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SPATIAL DISTRIBUTION OF HEAVY METALS IN THE SOILS AT ONITSHA URBAN, ANAMBRA STATE, SOUTHEASTERN, NIGERIA

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Abstract
The environmental condition of the soil in Onitsha, Anambra State has been examined by determining the heavy metal concentrations of 50 samples.The study to determine the environmental condition of heavy metals inthe soil was conducted using the spatial distribution of the selected heavy metals.The results showed that the concentration values of heavy metals were in the following order Zn>Cr>Cu>Pb>Ni>Cd>As>Co>Hg. In these selected heavy metals, As, Cu, Ni, Pb and Zn exceed the values of thenatural geological background level of rocks that form the study area.All metals build-up in the soil emanated from human mediated activities such as open dumpsite practices and the domestic effluents spurred by industrial development and rise in population growth.

Keywords: Ontisha; heavy metals; kriging; soil; spatial distribution

1. Introduction

Due to their durability and lack of biodegradability, toxic heavy metals found in soil, such as Cd, Cu, Pb, Zn, Ni, Cr, and As, may have an adverse effect on the environment (Plant et al., 2000).Due to their bioaccumulation in food, poisonous metals have an effect on natural ecosystems and may be dangerous to humans through the food chain (Olorundara, et al., 2011).The natural levels of trace elements in soil performs a crucial function in regulating the effect influenced by humans and the degree of soil quality in a given area (Olatunji and Osibanjo, 2012). Investigations into soil polluted by heavy metals have defined regions with a high possibility of contamination via the study of a typical local spatial values (Olorundara, et al., 2011). There are various standards and techniques.Nonetheless, spatial distribution analysis, identification of the sources of contamination and the evaluation of soil quality are of special importance(Iwegbue, 2007). The underlying rock, the soil's characteristics, and human - induced including industrial activity, transportation, and farming are all known to have an impact on the accumulation of heavy metals in soil (Ahmed et al., 2019).Heavy metals emitted by waste disposal, industrial effluent waters, the use of pesticides, fertilizers, and wastewater sludge, as well as other sources, can damage vast areas of land (Taofeek et al., 2012).

Geographic information systems (GIS) are used to conduct geostatistical analysis, which provides more precise and useful data for the assessment of environmental quality based on the presence of heavy metals in soil.Nowadays, the geostatistical approach "Kriging" is used satisfactorily to characterize and estimate the spatial heterogeneity of specific soil characteristics as well as to estimate the values of non-sampled areas(Iwegbue, 2007).In order to use the traditional statistical method, the data must be subjected to a variety of hypotheses, such as independent observations, vast and repeated sampling, etc.

Due to the toxicity and persistence of heavy metals in the environment, studies on the environmental geochemistry of these substances have made significant progress in recent years (Taofeek et al., 2012).The study of soil, particularly soil pollution from heavy metals, has recently been conducted in various disciplines using the analysis of principal components (Tiller, 1992).This is due to the fact that this particular investigation establishes the current relationships between heavy metals in various spatial dimensions and evaluates the relative significance of each metal (Xiangdong et al., 2010).

The current study sought to: quantify the environmental quality of the soil in Onitsha by examining its heavy metal content; evaluate the risk that heavy metals pose to the environment by looking at their spatial distribution; and establish the statistical link between the heavy metals.

2. Materials and Methods

2.1. Study Area

Onitsha is located within latitudes 6°6′00″ and 6°12′00″ and longitudes 6°45′00″ and 6°52′00″, and occupies approximately 49km^2 in the east bank of river Niger. The study area is characterized by two types of landforms, the undulating plains and the ridges. The altitudinal range in the study area is from 50 to 150m.a.s.l. The area has a temperate climate with rainy and dry seasons. The average annual rainfall is between 1761mm and 1850mm, while the average annual temperature is between 25.6ºC and 36.2ºC (Igbozurike, 1975).

From a geological view point, this area belongs to the Niger Delta Basin whose rocks range from Upper Cretaceous to Recent in age (Nwajide, 2013).This basin is bordered to the west by the Okitipupa Ridge, in the east by the Cameroun volcanic line, to the south by the Guinea

Abyssal plain (Onuoha, 1981).The two major geological formations that underlies in the area are Ameki Group and Ogwashi-Asaba Formation which predominantly consists of an alternation of shale, sandy shale, mudstone, coarse-grained sandstone, lignite seams, and light-colored clays of continental origin (Anyanwu and Arua, 1990; Kogbe, 1976).

2.2. Soil Samples

A total of fifty (50) soil samples (about 1 kg) were collected from 0-20 cm depthfrom abattoirs, mechanic workshops, major dumpsites, highways, markets, industrial areas, motor parks, river banks and mining sites across Onitshawith auger and the control soil samplewas collected 25 km away from the study area. Then the sampleswere placed in cleanpolyethylene bags and transported to the NASENI Centre of Excellence in Nanotechnology and Advanced Materials (NASENI CoEx) laboratory Akure for pre-treatment and analysis. The composite soils amples were air-dried in a dry and dust-free place at room temperature (25°C) for 5 days, followed by oven drying to constant weights. The samples were then ground with a mortar and pestle to pass through a 2 mm sieve and homogenized. The dried, sieved, and homogenized soil samples were stored in clean and dry containers after which it was subjected to Energy dispersive X-ray fluorescence (Skyray EDXRF 3600B Spectrometry) for heavy metals analysis.

2.3. Statistical Analysis Samples

The SPSS v.23.0 program was used to conduct the statistical analysis.The variables arithmetic mean, geometric mean, median, range, standard deviation, variable coefficient, and kurtosis were used to create a descriptive analysis. Lastly, a multivariate analysis was carried out utilizing the principal components approach to determine links between the heavy metal levels in the soil and to acquire information about the potential sources that may be responsible for the existence of the heavy metals (Aganigbo and Ifediegwu, 2021).

The GIS study (ArcGis v10.5), with the aids of spatial analytical software and geostatistical analyzers, evaluate the extent of spatial variation of each of the heavy metals utilizing conventional Kriging to define interpolation assessment (Yaserebi et al., 2009). A sophisticated geostatistical technique called kriging defines a surface area based on a set of distributed values. In this approach, soil pollution brought on by the presence of heavy metals can be generated interactively as one of the spatial characteristics.

The two parts of the technique used in this study are as follows: developing the variograms and the covariance values; and calculating the values based on statistics (spatial autocorrection) that are reliant on the model of autocorrection (adequacy of fit) (prediction).The usual Kriging methodology was utilized in this study, which assumes that fluctuations in the surface area can be explained by a spatial correlation between the distance or the direction between sampling locations (Trangmar et al., 1985).

3. Results and Discussion

3.1. Concentration of Heavy Metals in Soil

Table 1 displays the average heavy metal concentrations determined by statistically analyzing the soil of Onitsha.

Table 1. Statistical analysis of heavy metals in soilsatOnitsha.

	As	**Cd**	**Co**	**Cu**	**Cr**	**Hg**	**Ni**	**Pb**	**Zn**
Mean (x)	5.057	1.011	4.288	13.276	13.008	0.009	8.116	10.064	22.899
Geometric mean (GM)	-	0.395	-	0.166	-	-	0.109	-	0.355
Median (Me)	0.000	0.287	0.092	0.121	0.005	0.005	0.111	0.034	0.266
Minimum (min)	0.000	0.059	0.000	0.055	0.000	0.000	0.058	0.000	0.115
Maximum (max)	8.085	8.217	5.695	17.119	18.042	0.106	10.199	12.464	48.949
Standard deviation (S)	0.018	1.885	0.285	0.457	0.011	0.017	0.041	0.092	1.914
Kurtosis	10.683	7.669	16.092	32.566	3.222	24.758	0.954	9.954	9.977
Natural geological Background	5.67	0.07	4.18	12	12.53	0.10	8.63	9.39	21.17

The mean concentrations of As, Cd, Co, Cu, Ni, Cr, Ni, Pb, and Zn in Onitsha soil were 0.89, 0.06, 1.02, 1.10,1.03, 0.94, 1.07 and 1.08 times higher, respectively, than their natural geological background levels.The results indicated that there is an evidentd tendency towards the accumulation of heavy metals in the soil of the Onitsha.

The standard deviation of Zn and Cd, which were 1.914 and 1.885 respectively, were the highest, implying that these two metals had the greater variability throughout the area studied compared to the other metals also present in the soil: Cu, Co, Pb, Ni, As, Hg, and Cr (0.457, 0.285, 0.092, 0.041, 0.018,0.017 and 0.011), which also showed high values (>50%) dispersed along the sampled areas.

3.2 Pearson Correlation Coefficient

The Pearson correlation coefficients for the heavy metal concentrations in the soil samples (Table 2) showed a direct relationship between the majority of the metal concentrations from samples (if we exclude Cd as well as As and Hg in some cases, which had negative correlation values indicating an inverse relationship). These statistically significant levels, marked with asterisks (** p-value < 0.01; * p-value < 0.05), showed that the relationship between the metal concentrations were sometimes small but not negligible.

Table 2. Pearson correlation matrix for the heavy metal concentrations in Onitsha soil samples.

	As	**Cd**	**Co**	**Cu**	**Cr**	**Hg**	**Ni**	**Pb**	**Zn**
As	1								
Cd	0.101	1							
Co	0.280*	-0.041	1						
Cu	-0.209*	-0.179	0.587**	1					
Cr	-0.123	-0.174	0.600**	0.751**	1				
Hg	-0.233*	0.122	-0.051	0.057	0.069	1			
Ni	-0.030	-0.167	0.683**	0.798**	0.800**	0.009	1		
Pb	-0.100	-0.120	0.135	0.393**	0.378**	0.089	0.321**	1	
Zn	-0.015	-0.038	0.496**	0.512**	0.611**	0.057	0.489**	0.184	1

**, *: level of significance $p < 0.01$ and $p < 0.001$, each.

The most strongly linked elements with direct linkages were Cu, Cr, Ni, and Zn. Because these metals were typically found in the samples at the same time and in comparable or proportional amounts, this showed that their primary origin was lithology.The levels of Cd and As, were inversely correlated with those of the other metals. Hg and Cd exhibited an inverse connection with Co.These ties may help to distinguish artificial sources brought about by various human endeavours.

3.3. Spatial Distribution of Heavy Metal Content in Soil

The geostatistical approach of simulation (standard Kriging) enabled for the spatial variability of the levels of every metal in non-sampled locations (Figure 1) to be anticipated utilizing values acquired from the samples taken in the field.The nearest values were found to be more comparable than those that were farther apart.

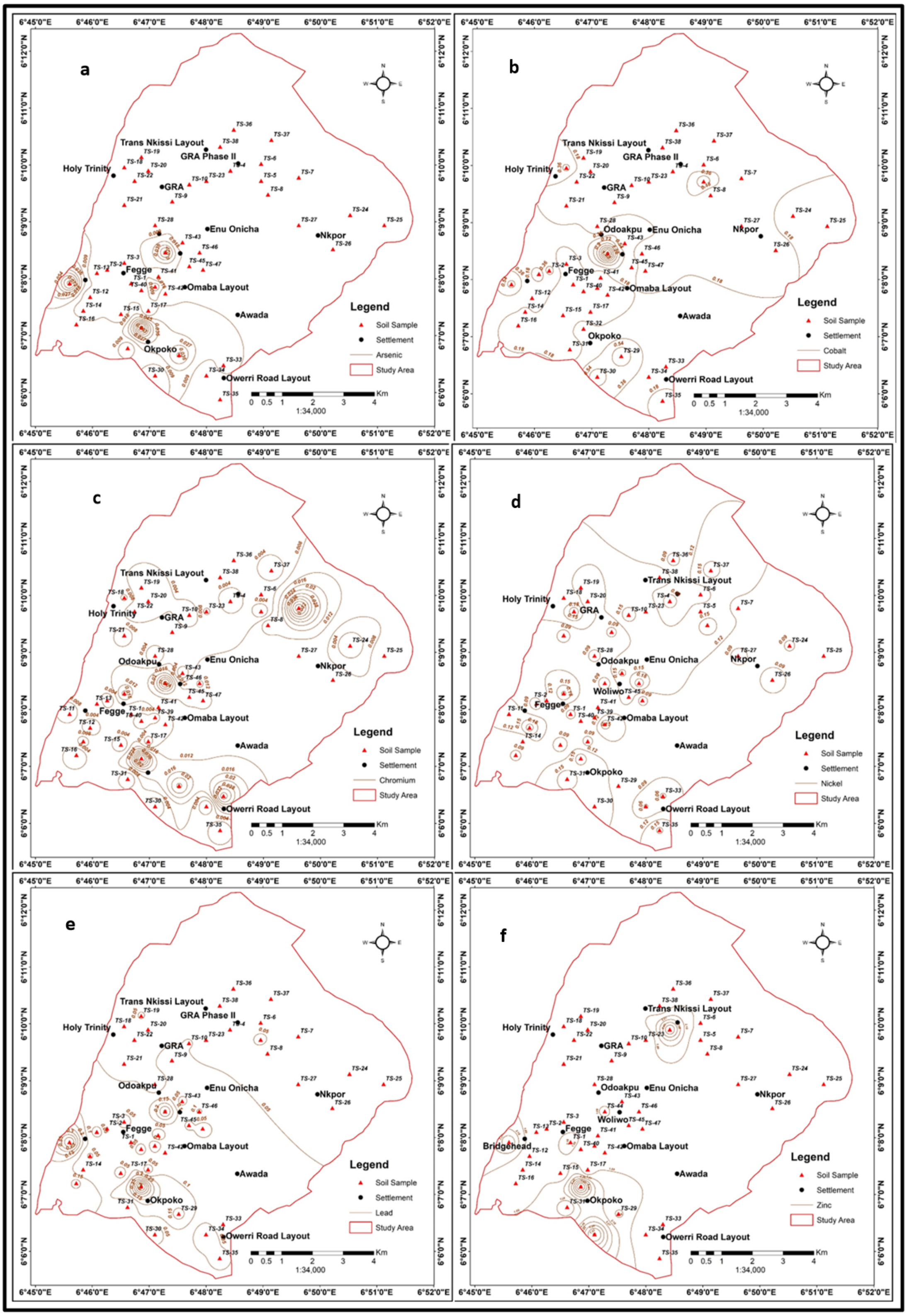

Figure 1 Spatial distribution concentration of (a) Arsenic (b) Cobalt (c) Chromium (d) Nickel (e) Lead and (f) Zinc

4. Conclusion

The rate at which heavy metals affect Onitsha soil is a major source of concern. Hence, there is an urgent need to persistently re-examine heavy metals status at regional scale, in order to avert several risks that heavy metal pose to the environment and if possible, reinstate soil to its natural state. Findings from study suggested that soil is affected by leaching of heavy metals from open dumpsite practices, and domestic effluents caused by industrial development and increase in population density within the study area and that heavy metals such as As, Cu, Ni, Pb and Zn exceed the values of thenatural geological background level of rocks that form the study area.

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