International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

Assessment of the Bioaccumulation and the Excretion Rate of Cd, Zn and Pb in Blood, Kidney and Liver of an African Catfish Juvenile in an Artificial Fish Pond

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Abstract: ***The bioaccumulation and the rate of excretion of Cd, Zn and Pb of a ten weeks old catfish juvenile placed in an artificially polluted aquatic medium for 96 hours and then transferred to an unpolluted medium were examined. The nitrate form of lead, $Pb(NO_3)_2$, the chloride form of cadmium, ($CdCl_2$) and the sulphate form of zinc ($ZnSO_4.7H_20$) was chosen because of its moderate toxicity. The Arithmetic method was used to determine the 96 LC_{50}, three different concentrations of the test solution of (10 ppm, 5 ppm and 2 ppm of lead; 8 ppm, 5 ppm and 2 ppm of cadmium and 8 ppm, 5 ppm and 2 ppm of zinc) of heavy metals were prepared. The highest concentration in each case was 20 below the $LC_{50,}$ previously determined. This sub – lethal concentration was used to ensure the survival of more than 50 of the fish. Each concentration as well as the control was prepared in triplicate. The Cappon, (1987) method was used for digesting fish organs and thus, metal concentration in the various organs and tissues were determined using Atomic Absorption Spectrophotometer. Results from analysis reveal that Catfish fish samples exposed to different concentrations of the metal solution in their artificial habitat to assess the level of bioaccumulation witnessed the death of the species and it was observed that the mortality rate do not only depend on the concentration of the toxicant, but also to the type of the toxicant and period of exposure. The study further reveals that the different toxicants were differentially bio-accumulated in species organs. Pb was more bio-accumulated than cadmium and zinc. Also, some bio-accumulated toxicants were excreted over a period of time. Lead had a higher rate of excretion than the other two heavy metals investigated; namely cadmium and zinc. While the initial rate of excretion is proportional to the concentration of the toxicant, rate of excretion gradually became insignificant after an appreciable period of time. It can thus be concluded that the determination of bioaccumulation can be used to monitor the health of aquatic environment as the degree of contamination was observed to be directly proportional to bioaccumulation. Results obtained from this work also indicated that if fish exposed to contaminated environment are able to migrate to safe unpolluted environment, they can, over a period of time naturally eliminate significant amount of ingested toxicants such as heavy metals. Though, the significance of this study lies in the fact that there is need to protect the environment so that sensitive aquatic organisms, such as catfish juvenile, can be protected from danger. Fish juvenile is obviously more sensitive to toxic environment than adult fish. Protection of the environment will not only safeguard the health of man as continuous consumption of contaminated fish is detrimental to human health, but will increase the quantity of fish available for consumption. It is thus, recommended that further studies or investigation could be carried out using fingerlings and adult catfish. Other heavy metals could be also considered in such investigation.***

Keywords: bioaccumulation, heavy metal, excretion rate, leather dose, mortality, juvenile, toxicant

1. Introduction

The demand for Catfish for food in Nigeria is unprecedented so much so that no matter the quantity supplied into the market, it would be consumed by ready buyers. This is so because of its low caloric value, low carbohydrate content, high in protein, low in fat, it is quick and easy to prepare and above all, it tastes great [1]. This all important source of food are grown in aquatic environment which are final destinations of contaminants released from domestic, industrial and other anthropological activities [2]. Heavy metals are natural trace components of the aquatic environment [3]. The levels of metals in upper members of the food web like fish can reach values many times higher than those found in aquatic environment or in sediments. This is so because most of our domestic and industrial wastes are not treated before they are indiscriminately disposed either directly into surface water bodies or on surface where they are either washed into surface water or permeate into ground water. The aquatic ecosystem becomes polluted and consequently aquatic organisms become contaminated. Heavy metals are dangerous because they tend to bioaccumulate in organisms over time, compared to the concentration of other chemicals in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are metabolized or excreted. Studies have shown that bioaccumulated patterns of contaminants in fish depend on both uptake or ingestion and output or excretion ratio [4]. The level of bioaccumulation of heavy metals cannot only be used to determine the mortality rate of the catfish juvenile exposed to toxic environment, but also to determine the critical concentration of heavy metal in fish that is safe for consumption. The indirect monitoring of the level of heavy metals in an aquatic environment - there is a relationship between the concentrations of toxicant in an aquatic environment and the amount of toxicant ingested by aquatic organisms - and the determination of the rate of excretion when fishes are placed in a pollution free environment. These are of immerse benefit as it will assist in understanding the migration pattern of fish in their natural environment. Previous studies reveal that heavy metals may alter the physiological activities and biochemical parameters in organs, tissues and blood [5]. [6] Reported that freshwater

fish collected from Warri River in Nigeria had significant accumulation of Pb, Cr and Hg in their organs. It was reported by [7] that the major source of metal pollution in the aquatic environment is the continuous and indiscriminate discharge of industrial effluent through man's anthropogenic behavior. The characteristic feature of heavy metals in the water bodies is their strong attraction to biological tissues and in general their slow elimination from biological systems. The uptake of heavy metals in fish was found to occur through absorption across the gill surface or through the gut wall tract. Diffusion facilitated transport or absorption in gills and surface mucus are the mechanisms of uptake from water. Bioaccumulation of metals reflects the amount ingested by the organisms, the way in which the metals were distributed among the different tissues and the extent to which the metals is retained in each tissue type. Thus heavy metals acquired through the food chain as a result of pollution are potential chemical hazards, threatening consumers. As a result, they get into man either through direct consumption of fish or organisms that feed on fish. Man is therefore exposed to pollution related health problems through consumption of contaminated food. At low levels, some heavy metals such as copper, cobalt, zinc, iron and manganese are essential for enzymatic activity and many biological processes. Other metals, such as cadmium, mercury and lead have not known essential role in living organisms and are toxic even at low concentrations. The essential metals also become toxic at high concentrations [8]. The effect of contaminated food on man can be very critical if children are involved. At such tender age when growth is rapid, any adverse effect on the biochemistry of their vital organs can have serious health implications during their adult life. However, when fish is exposed to heavy metals in their aquatic ecosystem, they may die or bioaccumulate the heavy metals. Fish juvenile are more susceptible to death when exposed to toxic environment than adult fish. This can lead to reduced availability of fish. This study was thus undertaken to investigate the level of bioaccumulation of some heavy metals in organs such as the blood, liver and the kidney of catfish juvenile in their artificial environment as well as the rate of excretion of bioaccumulated heavy metals in catfish juvenile when placed in pollution-free aquatic environment (pure water).

2. Materials and Methods

2.1 Sample Preparation

Sample organisms(catfish juvenile of about ten weeks old) were collected from fish tanks in the Department of Environmental Zoology of the Delta State University, Abraka and held in bulk container filled with chlorine-free water for five days at 28 ± 2^0C. The water was analyzed to be free from metals to be investigated. The fish were fed daily during the period of acclimatization with fish meal (also analyzed to be free from metals to be investigated) to avoid starvation. The water in the tank was changed every day to prevent accumulation of metabolites. The fish were considered acclimatized when no mortality was recorded within the five days period.

For Pb, the nitrate form was chosen because of its moderate toxicity [9] and high solubility. 1.30g of $Pb(NO_3)_2$ was weighed and added to about 750ml of de-ionized water and after dissolving it, the solution was made up to 1 litre mark with de-ionized water to give 1000ppm of lead ions. The chloride of cadmium was preferred to other salts, being less toxic [9]. 1.63g of $CdCl_2$ was weighed on top loading electronic balance with accuracy of 10mg, added to about 750ml of de-ionized water, and after dissolving it, the solution was made up to 1 litre mark with de-ionized water to give 1000 ppm of cadmium ions. Zinc sulphate ($ZnSO_4.7H_20$) was chosen because of its solubility and moderate toxicity [9]. 4.396 g of $ZnSO_4.7H_20$ was weighed and added to about 750ml of de-ionized water and after dissolving it, the solution was made up to 1 litre mark with de-ionized water to give 1000 ppm of zinc ions.

Test solutions were set up in triplicate and the number of death for each test solution was averaged. A control in triplicate was set up with the same number of test organisms (7 per container) in same volume of diluting medium (4 litres). The number of living and dead fish in each test series and triplicate were recorded after 96 hours. The 96 hours mortality data was used to calculate the LC_{50} for each replicate series. The Arithmetic graphic method which, according to [10] is the easiest and quickest way to determining 96 LC_{50} was used. The method involved the calculation of the average number of deaths at 96 hours in the replicates and converting to percent mortality. The concentration of the various test solution including the control was recorded and their respective logarithm determined. A plot of concentration and percent mortality was made. To obtain 50, a horizontal line drawn from 50 mortality point to intersect the graph and the point of intersection was extrapolated on the abscissa by dropping a vertical line on it. This gave the LC_{50} concentration.

Static bioassay test method was adopted for this study [9]. Seven fish of fairly average length and weight, 12cm and 93g respectively were selected randomly and placed in bioassay containers made up of plastic of dimension 42 cm length by 25 cm height and 30 cm width. The outer walls of the container were covered with black polythene to reduce light penetration. The tanks were initially washed with detergent, rinsed with tap water and thoroughly dried. The cleaning was done to prevent contamination and growth of mould.

Three different concentrations of the test solution of (10ppm, 5 ppm and 2 ppm of lead; 8 ppm, 5 ppm and 2 ppm of cadmium and 8 ppm, 5 ppm and 2 ppm of zinc) of heavy metals were prepared. The highest concentration in each case was 20 below the $LC_{50,}$ previously determined. This sub – lethal concentration was used to ensure the survival of more than 50 of the fish. Each concentration as well as the control was prepared in triplicate. This gave a total of 12 containers per concentration series. The volumes of the standard solution were 4 litres. The dead fish in each container were harvested after 96 hours exposure and the heavy metal concentration in various organs and tissue were determined. The percent mortality was also recorded.

2.2 Pre-Treatment and Analysis of Samples

Each fish samples were carefully opened using plastic knife in order to remove the organs and tissue. The organs/tissue harvested were gills, liver, kidney, flesh and blood. It was dried for a period of 36 hours before pulverized in a clean dry mortar. The pulverized fish samples were again dried for another 1 hour and finally preserved in a clean dry polythene bottle. The [11] method was used in digesting the fish sample as follows; 1g of dried fish was weighed and put in a 200 ml kjeldehl flash. 20 ml of the digested mixture made up of 10 ml $HClO_4$ and 100 ml of Conc. HNO_3 was added to the flask. It was carefully swirled and digestion started in a fume cupboard at increasing temperatures. This process continued until the complete disappearance of brown fumes of NO_2. The final digestate was poured into a 50ml volumetric flask, cooled and made to the mark with 0.7M HNO_3 solution. Metal concentration in the various organs and tissues were determined using Atomic Absorption Spectrophotometer.

2.3 Bioaccumulation Factor (BAF)

Bio-accumulation factor refers to the ratio between the concentration of a chemical measured in an organism and the concentration of the same in water. The ratio is usually derived from field – collected samples and water [12].

$$BAF = \frac{C_B}{C_W}$$

Where C_B = Chemical concentration in organism
C_w = Chemical concentration in water

2.4 Determination of Rate of Excretion

The fishes that survived after 96 hours exposure to different stated concentrations of the heavy metals solution were harvested. The harvested fishes were transferred to potable water to determine the rate of natural excretion of the bioaccumulated heavy metals. Meanwhile, the dissolved oxygen (DO) and pH of the water used were also determined. Fish samples were harvested on weekly basis for a period of five weeks and the concentration of the heavy metals in the tissue and various organs were analyzed with AAS.

2.5 Determination of Dissolved Oxygen (DO)

It is the amount of oxygen (O_2) in milligram per litre in a given water sample solution. In the determination of DO, the electrode of the DO meter was inserted into the beaker containing the water and the result read out. The purpose of this determination is to ensure that the dissolved oxygen is within the recommended level for fresh water organisms.

2.6 Determination of pH

In determining the PH of the fresh water, PH meter was used. The PH electrode was inserted into the water in a trough and the result from the meter monitor or screen was read. Again, the purpose of this determination is to ensure that the PH is within the recommended level for fresh water organisms.

3. Results and Discussions

The analysis of Water and Rate of Mortality of the Fish is shown in table 1 – 4. The results of ingestion of the heavy metals by the test species after 96 hour exposure to the toxicant and rate of excretion (for 5 weeks) after transferring the test species from the toxic environment into potable water are presented in Tables 5 – 13. The plot of concentration versus time for the three metals is presented in Figures 1 -9.

Table 1: Parameters of Water Used

Parameters	Values
Dissolved Oxygen	7.8 mg/l
pH	7.2

Table 2: Mortality Rate at 96hr Exposure to Pb^{2+}

Conc. (ppm)	*No. of Fish used*	*No. of live fish*	*No. of dead fish*	*% mortality*
10	10	7	3	30
5	10	8	2	20
2	10	9	1	10

Table 3: Mortality Rate at 96hr Exposure to Cd^{2+}

Conc. (ppm)	*No. of Fish used*	*No. of live fish*	*No. of dead fish*	*% mortality*
8	10	8	2	20
5	10	9	1	10
2	10	10	Nil	Nil

Table 4: Mortality Rate at 96h Exposure Zn^{2+}

Conc. (ppm)	*No. of Fish used*	*No. of live fish*	*No. of dead fish*	*% mortality*
8	10	8	2	20
5	10	10	Nil	Nil
2	10	10	Nil	Nil

Table 5: Excretion Results for Pb at 10 ppm Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	**0.**218	1.923±0.04	1.120±0.08	0.887±0.06	0.801±0.02	0.750±0.03	0.750±0.02
Liver	0.209	1.035±0.03	0.568±0.02	0.349±0.02	0.320±0.02	0.301±0.01	0.298±0.01
Blood	BDL	0.553±0.02	0.346±0.01	0.333±0.1	0.310±0.02	0.298±0.02	0.295±0.01

Table 6: Excretion Results for Pb at 5 ppm Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	0.218	0.778±0.03	0.770±0.11	0.750±0.13	0.735±0.04	0.730±0.04	0.723±0.03
Liver	0.209	0.478±0.02	0.460±0.03	0.455±0.04	0.430±0.04	0.425±0.03	0.420±0.03
Blood	BDL	0.428±0.02	0.400±0.02	0.390±0.02	0.380±0.02	0.371±0.02	0.370±0.01

Table 7: Excretion Results for Pb at 2 ppm Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	0.218	0.518±0.03	0.490±0.03	0.480±0.03	0.471±0.03	0.460±0.03	0.458±0.03
Liver	0.209	0.010±0.01	0.009±0.00	0.005±0.00	0.005±0.00	BDL	BDL
Blood	BDL	0.322±0.02	0.300±0.03	0.280±0.02	0.275±0.03	0.270±0.02	0.270±0.02

Table 8: Excretion Results for Cd at 8 ppm Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	0.150	1.35±0.02	1.300±0.01	1.255±0.04	1.150±0.04	1.010±0.01	0.990±0.08
Liver	0.225	1.84±0.01	1.490±0.04	1.400±0.02	1.380±0.01	0.840±0.01	0.830±0.05
Blood	0.100	1.30±0.02	1.300±0.01	0.920±0.03	0.850±0.03	0.840±0.02	0.830±0.02

Table 9: Excretion Results for Cd at 5 (ppm) Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	0.150	0.555±0.02	0.350±0.02	0.320±0.01	0.311±0.01	0.265±0.01	0.265±0.01
Liver	0.225	0.326±0.02	0.312±0.03	0.285±0.02	0.264±0.02	0.256±0.01	0.250±0.01
Blood	0.100	0.214±0.01	0.195±0.02	0.184±0.02	0.175±0.02	0.183±0.01	0.173±0.02

Table 10: Excretion Results for Cd at 2 (ppm) Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	0.150	0.412±0.02	0.395±0.02	0.382±0.02	0.374±0.01	0.370±0.02	0.370±0.01
Liver	0.225	0.551±0.01	0.445±0.03	0.424±0.02	0.410±0.01	0.395±0.01	0.394±0.01
Blood	0.100	0.314±0.02	0.310±0.02	0.300±0.01	0.284±0.01	0.280±0.01	0.280±0.01

Table 11: Excretion Results for Zn at 8 (ppm) Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	0.175	1.400±0.02	1.215±0.01	1.800±0.04	1.170±0.04	1.160±0.01	1.170±0.08
Liver	0.233	1.815±0.01	1.414±0.04	1.214±0.02	1.115±0.01	1.200±0.01	1.110±0.05
Blood	BDL	1.290±0.02	1.015±0.01	1.000±0.03	0.950±0.03	1.115±0.02	0.950±0.02

Table 12: Excretion Results for Zn at 5 (ppm) Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	0.175	1.04±0.02	1.00±0.03	0.905±0.02	0.900±0.01	0.910±0.03	0.810±0.01
Liver	0.233	1.11±0.01	1.01±0.02	0.915±0.01	0.817±0.01	0.800±0.01	0.801±0.01
Blood	BDL	0.5±0.02	0.49±0.03	0.484±0.02	0.414±0.10	0.412±0.20	0.410±0.01

Table 13: Excretion Results for Zn at 2 (ppm) Concentration

Fish Part	*Control*	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	0.175	0.411±0.03	0.378±0.03	0.370±0.03	0.370±0.03	0.365±0.03	0.411±0.03
Liver	0.233	0.505±0.01	0.420±0.03	0.410±0.01	0.395±0.02	0.395±0.02	0.505±0.02
Blood	BDL	0.312±0.02	0.300±0.02	0.284±0.01	0.280±0.02	0.280±0.01	0.312±0.02

4. Determination of Bioaccumulation Factor (BAF)

The results of the determination of bioaccumulation factor (BAF) of the test species for the 5 weeks duration during when the rate of excretion was determined are presented in Tables 14-15.

Table 14: BAF of Pb at 10 ppm Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	19.20	11.20	8.90	8.10	7.50	7.50
Liver	10.10	5.70	3.50	3.20	3.00	2.90
blood	5.50	3.50	3.30	3.10	2.90	2.90

Table 15: BAF of Pb at 5 ppm Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	15.660	15.40	15.00	14.70	14.60	14.50
Liver	9.60	9.20	9.10	8.60	8.50	8.40
blood	8.60	8.00	7.80	7.60	7.40	7.40

Table 16: BAF of Pb at 2 ppm Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	25.90	24.50	24.00	23.60	23.00	22.90
Liver	0.50	0.40	0.30	0.30	BDL	BDL
blood	16.10	15.00	14.00	13.80	13.50	13.50

Table 17: BAF of Cd at 8 ppm Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	16.90	16.30	15.60	14.40	12.60	12.40
Liver	22.90	18.60	17.50	17.30	10.50	10.40
blood	16.30	16.30	11.50	10.60	10.50	10.40

Table 18: BAF of Cd at 5 ppm Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	11.10	7.00	6.40	6.20	5.30	5.30
Liver	6.50	6.30	5.70	5.30	5.10	5.00
blood	4.30	3.90	3.70	3.50	3.60	3.40

Table 19: BAF of Cd at 2 ppm Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	20.60	19.70	19.10	18.70	18.50	18.50
Liver	27.60	22.30	21.20	20.50	19.80	19.70
blood	27.70	15.50	15.00	14.20	14.00	14.00

Table 20: BAF of Zn at 8 (ppm) Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	17.50	15.18	14.75	14.63	14.50	14.60
Liver	22.69	17.68	15.18	13.94	14.00	13.88
blood	16.13	16.13	12.50	11.88	13.94	11.88

Table 21: BAF of Zn at 5 ppm Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	20.90	20.00	19.00	18.00	18.20	16.20
Liver	22.20	20.20	18.30	16.30	16.00	16.00
blood	10.00	9.80	9.70	8.30	8.20	8.20

Table 22: BAF of Zn at 2 ppm Concentration

Fish part	*96hrs*	*1st week*	*2nd week*	*3rd week*	*4th week*	*5th week*
Kidney	28.55	19.85	18.90	18.50	18.50	18.25
Liver	25.25	22.25	22.10	20.50	19.75	19.75
blood	15.60	15.50	15.00	14.30	14.00	14.00

Comparison of uptake of heavy metal ions by various organs and tissues.

Tables 23 – 25 compare the results of tissue uptake of heavy metals with various metal ion concentrations.

Table 23: BAF of Pb at 96 hrs in Various Concentrations

Fish part	*10 ppm*	*5 ppm*	*2 ppm*
Kidney	19.20	15.60	25.90
Liver	10.10	9.60	0.50
Blood	5.50	8.60	16.10

Table 24: BAF of Cd at 96 hrs in Various Concentrations

Fish part	*10 ppm*	*5 ppm*	*2 ppm*
Kidney	16.90	11.10	20.60
Liver	22.90	6.50	27.60
Blood	16.30	4.30	15.70

Table 25: BAF of Zn at 96 hrs in Various Concentrations

Fish part	*10 ppm*	*5 ppm*	*2 ppm*
Kidney	15.18	20.90	28.55
Liver	17.68	22.20	25.25
Blood	16.13	10.10	15.60

5. Discussion

Range Finding

Statistical analysis of the range findings showed that lead was slightly more toxic than cadmium. Lead had a higher mortality rate (20%) than cadmium (10%) and zinc (0%) at the same concentration of 5ppm. This observation agreed with the finding of [9]. Consequently, the highest concentration of lead solution used was 10ppm while that of cadmium and zinc was each 8 ppm.

Bioaccumulation

The result of Tables 4 to 13 showed that when the test species were exposed to different concentrations of lead, cadmium and zinc solutions for 96 hours duration, reasonable amount of the heavy metals were ingested and deposited in different parts of the fish such as the liver, kidney and blood. . The highest bioaccumulation in (ppm) was highest at 1.923±0.04 for Pb at 10ppm, followed by the liver with concentrations of 1.035±0.03 and then 0.554±0.02 for the blood. At the same concentration after the 5th week, the concentration of Pb was lowest in blood with 0.295±0.01, closely followed by the liver with concentration of 0.298±0.01 and then the kidney with metal concentration of 0.750±0.02. Data's from this study reveals that the same trend of bioaccumulation of this metal is observed for Pb at concentration of 5ppm and different at 2ppm. At this concentration, the bioaccumulation of the metal in the kidney was 0.518±0.03; 0.322±0.02 for the blood and then 0.010±0.01 in the liver. The implication is that when the juvenile were exposed to Pb concentration, the metals accumulate more on the kidney at a higher concentration, then the liver and lastly the blood. Data's from this study further reveals that the bioaccumulation of Cd and Zn at the different concentration completely observed the trend as witness in Pb. This trend agreed with the assertion made by Cunningham, *et al.,* (1999) that bioaccumulation is directly related to concentration or volume of toxicant in an environment as well as the type of toxicant. This assertion also agreed with the observation made by [6, 13, 14, 15 and 16]. The researchers observed bioaccumulation ranged from 0.26 to 1.84 ppm in different parts of fish analyzed and the trend of heavy metal contents in both skin fish sample and muscle of croaker was: Cu > Pb > Ni > Cd. However, the bioaccumulation of the heavy metals in different parts of the fish was not uniform. This observation also agreed with the study of [17] in which the author stated thus: "considering the mean concentration of the metal in different organs, it was observed that in liver, the trend was Pb > Cd > Ni > Cr while it was Pb > Cd > Cr > Ni in the kidney. Obviously Pb appears to be the most retained metal of the four considered in this work." A critical analysis of the trend in the three different concentrations of the lead solution showed that the trend observed in the 10ppm solution can be said to be the generalized one; the highest bioaccumulation being in the kidney and the lowest in the blood. In a similar work done by [6, 18] it was observed that kidney bioaccumulated heavy metals than liver. The presence of the observed amount of heavy metals in the kidney, an excretion organ for detoxified materials, may cause biochemical changes that will adversely affect its functionality. The functionality of liver may also be affected by the presence of heavy metals too.

Rate of Excretion

The fish that survived after the 96hrs exposure to the heavy metal solution of different concentrations were transferred to potable water to determine the rate of natural excretion of bioaccumulated heavy metals. A close observation of the rate of excretion of ingested metals showed that the metals under investigation were excreted by the fish when placed in pure (unpolluted) water. In other words, when the catfish species were removed from contaminated environment, the body system naturally excreted the ingested metals. It had earlier been observed by [6] that kidney had the highest level

of bioaccumulation while blood had the lowest. It therefore stands to reason that the rate of bio-accumulation is directly proportional to the rate of excretion. Another observation made was that the excretion rate decreased with time. After the fourth week in virtually all cases investigated, there was insignificant excretion. It can therefore be concluded that the rate of excretion is not infinite. In case of lead solution, the rate of excretion at the first week was sharp. For instance, it decreased from 1.923 ± 0.04 ppm (in 10ppm) at 96hrs exposure to 0.750 ± 0.02ppm after one week in potable (unpolluted) water. It was not so in the other two concentrations. In the 5ppm and 2ppm solutions, the decrease in rate of excretion with time was not as high as in cadmium. It can be generally concluded that the fish excreted cadmium more than lead.

Bioaccumulation Factor (BAF)

As stated earlier, bioaccumulation factor, though analogous to bio-concentration factor, is usually limited to field measurements or laboratory measurements with multiple exposure routes. The bioaccumulation factor of the heavy metals was also determined from the results of excretion / bioaccumulation. It was observed that BAF of the various fish parts analyzed remained fairly constant when the fish samples were placed in potable water. However, there was a sharp decrease in the value of BAF in 10ppm lead solution after one week of excretion in pure (unpolluted) water. . Apart from this decrease, the BAF values in all the three concentrations of lead solution remained fairly constant. The same trend was observed in cadmium. Again the observed trend in the BAF values for lead, cadmium and zinc was kidney > liver > blood. However the highest BAF obtained for lead were 19.20 for test species exposed to 10ppm metal solution at 96 hours duration and the lowest was 5.0. There was a decreasing value for lower concentrations of the three metal toxicants.

6. Conclusion

Catfish fish juvenile samples exposed to different concentrations of the metal solution in their artificial habitat to assess the level of bioaccumulation witnessed the death of the species but observed that the mortality rate do not only depend on the concentration of the toxicant, but also to the type of the toxicant and period of exposure. The study further reveals that the different toxicants were differentially bio-accumulated in species organs. Pb was more bio-accumulated than cadmium and zinc. Also, some bio-accumulated toxicants were excreted over a period of time. Lead had a higher rate of excretion than the other two heavy metals investigated; namely cadmium and zinc. While the rate of excretion was initially proportional to the concentration of the toxicant, rate of excretion gradually became insignificant after sometime. It can thus be concluded that the determination of bioaccumulation can be used to monitor the health of aquatic environment as the degree of contamination was observed to be directly proportional to bioaccumulation. Results obtained from this work also indicated that if fish exposed to contaminated environment are able to migrate to safe unpolluted environment, they can, over a period of time naturally eliminate significant amount of ingested toxicants such as heavy metals. Though, the significance of this study lies in the fact that, there is need to protect the aquatic environment into it, from the continuous and indiscriminate discharge of waste water so that sensitive aquatic organisms, such as catfish juvenile, can be protected from danger. Fish juvenile is obviously more sensitive to toxic environment than adult fish. The protection of the environment will also not only safeguard the health of man as continuous consumption of contaminated fish is detrimental to human health, but will increase the quantity of fish available for consumption. Hence, it is hereby recommended that further studies or investigation could be carried out using fingerlings and adult catfish. Other heavy metals could also be considered in such investigation.

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