Assessment of Heavy Metal Contamination in Water, Soil and Different Varieties of Rice Grown in Nguru – Gashu'a and Geidam River, Yobe State, Nigeria.

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Abstract

This research was conducted to evaluate the degree of pollution in the Nguru-Gashua-Geidam river system in Yobe, Nigeria. The investigation involved the analysis of water, soil, and multiple rice varieties collected from three distinct sites. The analytical parameters included physicochemical properties, heavy metal concentrations, and calculated pollution indices. The pH of water and soil samples were found to be within the range of 6.47 ± 0.05 —6.85 ± 0.13 and 6.00 — 7.70 respectively. The EC, Alkalinity, chloride, hardness, TDS and turbidity of the water samples were in the ranges of 2.12 ± 0.27—2.67 ± 0.35 ds/m; 67.23 + 0.43 —92.33 ± 0.58 mg/L; 0.73 ± 0.02—0.89 ± 0.08 mg/L; 26.67 + 2.31 — 35.67 ± 0.58 mg/L 1357 ± 1.08— 1708 + 1.99 mg/L and 2.23 ± 0.77— 164.20 ± 0.32 FTTJ respectively. The results demonstrated significant heavy metal contamination across the sampled environments. Water was contaminated with Cr, Fe, and Pb (exceeding NSDWQ standards), while soil was contaminated with Cr, Cu, Fe, and Pb (exceeding WHO standards). This contamination transferred into the biota, with rice grains showing elevated Cu and Zn levels above WHO limits, though rice leaves retained acceptable Cr and Zn levels. While overall contamination indices suggested low to moderate pollution levels, a high transfer factor for Pb indicated a significant pathway into plants. Collectively, the data confirm widespread contamination by the metals under investigation.

Key word: *contamination, pollution, heavy metals, geoaccumulation, physicochernical.*

Introduction

Heavy metals, a broadly defined group of elements exhibiting metallic properties—including transition metals, metalloids, lanthanides, and actinides—are significant environmental pollutants. As noted by Bini and Wahsha (2024), their toxicity and environmental persistence make them among the most hazardous anthropogenic pollutants. These metals contaminate soils, water bodies, and plants through atmospheric deposition or the direct application of pollutants. Primary sources of environmental heavy metal contamination are anthropogenic activities such as mining, smelting, the iron and steel industry, chemical manufacturing, transportation, agriculture, and domestic waste (Nasir, 2015). Although these elements occur naturally in soils, both geologic and human-driven processes can elevate their concentrations to levels that are toxic to plants and animals (Goff et al., 2012). Furthermore, Akan et al. (2019) highlight that using polluted water for irrigation leads to the uptake and bioaccumulation of heavy metals in various tissues of agricultural crops.

MATERILS AND METHODS

Sample collection

Water samples (approximately 1.0 L) were collected in triplicate from the Nguru-Gashua-Geidam River using pre-cleaned plastic bottles, following the methodology of Ademoroti (2019). Replicate samples were obtained at 5-10 minute intervals. Concurrently, rice plants were sampled diagonally across the sites. Each plant was carefully uprooted, placed in a labeled polythene bag, and transported to the laboratory for analysis.

Soil samples were collected from the riverbanks at depths of up to six inches (approximately 15 cm) from the locations where the rice plants were uprooted, using a hand auger. The samples were stored in labeled plastic bags and transported to the laboratory for subsequent treatment and analysis.

Determination of heavy metal concentration

The digested rice samples were diluted to a final volume of 50 mL with distilled water in sampling bottles. All digestions, including procedural blanks, were performed in triplicate. The concentrations of Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Cadmium (Cd), Arsenic (As), and Zinc (Zn) were determined using a BUCK Scientific Atomic Absorption Spectrophotometer (AAS), Model 210VGP.. **NPK Analysis** The soil nutrients (NPK) were determined using standard operating procedure indicated in testing kit. pH, potassium, nitrogen and phosphorus in soil.

Results and discussion.

Table 1: Physicochemical properties of water samples

Parameter	Unit	Nguru (P1)	Gashu'a (P2)	Geidam (P3)	NSDWQ
pH		6.47±0.05	6.62±0.14	6.85±0.13	6.5-8.5
EC	dS/m	2.50±0.20	2.67±0.35	2.43±0.25	1
Alkalinity	mg/L	91.67 ± 0.58	92.33 ± 0.58	79.33 ± 0.58	500
Chloride	mg/L	0.89 ± 0.08	0.87 ± 0.03	0.73 ± 0.02	50
Hardness	mg/L	32.33 ± 0.58	35.67 ± 0.58	27.67± 0.58	150
TDS	mg/L	1600±2.17	1708± 1.99	1555±2.05	500
Turbidity	FTU	164.06±1.00	164.20±0.32	145.46± 15.20	5

The physicochemical properties of water samples from three sampling sites (P1-P3) in the river were analyzed. The mean pH values across the locations ranged from 6.47 ± 0.05 to 6.85 ± 0.13. With the exception of site P1, which was slightly below the standard, these values were within the permissible limits set by the Nigerian Standard for Drinking Water Quality (NSDWQ, 2017). The elevated Electrical Conductivity (EC) recorded suggests a significant presence of ionic

contaminants, including sodium, potassium, and chloride. The measured hardness ranged from 26.67 ± 2.31 to 35.67 ± 0.58 mg/L, which is well within the NSDWQ limit of 150 mg/L. In contrast, the Total Dissolved Solids (TDS) values, which ranged from 1357 ± 1.08 to 1708 ± 1.99 mg/L, substantially exceeded the NSDWQ regulatory limit of 500 mg/L at all sampling sites.

Table 2: Proximate analysis of rice samples

Parameter (%)	Sample	Nguru (P1)	Gashu'a (P2)	Geidam (P3)
MC	Grain	10.80 ± 0.29	11.78 ± 0.34	11.46 ± 0.03
	Leave	6.95 ± 0.24	7.88 ± 0.52	6.07 ± 0.21
AC	Grain	1.86 ± 0.25	1.96 ± 0.04	1.99 ± 0.02
	Leave	21.27±0.41	15.27±0.50	19.74±0.18

MC= Moisture Content. AC Ash Content

The moisture content analysis revealed that for leaf samples, values ranged from 6.07 ± 0.21% to 7.88 ± 0.52%, with site P3 exhibiting the lowest concentration and P1 the highest. In the grain samples, the highest moisture content was recorded at P2 (11.78 ± 0.34%), followed by P3 (11.46 ± 0.03%), while P1 had the lowest (10.80 ± 0.29%). All measured values for grain moisture were nearly within the acceptable limit of 12% established by Dipti et al. (2012) for the long-term storage of rice.

Table .3: Nutrient in the soil sample.

Nutrient	Nguru (P1)	Gashu'a (P2)	Geidam (P3)
pH	6.00 ± 0.25	7.33 ± 0.47	7.70 ± 1.05
Nitrogen	Li 2kg/Acre	LI, 2kg/Acre	Li, 2kg/Acre
Phosphorous	LI, 2kg/Acre	M1, I1kg/Acre	L2, 8kg/Acre
Potassium	H2, 25kg/Acre	H2, 25kg/Acre	H2, 25kg/Acre

The soil pH across the sampling sites ranged from slightly acidic (6.00) to slightly above neutral (7.70). Furthermore, nitrogen, a key nutrient for plants, serves as a fundamental building block for proteins, nucleic acids, and other cellular constituents essential to all life. As noted by Kahl (2014), its critical importance necessitates careful management, as mismanagement can result in significant environmental consequences.

Table: Correlation of metal in samples.

	Cr	Cu	Fe	Pb	Zn
Water					
Cr	1.00				
Cu	-0.59	1.00			
Fe	0.77*	-0.19	1.00		
Pb	0.97*	-0.44	0.89*	1.00	
Zn	-0.39	0.72*	-0.47	-0.38	1.00
Grain					
Cr	1.00				
Cu	0.78*	1.00			
Fe	-0.64	-0.59	1.00		
Pb	0.06	0.61	0.17	1.00	

Zn	-0.04	-0.42	-0.48	0.90*	1.00
Leaves					
Cr	1.00				
Cu	0.92*	1 .00			
Fe	-0.01	-0.34	1.00		
Pb	0.95*	0.81*	0.27	1.00	
Zn	0.24	0.05	-0.37	-0.18	1.00
Soil					
Cr	1 .00				
Cu	0.87*	1.00			
Fe	0.59	0.32	1 .00		
Pb	0.53	0.07	0.85*	1.00	
Zn	0.87*	0.97*	-0.51	-0.20	1.00

Correlation is significant at a 0.05

Conclusions

This study assessed the levels of physicochemical parameters and heavy metals in water, soil, and rice from three sites (P1, P2, P3) along the River Yobe, comparing the findings against established quality standards.

The analysis revealed that while key water quality parameters (pH, alkalinity, chloride, and hardness) were within permissible limits, the electrical conductivity exceeded the NSDWQ standard. Soil analysis indicated a consistently low nitrogen content across all sites. Phosphorus levels were low in P1 and P3 but medium in P2, whereas potassium concentrations were notably high at all three locations.

Regarding heavy metals, the concentrations of Chromium (Cr), Iron (Fe), and Lead (Pb) in the samples were found to exceed permissible limits. In contrast, Copper (Cu) and Zinc (Zn) levels remained within the acceptable regulatory thresholds.

Recommendations

The findings indicate that anthropogenic activities are a significant source of contamination for the water, soil, and plants along the banks of the Nguru, Geidam, and Gashu'a rivers. Given the potential for adverse environmental and public health consequences, several measures are recommended. First, the disposal of municipal waste near the riverbanks and adjacent farmlands must be prohibited. Furthermore, public education campaigns and stricter legislation on waste management should be intensified to mitigate the risks of contaminants entering the food chain.

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Reference

Akan, J. C., Abdulrahman, F. I., Ogugbuaja, V. 0., and Ayodele, J. T. (2019). *Heavy metals and anion levels in some samples of vegetable grown within the vicinity of Challawa industrial area, Kano State, Nigeria.* American Journal of Applied Sciences, 6(3), 534542..

Ademoriti,(2019) S. M., Haq, A. U., Byrd, J. A., Berhow, M. A., Cartwright, A. L. and Bailey, C. A. (2017). *Haemolytic and antimicrobial activities of saponin-rich extracts from guar meal*, Food Chern, 119, 600—605.

Akoto, 0., Ephraim, J. H. and Darko, G. (2018). *Heavy Metals Pollution in Surface Soils in the Vicinity of Abundant Railway*

Servicing Workshop in Kumasi, Ghana. International Journal of Environmental Research, 2(4)

Bini and Wahsha, (2024) *Assessment of physicochernical parameters of River Yobe, Gashua*, Yobe State, Nigeria.

Dasclotries, B; Valente, M. B. and Hall, A. (2015). *Physicochernical status of the middle and lower Zambezi prior to the closure of the Cobora Bassa Dam fresh water The Zambezi Rivers in Mozambique:* The Biology, 7, 187-189.

Dipti and Ojo. (2020). *Schedule 1 maximum and guideline for contaminants and toxins in food. Codex* alimentanius-General Standards for Contaminants and toxins in food. Joint

Guo, G., Wu, F., Xie, F., and Zhang, R. (2012). *Spatial distribution and pollution assessment of heavy metals in urban soils from southwest China*. Journal of Environmental Sci 24(3), 4 10-418.

KahI, H. (2019). *Role and importance of nitrogen in your soil*. Soil and Health Association of New Zealand.

Nasir, M. A., Feng, H. and Alinnor, J. (2011*). Trace metal dispersion in soil from automechanic village to urban residential areas in Owerri, Nigeria*. ProcediaEnviron,nental Sciences, 476

Obasi, N. A., Akubugwo, E. I., Ugbogu, 0. C. and Chinyere, G. C. (2012). *Heavy Metals Bioavailability and Phyto-accurnulation* Potentials of Selected Plants Biochemistry and Molecular Biology, 27(1), 27-45.