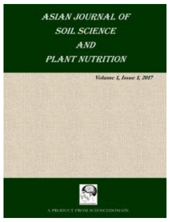

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Evaluation of Heavy Metal Content of Soil Sample from Njere River in Umuakam Okaiuga Nkwoegwu, Umuahia North L.G.A of Abia State

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Authors' contributions

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

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ABSTRACT

Aim: To evaluate the heavy metal content of soil samples from Njere river bank.
Study Design: Soil samples were sourced from three different locations, upstream, midstream and downstream of the river bank.
Place and Duration of Study: Department of Chemistry, Michael Okpara University of Agriculture, Umudike, between June 2009 and December 2009.
Methodology: In each location, soil sample was collected from various points and pooled together. The soil samples were air-dried and used for Atomic Absorption Spectroscopy.
Results: Total Ni and Zn concentrations were below W.H.O standard in the upstream and midstream samples. Fe and Pb were not detected in the midstream and downstream samples. Soluble concentrations of Ni, Fe and Zn and exchangeable concentrations of Ni, Cd, Fe, Zn and Pb were below the standard.
Conclusion: The results reveal that the heavy metal contamination of the soil around the Njere river bank is very low. The soil can support production of healthy crops for food security in the area.

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Keywords: Soil; heavy metals; metalloid; environment; locations; river.

1. INTRODUCTION

The increase in pollution of soil and environment by heavy metals as well as its effect on food security is an issue of great concern all over the world [1]. Heavy metals are usually found naturally in soils at concentrations that are non-toxic [2,3]. Their concentrations in the environment often become high primarily due to man-made activities which eventually becomes detrimental to plants and living organisms [4,5,6, 7]. In developing countries where industrial activities are heightening, indiscriminate disposal of wastes and effluents containing heavy metal compounds coupled with inefficient method of remediation, help to increase their concentrations in the environment. Heavy metals are usually found as single elements or in combination with soil components. The concentration of heavy metals is often higher in the top soil region [8], where nutrient uptake mainly occurs [9].

Heavy metals have been defined to include transition metals, some metalloids, lanthanides and actinides and metallic elements whose specific density is greater than that of water (5 gcm^{-3}) [10]. They are broadly divided into essential and non-essential heavy metals. Essential heavy metals are necessary for some biochemical and physiological functions in plants and animals. They include: cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se) and zinc (Zn) [11]. Heavy metals with no verified biological role such as aluminium (Al), antinomy (Sb), arsenic (As), bismuth (Bi), cadmium (Cd), gallium (Ga), germanium (Ge), gold (Au), indium (In), lead (Pb), mercury (Hg), platinum (Pt), silver (Ag), tellurium (Te), thallium (Tl), tin (Sn), titanium (Ti), vanadium (V) and uranium (U) are classified as non-essential [12].

Reports from some researchers have shown that certain physicochemical properties of soils like dissolved organic carbon, cation exchange capacity, oxidation-reduction potential as well as pH influence the bioavailability of heavy metals in soil [13,14]. Heavy metals are more tightly bound to soils with high clay and organic matter content [15]. When heavy metals combine with soil at even low concentrations, they hinder nutrient availability to plants [16]. Heavy metals resist chemical and microbial degradation and can enter the food chain. The frequency, toxicity and potency of As, Pb, Hg and Cd have been rated first, second, third and seventh respectively in humans [17]. Arao et al. [18], in a study conducted in Japan reported that soils and agricultural products became contaminated when heavy metal levels are beyond permissive levels. Khan et al. [19], reported that ingestion of food crops grown on soils irrigated with waste water stand the risk of accumulating significant amounts of metals. Ayodele et al. [20], assessed the heavy metal content of soil and water from an abandoned granite quarry. Another researcher Adama et al. [21] assessed the heavy metal content of soils around a hospital waste incinerator. The present study assessed the total, soluble and exchangeable metal ions in the soils from around the Njere river bank located in Umuakam Okaiuga, Nkwoegwu Umuahia South L.G.A, Abia state (Longitude N 05°34'24.3'' and latitude E 007°27'52.0'').

2. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Soil samples were collected from three different points: in the upstream, midstream and downstream locations around the bank of the Njere river. In each location, soil was collected from different points with the aid of a clean trowel and pooled together to form a composite sample for each location. The samples were stored in clean polythene bags and carried to the laboratory. Thereafter, the samples were air-dried, milled and sieved using 0.01 µm sieve. The soil samples were collected in June, 2009.

2.2 Determination of Total Metal Concentration

One gram of soil sample was weighed into a conical flask. To it was added 15 ml of HNO_3 and 10 ml of HCl. The resulting mixture was digested by heating it in a fume cupboard at 100°C for 30 minutes. After this, 25 ml of deionized water was added and heated for another 90 minutes. Thereafter, it was allowed to cool, filtered into 50 ml volumetric flask and made up to mark with deionized water. Thereafter, 10 ml of the above solution was poured into clean sample bottles for determination of total metal concentration using atomic absorption spectrophotometer.

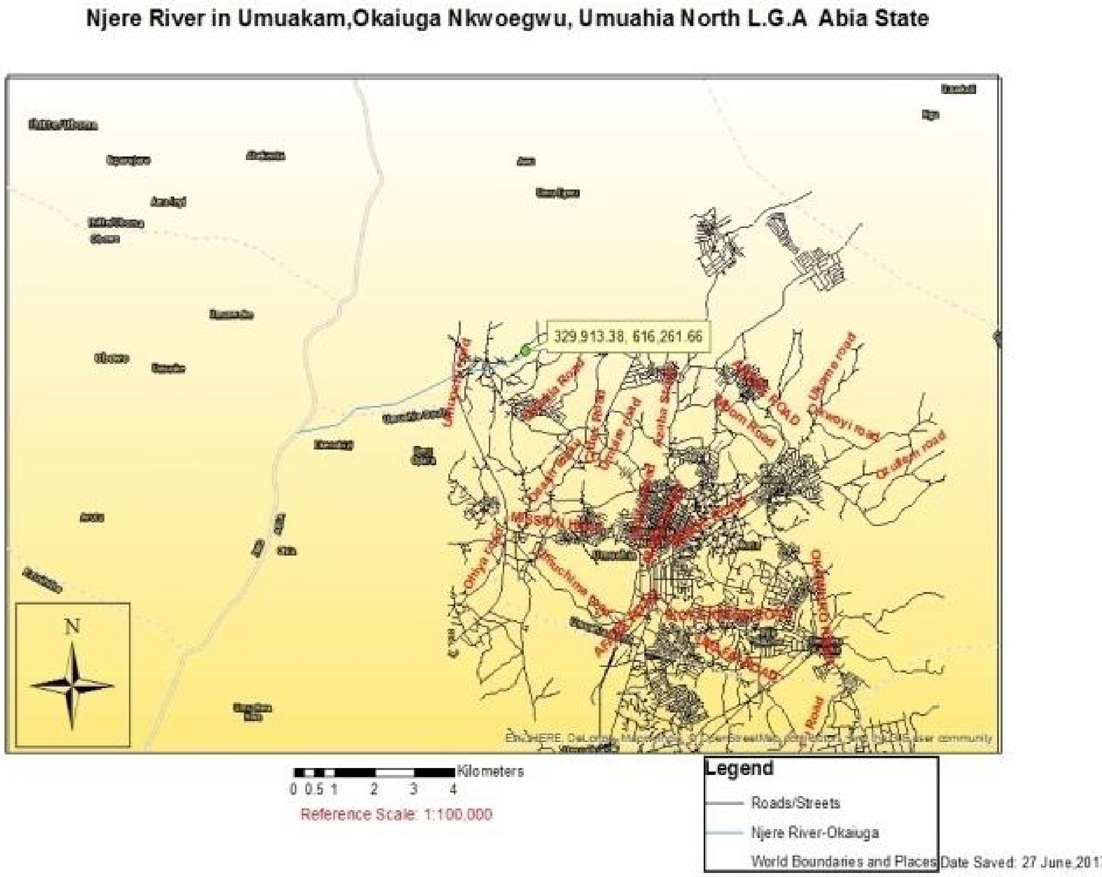

Fig. 1. Map of Umuakam, Okaiuga Nkwegwu L.G.A showing the Njere River

2.3 Determination of Water Soluble Metal Concentration

Twenty mls of deionized water was poured into a flask containing 1 g of soil sample and left to stand for 30 minutes. The content was filtered into 50 mls volumetric flask using whatmann no 1 filter paper and made up to mark with deionized water. Ten ml of the filtrate was poured into clean sample bottle for determination of water soluble metal concentration with AAS.

2.4 Determination of Exchangeable Metal Fraction

Into a clean conical flask was added 1 g of soil sample and 20 ml of 1M solution of $MgCl_2$ and the pH was adjusted using potassium phosphate buffer. After that, it was boiled inside a fume cupboard for 1 hour, filtered with whatmann no 1 filter paper into a volumetric flask and deionized water was added to make up the content to the 50 ml mark. Ten ml of the filtrate was measured out into clean sample bottle for determination of exchangeable metal fraction using AAS.

2.5 Statistical Analysis

The results are means of duplicate determinations and analyzed using Microsoft excel package, 2010.

3. RESULTS AND DISCUSSION

Table 1 shows the total metal ion concentration of soils from around the Njere river. The concentration of Ni and Zn were below the W.H.O standard. Cd was above the W.H.O standard of < 0.1 ppm in the upstream and midstream samples. Fe and Pb were not detected in the midstream and downstream samples. However, the concentrations of Fe and Pb in the upstream sample did not exceed the W.H.O standard given.

Table 1. Total metal ion concentration in soil samples from around Njere river bank

Type of metal ion	Sample location	Mean metal ion conc (ppm)	WHO standard (ppm) (2005)
Ni	Upstream	0.118	10-50
Ni	Midstream	0.076	10-50
Ni	Downstream	0.075	10-50
Cd	Upstream	0.315	<0.1
Cd	Midstream	0.196	<0.1
Cd	Downstream	0.018	<0.1
Fe	Upstream	1.688	10-1000
Fe	Midstream	ND	10-1000
Fe	Downstream	ND	10-1000
Zn	Upstream	0.674	60-780
Zn	Midstream	0.122	60-780
Zn	Downstream	0.142	60-780
Pb	Upstream	0.208	2-13.4
Pb	Midstream	ND	2-13.4
Pb	Downstream	ND	2-13.4

Values are means of duplicate determination

Table 2 is the result of soil water soluble metal ions from Njere river. Ni, Fe and Zn levels were below W.H.O standard. Pb was not detected in the soil samples from the three locations. Cd was not detected in the upstream and midstream sample. Cd level was above the W.H.O standard in the downstream sample.

Table 3 is the result of the exchangeable metal ions of soil samples from around the Njere river. Ni, Cd, Fe, Zn and Pb levels were below the W. H.O standard.

Ni, Cd, Fe and Zn are transition metals. Ni, Fe and Zn are essential at low concentrations. Above the maximum permissible level, Ni can be very toxic. It is responsible for decreased chlorophyll content, nutrient uptake, inhibition of enzyme growth and activities in plants; alteration of cell membrane and oxidative stress in microorganisms; and health disorders such as cancer, cardiovascular, skin, respiratory and kidney diseases [22,23]. The total Ni concentration in the soil samples is well below the W.H.O standard and a possible indication of an environment with poor industrial activities like painting that contributes to the natural level of Ni in the soil [24]. The higher concentration of soluble Ni ion in the downstream soil sample could be attributed to bioaccumulation due to the direction of the flow of the river. The Ni concentration in this study is within the safe limits.

Table 2. Exchangeable metal ion concentration of soil samples from around Njere river bank

Type of metal ion	Sample location	Mean metal ion conc (ppm)	WHO standard (ppm)
Ni	Upstream	0.152	10-50
Ni	Midstream	0.181	10-50
Ni	Downstream	0.179	10-50
Cd	Upstream	0.02	<0.1
Cd	Midstream	0.033	<0.1
Cd	Downstream	0.088	<0.1
Fe	Upstream	0.079	10-100
Fe	Midstream	0.099	10-100
Fe	Downstream	0.08	10-100
Zn	Upstream	0.016	60-780
Zn	Midstream	0.123	60-780
Zn	Downstream	0.125	60-780
Pb	Upstream	0.023	2-13.4
Pb	Midstream	0.019	2-13.4
Pb	Downstream	0.026	2-13.4

Values are means of duplicate determinations

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Pb	Downstream	0.026	2-13.4

Values are means of duplicate determinations

Cadmiun has no known biological role [25]. Cd causes chlorosis, decrease in plant nutrient content, growth inhibition, and reduced seed germination in plants. It damages nucleic acid, denatures proteins, and inhibits cell division and transcription, carbon and nitrogen mineralization in micro-organisms. It is responsible for bone disease, coughing, emphysema, headache, hypertension, itai-itai, kidney diseases, lung and prostate cancer, lymphocytosis, microcytic hypochromic anemia, testicular atrophy, vomiting in man [26,27].

Zinc affects photosynthesis, inhibits growth rate, reduce chlorophyll content, germination rate and plant biomass. In humans, it is a leading cause of Ataxia, depression, gastrointestinal irritation, haematuria, icterus, impotence, kidney and liver failure, lethargy, muscular degeneration, metal fume fever, prostate cancer, seizures and vomiting [28]. Lead is a group IV metal that affects photosynthesis and growth, causes chlorosis, inhibits enzyme activities and seed germination. It causes anorexia, chronic nephropathy, damage to neurons, high blood pressure, hyperactivity, insomnia, learning deficits, reduced fertility, renal system damage, risk factor for Alzheimer's disease and shortened attention span [29,30]. In the present study, the concentrations of the soluble and exchangeable metal ions were all higher in the downstream soil samples. This could be because the downstream location can be said to be a dumping site and hence, the accumulation of various heavy metals. However, the observed concentrations were still within the safe limits.

4. CONCLUSION

The heavy metal content of soil determines its suitability for healthy crops production for human and animal consumption. It also affects the microbial activities in the soil. Heavy metals in soil may be from natural or anthropogenic origin. The soil around the Njere River has relatively low concentration of heavy metals. The observed quantity may be attributed to natural source since industrial activities that increase heavy metal concentrations in an area are still very minimal. The soil around the Njere River is still relatively safe for agricultural purposes. It will enhance production of quality agricultural food products and help attain food security.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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