Medical and life Sciences (2022) 1(1): 22–27
ISSN 2976-7245

Antioxidant enzyme activity under exposure of cadmium to fish

Unab Zahra[1]

How to cite this article:

Zahra, U. Antioxidant enzyme activity under exposure of cadmium to fish. *Medical and Life Sciences*, *1*(1), 22-27.

Received: 8 Feb 2022 / Accepted: 21 May 2022 / Published online: 5 June 2022

Abstract

A study was conducted to investigate the acute toxicity of cadmium (Cd) in two fish species, specifically Catla Catla. After subjecting the fish to the 96-hour LC50 and lethal concentration tests, their organs, including the gills, kidney, and liver, were examined for antioxidant enzyme activity. The results indicated that Cd was significantly more toxic, with mean 96-hr LC50 values for fish species of 64.21 11.24 and 170.39 40.69, respectively. It was also observed that Catla Catla was less vulnerable to the detrimental effects of Cd. Additionally, the study revealed that the superoxide dismutase activity of both fish species increased with an increase in the number of metallic ions in the test media. Conversely, as the number of metallic ions in the test media increased, the activity of catalase and peroxidase decreased. The control group exhibited the highest activity of catalase and peroxidase when there was no metal stress. The liver, kidney, gills, fins, skin, muscle, and bones of the fish were found to have the highest Cd accumulation, with Catla Catla exhibiting a similar pattern of metal accumulation to the other fish species. The results of both fish species were comparable, with the order of metal accumulation in fish organs being liver > kidney > gills > fins > skin > muscle > bones.

Keywords: Paternalistic Leadership, Organization Citizenship Behavior, Effectiveness

1 Introduction

Heavy metals and other chemical pollutants from hospitals and manufacturing facilities have contaminated the aquatic environment. These pollutants can be harmful to aquatic life and the environment, endangering both human health and the environment at even trace levels. (Aldoghachi et al., 2022) Common aquatic organisms are seriously threatened by the toxic and unnecessary transition metal cadmium. It is well known that it significantly pollutes water, and because it enters the food chain, it eventually endangers human health. In (Okearafor et al 2020) The use of metals and minerals in industry, the development and use of chemical fertilizers in agriculture, and the use of some industrial products that may be dumped into water with wastewater are the main causes of cadmium pollution. Fish, an important component of the aquatic food web,

[1]Department of Zoology, The government Sadiq college and women university, Bahawalpur
e-mail: anabzhara87@gmail.com

consume a significant amount of heavy metals from contaminated water, including cadmium) Ismail and Saleh in 2012. The toxicological effects of cadmium pollution on various organs of living things include cramps in the stomach, nausea, vomiting, diarrhoea, hematuria, kidney failure, and other symptoms. Even at low concentrations, cadmium can easily be enriched and spread its toxic effects up the food chain. (Wang et al 2021) Cadmium has an atomic weight of 112.4 and an atomic number of 48. It is a divalent element. Although it is insoluble in water, it is freely soluble in its salts of chloride and sulphate. The rate of cadmium absorption and desorption from terrigenous materials, pH, eh, chemical speciation, and many other modifiers all affect how much cadmium is available to living things in their immediate physical and chemical environments. When (Naz et al 2020). Ingesting tainted food, suspended particulate matter, or dissolved metal contents from a variety of sources can all expose fish to toxic metals. Due to the persistent nature of toxic metals, particularly cadmium, which can easily accumulate in various human tissues and cause a number of serious health consequences, contaminations not only endanger fish but also pose serious risks to the general public's health. 2019 (Junejo et al 2019). Fish contribute to the world's protein supply in addition to offering nutrients, proteins, and minerals that are not present in any other food (Lynch et al., 2016) Fish makes up more than 50% of the animal protein diet in nations like Ghana and Bangladesh. In countries like Ghana and Bangladesh, the animal protein diet consists primarily of fish. (Sores et al., 2016). Fish identification, which is frequently based on visible external morphology, is one of the most significant taxonomic measures, though. (Naz et al. 2022). Fish is a significant source of protein and has numerous health benefits Quality and safety are of the utmost importance due to its nutritional importance. Fish have undergone extensive global research for heavy Consuming contaminated fish is one important way that people are exposed to heavy metals. (You et al 2018). Fish is an energy-dense complete food that contains protein, amino acids, minerals, and vitamins. Fish also defends against diabetes and cardiovascular disease. Fish contains the omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (EPA) If the fish is contaminated, consumers may experience negative health effects, rendering the health benefits of fish useless. (Varol et al., 2017). Typically, the Mrigal fish is consumed as food. It is very significant economically in its home country (Ayyappan et al., 2003). Mastacembelus armatus, also known as the "zig-zag eel" or "tire-track spiny eel," is a common fish species found in the Indian subcontinent. It is a member of the order Synbranchiformes' family Mastacembelidae. It is one of the most popular table fishes, and its succulent flesh is full of protein, oil, and vitamin C and has a distinctive texture and flavour. (Han et al., 2019).

2 Material and Methods

A public fish seed hatchery in Bahawalpur, Punjab, provided 160 freshwater fish (Catla catla), each weighing 230-235 g and measuring 12-15 cm in length.. The fish were about 3 months old, about that weight, and that length. For 15 days, the fish were exposed to laboratory conditions while being transported in plastic bags with enough oxygen. During this time, the water was changed daily, maintaining the same conditions of temperature (30°C), hardness (255 mg/l), and pH (6.5). To test the enzyme assay, the fish were fed 2% of their body weight and exposed to cadmium. In St. Louis, Missouri, the United States, Sigma-Aldrich and Merck were the only suppliers of chemicals used (Germany). Temperature, pH, electrolytes, electrical conductivity (EC), and dissolved oxygen were among the physicochemical characteristics of water that were maintained throughout the experiment (DO). The toxicants cadmium chloride and were dissolved in a concentration of tap water to get the desired results. After the experiment, the liver, kidney, and gills of fish were examined for the activity of the enzyme’s catalase and superoxide dismutase (Naz et, 2023). Following (Steel et al., 1997), statistical software such as STATISTICA, MSTATC, and MICROSTAT were used to analyse the experiment's data. To identify statistical differences between variables, Tukey's/Student Newnan-Keul tests were used.

3 Result

By calculating their 96-hour LC50 and lethal concentrations, the study evaluated the toxicity of cadmium and chromium on Catla Catla fish. With mean 96-hour LC50 values of 64.21 11.24 and 170.39 40.69, respectively, the findings demonstrated that cadmium was significantly more toxic than chromium (Table 1.

Table 1 Acute Toxicity of Cadmium

Treatments	Metal	Concentrations
96-hr LC_{50}	Cadmium	64.21 ±11.24
96hr lethal concentration	Cadmium	170.39 ± 40.69

Table 2 Enzyme activity of fish exposed to Cadmium

Enzymes	Organs	Treatments			
		10 days		20 days	
		96-hr LC_{50}	96hr lethal conc.	96-hr LC_{50}	96hr lethal conc.
SOD	Gill	3.274±0.041	4.611±0.058	4.567±0.043	5.367±5.435
	Liver	4.355±4.355	6.456±0.080	5.356±0.011	6.486±0.082
	Kidney	2.156±0.070	2.895±0.567	0.929±0.389	1.131±0.583
CAT	Gill	2.18±0.012	3.19±0.023	0.837±0.456	0.948±0.578
	Liver	3.24±0.370	4.35±0.457	3.654±0.237	5.789±0.357
	Kidney	4.67±3.466	5.78±4.567	9.158±0.098	9.199±0.99

Additionally assessed were the superoxide dismutase and catalase activities in the liver, kidney, and gills of Catla Catla fish. The liver, kidney, and gills had the highest mean superoxide dismutase activity levels. Although the control fish showed the least activity, superoxide dismutase activity increased with increasing metallic ion concentrations in the test media. In different fish species' organs, catalase and superoxide dismutase activity varied. Average catalase activity was found to be 2.18 0.012, 4.35 0.457280.451, and 5.78 4.567 U/ml in the liver, kidney, and gills of Catla Catla, respectively (Table 2).

4 Discussion

According to research on cadmium's effects on tilapia fish, being exposed to toxic metals during the acclimatisation period can cause a variety of physiological, biochemical, histopathological, and DNA-damaging problems. Such exposure causes aquatic organisms to experience oxidative stress, which increases the production of reactive oxygen species and interferes with antioxidant enzyme mechanisms, ultimately changing how various visceral organs function (Hussain, 2011). Fish rely on enzymatic antioxidants to change their activity and adapt to stressful situations. The degree of the alteration depends on the stressor's intensity, species, and method of exposure (Gravato et al., 2006). Protecting organisms in aquatic and terrestrial ecosystems from oxidative stress, whether it be natural or artificial, the volatile antioxidant enzymes CAT and SOD detoxify hydrogen peroxide and superoxide anions (Naseem et al., 2022). When the body is under stress from environmental pollutants, SOD serves as the first line of defence against free radicals, making it particularly crucial (Jindal et al., 2014). After 21 days of treatment, the antioxidant enzymes SOD and CAT activity in the gills of fish exposed to cadmium significantly decreased. This result is in line with earlier studies on Catla Catla. The antioxidant enzymes SOD, GST, CAT, and GPx are crucial in preventing tissue damage brought on by metal exposure because metals are known to cause oxidative stress in fish (Mahmood et al., 2022), which leads to an excess of free radicals. 2022 will see Li and associates (Veedu et al., 2022).The study also found that the treated fish's gills, kidneys, and liver tissues had higher rates of DNA damage on days 21 and 26. Previous research has shown that accurate, widely used, sensitive, and reliable methods can be used to quantify DNA damage in various tissues. (Raza et al., 2020). The study also discovered that fish exposed to metals had significantly higher DNA damage potential in different tissues, which was possibly brought on by oxidative stress and the rapid production of free radicals.

Numerous microscopic conditions, including cartilaginous core congestion, lamellar fusion and atrophy, lamellar pillar cell necrosis, and lamellar disorganisation, have been discovered in fish gills. Additionally, cadmium exposure has been linked to histopathological variations in the Catla catla's gills in previous studies (Soares et al., 2016). The gills are essential for osmoregulation, gas exchange, and waste product excretion due to their proximity to water, but they are also susceptible to damage from metals and pollutants (Ghelichpour et al., 2017). The structural integrity of the gills can also be harmed by these changes, which can also cause respiratory and ionic disruptions. These modifications might be toxins' adaptive responses (Kim et al., 2016; Aldoghachi et al., 2016).Higher cadmium concentrations (1.2 and 1.7 g/L) in the fish's liver led to histopathological changes like congestion, vacuolar degeneration, and pyknosis, among other things. Prior studies on Catla Catla have noted comparable histopathological changes (Ghelichpour et al., 2020). Many fish's hearts displayed congestion, edoema, myofibrillosis, and neutrophilic myocarditis. In contrast, mild to moderate histological changes in fish's brains included neuronal necrosis and intracellular edoema. Additionally, exposure to cadmium caused histopathological changes in the kidneys, such as renal tubule necrosis and enlargement of the urinary space. Prior to this study, it was unknown whether cadmium could cause toxic histopathological changes in the heart, kidney, and brain of different fish species.

5 References

A review on Cadmium Exposure in the Population and Intervention Strategies Against Cadmium Toxicity | SpringerLink. (n.d.). Retrieved April 6, 2023, from https://link.springer.com/article/10.1007/s00128-020-03088-1

Acetochlor Affects Bighead Carp (Aristichthys Nobilis) by Producing Oxidative Stress, Lowering Tissue Proteins, and Inducing Genotoxicity. (n.d.). Retrieved April 6, 2023, from https://www.hindawi.com/journals/bmri/2022/9140060/

Acute and chronic toxicity of the benzoylurea pesticide, lufenuron, in the fish, Colossoma macropomum—ScienceDirect. (n.d.). Retrieved April 6, 2023, from https://www.sciencedirect.com/science/article/abs/pii/S0045653516309286

Aldoghachi, M. A., Azirun, Mohd. S., Yusoff, I., & Ashraf, M. A. (2016). Ultrastructural effects on gill tissues induced in red tilapia Oreochromis sp. By waterborne lead exposure. *Saudi Journal of Biological Sciences*, *23*(5), 634–641. https://doi.org/10.1016/j.sjbs.2015.08.004

Analysis of Heavy Metals in Water and Fish (Tilapia sp.) Samp..|INIS. (n.d.). Retrieved April 6, 2023, from https://inis.iaea.org/search/search.aspx?orig_q=RN:44127739

Antioxidant enzymes activity during acute toxicity cadmium to fish | Medical and Life Sciences. (n.d.). Retrieved April 6, 2023, from https://journals.smarcons.com/index.php/mls/article/view/62

Cadmium and Lead Hazardous Impact Assessment of Pond Fish Species | SpringerLink. (n.d.). Retrieved April 6, 2023, from https://link.springer.com/article/10.1007/s12011-018-1628-z

Comparison of the traditional outdoor and recirculation indoor rearing systems on survival rate and growth performance of common carp (Cyprinus carpio) larvae during early development | International Journal of Aquatic Biology. (n.d.). Retrieved April 6, 2023, from https://ij-aquaticbiology.com/index.php/ijab/article/view/1711

da Silva, R. F., Kitagawa, A., & Sánchez Vázquez, F. J. (2016). Dietary self-selection in fish: A new approach to studying fish nutrition and feeding behavior. *Reviews in Fish Biology* *and Fisheries*, *26*(1), 39–51. https://doi.org/10.1007/s11160-015-9410-1

Evaluation of DNA Damage, Biomarkers of Oxidative Stress, and Status of Antioxidant Enzymes in Freshwater Fish (Labeo rohita) Exposed to Pyriproxyfen. (n.d.). Retrieved April 6, 2023, from https://www.hindawi.com/journals/omcl/2022/5859266/

Ghelichpour, M., Taheri Mirghaed, A., Hoseini, S. M., & Perez Jimenez, A. (2020). Plasma antioxidant and hepatic enzymes activity, thyroid hormones alterations and health status of liver tissue in common carp (Cyprinus carpio) exposed to lufenuron. *Aquaculture*, *516*, 734634. https://doi.org/10.1016/j.aquaculture.2019.734634

Hama Aziz, K. H. (2019). Application of different advanced oxidation processes for the removal of chloroacetic acids using a planar falling film reactor. *Chemosphere*, *228*, 377–383. https://doi.org/10.1016/j.chemosphere.2019.04.160

Jindal, R., & Kaur, M. (2014). Phenotypic alterations in erythrocytes of Ctenopharyngodon idellus (Cuvier & Valenciennes) exposed to chlorpyriofs: SEM study. *International Journal of Fisheries and Aquatic Sciences*, *4*, 23–30.

Kim, J.-H., & Kang, J.-C. (2016). The toxic effects on the stress and immune responses in juvenile rockfish, Sebastes schlegelii exposed to hexavalent chromium. *Environmental Toxicology and Pharmacology*, *43*, 128–133. https://doi.org/10.1016/j.etap.2016.03.008

Nuclear and Morphological Alterations in Erythrocytes, Antioxidant Enzymes, and Genetic Disparities Induced by Brackish Water in Mrigal Carp (Cirrhinus mrigala). (n.d.). Retrieved April 6, 2023, from https://www.hindawi.com/journals/omcl/2022/4972622/

Okereafor, U., Makhatha, M., Mekuto, L., Uche-Okereafor, N., Sebola, T., & Mavumengwana, V. (2020). Toxic Metal Implications on Agricultural Soils, Plants, Animals, Aquatic life and Human Health. *International Journal of Environmental Research and Public Health*, *17*(7), Article 7. https://doi.org/10.3390/ijerph17072204

Okocha, R., & Adedeji, O. (2011). Overview of cadmium toxicity in fish. *Journal of Applied Sciences Research*, *7*, 1195–1207.

Oxidative stress, liver biotransformation and genotoxic effects induced by copper in Anguilla anguilla L. – the influence of pre-exposure to β-naphthoflavone—ScienceDirect. (n.d.). Retrieved April 6, 2023, from https://www.sciencedirect.com/science/article/abs/pii/S004565350600422X

Pathological and genotoxic effects of atrazine in male Japanese quail (Coturnix japonica) | SpringerLink. (n.d.). Retrieved April 6, 2023, from https://link.springer.com/article/10.1007/s10646-010-0515-y

Plasma proteins, hepatic enzymes, thyroid hormones and liver histopathology of Cyprinus carpio (Linnaeus, 1758) exposed to an oxadiazin pesticide, indoxacarb—Ghelichpour—2017—Aquaculture Research—Wiley Online Library. (n.d.). Retrieved April 6, 2023, from https://onlinelibrary.wiley.com/doi/abs/10.1111/are.13390

Principles and procedures of statistics, a biometrical approach. (n.d.). Retrieved April 6, 2023, from https://www.cabdirect.org/cabdirect/abstract/19810721475

The effects of heavy metals on embryonic development of fish (a review) | SpringerLink. (n.d.). Retrieved April 6, 2023, from https://link.springer.com/article/10.1007/s10695-008-9284-4

The social, economic, and environmental importance of inland fish and fisheries. (n.d.). Retrieved April 6, 2023, from https://cdnsciencepub.com/doi/full/10.1139/er-2015-0064

Toxic effect of some heavy metals on hematology and histopathology of major carp (Catla catla) | SpringerLink. (n.d.). Retrieved April 6, 2023, from https://link.springer.com/article/10.1007/s11356-020-10980-0

Transcriptome analysis of the spleen provides insight into the immunoregulation of Mastacembelus armatus under Aeromonas veronii infection—ScienceDirect. (n.d.). Retrieved April 6, 2023, from https://www.sciencedirect.com/science/article/abs/pii/S1050464819300944

Varol, M., Kaya, G. K., & Alp, A. (2017). Heavy metal and arsenic concentrations in rainbow trout (Oncorhynchus mykiss) farmed in a dam reservoir on the Firat (Euphrates) River: Risk-based consumption advisories. *Science of The Total Environment*, *599–600*, 1288–1296. https://doi.org/10.1016/j.scitotenv.2017.05.052

Veedu, S. K., Ayyasamy, G., Tamilselvan, H., & Ramesh, M. (2022). Single and joint toxicity assessment of acetamiprid and thiamethoxam neonicotinoids pesticides on biochemical indices and antioxidant enzyme activities of a freshwater fish Catla catla. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, *257*, 109336. https://doi.org/10.1016/j.cbpc.2022.109336

You, S. H., Wang, S. L., Pan, W. H., Chan, W. C., Fan, A. M., & Lin, P. (2018). Risk assessment of methylmercury based on internal exposure and fish and seafood consumption estimates in Taiwanese children. *International Journal of Hygiene and Environmental Health*, *221*(4), 697–703. https://doi.org/10.1016/j.ijheh.2018.03.002