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Research Article

Seasonal Investigation of Heavy Metal Risk Assessment in Tilapia (*Oreochromis niloticus*) From Contaminated River Chanchaga Niger State, Nigeria

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Abstract

The contamination of fresh water with a wide range of pollutants has become a matter of great concern over the last few decades, not only because of the threats to public water supplies but also the damages caused to the aquatic life. This study investigates the Heavy Metal Risk Assessment in wet and dry season's African Tilapia (*Oreochromis niloticus*) contaminated with water treatment sludge from river Chanchaga Niger State, Nigeria. Fishes and water samples were collected from river contaminated with sludge (Chanchaga River) and other samples from a private farm (Makolo farm) where there was no sludge served as control during February and June 2019 (dry and wet seasons respectively). The water samples were collected and analyzed for physicochemical properties (dissolved oxygen, electrical conductivity, pH and temperature) using a standard method and concentrations of heavy metal both in fish and water, As, Cd, Cr, Cu, Hg and Pb were analyze using Flame Atomic Absorption Spectroscopy (FAAS). The potential risk from the consumption of these fish was assessed using standard methods and formula. All the samples collected were digested using a modified procedure from the Association of Official Analytical Chemists and were subsequently analyzed using Atomic Absorption Spectroscopy. The physicochemical properties and Heavy metal concentration in water shows a significant different ($P<0.05$) between the C. river and M. pond during dry and wet season. The mean of concentration of Heavy Metals (As, Cd, Cr, Cu, Hg, and Pb) in *O. niloticus* from C. river during dry and wet season were 2.73, 3.66, 1.79, 2.27, 3.70, 2.90, and 2.90, 3.84, 2.14, 2.69, 3.91, 2.65 mg/kg respectively and from Makolo farm pond during dry and wet were 0.72, 0.95, 1.05, 0.86, 0.22, 1.01 and 0.82, 0.96, 1.17, 1.01, 0.83, 1.17 mg/kg respectively. Fishes in C. river elicited higher (P<0.05) heavy metals concentrations compare to Fishes in M. pond. The values were all greater than the maximum permissible limit of heavy metal in fish 0.01, 0.05, 1.5, 0.5, 0.01 and 0.3 mg/kg respectively recommended by FAO/WHO except Cr in the control pond which is within the limit. The result of health risk assessment shows that fishes from C. river have a higher risk with average hazard index values greater than one (2.6755) and compared to fish in M. pond with average less than one (0.529). The study concludes that water treatment sludge discharge in C. river can bio accumulate toxic substance such as heavy metals in the fish. The risk assessment shows that fish in C. River are contaminated with heavy metals especially during wet season and could pose health risk from the Contamination.

Keywords: Heavy metals; *Oreochromis niloticus*; Risk assessment; Seasons; Water

Introduction

The contamination of fresh water with a wide range of pollutants has become a matter of great concern over the last few decades, not only because of the threats to public water supplies but also the damages caused to the aquatic life. The natural aquatic systems may extensively be contaminated with heavy metals released from domestic, industrial wastes, sludge discharge from treatment plant, agricultural activities, physical and chemical weathering of rocks, soil erosions, as well as sewage disposal and atmospheric deposition. The sources of heavy metals were reported by The FAO [1] as follows mining effluents, industrial effluents, domestic effluents, urban storm-water, cigarette, leaching of metals from garbage and solid wastes dump, metal inputs from rural areas, batteries, pesticides, insecticides, pigments, paints, glass, fertilizers, textiles, dental and cosmetics, atmospheric sources and petroleum industrial activities. Cadmium, lead and zinc are released into tiny particles as dust from rubber tires on road surface by Oguh C. Egwu, et al. [2]. Fish and Bivalve molluscs are used in bioaccumulation tests because they are higher tropic level organisms and are usually eaten by man. Fish have been used for many years as indicators of environmental pollution status, and, thus, they are regarded as good indicators of metal pollution in marine environments by Marcus AC, et al. [3].

Consequently, sludge produced from water purification processes contain high concentrations of those chemical removed by the purification processes by Uwimana A, et al. [4]. Water Treatment Sludge (WTS) is produced in conventional drinking-water treatment processes as sedimentation including suspended and dissolved solids, organic matter, and other suspensions from the water. Due to these facts, the safe disposal of WTS has become one of the main environmental concerns throughout the world due to the enormous quantity of sludge generated by Oguh CE, et al. [5]. Typically, the pumping of WTS into the river causes a number of hazards to marine life, including phytoplankton, zooplankton, and crustacean, macro-algae and fish species. This WTS is dispose and channel back to the river close to the treatment and aquatic life are effected. Metals entering the aquatic ecosystem can be deposited in aquatic organisms through the effects of Bio-concentration, bioaccumulation via the food chain process and become toxic when accumulation reaches a substantially high level by Al-Najjar, et al. [6]. The harmful effect of trace elements when consumed above the recommended limit can be toxic (acute, chronic or Sub-chronic), and heavy metals can be neurotoxic, carcinogenic, mutagenic or teratogenic by Alipour H, et al. [7].

Water pollution is defined as introduction by man, directly or indirectly, of substances or energy to the aquatic environment resulting in deleterious effects such as hazards to human health, hindrance of fish activities, impairment of water quality and reduction of climate amenities. Contamination also, caused when an input from human activities causes an increase of a substance in fresh or seawater, sediments and organisms above the natural background level for that area and for those organisms by Clark RB, [8]. The results of many field studies of metal accumulation in fish living in polluted waters show that considerable amount of various metals may deposited in fish tissues without causing mortality by Moustafa, M. Zeitoun, et al. [9]. Heavy metals are natural components of the earth' crust. They can't be degraded or destroyed. Heavy Metals (HM) are trace components of the aquatic environment, but their levels have been increased due to industrial wastes, geochemical structure, agricultural and mining activities by Sprocati AR, et al. [10]. The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Examples of heavy metals include mercury, cadmium, arsenic, chromium, thallium and lead. Trace metals are classified as 'light' or 'heavy' with densities less or greater than 5 g/cm3. The densities of Pb, Hg and Cd are 11.4 gcm-3, 13.6 gms/cubic cms and 8.65 gms/cubic cms respectively.

All of these sources of pollution affect the physicochemical characteristics of the water, sediments and biological components and thus the quality and quantity of fish stocks by Singh RK, et al, [11]. Fishes, being major components of most aquatic habitats have also been recognized as good Bio-accumulators of organic and inorganic pollutants by King RP, et al. [12]. Fish are exposed to heavy metals through the uptake of water from the contaminated river, human eat these fishes, ingestion of Fish-and-Animal based foods is the largest sources of heavy metals in human by Amadi BA, et al. [13]. Heavy metal contamination of aquatic environments is of critical concern because of their toxicity and accumulation in aquatic organisms. Many dissolved metals entering rivers are adsorbed onto colloid particulates at high alkalinity and pH, the metals particularly lead and cadmium, precipitate by forming complexes, further influencing the metal toxicity by Dimari GA, et al. [14]. Heavy metals such as mercury, lead and cadmium, even at very low concentrations in marine organisms will be very dangerous for humans if they are used for a Long-term. Heavy metals toxicity can result in damaged or reduced mental and central nervous function, lower energy levels and damage to blood composition, lungs, kidneys, liver and other vital organs. Long-term exposure may result in slowly progressing physical, muscular and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy and multiple sclerosis. Allergies are not common and repeated Long-term contact with some metals may cause cancer by Oguh CE, et al. [15]. Metals such as cadmium, mercury, arsenic and lead are non-essential and therefore have toxic effects on living organisms such as damage to the renal and nervous systems of fish as well as gill damage (severe destructive pathological changes, i.e. structural lesions) [16-19].

The accumulation of heavy metals in fish is an important issue because many fish species are consumed as a source of protein by a large section of the population, especially those who live near rivers. Due to the insufficiency of protein sources for the vast increased population in the third world countries, fish farming has gained popularity as alternative source of a cheap protein. The low saturated fat and sufficient omega fatty acids in fish are also important in supporting good human health. In human, exposure to high levels of heavy metals through the consumption of fish is known to pose severe health risk such as damage to the organs (such as liver, kidney), cancer and may result in death, and also pause risk for, animals, plant and environmental. Therefore, this study aimed to assess the level of Heavy metal in wet and dry seasons Tilapia fish *Oreochromis niloticus* contaminated with water treatment sludge from river Chanchaga Niger State, Nigeria and its Risk Assessment.

Materials and Methods

A commonly consumed fish African Tilapia *(Oreochromis niloticus)*, were selected for the study. The fishes used for the study were harvested fresh from river Chanchaga, Minna Niger State.

Study Areas

The study was carried out in river close to Niger State water board and a private farm (Makolo farm) at Chanchaga, Bosso Local Government Area in North-central, Niger State of Nigeria from May to June 2019. Chanchaga is situated at 9°34' North latitude, 6°33' East longitude, with an area of 72 km^2 and a population of 201,429 at the 2006 census (Figure 1). River Chanchaga is originated from Tagwai Dam in Minna Niger State. It has a moderate climate with a very high temperature during the dry season and average rainfall during the rainy season. The river is use as water source in Niger State water board authority for water treatment. Makolo farm is a major agricultural enterprise in Chanchaga whose operations include fish farming. It supplies about 1 tonnes of fish per day and is located at Kangiwa road Chanchaga Minna, Niger State.

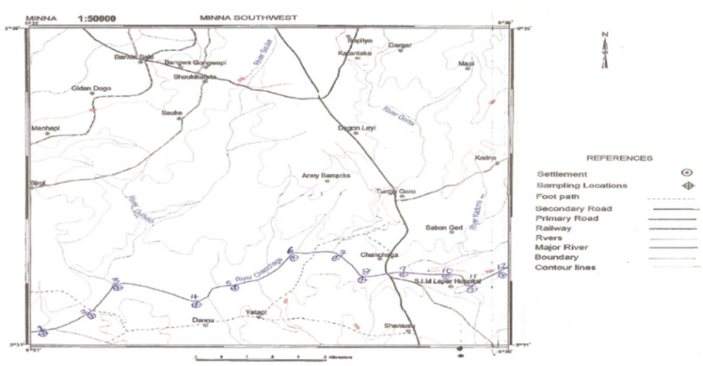

Figure 1: Topo-Map of Minna Niger State showing River Chanchaga with numbering 1-12.

Study Design

The experiment was carried out under a Completely Randomized Design (CRD) with four samples and three replicate groups for each. The concentrations of the Heavy metals both in water and fish samples, were done in four groups, from group 1 to 4 which are samples during February and June 2019 (dry and wet seasons respectively) from Chanchaga river and a control pond (where no activities) for (*Oreochromis niloticus*). Both water and fish sample were randomly collected and analyzed for water physicochemical properties and Heavy Metals As, Cd, Cr, Cu, Hg and Pb.

Sampling

Sampling of Adult O. niloticus was carried out during February and June 2019 (dry and wet seasons respectively). Two experimental gill nets (measuring 30 m length, 1.5 m depth with stretch mesh size of 3 and 4 inches) were set up and left for three consecutive days. Each net was inspected every day for three days from morning until afternoon. The net was set up along the river that covers the most river pools. The total of 36 fish of similar weights was used from the study area and Makolo fish pond. The average length and weight of the samples were 38 cm and 1 kg from the river and fish farm. Water samples were also collected from the study samples and the control in plastic containers, sealed and transferred to the laboratory in iced packs. Approximately 1ml of concentration HNO_3 is added to the water samples to prevent the microbial utilization of heavy metals. The fish samples were frozen in the laboratory in a clean ice Box before heavy metal analysis. The mean was calculated to get triplicate figures for statistical analysis.

Fish Tissue Preparation

Fish samples were rinsed by distilled water to get rid of any remnants of trace metals on the outer surface of the fish, and the scales were removed. Muscle tissues of fish (dorsal muscle) was used in this study because it is the major target tissue for metal storage and is the most edible part of the fish. Fish tissues were cut and oven dried at 110° C to a constant weight. After ensuring of samples dryness they were removed and then were grounded into powder using ceramic mortar and sieved through 20µm mesh and then stored in polyethylene bottles at 30° C until analysis. A wet digestion method was used based on the Analytical Methods for Atomic Absorption Spectrometry.

Physico-Chemical Properties

pH

The pH value which is a measure of the hydrogen or hydroxyl ion activity of the water system indicates whether the water is acidic, neutral or alkaline in reaction. Fishes suffers much both under very low as well as high pH. The instrument for pH measurement commonly used is a digital pH meters have single electrode assembly. The instrument being a potentiometer, the pH scale has to be calibrated before use with buffer solutions of known pH values. 75 ml of water sample is taken in a 100 ml beaker. The suspension is stirred at regular intervals for 30 minutes and the pH is recorded. The suspension is stirred well just before the electrode are immersed and readings are taken. Three readings were observed and then mean of it was calculated.

Temperature

Water temperature was determined using a Mercury-in-glass thermometer.

Dissolved Oxygen

Dissolved Oxygen (DO) was performed by Wrinkler method [20]. Manganous sulfate solution (2 ml) and 2 ml of alkaline potassium iodide was added to the water. The solutions were mixed thoroughly 2 ml of conc. Sulfuric acid was added to it. From the above solution 200 ml was transferred into a conical flask. Few drops of starch indicator were added. Then it was titrated against sodium thiosulfate till blue color turns violet. The amount of titrants used gives DO value. Three readings were taken and mean of it was calculated.

The oxygen content of the water was obtained by calculation using the formula

D.O content (mg/L) = Volume of original sample taken/Volume of sample titrated × A

Where A = Volume of the Thiosulphate used in titration.

Electrical Conductivity

The electrical conductivity was determined by [21]. In this method, a 5 ml of sample water mixture is shaken for 30 minutes, allowed to settle then the conductivity measured with a temperature-compensated probe. An approximate soluble salts value may be derived from the conductivity using the empirical relationship

Soluble salts (%) = Conductivity (dS/m) × 0.35.

Digestion of Water Samples

Water samples were analyzed by a modified procedure from the Association of Official Analytical Chemists [22]. Nitric acid (10 ml) was added to 50 ml of each water sample and heated at 150° C for 30 mins. 5 ml of nitric acid was then added to each tube and heated for 30 minutes at 200^{o} C, to the mixture was added 2 ml of hydrogen peroxide before further heating at 200^{o} C for 30 minutes. The resulting solutions were allowed to cool at room temperature and then the volume made up to 25 ml with distilled water. Digested samples were analyzed for levels of As, Cd, Cr, Cu, Hg and Pb using Atomic Absorption Spectroscopy.

Digestion of Fish Samples

A 5 g of the dry powdered sample was put into a 50 ml beaker with 5 ml of HNO_3 and 5 ml of H_2SO_4. When the fish tissue stopped reacting with HNO_3 and H_2SO_4, the beaker was then placed on a hot plate and heated at 60° C for 30 min. After allowing the beaker to cool, 10 ml of HNO_3 was added and returned to the hot plate to be heated slowly to 120° C. The temperature was increased to 150° C, and the beaker was removed from the hot plate when the samples turned black. The sample was then allowed to cool before adding H_2O_2 until the sample was clear. The content of the beaker was transferred into a 50 ml volumetric flask and diluted to the mark with ultra-pure water. All the steps were performed in the fume hood. Digested samples were analyzed for levels of As, Cd, Cr, Cu, Hg and Pb using Atomic Absorption Spectroscopy. The above procedures in this section followed the guidelines from the Analytical Methods for Atomic Absorption Spectroscopy [23].

Bio-accumulation Factor (BAF)

The ratio of the contaminant in the fish to the concentration in the ambient environment at a steady state, where the fish can take in the contaminant through ingestion with its food as well as through direct content [24]. The transfer coefficient was calculated by dividing the concentration of toxic metals in fish by the total toxic metals concentration in the water. This index of Water-fish transfers or intake of toxic elements from water through fish was calculated using

$BAF = C_{fish}/C_{water}$

where

BAF represent the transfer factor of snail

C_{fish} = Toxic elements concentration in fish tissue, mg/kg fresh weight

C_{water} = Toxic elements concentration in water, mg/kg dry weight

BAF > 1 indicates that the fish are enriched in elements from the water (Bio-accumulation)

BAF < 1 means that the water excluded the toxic elements from water (excluder)

Risk Assessment of Heavy Metals via the Consumption of Fishes

Risk assessment was evaluated by considering only the edible part (muscles tissues) to determine Daily Intake of Metal (DIM), Health Risk Index (HRI) and Hazard Index (HI).

Daily Intake of Metals (DIM)

The Daily Intake of Metals (DIM) was calculated to estimate the daily loading of metals into the body system (via the consumption of fish meal) of a specified body weight of a consumer according to [25]. This would entail the relative bioavailability of the studied metals in this study. The Daily Intake of Metals (DIM) was determined by the following

$ADDM = DI\ (kg/day) \times M_{fish}\ (mg/kg)/BW\ (kg)$

where

ADDM = Average daily dose (mg,kg/d) of the metal into the body via the consumption of fish.

DI = The daily intake of fish for adult is 0.227 kg/day^{-1} for food describe by [26].

M_{fish} = The trace toxic elements (metals) concentration in the fish tissues (mg/kg)

BW = Represent the estimated average body weight of investigated in adult (60 kg for adults).

Health Risk Index (HRI)

The Health Risk Index (HRI) for the populations through the consumption of contaminated fish from sludge contaminated river was assessed based on the Daily Intake of Metals (DIM) relative to Reference Oral Dose (RfD) for each metal. This is an index justifying individual's risk of heavy metals. The HRI value of less than one implies safe tread and is considered acceptable, otherwise, the fish may pose heavy metals risk. The following equation describe by [27] is used to calculate the HRI of fish.

HRI = ADDM/ RfDM

where

ADDM = represents the average daily dose (mg,kg/d) of the metal

RfDM = is the reference dose of the metal (mg,kg/d)

RFDM is define as the maximum tolerable daily intake of metal with no adverse effect.

HRI is the ratio between exposure and the Reference Oral Dose (RfD). If the ratio is lower than one, there will be no obvious risk.

Estimation of Hazard Index (HI)

The Hazard Index (HI) was calculated to determine the overall risk of exposure to all the heavy metals via the ingestion of a contaminated fish [28]. The Hazard Index (HI) was calculated as the summation of the Hazard Quotient (HQ) arising from all the metals examined. The value of the hazard index is proportional to the magnitude of the toxicity of the fish consumed. HI > 1 indicates that the predicted exposure is likely to pose potential health risks. However, a hazard index >1 does not necessarily indicate that a potential adverse health effects will result, but only indicates a high probability of posing health risks.

$$HI = \Sigma HQ_{As} + HQ_{Cd} + HQ_{Cr} + HQ_{Cu} + HQ_{Hg} + HQ_{Pb}$$

Statistical Analysis

The data obtained were analyzed using IBM Statistical Product and Service Solution (SPSS) version 20 and Microsoft excel 2013. The results were expressed as mean ± Standard Deviation (SD). One-way analysis of variance (ANOVA) was carried out as $P < 0.05$ considered statistically significant.

Results

Physicochemical Properties of Chanchaga River and Makolo Pond During Dry and Wet Seasons

The physico-chemical properties (dissolved oxygen, pH, Temperature, and electrical conductivity) of water were determined in Table 1. The values of physicochemical properties of C. river and M. pond during dry and wet seasons were dissolve oxygen (6.17, 6.34 and 5.26, 5.93 mg/l), pH (6.26, 6.62 and 5.22, 6.52), Temperature (31.49, 27.34 and 35.73, 28.69° C), and electrical conductivity (622.33, 578.00 and 686.66, 589.66 mg/l) respectively which are significantly different (P<0.05).

Physicochemical Properties		Water Samples		
		Dry Season	Wet Season	PL (29)*,(30**)
Dissolve Oxygen (mg/l)	C. River	6.17 ± 0.02^{b}	5.26 ± 0.02^{d}	6-8mg/l*
	M. Pond	6.34 ± 0.03^{a}	5.93 ± 0.04^{c}	
pH	C. River	6.26 ± 0.04^{c}	5.22 ± 0.02^{d}	6.5-8.5*
	M. Pond	6.62 ± 0.03^{a}	6.52 ± 0.02^{b}	
Temperature (ºC)	C. River	31.49 ± 0.61^{b}	35.73 ± 0.10^{a}	20-30 ºC*
	M. Pond	27.34 ± 0.08^{d}	28.69 ± 0.02^{c}	
EC (mg/l)	C. River	622.33 ± 9.60^{b}	686.66 ± 5.50^{a}	500 mg/l**
	M. Pond	578.00 ± 4.58^{c}	589.66 ± 5.50^{c}	
Results Expressed as Mean ± SD. Mean values with different superscript letters on the rows are considered significant (P<0.05). PL=Permissible limit, C: Chanchaga, M: Makolo, EC: Electrical conductivity n=3				

Table 1: Physicochemical Properties of Chanchaga River and Makolo pond.

Concentration of Heavy Metals in Water Samples

The mean concentration of HMs (As, Cd, Cr, Cu, Hg and Pb) in different water samples (C. river and M. pond) during dry and wet seasons are shown on Table 2. The result of C. river shows a significant different (P<0.05) between the M. pond during dry and wet season. The concentration of As, Cd, Cr, Cu, Hg and Pb were above the [29] permissible limits of HMs in water 0.01, 0.003, 0.05, 1.0, 0.001, and 0.01 mg/kg respectively.

Heavy Metals	**Water Samples**				
(mg/kg)	**DSC River**	**WSC River**	**DSM Pond**	**WSM Pond**	**PL (mg/kg) by (31)**
As	2.08 ± 0.05^b	2.88 ± 0.11^a	0.91 ± 0.05^d	1.08 ± 0.03^c	0.01
Cd	2.52 ± 0.10^b	2.99 ± 0.02^a	0.95 ± 0.01^d	1.31 ± 0.02^c	0.003
Cr	1.98 ± 0.01^b	2.12 ± 0.01^a	1.02 ± 0.02^d	1.13 ± 0.01^c	0.05
Cu	2.34 ± 0.03^b	2.82 ± 0.10^a	0.93 ± 0.04^c	1.00 ± 0.02^c	1
Hg	3.64 ± 0.05^b	3.94 ± 0.04^a	0.24 ± 0.03^d	0.57 ± 0.01^c	0.001
Pb	2.91 ± 0.08^a	2.63 ± 0.04^b	1.01 ± 0.02^d	1.15 ± 0.01^c	0.01
Results Expressed as Mean ± SD. Mean values with different superscript letters on the rows are considered significant (P<0.05). PL=Permissible limit, DSC: Dry Season Chanchaga, M: Makolo n=3, WSC: Wet season Chanchaga, DSM: Dry season Makolo WSM: Wet season					

Table 2: Concentration of Heavy Metals in Water Samples

Concentration of Heavy Metals in Fish Samples

The mean concentrations of heavy metals analyzed on the tissue of *Oreochromis niloticus* from C. river and M. pond during dry and wet seasons. The concentration of HMs on fish from C. river were all greater than the maximum permissible limit of HMs As, Cd, Cr, Cu, Hg and Pb in fish 0.01, 0.05, 1.5, 0.5, 0.01, 0.3 mg/kg respectively recommended by [29-31]. While the fishes from M. pond were also slightly greater than the maximum permissible limit except Cr which is below the recommended values. The results are shown on Table 3.

Heavy Metals	***Oreochromis niloticus* Samples**				
(mg/kg)	**DSC**	**WSC**	**DSM**	**WSM**	**PL (mg/kg) by (31) *,(32)****
As	2.73 ± 0.11^b	2.90 ± 0.05^a	0.72 ± 0.03^c	0.82 ± 0.04^c	0.01*
Cd	3.66 ± 0.08^b	3.84 ± 0.05^a	0.95 ± 0.06^c	0.96 ± 0.03^c	0.05*
Cr	1.79 ± 0.05^b	2.14 ± 0.01^a	1.05 ± 0.02^d	1.17 ± 0.01^c	1.5**
Cu	2.27 ± 0.01^b	2.69 ± 0.05^a	0.86 ± 0.13^d	1.01 ± 0.01^c	0.5*
Hg	3.70 ± 0.01^b	3.91 ± 0.06^a	0.22 ± 0.06^d	0.83 ± 0.06^c	0.01*
Pb	2.90 ± 0.02^a	2.65 ± 0.02^b	1.01 ± 0.02^d	1.17 ± 0.01^c	0.3*
Results Expressed as Mean ± SD. Mean values with different superscript letters on the rows are considered significant (P<0.05). PL=Permissible limit, D: Dry, W: Wet, M: Makolo, S: Season, C: Chanchaga, n=3					

Table 3: Concentration of Heavy Metals in Fish Samples.

Estimation of Bioaccumulation Factor (BAF) Of Toxic Element in Fish

The BAF shows the amount of heavy metal that is transferred from water to fish tissue. The BAF of metals As, Cd, Cr, Cu, Hg, and Pb obtained in fish (*O. niloticus*) from C. river and M. pond during dry and wet seasons are shown on Figure 1. Where the BAF is greater than one (>1) indicates that the fishes are enriched with the elements from the water (Bio-accumulators). Also where BAF is less than one (<1) means that the fishes exclude the elements from the water (excluders).

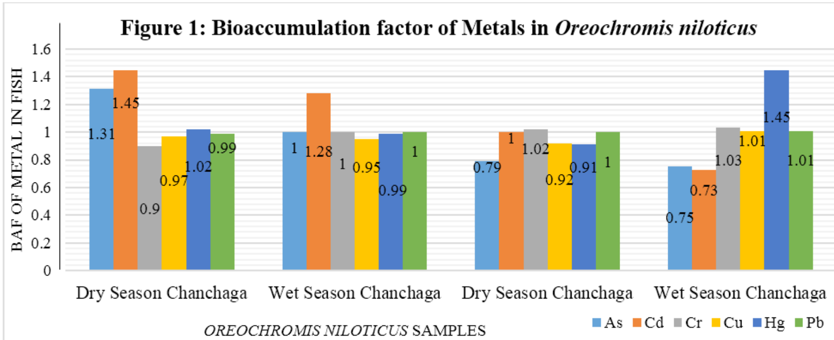

Figure 1: Bioaccumulation factor of Metals in *Oreochromis niloticus.*

Estimation of Average Daily Dose of Metal (ADDM) For Adult

The average daily dose of HMs into the body system for adult (via the consumption of fish tissue) was estimated according to the average fish consume through the food chain. The result of ADDM shows that fishes in C. river has higher values of ADDM (As, Cd, Cr, Cu, Hg, and Pb) both dry and wet seasons compared to fish in M. pond shown on Figure 2.

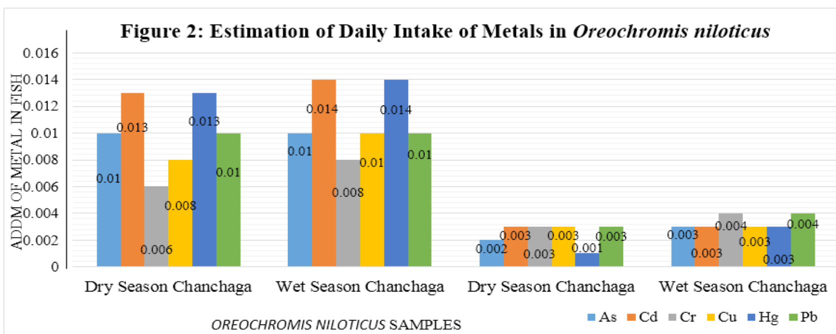

Figure 2: Estimation of Daily Intake of Metals in *Oreochromis niloticus.*

Estimation of Health Risk Index HRI

The HRI of metals through consumption of fish from C. river and M. pond during dry and wet season were given in Figure 3. The HRI for fish from C. river recorded high HRI than that of fish from M. pond during dry and wet seasons. Metals As and Pb from C. river in both dry and wet were greater than one, which indicate toxicity (Fiureg 3).

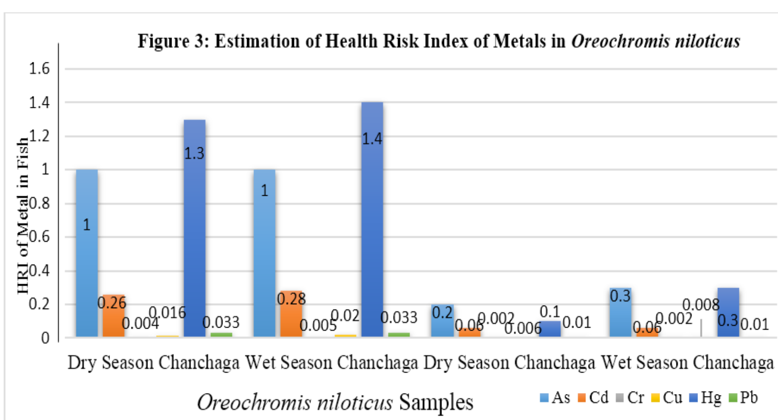

Figure 3: Estimation of Health Risk Index of Metals in *Oreochromis niloticus*.

Estimation of Hazard index (HI)

The overall health risk of exposure to all the heavy metals analyses via the ingestion of fish from C. river and M. pond during dry and wet seasons is shown in Figure.4. The total Index of all metals in *O. niloticus* from C. river and M. pond during dry and wet seasons were 2.613, 2.738 and 0.378 and 0.68. The result shows that Fishes from C. river were highly contaminated with heavy metals compare to the fish in M. pond. HI > 1 indicates that the predicted exposure is likely to pose potential health risks.

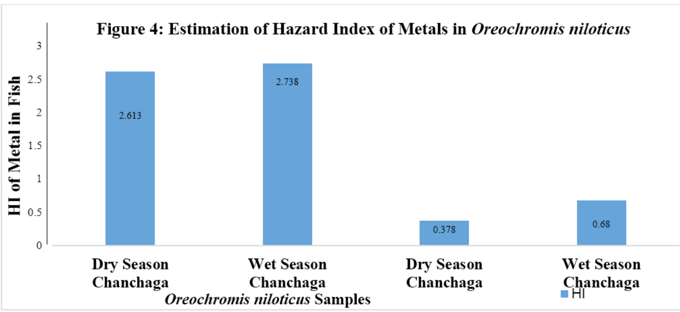

Figure 4: Estimation of Hazard Index of Metals in *Oreochromis niloticus*.

Discussion

The mean value of physico-chemical properties of C. river and M. pond (dissolved oxygen, pH, Temperature, and electrical conductivity) were determined were significantly different (P<0.05). The physicochemical changes in water parameter may be due to the sludge discharge and other anthropogenic activities. The amount of dissolve oxygen in a water body has a major impact on fish behavior, stability and survival. Dissolved Oxygen (DO) refers to the level of free, non-bonded oxygen present in water. Dry and wet seasons of C. river has lower DO with 6.17 and 5.26 mg/l compared to Makolo fish pond water in dry and wet season with 6.34 and 5.93 mg/l. The lower concentration of DO in C. river can lead to hypoxia (Absence of enough oxygen in water). The recommended minimum dissolved oxygen require in fresh water is within 6-8 mg/l. The lower DO in C.river may be due to the waste discharge in the river which covers the surface of the river for oxygen penetration. The oxygen dissolves by diffusion from the surrounding air. Oxygen level can be reduced depending on pollutants present, dissolved minerals such as salt and temperature. Most fish species tolerate a drop below these minimum values for a short period of time and the period of time during which the oxygen levels drops below required limit, will cause fish to become stressed. The lower the concentration of DO, the greater the stress. The stress can cause fish death.

The pH concentration in dry and wet season of C. river recorded low values (6.26, and 5.22) than M. pond (6.62 and 6.52) respectively. Low pH level reduces the active nature of fish and also accelerate the release of heavy metals which is due to the waste water channel to the river and also runoff from polluted environment. The World Health Organization [32] recommends a pH value of 6.5 -8.5 for drinking water to prevent corrosion. Fish are influenced by the temperature around them because they are unable to regulate their body temperature. C. river during dry and wet seasons recorded higher temperature (31.49 and 35.35.73) than Makolo fish pond (27.34 dry and 28.69 wet) and electrical conductivity values during dry and wet seasons of C. river are higher (622.33 and 686.66) than M. pond (578.00 and 589.66) shown on Table 1. High temperature do not hold enough oxygen for aquatic organisms to survive. Increase in water temperature means a decrease in dissolved oxygen available for the fish to breathe from the water. Water temperature according [33] affects the EC so that its value increases from 2 up to 3% per 1°C. The average limit of temperature in fish water is 20-30º C. The increase in EC may be due to runoff, sewage waste, sludge, which also increases chloride, phosphate, and nitrate ions. Lower pH also increases electrical conductivity. The permissible limit of EC is 500 mg/l according to [34].

The mean concentration of heavy metals (As, Cd, Cr, Cu, Hg and Pb) in C. river samples during dry and wet season (2.08, 2.52, 1.98, 2.34, 3.64, 2.91 and 2.88, 2.99, 2.12, 2.82, 3.94, 2.63 mg/kg) respectively. The concentrations of HMs in M. pond were all lower than C. river as shown in Table 2. The result of C. river shows a significant different (*P*<0.05) between the M. pond. The result shows that water samples from C. river were more contaminated with Heavy metals compared to water from M. pond especially during wet seasons. The concentration of as, Cd, Cr, Cu, Hg and Pb in all water samples were above the [29] permissible limits of HMs in water 0.01, 0.003, 0.05, 1.0, 0.001, and 0.01 mg/kg respectively. The study also indicates that Hg in the C. river among the metals had the highest concentration, while Cr was the lowest. The sequence of occurrence for C. River Cr<As<Cu<Cd<Pb<Hg and for M. Pond Hg<As<Cu<Cd<Pb<Cr. This is probably as a result of heavy metals from water treatment plant sludge discharge in the water, which are main pollutants in C. River. The heavy metal concentrations recorded in C. river were higher than standard limits for portable water and aquaculture (FAO/WHO, 2016). Aquatic life abounds in the waters and can Bio-accumulate these metals and subsequently transfer it to consumers via food chain.

The ability of fishes to accumulate essential metals equally enables them to acquire other nonessential metals from the river or pond. Fish being at the higher level of the food chain accumulate large quantities of metals and the accumulation depends upon the intake and elimination from the body. There was a highly significant difference in the concentrations of HMs in *O. niloticus* from C. river and M. river. The entire fish Samples from C. river and M. pond contained detectable levels of the elements studied. The accumulation of these heavy metals in fish may represent a health risk, especially for populations with high consumption rates of fish (2). One-way Analysis of variance (ANOVA) revealed a significant (P<0.05) variation in the concentrations of HMs during dry and wet seasons in C. river and M. pond, which is an indication of the extent of metal pollution from the river. HMs recorded during wet seasons were significantly higher than values recorded during dry season. These may be due to runoff during raining season, waste materials are move along side with water from contaminated areas and dump site to the river. Generally, C. river had higher heavy metals concentrations (As, Cd, Cr, Cu, Hg, and Pb) than the controls, which were all above the [29] permissible limit of 0.01, 0.05, 1.5, 0.5, 0.01, and 0.3 mg/kg respectively (Table 3). The mean values recorded at the control pond were also higher than the FAO/WHO acceptable value except Cr which is below the permissible limit of 1.5 mg/kg. The mean concentration of heavy meals in *O. niloticus* from C. river is decrease in the following order Hg>Pb>Cd>Cu>As>Cr. The levels of chromium were comparatively lower in the fish samples which is in accordance with the findings of [35]. Heavy metals and nutrients absorbed by fish are usually translocate to different parts of the fish which could limit the concentrations in the river. However, availability of heavy metals in the water and continuous stay in the polluted water could lead to higher concentration in the fish.

The high concentration of As and Cd at C. river may be due to sludge from water treatment plant, atmospheric deposition, combustion, etc. which translocate through the fishes. Arsenic affects almost all organs during its acute or chronic exposure. Liver has been reported as target organ of arsenic toxicity. Toxicity is due to arsenic's effect on many cell enzymes, which affect metabolism, DNA repair and brain problem. The most prominent chronic manifestations of as involve the skin, lungs, liver and blood systems. The levels of Cd recorded in this study was however much higher than the values of 0.27 mg/kg reported for fish by [36]. Cadmium is a dangerous element because it can be absorbed via the alimentary track, penetrate through placenta during pregnancy and damage membrane and DNA. Significant concentration of Cd may have gastrointestinal effect and reproductive effect on livestock [37,38] reported that cadmium causes both acute and chronic poisoning, adverse effect on kidney, liver, vascular and the immune system.

High dose of chromium is observed to cause Bronchopneumonia, chronic bronchitis, diarrhea, emphysema, headache, irritation of the skin, itching of respiratory tract, liver diseases, lung cancer, nausea, renal failure, reproductive toxicity, and vomiting. Copper is indeed essential, but in high doses it can cause anaemia, diarrhea, headache, metabolic disorders, nausea, vomiting, liver and kidney damage, stomach and intestinal irritation on human health. The levels of Cu recorded in this study was however much higher than the values of 0.02 ± 0.002 mg/kg reported for *C. anguillaris* by [39]. According to high levels of copper can cause metal fumes fever with flu-like symptoms, hair and skin decolouration, dermatitis, irritation of the upper respiratory tract, metallic taste in the mouth and nose.

Mercury poisoning symptoms include blindness, deafness, brain damage, digestive problems, kidney damage, lack of coordination and mental retardation. Lead has no beneficial biological function and is known to accumulate in the body. [40] reported that lead causes both acute and chronic poisoning and thus, poses adverse effects on kidney, liver, vascular and immune system. Lead can cause serious injury to the brain, nervous system, red blood cells, low IQ, impaired development, shortened attention span, hyperactivity, mental deterioration, decreased reaction time, loss of memory, reduced fertility, renal system damage, nausea, insomnia, anorexia, and weakness of the joints when exposed to high lead. The Bio-accumulated metals on the fish may interact directly with biomolecules such as nucleic acid, protein, carbohydrate, disrupting critical biological processes, resulting in toxicity and the concomitant transfer of these metals through the food chain could ultimately pose risk to human life [41,42].

The BAF of HMs from water-fish is the main component of human exposure to HMs through the food chain. The BAFs during dry and wet season of *O. niloticus* from C. river were significantly different from M. pond. This indicate the high presence of metals in the C. river. The more the presence of metal in the water the more the bioaccumulation on the fish. The water-fish BAF of *O. niloticus* from C. river during dry season for Cr, Cu, and Pb were below one (<1) except As, Cd, and Hg which were up to and greater than one (>1). The BAF from C. river during wet season for As, Cd, Cr, and Pb were above one except Cu and Hg which is below one. The BAF of *O. niloticus* from M. pond were all below one except Cd, Cr and Pb for dry season while the BAF in wet season were above one except As and Cd which were below (<1). The BAF values below one (<1) indicate that the fish do not take up toxic element or exclude the element from the river or pond shown in Figure 1. Where BAF > 1 indicates that the fish are enriched in elements from the water (Bio-accumulation).

As intake of fish is a possible source of metal accumulation in humans, there is an important interest in calculation of the daily and weekly consumptions of heavy metals through fish eating. The ADDM values for heavy metals were significantly little high in fishes from C. river than fishes from M. pond. The highest intakes of As, Cd, Cr, Cu, Hg, and Pb in fish were from C. river. The Daily intake indicate the amount of HMs that will be taken in the body when such fish is consume.

The HRI values for Heavy metals were significantly high in fishes from C. river. The (HRI) values were significantly <1, in fishes from M. pond, indicating that consumers of fishes from these pond is not exposed health risk of As, Cd, Cr, Cu, Hg, and Pb. The HMs as (1.0) and Hg (1.30) were greater than one >1 for both seasons which indicate that consumption of fishes from C. river will lead to accumulation of as and Hg in the body, which can lead to severe health problem. Hazard Index (HI) shows the overall risk of exposure to all the metal in fish from C. river and M. pond. The control fishes from M. pond were below <1, which indicates that the consumption of fish cannot pose health risk to consumer. The values of HI in fishes from C. river were above >1, it indicates that the consumption of all the fish can pose health risk to consumer through the intake of metal.

Conclusion

The present study revealed that African Tilapia Fish *O. niloticus* from Chanchaga river are contaminated with heavy metals that exceed the maximum prescribed limits for elements in fish especially during wet season, which toxicity can disrupt natural ecosystems and affects the food chain, which leads to deleterious health problems in humans.

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