Research Article
Volume 04:05, 2021

Journal of Pollution

ISSN: 2684-4958 Open Access

Comparative Assessment of Some Heavy Metals Bioaccumulation in Juvenile African Catfish (Clarias Gariepinus) Exposed to Detergent and Spent Oil Pollutants

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Abstract

Head, trunk and tail of juvenile *Clarias gariepinus* exposed to pollutants; Detergent, Spent Oil and Detergent & Spent Oil in the volume 20 mg/L, 4 mg/L and 20 mg/L & 4 mg/L respectively, and were observed for the uptake of some selected heavy metals (Cu, Pb, Fe, Mn, and Zn). The study reveals the contamination of fish samples with heavy metals. The uptake of heavy metals in Fish samples were in the order of Fe> Zn> Cu> Mn> Pb in all pollutants, in the trend of Head>Trunk>Tail. The highest mean concentration was observed in Fe 48.33 ± 0.88(mg/kg) in the head of samples treated with detergent and Spent Oil, with uptake levels higher than the maximum permissible limits prescribed by WHO/FAO. Whereas the concentration of heavy metals Cu, Pb, Mn and Zn were below the maximum permissible limits. The lowest mean concentration was observed in the tail.

Keywords : Heavy metals• Detergents• Clarias gariepinus

Introduction

Environmental pollution is a worldwide problem and heavy metals belong to the most relevant pollutants. The development of industries has led to increased emission of pollutants into the ecosystem [1] . Environmental pollution can cause diseases, poisoning, and even bring about mortality for fish and aquatic organisms at large, the absorption and the accumulation of different biological tissues on pollutant varies [2] . Pollution is the contamination of Earth's environment with materials that interfere with human health, the quality of life, or the natural functioning of ecosystems (living organisms and their physical surroundings) [3]. Although some environmental pollution is a result of natural causes such as volcanic eruptions, most is caused by anthropogenic activities. Some of these pollutants sometimes find their way into the human system through the food chain. In the body, pollutants may undergo biotransformation, metabolism and excreted without the risk of toxicity depending on the chemical characteristics and their dose [4]. However, some of the pollutants resist chemical transformation and accumulated in the tissues including the liver, kidney and nerve to cause toxicity [5].

Water pollution is the introduction by man, directly or indirectly, of substances or energy to the aquatic environment resulting in delirious effects such as hazards to human health, hindrance to fishing activities, impairment of water quality and reduction of climate amenities [6]. Contamination also, caused when an input from human activities causes an increase of a substance in fresh or seawater, sediment and organism above the natural background level for that area and for those organisms. Industrial development in the developing and undeveloped countries has resulted in heavy metal contamination of local water [7]. Metal pollution may damage aquatic organism (either fresh or marine water) at the cellular level and possibly affect ecological balance [8]. Exposure and ingestion of polluted aquatic marine products such as seafood can cause health problems in human and animals including neurological and reproductive problems [9].

The term heavy metal refers to any metallic chemical element that has a relative high density and is toxic or poisonous at low concentrations or a metal, often toxic to organisms, that has a relative density of 5.0 or higher, e.g. lead, mercury, copper, and cadmium [10]. Heavy metals consist less than one per cent of living mass organisms, and their different density cause to some disorders, Heavy Metals (HM) are natural trace components of the aquatic environment, but their levels have been on the increase due to industrial effluent, geochemical structure, agricultural and mining activities [11]. All these sources of pollution affect the physicochemical properties of the water, sediments and biological components, thus negatively affecting the quality and quantity of fish stocks. Environmental pollution is a worldwide problem; heavy metals constitute one of the most important pollutant challenges [12]. The

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Received: 01 December, 2021; **Accepted:** 15 December, 2021**;** **Published:** 22 December, 2021

progress of industry has led to increased emission of pollutants into the ecosystem. Environmental pollution can cause poisoning, diseases and even death to fish [13]. The absorption and accumulation of different pollutants vary among different biological systems. Therefore, the aim of the present article is to highlight the impact of the bioaccumulation of heavy metals in the head, trunk and tail of fish and the factors affecting their dissemination [14].

Objectives of the Study

The objectives of the study are to know the accumulation levels of toxic heavy metals in Juvenile catfish. These objectives can be achieved through the following:

Determine the rate of heavy metals concentration and accumulation using different pollutants (Detergent, spent oil and detergent and spent oil);

Determine the quantity of the accumulation of selected heavy metals (Cu, Zn, Pb, Mn and Fe);

To identify what Part of the fish (Head, Trunk and Tail) are most affected;

To check if accumulation levels of these selected heavy metals is above the permissible limits of WHO/FAO [15].

Materials and Methods

Study Location: The study was conducted in Federal University of Technology Akure, Ondo state Nigeria, at the school fisheries research farm of the fisheries and aquaculture department technology.

Pond Preparation: 8 ponds were prepared, limed with agricultural lime $CaCO_3$. Each pond dug to a square shape with a dimension of 2m x 1.4m x 1m and an outlet pipe (0.7m) was fixed with a wire screen (72 mm) at the opening of the pipe to prevent fish from escape and to stop overflow. The water source of the ponds is mainly through seepage and rainfall and was filled to a water level of 0.6m depth[16].

Experimental Procedure: 160 juvenile *Clarias gariepinus* were stocked in the ponds, 20 fishes to each pond with mean weight 28.58 ± 0.41g and standard length of 6.3 ± 0.3cm, and fishes were acclimatized for 24 hours. After 24 hours, fishes are feed daily in the morning and night with feeds; Durante, Multifeed, Coppens and Vitals feed to each pond respectively. Growth parameters; weight and standard length were taken every 3 weeks. Pollutants were introduced by week 3, The period of the exposure of juvenile *Clarias gariepinus* to pollutants was such that no mortality was observed in detergent (20 mg/L), spent oil (4 ml/L) and mixture of detergent and spent oil (20 mg/L and 4 ml/L). At week 9, fishes were analysed for bioaccumulation of heavy metals of the head, trunk and tail of the fish [17].

Experimental Design: 8 ponds (earthen) with dimension of 2 m x 1.4 m x 1 m, was used for 4 treatments (pollutants) with 1 replicate, the experiment was designed as such, Treatment 1; control, Treatment 2; detergent, Treatment 3; Spent oil and Treatment 4; Detergent and spent oil [18]. The concentration of pollutants is detergent (20 mg/L), spent oil (4 ml/L) and mixture of detergent and spent oil (20 mg/L and 4 ml/L) and this was applied every 2weeks [19].

Sample Preparation: 3 Samples of juvenile *Clarias gariepinus* were collected randomly from each pond (FUTA fish farm) and taken immediately to the laboratory for analysis [20]. A clean washed stainless knife was used to cut the fish samples into 3 regions which are the head, trunk and tail region, each sample region is then placed and oven dried at 550oC FOR 24 hours in an electric laboratory oven model TT 9803 techmel USA [21]. Each sample was macerated using porcelain mortar and a pestle, 1g of dried fish sample is then taken to the muffle furnace to produce ash, samples are allowed to cool in a desiccator, then mixed with Nitric acid (10 ml), add distilled water was added to make up 50 ml in a volumetric flask [22]. It was then filtered into a conical flask with filter paper into a dispensing bottle to the extract. Determination of heavy metals was done using the Using Atomic Absorption Spectrophotometer [23].

Statistical Data Analysis: Statistical analysis of the results was carried out using analysis of variance (ANOVA). Means of significance were separated using Duncan's t-test ($p<0.05$).

Results

The results in the Tables below shows the concentration of selected heavy metals in the head, trunk and tail of Juvenile (Catfish) obtained from samples across treatments and compared with standard guidelines on food safety by the WHO (2011) and FAO [24].

Control					
Fish Part	**Fe**	**Pb**	**Cu**	**Mn**	**Zn**
Head	45.41 ± 3.20a	0.44 ± 0.44a	0.80 ± 0.24a	0.75 ± 0.003a	17.73 ± 0.77a
Trunk	36.24 ± 4.44b	0.29 ± 0.29b	0.62 ± 0.11b	0.59 ± 0.00b	5.86 ± 0.02b
Tail	27.14 ± 1.16c	0.24 ± 0.24c	0.19 ± 0.13c	0.16 ± 0.01d	5.86 ± 0.02b
WHO limits, 2011	43	2	30	N/A	1000

N = 2, (P>0.05), Values are means ± SE from two replicates. N/A= Not available

Table 1: Heavy Metals Uptake Compared in the Head, trunk and Tail of juvenile C gariepinus.

Detergent					
Fish Part	**Fe**	**Pb**	**cu**	**mn**	**Zn**
Head	46.58 ± 2.95a	0.34 ± 0.34a	1.15 ± 0.38a	0.76 ± 0.05a	20.11 ± 3.16a
Trunk	35.53 ± 5.33b	0.25 ± 0.25b	0.78 ± 0. 28b	0.62 ± 0.15b	6.96 ± 0.76b
Tail	26.31 ± 1.09c	0.17 ± 0.17c	0.26 ± 0.20c	0.18 ± 0.008c	6.80 ± 0.92b

WHO limits, 2011	43	2	30		N/A	1000

N = 2, (P>0.05), Values are means ± SE from two replicates. N/A= Not available

Table.2 Heavy Metals Uptake Compared in the Head, trunk and Tail of juvenile C gariepinus.

Spent Oil					
Fish Part	**Fe**	**Pb**	**Cu**	**Mn**	**Zn**
Head	46.76 ± 0.42a	0.72 ± 0.63a	1.55 ± 0.50a	0.76 ± 0.05a	24.68 ± 2.43a
Trunk	36.17 ± 2.59b	0.47 ± 0.44b	0.82 ± 0.23b	0.63 ± 0.003b	7.35 ± 0.76b
Tail	29.35 ± 1.09c	0.45 ± 0.28b	0.26 ± 0.23c	0.18 ± 0.02c	7.35 ± .76b
WHO limits, 2011	43	2	30	N/A	1000

N = 2, (P>0.05), Values are means ± SE from two replicates. N/A= Not available

Table.3 Heavy Metals Uptake Compared in the Head, trunk and Tail of juvenile C gariepinus.

	Detergent and Spent Oil				
Fish Part	**Fe**	**Pb**	**Cu**	**Mn**	**Zn**
Head	48.33 ± 0.88a	0.68 ± 0.48a	1.45 ± 0.72a	0.75 ± 0.01a	24.72 ± 2.74a
Trunk	37.05 ± 3.29b	0.55 ± 0.43b	0.83 ± 0.31ab	0.64 ± 0.05b	6.78 ± 0.34b
Tail	26.50 ± 3.37c	0.36 ± 0.30c	0.47 ± 0.25c	0.18 ± 0.01c	6.78 ± 0.34b
WHO limits, 2011	43	2	30	N/A	1000

N = 2, (P>0.05), Values are means ± SE from two replicates. N/A= Not available

Table.4 Heavy Metals Uptake Compared in the Head, trunk and Tail of juvenile C gariepinus.

Fish Parts		**Selected Heavy Metals (Mg/Kg).**				
		Fe	**Pb**	**Cu**	**Mn**	**Zn**
CTRL	Head	45.41 ± 3.20a	0.44 ± 0.44a	0.80 ± 0.24a	0.75 ± 0.003a	17.73 ± 0.77a
	Trunk	36.24 ± 4.44b	0.29 ± 0.29b	0.62 ±0 . 11b	0.59 ± 0.00b	5.86 ± 0.02b
	Tail	27.14 ± 1.16c	0.24 ± 0.24c	0.19 ± 0.13c	0.16 ± 0.01d	5.86 ± 0.02b
DET	Head	46.58 ± 2.95a	0.34 ± 0.34a	1.15 ± 0.38a	0.76 ± 0.05a	20.11 ± 3.16a
	Trunk	35.53 ±5.33b	0.25 ± 0.25b	0.78 ± 0.28b	0.62 ± 0.15b	6.96 ± 0.76b
	Tail	26.31 ± 1.09c	0.17 ± 0.17c	0.26 ± 0.20c	0.18 ± 0.008c	6.80 ± 0.92b
SP. OIL	Head	46.76 ± 0.42a	0.72 ± 0.63a	1.55 ± 0.50a	0.76 ± 0.05a	24.68 ±2.43a
	Trunk	36.17 ± 2.59b	0.47 ± 0.44b	0.82 ± 0.23b	0.63 ± 0.003b	7.35 ± 0.76b
	Tail	29.35 ± 1.09c	0.45 ± 0.28b	0.26 ± 0.23c	0.18 ± 0.02c	7.35 ± 0.76b
DET&SP. OIL	Head	48.33 ± 0.88a	0.68 ± 0.48a	1.45 ± 0.72a	0.75 ± 0.01a	24.72 ± 2.74a
	Trunk	37.05 ± 3.29b	0.55 ± 0.43b	0.83 ± 0.31ab	0.64 ± 0.05b	6.78 ± 0.34b
	Tail	26.50±3.37c	0.36±0.30c	0.47±0.25c	0.18±0.01c	6.78±0.34b

Table.5 Heavy Metals Uptake Compared in the Head, trunk and Tail of juvenile C gariepinus.

Discussion

The results in the Tables above shows the heavy metals concentrations are the highest in fish samples contaminated with detergent mixed with spent oil, spent oil, and detergent and control respectively, and. It shows that the distribution of these heavy metals varies with body part, that the head has the highest concentration followed by the trunk and the tail. The adsorption of metals onto the gills surface as the first target for pollutants in water could also be a significant influence in the total metal levels of the gills (head). Target organs such as gills and intestine are metabolically active parts that can accumulate heavy metals in higher levels. The estimated accumulation of heavy metals in the Fish samples in all treatments (control, detergent, spent oil and spent oil & detergent) were all in the descending order: Fe> Zn > Cu> Mn> Pb [25].

The grand mean concentrations of the selected heavy metals in these fish samples were such that, the highest grand mean concentrations of Fe found in the Head, Trunk and tail across treatments are head (detergent and spent oil);48.33 ± 0.88(mg/kg),trunk(detergent and spent oil); 37.05 ± 3.29(mg/kg), and tail(spent oil); 29.35 ± 1.90(mg/kg) respectively, while the lowest grand mean concentrations of Fe found in the Head, Trunk and tail across treatments are head (control); 45.41 ± 3.20(mg/kg), trunk(detergent);0.25 ± 0.25(mg/kg) and tail(detergent); 0.17 ± 0.17(mg/kg)[26].

Iron (Fe) is essential to most life forms and to normal human physiology. In humans, iron is an essential component of proteins involved in oxygen transports from the lungs to the tissues. It is also essential for the regulation of cell growth and differentiation. The grand mean concentration of iron 48mg/kg was higher than WHO/FAO maximum permissible limit of 43mg/kg for Catfish. Fe interactions in biological tissues has reported that excess amount of Fe causes rapid increase in pulse rate and coagulation of blood in blood vessels, hypertension and drowsiness [27].

Zinc (Zn) is toxic to fish and macroinvertebrates at sublethal concentration. Although zinc is an essential element [28]. it is a potential toxicant to fish with adverse effects. The highest grand mean concentration for zinc in the head, trunk and tail across treatments are head (detergent & spent oil); 24.72 ± 2.74 (mg/kg), trunk (spent oil) 7.35 ± 0.76 (mg/kg) and tail (spent oil) 7.35 ± 0.76 (mg/kg), while the lowest grand mean found in the head, trunk and tail are all found in (control); Head; 17.73 ± 0.77 (mg/kg), Trunk (control); 5.86 ± .022(mg/kg), and tail 5.86 ± 022(mg/kg). The bioaccumulation of zinc affects tissue respiration leading to death by hypoxia, induces changes in vein and heart physiology, and causes a significant decrease in haemoglobin and haematocrit [29]. Decreases plasma protein.The estimated accumulation of Copper (Cu) with the highest grand mean concentration in the head, trunk and tail across treatments are all found in the treatment with detergent head1.15 ± 0.38(Mg/kg), trunk 0.78 ± 0.28(Mg/kg), and tail 0.26 ± 0.20(Mg/kg)while the lowest grand mean concentrations were found in control Head 0.78 ± 0.24(Mg/kg), Trunk 0.62 ± 0.11(Mg/kg), and tail 0.19 ± 0.13(Mg/kg),, High concentrations of copper can alter haematology, respiratory and cardiac physiology , and may also lead to retarded growth and inhibition of spawning [30]. Concentrations as low as 5.3 to 31.9 mg/ℓ in soft waters may be toxic to larval fish (depending on the pH and dissolved organic carbon and calcium concentrations),

Manganese is an essential trace element for both animals and man; necessary for the formation of connective tissues and bone, growth, carbohydrate and lipid metabolism, embryonic development of the inner ear, and reproductive function [31] . The highest grand mean concentration of manganese detected in the Head trunk and tail of fish samples from this study are Head (spent oil); 0.76 ± 0.05(mg/kg); trunk(detergent and spent oil); 0.64 ± 0.05(mg/kg) and tail(spent oil); 0.18 ± 0.02(mg/kg) while the lowest grand concentration detected are all found in (control) Head; 0.75 ± 0.00(mg/kg), trunk 0.5900 ± 0.00 (mg/kg) and tail 0.16 ± 0.01 (mg/kg) which are all below the WHO/FAO maximum permissible limit of 5.5(mg/kg), symptoms of manganese toxicity in man include dullness, weak muscles, headaches and insomnia but from the results of this study, the traces found in the fishes could not cause such severe health effects in a short run among the majority of fish consumers [32]. Mn in the fish samples could also be traced to entry to the pond through the introduction of detergent and spent oil overtime [33].

Relatively low concentrations of Pb were found in fish samples with the highest grand mean concentration detected are as such that the head (spent oil) 0.72 ± 0.63(mg/kg), trunk(detergent & spent oil) 0.55 ± 0.43(mg/kg) and tail (spent oil) 0.45 ± 0.28(mg/kg) were found, compared to those of the lowest grand mean concentration found in the head 0.34 ± 0.34 (mg/kg), trunk 0.25 ± 0.25(mg/kg), and tail 0.17 ± 0.17167(mg/kg) which were found in the treatment with detergent [34].

Conclusion

In very small concentrations, many of these metals are necessary to support life. However, in larger concentrations, they become toxic [35]. They build up in biological systems and become a significant health hazard. This study shows that the distribution of these heavy metals varies with body part of fish samples, that the head has the highest concentration followed by the trunk and the tail [36]. The adsorption of metals onto the gills surface as the first target for pollutants in water could also be a significant influence in the total metal levels of the gills (head) [37]. It indicates that while the concentration of Zn, Cu, Mn, and Pb both in the Head, Trunk and tail of all the fish samples were within the WHO (2011) and FEPA (2003) prescribed limits that of Fe (except in the trunk and tail), were beyond the limits [38]. The general trend of bioaccumulation of metals were all the same with all pollutants, Fe at the highest while Pb at the lowest closely followed by Mn, Cu and Zn in ascending order. The highest concentration observed with pollutants is the spent oil. Although, the concentrations of heaviest metals especially in the detergent did not reach critical levels presently, the cumulative effect might be dangerous in the future if exposure to pollutants is long term [39].

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How to cite this article: Iromini A,et al. . "Comparative Assessment of Some Heavy Metals Bioaccumulation in Juvenile African Catfish (Clarias Gariepinus) Exposed to Detergent and Spent Oil Pollutants." J *Pollut* 04 (2021) : 1.