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CONCENTRATION OF HEAVY METALS IN PADDY SOILS AND ITS ACCUMULATION IN RICE (*ORIZA SATIVA*) GRAINS IN GASHUA, BADE LOCAL GOVERNMENT AREA, YOBE STATE, NIGERIA

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ABSTRACT

Heavy metals are large group of metals having specific density greater than 5 g/cm3 and are known to exist naturally in the earth crust. The study determined the concentration of heavy metals in paddy soil and rice grains in Gashua, Bade local government area, Yobe state. Three sampling stations were selected, Station A (Jabulle), B (Bayan Gada) and C (layin Kwata). The quantities of heavy metals (Pb, Cr, Cd, Cu, As, and Ni) were determined in both the soil and paddy rice grains. The mean values of metals found in soil (mg/kg) in station A were as follows: Lead (3.13±0.137), Chromium (2.82±0.65), Cadmium (1.37±0.14), Copper (5.86±0.63), Arsenic (1.33±0.14) and Nickel (2.93±0.32), while station B: Lead (6.10±1.027), Chromium (2.94±0.17), Cadmium (2.67±0.49), Copper (9.38±1.34), Arsenic (2.35±0.10) and Nickel (4.69±0.67) and station C: Lead (1.85± 0.41), Chromium (2.38±0.14), Cadmium (1.49±0.44), Copper (4.58±0.37), Arsenic (1.04±0.08) and Nickel (2.29±0.18). Heavy metals were detected in the order Cu > Pb > Ni > Cr > Cd > As and as > Cd > Cr > Ni > Pb > Cu > in the soil and rice samples, respectively. The physico-chemical value obtained in station A were pH (6.7 ± 0.21), Electrical Conductivity (504±430.62), Organic Carbon (3.4±0.66) and Moisture (11.10±1.08), while for station B: pH (6.9±0.31), Electrical Conductivity (545±97.04), Organic Carbon (2.34±1.29) and Moisture (11.49±1.66) and station C: pH (6.4±0.2), Electrical Conductivity (824±27.22), Organic Carbon (2.43±0.37) and Moisture (8.94±1.30). It was observed that the concentrations of Cu, Cd, Cr, and As were higher than the WHO/FAO recommended maximum tolerance values.

Keywords: Heavy Metals, Paddy Soils, Rice Grains, Concentration, Accumulation

INTRODUCTION

Heavy metals are large group of metals having specific density greater than 5 g/cm3 and are known to exist naturally in the earth crust. These classes of metals are widely distributed in different soil formations, sediments and water at a natural background level. This, however, depends on the origin and parent materials in which they were formed (Adriano, 2001; Kunhikrishnan *et al*., 2015). One major concern regarding heavy metals is that they are neither destroyed nor degraded, although their chemical forms may change. Heavy metal-mediated environmental contamination has become a global issue in recent years because of extensive industrialization worldwide (Ahmad and Goni, 2010). Heavy metal contaminated soil adversely affects the whole ecosystem when these toxic heavy metals migrate into groundwater or are taken up by flora and fauna, which may result in great threat to ecosystems due to translocation and bioaccumulation (Bhagure and Mirgane, 2011). Aside the natural background levels, human activities arising from urbanization and industrialization are responsible for elevated levels of heavy metals in the environment. These human actions over the years have resulted to different levels of exposure (WHO, 2021).

The contamination has continued to be on the increase and has become a global trend. Due to geological and anthropogenic activities, plants are polluted with heavy metals, especially in paddy soil environments (Adewumi *et al*., 2021). Excessive use of agrochemicals like fertilizers, pesticides and herbicides in farmlands owing to the quest for greater crop yields and increase productivity can lead to contamination and accumulation of both essential and non-essential metals in agricultural soils (Wong *et al*., 2002, Tariq and Rashid, 2013).

It has also been reported that crops have different abilities to absorb and accumulate heavy metals in their body parts and that there is a broad difference in metal uptake and translocation between plant species and even between cultivars of the same plant species (Yu *et al*., 2013). The greater urgency to obtain more crop yield per capita has led to the excessive use of agrochemicals which not only supply the nutrients to the soils and adjust their pH but also protect the crops from various pests (Wong *et al*., 2002). Cultivated soil not only acts as a reservoir of heavy metals deposition from agrochemicals but also as a major indicator of longterm contamination and a source of transfer to plant, animals, humans and other biological systems (Senthilkumar and Narayanaswamy, 2016). The aim of this study is to determine the concentrations of heavy metals (Pb**,** Cd, Cr, Cu, Ar and Ni) in paddy soil and their accumulation in rice grains in Gashua, Bade Local Government Area, Yobe State.

MATERIALS AND METHODS

Study Area

Gashua is located between latitude 12^0 52' 05 N and 12^0 87'11 N and longitude 11^0 57'26 E and 11^0 02'47 E. Gashua lies in plain region that covered by savannah, which support the cultivation of crops such as millet, groundnut, guinea corn, and rearing of animals that support the life of people (Oladimeji, 2001). Gashua is also a riverine community situated in relatively flatland in Northern part of Yobe State and also is the Bade Local Government headquarters. Gashua town lies along the famous river Yobe few kilometers from convergence of River Jama'are and Hadejia. According to the last national population census in 2006, the population of Gashua was about 125,000 persons. This community experienced an annual average rainfall of 500 to 1000mm with maximum summer temperature ranges of 38^{o}C to 40^{o}C (March-April) and minimum temperature of as low as 23-28^{o}C (June to September) (Nwankwoala, 2012). The mean annual temperature is about 390c but the mean monthly value range between 27^{o}C in the coolest month of December to January and 32^{o}C in the hottest month of April to May. The major river that flows in Gashua and the adjoining area is the River Komadugu Yobe. The Hadajia Jama'are River Basin is part of the vast Lake Chad drainage Basin and consists of three main tributaries. The water table is usually 0-15m below the drainage line. (Kimmage, 2012). The spoken language of the indigenous people of this town is called Bade. Gashua is one of the most developed towns in Yobe State and was regarded to have both economical as well as ecological relevance to the entire ecosystem of this region which is largely associated with the location of the town within Nguru-Gashua Wetlands (Thompson and Polet, 2000).

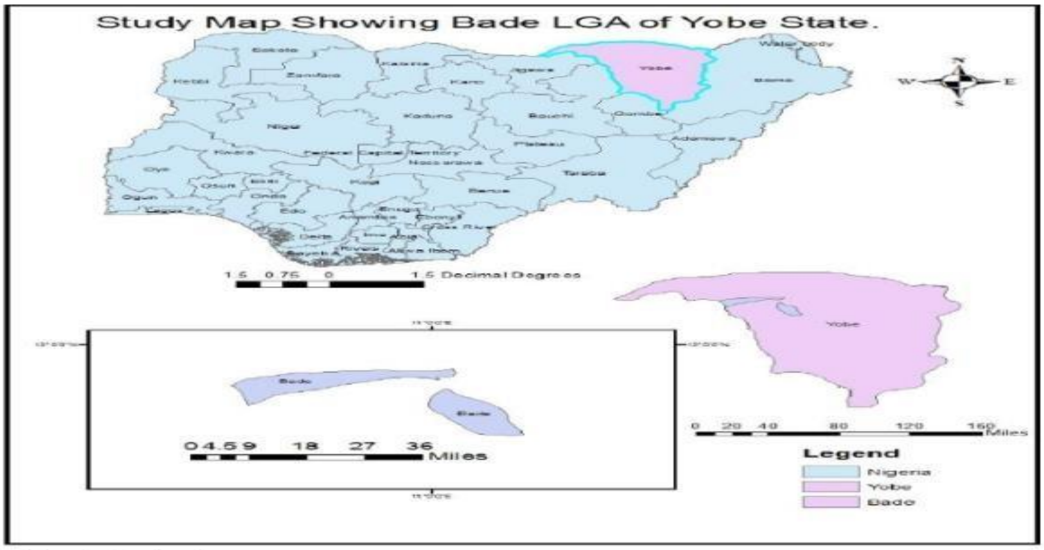

Figure 1: Map of the Study Area (Source, Department of Geography GIS Unit, 2021)

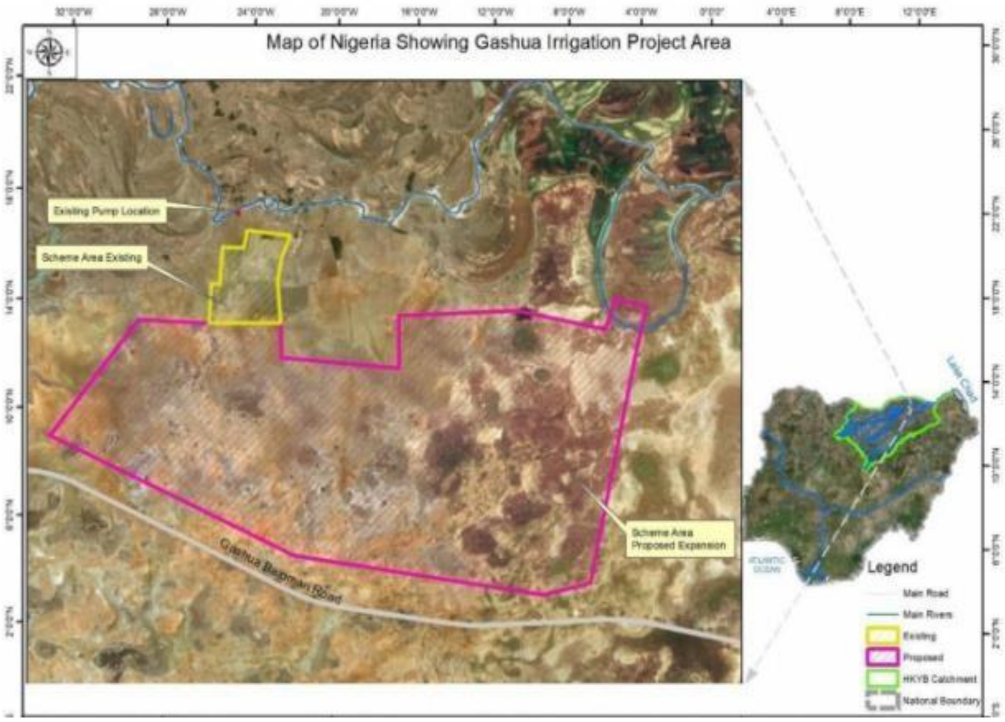

Figure 2: Map of Study Stations Showing Coordinates (Source, OSGOF, FAO, GEOYE and SMEC, 2019)

Sample Collection

Paddy rice samples were collected from three main agricultural areas of Rice production; Station A (Jabulle), Station B (Bayan-gada), and Station C (Bayan kwata) of Gashua Town, Bade Local Government Area, Yobe State. Surface soil samples were taken at a depth of 30 cm with a soil hand auger, stored in clean bags and labelled properly. The labelled samples were transported in a cooler to the Department of Biological Sciences laboratory, Faculty of Sciences, Yobe State University further analysis.

Laboratory Analysis

Heavy Metal Analysis

The soil samples collected were dried at 100°C for one hour before being ground to powder using pestle and mortar, and sieved with a 250 µm sieve, prior to analysis. Powdered material was weighed (0.5g to 1g) OHOUS (Pioneer A03). Rice and soil samples were digested; for rice grains, 6ml HNO_3 was added to 2ml H_2O_2 in a digesting vessel. For soil sample, 6ml HNO_3 was added to 2ml hydrogen peroxide and 2ml H_2O_2 in a digesting vessel as earlier stated for rice grain. To these, one hundred (100ml) of deionized water was added and filtered using Whatman filter paper. Absorbance reading was determined using Atomic Absorption Spectrophotometer (Buck Scientific 210VGP, USA)

Physicochemical Parameters

The physicochemical parameters of the soil samples were determined by using the water extracts of these samples, prepared by shaking soil sample with deionized distilled water in 1:100 for 5 minutes. Subsequently, the contents were equilibrated for thirty minutes and filtered. The filtrate was used for the determination of physicochemical parameters in accordance with standard methods. The moisture content of the soil samples was determined gravimetrically.

Statistical Analysis of Data

One-way Analysis of Variance (ANOVA) was carried out to establish the variation between the means of various metal pairs in the paddy soil and rice grain from three different sampling/ study sites.

RESULTS AND DISCUSSION

Heavy Metal Concentration in Sample of Paddy soil and Rice in Gashua

Results obtained indicates high concentration of cupper which ranges from (18.57±0.29 - 4.58±0.37 mg/Kg) in all samples (rice grain and paddy soil) analyzed from different study sites, while the concentration of Arsenic which ranges from (2.35±0.10 - 1.04±0.08 mg/kg) is the least in paddy soils. However, there is a slight variation in the least concentration of heavy metals between paddy soils and rice grains, with cadmium 1.48±1.07mg/kg being the least in rice grain from sampling site SA, chromium 4.71±0.84mg/kg in sampling site SB and Arsenic 4.06±0.32 mg/kg in sampling site SC (Table 2)

Physicochemical Parameters of Paddy Soil

Following the analysis of water samples from paddy soil, results revealed an acidic pH (<7.0) in all sampling sites, while the mean electrical conductivity (EC) levels ranges between 504±430.62 – 824±27.22 µS/L in the three (3) sampling sites. There is an indication that sampling site C is more fertile with high nutrient level due to high EC levels (824±27.22 µS/L). For moisture and organic carbon (OC) however, results indicate too low moisture contents (<45%), while organic carbon (OC) levels falls within the range of OC in top soils (0.5 – 3.0%), in all sampling sites respectively (Table 1).

Comparison of Heavy Metal Concentration Between Rice Grain and Paddy Soil in Gashua

These Results obtained indicated no statistical significant ($P \leq 0.05$) for all metals in rice grain, except Cadmium and Arsenic in which a significant difference (P=0.25136) and (P=1.49) respectively, was observed. For paddy soil however, there is a significant difference ($P \geq 0.05$) for all metals from different study sites with exception of Nickel in which no significant difference (P=0.04758) was observed (Table 3).

Table 1: Physicochemical Parameters of Paddy Soil

Sampling Site	Sample	Parameter (Mean ±SD)			
		pH	EC (µs/cm)	Moisture (%)	OC (%)
A	Paddy Soil	6.7 ± 0.21	504±430.62	11.10±1.08	3.4±0.66
B	Paddy Soil	6.9±0.31	545±97.04	11.49±1.66	2.34±1.29
C	Paddy Soil	6.4±0.2	824±27.22	8.94±1.30	2.43±0.37

Key: EC= Electrical Conductivity, OC= Organic Carbon
F=23.55 P=0.0014 F crit= 5.143

Table 2: Heavy Metal Concentrations in Samples (Paddy Soil, Rice) From Three Different Sites in Gashua

Sample	Pb	Heavy Metal Concentration (mg/kg) (Mean±SD)				
		Cr	Cd	Cu	As	Ni
Soil						
A	3.13±0.137	2.82±0.65	1.37±0.14	5.86±0.63	1.33±0.14	2.93±0.32
B	6.10±1.027	2.94±0.17	2.67±0.49	9.38±1.34	2.35±0.10	4.69±0.67
C	1.85± 0.41	2.38±0.14	1.49±0.44	4.58±0.37	1.04±0.08	2.29±0.18
Rice Grains						
A	10.92±2.33	5.26±0.45	1.48±1.07	14.13±2.87	5.19±0.56	7.07±1.43
B	8.54±1.89	4.71±0.84	9.57±0.78	15.75±2.84	9.18±0.39	8.57±0.36
C	10.76±0.14	3.81±0.51	8.61±0.41	18.57±0.29	4.06±0.32	9.29±0.144

SD= Standard Deviation. SS= 10.425 MS= 0.1963 P=0.047

Table 3: Comparison of Heavy Metal Concentration between Rice Grain and Paddy Soil

Metal	Sample	F cal.	F tab.	P value
Pb	Rice Grain	34.48895	5.143253	0.000512
	Paddy soil	1.770678	5.143253	0.24867
Cr	Rice Grain	9.740035	5.143253	0.013057
	Paddy soil	150.9885	5.143253	7.39E-06

Metal	Sample	F cal.	F tab.	P value
Cd	Rice Grain	1.753598	5.143253	0.25136
	Paddy soil	2.506445	5.143253	0.161715
Cu	Rice Grain	23.73753	5.143253	0.001413
	Paddy soil	2.772273	5.143253	0.140386
As	Rice Grain	118.8964	5.143253	1.49
	Paddy soil	112.7528	5.143253	1.74088E-05
Ni	Rice Grain	23.55046	5.143253	0.001443
	Paddy soil	5.279054	5.143253	0.04758

Discussion

Physicochemical Parameters of Paddy Soil

Studies on the physicochemical parameters of paddy soils from three different sampling sites in Gashua, Bade LGA of Yobe State indicate slightly acidic pH (6.4±0.2 - 6.9±0.31) from all sampling sites. These low pH levels recorded could be attributed to overuse of pesticides and herbicides in agricultural fields in the study area. This finding is consistent with the studies of Kayode *et al.* (2019) who reported acidic soil pH (4.1 to 5.1) in Southeastern (Anambra, parts of Enugu and Ebonyi States) Nigeria. In a similar study by Nnaji and Igwe, (2014) however, alkaline pH (7.50-8.92) levels were reported in four (4) of five (5) rice fields in New Bussa, Niger State, North Central Nigeria. This alkaline pH was attributed to high application of organic fertilizer, because fertilizers such as NPK were reported to be acidic in the area (Ukpabi *et al*., 2012). Similarly, this study revealed EC levels (504±430.62 to 545±97.04) in study sites A and B falling within the standard range, except site C where EC levels were above the range. This is an indication that sites A and B are less fertile and could produce less yield compared to site C, which might be attributed to low fertilizer application in the two sites. This finding is in consonance with the work of Nnaji and Igwe, (2014) who reported a significantly lower ($P \leq 0.05$) EC levels in rice fields with low fertilizer applications.

Heavy Metal Concentrations in Samples (Paddy Soil and Paddy Rice) from three different sites in Gashua.

The concentrations of heavy metals (Lead, Chromium, Cadmium, Cupper, Arsenic and Nickel) in paddy soils from rice fields and rice grains cultivated in such fields showed the concentration of cadmium to be above (1.37±0.14 to 9.57±0.78) the maximum permissible levels established by the World Health Organisation (WHO, 2021) for both rice and paddy soils analysed was 0.2. Other metals were however, observed to fall below the maximum range as per the WHO guideline. This finding contradicts the findings of Ezeofor *et al.* (2019) who reported lower concentrations of these heavy metals (potential toxic elements) in paddy soil from Ugbawka rice fields, Enugu, Nigeria. While the concentration of heavy metal was compared between rice grain and paddy soils from the study sites, no statistical significance ($P \leq 0.05$) was observed for all potential toxic elements except cadmium and arsenic which revealed a statistical significance ($P \geq 0.05$) between rice grains cultivated from the three study sites, although a statistical significance ($P \geq 0.05$) difference existed for all paddy soils in the sampling sites.

CONCLUSION

Six heavy metals (Pb, Cr, Cd, Cu, As and Ni) were determined in this study sites. With station B having the highest amount of the heavy metals among the study areas due to much anthropogenic activities like dumping of refuse, excessive application of chemical fertilizers and herbicides.

The results revealed an acidic pH (<7.0) in all sampling sites, while the mean electrical conductivity (EC) levels ranges between 504±430.62 – 824±27.22 µS/L in the three (3) sampling sites. There is an indication that sampling site C is more fertile with high nutrient level due to high EC levels (824±27.22 µS/L). For moisture and organic carbon (OC) however, results indicate too low moisture contents (<45%), while organic carbon (OC) levels falls within the range of OC in top soils (0.5 – 3.0%), in all sampling sites respectively. The significance values of heavy metals concentration in paddy soil and rice grains cultivated from three different study sites, respectively.

REFERENCES

Ahmad, J. U. and Goni, M.A. (2010). Heavy metal contamination in water, soil, and vegetables of the industrial areas in Dhaka, Bangladesh, *Environmental Monitoring and Assessment*, 166(1–4): 347–357.

Bhagure, G.R. and Mirgane, S.R. (2011). Heavy metal concentrations in groundwaters and soils of Thane Region of Maharashtra, India. *Environmental Monitoring and Assessment*, 173(1–4): 643–652.

Ezeofor, C.G. and Järup, L. (2019). Cadmium exposure and health risks: Recent Findings. *Ambiology*, 25: 370.

Kayode, O.T., Aizebeokhai, A.P., and Odukoya, A.M. (2019). Soil characterisation for precision agriculture using remotely sensed imagery in southeastern Nigeria. *Journal of Physics: Conference Series*, 1299: 012070

Nnaji, J. C. and Igwe O. U. (2014). Fractionation of heavy metals in soil samples from rice fields in New Bussa, Nigeria. *International Journal of Chemical Technology Research*, 6(14):5544-5553.

Nwankwoala, H. (2012) Case studies on coastal wetlands and water resources in Nigeria. *European Journal of Sustainable Development*, 1: 113-126.

Tariq, S.R., Shah, M.H., Shaheen, N., Khalique, A., Manzoor, S. and Jaffar, M. (2005). Multivariate analysis of selected metals in tannery effluents and related soil. *Journal of Hazardous Materials*, 122(1-2): 17–22.

Thompson, J. R. and Polet, G. (2000). Hydrology and land use in a sahelian floodplain wetland. *Wetlands*, 20(10): 639-659.

WHO/IPCS. World Health Organization. Geneva, Switzerland: (2021). Environmental Health Criteria Chromium.

Wong, S.C., Li, X.D., Zhang, G., Qi, S.H. and Min, Y.S. (2002). Heavy metals in agricultural soils of the Pearl River Delta, South China. *Environmental Pollution*, 119(1): 33–44.