treatment with chromium can cause reduction in reproduction ability of fishes.

**Cirrhinus mrigala**

*C. mrigala* is the fresh water fish. *C. mrigala* is the species of rayfinned fish. The study reports that fishes were provided with 34 mg/L to 40 mg/L concentration of trivalent chromium for 30 days. LC$_{50}$ was found to be 34 mg/L. The physico-chemical parameters were maintained at optimum level. For lower sublethal concentration, the accumulation of chromium in different organs were in the order: kidney > muscle > liver. In an another study *C. mrigala* was treated with different concentrations of chromium. The LC$_{50}$ was determined to be 18.20 mg/L. The physico-chemical parameters were maintained at optimum level. For lower sublethal concentration, the accumulation of chromium in different organs were in the order: kidney > liver > gill.
> liver > gill. Accumulation of maximum level of Cr in the kidney were recorded to be 97.326 mg/g and 162.637 mg/g. Next to the kidney, the liver accumulates high amount of chromium and was demonstrated to be 87.325 ± 3.683 µg/g. It was evaluated that muscle also accumulates high level of Cr in higher sublethal concentration is 91.227 µg/g.

**Carassiusauratus (Goldfish)**

The Gold fish is a fresh water fish of the family cyprinidae. Gold fish were exposed to the chromium in the concentration range 4ppm, 6ppm, 8ppm and 12ppm for 96 h, which demonstrated multiple morphological and behavioral changes. The accumulation of chromium was in order gills > intestine > skin. Gold fish were acclimitized to laboratory conditions and exposed to aqueous hexavalent chromium of 5% and 10% for 96 h. The LC₅₀ was determined to be 85.7 mg/L. The lipid hydroperoxide (LHP) in liver was exposed to 5% and 10% LC₅₀ with increase in concentration for 1, 2, 3 and 4 weeks separately. The increase in 1 week was significant p < 0.005 when compared to the control. However, elevation in week 2, 3 and 4 were not significant p > 0.05 from control. DNA damage in Gold fish were assessed by Comet Assay by staining. The gold fish were exposed to 5% and 10% LC₅₀ dosage and observed for all 4 weeks of exposure to check the percentage of DNA damage in kidney cells. The research group, noted the increase in week 1 and 2 was 5% and 10% respectively and was significant p < 0.05 from control, whereas elevation in week 3 and 4 were not significant p > 0.05 compared to the control.

**Cyprinuscarpio L.**

The common carp or European carp is widespread fresh water fish in Europe and Asia. According to a study, fish were exposed to chromium in the concentration range 15 mg/L, 25 mg/L, 35 mg/L and 45 mg/L. LC₅₀ for 96 h was found to be 30 mg/L. Upon increasing the chromium concentration, gills pavement cells were desiccated. In another study, Cyprinuscarpio were treated to trivalent chromium in the concentration range 7.5, 15, 30 and 60 µg/L for 21 days. Scales were highly damaged in the concentration range of 30 µg/L and 60 µg/L. A study was performed on C. carpio which were exposed to sublethal concentration of 5ppm for 48 h to examine the bioaccumulation in different organs. High amount of metal was found in liver resulting in liver damage and also metabolism of all organs were disturbed. A study reported that Cyprinuscarpio were exposed to sublethal concentrations of hexavalent chromium in the range 0, 25, 50, 75, 100, 125 and 150 mg/L. They observed that high concentration of chromium led topriority hematological changes such as increase in WBC, mean corpuscular volume, erythrocyte sedimentation rate and enzymes such as aspartate aminotransferase, ALT, ALP and ACP, RBC indicating anemia.

**Catlacatla**

Catlacatla is a fresh water fish. C. catla were treated to chromium for 60, 120 and 240 days at constant water temperature 30±°C, pH 7.5 and total hardness 300 mg/L. LC₅₀ for 96 h was recorded to be 77.01 mg/L for 60 days. It was observed that 15.37µg/g of chromium was accumulated in the different organs of the fish. Percentage of accumulation depends on the age of the fish, while chromium accumulation was found to be maximum in fish exposed for 240 days. In a different study catla fish were exposed to both Cr³⁺ and Cr⁶⁺ for 8, 16 and 32 days to study the histopathology modifications of gills. Lethal and sub-lethal concentration of C. catla was determined by Probit method. Trivalent chromium of LC₅₀ was found to be 59.68 mg/L and sub lethal concentration of 100 mg/L for 96 h and lethal concentration of hexavalent chromium was shown to be 10 mg/L and sub lethal concentration was 3.5 mg/L.

**Oreochromis aureus (Blue tilapia)**

Oreochromis aureus is a fresh water fish of the family Cichlinidae. It is native to Northern and western Africa and Middle East and is an important food source throughout the world. According to a study, O. aureus fish were treated with the chromium in the concentration range of 10, 15, 20, 25 and 30 µg/L for 28 days. There were no much behavioral changes in low concentrations of chromium. But upon treating with 20 µg/L, there was a minor change in the behavior of fish and at the concentration 30 µg/L, the fish were shivering with respiratory disorder, swimming in capsized position had been observed. Accumulation of chromium in gills was four times greater than the muscle. And the accumulation of chromium in the skin is almost twice as muscle. In another study O.aureus were treated with chromium in
the concentration range of 10, 15, 20, 25 and 30 mg/L for 28 days. The LC$_{50}$ was found to be 32.35 mg/L. Accumulation of chromium in different organs were in the order: gill > skin > muscle. The concentration range of chromium accumulation in the gill was 3.11-45.23 µg/g and in the muscle was 0.86-12.34 µg/g. To study the effect of dietary chromium complement on humoral antibody response and some blood constituents, O. aureus was fed at 1 or 2 mg/kg of fish and immunized with sheep red blood cells simultaneously. There was decreased plasma glucose and increased cholesterol and decreased albumin:globulin ratio.

**CONCLUSION**

The literature review concludes that the chromium derivatives such as ions, oxides, chlorides, nanoparticles pose a major impact on aquatic biota. Exposure of significant amount of chromium to wide array of fishes will involve a crucial and harmful impact are histopathology, DNA damage, behavioral changes such as swimming, cell disruption, metabolism, physiological changes etc. This can be concluded that the unnatural amount of chromium or any other component will impose a great impact on nature.

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