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Research Article

Assessment of the toxic effects of Cadmium on Clarias gariepinus (Burchell, 1822)

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Abstract

The toxic effects of cadmium ($CdCl_2$) on Clarias gariepinus in terms of physical and behavioural responses as well as 96 hrs LC50 were investigated. A total number of 150 samples of the fish were acclimated for a period of 14 days during which they were fed to satiation twice daily. The test was made up of five treatments with replicate in each case with the following nominal Cd concentrations: 00, 50, 80, 110, 140 and 170 mg/L. Each trough contained 10 fingerlings (10-20 mg). The experiment ran for a period of 96 hrs; and probit analysis was used in obtaining the 96hrs LC50. From the results: Cd toxicant elicited physical and behavioural responses such as lassitude, emaciation, frequent gulping and gasping for air at the surface of the trough, attempts to jump out of the trough, lacerations and exuding of blood from sides of the opercular and bulging of the abdominal region of the body before their eventual death in most cases especially in treatments with higher concentrations. The 96 hrs LC50 was 79.72mg/L. There should be routine check on this important staple food especially those obtained from the wild to ensure that the level of contamination is within permissive limit by relevant authority as well as creating public awareness on the dangers of the subject matter.

Key words: Cadmium, Clarias Gariepinus, Physical and Behavioural responses, 96 hrs LC50 and Acute Toxicity Assessment.

INTRODUCTION

Environmental pollution is on the increase all over the world principally due to anthropogenic activities. Of major concern among these environmental pollutants are heavy metals. Heavy metals could be essential or non-essential. Heavy metals such as Fe, Cu, Zn, Ni, Co, Cr, and Mn are vital to human only at lower concentrations, but they become more toxic when they are taken up more than the bio-recommended limits (Shilpi et al., 2015). It is also known that even essential metals may be toxic on the biological activities of organisms above certain concentrations (Merciai et al., 2014). Among all the heavy metals (that are regarded as non-essential), Cd, Arsenic, Mercury and lead pose highest degree of toxicity and that is of great concern to plants and human health (Athar et al., 2018). Contamination of the ecosystem by heavy metals has given rise to one of the most important ecological and organismic problems, particularly human, early developmental stages of fish and animal life. Diverse living organisms, such as insects, fish, planktons, livestock and bacteria can be used as bioindicators for monitoring the health of the natural ecosystem of the environment; fish are the most important aquatic organisms that can accumulate heavy metals in their organs over time.

Heavy metals induce significant damage to the physiologic and biochemical processes of the fish and subsequently, to fish consumers (Mehana et al., 2020). Long-term exposure to cadmium through air, water, soil, and food leads to cancer and organ system toxicity such as skeletal, urinary, reproductive, cardiovascular, central and peripheral nervous, and respiratory systems. Cadmium levels can be measured in the blood, urine, hair, nail and saliva samples (Rahimzadeh et al., 2017). For human beings, there are several different sources of heavy metal pollution such as rechargeable nickel-cadmium batteries and cigarette smoking, which is considered as the major source for cadmium exposure, inducing serious effects such as renal damage and bone fracture (Khafaga et al., 2019).

When Cd gets to the blood stream, it binds to alpha-2-macrogobulin and albumin and gets distributed to the liver and kidneys as some of its mechanisms of operation. It also concentrates in the pancreas, spleen, heart, lungs and testes. Cd binds to metalothioneine in the liver and is slowly released from this organ. Because of this slow release, its biological half-life can be at least ten years. Cd usually travels to the glomerulus, and large amount concentrate in the proximal tubule_confering its renal toxic effects (Nordberg et al., 2012). Cd affects cell adhesion and calcium transport that can lead to cell dysfunction and cell death (Pan et al., 2018). Studies have linked Cd with hypertension, immunosuppression, and testicular dysfunction (Rani et al., 2014). They can also be classified as carcinogens (Chung et al., 2016).

Fish are particularly vulnerable and heavily exposed to pollutants due to feeding and living in aquatic ecosystems, because they cannot avoid pollutant harmful effects (Ahmed et al., 2020). Heavy metals enter fish by direct absorption from water through their gills and skin, or by ingestion of contaminated food (Ayyat et al., 2020). Clarias gariepinus is a hardy fresh water cat fish that has both economic and commercial relevance in our world today. Clarias species is a widely distributed fish in Asia and Africa. In these areas, the fish is extremely popular on account of its tasty flesh, its unparalleled hardness, its rapid growth and its somewhat acceptable market price (FAO, 2003). This is why it is important to know the inherent deleterious effects that could arise from consumption of such staple food when contaminated with heavy metal such as cadmium.

Materials and Methods

Samples/materials collection and Acclimatization

A total number of one hundred and fifty (150) fingerlings of Clarias gariepinus were purchased from a commercial fish farmer and transported in 50L containers filled with water to the Old Farm Research Unit of the Department of Water, Aquaculture and Fisheries Technology, Bosso Campus, Federal University of Technology, Minna, Nigeria. The fishes were placed in fish ponds with water for acclimatization. The fishes were fed twice daily (morning and evening) with vital feed (3 mm) for 14 days (2 weeks) for the acclimatization. The holding water was changed every three days during the period.

The toxicant, Cd (100g) analar grade was purchased from commercial chemical store and stored in a cool dry condition throughout the period of the experiment. This toxicant was administered according to the concentrations corresponding to the treatments during the acute exposure.

2.2 Acute Toxicity Test of Cd

Experimental set-up included 20L plastic aquarium (43.8cm by 30.8cm) containing 10 fingerlings (3-11mg). The test was made up of five treatments with replicate in each case with the following nominal Cd concentrations: 00, 50, 80, 110, 140 and 170 mg/L which were carefully measured out using weighing balance (Digital sensitive pocket scale). Detailed physical and behavioural changes within the first 2-4 hrs and then, 12 hrs later were noted. Further observations were made every 24 hrs subsequently for the 96 hrs exposure period. In each tank, the dead specimens were removed as soon as possible.

2.3Data Analysis

Probit analysis was used to analyse the ranges of values from LC10-LC99 from the acute exposure of the samples.

Results

Range Finding Test for Cd/ physical and behavioural changes.

When Clarias gariepinus samples (5 fish samples) were exposed to 300mg/L concentration of Cd toxicant, there was no initial visible impact and swimming was normal for 30 minutes; panic reactions with attempts to jump out of the trough followed shortly afterwards. All the five samples soon became weak, lethargic and died within two and the half hours. The exposure to 200mg/L followed the same initial trend. Erratic swimming and frequent gasping for air, display of lassitude, sticking to one end of the trough for several minutes before swimming slowly to other locations within the trough; and ultimately, loss of ability to gasp for air at the surface in about 150-180 minutes of exposure characterized the later stages. Four died within three hour with only one left weak and lethargic. It eventually died within six hours. Two died within 10-12 hours with three left swimming normally in those samples exposed to 150mg/L. Samples exposed to 50mg/L displayed no visible impact within 24 hours of exposure as they all swarm actively and normally.

Definitive Tests

Samples exposed to Cd toxicant displayed agitations, frequent gasping for air at the surface and erratic swimming in about 4-6 hour with greater severity in the higher concentrations (140 and 170mg/L). Mortalities occurred in 20-24 hours of exposure and subsequently with greater effects in higher concentrations. (Table 1). There were also oozing out of blood at both ends of the opercula, lacerations and bulging of the abdominal region of the fish. The LC50 obtained in this research for Cd was 79.72 mg/L. (Table 2).

Discussions

Acute Toxicity and LC50 of Clarias gariepinus exposed to lethal concentrations of Cd

The ability of heavy metals to bioaccumulate, biomagnify and the difficulty in eliminating them from the body by the ordinary metabolic activities make them one of the most dangerous sources of chemical water pollution to fish, causing big losses to fish and effects on the fish consumers (Mirghaed et al., 2018). From the results of the lethal exposure of Clarias gariepinus to Cd toxicant it was quite evident that low to medium concentrations were required to elicit both physical and behavioural changes. This is probably indicative of the fact that Cd is highly potent and that lower concentration of the toxicant was required to

Table 1: Mortality rate of samples of C. gariepinus exposed to lethal concentrations of Cd.

Concentration (mg/L)	No. of individuals per trough	No. of respondents per trough	% mortality
50	10	2	20
80	10	6	60
110	10	5	50
140	10	9	90
170	10	10	100
00	10	0	0

elicit cascades of physiological reactions. These responses were concentration and duration (time) dependent. The presence of Cd toxicant elicited physical and behavioural responses such as lassitude, emaciation, frequent gulping and gasping for air at the surface of the trough, attempts to jump out of the trough especially within few minutes to 2hrs of exposure; lacerations and exuding of blood from sides of the opercular especially in treatments with higher concentrations. In addition to these, there was bulging of the abdominal region of the body before their eventual death in most cases. This is probably due to the potency of the toxicant as this became more prominent and frequent in higher concentrations. This buttresses the fact that heavy metals are deleterious and are capable of posing a whole a lot of danger to living organisms because of their bioaccumulation and biomagnifications tendencies. It is known that long-term exposure to cadmium through air, water, soil, and food can lead to cancer and organ system toxicity such as skeletal, urinary, reproductive, cardiovascular, central and peripheral nervous, and respiratory systems (Rahimzadeh et al., 2017). Also, moderate exposure to heavy metals, associated with fish consumption, during pregnancy and early childhood may cause negative effects on the immune system of the offspring, resulting in ANA (Antinuclear Antibodies) positivity and JIA (Juvenile Idiopathic Arthritis) (Kindgren et al., 2019). Cadmium is one of the most prevalent nephrotoxic heavy metal, but it may cause other systemic toxicity as well; and may also cause adverse health effects by impairment of the immune systems and induction of reactive oxygen species (Ansari et al., 2015).

Table 1: Probit range of Values (LC10-LC99) of C. gariepinus exposed to lethal concentrations of Cd.

Lethal Con.	Values (mg/L)
LC_{10}	41.48
LC_{20}	51.91
LC_{30}	61.02
LC_{40}	70.07
LC_{50}	79.72
LC_{60}	90.71
LC_{70}	104.16
LC_{80}	122.44
LC_{90}	153.22
LC_{99}	260.98

Furthermore, acute toxicity of cadmium (Cd) on zebrafish (Danio rerio) indicated that the 24, 48, 72 and 96 h LC50 values were 16.73 (20.03-13.98), 12.88 (14.96-11.08), 11.46 (13.21-9.94), 9.68 (11.12-8.43) mg L-1, respectively (Al-sawafi et al., 2017) which are lower than the values obtained in this research on Clarias gariepinus. This probably suggests that Cd toxicity is species dependent.

Conclusion and Recommendations

The acute assessment of Cd on Clarias gariepinus revealed that the toxicant elicited physical and behavioural responses such as lassitude, emaciation, frequent gulping and gasping for air at the surface of the trough, attempts to jump out of the trough, lacerations and exuding of blood from sides of the opercular and bulging of the abdominal region of the body before their eventual death in most cases especially in treatments with higher concentrations. The 96 hrs LC50 was 79.72mg/L.

There should be routine check on this important staple food especially those obtained from the wild to ensure that the level of contamination is within permissive limit by relevant authority.

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