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Heavy Metal Contamination in Swampy Agricultural Soils of Kokona, Nasarawa, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author UR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors UR and AAA managed the analyses of the study. Authors UR and HA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Absorption of heavy metals through swampy agricultural soils may have serious consequences on human health. Present study determined the levels of Chromium (Cr), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As), Cadmium (Cd) and Lead (Pb) using X- Ray Spectrometry in 10 swampy agricultural soils. The result of this study revealed that, the heavy metals with their respective concentrations (Cr (278.1), Ni (462.1), Cu (314.1), Zn (502.8), As (13.5), Cd (524.5) and Pb (295.5)) were found in the soil samples in mg/kg. It also pointed out that the concentration of the heavy metals in the all soil samples for all locations in decreasing order was Cd > Zn >Ni > Cu >Pb > Cr >As. The concentration in swampy agricultural soils from Kokona was obviously higher than the safe limit set by the regulatory bodies which may be because of the geological activities in the studied area. Hence, heavy metals accumulation in swampy agricultural soils is a big concern in Kokona where people's daily meal largely contains rice or rice based products which are mostly cultivated in swampy agricultural soils.

Keywords: Heavy metals; swampy; agricultural; soils; rain-fed rice; risk exposure.

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1. INTRODUCTION

Absorption of heavy metals through swampy agricultural soils may have serious consequences on human health. Historically, agriculture was the first human influence on the soil [1]. Swampy agricultural soils could be contaminated as a result of accumulation of heavy metals through emission from rapidly expanding industrial areas, mines tailings, disposal of high metal wastes, leaded gasoline, paints, application of fertilizers, animals manure, sewage sludge, pesticide, waste water irrigation, coal combustion residue, spillage of petrochemicals and atmospheric deposition [2].

Elementsthat pose major threat to human health that are commonly found in contaminated soils are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), and nickel (Ni) [3]. Soils are the major sink for heavy metals emission into the environment, as such; their total concentration in soils persists for a long time after their introduction [4]. A certain amount of these heavy metals for instance are needed for normal body functions; but at the same time high concentrations may cause toxic effect such as liver, kidney problems and genotoxic carcinogen [5].

Heavy metals contaminants in soils may pose risk and harmful effects on human being and the environment through contact with contaminated soil or direct ingestion, drinking of contaminated ground water, the food chain [6]. The adequate restoration and protection of soil ecosystem contaminated by heavy metals required remediation and characterization. The Standard Organization of Nigeria (SON), Department of Petroleum Resources of Nigeria (DPR), United State Food and Agricultural Organization (US/FAO), European Union Environmental Protection Agency (EUEPA) and the World Health Organization (WHO) characterize chemical properties of environmental phenomena, specifically on food chain [7]. While soil characterization will provide an insight into heavy metals bioavailability and speciation, an attempt to remediate heavy metals contaminated soils will entail knowledge of the source of contamination, basic chemistry, associated health and environmental effects (risks) of these heavy metals. Risk assessment will go a long way as an effective scientific tool which enables decision makers (government and stake holders) to manage site so contaminated in a cost effective way and manner while preserving the ecosystem and public health [8]. Agriculture therefore, is the mainstay of the economy because majority of the populace are involved in subsistence farming. Therefore, this work centered on some swampy agricultural soils where food crops like rice, vegetables, sugar cane, etc. are cultivated. This study will serve as a baseline data for ecological integrity and human wellbeing in Kokona, Nasarawa, Nigeria.

2. METHODOLOGY

Ten (10) random soil samples were collected from Kokona Local Government Areas in order to conduct this elemental analysis. Consideration was employed by randomly collecting the soil samples on each of the swampy agricultural soil area under investigation and the soil samples were collected thirty centimeter (30 cm) depth from the top soil so as to obtain the desired standard result.

2.1 Study Area

This research work centered on Kokona Local Government, in Nasarawa West, where soils are found among the flood plains which are always swampy in nature due to availability of water all the year round. The forest soils are rich in humus and laterite soils. They are found in most part of the state and very good for crop production. Kokona has arable land for commercial farming, fishery development, wild life and forestry conservation. Agriculture therefore, is the mainstay of the economy because majority of the populace are involved in subsistence farming. The sample points and their coordinates are tabulated in Table 1.

The coordinates presented in Table 1 are then used to plot a map of the study are as seen in Fig. 1.

2.2 Samples Preparation

The soil samples were dried under ambient temperature, grinded with pestle and mortar, and allowed to pass through 2.0 mm meshed sieved, packaged properly in paper bags and coded for easy identification. The soil samples were then taken to Center for Energy Research and Development (CERD) in Obafemi Awolowo University (OAU) Ile Ife in Osun State, Nigeria for analyses.

2.3 Method of Sample Analyses

X-Ray Fluorescence (XRF) Spectrometry analysis was used for routine, non- destructive spectrometric determination of food, rocks, soils, minerals and liquid samples with little or no pre-treatment needed. It enables chemical composition to be determined in seconds. It involves mass analysis and every component in the irradiated substance is included. However, X.R.F. cannot generally make analysis at the small spot sizes (2-5 microns). It is typically used for bulk analysis of larger fractions of geological materials. The relative ease, low sample preparation and the stability and ease of use of X-Ray Spectrometers make it one of the most widely used methods for analysis of major and trace elements in rocks, soil, water, mineral sediment etc.

When an X-ray emission from a radioactive source strikes a sample, the x-ray can either be absorbed by an atom or scattered through the material after absorption. The atom becomes exited and gives off a characteristics x-ray whose energy level is unique to the element impacted by the incident x-ray. The emission of this characteristics x-ray is called X-Ray Florescence. Measurement of the number of emitted x-ray provides a quantitative indication of the concentration of the metal present in the sample.

Table 1. Sample points and their coordinates

	Coordinates	
Sample points	**North**	**South**
PT1	$8^0$50'22.62"	$7^0$58'80.33"
PT2	$8^0$50'21.28"	$7^0$58'50.72"
PT3	$8^0$50'25.71"	$7^0$58'24.78"
PT4	$8^0$49'23.98"	$7^0$59'70.68"
PT5	$8^0$49'24.558"	$7^0$59'60.48"
PT6	$8^0$49'24.47"	$7^0$59'5.478"
PT7	$8^0$49'1.128"	$7^0$59'26.28"
PT8	$8^0$49'1.998"	$7^0$59'28.24"
PT9	$8^0$49'3.078"	$7^0$59'28.94"
PT10	$8^0$49'2.322"	$7^0$59'31.92"

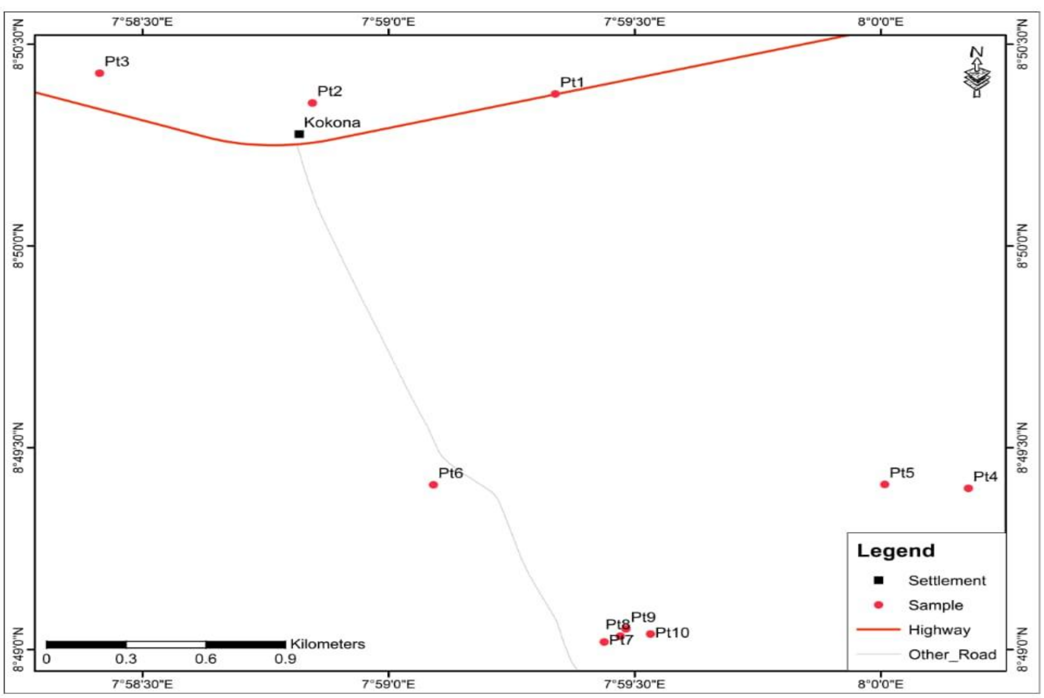

Fig. 1. Map of the study area showing sample points

3. RESULTS AND DISCUSSION

3.1 Results

The data collected from different Swampy Agricultural Soils from Kokona L.G.A were analyzed using X-Ray Fluorescence (XRF) Spectrometry. The results of the analysis were obtained and presented in Table 2, which are the Concentration Level of Heavy Metals such as chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), arsenic (As), cadmium (Cd) and lead (Pb).

3.1.1 Result analysis

In this study, the results presented in Table 2 were used to plot chart presented in Fig. 2 in order to compare the results with previous works.

3.2 Discussion

The results of the Heavy metal contamination in swampy agricultural soils of Kokona, Nasarawa West, Nigeria using X- Ray Fluorescence (XRF) Spectrometry have been presented. The heavy metals found in the soil samples are presented in Table 2. Finding of this study have revealed that the mean concentration of the heavy metals in all soil samples for all points arranged in decreasing order was Cd > Zn >Ni > Cu >Pb > Cr >As. These values were found to be higher than the safe limit recommended by WHO except for arsenic (As) and chromium (Cr) which are found to be lower. This implies that the mean concentration level of heavy metals in those areas was significantly high and may cause immediate radiological hazard to the populace of the study area.

On Chromium mean concentration level, finding of this study has revealed that the Chromium mean concentration level for soil samples was 278.1 mg/kg. This implies that the mean concentration level of chromium in those areas is low and may not cause radiological hazard to the populace of the study area. This finding is not in line with the finding of [9] whose mean concentration level for chromium was 47.49 mg/kg and [10] whose mean concentration level for chromium was 300 mg/kg.

On Nickel mean concentration level, finding of this study has revealed that the Nickel mean concentration level for soil samples was 462.1 mg/kg. This implies that the mean concentration level of nickel in those areas is significantly high and may cause radiological hazard to the populace of the study area. This finding is not in line with the finding of [11] whose mean concentration level for nickel was 47 mg/kg and [10] whose mean concentration level for nickel was 50 mg/kg.

On Copper mean concentration level, finding of this study has revealed that the Copper mean concentration level for soil samples was 314.1 mg/kg. This implies that the mean concentration level of copper in those areas is significantly high and may cause radiological hazard to the populace of the study area. This finding is not in line with the finding of [11] whose mean concentration level for copper was 9.23 mg/kg and [10] whose mean concentration level for copper was 200 mg/kg.

On Zinc mean concentration level, finding of this study has revealed that the Zinc mean concentration level for soil samples was 502.8 mg/kg. This implies that the mean concentration level of zinc in those areas is significantly high and may cause radiological hazard to the populace of the study area. This finding is not in line with the finding of [11] whose mean

Table 2. Concentration of heavy metals in mg/kg

S/N	Sample points	Cr	Ni	Cu	Zn	As	Cd	Pb
1.	PT1	127	325	046	389	389	261	985
2.	PT2	201	628	43	723	N.D	853	634
3.	PT3	208	545	438	343	13	592	142
4.	PT4	154	506	326	653	25	345	N.D
5.	PT5	211	616	454	505	15	390	543
6.	PT6	189	178	804	745	16	342	250
7.	PT7	483	680	322	607	14	23	549
8.	PT8	302	592	535	681	18	433	319
9.	PT9	203	473	135	279	N.D	938	106
10.	PT10	703	78	38	103	10	344	24
11.	Mean	278.1	462.1	314.1	502.8	13.5	524.5	295.5
12.	WHO/USFAO, (2001)	300.0	50.0	200.0	300.0	20.0	3.000	100.0

ND = Not Detected

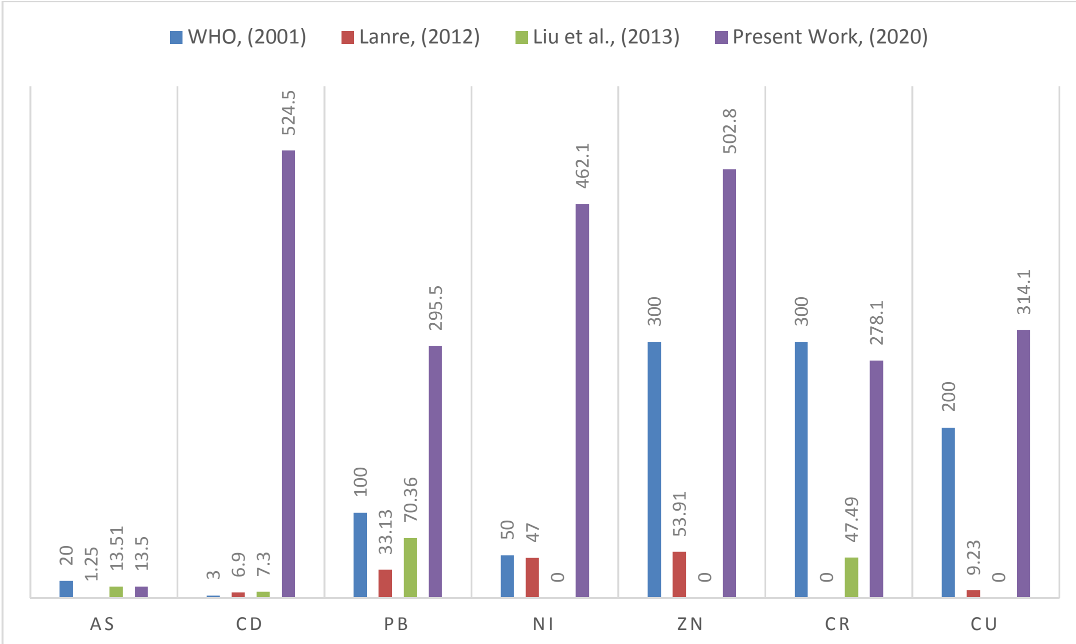

Fig. 2. Comparison of mean concentration with others in literatures

concentration level for zinc was 53.91 mg/kg and [10] whose mean concentration level for zinc was 300 mg/kg.

On Arsenic mean concentration level, finding of this study has revealed that the Arsenic mean concentration level for soil samples was 13.5 mg/kg. This implies that the mean concentration level of arsenic in those areas is not significant and may not cause radiological hazard to the populace of the study area unless accumulated for a long period of time. This finding is in line with that of [9] and [10], but not in line with the finding of [11] whose mean concentration level for arsenic was 1.25 mg/kg.

On Cadmium mean concentration level, finding of this study has revealed that the Cadmium mean concentration level for soil samples was 524.5 mg/kg. This implies that the mean concentration level of cadmium in those areas is significantly high and may cause radiological hazard to the populace of the study area. This finding is not in line with the finding of [11] whose mean concentration level for cadmium was 6.9 mg/kg, [9] whose mean concentration level for cadmium was 7.3 mg/kg and [10] whose mean concentration level for cadmium was 3 mg/kg.
On Lead mean concentration level, finding of this study has revealed that the Lead mean concentration level for soil samples was 295.5 mg/kg. This implies that the mean concentration level of lead in those areas is significantly high and may cause radiological hazard to the populace of the study area. This finding is not in line with the finding of [11] whose mean concentration level for lead was 33.13 mg/kg, [9] whose mean concentration level for lead was 70.36 mg/kg and [10] whose mean concentration level for lead was 100 mg/kg.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

The results showed that the mean concentration levels of heavy metals in some swampy agricultural soil from Nasarawa West, Nigeria varied significantly and decreased in the order of Cd > Zn >Ni > Cu >Pb > Cr >As. These values were found to be higher than the safe limit recommended by WHO and USFAO except for arsenic (As) and chromium (Cr) which are found to be lower. This implies that the mean concentration level of heavy metals in those areas is significantly high and maybe attributed to the geological strata and the pollution of the studied area. Consequently, this indicates threat to adverse health effects to the population in the area.

4.2 Recommendation

Remediation techniques are important to eliminate the human adverse health effects in contaminated soils. This calls for regular monitoring and risk assessment of crops cultivated at the sample locations. Furthermore, Government authorities at all levels should create awareness on the health implications of human interaction with heavy metals. Heads of cattle crossing from nearby communities should be restricted from grazing on the grasses in the study area as the cow dump deposits has great influence on concentration levels of these toxic heavy metals. Also drying of eatable food on tarred roads in rural and urban community should be discouraged and agricultural farms should not be close to highways to prevent excessive buildup of heavy metals.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ogamba EN, Izah SC, Ofoni AS. Bioaccumulation of heavy metals in the gills and liver of a common Niger Delta Wetland fish. Clarias Garepenus. 2016;7(1):17.
2. Pais I, Stoeppler M. Hazardous metals in the environment. Amsterdam. Elsevier Publishers. 1997;36.
3. Izah SC, Chakrabarty N, Srivastav AL. Review on heavy metals concentration in portable water sources in Nigeria. Human Health and Mitigating Measures. 2016;5(9):285-304.
4. Iwegbue CMA, Bassey FI, Tesi GO, Nwajei GE, Tsafe AI. Assessment of heavy metal contamination in soils around cassava processing mills in sub-urban areas of Delta State, Southern Nigeria. Nigerian Journal of Basic and Applied Sciences. 2013;21(2):96-104.
5. Pattabhi S, Madhavakrishan S, Manickavasagam K, Rasppan K, Vanekatesh R, Shabudeen PSS. Activated carbon used as an adsorbent for the removal of Ni (ii) from aqueous solution. Environmental Journal on Chemistry. 2008;5(4):761-769.
6. Ohimain EI, Tuwon PE, Ayibaebi EA. Traditional fermentation and distillation raffia palm sap for the production of bioethanol in Bayelsa State, Nigeria. Nigerian Journal of Basic and Applied Sciences. 2012;3(1):131.
7. Evans CE, Omoaruemike EO, Muhammed AV. Effect of fermentation varriables on nutritional and organoleptic scores of Kunu Zaki produced from rice and Acha blends. Abuja, Nigeria. Advanced Journal Food Science and Technology. 2012;9(4):1117.
8. Umar M, Waseem A, Sabir MA, Kassi AM. The impact of geology of recharge areas on ground water quality: A case study of Zhob River Basin. Pakistan Journal of Saudi Chemical Society. 2013;4(1):32.
9. Lui X, Song Q, Tang Y, Li W, Xu J, Wang F. Human health risk assessment of heavy metals in soil-vegetation system. Zhejiang University, Hangzhou, China. Journal College of Environmental and Natural Resourse Sciences. 2003;6(9):23.
10. WHO. Guidelines for drinking water quality. (2nd Ed.) Recommendations Geneva. 2001;1.
11. Lanre-Iyanda TY, Adekunle IM. Assessment of heavy metals and their estimated daily intakes from two commonly consumed foods (Kulikuli and Robo) found in Nigeria. African Journal of Food, Agriculture, Nutrition and Development. 2012;12(3):6156-6169.

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