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Prevalence of Hexavalent Chromium (VI) Induced Alterations in Fish: A Review

Hareem Sajjad* **and Neelam Arif**

Department of Zoology, University of Gujrat, Hafiz Hayat Campus, Gujrat, Pakistan

***Corresponding author:** Sajjad H, Department of Zoology, University of Gujrat, Hafiz Hayat Campus, Gujrat, Pakistan, Tel: +923334116701; E-mail: hareemajjad123@gmail.com

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Abstract

Chromium is considered as a standout amongst the most well-known universal toxins in the aquatic condition, however the pure metallic form is absent normally. There are three oxidation states on the off chance that of Chromium viz., Cr (II), Cr (III), Cr (VI). Among which Cr (II) is generally unsteady. Cr (III) and Cr (VI) are the steady oxidation state of Chromium in the earth. Being one of the regularly utilized metals Chromium and its particulates enter the sea-going medium through effluents released from various enterprises like materials, tanneries, electroplating workshops, mineral mining, coloring, printing-photographic and therapeutic industries. Among these, hexavalent chromium is considered as the most poisonous form since it promptly passes cell layers and afterward reduced to trivalent form. This trivalent chromium joins with a few macromolecules including hereditary material inside the cytosol, and is at last uncovered the poisonous and mutagenic adjustments due of chromium lethality. Chromium is taken up either through gastrointestinal tract or respiratory tract. The amount fluctuates relying on the medium and the type of chromium. The aim of this review paper is to give a future rule for mainstream researchers and open authorities associated with health hazard evaluation and administration ensuring a superior ecological condition for human health.

Keywords: Toxicity; Chromium; Concentration; Hexavalent; Fish; Effects

Introduction

These days, contamination, particularly in sea-going medium, because of overwhelming metal pollution has turned into an important issue of worry to the scientists. Broad industrialization, and fast urbanization have quantifiably forced unfavorable effect on the water nature of lakes, ponds and streams everywhere throughout the world [1]. The issue has turned out to be more risky on the earth that the businesses regularly discharge their waste components containing metallic contaminants into the earth which exceeds as far as possible [2]. Disregarding the advance in natural waste administration framework, the entanglements because of overwhelming metal release are as yet posing adverse antagonistic effect on oceanic biolife [3]. Particularly lithophilic metals are set apart to be more toxic to the biological community and center gathering of oceanic poisons [4,5] in view of their long ingenuity, properties of bioaccumulation, biomagnification and non-biodegradibility [6] as they can damage the system of species decent variety [7,8]. Overwhelming metals can indicate high poisonous quality even in low concentration creating combined harmful impacts in an oceanic biological system [2].

Chromium, a standout amongst the most widely recognized metal poisons in nature enters the aquatic ecosystem through effluents from ventures like textiles, tanneries, mining, electroplating, coloring, printing, photographic printing, pharmaceuticals, stainless steel assembling and elastic assembling enterprises [9-12]. Chromium is generally found in the trivalent shape, and this frame (Cr^{3+}) is accounted for as a fundamental component in mammals as it takes successful part in glucose, lipid, and protein digestion [13]. Because of poor membrane permeability, non-destructiveness and less inclination to biomagnify in the natural way of life, the harmfulness of trivalent chromium is very low [5].

Hexavalent chromium is thought to be more harmful than trivalent form on account of its simple permeability through the cell film. Hexavalent Chromium has two fundamental oxy-anion frames CrO_4^{2-} and CrO_7^{2-} which are engaged with reversible change. After entering the cell, the hexavalent chromium promptly diminishes to its trivalent shape and complexes with intracellular macromolecules even with hereditary materials [14,15]. The simple permeability and biotransformation property of hexavalent chromium is at last in charge of its harmfulness and mutagenic action [2]. Chromium concentration is very much important for its toxicity; the more the toxicity; the more it is lethal and vice versa. As indicated by WHO, the allowable limit of chromium in drinking water is 0.1 mg/l and 0.05 mg/l respectively [16]. As per the reports of WHO and FEPA or Federal Environmental Protection Agency, the most extreme suitable breaking point of chromium in fish nourishment is 0.05-0.15 mg/kg body weight [16,17].

The fresh water biological community of fishes possesses a small territory in contrast with marine environment. Fresh water assets now a days debased at an extensive scale, because of water contamination. Developing nations are confronting the issue of water contamination because of quick spread of industrialization and human advancement [5]. These enterprises deliver extensive measure of contaminated items particularly substantial metals that are continually depleted untreated into adjacent streams. The effect of substantial metals on fishes has ended up being a worldwide concern [18].

Fishes have really been used as test life forms for intense lethality bioassays because of a few advantages. As indicated by U.S. Ecological Protection Agency, they are advantageously kept up under research lab conditions, and are delicate to an assortment of contaminations and promptly accessible during the time from both commercial and also natural resources [16]. This review summarizes the major toxicological effects of hexavalent chromium in the fresh water fishes. It also gives an investigation of the sources of chromium in various situations and its component of poisonous quality to fish fauna.

Chromium in the natural ecosystem

Chromium (nuclear weight of 51.996), in the crystalline frame, is a steel-dim, shiny, hard metal described by a atomic number of 24, a thickness of 7.14, a melting point of 1900°C, and a boiling point of 2642°C [19]. It is most commonly display in trivalent (+3) and hexavalent (+6) oxidation states in the earth [20]. Convergence of chromium in soil shifts from 1 to 3000 mg/kg, 5 to 800 µg/L in ocean water, and 26 µg/L to 5.2 mg/L in waterways and lakes [21]. Chromite ($FeOCr_2O_3$ or $FeCr2O_4$) is the most essential metal mineral. It can likewise be found as result of both marine or earthly volcanic ejection [22].

Industrial use of chromium

Chromium is a generally spread industrial component originating from a few ventures like electroplating, compound cast irons, paints, tempered steel fabricating businesses; chrome plating, elastic assembling enterprises; leather industry, wood treatment, coloring processing plants and so on [9-11]. It has likewise been accounted for that chromium is additionally discharged from material, tanneries, mining, compost, printing, photographic and pharmaceuticals businesses [5].

Bioaccumulation, metabolism and excretion of chromium

Cr (VI) has been accounted for to be diverse toxicologically from other overwhelming metals as it can promptly infiltrate the gill membrane by the procedure of passive diffusion which is interceded by pH of the system. Chromium fixations in fish tissue emerge through bio-amplification at each trophic level and particularly bottom feeders focus higher measure of metal [23]. Chromium (VI) gets related with the plasma protein and includes in transportation subsequent to passing the cell membrane through sulfate ion channel. At that point the metal naturally gets gathered in different organs. The general example of dispersion of Cr (VI) in fishes is as per the following: Gills>Liver>Skin>Muscles [24]. Bio accumulation of chromium in the fish muscle, gills and liver has been accounted for to increment contingent upon the concentration in the medium and the exposure time [25]. Chromium concentration in the tissues of Rainbow trout (*Salmo gairdneri*) is exceedingly affected by pH of the encompassing water [26]. They have likewise announced that gill contains more measure of chromium at pH-6.5 than other inward organs though, turn around is apparent at pH-7.8. Relative examinations have uncovered that Chromium fixation stays higher in gill than different organs at same pH [27].

Subsequent to getting entry, the hexavalent chromium experiences metabolic diminishment inside the cell. A definitive aftereffect of this marvel coordinates the prevalence of trivalent chromium in the cytoplasm [28]. During these metabolic responses, distinctive reactive intermediates are discharged which are accounted for to be inconvenient to ensuring the dependability of DNA helix, causing lethal impacts in the influenced person. Similarly, researchers have likewise announced that relocation of different halfway chromium metabolites to the nuclei and communication with DNA are clear during this procedure causing the final negative impact [29].

Major toxicological effects of chromium induced alteration in fishes

The aquatic toxicology of Chromium relies upon a few biotic elements viz., exploratory species, age and developmental stage and additionally extraordinary abiotic factors viz., temperature, convergence of Cr, oxidation territory of Cr, pH, alkalinity, saltiness, and hardness of water and so on. Similarly, deadly and sub-lethal amount of the metal and its speciation likewise control the affectability of the trial organisms [2]. Following are some acute, chronic, biochemical effects to various concentration on fishes.

Acute toxic effects of chromium: Short term exposure to different concentrations of chromium may bring changes in fresh water fishes in various aspects. Distinctive types of fish specifically dace, roost, stickle back, rouch and rainbow trout was examined for Cr (VI) affectability and it was discovered that even at minute fixation rainbow trout is 1.16 to 2.52 times more delicate as contrasted with other test species [30]. The root cause of acute toxicity are multiple and depends on time-concentration combinations.

Biochemical toxicity of chromium: Biochemical examinations have uncovered that changes in amount and action of a few catalysts are obvious in chromium initiated condition. An investigation was done *in-vitro* impact of five metals in particular chromium, mercury, nickel, cadmium and zinc on the properties of a chemical NADPH-cytochrome P450 (CYP450) reductase in jumping mullet (*Liza saliens*). These discoveries demonstrated that Cr represses the action of CYP450 reductase in fishes [31]. Another examination on Indian common carp has built up that Chromium isn't

essentially imperative for the exercises of alanine amino transferase (ALT) or aspartate amino transferase (AAT) in *Labeo rohita* [4].

Chromium applies its impact on the epithelial cells of the digestive tract and can likewise change the rate of glucose transport. One of the investigation led on the digestive tract of rainbow trout mirrored a low rate of glucose assimilation by epithelial cells. In another research, a study was conducted on the effect of various concentrations of Cr on glucose intake in *Channa punctatus* featured enormous retention rate at 0.001 mM [32]. On the other hand, *Colisa fasciatus* presented to Cr (VI) showed drained glycogen levels in liver and hyperglycemic conditions in blood [33]. Some biochemical profiles were researched at lethal concentration of 39.4 mg/L^{-1} Cr in different organs of *L. rohita* like gill, liver, and muscle. The lipids, glycogen and protein levels were fundamentally lessened because of metallic pressure, hypoxic or anoxic conditions in every one of the three organs [34]. The results are in concurrence with a prior examination who revealed that *L. rohita* presented to Cr demonstrate proof of hypoxia with low oxygen use [34].

Toxicity of chromium at hematological level

Different alterations in the hematologic records of fresh water fish subjected to Cr (VI) are very much perceived. Concentrates on *Labeo rohita* explains a noteworthy decrease in the hemoglobin rate, iron deficient condition of the fish and the total erythrocyte count after presentation to Cr (VI) at concentration 39.4 mg/L^{-1} [35]. Blood coagulation research on *Tilapia sparrmanii* showed that when it is presented to potassium dichromate it brings about an expansion of clotting time at various pH levels [36].

Another examination researched hematological parameters of freshwater fish *Channa* after introduction to chromium trioxide. The uncovered fish spoke to an expansion in Hb % while indicated decreasing level of TLC. TEC and PCV helped between 7 to 30 days yet it turn down following 60 days. Similarly CT and ESR uncovered a declining inclination from 7 to 30 days yet unexpectedly increase in these parameters were noted following 60 days [37].

In another examination deadly impact of Cr was noted in fresh water fish, *Labeo rohita* for 7 and 30 days. The reduction in hematological parameters prescribed that the exposed fish after presentation to Chromium become anemic and their glycogen, protein and cholesterol level diminished essentially [1].

Effects of chronic toxicity of chromium: Long term introduction to hexavalent chromium display a few modifications in conduct, physiology, cytology, histology and morphology, Decrease in antibody creation and lymphocyte check, diminishment in spleen weight DNA damage [38], diminish in Growth and survival rate [14] reduction in protein level, decreased humoral responses, increase in blood and muscle lactic acid [39], decrease in larval development and embryo survival rate [40] and disintegration in fin and fin ray morphology have been accounted for to be the major recognized constant impacts of Chromium in various trial conditions for various exploratory fishes. The greater part of the aforesaid indications are found as concentration and duration dependent.

Few studies have detailed report about the histopathological changes in the tissues like liver, gill, kidney, muscle and so on of test fishes after perpetual exposure to sublethal concentrations [2,41,42]. Long term introduction of chromium applies some measurements span depended consequences for various enzyme exercises. In an investigation, scientists have presented *Channa punctatus* to 2.6 mg/l of the metal for 60 to 120 days to decide the action of succinate dehydrogenase (SDH), lactate dehydrogenase (LDH), pyruvate dehydrogenase (PDH) on its distinctive organs like kidney, cerebrum, liver, gill, digestive system and muscles [40]. They have additionally referred to the restraint in enzymatic movement of PDH in every chose organ during same examination period. Accordingly, hyperglycemia and hyperlactamia have turned out to be obvious in exploratory fish following 120 days exposure. The movement of PDH has likewise been accounted for to be reduced altogether in liver, kidney and muscle during 120 days introduction. Chromium advances the arrangement of receptive oxygen species (ROS, for example, hydrogen peroxides which improves the peroxides and responsive hydroxyl radicals. These lipid peroxides and hydroxyl radicals may cause cell membrane harm and therefore devastate the cell [43].

Effects of chromium toxicity on fish behavior: At the point when fish is at first experienced to chromium it experiences different social changes like suspending bolstering conduct, uneven swimming and quickened operculum. It may activated basic changes, for example, hypertrophy and paraplegia at gill epithelium and debilitates the body resistant framework [38,44].

An investigation was led to check the effect of chromium trivalent and hexavalent poisonous quality on the conduct of *Danio rerio* (zebra fish). Sporadic movement, bodily fluid release, opening mouth for heaving, shading and shade changes, sporadic swimming was typically checked out [45]. In other studies, researchers researched the behavioral changes in gold fish (*Carassius auratus*) and noticed that every one of the fingerlings go to the side of the aquarium and there was likewise craving diminish because of chemical impacts [46]. In another examination after introduction to hexavalent chromium change in behavioral standards of *Channa punctatus* was considered. The exposed fish demonstrated unpredictable swimming and became sluggish. The adjustments in gills were delineated by epithelial hyperplasia, oedema, epithelial lifting and necrosis [47].

Conclusion

In spite of the fact that chromium is universal metal in nature and trivalent chromium is likewise fundamental for biolife, hexavalent chromium is said to be a dangerous metal with mutagenic, cancer-causing, also, unique harmful effect on biota. Specialists have uncovered that chromium influences

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the physiological, social, histological, biochemical, hereditary and immunological state of the exploratory living being. Trivalent chromium is fundamental part of various proteins whereas, hexavalent chromium with the bio-layer penetrable limit is found to have poisonous effect fresh water fishes. Hematological change, for example, diminished hemoglobin rate, diminished RBC consider can be thought about biomarker. Huge histopathological crumbling has been found in gill, liver, kidney and digestive tract of trial living beings when presented to a sub-lethal fixation. Huge changes in absolute glycogen, add up to protein and aggregate lipid fixation in gill, muscle and liver tissues of exploratory living beings have been found during chronic exposure study about particularly when presented to sub-lethal concentrations. In this manner, it can be concluded that industrial emanating releases with chromium contamination is forcing. This review can put forward the basic potential alterations of chromium pollution in aquatic ecosystem and will be helpful for the future researchers to gather advanced knowledge of the ecotoxicology and risk assessment of chromium huge alteration in oceanic life however all the hazardous notations are dosage time dependent.

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