American Journal of Engineering Research (AJER)
E-ISSN: 2320-0847 p-ISSN: 2320-0936
Volume-8, Issue-3, pp-32-38
www.ajer.org
Research Paper Open Access

Heavy Metals in Water and Plants along Rivers Dilimi and Jenta, Jos. Plateau State, Nigeria.

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ABSTRACT: *Heavy metals contamination represents one of the most pressing threats to water and plant resources as well as human health. The use of polluted river water for irrigation can lead to the accumulation of heavy metals into plants and get into the human body when consumed as food. These heavy metals can cause an array of diseases. This study aimed at assessing the concentration of heavy metals (Cd, Zn, Co, Pb and Ni) in water and plants in the study area, along rivers Delimi and Jenta in Jos North LGA of Plateau State. Water and plant samples were collected from five (5) different irrigation sites in the area, namely Congo, Katakobridge and AnguwanRogo, along the Dilimi river, and JentaMangoro and Anguwan Soya, along River Jenta. The samples were analyzed to determine the concentration of the heavy metals using the Atomic Absorption Spectrometer. Results show that the concentration of the heavy metals in all the plant samples were found to be less than the permissible limit set by WHO/FAO except Lead (Pb) which was higher than the permissible limit.Similarly, the concentration of Pb in the water samples was higher than the WHO/FAO limit. The concentration of Cadmium (Cd) from all the sample sites was also above the permissible level. The concentration of Nickel (Ni) was above the permissible limit at sample points W1, W4 and W5. As such these put the consumers of vegetable crops/plants from these sites at high risk of Pb intake. The variation in these concentrations was confirmed using ANOVA statistical analysis.*

***KEYWORDS**- Heavy metals, Contamination, Concentration, threats, Intake, water, plant, disease.*

Date of Submission: 20-02-2019 Date of acceptance: 08-03-2019

I. INTRODUCTION

As human activities increases, especially with the application of modern technologies, pollution and contamination of the human food chain has become inevitable. Heavy metals uptake by plants grown in polluted soils and water has been studied as a considerable extent [1]. Heavy metal exposure is not an entirely modern phenomenon: historians have cited the contamination of wine and grape drinks by lead-lined jugs and cooking pots as a contributing factor, in the "declining and fall" of the Roman empire and the Mad Hatter character in Alice in Wonderland was likely modeled after nineteenth-century that makers who used mercury to stiffen hat material and frequently became psychotic from mercury toxicity [2].

Human exposure to heavy metals has risen dramatically in the last 50 years, however, as a result of an exponential increase in the use of heavy metals in industrial processes and products.Their contamination in vegetables cannot be underestimated since these foodstuffs are important components of the human diet. Heavy metal contamination of food items is one of the most important aspects of food quality assurance [3]. International and national regulations on food quality have lowered the maximum permissible levels of toxic metals in food items due to an increased awareness of the risk; these metals pose to food chain contamination [4].

The risk of contaminants accumulating in soil, environment and crops due to sewage water, fertilizer and pollutants are of serious concern. Heavy metals have been reported to produce mutagenic, teratogenic, neurotoxic and carcinogenic effects even at very low concentrations [5]. Human beings have also been reported to develop several diseases like cardiovascular, tubular dysfunction in kidneys and nervous disorders due to metal toxicity [6].

It has been established that most of the solid waste generated in the city is dumped in the rivers [7]. According to [8], Rivers Delimi and Jenta are the major source of water for irrigation in and around the Jos city. These rivers containasubstantial amount of beneficial nutrients and toxic heavy metals, which creates opportunities and problems for agricultural production. Excessive accumulation of heavy metals in Agricultural soils through wastewater irrigation, not only result in soil contamination but also lead to elevated heavy metal uptake by crops and thus affect food quality and safety. As a result, heavy metal accumulation in soils plants is of increasing concern because of the potential human health risks.

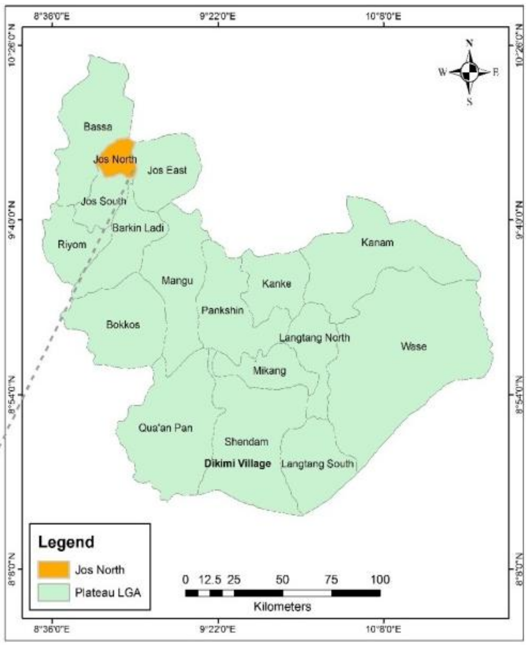
II. MATERIALS AND METHOD

2.1 Study Area

Jos – North local government is located at the extreme north of Plateau State on Latitudes 09^0 53^1 and 09^0 59^1 North, and Longitudes 08^0 51^1 and 09^0 02^1 East. It shares boundary to the North with Toro Local Government Area of Bauchi State; to the South with Jos-South Local Government area; to the North-East with Jos-East Local Government Area; and to the West with Bassa Local Government Area [9].

Jos-North Local Government enjoys a temperate climate with average temperatures of between 28^0C (81.7^0F) maximum and 11^0C (51.7^0F) minimum. It covers the total land area of 291 km^2 (112 sq mi) with the 2006 provisional population census figure of 429,300 people.The warmest temperatures usually occur in the dry season months of March and April [10]. Similarly, Jos-North Local Government is characterized by a mean annual rainfall of between 1317.5mm (131.75cm) and 1460.00mm (146.0cm), mostly in May to August. The Onset and Cessation of rainfall in Jos-North are experienced in April (±15 days in April), and October (±15 days in October). Relative humidity is characterized by a marked seasonal variation [11].

The Jos Plateau makes it the source of many Rivers in northern Nigeria including the Kaduna Gongola, Hadejia and Yobe River [12]. As a result, this study was conducted at two major rivers; the Delimi and Jenta of Jos North Local Government Area of Plateau State in Central Nigeria. Water from these streams is used for domestic purposes and irrigation. The portion of the River Delimi and River Jenta studied are located at latitude 9^o 52'59N" and longitude 8^o 54'26". Figure 1 shows the location of the study area in Plateau State while Figure 2 shows the location of the sample points along rivers Delimi and Jenta.



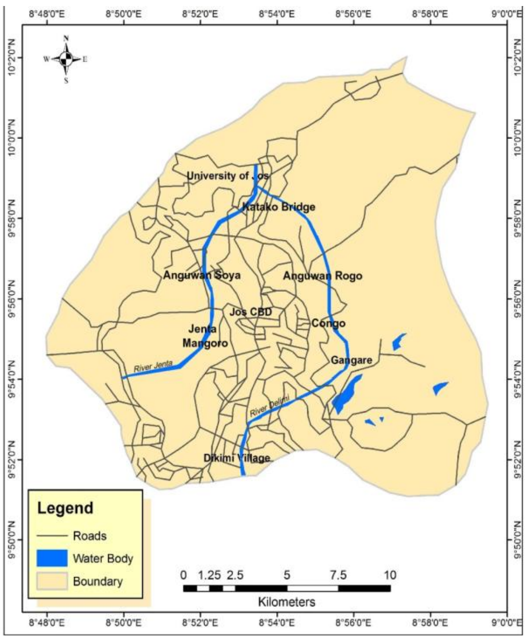


Figure 1: Plateau State Showing Jos-North **Figure 2: Rivers Delimi and Jenta**

2.2 Sample Collection

A total of 14 samples comprising of two types of plants (Spinach and Maize Foliage) alongside water samples each from the five sites along River Delimi and River Jenta where taken for laboratory analysis (see Tables 1 and 2).

Table 1: Samples Collection Points for Spinach

Sample	Site description
SS I	Congo along river Delimi
SS II	AnguwanRogo along River Delimi
SS III	Katako bridge along River Delimi
SS IV	JentaMangoro along river Jenta
SS V	Anguwan Soya along rive Jenta

SS = Spinach sample

Table 2: Samples Collection Points for Maize Foliage

Sample	Site description
MF_1	Congo along river Delimi
MF_2	AnguwanRogo along River Delimi
MF_3	Katako bridge along River Delimi
MF_4	Jentamangoro along river Jenta
MF_5	Anguwan Soya along rive Jenta

MF = Maize Foliage sample

Table 3: Samples Collection Points for Water Sample

Sample	Site description
W_1	Congo
W_2	AnguwanRogo
W_3	Katako
W_4	Jenta
W_5	Angwan Soya

W = water sample

III. RESULTS

Table 4:Concentration of Zn, Pb, Ni, Co and Cd in water from all the Sampling Sites

Element	W1	W2	W3	W4	W5	WHO/FAO Limit
Zn	0.042	0.000	0.000	0.048	0.265	5.000
Pb	0.185	0.111	0.185	0.111	0.111	0.050
Ni	0.038	0.016	0.016	0.027	0.038	0.020
Co	0.127	0.127	0.127	0.127	0.127	0.010
Cd	0.000	0.000	0.127	0.000	0.000	0.005

Table 5 Concentrations of Heavy Metals from All Sampling Sites

Sampling Site/Type	Zn	Pb	Ni	Co	Cd
SS1	0.619	0.407	0.147	0.127	0.000
SS2	0.642	0.782	0.158	0.127	0.000
SS3	0.662	0.481	0.147	0.127	0.000
SS4	0.756	0.407	0.136	0.127	0.000
SS5	0.921	1.074	0.179	0.127	0.000
MF1	0.824	0.630	0.136	0.091	0.000
MF2	0.401	1.074	0.158	0.127	0.000
MF3	0.000	0.000	0.000	0.000	0.000
MF4	0.409	0.407	0.168	0.127	0.000
MF5	1.577	1.222	0.168	0.127	0.000
WHO/FAO Limit	99.400	0.300	67.000	50.000	0.200

3.1 Concentration of Lead (Pb)

Figure 4 illustrates the concentration of Lead (Pb) in all sample locations. The highest concentrations are in sample locations W1 (Congo) along Delimi river and W3 (Katako) also along the Delimi river. Concentrations were lower in W2 (AngwanRogo) along the Delimi, as well as W4 (Jenta) and W5 (Agwan Soya) both along River Jenta. However, their means showed some variation.

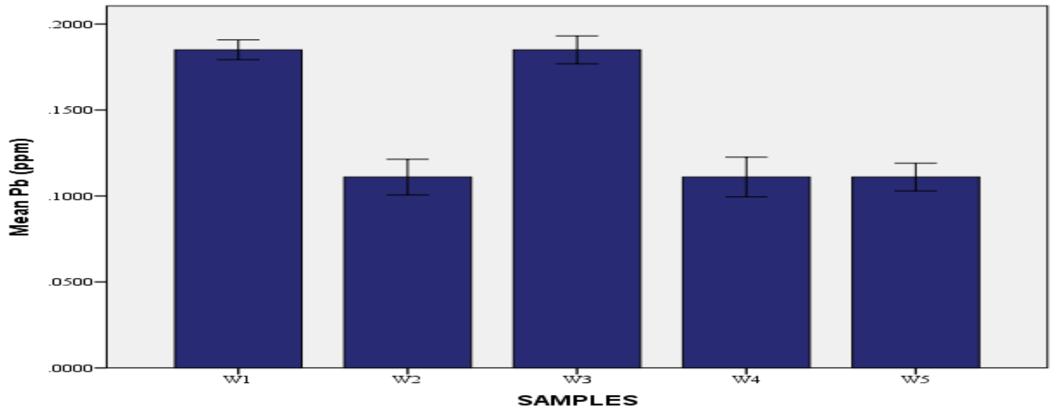


Figure 3: Concentration of Pb in Water from the Entire Sampling Site

3.2 Concentration of Nickel (Ni)

Figure 5 illustrates the concentration of nickel in water from all sample location. The concentration was high in sample W1 (Congo) along river Dilimi and W4 (Jenta) and W5 (Anguwan Soya) along river Jenta. However, the lowest concentration was recorded at sample station W2 (AnguwanRogo), W3 (Katako)

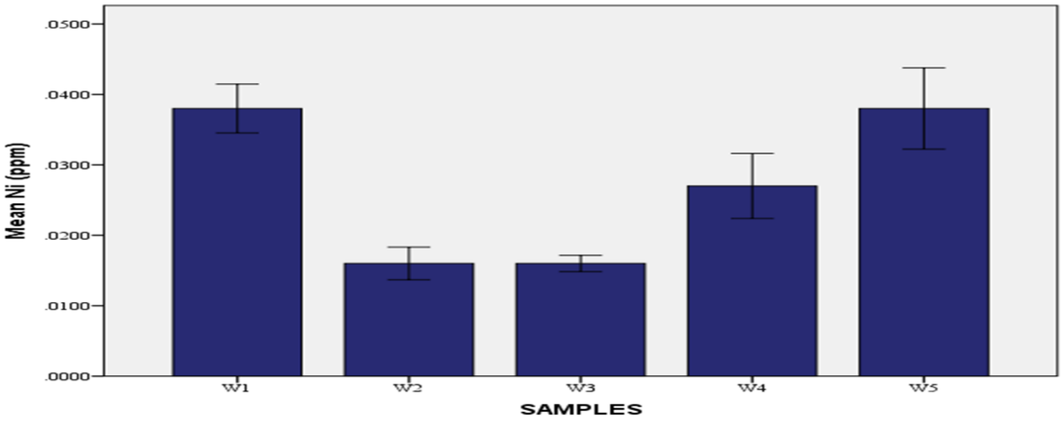


Figure 4: Concentration of Nickel from all the sample sites

3.3 Concentration of Cobalt (Co)

Figure 6 illustrates the concentration of cobalt in all sample locations. The concentration of cobalt is higher in all the sample locations from W1-W5 both along river Dilimi and Jenta.

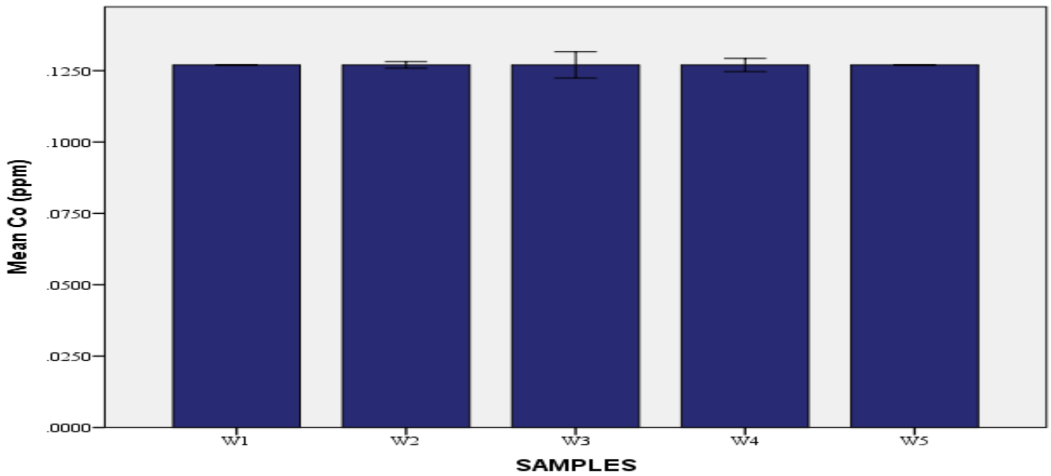


Figure 5: Concentration of Co in water from the entire sampling site

3.4 Data Analyses

This work uses descriptive statistics to present the data in the form of frequencies, charts and oral responses to the use of polluted river water for domestic/agriculture uses and the adverse effect on human health. In order to test the postulated hypothesis, the one-way analysis of variance (ANOVA) was used to determine whether there are any statistically significant differences between the means of the samples collected as independent (unrelated) groups.

3.5 Variation in the Concentration of Elements in Water

Table 5 gives the summary of the Analysis of Variance (ANOVA) test of the hypothesis (Ho) that there is no significant variation in the concentration of the selected elements (heavy metals) in water samples among the five locations in the study area. Since the calculated F distribution value is greater than the critical value and lies within the region of rejection, the null hypothesis is rejected.These,however, shows that there is a significant variation ($p<0.05$) in the concentration of the selected elements (heavy metals) in water among the five samples locations in the study area, whereas ($p>0.05$) shows no significant variation in lead, nickel and cobalt respectively.

Table 6: Summary of ANOVA Test (Water samples)

Source of Variation	SS	df	MS	F	P-Value	F Crit
Between Groups	0.074673	4	0.018668	6.650266	0.001422	2.866081
Within Groups	0.056143	20	0.002807			
Total	**0.130817**	**24**				

3.6 Variation in the concentration of Elements in plant

Table 6 gives the summary of the Analysis of Variance (ANOVA) test of the second hypothesis (Ho) that there is no significant variation in the concentration of the selected elements (heavy metals) in plant foliage crops among the samples five locations in the study area. Since the calculated F distribution value is greater than the critical value and lies within the region of rejection, the null hypothesis is rejected. Therefore, there is a significant variation in the concentration of the selected elements (heavy metals) in plant foliage of crops among the five sample locations in the study area.

Table 7: Summary of ANOVA Test (Plant Foliage of Crops)

Source of Variation	SS	dfms		f	p-value	f crit.
Between Groups	3.83209	4	0.95802	11.9015	2.58488E-07	2.1304
Within Groups	5.23225	65	0.0805			
Total	**9.06434**	**69**				

IV. DISCUSSION

Zinc (Zn) from both maize foliage and spinach was found to be below the standard set by WHO/FAO, as such the plants from that sampling sites are safe for consumption, this agreeswithSaraf&Samant, (2013) who affirm that Zinc (Zn) is essential to all living organisms; because it plays a vital role in growth and development. Lead (Pb) from all the three sampling sites SS1-5 and MF1-5 was found to be higher than the permissible limit set by WHO/FAO. Concerning this result, Farooq et al. (2008) reaffirmed that Pb concentration was above toxicity level in leafy plants grown in the vicinity of an industrial area. In this study, the level, the concentration of Pb level is at least among the other vegetables. The high level of Pb in all the plant (foliage & spinach) suggests that the water used for irrigation was not good for irrigation of crops in general.

Nickel (Ni) is of beneficial in a trace amount in the body, but its toxicity at higher levels is more enzyme prominent. Ni concentration in both spinach and foliage was below the said standard by WHO/FAO (2001). Cobalt (Co) is an essential component of vitamin B-12 molecule. However, excess intake of Cobalt may lead to over production of red blood cell since Co is required for the manufacture of red blood cells. The concentration of cobalt in this work was found to be below the standard set by WHO/FOA for both the plant samples. Cadmium (Cd) in this study was not detected from any of the sampling sites of the two rivers as such Cd is safe.

V. CONCLUSION

Vegetables are very essential nutrients to the body. The consumption of vegetable crops with a high level of heavy metals causes muchhavoc to humans. The study reveals that Pb and Co are higher than the permissible limit set by WHO/FAO in water. This indicates that the use of water from these rivers for irrigation may cause danger to the crops growing. Also, Ni was observed to be high in water from three sampling site namely; W1, W4 and W5 which is also above the said standard by WHO/FAO. Zn found in the water was very low and below the permissible limit. Cd could not be traced from any of the water samples.

The result of Pb in vegetable shows that there was an uptake as a result of the use of Pb contaminated water for irrigation in both spinach and maize foliage which is higher than the permissible limit set by WHO/FAO. Whereas Zn, Ni and Co are generally lower than the standard limit set by WHO/FAO. Cd, on the other hand, could not be detected in any of the samples. However, this result shows an important health risk as Pbcontamination in both water and vegetable is high and therefore, consumers of these vegetables are at risk. As such monitoring of heavy metals in plants and water is very essential in other to prevent an excessive build-up of these metals in the human food chain as it undergoes bioaccumulation.

VI. RECOMMENDATIONS

Given the negative effect of heavy metals consumption in vegetables, the study recommended that: the government should enforce the ever existing law that bans dumping of solid, liquid and industrial waste into rivers. Farmers particularly irrigation farmers should construct blowholes and wells in their farms to sub-limit the use of polluted river water. The use of synthetic fertilizer should be minimized and encourage the use of organic fertilizer on farms as well as public enlightenment campaign should be encouraged on the hazard and dangers of heavy metals. Lastly,the government should provide dams for an adequate supply of water to the farmers.

ACKNOWLEDGEMENT

The authors appreciate the management of AbubakarTafawaBalewa University for their support.

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