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Original Research Article

Health Risk Assessment of Some Toxic Elements in Aquatic Bioindicator (*Clarias gariepinus* and *Oreochromis niloticus*) from Tagwai Reservoir Dam Minna, Niger State Nigeria

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Abstract

Fishes are considered to be most significant bioindicator in aquatic systems for the estimation of toxic metal pollution or facet of the impact of toxic substances on the natural environment. This study aimed to analyze the Hazard Assessment of Some Toxic Elements in *Clarias gariepinus* (Cat fish) and *Oreochromis niloticus* (Tilapia fish) from Tagwai Reservoir Minna, Niger State Nigeria and the health risk associated with their consumption. The water samples were collected from Tagwai Reservoir and analyzed for water physicochemical properties (pH, dissolved oxygen, electrical conductivity and temperature) using a standard method and concentrations of heavy metal in fish and water, As, Cd, Cr, Hg and Pb were analyze using Atomic Absorption Spectroscopy (AAS). The Bioaccumulation factor and health risk (daily intake, health risk index and hazard index) from the consumption of these fishes was assessed using standard methods and formula. All samples (fish and water) collected were digested using a modified procedure from the Association of Official Analytical Chemists (AOAC) and were subsequently analyzed using AAS. The result of the physicochemical properties and Heavy metal concentration in water and fishes shows a significant increase ($P<0.05$) in parameters. The values of physicochemical properties were dissolve oxygen (5.03 mg/l), pH (5.75), Temperature (32.45 ºC), and electrical conductivity (691.52 mg/l) which are significantly higher than the WHO recommended values. Water and fish samples from Tagwai reservoir were contaminated with HMs. The concentration of HMs on fish from Tagwai reservoir were all greater than the maximum permissible limit of metals As (0.01), Cd (0.05), Cr (1.5), Hg (0.01), and Pb (0.3 mg/kg) of HMs in fish as recommended by FAO/WHO. Total hazard Index of all metals in *O. niloticus*, and *C.gariepinus* from Tagwai reservoir were 2.65 and 3.07 respectively. This conclude that fish in Tagwai reservoir are contaminated with HMs with deleterious effect on fishes and also bioaccumulate in the fish. The risk assessment shows that fish in Tagwai reservoir are contaminated with potentially toxic elements and could pose health risk from heavy metal contamination when consume via food chain.

Keywords: *Clarias gariepinus*, *Oreochromis niloticus*, Hazard Assessment, Heavy Metals, Water.

INTRODUCTION

Fish have been used as indicators of environmental pollution status, and, thus, they are regarded as good indicators of metal pollution in aquatic environments [1, 2]. Fishes are mostly vulnerable and heavily exposed to pollution because they cannot escape from the detrimental effects of pollutants in their environment i.e. they are cold blooded animals and survive only on water bodies [3]. In aquatic environments, heavy metals (HMs) pollution is cause by direct atmospheric deposition, geologic weathering or through the discharge of agricultural chemicals, municipal waste, residential or industrial waste products, and water treatment plants waste [4]. An environmental pollutants such as HMs bioaccumulate in food chain when the fish are consume by human which can cause an antagonistic effects (chronic or acute diseases) and even death of consumers, so fish among other animals are used to determine the health condition of aquatic ecosystem. Bioaccumulation of heavy metals means an increase in the degree of a toxic metals in a living organism over a period of time, compared with chemical's level in the environment. Several studies have showed that accumulation of HMs in fish tissue is mainly dependent on the HMs concentration in the water and exposure period; though some other environmental factors such as pH, water temperature, hardness, oxygen concentration, salinity, alkalinity and dissolved organic carbon may affect and play significant roles in metal's accumulation and toxicity to aquatic life especially fish [5-7].

Toxic elements i.e. HMs are the most important pollutants in aquatic life because of their toxicity, accumulation and bio-magnification by marine organism. The high level of HMs in the reservoir could indicate similar high concentration in fishes by accumulation causing serious risk to human health through food chain. More times very young stages of fish (larvae and juveniles) grow up in the near shore zone of the river, where the water quality is heavily contaminated [8]. Accumulation of HMs varies from fish species to the other, some fish accumulate more heavy metal than others. The toxicity effects of toxic elements can affect individual growth rates, physiological functions, reproduction, and even mortality in fish. Toxic metals are accumulate in fish bodies by three possible ways: gills, digestive track and body surface. The gills are considered as the significant site for direct uptake of metals from the water [9], HMs in fish come mainly from their diet, though the body surface is normally estimated to take minor part in uptake of heavy metals in fish [10]. Fish are used in bioaccumulation tests for aquatic organism because it is a higher tropic level organisms and are usually eaten by human [11].

Heavy metal refers to any metallic chemical element that has a relatively high density greater than 5 g/cm^3 and is toxic or poisonous even at low concentrations. Examples of some toxic heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Ti) and lead (Pb). The densities of Pb, Hg and Cd are 11.4 gcm-3, 13.6 gms/cubic cms and 8.65 gms/cubic cms respectively [4]. It has been shown that even low concentration of Hg, Cd, Pb, Al and As can cause a wide variety of health problems [12]. Toxicity of heavy metal 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 of HMs 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 toxic metals may cause cancer. Metals elements such as Cd, Hg, As and Pb 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) [13-16].

Lead severely damage the liver, kidneys, heart, brain, nerves and other organs. Exposure to Pb causes increase in heart disease, anemia, high blood pressure, and reproductive disorders osteoporosis (brittle bone disease) especially in men. Cadmium is highly toxic metal because it's cause serious illness, rheumatoid arthritis (RA), full skeletal deformities, cancer, depressed growth, hypertension, diarrhea, vomiting, stomach problems, fractures in bone, damage to DNA, failure in reproduction and fertility, cause damage to nervous system, damage to immune system, cancer, fetal deformity and death [17]. Effect of chromium on humans by fish intake are faded immune system, Skin diseases, Cause ulcer and upset stomach, Respiratory track problem, Alteration in genetic material, Lung cancer, liver and kidney damage and Death. Mercury toxicity include visual field construction, behavioral changes, memory loss, headaches, tremors, loss of fine motor control, spasticity, hair loss, mental retardation to fetus and fetal deformity, cerebral polsy, blindness, deafness and muscular rigidity [18]. Arsenic is acutely toxic element and large intakes can result in adverse symptoms to gastrointestinal tract, severe disturbances of the cardiovascular and central nervous systems and eventually death. The latest WHO evaluation concludes that, exposure to arsenic via drinking water is causally related to cancer in the lungs, kidneys, urinary bladder and skin [19].

Fish are considered as an excellent source of polyunsaturated fatty acids (predominantly omega-3 fatty acids), protein, Zn, iron and calcium [20]. Fish is a valuable and cheap food item, and also major part of the human diet. The accumulation of several chemicals such as pesticides runoff from nearby farms, detergent as a result of washing in the reservoir and dump materials in the sites. This increases high concentrations of heavy metals in the water body, which cause the disruption of the ecological balance of river water. Fish in such areas can be contaminated with HMs, consumption of this fishes by humans can cause accumulation of these toxic metals in the food chain which could cause an adverse health effect from consuming fishes in the river. Hence, the study aim to determine the effect of Some Toxic Elements (As, Cd, Cr, Hg, and Pb) in *Clarias gariepinus* and *Oreochromis niloticus* from Tagwai Reservoir Minna, Niger State Nigeria and the health risk associated with their consumption.

MATERIALS AND METHODS

African Tilapia *(Oreochromis niloticus)*, and African Catfish (*Clarias gariepinus)*, were selected for the study because they were the two major consumed fish. The fishes used for the study were harvested fresh from Tagwai dam reservoir, Minna, Niger State Nigeria.

Study Areas

The study was carried out at Tagwai reservoir. The reservoir has a total surface area of 44 hectares and storage capacity of 28.3 million m3 of water. The reservoir have a depth of 25 m and length of 18 km. Tagwai reservoir was constructed in 1980 on longitude 60º39’ to 60º44’ East, and latitude 34º to 90º39’ North to South-West of Minna. Tagwai village have a moderate climate with a very high temperature during the dry season and average rainfall during the rainy season. The reservoir is also a source of water to Niger state water board authority for water treatment.

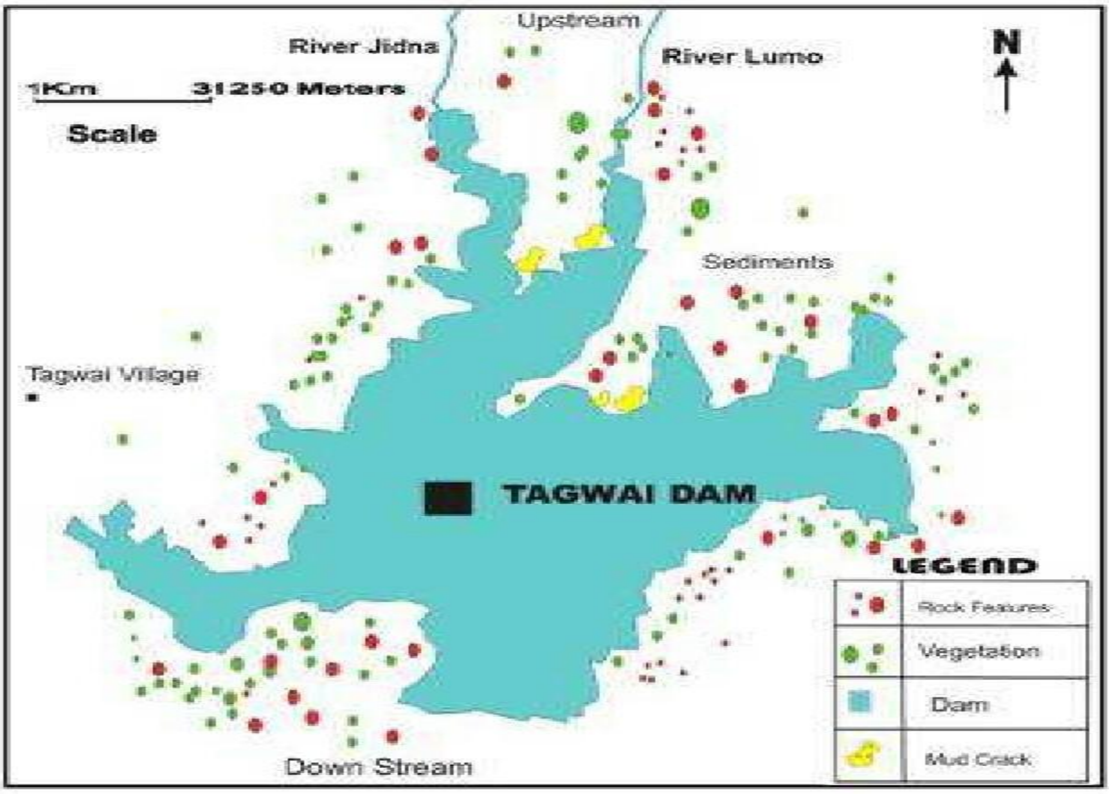

Fig-1: Map Showing Tagwai Dam

Study Design

The study design was carried out under a Completely Randomized Design (CRD) with two samples and three replicate groups for each. The concentrations of the HMs both in water and fish samples, were done in two groups, from group 1 to 2, which are fish samples from Tagwai reservoir using two species of fish. Both water and fish sample were randomly collected and analyzed for water physicochemical properties pH, dissolved oxygen, electrical conductivity and temperature and HMs As, Cd, Cr, Hg and Pb.

Sample Collection

Sampling of Adult *O. niloticus* and *C. gariepinus* was carried out in the month of December 2019 during dry seasons. 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 two days from morning until afternoon. The net was set up along the river that covers the most reservoir pools. The total of 18 fish of similar weights was used from the study area (9 samples for each fish species). The average length and weight of the samples of fishes used were 38 cm and 1kg respectively from the reservoir. Water samples were also collected from the study area in a plastic containers, sealed and transferred to the laboratory in iced packs. Approximately 1 ml of concentration HNO_3 is added to the water samples to prevent the microbial utilization of HMs. The fish samples were frozen in the laboratory in a clean ice Box before HMs analysis.

Fish Tissue Preparation

Fish samples were rinsed with distilled water to get rid of any remnants of trace metals on the outer surface of the fish, and the scales were removed for *O. niloticus*. 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 for 3 hours at 110^{o}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.

Water Physico-chemical Properties pH

Fishes suffers at very low pH as well as very high pH value. 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. Digital pH meters is the common instrument used in measurement, the instrument being a potentiometer, the pH scale is calibrated before use with buffer solutions of known pH values. Water sample 75 ml is taken in a 100 ml beaker and 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 mean value was calculated.

Temperature

Test for water temperature was determined using a mercury-in-glass thermometer.

Dissolved Oxygen

Dissolved oxygen (DO) was determined`w6ty by Wrinkler method [21]. Manganous sulfate solution (2 ml) and 2 ml of alkaline potassium iodide was added to the water. The solutions were mixed thoroughly and exactly 2 ml of concentrated 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 22. 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 analysed by a modified procedure from the Association of Official Analytical Chemists [23]. Nitric acid (10 ml) was added to 50ml of each water sample and heated at 150ºC for 30 mins. Exactly 5ml of nitric acid was then added to each tube and heated for 30 minutes at 200^{o}C, to the mixture was added 2ml of hydrogen peroxide before further heating at 200^{o}C for 30minutes. 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, Hg and Pb using Atomic Absorption Spectroscopy.

Digestion of Fish Samples

Exactly 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, Hg and Pb using Atomic Absorption Spectroscopy. The above procedures in this section followed the guidelines from the Analytical Methods for Atomic Absorption Spectroscopy.

Bioaccumulation 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 BAF was calculated by dividing the concentration of toxic metals in fish by the total toxic metals concentration in the water using:

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

Where;

BAF represent the transfer factor of fish
C_{fish} = Toxic elements concentration in fish tissue, mg/kg fresh weight
C_{water} = Toxic elements concentration in water, mg/kg dry weight
BAF greater than one (1) indicates that the fish are en-riched with the toxic elements from the water (Bio-accumulation)
BAF less than one (1) indicates that the fish excluded the toxic elements from water (excluder)

Health Risk Assessment of HMs via the Consumption of Fishes

Risk assessment was evaluated by considering only the edible part (muscles tissues) of the fish and to determine daily intake of metal (DIM), health risk index (HRI) and hazard index (HI).

Daily Intake of Metals (DIM)

The 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]. The DIM was determined using:

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

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 concentration of HMs in the fish tissues (mg/kg)

BW = Represent the estimated average body weight of investigated in adult (55 kg for adults).

Health Risk Index (HRI)

The health risk index (HRI) for the populations through the consumption of contaminated fish was assessed based on the DIM relative to reference oral dose (RfD) for each metal. This is an index justifying individual's risk of HMs. The HRI value of less than one implies safe tread and is considered acceptable; otherwise, the fish may pose heavy metals risk. The HRI of the fish was calculated using a formula describe by [27].

$$HRI = ADDM/\ RfDM$$

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 values are lower than one (1), 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 using a formula describe by [28]. The hazard index (HI) is the summation of the HRI 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.

$$HI = \Sigma HQAs + HQCd + HQCr + HQHg + HQPb$$

STATISTICAL ANALYSIS

The data obtained were analysed using IBM Statistical Product and Service Solution (SPSS) version 25 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 Tagwai dam reservoir

Some of the physico-chemical properties (dissolved oxygen, pH, Temperature, and electrical conductivity) of water was studied shown in Table-1. The values of physicochemical properties of Tagwai water were dissolve oxygen (5.03 mg/l), pH (5.75), Temperature (32.45 ºC), and electrical conductivity (691.52 mg/l) which are significantly higher than the WHO recommended values.

Table-1: Physicochemical Properties of Tagwai dam reservoir

Physicochemical Properties	Tagwai Reservoir Water Sample	WHO, (29)**, (30)* Permissible Limit
Dissolve Oxygen (mg/l)	5.03 ± 0.12	6 -8 mg/l*
pH	5.75 ± 0.17	6.5 – 8.5*
Temperature (°C)	32.45 ± 0.03	20 – 30 °C*
Electrical Conductivity (mg/l)	691.52 ± 4.76	500 mg/l**

Results Expressed as Mean ± SD.

Concentration of Heavy Metals in Tagwai Dam reservoir

The mean concentration of HMs (As, Cd, Cr, Hg and Pb) in Tagwai water samples were 2.34, 3.75, 1.93, 3.13, 2.29 mg/kg respectively. The result shows that water samples from Tagwai reservoir were more contaminated with HMs. The concentration of As, Cd, Cr, Hg and Pb were above the [31] permissible limits of HMs in water 0.01, 0.003, 0.05, 0.001, and 0.01 mg/kg respectively. The study also indicates Cd to be higher among other metals while Cr had the lowest value shown in Table-2.

Table-2: Concentration of Heavy Metals in Tagwai Dam Reservoir

Heavy Metals (mg/kg)	Tagwai Reservoir	PL(mg/kg) by FAO/ WHO, (31)
As	2.34 ± 0.15	0.01
Cd	3.75 ± 0.08	0.003
Cr	1.93 ± 0.03	0.05
Hg	3.13 ± 0.13	0.001
Pb	2.29 ± 0.17	0.01

Results Expressed as Mean ± SD. PL=Permissible limit, n=3

Concentration of Heavy Metals in Fishes from Tagwai Reservoir

The HMs mean concentrations of As, Cd, Cr, Hg and Pb analysed in *Oreochromis niloticus*, and *Clarias gariepinus* from Tagwai reservoir are shown in Table-3. The concentration of HMs (As, Cd, Cr, Hg, and Pb) in *O. niloticus* and *C. gariepinus* from Tagwai reservoir were 2.48, 3.91, 1.92, 3.28, 2.33 and 2.97, 4.01, 2.05, 3.69, 2.94 mg/kg respectively. The mean concentration of HMs in the fishes indicate bioaccumulation from the reservoir. The result shows that fishes from Tagwai reservoir were more contaminated with HMs. The concentration of HMs on fish from Tagwai reservoir were all greater than the maximum permissible limit As (0.01), Cd (0.05), Cr (1.5), Hg (0.01), and Pb (0.3 mg/kg) of HMs in fish as recommended by FAO/WHO [31]; FAO [32] and Saha *et al*., [33] shown in Table-3.

Table-3: Concentration of Heavy Metals in Fish Samples

Heavy Metals	Fish samples		PL(mg/kg) by FAO/WHO
(mg/kg)	*O. niloticus*	*C. gariepinus*	(31)*, Saha et al., (33)**
As	2.48 ± 0.23^{b}	2.97 ± 0.09^{a}	0.01*
Cd	3.91 ± 0.09^{b}	4.01 ± 0.13^{a}	0.05*
Cr	1.92 ± 0.07^{b}	2.05 ± 0.07^{a}	1.5**
Hg	3.28 ± 0.10^{b}	3.69 ± 0.12^{a}	0.01*
Pb	2.33 ± 0.10^{b}	2.94 ± 0.09^{a}	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 n=3

Estimation of bioaccumulation factor (BAF) of Toxic Element in fishes

The bioaccumulation factor (BAF) gives the ratio of the concentration of HMs in fish to the total concentration in the water i.e the amount of toxic elements that is transferred from water to fish. The BAF of toxic metals As, Cd, Cr, Hg, and Pb obtained in fish (*O. niloticus*, and *C.gariepinus*) from Tagwai reservoir were 1.05, 1.04, 0.99, 1.04, 1.01 and 1.26, 1.06, 1.06, 1.17, 1.28 respectively. The values for BAF were greater than one (>1) indicates that the fishes are enriched with the elements from the water (Bioaccumulators). In this study the BAF shows that Cat fish *C.gariepinus* bio accumulate more HMs compared to Tilapia fish *O. niloticus* which shows that different species of fish have different rate of accumulation (Fig-2).

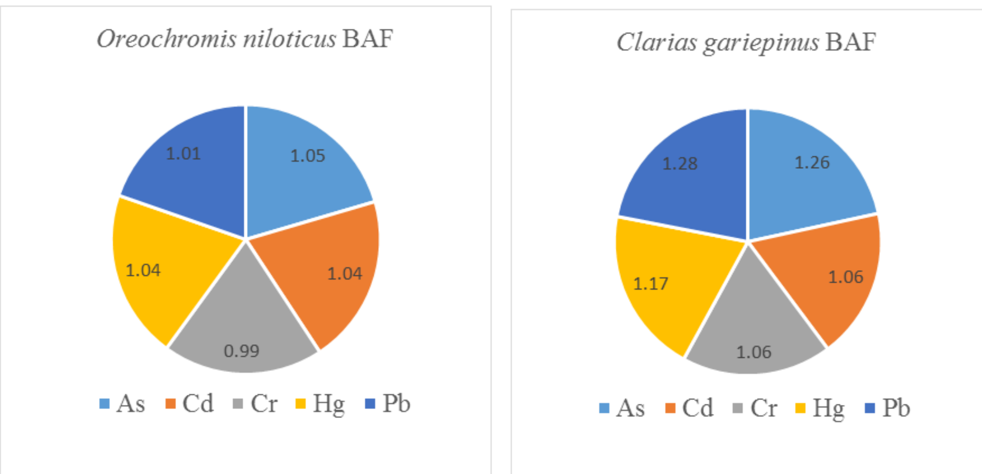

Fig-2: Estimation of Bioaccumulation Factor (BAF) of Toxic Element in fishes

Estimation of average daily dose of metal (ADDM)

The average daily dose of metals for adult (via the consumption of fish from Tagwai reservoir) was estimated according to the average fish consume through the food chain. The ADDM values for HMs As(0.010, 0.012), Cd(0.016, 0.016), Cr(0.007, 0.008), Hg(0.013, 0.015), and Pb(0.009, 0.012) in *O. niloticus* and *C.gariepinus* respectively for HMs. The result shows that fishes in Tagwai reservoir have less ADDM but continuous consumption may cause health risk (Fig-3).

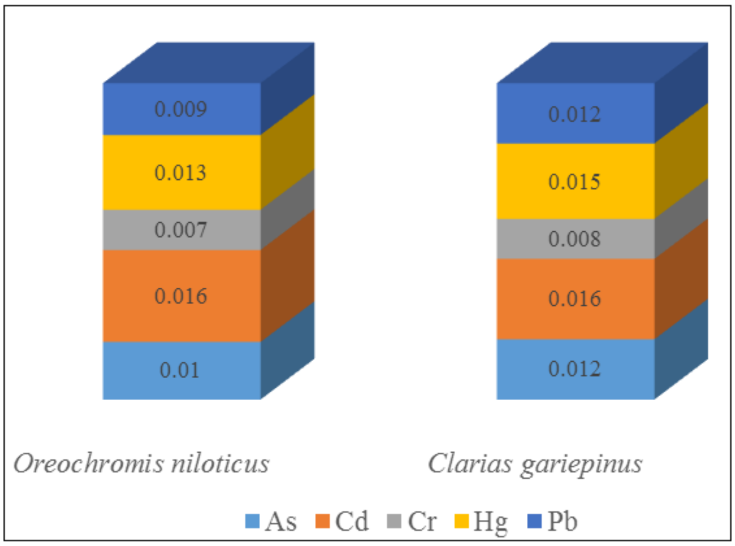

Fig-3: Estimation of average daily dose of metal (ADDM)

Estimation of Health Risk Index HRI

The HRI of HMs As, Cd, Cr, Cu, Hg, and Pb in *O. niloticus*, and *C.gariepinus* were 1.00, 0.32, 0.00, 1.30, 0.03 and 1.20, 0.32, 0.01, 1.50, 0.04 respectively. The HRI for fishes for As and Hg were greater than one for both fish species which indicate toxicity of metals (Fig-4).

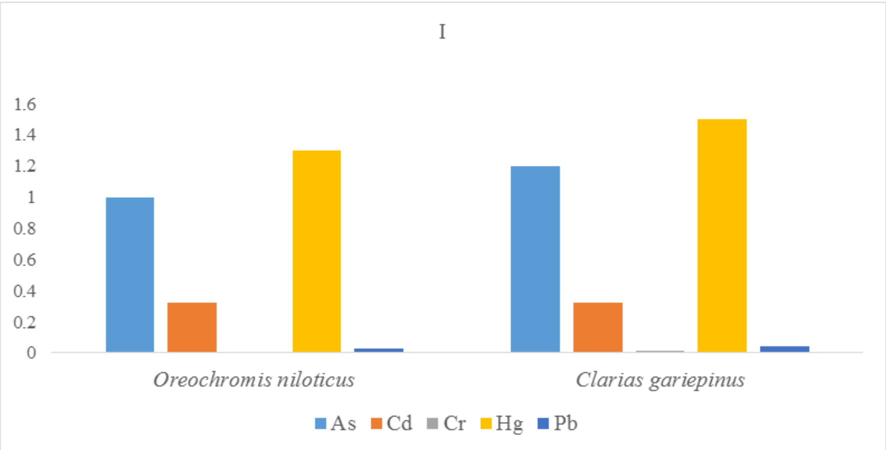

Fig-4: Estimation of Health Risk Index HR

Estimation of Hazard index (HI)

The HI of the overall health risk exposure of all analysed heavy metals via the ingestion of a contaminated fish is shown in Fig-5. Total Index of all metals in *O. niloticus*, and *C.gariepinus* from Tagwai reservoir were 2.65 and 3.07 respectively. The result shows that Fishes were highly contaminated with heavy metals. HI > 1 indicates that the predicted exposure is likely to pose potential health risks.

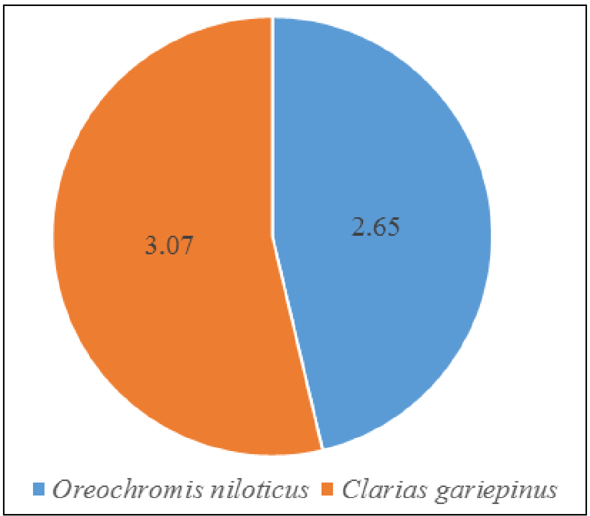

Fig-5: Hazard index of metals

DISCUSSION

The physicochemical properties of water analyze shows that the amount of dissolve oxygen in Tagwai dam reservoir water has a major impact on fish behavior and survival. Dissolved oxygen (DO) is the level of free, non-bonded oxygen present in water. Tagwai dam reservoir has a lower DO with 5.03 mg/l which indicate that the water can lead to hypoxia to fishes and other aquatic organism. The lower DO may be due to grasses on the water, waste discharge into the reservoir which covers the surface of the river for oxygen penetration. The recommended minimum dissolved oxygen require in fresh water is within 6-8 mg/l [4]. Dissolve oxygen level can be reduced depending on pollutants present, dissolved minerals such as salt and temperature. The oxygen dissolves by diffusion from the surrounding air to the water. Most fish species tolerate a lower DO below the minimum values for a short period of time and when the values drops below required limit for a long period of time, it causes fish to become stressed and eventually start dying. The lower the value of DO concentration, the greater the stress, which can cause fish death. The site area recorded a low pH (5.75) value. Low pH level reduces the active nature of fish and also accelerate the release of HMs which is due to runoff from polluted environment. Toxic metals are more mobile when pH values are reduce or lower than 7 which runs towards acidity. The World Health Organization [30] recommends a pH value of 6.5-8.5 for drinking water to prevent corrosion. Fish are always influenced by the temperature around them because they always regulate their body temperature. Tagwai reservoir recorded high temperature and electrical conductivity (32.45 °C and 691.52 mg/l). The average limit of temperature in fish water is 20-30 °C and the permissible limit of EC is 500 mg/l. High temperature in water 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 [7]. Water temperature according [34] affects the EC so that its value increases from 2 upto 3% per 1°C. The increase in EC may be due to runoff, washing close to the reservoir, and waste from surroundings, which also increases chloride, phosphate, and nitrate ions. Electrical conductivity is increase when pH is low.

The result shows that water samples from Tagwai dam were contaminated with HMs. This is probabaly as a result of anthropogenic activities around the area such as washing of clothes, nitrate from soap are discharge in the water and combustion. The HMs concentrations recorded in water were higher than standard limits for portable water and aquaculture FAO/WHO [31]. Aquatic life abound in the waters can bioaccumulate these toxic metals and subsequently transfer it to consumers via food chain. Fish accumulate large quantities of toxic metals and the accumulation depends upon the intake and elimination from the body. There was significant difference in the concentrations of HMs in fish's species (*O.niloticus and C.gariepinus*) from Tagwai reservoir. There was a significant increase of metal in *C.gariepinus* than in O. niloticus from the reservoir. The variation in the level of HMs accumulation in different fish species may support the view that there is a variation in ability of fish species to accumulate HMs. The present of scales in Tilapia fish (*O. niloticus*) also reduces the transfer of metals to the tissue. The HMs (As, Cd, Cr, Hg, and Pb) dictated in fishes from Tagwai dam reservoir were all above the FAO/WHO [31] permissible limit of 0.01, 0.05, 1.5, 0.01, and 0.3 mg/kg respectively (Table-3). The mean concentration of HMs in *O.niloticus* and *C.gariepinus* decrease in the following order Cd>Hg>As>Pb>Cr. The levels of Cr were comparatively lower in the fish samples which is in accordance with the findings of Oguh *et al.*, [4] who also recorded low Cr in fish sample from contaminated water. Heavy metals and nutrients absorbed by fish are usually translocated to different parts of the fish which could reduce the concentrations in the water. However, availability of HMs in the water and continuous stay in the polluted water could lead to higher concentration in the fish.

Arsenic affects almost all organs during its acute or chronic exposure. 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 [35]. Cadmium is a dangerous element because it can be absorbed via the alimentary track; penetrate through placenta during pregnancy and damage membrane and DNA. 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. Mercury poisoning symptoms include blindness, deafness, brain damage, digestive problems, kidney damage, lack of coordination and mental retardation. 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 and disrupting critical biological processes which results to toxicity [36, 7].

The BAF of *O.niloticus* and *C.gariepinus* from Tagwai reservoir were above one which indicates that the fish are en-riched (Bio-accumulation) in elements from the water. The BAF of HMs from water to fish is the key component of human exposure to HMs through the food chain. The Daily intake indicate the amount of HMs that will be taken in the body when such fish is consume. The study shows a significant amount of HMs from the consumption of fish in a day. The HRI values for As and Hg were greater than one indicating that consumers of fishes from Tagwai dam are exposed health risk. Hazard index (HI) which shows the overall risk of exposure to all analyzed metal indicate that the consumption of fish can pose health risk to consumer through the intake of metal since the values of the HI obtain were all greater than 1.

CONCLUSION

The study concludes that HMs concentrations exceed the permissible recommended value, which suggest that fish from Tagwai reservoir are not fully safe for human health. The result also shows that *Clarias gariepinus* cat fish accumulate more heavy metals than *Oreochromis niloticus*.

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