ChemSearch Journal 10(2): 54 – 61, December, 2019
Publication of Chemical Society of Nigeria, Kano Chapter

Received:16/09/2019 Accepted:17/10/2019
http://www.ajol.info/index.php/csj

Physicochemical Parameters, Levels of Cu and Pb in Water and Water Lily Plant from the Bank of River Benue

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ABSTRACT

In this study three (3) water samples were collected from the River Benue Basin, within the catchment of the Benue State Works. The water samples were collected at different points within this region alongside water Lilly plants at the same points in the study area. This research was aimed at assessing the physicochemical properties and heavy metals (Cu and Pb) content in water and water lily plant around Benue Water Works in Makurdi. The physicochemical parameters of the water samples as well as determination of Cu and Pb in the water samples, and water lily plant was done using standard methods. Results were compared to the World Health Organisation (WHO) guidelines to assess suitability. The results of the physicochemical parameters were either below or within the accepted limit except for colour (179 - 220 mg/units) and electrical conductivity (919 – 1760 µS/cm) which were above the WHO recommended limits of 15 TCU and 1000 µS/cm respectively. Trace metal contamination was exceedingly above WHO recommended level of 0.01 mg/L for Pb in water. Similarly, Pb concentration (48.5 – 53.6 mg/kg) in the plant samples was above the WHO/FAO recommended value of 5 mg/kg indicating pollution. It was concluded that the water is not completely safe for drinking and with the high level of Pb both in the water and plant samples, the water poses environmental health risk to inhabitants and the society in general.

Keywords: Heavy metals, Physicochemical parameters, Water quality, WHO/FAO guidelines

INTRODUCTION

The environment is progressively being altered in recent times through the activities of man and his technological advancement (Essoka *et al.*, 2006). Through urbanization, industrialization and technology, man has developed the capacity to alter the natural interaction to an extent that the environment has been threatened to a devastating point (Greaney, 2005). The role of heavy metals in the environmental matrices is increasingly becoming an issue of global concern to farmers, policy makers and researchers.

Heavy metals have become a widespread problem around the world in recent years (Castro-González and Méndez-Armenta, 2008). The level of heavy metals in the environment varies between different regions resulting in spatial variations of its concentration (Morais *et al.*, 2012). Although heavy metals occur naturally in the earth's crust, they tend to be concentrated in agricultural soils because of the application of commercial fertilizers, manures and sewage sludge containing heavy metals (Zeng *et al.*, 2008). According to Essoka *et al.* (2006) oil industries constitute a major source of pollutants to the environment especially through liquid discharges and oil spills as well as gas flaring resulting in atmospheric deposition of metals. Osam *et al.* (2013) added that activities such as burning of fossil fuel, smelting and discharge of industrial, agricultural and domestic waste as well as deliberate application of pesticides are some of the pathways by which heavy metals are released into the environment. Anthropogenic activities such as petroleum prospecting and mining as well as oil spillage are also major sources of heavy metals in the environment (Osuji and Onojake, 2004).

Contamination of the soil ecosystem with heavy metals is thus a critical environmental problem (Babatunde *et al.*, 2014). The presences of heavy metals in the soil subsequently enter the food web through plants which eventually constitutes health risk to plants, humans and animals when they bioaccumulate in the tissues of plants and animals. Boran and Altynok (2010) described heavy metals as one of the most harmful pollutants because of its toxicity.

The loading of ecosystems with heavy metals may be due to excessive fertilizer and pesticide use, irrigation, atmospheric deposition, and pollution by waste materials (Aydinap and Marinova, 2003). The source of heavy metals in plants is the environment in which they grow and the soil from which heavy metals are taken up by roots or foliage (Okonkwo *et al.*, 2005). Plants grown in polluted environments can accumulate heavy metals in high concentration causing serious risk to human health when consumed. (Kisamo, 2003).

Heavy metals are very harmful because of their non-biodegradable nature, long biological half lives and potential to accumulate in different body parts (Arora *et al.*, 2008). Most of the heavy metals are extremely toxic because of their solubility in water. Even low concentrations of heavy metals have damaging effects on man and animals because there is no good mechanism for their elimination from the body (Chen *et al.*, 2005). Food and water are the main sources of man's essential metals; they are also the route through which he is exposed to various toxic metals. Heavy metals are easily accumulated in the edible parts of leafy vegetables, as compared to grain or fruit crops (Mapanda *et al.*, 2005).

In most cases in Makurdi, crops are cultivated on and around the river banks. These crops have the tendency to accumulate heavy metals in their edible parts and consumption by man may result in severe implication on health. The problem therefore is lack of awareness of the likely effect of cultivation and consumption of crops cultivated on such soils hence this research.

MATERIALS AND METHODS

Study Area

The study was carried out in Makurdi metropolis, Makurdi Local Government Area of Benue State, North Central Nigeria. Benue State has a fluctuating temperature of 21-37℃ with annual rainfall in the range of 100 – 200 mm. Its geographical coordinates are longitude 7° 47′ and 10° 0′ East, Latitude 6° 25′ and 8° 8' north. Makurdi is the state capital and also the headquarters of Makurdi local government area. The town is divided into north and south banks. 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.

The Makurdi Water Works is the major commercial hub that provides domestic water supply to the residents of Makurdi. It is located at the Bank of the River Benue, about 600 m away from New Bridge and 4.5 km away from Wadata Market. Effluents from the new and old bridges flow directly through the Benue Water Works (Figure 1). The choice of site is based on the proximity to refuse dumps, water traffic, human activities such as washing, discharge of human waste, buying and selling of fresh fish, and the cultivation of crops by farmers for sale in Makurdi and neighboring towns and villages.

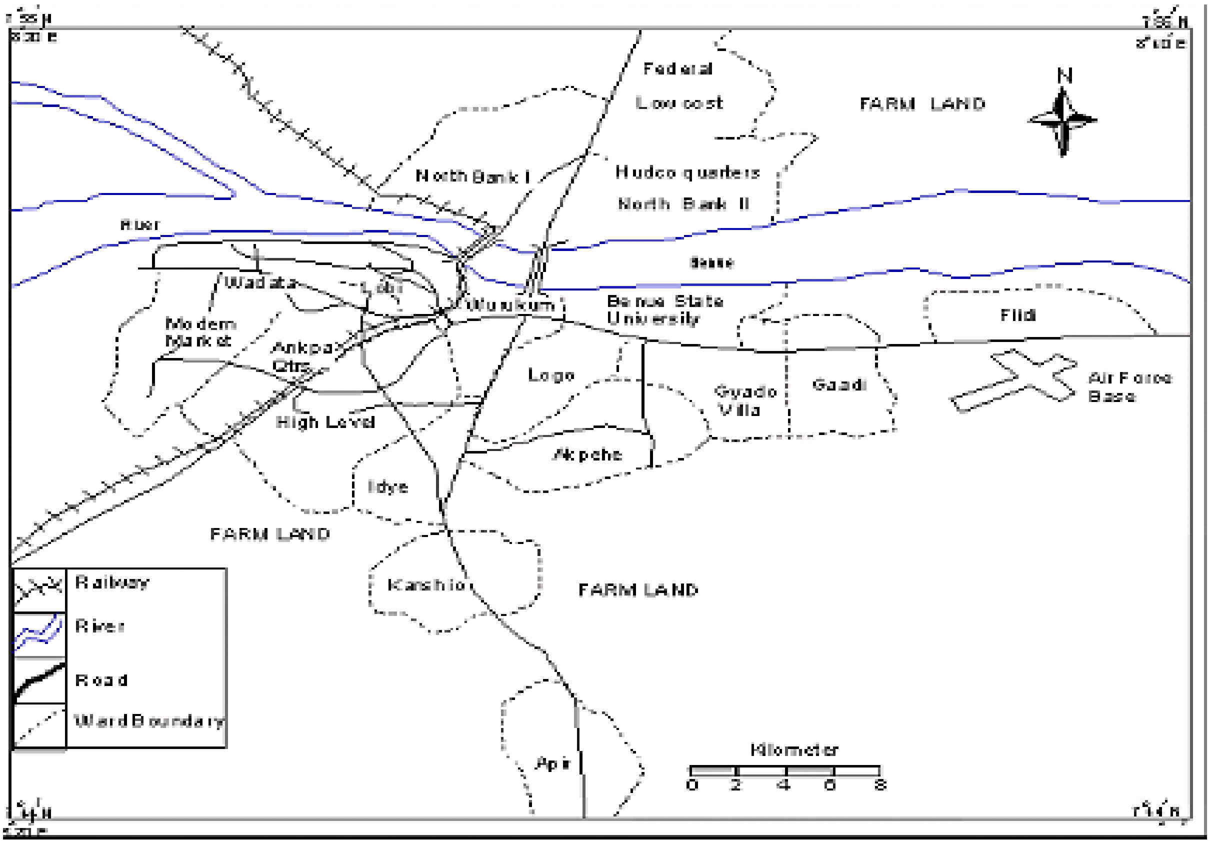

Figure 1. Map of Makurdi metropolis showing the study location; Source: Nnamonu *et al*. (2015)

Water Sampling and Preparation

Three (3) water samples were collected from the River Benue basin, within the catchment of the Benue State Water Board. Three water samples were collected at different points (To produce a composite sample) within this region into a 500 mL plastic bottle that were washed and soaked in 10% nitric acid for 24 h, rinsed thoroughly with double distilled water and oven dried APHA (2005). The water samples for heavy metal analysis were acidified with 1% HNO_3. In the laboratory, the water samples were filtered through Whatman's 0.45 µm membrane filter paper. One hundred milliliters of the filtered water was mixed with 5 mL HNO_3 and 5 mL H_2SO_4. To allow the acids to become concentrated, the mixture was heated until the volume was reduced to about 15 to 20 mL (Asante *et al.*, 2007). The digested samples were allowed to cool to room temperature. It was then filtered through Whatman's 0.45 µm filter paper. The final volume was adjusted to 100 mL with double distilled water and stored for analysis.

Analysis of water sample

Physicochemical parameters studied in this work which include electrical conductivity (EC), colour, turbidity, total dissolved solids (TDS), total suspended solids (TSS), pH, dissolved oxygen (DO), biological oxygen demand (BOD), chloride (Cl^-), total hardness were determinedusing the standard laboratory methods described by APHA (2005). All measurements were carried out in triplicates.

Plant sampling and Preparation

Water Lilly plants were collected at three different points in the study area. The plant samples were packed in polythene bags and transported to the laboratory for analysis. Plant samples were also washed thoroughly with distilled water to remove any particle on the leaves of the plants. Each plant sample was placed in a brown envelope and kept in the oven at 70 - 80 °C until constant dry weight was attained. The samples were then milled into a powdery form. The milled samples were passed through a 2 mm sieve and then stored in well labeled plastic polythene bags for acid digestion in order to determine the presence of heavy metals in the samples.

Digestion of plant samples

For each plant sample, 0.5 g was weighed into a 100 mL conical flask and 5 mL of concentrated H_2SO_4 was added and left to react overnight. The sample was then placed on a hot sand bath at 95 °C for some time and few drops of hydrogen peroxide (H_2O_2) were added until the samples completely oxidized. After cooling, the digested samples were filtered into 100 mL volumetric flask and made up to the mark with distilled water.

Heavy Metal analysis of water and plant samples

Flame Atomic Absorption Spectrophotometry; Varian SpectrAA 600 Model was used to measure the metals (Cu and Pb) both in the water and plant samples.

RESULTS

Table 1 shows the results of the physicochemical properties of the water and heavy metals in the water and plant samples analysed; Total dissolved solid (TDS), Total soluble solids (TSS), Electrical conductivity, turbidity and color. The values of TDS, TSS and turbidity were expressed in mg/L while electrical conductivity and color were expressed as µS/cm and mg/units respectively. The values obtained for sample A were 395, 38, 1760, 1.83 and 220 for TDS, TSS, Conductivity, Turbidity and color respectively. Sample B had 635, 36.5, 979, 1.15 and 180 for all the measured parameters in that order. Sample C had 622, 37, 919, 1.76 and 179 accordingly. Other parameters measured were pH, total hardness, biological oxygen demand (BOD), dissolved oxygen (DO) and chloride ions. The values for each parameter were expressed in mg/L. The values obtained for sample A across the parameters were; 5.99, 100, 3.0, 6.2, and 213 respectively. Sample B had 6.13, 105, 5.0, 5.7 and 35.5 across the parameters accordingly. Sample C had 5.96, 112, 3.6, 5.6 and 35.5 respectively.

Heavy metal concentration in water was measured in (mg/L). Copper content in sample A was 0.0323, B had 0.0243 while that of C was recorded to be 0.0231. The Pb content in samples A, B and C were recorded to be 0.135, 0.190 and 0.152 respectively. The values of heavy metals in water lily plant measured in (mg/kg). Copper content in the three samples were recorded to be 7.10, 4.28 and 5.50 respectively while that of Pb in the samples were recorded to be 53.6, 48.5 and 53.3 respectively.

Table 1: Result of the physicochemical parameters of the water sample

Sample	pH	EC (µS/cm)	Turbidity (mg/L)	Colour (TCU)	Hardness (mg/L)	TDS (mg/L)	TSS (mg/L)	DO (mg/L)	BOD (mg/L)	Cl^-(mg/L)
A	5.99 ± 0.01	1760 ± 1.20	1.83 ± 0.02	220 ± 2.20	100 ± 2.20	395 ± 6.00	38.0 ± 2.60	6.20 ± 0.02	3.00 ± 0.05	213 ± 4
B	6.13 ±0.18	979 ±3.30	1.15 ± 0.01	180 ± 0.60	105 ± 1.20	635 ± 8.00	36.5 ± 1.20	5.70 ± 0.04	5.00 ± 0.1	35.5 ± 2.4
C	5.96 ± 0.02	919 ± 0.05	1.76 ± 0.04	179 ± 2.50	112 ± 1.10	622 ± 7.00	37.0 ± 3.50	5.60 ± 0.01	3.60 ± 0.01	35.5 ± 2.4

Sample A = Water sample collected close to the Water Board Sample; B = Water sample collected 15 m away from sample A Sample C = Water sample obtained across the river bank

Table 2: Concentration of Cu and Pb in the water and Lily plant samples

Sample ID	Cu	Pb
Water sample (mg/L)		
A	0.0323 ± 0.001	0.135 ± 0.001
B	0.0243 ± 0.00	0.190 ± 0.002
C	0.0231 ± 0.001	0.152 ± 0. 001
Mean	0.0266 ± 0.001	0.159 ± 0.01
Lily plant sample (mg/kg)		
A	7.10 ± 0.10	53.6 ± 0.50
B	4.28 ± 0.02	48.5 ± 0.20
C	5.50 ± 0.30	55.3 ± 0.30
Mean	5.63 ± 0.10	52.5 ± 0.50

Sample A = Water sample collected close to the Water Board Sample; B = Water sample collected 15 m away from sample A; Sample C = Water sample obtained across the river bank

DISCUSSION

The results of electrical conductivity in sample B and C were below the WHO (2004) limit of 1000 μS/cm while that of sample A is above the standard as shown in Table 2. Although conductivity is not a human or aquatic health concern, it serves as an indication of other water quality problems (Dan *et al.,* 2014).. The values of electrical conductivity recorded in this study are similar to those found by Oluyemi *et al*. (2012) in some selected areas of Ife - North Local Government of Osun State Nigeria.

Total dissolved solids (TDS) of water measures the amount of inorganic and organic substances dissolved in water. The values of TDS measured at all sampling sites were below the WHO (2004) permissible limit of 1000 mg/L as shown in Table 2 above. The TDS value of water close to 600 mg/L is acceptable whereas those greater than 1000 mg/L is unpalatable for human consumption (Apau *et al.,* 2014). Samples A, B and C showed TDS of 395, 635 and 622 respectively which are all below the standard values set by WHO (2004). Some treatments such as addition of coagulants may be required to make these waters suitable for domestic purposes. The results of TDS in this study is similar to those reported by Raji *et al.* (2015) from water samples collected in River Sokoto, North-Western Nigeria.

Total suspended solids (TSS) give a measure of the turbidity of the water. TSS was higher in sample A followed by sample B as shown in Table 2. Total suspended solids just like turbidity measures the transparency of the water sample. A high TSS value as in sample A (38.0 mg/l) indicates an equally high turbidity. The TSS values in this study were well within the permissible limits of 1700 mg/l set by (WHO, 2004). The results of TSS in this study is similar to those reported by Raji *et al.* (2015) from water samples collected in River Sokoto, Northwestern Nigeria.

Turbidity is a measure of water clarity how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. Turbidity values were low for samples B and C, but relatively higher for sample A. Turbidity indicates the degree of interference, scattering or absorption of light or the reduction of transparency in water due to the presence of particulate matter such as clay or slit, finely divided organic matter, plankton or other microscopic organisms. The higher the turbidity values the lower the light transparency. Sample B has low turbidity value which indicates a high transparency. Sample A has high turbidity value which indicates the density of debris which shields the passage of light.

The colour assessment of the samples ranged from 179 to 220 TCU. Sample A recorded the highest value followed by sample B while sample C had the least value. Colour in water may be due to the presence of organic matter such as humic substances, metals such as iron and manganese, or highly coloured industrial wastes. The result obtained for colour in this study is above the standard of 15 TCU set by (WHO, 2004).

The pH of the water samples in this study ranged from (5.96 - 6.13) which is acidic for human consumption. The pH value of water below 6.5 is regarded as acidic for human consumption because it can cause health issues such as acidosis and damage to the digestive and lymphatic system (Nkansah *et al.*, 2010). At lower pH, the solubility of toxic metals in water increases and makes it harmful for consumption. According to Kim *et al.* (2002) the pH of this range may be attributed to the effects of bicarbonates, geology of the area and the buffering capacity of the water system. This result is in line with those reported by Koffi *et al.* (2014) and Mohamed & Zahir (2013) in Ivory Coast and India respectively.

Dissolved oxygen (DO) is the amount of gaseous oxygen dissolved in water. The DO in water is a very important parameter in water quality because it serves as an indicator of the physical, chemical and biological activities of the water body (Manikannan *et al.,* 2011). The DO values measured in sample A, B and C were below the WHO (2008) standard of 7.5 mg/L as shown in Table 2. The presence of high concentration of organic matter, dissolved gases and domestic effluents leaching into the water system decreases the oxygen content of water. High salinity and temperature is known to affect the dissolution of oxygen in water bodies (Manikannan *et al.*, 2011).

Biochemical oxygen demand is used to measure the amount of biochemically degradable organic matter present in water. According to Oluyemi *et al.* (2012), BOD values less than 6 mg/L suggests that the water is least polluted with organic matter. Sample A recorded the lowest BOD followed by sample C while the highest BOD was recorded in sample B. This suggests that the water from the sample area is less polluted by organic matter and they could support aquatic life.

Total hardness is a measurement of the mineral content in a water sample that is irreversible by boiling. Total hardness of the water sample ranged from 100 - 112 mg/L. Total hardness as shown in Table 1 shows that sample C has the highest value followed by sample B while sample A had the least value. The concentration obtained in this study is below the (WHO, 2008) permissible limit of 500 mg/L.

The chloride ion in the water samples analyzed is below the level of 250 mg/L set by WHO (2008) as shown in Table 1. Chloride concentrations in excess of about 250 mg/L can give rise to detectable taste in water, but the threshold depends upon the associated cations.

Copper enters the water system through mineral dissolution, industrial effluents or use of pesticides (Gyamfi *et al.*, 2012). The amount of copper detected in water at all sampling points was below the WHO (2008) permissible limit of 2 mg/L. The mean concentration of Cu in water was found to be 0.027 mg/l as shown in Table 2. However, some amount of copper are required for metabolism and the synthesis of haemoglobin, myoglobin, cytochromes and several enzymes (Maughan, 1999) whereas high consumption of copper may lead to neurological complications, hypertension, liver and kidney problems (Krishna & Govil, 2004).

The mean concentration of lead in the water sample (0.159 mg/L**)** exceeded the WHO (2004) permissible limits of 0.01 mg/L. Hence, the consumption of water can pose a significant risk to the consumers. The findings of lead in water which ranged from 2.79 to 6.64 mg/L by Oluyemi *et al.* (2012) were higher than those reported in this study. Lead is known to induce a broad range of physiological, biochemical, and behavioural dysfunction in human and animals which affects the central and peripheral nervous system, cardiovascular system, kidney, and liver (Hsu & Leon, 2002).

According to planks (1973) normal Cu concentration in plants should range from 5 - 20 mg/kg where concentration higher than 20 mg/kg may be harmful to plants. However, WHO/FAO (2007) recommended a guideline value of 40 mg/kg. The concentration of copper recorded in this study fell within the normal range of Cu required by plants for growth and development. However, the concentration of Cu recorded in this study was below the permissible limit set by WHO/FAO (2007). The mean concentration of copper in the plant samples as shown in Table 2 is 5.63 mg/kg.

The mean concentration of lead in the water lily plant analysed, exceeded the WHO/FAO (2007) guideline value of 5 mg/kg. The high concentration of lead found in the water lily plants may be attributed to the release of domestic effluent containing lead, automobile exhaust, industrial emissions, smoke and dust emissions from gas and petrol fired stations. The high level of lead in plants can cause anaemia, headache, brain damage, and nervous system disorder to humans and animals (Rehman *et al.*, 2013).

CONCLUSION

The physiochemical parameters of water samples were examined to evaluate the quality of drinking water. The results of the physicochemical parameters of water samples revealed that most of the water quality parameters were within the World Health Organization limits (2008) with the exception of colour and electrical conductivity, which was relatively higher indicating some source of pollution. The concentration of the heavy metals in water and plant was below the WHO, 2004; WHO, 2008) standards except Pb which exceeded the WHO (2004) permissible limit. It is therefore, observed that the water sources from the studied area have a lot of potentials for wide applications to the people if only they can be subjected to further treatments that will reduce drastically, the concentration of the few identified elements parameters that may pose some danger to health and the society. There is need for proper enforcement of environmental laws by relevant authorities, particularly on illegal dumping/discharge of waste into rivers. Remediation process for Pb in the area is therefore recommended.

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