Full Length Research Paper

Elemental Analysis of Flesh, Bones and Gills of *Oreochromis niloticus* Consumed in Nigeria for Improvement of Nutrition and Health

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Received 30 March 2013; Accepted 24 April 2013

Abstract. Instrumental Neutron Activation Analysis (INAA) was used to determine elemental concentrations in flesh, bones and gills of *Oreochromis niloticus* fish, an abundant and popularly consumed fish in Nigeria as a step to improvement of nutrition and health in the country. One hundred and twenty samples were collected from the research sites of the Ahmadu Bello University Reservoir. The samples were irradiated using a neutron flux of 5 x 10¹¹ n cm⁻² s⁻¹ in inner site of the Nigeria Research Reactor-1 (NIRR-1). Results obtained indicate that calcium (5,000-186,600mg/kg) dominated in the organs, followed by potassium (3,400-12,300mg/kg) and the least was samarium (0.13-0.36mg/kg). Our result also shows that sample location had no significant (p≤0.05) effect on concentration of the elements in the organs. The data obtained illustrated that Calcium, Magnesium and Manganese are predominant in bones and gills. Chlorine, Potassium and Sodium were found to be highly concentrated in the flesh and bones. While Vanadium, Lanthanum, Samarium and Uranium are more prominent in gills, Bromine is more visible in flesh and gills. In general, bones and gills were found to have the highest distribution of major elements. Manganese concentrations obtained in these organs are above the WHO reference values and apart from Manganese, the concentrations of Calcium, Magnesium, Potassium, Sodium, and Chlorine obtained in these organs are above the International Union of Pure and Applied Chemistry recommendation. The study reveals that *Oreochromis niloticus* fish is a good bio-indicator of an aquatic environment pollution and fresh water contamination.

Key words: *Oreochromis niloticus*, nutrition, trace elements, bio-indicator, INAA

1. INTRODUCTION

Nigeria is a water-rich country blessed with many rivers and distributaries that empty into the Atlantic Ocean. Fishing has therefore become a way of life to many Nigerians. *Oreochromis niloticus* fish is the most predominant fish species in most of the country’s rivers and distributaries and hence became a vital source of nutrition as well as health risk. Over the years, governments at various levels in the country made concerted efforts to provide all year round gainful employment to farmers and the fishermen who depend on these rivers, lakes and streams. Dams and reservoirs were also constructed in strategic locations for use during dry season and to meet up the agricultural and domestic water needs of some communities. However, wide spread contamination caused by industrialization and rapid population growth makes it desirable to have data on the state of the environment and the quality of food we eat (Kapsimalis et al., 2009; Ahmed et al., 2010), especially impact of pollutants such as heavy metals on local diet (Park et al., 1989). The influx of urban wastes and industrial pollution into dams and reservoirs post serious threat to the safety of their resident fish and other marine animals used as meat by the populace. Similarly, fertilizer wastes from farms around dams and flood runoffs into reservoirs have of recent generated a lot of pollution problems (Tukura et al., 2005). One of such affected reservoir is the Ahmadu Bello University water works dam.

Dietary minerals are mineral nutrients. These mineral elements (metals) are of great importance in the physiological processes of living organisms. These minerals in order of abundance in the human body include the seven major minerals calcium, phosphorus, potassium, sulfur, sodium, chlorine, and magnesium. Important “trace” or minor minerals, necessary for mammalian life, include iron, cobalt, copper, zinc, molybdenum, iodine, and selenium (http://en.wikipedia.org/wiki/nutrients). In fish, minerals (metals) play a very important role (Laure and McDonald, 1985). It has been established that fish take in inorganic elements (metals) from the surrounding water and sediment and as well as from diets (Abolude, 2007). The minerals found distributed throughout the animal body are therefore dependent on the need for them by the metabolizing cell (Lauren...
Calcium is essential for living organisms, in particular in cell physiology, where movement of the calcium ion $\text{Ca}^{2+}$ into and out of the cytoplasm functions as a signal for many cellular processes. As a major material used in mineralization of bone, teeth and shells, calcium is the most abundant metal by mass in many animals. Calcium is an important component of a healthy diet and a mineral necessary for life. The National Osteoporosis Foundation says, "Calcium plays an important role in building stronger, denser bones early in life and keeping bones strong and healthy later in life." Calcium is required for vascular contraction and vasodilatation, muscle function, nerve transmission, intracellular signaling and hormonal secretion, though less than 1% of total body calcium is needed to support these critical metabolic functions (http://ods.od.nih.gov/factsheet/Calcium - Health Professional/#en1). Approximately 99 percent of the body's calcium is stored in the bones and teeth http://en.wikipedia.org/wiki/Calcium#cite_note24.

Calcium is required for vascular contraction and vasodilatation, muscle function, nerve transmission, intracellular signaling and hormonal secretion, though less than 1% of total body calcium is needed to support these critical metabolic functions (CRDFI, 2010). Calcium is needed for muscle, heart and digestive system health, builds bone and supports synthesis and function of blood cells. Serum calcium is very tightly regulated and does not fluctuate with changes in dietary intakes; the body uses bone tissue as a reservoir for, and source of calcium, to maintain constant concentrations of calcium in blood, muscle, and intercellular fluids (CRDFI, 2010). The Dietary Reference Allowance (RDA/ AI in mg) is 1300mg. Its insufficiency results in hypocalcaemia while its excess of it results in hypercalcemia (IUPAC, 2005). Calcium Dietary Reference Intake (RDA/ AI in mg) is 1500mg (IUPAC, 2005). Sodium is a systemic electrolyte and is essential in co regulating ATP with sodium. Insufficiency of Potassium causes hypokalemia while excess causes hyperkalemia. (http://en.wikipedia.org/wiki/Potassium). Sodium is a systemic electrolyte and is essential in co regulating ATP with Potassium. Its deficiency causes hyponatremia and excess of it results in hyponatremia. A low sodium diet is beneficial for people with high blood pressure. A Cochrane review published in 2008 concluded that a long term (more than 4 weeks) low sodium diet in Caucasians has a useful effect to reduce blood pressure, both in people with hypertension and in people with normal blood pressure (He and MacGregor, 2004). The DASH diet (Dietary Approaches to Stop Hypertension) is a diet promoted by the National Heart, Lung, and Blood Institute (part of the NIH, a United States government organization) to control hypertension. A major feature of the plan is limiting intake of sodium, and it also generally encourages the consumption of nuts, whole grains, fish, poultry, fruits and vegetables while lowering the consumption of red meats, sweets, and sugar which is also "rich in potassium, magnesium, and calcium, as well as protein (DASH, 2009)".

Vanadium compounds are considered toxic. Tetravalent VOSO$_4$ has been reported to be over 5 times more toxic than trivalent VO$_2$ (Roschin, 1967). The Occupational Safety and Health Administration (OSHA) has set an exposure limit of 0.05 mg/m$^3$ for vanadium pentoxide dust and 0.1 mg/m$^3$ for vanadium pentoxide fumes in workplace air for an 8-hour workday, 40-hour work week (http://en.wikipedia.org/wiki/Vanadium#cite_note-OSHA-65). The National Institute for Occupational Safety and Health (NIOSH) has recommended that 35 mg/m$^3$ of vanadium be considered immediately dangerous to life and health. This is the exposure level of a chemical that is likely to cause permanent health problems or death (http://en.wikipedia.org/wiki/Vanadium#cite_note-OSHA-65). Manganese RDA is 2.3 is a cofactor in enzyme functions. It functions in the processing of oxygen in the body. Chlorine RDA is 2300. It is
The aim of this work was: to quantify the levels of nutrients and heavy metals in the body parts of the *Oreochromis niloticus* popularly consumed in Nigeria using instrumental neutron activation analysis (INAA) and compare the values with the World Health Organization (WHO) safe tolerance levels and to ascertain if *Oreochromis niloticus* fish is a good bio-indicator of an aquatic pollution and fresh water contamination.

2. MATERIALS AND METHODS

2.1. Study Area

Ahmadu Bello University (ABU) Reservoir is a typical small and shallow domestic water supply reservoir. It came into existence by the impoundment of the Kubanni River and Kudingi Stream. The Reservoir is located in the southern part of Ahmadu Bello University’s main Campus in Samaru, Zaria (11° 6’N 7°30’E) (Fig. 1). Sampling Station 1 is the sampling point close to the Institute for Development Research (Now being occupied by the Postgraduates School). The Station takes care of the agricultural, domestic and other wastes from the University Community. It is the point where Kubanni River enters the Reservoir. Sampling Station 2 is the Sampling point below where Kudingi Stream enters the Reservoir. This Station takes care of the wastes from adjacent farmland settlements.

2.2. Sample collection and preparation

The *Oreochromis niloticus* fish samples were collected from two stations (Stations 1 and 2) on the A.B.U. Reservoir, Zaria during the raining season (May-October 2005) using a 10-25cm stretched mesh surface gillnets for four days (at a time). The method adopted was as described by Powell and Powell (2001). On each day, nets were set at 1200h and fished at 1800h, 2400h and 0600h on the following day. Captured fish were placed in ice-box and transported to the laboratory immediately. The collected coded fish specimens were weighed to the nearest 0.01g using the electronic Mettler balance (Model P1200N). The total length and standard length were measured following the procedure suggested by Lagler (1962) and Olatunde (1980). In addition, body depth and body width were measured with a pair of Venire Calipers (Abolude, 1990). These samples were placed in the pre-treated oven (Gallenkamp Model Ov-420) set at 110°C for 3 days.

The dry fish were gutted, headed and scaled before the fins and bones were filleted out. After weighing and recording similar body components, the samples (flesh, bones and gills) were bagged in separated new plastic labeled bags and sealed with a unique identifying number. Each component was crushed with pre-treated mortar and pestle. Two well ground and homogenized sub samples with masses between 200-250mg were prepared from each set of sample and standard for short and long irradiations. Each of the sub samples/standards was wrapped in a...
polyethylene material, placed inside a small plastic polyethylene vial (manufactured by Emerald Plastics, Inc) of 1.3cm internal diameter and 2-3cm high and heat sealed.

2.3. Sample irradiation and analysis

For short and intermediate-lived nuclides, irradiation of samples/standards were carried out for 2-10m in the outer irradiation channel B4 with the reactor operating at half its rated power (15kW), and the neutron flux of $5\times10^{11}$ n cm$^{-2}$s$^{-1}$ in one of the irradiation channels. For long irradiation, the samples/standard was irradiated for 6h in the inner irradiation channel B2 with a neutron flux of $2\times10^{9}$ n cm$^{-2}$s$^{-1}$. Characteristics of the NIRR-1 irradiation channels were reported earlier by Jonah et al. (2005). After irradiation process the samples/standard were removed from rabbit container and counted from an appropriate geometry measured on a gamma spectroscopic system consisting of a P-type High Purity Germanium Detector (HPGe) coaxial, horizontal dip-stick detector having a resolution for the Co-60 of 1332 KeV line 2.0keV(FWHM) was used in this work. The signals from the samples which were detected by the detector were routed through the appropriate amplifiers and analog to digital converters to a computer based Maestro Multichannel Analyzer emulation software coupled to the detector as its gamma-ray acquisition facility. The Multi-purpose gamma-ray analysis software, WinSPAN-2004 was use for peak identification and evaluation (Liu, 2004). The detector operates on a bias voltage of 2200V (positive), the short-lived radionucleids in the samples and standard were identified after a 2m decay or a cooling period and 10m counting at a distance of 15cm from the detector to eliminate errors due to coincidence losses while the intermediate-lived radionucleids went for 2-3 hours decay, 40m counting and 15cm sample-detector distance and the long nuclides for 4-5days of decay and 60mins counting with 15cm sample-detector distance. Final concentrations of the element of interest are computed using software, which compares the corrected specific activities in both samples and standards (Oladipo et al., 2005). Nuclear data used for the analysis were taken from compilation by Decorte and Simonitis (2003).
3. RESULTS AND DISCUSSION

The irradiation and counting schemes employed in this work is presented in Table 1. The table shows that Cl, Na, Mg, K, Ca, V, Mn, Sm, and U were detected during short-lived irradiation of the samples. Na, La and Sm were obtained during the long-lived irradiation of the samples while Na, K and Mn were detected during the intermediate irradiation and counting schemes. The concentrations of the elements analyzed in *O. niloticus* are presented in Table 2. The ranges in the elemental concentrations of the body components in (mg/kg) are Calcium (5000-186600), Magnesium (0-3929), Potassium (5200-12300), Sodium (2321-6154), Vanadium (0-5.22), Manganese (0-74.26), Chlorine (1913-4422), Bromine (0-7.44), Lanthanum (0-1.2), Samarium (0-0.36) and Uranium (0-0.74). Table 2 also shows that of the total elements detected from the organs examined, the flesh stored 0.97% Ca, Bones 70% and the gills 28.62%. While

### Table 1: Irradiation and counting schemes used in this work

<table>
<thead>
<tr>
<th>Type of Irradiation</th>
<th>Irradiation time</th>
<th>Cooling Time</th>
<th>Counting Time</th>
<th>Nuclide Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-lived</td>
<td>2-5 minutes</td>
<td>10 minutes</td>
<td>10 minutes</td>
<td>$^{17}$Cl, $^{24}$Na, $^{42}$K, $^{54}$Ca, $^{52}$V</td>
</tr>
<tr>
<td>Intermediate</td>
<td>2-5 minutes</td>
<td>2-3 hours</td>
<td>30 minutes</td>
<td>$^{24}$Na, $^{42}$K, $^{56}$Mn, $^{82}$Br, $^{239}$U</td>
</tr>
<tr>
<td>Long-Lived</td>
<td>6 hours</td>
<td>7-14 days</td>
<td>1 hour</td>
<td>$^{146}$La, $^{152}$Sm</td>
</tr>
</tbody>
</table>

### Table 2: Bioaccumulation of some metals (ppm) in some Organs of *Oreochromis niloticus*

<table>
<thead>
<tr>
<th>Station</th>
<th>Body Component</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>Na</th>
<th>V</th>
<th>Mn</th>
<th>Cl</th>
<th>Br</th>
<th>La</th>
<th>Sm</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flesh</td>
<td>BDL$^b$</td>
<td>BDL$^a$</td>
<td>12200$^b$</td>
<td>2321$^b$</td>
<td>BDL$^a$</td>
<td>4422$^a$</td>
<td>7.44$^a$</td>
<td>BDL$^a$</td>
<td>BDL$^a$</td>
<td>BDL$^a$</td>
<td>BDL$^a$</td>
</tr>
<tr>
<td>2</td>
<td>Flesh</td>
<td>5000$^a$</td>
<td>BDL$^a$</td>
<td>12300$^b$</td>
<td>2323$^b$</td>
<td>BDL$^a$</td>
<td>3724$^b$</td>
<td>7.33$^a$</td>
<td>BDL$^a$</td>
<td>BDL$^a$</td>
<td>BDL$^a$</td>
<td>BDL$^a$</td>
</tr>
<tr>
<td>1</td>
<td>Bone</td>
<td>186600$^a$</td>
<td>3977$^a$</td>
<td>9200$^a$</td>
<td>6154$^a$</td>
<td>BDL$^a$</td>
<td>73.24$^a$</td>
<td>3024$^a$</td>
<td>4.10$^b$</td>
<td>BDL$^a$</td>
<td>BDL$^a$</td>
<td>BDL$^a$</td>
</tr>
<tr>
<td>2</td>
<td>Bones</td>
<td>177200$^b$</td>
<td>BDL$^b$</td>
<td>3400$^b$</td>
<td>3756$^b$</td>
<td>BDL$^b$</td>
<td>61.43$^b$</td>
<td>1024$^b$</td>
<td>BDL$^b$</td>
<td>BDL$^b$</td>
<td>BDL$^b$</td>
<td>BDL$^b$</td>
</tr>
<tr>
<td>1</td>
<td>Gill</td>
<td>84090$^b$</td>
<td>1142$^a$</td>
<td>5200$^b$</td>
<td>2857$^b$</td>
<td>1.22$^b$</td>
<td>74.26$^b$</td>
<td>1913$^b$</td>
<td>5.0$^b$</td>
<td>1.2$^b$</td>
<td>0.13$^b$</td>
<td>0.74$^b$</td>
</tr>
<tr>
<td>2</td>
<td>Gill</td>
<td>63800$^b$</td>
<td>BDL$^b$</td>
<td>5200$^b$</td>
<td>3049$^b$</td>
<td>5.22$^b$</td>
<td>39.44$^b$</td>
<td>3087$^b$</td>
<td>5.7$^b$</td>
<td>BDL$^b$</td>
<td>0.36$^b$</td>
<td>BDL$^b$</td>
</tr>
</tbody>
</table>

WHO (1999)

<table>
<thead>
<tr>
<th>Station</th>
<th>Body Component</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>Na</th>
<th>V</th>
<th>Mn</th>
<th>Cl</th>
<th>Br</th>
<th>La</th>
<th>Sm</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>IUPAC (2005)</td>
<td>ref value</td>
<td>75000</td>
<td>7.70</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Station</th>
<th>Body Component</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>Na</th>
<th>V</th>
<th>Mn</th>
<th>Cl</th>
<th>Br</th>
<th>La</th>
<th>Sm</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDA/AI (mg)</td>
<td>ref value</td>
<td>1300</td>
<td>420</td>
<td>4700</td>
<td>1500</td>
<td>2.30</td>
<td>2300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BDL = Below Detection Limit
$^{a,b}$ Sample superscript on same component are not significantly different (p≥0.05) Duncan’s test.

RDA = Recommended Dietary Intake

Al = Allowable Intake

### Table 3: Quality Assurance and Quality Control Results

<table>
<thead>
<tr>
<th>ELEMENTS</th>
<th>CABBAGE</th>
<th>LICHEN</th>
<th>TOTAL DIET</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Measured</td>
<td>Certificate</td>
<td>Measured</td>
</tr>
<tr>
<td>Ca (ppm)</td>
<td>16200 ± 700</td>
<td>17990 - 19010</td>
<td>1.62 ± 0.07</td>
</tr>
<tr>
<td>Mn (ppm)</td>
<td>1990 ± 150</td>
<td>2110 - 2210</td>
<td>3.0 ± 0.3</td>
</tr>
<tr>
<td>Na (ppm)</td>
<td>470 ± 4</td>
<td>567 - 601</td>
<td>0.76 ± 0.01</td>
</tr>
<tr>
<td>K (ppm)</td>
<td>2519 ± 252</td>
<td>31810 - 33190</td>
<td>0.65 ± 0.06</td>
</tr>
<tr>
<td>As (ppm)</td>
<td>0.27 ± 0.03</td>
<td>0.096 - 0.104</td>
<td>BDL</td>
</tr>
<tr>
<td>Br (ppm)</td>
<td>3.5 ± 0.1</td>
<td>----</td>
<td>7.3 ± 0.2</td>
</tr>
<tr>
<td>La (ppm)</td>
<td>BDL</td>
<td>----</td>
<td>BDL</td>
</tr>
<tr>
<td>Sc (ppm)</td>
<td>0.03 ± 0.01</td>
<td>----</td>
<td>BDL</td>
</tr>
<tr>
<td>Fe (ppm)</td>
<td>162 ± 29</td>
<td>144.1 - 151.9</td>
<td>35 ± 3</td>
</tr>
<tr>
<td>Co (ppm)</td>
<td>BDL</td>
<td>----</td>
<td>BDL</td>
</tr>
<tr>
<td>Zn (ppm)</td>
<td>38.5 ± 1.7</td>
<td>37.9 - 39.3</td>
<td>26 ± 2</td>
</tr>
<tr>
<td>Rb (ppm)</td>
<td>7.0 ± 1.5</td>
<td>4.7 ± 0.9</td>
<td>4.8</td>
</tr>
</tbody>
</table>
77.69% of Magnesium was found in the bone, the remaining 22.32% was obtained in the gills. Magnesium was not obtained in the flesh. 51.58%, 26.53% and 21.89% Potassium was obtained in the flesh, bone and gills respectively. 22.70%, 48.43% and 28.87% of Sodium was obtained in the flesh, bone and gills of O.niloticus respectively.

Manganese was not obtained in the flesh but, while 54.23% of Manganese was obtained in the bone of O.niloticus analyzed, the remaining 45.77% Manganese was obtained in the gills. While Chlorine concentration in the flesh was 47.38%, 23.54% and 29.08% of Chlorine was obtained in the bones and the gills respectively. The obtained concentration of Bromine in the flesh, bones and gills was 49.95%, 13.86%, 36.19% respectively. While the gills of O.niloticus from Station 1 stored Lanthanum, Samarium and Uranium, Samarium was also obtained in the gills of fish samples from Station 2 only. Generally, the metals were more concentrated in the bones and gills but least in the flesh. According to Abolude and Abdullahi (2005) and Abolude et al. (2007), most of the metals detected in a similar study accumulated more metals in the bone and bony structures. Since the flesh remains the most favored component for human consumption, the recorded levels for the flesh were far below the WHO (1990) safe reference values. The fish bony structures are therefore good vehicles of detecting and assessing metal pollution in the aquatic environment. Similar reports were earlier given by (Cortes Toro et al., 1994; Ewa et al., 1999; Jonah et al., 2005; and Tukura et al., 2005). Magnesium, Vanadium, Manganese, Lanthanum, Samarium and Uranium were not detected in the flesh of samples from Stations 1 and 2. While Calcium, Potassium and Sodium obtained from the flesh of O.niloticus from Station 2 were significantly higher (P<0.05) than those obtained from Station 1, the concentration of Calcium, Magnesium, Potassium, Sodium, Manganese, Chlorine and Bromine obtained from the bone of O.niloticus from Station 1 were significantly higher (P<0.05) than those obtained from Station 2. In addition, the gills of O.niloticus from Station 1 significantly (P<0.05) stored higher Calcium, Magnesium, Manganese, Lanthanum and Uranium than the concentrations obtained for the gills of O.niloticus from Station 2. The higher concentration of some metals in Station 2 might be as a result of more farming activities. More so Station 2 receives less volume of water than as obtained in Station 1. Vanadium, Lanthanum, Samarium and Uranium were not detected in the bones of fish from both stations. All vanadium compounds are considered toxic. Tetravalent VOSO4 has been reported to be over 5 times more toxic than trivalent V2O3 (Roschin, 1967). The Occupational Safety and Health Administration (OSHA) has set an exposure limit of 0.05 mg/m3 for vanadium pentoxide dust and 0.1 mg/m3 for vanadium pentoxide fumes in workplace air for an 8-hour workday, 40-hour work/week (http://en.wikipedia.org/wiki/Vanadium#cite_note-OSHA-65). The National Institute for Occupational Safety and Health (NIOSH) has recommended that 35 mg/m3 of vanadium be considered immediately dangerous to life and health. (http://en.wikipedia.org/wiki/Vanadium#cite_note-OSHA-65). Vanadium was obtained only in the gills and the obtained concentration was less than the WHO (1999) reference value. However, there was no RDA value for Vanadium by the IUPAC (2005) but Vanadium concentration ranged from 1.22 – 5.22.

Generally, Calcium, Magnesium, Potassium, Sodium, Manganese, Chlorine and Bromine were significantly higher (P<0.05) in samples from Station 1. The allochthonous water supply from station 1 probably contained more of these metals which become bio accumulated in the bones of the fish examined. Calcium, a common electrolyte, but also needed structurally (for muscle and digestive system health, bones, some forms to neutralize acidity, may help clear toxins, and provide signaling ions for nerve and membrane functions). Although, Calcium was not obtained in the flesh of the fish obtained in Station One, the need for Calcium in the body might have been the reason for the extra accumulation of the metal in the flesh, bone and gills of the fish examined. The concentrations of Calcium in the bones of these fish agreed with the 99% of calcium found in the bones (and teeth) as observed by Kathleen Mahan et al. (2012). Magnesium is required for processing ATP and related reactions (builds bone, causes strong peristalsis, increases flexibility, increases alkalinity (http://en.wikipedia.org/wiki/Dietary mineral). According to Kathleen Mahan et al. (2012) approximately 50% of Magnesium is in the bone, the remaining 50% is almost all inside body cells, and with only about 1% located in extracellular fluid. This could have accounted for the extra concentrations of Magnesium in the bones and the gills of fish examined. However, Magnesium was not detected in the flesh of the fish analyzed but the observed concentrations were obtained in the bones and gills. Magnesium deficiency results in hypomagnesaemia and its excess results in hypermagnesaemia (IUPAC, 2005). Magnesium Dietary Reference Intake (RDA/ AI in mg) is 420mg (IUPAC, 2005). This figure is far less than the obtained concentration in the bones and in the gills. Indicating that Magnesium is over concentrated in the bones and gills of fish examined. Potassium is a very common electrolyte (heart and nerve health). With sodium, potassium is involved in
maintaining normal water balance, osmotic equilibrium, and acid-base balance. In addition to calcium, it is important in the regulation of neuromuscular activity (Kathleen Mahan et al., 2012). These properties could have accounted for the metal’s presence in all the organs analyzed. It has been established that a low sodium diet is beneficial for people with high blood pressure. A Cochrane review published in 2008 concluded that a long term (more than 4 weeks) low sodium diet in Caucasians has a useful effect to reduce blood pressure, both in people with hypertension and in people with normal blood pressure (He and MacGregor, 2004). The DASH diet (Dietary Approaches to Stop Hypertension) is a diet promoted by the National Heart, Lung, and Blood Institute (part of the NIH, a United States government organization) to control hypertension. A major feature of the plan is limiting intake of sodium, and it also generally encourages the consumption of nuts, whole grains, fish, poultry, fruits and vegetables while lowering the consumption of red meats, sweets and sugar. These are also "rich in potassium, magnesium, and calcium, as well as protein (DASH, 2009)". The concentration of Sodium obtained in this work is highest in the bone and least in the flesh. The concentrations of Sodium in the gills are more than the obtained concentrations in the flesh. This could be due to the presence of bones in the gills. Sodium is an extra cellular fluid hence it is more concentrated in the bones than in the flesh (Abolude, 2008a). The obtained concentration is greater than the 1500mg required for a normal person RDA/AI (IUPAC, 2005).

The gills examined contain more metals and elements including Lanthanum, Samarium and Uranium. The gills of fish collected from Station 2 were significantly (P≤0.05) found to contain more Sodium, Vanadium, Chlorine, Bromine and Samarium, while the gills of samples collected from Station 1 significantly (P≤0.05) contained more Calcium, Magnesium, Manganese, Lanthanum and Uranium. Gills are filtering organs and therefore the presence of more metals in the gills than in the flesh. Uranium is not detected in samples from station 2. Generally, the distributions of minerals have been found not only to depend on species, age and habitat but also on the gastro-intestinal tract and the amount of chemical form of the ingested food (Love, 2008; Abolude, 2008a).

4. CONCLUSION

The present study detected accumulation of metals in gills. Oreochromis niloticus collected from Ahmadu Bello University Reservoir, Zaria, Nigeria bioaccumulated some metals within the safe range recommended by WHO. However, Calcium and Manganese concentrations in the bones and gills were above the WHO recommended value. So also, the obtained concentrations of Calcium, Magnesium, Potassium, Sodium and Chlorine were also above the RDA Value. This indicates that the fish could be used as bio indicator of metal pollution in an aquatic environment.

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Elemental Analysis of Flesh, Bones and Gills of Oreochromis niloticus Consumed in Nigeria for Improvement of Nutrition and Health

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