Evaluation of Some Trace Metal Levels in the Water, Fish and Aquatic Plant in River Sokoto, North-western Nigeria

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ABSTRACT—*The distribution of trace metals (Fe, Cu, Zn, Pb, Cr and Cd) levels in water, fish (Clarias batrachus) and aquatic plant (Heteranthera callifolia) in River Sokoto was studied to ascertain the extent of pollution of the water body. The analyses of the trace metals in the samples was carried out using the atomic absorption spectroscopy (AAS) and the results revealed that the levels of Fe, Zn, and Cu in the water, Clarias batrachus and Heteranthera callifolia were within the UNESCO/WHO permissible limits, while the levels of Pb, Cd and Cr were higher or above UNESCO/WHO recommended standards for drinking water.. This may be as a result of runoff from neighbouring farms.*

Keywords— Trace metals, environmental pollution, aquatic plant and bioaccumulation

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1. INTRODUCTION

Trace elements refers to those elements that occur at very low levels of few parts per million in a given system. They are among the most harmful of the elemental pollutants.[1]. Trace elements such as copper, iron, chromium and nickel are essential metals since they play important roles in biological systems, whereas cadmium and lead are non-essential metals, since they are toxic, even in trace amounts [2].

Trace metals are those having density greater than $5gcm^{-3}$. Most often this term denotes metals that are toxic, which include Al, As, Cd, Cr, Co, Pb, Hg, Ni, Se, and Zn [3]. These metals or their compounds when discharged from industries, farmlands, municipal urban water runoffs, and agricultural activities into surface water can cause pollution. Many of these wastes are toxic and they find their ways into land water/sediments and air [4]. Trace metals have the tendency to accumulate in various organs of the aquatic organisms, especially fish, which in turn may enter into the human metabolism through consumption causing serious health hazards [5]. Bioaccumulation of these metals can only take place if the rate of uptake by the organism exceeds the rate of elimination [6], which may cause cytotoxic, mutagenic and carcinogenic effects in these organisms [7].

The measurement of trace metal concentrations in water provides the advantage of evaluating the quality and state of the water distribution. The concentration of pollutants in an aquatic environment relies primarily upon both the chemical composition of sediment and upon kind and amount of absorbed pollutants [8].

River water supports many life forms, provides recreation and fishing to the communities, and may also be used for drinking purposes and irrigation. However, contamination of river water systems by trace metal is of major concern and their determination has received great attention for monitoring environmental pollution since the events of Hg and Cd poisoning in Minamata, Japan [9]

Fish provides nutritional benefits to humans, by being a source of protein, omega 3-fatty acids that helps reduce the risk of certain types of cancer [10].) and cardiovascular disease [11]. In Nigeria, fish is one of the main sources of protein, therefore, contamination of water bodies and consequently fishes, deserve a greater attention [12].

Trace metals analysis, therefore, is an important part of environmental pollution studies. When the trace metals are taken above the tolerance limit, they produce unhealthy and intoxicating effects to various terrestrial and aquatic life of which aquatic fauna (e. g. fish), is the most susceptible [13].

2. AIM OF THE STUDY

The assessment of heavy metal levels of surface water, fish (*Clarias batrachus)* and aquatic plant (*Heteranthera callifolia*) in River Sokoto was is the focus of this research and is aimed at assessing and evaluating the water quality of the river.

3. MATERIAL AND METHODS

3.1 Sample Collection and Treatment

The sample containers (2L plastic container with double cap device) were washed properly with detergent, rewashed with (1:4) HNO_3 and rinsed with distilled water until acid free. Water samples were collected from River Sokoto at different (at approximately 100m away from each other) locations by lowering pre-cleaned plastic containers into the water body (20-30cm below the surface) at the river bank and subsequently treated by the addition of 1 cm^3 of concentrated HNO_3 to $100cm^3$ of the water sample [14].

Four samples of *Clarias batrachus* (the most common type of fish in the River) were caught using the local trapping method. Each fish was dried in an electric oven at 110°C for 3 hours and allowed to cool to room temperature. These were individually pulverized in a clean mortar with pestle, dried again and stored a polythene bag. The method of Capon as reported by Oze *et al* was adopted for digestion of the fish: 1.0g of pulverized fish was weighed into a 200 cm^3 Kjedahl's flask and then $10cm^3$ of $HClO_4$ and $100cm^3$ of HNO_3 were added. The mixture was gently swirled and digested in a fume cupboard until the brown fumes of NO_2 escaped. The resulting golden yellow solution obtained after 3 hours of digestion was cooled to room temperature and filtered into 50 cm^3 volumetric flask and made up to the mark with 0.7% HNO_3 solution.[15].

Aquatic plant sample ((*Heteranthera callifolia)* was collected from River Sokoto washed thoroughly and rinsed with distilled water. This was dried and ashed at 450°C followed by treatment with HCl [16].

3.2 Sample Analysis

The metal concentrations were determined using Atomic Absorption Spectroscopy (Shimadzu AA – 6300 Model) by using specific cathodes for specific metals [17].

All assays were carried out in triplicates and the mean and standard deviation of all the values were determined.

4. RESULTS AND DISCUSSION

4.1 Results

The results of the concentrations of trace metals were summarised in Table1

Table 1.: Trace Metal concentration of water, *Clarias batrachus)* and *Heteranthera callifolia*) samples

Sample	**Trace Metal Concentration**				
	Zn	**Cu**	**Pb**	**Cr**	**Cd**
Water (mg/L)	2.05±0.32	2.85±0.53	0.38±0.02	0.66±0.46	0.04±0.00
C. batrachus(mg/kg)	3.48±1.03	0.32±00.10	0.52±0.04	0.68±0.50	0.18±0.00
H. callifolia (mg/kg)	1.06±0.38	0.48±0.22	0.25±0.02	0.56±0.42	0.27±0.00

Data are mean ± The Standard Deviation of three replicate results

4.2 Discussion

The summary of the results of the trace metal concentrations in water, fish (*Clarias batrachus*) and aquatic plant (*Heteranthera callifolia*) samples of river Sokoto were reported in Table 1 above

4.2.1 Zinc

Zinc is an essential nutrient for humans and animals that is necessary for the function of a large number of metallo-enzymes, including alcohol dehydrogenase, alkaline phosphatase, carbonic anhydrase, leucine aminopeptidase, and superoxide dismutase. Zinc deficiency has been associated with dermatitis, anorexia, growth retardation; poor wound healing, hypogonadism with impaired reproductive capacity. However, zinc as a neurotoxin is able to chelate and deplete the neuronal concentration of the glutathione (GSH), causing neuronal cell death in a dose dependant manner [18].

The concentration of zinc was found to be 2.05±0.32mg/L in the water sample, 3.48±1.03 mg/Kg in the *Clarias batrachus*, and 1.06±0.38mg/Kg in the *Heteranthera callifolia*. High concentration of Zn in the fish than in water or plant could be due to the fact that fishes are notorious for their ability to concentrate heavy metals in their muscles. However, these results were found to be lower than the 3.0 mg/L UNESCO/WHO standard for drinking water, and less than 150 mg/kg UNESCO/WHO standard for fish [19]. Similarly the result was found to be lower than the 6.65mg/L Zn in the fish of the Qua-Iboe river estuary [15]. Despite the widespread use of zinc for domestic purposes such as electroplating, dyeing, etc the values were still within the accepted range. It could be deduced, therefore that the values obtained in this work were not harmful, but further work needs to be carried out before making any conclusive statement.

4.2.2 Copper

The mean concentrations of cupper in the three samples were 2.85±0.53mg/L, 0.32±0.10mg/kg and 0.48±0.02mg/kg for water, fish and plant respectively. The 0.32±00.10mg/kg Cu for fish reported in this work was found to be lower than the 10mg/kg UNESCO/WHO standard [19], and also lower than the results reported for the fish samples of Lake Kainji [20]. Copper deficiency, even though rare, is associated with hyperchronic, mycrocytic anaemia resulting from defective haemoglobin synthesis [21]

4.2.3 Lead,

Lead, on the other hand, is known to exert its most significant effect on the nervous system, including motor disturbances, sensory disturbances, the haematotiopic system and the kidney and ultimately, can cause major brain damage [22]. Lead ingestion has been associated with deleterious health effect, including disorder of the central nervous system [23]. The levels of lead in this work were found to be higher than the 0.01mg/L for drinking water but lower than the 1.5mg/kg recommended threshold limit for fish by the UNESCO/WHO standard [19], and also higher than the 17.85mg/L Pb for surface waters from the Niger-Delta [24]. High concentration of lead in a given sample can be from automotive exhaust [25, 26], soldering metals and paints [27], but further work needs to be carried out in order to make a conclusive statement.

4.2.4 Chromium

The acute toxicity of chromium (VI) is due to its strong oxidation properties. After it reaches the blood stream, it damages the kidneys, the liver and blood cells through oxidation reactions, resulting into haemolysis, renal and liver failure. Aggressive dialysis can improve the situation [22]. The mean chromium concentrations in the three samples concentrations were found to be 0.66±0.46mg/L for water, 0.68±0.50mg/L for fish and 0.56±0.42mg/L for the aquatic plant. These concentrations were higher than the UNESCO/WHO threshold limit for chromium in water and fish respectively [19].

4.2.5 Cadmium

Cadmium is a cumulative toxin. Its levels in the body increase over time because of its slow elimination. It accumulates chiefly in the liver and kidneys, causing causes mutations, DNA strand breaks, chromosomal damage, cell transformation and impaired DNA repair in cultured mammalian cells [28]. Cadmium is known to modulate gene expression and signal transduction [29] and is also a known testicular and prostate carcinogen [30]. The levels of cadmium in the samples analyzed were found to be higher than the 0.005mg/L UNESCO/WHO standard [19] for drinking water and lower than the 0.2mg/kg standard for fish. The result reported for fish in this work is higher than those obtained in the fishes of River Rima [12].

At the moment, there is no known direct reported case of metal poisoning arising from consumption of fish from this river but, the increase in the levels of these toxicants could pose potential health hazard for the inhabitants and the environs considering the fact that fish is the cheapest available source of protein.

Sokoto, on the other hand, is not known for many industries that release effluents into its rivers except for the Cement Company of Nigeria(CCNN) Plc which is about 2-3 kilometres from the river. Cement production emits the greatest percentage of particulates, thus, this cement company could also be the source of heavy metals in River Sokoto [20]. Similarly, metals as well as organic contamination could have been associated with runoffs from the cement industry [4]. The accumulation of heavy metals in the tissues of fishes may cause various physiological defects and mortality [31. Bioaccumulation and magnification is capable of leading to toxic level of these metals in fish, even when the exposure is low. The presence of metal pollutant in fresh water is known to disturb the delicate balance of the aquatic ecosystem. Fishes are notorious for their ability to concentrate heavy metals in their muscles and since they play important role in human nutrition, they need to be carefully screened to ensure that unnecessary high level of some toxic trace metals are not being transferred to man through fish consumption [32].

The uptake of metal in fishes is influenced by the fish species and various environmental factors such as pH and temperature, while elimination of metal in fish is an active biochemical and physiological process dependent on growth, salinity, age, sex, position relative to shoreline, water depth and pollutant interaction [33].

The characteristic levels of heavy metals in plants vary significantly with plant species and individual metal, hence, the uptake of the metal is dependent on pH, individual metal characteristics and the plant species [33]. Aquatic macrophytes may accumulate great amounts of chemicals, contributing to a nutrient cycling, water quality control, and sediment stability [34]. The levels of trace metals in *Heteranthera callifolia*, shows that there is bioaccumulation of the said metals by the plant from the river. It was also found that, the concentrations of trace metals in *Heteranthera callifolia* were lower than the 100mg/L (Zn) , 10mg/L (Cu) and 0.3mg/L (Pb) reported for aquatic plants by the FAO/WHO (1992) and also lower than the values obtained for *Dryosteris filix max* and *Pennisteum purpureum* of river Ekwulu [33]

5. CONCLUSION

Generally, the trace metal concentrations were high in the fish sample than in water and plant samples for Zn, Pb, and Cr while Zn and Cu were higher in fish than in water sample. The levels of Zn and Cu are within the permissible limits while Pb, Cd and Cr were above the WHO recommended standards for drinking water. Similarly Zn and Cu were lower than the WHO permissible limits for fish, while all the trace metals determined in the aquatic plant were within the permissible limits set by the WHO. The results of the study, therefore, supply valuable information on the metal content in the water, fish and aquatic plant from river Sokoto.

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