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Studies on contamination of surface waters of river Benue with trace elements at Makurdi, Benue State, Nigeria

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The concentration of trace metals were determined in the world of waters River Benue within Makurdi Metropolitan area using atomic absorption spectrophotometer for two seasons. The mean concentration of the heavy metals Pb, Ni, Cu, Cr, Cd and Al obtained in mg/L were 0.42, 0.39, 0.35, 1.58, 0.19 and 0.04 respectively. There was no significant difference in the concentration of heavy metals across the studied stations (P>0.05). However, during the seasons there was significant difference in the concentration of heavy metals (P<0.05). The mean values of the heavy metals (Pb, Ni, Cr, Cd and Al) in the waters of River Benue were above the drinking water quality standard set by WHO except for Cu. There is clear evidence that River Benue within Makurdi is polluted with heavy metals and there is need to monitor the River regularly by the regulatory authority. The waters of River Benue should not be consumed without adequate treatment.

Key words: Trace metals, River Benue, contamination.

INTRODUCTION

Heavy metals are intrinsic natural constitutes of the environment. Generally, they are present in trace amount in natural aquatic environments (Aderinola et al., 2009). Industrial activities have the ability of elevating the natural concentrations of heavy metals in recent times, causing serious environmental challenge (Aderinola et al., 2009). Heavy metal contamination in aquatic environment is of critical concern because of their toxicity and accumulation in aquatic organisms (Akintujoye et al., 2013). The impact of anthropogenic sources such as industrial discharge, domestic sewage, non- point pollution source runoff and atmospheric precipitation are the main sources of toxic heavy metals that enter aquatic ecosystem (Langston et al., 1999). Naturally, heavy metals tend to accumulate in soils and sediments after weathering processes and can be deposited in water bodies during surface runoffs. When the heavy metals get into the aquatic ecosystem they usually scatter among the various compounds in the water (Anim-Gyampo et al., 2013). Agrochemicals such as fertilizer and herbicides which are usually used on our farms contain heavy metals that easily accumulate in the soils which may leach into water bodies around farm

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lands as it is observed in River Benue at Makurdi (Anim-Gyampo et al., 2013). Therefore, the contamination of fresh water with heavy metals like, cadmium, lead, arsenic, copper, etc has implication for public health (Anim-Gyampo et al., 2013). The rapid development of industrial activities has resulted in heavy metal pollution which is a significant health hazard to human beings through food chain (Krishna et al., 2014). However, the contamination of rivers, water bodies and aquatic biota by heavy metals have been a global challenge especially in developing countries such as Nigeria (Alinnor and Obaji, 2010). This scenario is not different from what is obtainable in River Benue at Makurdi. Accumulation of heavy metals in an aquatic environmental has direct consequences for man and the ecosystem (Akintujoye et al., 2013). This study therefore becomes imperative to assess the heavy metal load in River Benue at the wake of global warming leading to flooding and mass deposition of pollutants to bridge the gap of the earlier studies.

MATERIALS AND METHODS

Study area

The Benue River originates in the Adamawa mountains of the Central Cameroon and flows Westward for about 1,400 km until it meets the Niger River about 450 km above the delta, near the city of Lokoja, Kogi State, Nigeria (Ashley, 2010). The upper reaches of River Benue forms narrow valleys and contain falls and rapid. Most of the lower portion however are free from rapids and have extensive flood plains (1,800 km^2) and braided stream channels of different sizes which meander across the flood plain. The flood plain also contains seasonally inundated depressions known as Fadamas. These provide importance fishery resources which are exploited after the flood has receded (Sarch et al., 1997). The new bridge over River Benue at Makurdi is located on the eastern edge of Makurdi which receives discharge and runoff from the Eastern part of North Bank, Wurukum and Gyado-villa areas of Makurdi town (Anyam et al., 2005). The River Benue enters Makurdi metropolitan area (latitude 7°44` and longitude 88° 31`E) at its tributary with a minor river the Mu and flows on by dividing the city of Makurdi into (North Bank and South Bank). During the rainy season, the River Benue overflows its banks and inundates the grassy riparian zones. However, during the dry season the water level in the river recedes considerably leaving a silted river bed with clear shallow water. The River within Makurdi metropolis receives effluent principally from Wurukum abattoir, Wadata market and industries of coca-cola Plc, Brewery Plc and Mikap Nigeria Ltd. The river receives copious amounts of human and industrial pollutants/debris through small open drainages as it flows through the highly populous area of Makurdi.

Sampling stations

Five sampling stations at approximately 1 km intervals were mapped out along the River within the Makurdi metropolitan area (Figure 1). At each station, three samples were taken along transect across the River North – South axis. The sampling stations were as follows:

(i) Brewery Station – Site I: The brewery is located 5 km away from Makurdi town along Makurdi-Gboko road. The brewery produce effluents from its daily routine production. The effluent are channeled into Ageba, a tributary of River Benue and if flows into the River.

(ii) New Bridge Station – Site II: This station was designed II and it's about 5 m from Wadata market. Its effluent flow from the Wurukum abattoir.

(iii) Old Bridge station – Site III: It is about 500 m away from New Bridge and 4.5 km away from Wadata market. Effluents from New bridge flows directly into the old bridge station.

(iv) Saint Joseph Station – Site IV: This station, was designed as IV. It is about 1.5 km away from Wadata market and about 200 m away from Makurdi Water Works. It receives discharge from the Makurdi Water Works.

(v) Wadata market Station Site V: Wadata market is located on the bank of River Benue. This station was designed as V and it receives municipal wastes that composed of solid wastes, abattoir effluents and domestic wastes generated from the market. A huge heap of refuse dump is found at this location where its wastes are leached directly into the river.

(vi) Control Station – Site VI: This was stationed out of River Benue. This station was at a special science secondary school fish farm Makurdi and was designed as VI.

Collection of water samples

At each sampling station, three water samples were collected along the North-South transect of the River. Water samples were collected from May to September 2014 during the rainy season and November 2014 to March 2015 during the dry season. Samples were taken 30 cm below the water surface with the aid of a graduate rope with 500 ml transparent glass bottles and transported to the laboratory. In the laboratory the water samples were digested and preserved prior to AAS analysis. The water samples were digested by measuring two hundred and fifty militers of each of the water samples and were filtered through a whatmann filter paper of 0.45 µm and then 2.0 ml of concentrated trioxonitrate (V) acid of high purity was added to the 100 ml of the sample to obtain a pH of approximately 1 (Cenci and Martin, 2004).

Determination of heavy metals

The concentration of heavy metals (Cadmium, Chromium, lead, copper and Al) in each of the samples was determined using atomic absorption spectrophotometer (AAS) UNICAM SOLAAR32 model at the Food and Agriculture Organization Laboratory at Kaduna, Nigeria.

Statistical analysis

Results obtained were subjected to mean, standard deviation and standard error of means. ANOVA was determined and $p < 0.05$ was considered to indicate statistical significance.

RESULTS

The data presented in Table 1 is the concentration of trace elements in River Benue during the period of the study. The results indicate that the mean concentration of Chromium was highest at Stations: I, III, IV, V and VI while at Station II it was the mean concentration of Lead that was the highest among the other trace elements in

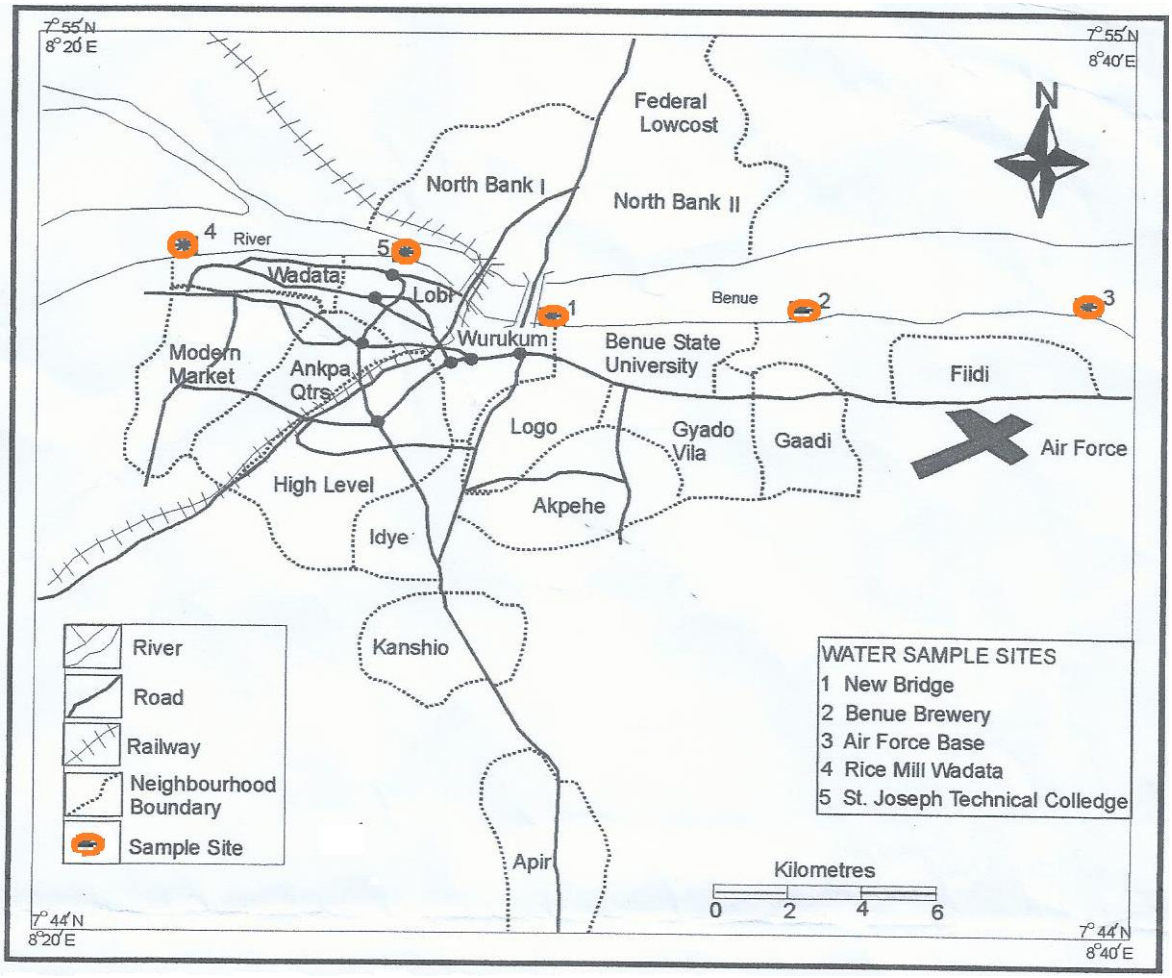

Figure 1. Map of Makurdi Town Showing Sample site on the Shoreline of River Benue. Source: Ministry of Lands and Survey Makurdi.

Table 1. Concentration of trace elements in River Benue at Makurdi.

	Sampling Station Codes					
Trace elements (mg/L)	**I**	**II**	**III**	**IV**	**V**	**VI**
Pb	0.33±0.16	0.54±0.53	0.33±0.08	0.46±0.59	0.68±0.81	0.17±0.39
Ni	0.22±0.30	0.44±0.61	0.30±0.25	0.50±0.68	0.35±0.35	0.56±0.66
Cu	0.21±0.28	0.22±0.09	0.41±0.52	0.05±0.04	0.64±0.89	0.57±0.73
Cr	1.08±0.47	0.12±0.08	1.46±0.91	2.67±3.62	1.66±0.57	2.50±0.64
Cd	0.21±0.007	0.19±0.007	0.15±0.06	0.19±0.04	0.15±0.08	0.27±0.03
Al	0.04±0.007	0.03±0.04	0.04±0.02	0.02±0.01	0.09±0.001	0.03±0.03

the waters of River Benue during the study period. However the mean concentration of Aluminum was the lowest at all the studied stations throughout the study period. A perusal at the result in Table 2 revealed that the mean concentration of Chromium, Nickel, Lead and Copper were higher during the dry season as compared to the rainy season throughout the period of the research. Descriptive statistic results of the trace elements is presented in Table 3 showed that Cr have the highest maximum and mean concentration values while Al have the lowest during the study period. During the rainy season the control station had the highest concentration of Cr while Al the lowest (Figure 2). The result in Figure 3 showed that station IV had the highest concentration of

Table 2. Seasonal variation in trace elements in River Benue at Makurdi.

Trace elements(mg/L)	Rainy season	Dry season
Pb	0.19±0.08	0.68±0.40
Ni	0.06±0.05	0.73±0.26
Cu	0.05±0.06	0.66±0.47
Cr	0.97±0.89	2.19±1.75
Cd	0.21±0.02	0.18±0.08
Al	0.04±0.03	0.04±0.03

Table 3. Descriptive statistics of trace elements in River Benue.

Trace elements(mg/L)	Min.	Max.	Mean	Std. Error
Pb	0.04	1.26	0.42	0.11
Ni	0.01	1.03	0.39	0.15
Cu	0.01	1.28	0.35	0.13
Cr	0.06	5.24	1.58	0.42
Cd	0.09	0.30	0.19	0.02
Al	0.00	0.09	0.04	0.008

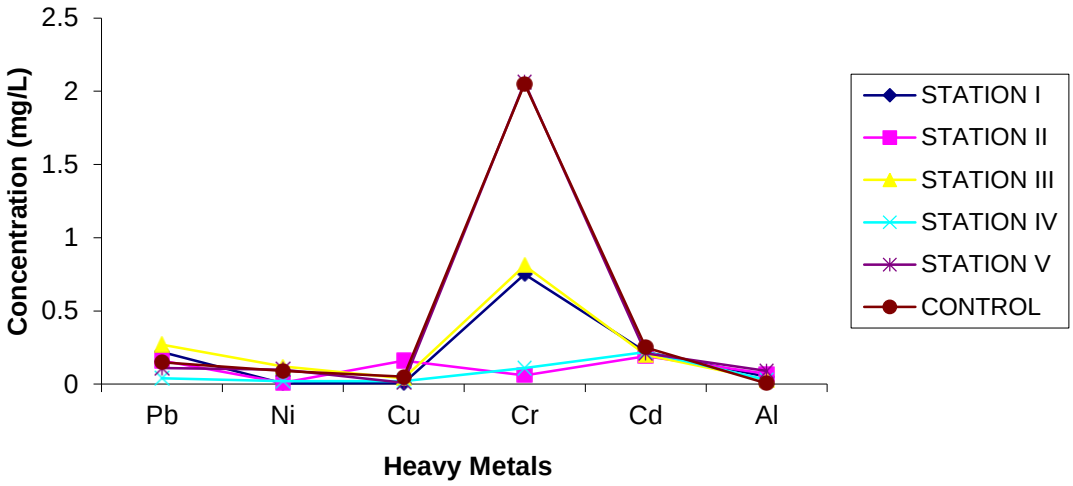

Figure 2. Mean concentration of trace elements in River Benue at Makurdi during rainy season.

Cr and the control the lowest concentration of Al.

DISCUSSION

During the course of this study, heavy metals like Pb, Ni, Cu, Cr, Cd and Al were detected in River Benue at different concentration at the studied locations. The mean value of Pb exceed the maximum permitted value of 0.01 mg/L in drinking water quality (WHO, 2004). Eneji et al. (2011) reported Pb concentration within the drinking water quality standard in River Benue which differs significantly from the findings of this study. Pb is well-known as cumulative poison that has several damaging effects on public health even at trace concentration in the body of humans and organisms (Hong et al., 2014). Therefore Pb concentration in water beyond recommended standard may be detrimental to the health of the consumers. Although Pb is usually found in natural water but not in high concentrations. The level of Pb in River Benue may be due to surface runoff of Pb containing substances like used battery materials into the River during the study period. The result of analysis of variance ANOVA between the seasons showed that there

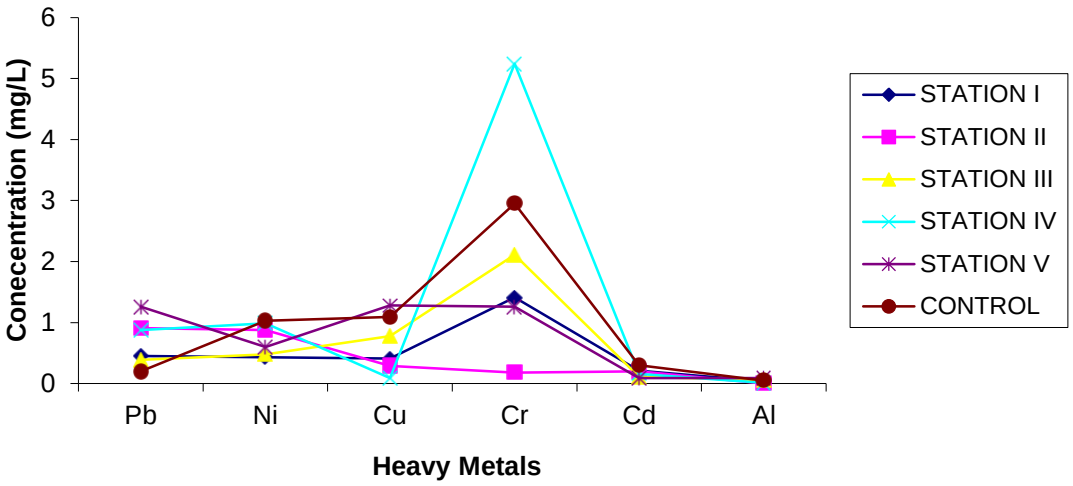

Figure 3. Mean concentration of trace elements in River Benue at Makurdi during dry season.

was significant difference in the concentration of Pb during the rainy and dry seasons (ANOVA – P<0.05). Nevertheless, across the studied stations there was no significant difference (ANOVA – P>0.05). This may be that the season is contributing to the concentration of Pb in River Benue while the station is not. The results of this study agrees with the finding of other studies that reported Pb beyond the permitted limits (Hong et al., 2014; Wangboje and Ekundayo, 2013; Olatunji and Osibanjo, 2012; Aderinola et al., 2009). The result of the seasonal variation of the Pb concentration in the water samples showed that the concentration of Pb during the dry season was higher compared to the rainy season. This may be due to the fact that during the dry season, the quantity of the water is reduced and the concentration therefore increased. This result is similar to the findings of Olatunji and Osibanjo (2012) that reported higher values of Pb during the dry season in lower River Niger drainage in North central Nigeria. Across the stations, station V had the highest Pb concentration while station VI the lowest during the study period. The high concentration of Pb at station V could be attributed to the impact of anthropogenic activities and the heap of waste at this station that leached waste directly into the River Benue.

During the course of this study Ni ranged from 0.01 to 1.03 mg/L in River Benue with a mean concentration of 0.40 mg/L. This result exceeds the maximum permitted concentration of Ni of 0.02 mg/L in drinking water quality (WHO, 2004). Studies have shown that drinking water with more 0.02 mg/L of Ni may be carcinogenic (WHO, 2004). The findings of this study conform to that of other studies that reported Ni in surface waters beyond the WHO recommended value (Wangboje and Ekundayo, 2013; Tabinda et al., 2013; Olatunji and Osibanjo, 2012; Yahaya et al., 2012, Aderinola et al., 2009; Enuneku et al., 2013). However, the result of Ayas et al. (2007) differs significantly from this study. They did not detect Ni in the water of Nallihan Bird Paradise, Turkey. A perusal at the result of concentration of Ni in River Benue showed that during the dry season, the concentration of Ni in the water samples across the station was higher as compared to the rainy season. This could be attributed to the dilution factor and anthropogenic sources such as the activities of brewery and food processing industries on the bank of the River that push their effluents into the River directly. Similarly, the result of ANOVA was significant during the seasons (ANOVA-P<0.05). This is because the season is contributing to the increase and decrease in the concentration of Ni in River Benue at Makurdi during the period of the study. The high concentration of Ni during the dry season as compared to rainy seasons is similar to the findings of others studies (Olatunji and Osibanjo, 2012). However, the result of this study differs significantly from the findings of other studies that reported higher concentration of Ni in rainy season as compared to the dry season (Tabinda et al., 2013). Across the stations, station VI had the highest Ni concentration and station I the lowest. The high concentration of Ni at station VI could be attributed to anthropogenic impact of industrial activities located on the bank of River Benue. The result of ANOVA showed that there was no significant difference in the concentration of Ni across the studied stations (ANOVA-P>0.05). This indicate that the stations were not impacting on the concentration of the Ni in river Benue during the study time.

The concentration of Cu in the surface water of river Benue during the course of this study varied from 0.01 to 1.28 mg/L with a mean concentration of 0.33 mg/L. This result falls within the WHO recommended standard (WHO, 2004). This result is similar to the earlier result obtained in River Benue that reported Cu level within the recommended standard (Eneji et al., 2011; Akaahan et

al., 2014). Copper is an essential element that facilitates the action of some enzymes in the body of humans. Other studies elsewhere also reported Cu concentration within the recommended standard (Wangboje and Ekundayo, 2013; Ayas et al., 2007; Aderinola et al., 2009). Nevertheless the result of other studies differs significantly with the findings of this study that reported the concentration of Cu in surface waters beyond the recommended concentrations (Ekpo et al., 2013; Olatunji and Osibanjo, 2012; Hong et al., 2014). A perusal at the seasonal variation in the level of Copper in River Benue during the study period showed that the concentration of Copper during the dry season was higher as compared to the rainy season. Possible reasons could be decreased in concentration as a result of reduced quantity of water in River during the dry season. This finding agree with other studies that reported higher concentration of Cu in surface water during the dry season as compared to the rainy season (Olatunji and Osibanjo, 2012; Akaahan et al., 2014). However, the result of this study disagree with the findings of other studies that reported higher values of Cu during the rainy season as compared to the dry season (Tabinda et al., 2013). The result of ANOVA showed that there was a significant difference in the level of Cu in River Benue during the season (ANOVA – $P<0.05$). This may be attributed to the fact that the concentration of Cu in River Benue was increasing and decreasing with respect to the season. Similarly across the sample locations, location V had the highest mean copper concentration while station IV the lowest during the course of the study. The highest concentration of Cu at station V may be attributed to the heap of wastes at this station and leachates from the wastes that are washed directly into the River Benue at this point. All the same, there was no significant difference in Copper concentrations at the studied locations on the bank of River Benue (ANOVA – $P>0.05$).

The level of Cr in River Benue during the study period varied from 0.06 to 5.24 mg/L with a mean concentration of 1.58 mg/L. This value is higher than the WHO recommended standard of 0.05 mg/L of Cr in drinking water (WHO, 2004). Elevated concentration of Cr in water may cause cancer to the consumers of the water without adequate treatment (WHO, 2004). The result of this study is similar to the result of an earlier study in River Benue at Makurdi that reported Cr in excess of the recommended standard (Eneji et al., 2011). Cr is a key element in the metabolism of sugar in plants and animals and also regulate the rate of played by insulin molecules in transporting glucose into the cells for glycolysis. The result of this study is similar to other studies that reported higher concentrations of Cr beyond the recommended standard (Hong et al., 2014; Olatunji and Osibanjo, 2012; Aderinola et al., 2009; Ekpo et al., 2013). All the same the result of this study differs significantly from the findings of other studies that reported Cr below the recommended standard (Akintujoye et al., 2013; Wangboje and Ekundayo, 2013). The result of the seasonal variation of Cr concentration showed that higher concentrations of Cr were obtained during the dry season as compared to the rainy season. Reduced water quantity and human impact through industrial production could be the plausible reasons for this scenario. This situation is also reported by other studies at different places (Olatunji and Osibanjo, 2012). However, some other studies reported higher value of Cr during the rainy seasons as compared to the dry season (Tabinda et al., 2013). All the same, there was no significant difference in the concentration of Cr during the course of the study (ANOVA $P>0.05$). This may be due to the fact that other factors rather seasons are impacting on the concentration of Cr in River Benue at Makurdi.

Across the stations, station IV had the highest Cr concentration while station II the lowest. The highest Cr concentration at station IV may be due to surface runoff of effluents from Makurdi water works into this station that is after the water works. No significant difference was observed across the stations in the concentration of Cr (ANOVA $P > 0.05$). This may be attributed to the fact that the stations are independent of each other during the study period.

The concentration of Cd in River Benue during the study period varied from 0.09 to 0.30 mgg/L with a mean concentration of 0.19 mg/L. This value exceeds the recommended concentration of 0.003 mg/L of Cd in drinking water quality (WHO, 2004). Studies have shown that elevated concentrations of Cd is toxic to the kidney (WHO, 2004). This result is similar to the result of an earlier study that reported Cd above the acceptable limits in the surface water of River Benue (Eneji et al., 2011). However, the result of this study is also similar to the result of other studies elsewhere that reported Cd in surface water beyond the acceptable limits (Hong et al., 2014; Wangboje and Ekundayo, 2013; Olatunji and Osibanjo, 2012; Aderinola et al., 2009; Ekpo et al., 2013; Yahaya, et al., 2012; Asante et al., 2013; Akintujoye et al., 2013).

Similarly the result of this study differ significantly from the findings of other studies that reported Cd concentration in surface waters that within the acceptable limit for drinking water quality (Ayas et al., 2007; Abah et al., 2013). During the seasons, a different situation was noticed compared to the other heavy metals. The Cd concentration during the rainy season was higher as compared to the dry season. However, the result of this study differs significantly from that of Olatunji and Osibanjo (2012) that reported higher concentration of Cd during dry season as compared to the dry season. There was no significant difference in the concentration of Cd across the stations and between the seasons (ANOVA- $P > 0.05$). This could be attributed to the fact that concentration of Cd in River Benue during the study time was independent of season and stations.

During the period of this study the concentration of Al in

the surface water samples of River Benue ranged from 0.00 to 0.09 mg/L with a mean value of 0.04 mg/L. The mean value of Al during the study period was within the acceptable limit of 0.2 mg/L in drinking water quality (WHO, 2004). During the course of this study there was no significant difference in the concentration of Al across the stations and between the seasons (ANOVA- P > 0.05). This could be that Al concentration in River Benue is independent of season and stations but due to other unknown factors. However, the result of this study differs significantly from that of Gidde et al. (2012) who reported the concentration of Al in surface water below the acceptable limit.

Conclusion

The result of this study indicate the significant concentration of trace elements in the waters of River Benue at the studied stations. The mean value of trace elements like Pb, Ni, Cr and Cd, were above the maximum permissible level allowed for drinking water quality set up by WHO. This situation pose a threat to the health of humans who depends directly on this water source for consumption without adequate treatment.

Conflict of Interest

The authors have not declared any conflict of interest.

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