HEAVY METAL CONCENTRATIONS IN WATER FROM FISHING SITES IN FEDERAL CAPITAL TERRITORY AND FOUR SELECTED STATES IN NORTH CENTRAL NIGERIA

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Abstract: Water collected from fifteen active fishing sites in Niger, Kogi, Kwara, Benue states and the Federal Capital Territory (FCT) were analyzed for its physico-chemical properties (pH, temperature, conductivity, total hardness and dissolved oxygen). The heavy metal contents (Cu, Zn, Ni, Cr, Pb and Cd) of the water samples were determined using MP-AES. The results obtained show that the pH of the water collected from Aliara fishing site in Kwara State was higher (8.111) and significantly different ($p<0.05$) from the pH of the water collected from other fishing sites. The mean conductivity values of the water collected from the study area (110.667-115.111 µs/cm) showed significant differences ($p<0.05$) from each other. Also, the Cu content in the water collected from Jabi mechanic fishing site (1.046 mg/dm^3) was higher and differed ($p<0.05$) from the Cu content in the rest samples. Generally, the Zn (0.016-0.863 mg/dm^3), Ni (0.001-0.074 mg/dm^3) and Cr (0.001-0.062 mg/dm^3) in the water samples from the study area were lower than the WHO permissible limits. However, the Cd content in these water samples evaluated in this study (0.005-0.015 mg/dm^3) was higher than the WHO recommended permissible limits. The Principal component analysis (PCA) showed the following sequence: Pb>Ni>Cd>Cu>Zn>Cr. High level of heavy metals in River waters could be toxic to aquatic life and invariably affect humans following consumption. Relevant governmental agencies should enlighten the fishing communities on the best way to discharge their waste.

Keywords: Fishing sites, heavy metals, PCA, physicochemical

Introduction

Water contamination is a burning issue nowadays all over the world. Aquatic ecosystems are frequently polluted with different toxicants through anthropogenic activities, and some of them such as metals may be naturally present and essential in low but toxic in higher concentrations (Sekabira *et al*., 2010; Carassco *et al*., 2011; Lushchak, 2011; Ondarza *et al*., 2012; Pereira *et al*., 2013; Jorundsdottir *et al*., 2014). Several water bodies which lie in vicinity of population have been polluted by effluents released by industries, factories, power stations, domestic waste which besides disturbing the quality of water also degrade the protein source in the form of fish food and limits their use (Baki *et al*., 2011; Taweel *et al*., 2012; Emere and Dibal, 2013; Javed and Usmani, 2013). Metal pollutants present in water can accumulate in aquatic organisms from water, sediments or through the food chain (Mendil *et al*., 2010; Dukowska *et al*., 2012; Squadrone *et al*., 2013). Some metals like copper, zinc or iron are also important for many biochemical processes in living organisms and they are essential elements for aquatic plants and animals. However, in the case of higher concentrations of these metals, they become toxic and are considered as pollutants (Akan *et al*., 2012).

According to Olaifa *et al*. (2014) heavy metals occur in the environment in both free state as well as bound forms. Ionic species are readily available to biota for ingestion and cause deleterious changes at various levels of organization of the animals. Several studies have confirmed that significant amounts of chemical elements are leached from refuse dumps into ground water, streams and rivers (Butu *et al*., 2013). Accordingly, a variety of species of aquatic organism becomes limited with the level of heavy metal pollution (Mohammadi *et al*., 2012). Aquatic environment is one of the receiving ends of heavy metals which go back into the food chain through bioaccumulation and bio-magnification in marine animals and man respectively (Edward *et al*., 2013). Bio-magnification is swayed by metal absorption or contaminants which could be shifted through the numerous tropic levels in an ecosystem (Ismaniza and Idaliza, 2012). Pollutants exist in small concentration in water and at high levels in sediments and biota (Squadrone *et al*., 2013).

Heavy metal contaminations in inland waters can be monitored by using the metal levels in water; sediments and resident biota especially fish (Wu and Chen, 2013). The toxic metals of most environmental concern in water are lead, chromium, arsenic, cadmium, copper and zinc. Contamination by these heavy metals can be expressed by their high concentrations in water, as well as in sediments and aquatic organisms (Wiberg *et al*., 2011). Heavy metals are contaminants of the aquatic environment because of their ability to poison humans and accumulate in marine organisms (El-Zokm *et al*., 2012). The poisonous impacts of these heavy metals causes serious problems on the health of man due to their easy assimilation into the food chain and bioaccumulation processes (Tabari *et al*., 2010). According to Butu *et al*. (2013) potential toxic metals may be generated from many origins in rural and urban settlements and other activities such as vehicular emissions and industrial discharges. Heavy metals are natural constituent of our environment produced from an array of natural and anthropogenic origin (Edward *et al*., 2013). Water contamination is caused when an input from human activities causes an increase of a substance in fresh water, sediments and organisms above the natural background level for that area and for those organisms. Occurrence of potential toxicants in aquatic ecosystem causes a reduction in the quality of the aquatic environment that results in impaired level of dissolved oxygen, pH, temperature, biological oxygen demand, and chemical oxygen demand. The objective of this study is to ascertain the heavy metal content in water collected from fishing sites in FCT and four states in North Central Nigeria.

Materials and Methods

Study area

Three active fishing sites each in FCT and four States (Niger, Benue, Kogi & Kwara) in North Central Nigeria were selected as the sampling area after several visitation to identify such sites.

Water samples

Two litres (2 dm^3) of water sample collected from the River from each of the fishing sites between the months of January and March 2017 were transferred into an acid cleaned (2M HNO_3) Two litre plastic container and then acidified with 2M HNO_3 to stabilize the metal ions so as to prevent its precipitation. The collected samples was transported to the laboratory and stored in the refrigerator until the samples were analyzed.

Digestion of water samples

The methods described by AOAC (2000) were used to digest the water samples. 10 cm^3 of HNO_3 was added to 50 cm^3 of water sample and heated at 200ºC for 1 h following which 2 cm^3 of hydrogen peroxide (H_2O_2) was added, mixed and further heated for 30 min. The resulting solution was then made up to 50 cm^3 marks with distilled water and filtered. A blank was prepared using the same procedure.

Physicochemical properties of water

The physico-chemical properties (dissolved oxygen, pH, temperature, conductivity and total hardness) of the water samples collected from various fishing sites were determined according to the methods described by Onwughara *et al*. (2013) and Sinha and Biswas (2011).

Heavy metal analysis

The heavy metal contents (Cu, Zn, Ni, Cr, Pb and Cd) of the digested water samples were determined using Microwave Plasma Atomic Emission Spectrophotometric (MP-AES) methods (4200 MP-AES Instrument, Agilent Technology, England).

Statistical analysis

One-way analysis of variance (ANOVA) and Duncan Multiple Range Test was used to evaluate the significant differences ($p<0.05$) in the concentrations of different studied metals with respect to different fishing sites within and across the various states and FCT using IBM-SPSS version 20 software; while the Hierarchical Cluster and Principal Component Analyses were computed using Minitab version 10 software.

Results and Discussion

Physicochemical property of water

The pH of the water samples collected from the study area (Table 1) ranged from (4.033-8.111). The pH in the water collected from Aliara was higher (8.111) and significantly different ($p<0.05$) from the pH in water samples collected from Egba (6.633), Nupeko (5.333), Gbamjimba (5.333) and Nusagbodu (5.111). However, the pH in the water collected from Akabu (6.944), Girinya (6.933), Shintaku (7.178), River Benue (6.833), Katsina-Ala (7.167), Jabi (7.167) and Usuma (7.189) did not differ ($p>0.05$) but these differed from the water collected from Nupeko and Nusagbodu. The pH values of the water samples obtained in this study are within the permissible limits of 6.5-8.5 (WHO, 2013) except for those collected from at Terminus River (4.033) which may be due to the acidic nature of the water; it was observed that the water from this fishing site was highly contaminated.

The water temperatures obtained during the sampling period in all the fishing sites except those of Akabu did not differ ($p>0.05$). The results of this study (Table 1) are within the (18-35ºC) permissible limits of WHO (2013). Other workers (Patill *et al.*, 2012; Kar *et al.*, 2008; Chiroma *et al*., 2012) reported water temperature ranges of 19.5-21ºC, 10.18-19.73ºC and 20.5-22ºC, respectively. Again the mean conductivity values (110.667-115.111 µs/cm) obtained in this study (Table 1) showed that there was significantly differed ($p<0.05$) from each other. The conductivity of the water collected from Katsina-Ala (115.111), Gbajimba (114.833 µs/cm), Egba (114.667 µs/cm) and Etsugi (114.889 µs/cm) did not differ ($p>0.05$) but these differed ($p<0.05$) from the water collected from River Benue (110.667 µs/cm) and are within the ranges of the permissible limit set by WHO (2013) for drinking water (500-750 µs/cm). Higher conductivity in a body of water implies that less amount of water will be available to plants, even though the soil may appear wet. Therefore, irrigation water with high conductivity reduces yield potentials.

Likewise the total hardness of the water collected from the sampling sites in this study ranged from 21.111-148.222 mg/dm^3 (Table 1). Based on the hardness, water is classified into three different categories by Soni *et al.* (2013): soft water (0-75 mg/dm^3), moderately hard water (76-150 mg/dm^3) and hard water (151-300 mg/dm^3). Therefore, the water sample collected from Terminus River (148.222 mg/dm^3) is categorized as being moderately hard water. The recorded values for total hard water from all the study sites are in accordance with the permissible limits of 300 mg/dm^3 (WHO, 2013). Higher total hardness values are mainly due to weathering of Ca and Mg-rich rocks in the area (Zeitoun and Mehana, 2014) and this may be related to the dominance of limestone rocks within the study area which occupies the elevation in the topography. Therefore, the results of this study indicate that water obtained from Terminus River would be unsuitable for drinking. Sinha and Biswas (2011) reported that the dissolved oxygen <5.0 mg/dm^3 adversely affects aquatic life. Thus dissolved oxygen obtained in this study (5.216-5.491 mg/dm^3) could be said to be suitable for lives in the aquatic ecosystem.

Heavy metals in water

As shown in Table 2, the Cu content in the water collected at Jabi mechanic fishing site (1.046 mg/dm^3) was higher and significantly different ($p<0.05$) from the Cu content in the water collected from the other fishing sites which did not show any significant difference ($p>0.05$) from one another. Generally, the Cu content in the water obtained from the fifteen fishing sites as shown in this study was low (0.004-1.046 mg/dm^3) and is within the WHO (2013) standard limits for Cu in water (1-2 mg/dm3). Cu being an essential part of several enzyme and it is necessary for the synthesis of haemoglobin but potentially toxic to humans at high concentrations and may cause serious health problems particularly liver damage and in varieties of fishes and invertebrates with prolonged exposure (Gupta *et al*., 2015). Therefore, the high Cu content (Table 2) in the water collected from Jabi mechanic (1.046 mg/dm^3) could be of serious health implication to those communities. It was observed at Jabi mechanic that waste (used lubricants and metals filling) from the mechanics were washed into the body of water.

The Zn content in the water collected from the fifteen fishing sites in this study (Table 2) shows that the Zn content in the water collected from Gbajimba fishing site (0.863 mg/dm^3) was higher and significantly different ($p<0.05$) from those collected from the other fishing sites.

Table 1: Physicochemical properties of water collected from fifteen fishing sites in four states and FCT

Fishing sites	Physical parameters[1,2]				
	pH	**Temperature (^{o}C)**	**Conductivity (µS/cm)**	**Total Hardness (mg/dm3)**	**Dissolved O_2 (mg/dm^3)**
Kwara					
Aliara	8.111±0.889^{a}	27.544±1.485^{a}	112.889±1.111^{ab}	64.444±5.556^{def}	5.248±0.017^{a}
Terminus	4.033±0.223^{ab}	28.667±0.747^{a}	113.778±1.128^{ab}	148.222±10.512^{a}	5.249±0.016^{a}
Nusagbodu	5.111±0.633^{d}	26.567±1.881^{a}	113.778±0.722^{ab}	102.889±16.283^{b}	5.238±0.016^{a}
Niger					
Nupeko	5.333±0.456^{cd}	25.223±1.062^{a}	112.222±1.024^{ab}	91.111±16.111^{cd}	5.346±0.096^{a}
Egba	6.633±0.611^{bc}	18.589±2.749^{a}	114.667±1.106^{a}	51.111±9.196^{efg}	5.468±0.173^{a}
Etsugi	6.678±0.468^{abc}	27.200±1.690^{a}	114.889±1.111^{a}	42.222±6.620^{efg}	5.257±0.017^{a}
Kogi					
Akabu	6.944±0.348^{ab}	18.253±0.563^{a}	113.556±0.929^{ab}	101.111±0.334^{bc}	5.216±0.011^{a}
Girinya	6.933±0.179^{ab}	26.538±1.214^{a}	114.001±1.155^{ab}	58.889±20.169^{defg}	5.217±0.021^{a}
Sintaku	7.178±0.233^{ab}	26.100±1.426^{a}	112.444±0.729^{ab}	59.889±8.715d^{ef}	5.234±0.029^{a}
Benue					
River Benue	6.833±0.186^{ab}	22.911±3.674^{a}	110.667±0.471^{b}	40.000±3.333^{fg}	5.216±0.017^{a}
Katsina Ala	7.167±0.167^{ab}	26.411±0.868^{a}	115.111±1.207^{a}	45.556±12.031^{efg}	5.239±0.016^{a}
Gbajimba	5.333±0.464^{cd}	24.733±0.610^{a}	114.833±1.312^{a}	130.000±14.907^{ab}	5.537±0.378^{a}
FCT					
Jabi	7.167±0.157^{ab}	23.667±1.163^{a}	112.444±0.648^{ab}	21.111±4.231^{g}	5.491±0.154^{a}
Usuma	7.189±0.238^{ab}	27.789±0.819^{a}	113.778±1.128^{ab}	78.889±14.855^{cde}	5.248±0.017^{a}
Jabi mechanic	6.156±0.536^{bcd}	28.167±1.831^{a}	113.333±1.155^{ab}	114.444±14.114^{abc}	5.470±0.145^{a}
WHO					

[1]Each data is the mean±SE of replicate (9) determinations; [2]Different letters within the same column are significantly different ($p<0.05$)

Table 2: Heavy metal content in water from fifteen fishing sites in FCT and four states of North-Central Nigeria

Fishing sites	Heavy metals (mg/dm^3)[1,2]					
	Copper	**Zinc**	**Nickel**	**Chromium**	**Lead**	**Cadmium**
Kwara						
Aliara	0.060±0.003^{b}	0.171±0.024^{d}	0.006±0.001^{cd}	0.069±0.063^{a}	0.009±0.001^{de}	0.005±0.001^{b}
Terminus	0.012±0.002^{b}	0.033±0.004^{d}	0.015±0.004^{c}	0.001±0.001^{b}	0.005±0.000^{ef}	0.007±0.001^{b}
Nusagbodu	0.147±0.106^{b}	0.292±0.079^{cd}	0.015±0.002^{c}	0.013±0.002^{ab}	0.018±0.004^{c}	0.015±0.001^{a}
Benue						
Gbamjimba	0.045±0.033^{b}	0.863±0.239^{a}	0.039±0.006^{b}	0.024±0.021^{ab}	0.032±0.000^{b}	0.007±0.003^{b}
River Benue	0.054±0.009^{b}	0.016±0.003^{d}	0.001±0.001^{d}	0.012±0.002^{ab}	0.007±0.001^{def}	0.005±0.001^{b}
Katsina Ala	0.024±0.006^{b}	0.165±0.019^{d}	0.013±0.002^{c}	0.007±0.002^{ab}	0.017±0.002^{c}	0.006±0.000^{b}
Niger						
Egba	0.021±0.003^{b}	0.098±0.023^{d}	0.005±0.001^{cd}	0.027±0.021^{ab}	0.007±0.000^{de}	0.006±0.006^{b}
Etsugi	0.074±0.025^{b}	0.163±0.135^{d}	0.005±0.001^{cd}	0.035±0.009^{ab}	0.004±0.001^{ef}	0.007±0.001^{b}
Nupeko	0.074±0.017^{b}	0.526±0.118^{bc}	0.013±0.004^{c}	0.022±0.007^{ab}	0.009±0.002^{de}	0.013±0.002^{a}
Kogi						
Akabu	0.029±0.001^{b}	0.071±0.011^{d}	0.010±0.001^{cd}	0.022±0.006^{ab}	0.006±0.001^{def}	0.005±0.001^{b}
Girinya	0.027±0.004^{b}	0.187±0.035^{d}	0.009±0.007^{cd}	0.018±0.003^{ab}	0.005±0.000^{ef}	0.005±0.001^{b}
Shintaku	0.108±0.077^{b}	0.233±0.044^{cd}	0.074±0.005^{a}	0.015±0.003^{ab}	0.043±0.003^{a}	0.004±0.003^{b}
FCT						
Usuma	0.024±0.006^{b}	0.069±0.008^{d}	0.008±0.002^{cd}	0.010±0.001^{ab}	0.010±0.001^{de}	0.006±0.001^{b}
Jabi Mechanic	1.046±1.016^{a}	0.648±0.239^{ab}	0.012±0.001^{cd}	0.026±0.016^{ab}	0.016±0.001^{d}	0.007±0.002^{b}
Jabi	0.004±0.002^{b}	0.048±0.007^{d}	0.001±0.000^{d}	0.005±0.001^{b}	0.001±0.000^{f}	0.009±0.000^{b}
Standards						
WHO (2013)	2.0	3.0	0.07	0.05	0.01	0.003
FEPA (1991)	-	-	0.1	0.03	0.05	0.01
SON (2002)	1	3	0.02	0.05	0.01	0.005
EPA (2002)	1.3	-	-	0.05	0.05	0.01

[1]Each data is the mean±SE of nine determinations; [2]Different letters within the same column are significantly different ($p<0.05$)

However, there were no significant differences ($p>0.05$) in the Zn content in the water collected from Aliara, Terminus, Nusagbodu, River Benue, Kastina Ala, Egba, Etsugi, Akabu, Giringa, Shintaku, Usuma and Jabi fishing sites and likewise those collected from Nusagbodu (0.292 mg/dm^3) and Shintaku (0.233 mg/dm^3) fishing sites (Table 2). Generally, the Zn contents (0.016-0.863 mg/dm^3) in the water obtained across the fifteen fishing sites (Table 2) were lower than the WHO (2013) permissible limit of (3 mg/dm^3). Again the presence of this element in the body of water could be traceable to the activities of the farmers and the fisher men along the River banks. Zn is physiological important in both plants and animal, however at excessive level could cause problem as the water becomes bitter, astringent in taste and physiological dysfunction.

The Ni contents in the water collected from the fifteen fishing sites in this study (Table 2) show that the Ni in the water collected from Shintaku (0.074 mg/dm^3) was higher and differed ($p<0.05$) from the Ni content in water collected from Gbajimba (0.039 mg/dm^3), Terminus, Nusagbodu, Kastina Ala and Etsugi (0.015, 0.015, 0.013 and 0.013 mg/dm^3, respectively) and River Benue (0.001 mg/dm^3). Also the Ni content in the water collected from the fifteen fishing sites in this study (0.001-0.074 mg/dm^3) is within the WHO (2013) 0.5 mg/dm^3 permissible limit with the exception of the Ni content in the water obtained from Shintaku (0.074 mg/dm^3). The result obtained in this study is lower than those reported by Akaahan *et al*. (2015) in River Benue (0.01-1.03 mg/dm^3) and Omozokpia *et al*. (2015) in Shiroro Dam (0.01 mg/dm^3). Chennaiah *et al*. (2014) reported that Ni an essential trace metal, could be toxic to human health if present in large amount and according to these authors high amount of Ni could be carcinogenic.

In addition, the Cr content in the water collected from all the fishing sites as shown in Table 2 revealed that the Cr content in the water collected from Aliara (0.069 mg/dm^3) was higher and significantly different ($p<0.05$) from the Cr content in the water collected from Terminus (0.001 mg/dm^3) and Jabi (0.005 mg/dm^3). However, the Cr content in the water obtained from Nusagbodu (0.013 mg/dm^3), Gbajimba (0.024 mg/dm^3), River Benue (0.012 mg/dm^3), Kastina Ala (0.007 mg/dm^3), Egba (0.027 mg/dm^3), Etsugi (0.035 mg/dm^3), Nupeko (0.022 mg/dm^3), Akabu (0.022 mg/dm^3), Girinya (0.018 mg/dm^3), Shintaku (0.015 mg/dm^3) Usuma (0.010 mg/dm^3) and Jabi mechanic (0.026 mg/dm^3) were not significantly different ($p>0.05$) from each other (Table 2). Generally, the Cr contents (0.001-0.069 mg/dm^3) in the water collected from fifteen fishing sites in this study (Table 2) are within the WHO (2013) 0.05 permissible limit except the Cr content in the water collected from Aliara fishing site (0.069 mg/dm^3). However, the result of this study is not in agreement with the findings of Chennaiah *et al*. (2014) who reported a Cr content of 1.08 mg/dm^3 in Bhongiri River in India.

Similarly, as shown in Table 2 the Pb content in the water collected from Shintaku (0.043 mg/dm^3) differed significantly ($p<0.05$) from the Pb content in the water collected from the other fishing sites. However, the Pb content in the water collected from River Benue and Akabu did not differ significantly ($p>0.05$) and also those of Aliara, Egba, Nupeko and Usuma (Table 2). Furthermore, the Cd content in the water collected from all the fishing sites in this study (Table 2) shows that the Cd content in the water collected from Nupeko (0.013 mg/dm^3) and Nusagbodu (0.015 mg/dm^3) did not differ ($p>0.05$) but these differed ($p<0.05$) from the Cd content in the water collected from the other fishing sites. Generally, the Cd content in the water collected from Aliara, Terminus, Gbajimba, River Benue, Kastina Ala, Egba, Etsugi, Akabu, Girinya, Shintaku, Usuma, Jabi mechanic, and Jabi fishing sites were not significantly different ($p>0.05$) from each other (Table 2).

The WHO standards for Pb and Cd in water are 0.01 mg/dm^3 and 0.003 mg/dm^3 respectively (WHO, 2013). The Pb and Cd in the water obtained from the study area is far more greater than the WHO reference standards. Ubwa *et al*. (2013) in their study of surface water pollution around Gboko abattoir (Nigeria) reported a Pb and Cd content of 0.1780-0.3782 mg/dm^3 and 0.0056-0.0135 mg/dm^3 respectively and likewise, Umar and Ebong (2013) reported a Pb and Cd content of 0.05 and 0.32 mg/dm^3 in Jabi Lake (Abuja) the results obtained in this study was however lower in the Pb and Cd contents than the reports of these workers. Again this could be attributable to the activities such as improper disposal of batteries, electronic waste and rotten pipes into the body of water. Olafisoye *et al.* (2013) reported that a high Pb concentration in drinking water may result in metallic poisoning which could manifest symptoms like tiredness, slight abdominal discomfort and possible human carcinogenic. Furthermore, Cd an essential metal important in the regulation of both human and plant physiological mechanisms however, at excessive concentrations is regarded as a potential hazard which could endanger human health (Olawola *et al.*, 2016).

Principal component and hierarchical cluster analyses

The results of this study (Table 3) show that lead and nickel correlated strongly with PC1 and their loading were close showing a strong relationship between them which is reflected in Fig. 1. Copper, zinc and cadmium were correlated with PC2. Copper and zinc have moderate correlation (loading) with PC2, with their values were close to each other which showed some level of relationship between them while cadmium had strong correlation with PC2. Also, chromium had strong correlation with PC3. Therefore, lead and nickel can be group together as having similar impact on the study as well as copper and zinc.

Table 3: Extracted co-variance of principal component correlation matrix

Variable	PC1	PC2	PC3
Copper (mg/dm^3)		0.498	
Zinc (mg/dm^3)		0.461	
Nickel (mg/dm^3)	0.636		
Chromium (mg/dm^3)			0.950
Lead (mg/dm^3)	0.644		
Cadmium (mg/dm^3)		0.722	

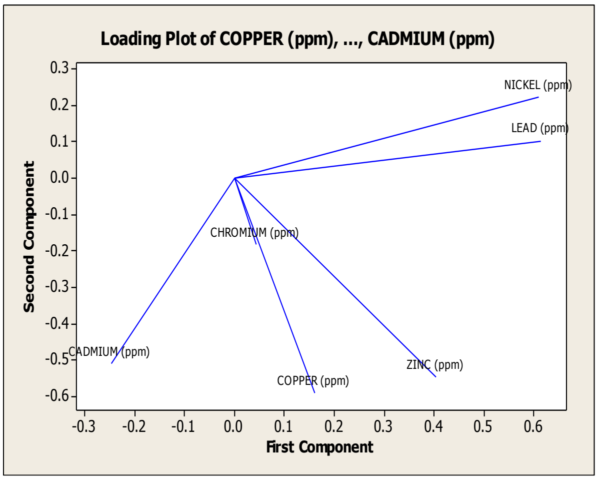

Fig. 1: Loading plot of the first and second component

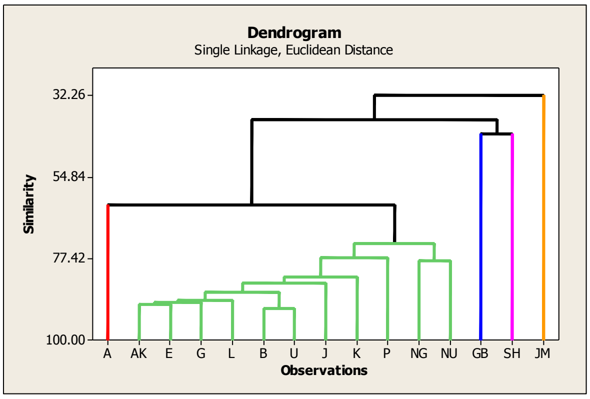

Fig. 2: Cluster analysis dendrogram for grouping within the variable across the locations (AK-Akabu; E-Egba; G-Girinya; L-Etsugi; B-River Benue; U-Usuma; J-Jabi; K-Katsina Ala; P-Terminus; NG-Nusagbodu; A-Aliara; SH-Gbajimba; GB-Shintaku; JM-Jabi mechanic and NU-Nupeko)

The order of their impact on the study is lead > nickel > cadmium > copper > zinc > chromium. Furthermore, Fig. 2 shows the grouping of the location base on their similarities in the studied metals at these locations:- Akabu, Egba, Girinya, Etsugi, River Benue, Usuma, Jabi, Katsina Ala, Terminus, Nusagbodu, Aliara, Gbajimba, Shintaku, Jabi mechanic and Nupeko have some levels of similarities and can be group together. Locations Shintaku and Gbajimba can also be grouped because of some levels of similarities. The locations can therefore be four (4) groups; group 1 (Aliara), group 2 (Akabu, Egba, Girinya, Etsugi, River Benue, Usuma, Jabi, Katsina Ala, Terminus, Nusagbodu and Nupeko), group 3 (Shintaku and Gbajimba) and group 4 (Jabi mechanic).

Conclusion

Water samples collected from fifteen fishing sites in four states and FCT in North Central Nigeria were studied for its heavy metal contents (Cu, Zn, Ni, Cr, Pb and Cd). Cu (1.046 mg/dm^3) and Zn (0.648 mg/dm^3) content in the water samples collected from Jabi mechanic fishing site were higher and significantly different ($p<0.05$) from these heavy metals content in the rest fishing sites but however were not above the WHO permissible limits of heavy metals in drinking water. Also, the order of impacts of these heavy metals in this study is Pb>Ni>Cd>Cu>Zn>Cr. Dumping of waste into body of water has severe health consequences; therefore, appropriate governmental agencies should enlighten the fishing communities on the health implications of such activities.

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