Evaluation of the heavy metal levels in soil and water from coal mining communities of Enugu State, Nigeria

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ABSTRACT

Water and soil from Akwuke, Ngwo and Udi were analyzed for their heavy metal content using the atomic absorption spectrometry (AAS). All the well water samples were found to be higher in heavy metal concentration when compared with the WHO permissible limit, except nickel in drinking water. The soil samples in the three communities were found to have lower concentration of Mn, Cr, Pb, Cd, and Ni when compared to the WHO permissible limit in soil. This study has revealed high concentration of manganese, lead, chromium, cadmium and nickel in water samples in the three studied area Akwuke, Ngwo and Udi, all in Enugu State. Though the concentrations of these heavy metals were not high in any of the soil samples, but high concentration of these heavy metals, compared to WHO/FAO in well water was observed, especially in Udi and Ngwo community.
Keywords: Heavy metal, levels, soil and water.

INTRODUCTION

Several studies have shown that heavy metals such as lead, cadmium, nickel, manganese and chromium amongst others are responsible for certain diseases [1]. In general heavy metals are systemic toxins with specific neutrotoxic, nephrotoxic, fetotoxic and tetratogenic effect [1]. Heavy metals can directly influence behaviour by impairing mental and neurological function, influencing neurotransmitter production and utilization and altering numerous metabolic processes. Systems in which toxic metal elements can induce impairment and dysfunction include the blood and cardiovascular, eliminative pathways (colon, liver, kidney, skin), endocrine (hormonal), energy production pathways, enzymatic, gastrointestinal, immune, nervous (central and peripheral), reproductive and urinary that have lethal effects on man and animals [1]. Diseases associated with the heavy metal toxicity include, pulmonary, abdominal pain, chronic bronchitis, kidney disease, pulmonary edema (accumulation of fluid in the lungs), cancer of the lungs and nasal sinus ulcers, convulsion, liver damage and even death [1]. Heavy metals get into the environments: water, soil and food cultivars through activities like intense agriculture, power generation, industrial discharges seepages and municipal landfills, septic tank effluents etc. Many authors have reported high levels of heavy metals ions in the soil and groundwater in different areas of Nigeria [2]. Diseases associated with the heavy metal toxicity include, pulmonary, abdominal pain, chronic bronchitis, kidney disease,

pulmonary edema (accumulation of fluid in the lungs), cancer of the lungs and nasal sinus ulcers, convulsion, liver damage and even death [3]. Heavy metals get into the environments: water, soil and food cultivars through activities like intense agriculture, power generation, industrial discharges seepages and municipal landfills, septic tank effluents etc. Many authors have reported high levels of heavy metals ions in the soil and groundwater in different areas of Nigeria [4].

Aim of the Study

This research work is aimed at determining the heavy metal levels in soil and water from coal mining communities of Enugu State, Nigeria.

DESCRIPTION OF STUDY SITES

The major activities that are going on the three major communities of coal mining environment of Udi, Ngwo and Akwuke is intensive agriculture. Apart from intense agriculture, Ngwo, Akwuke and Udi has a lot of activities that is going on in their communities, especially mining of coal and other mineral resources, such as sand, granite, chippings gravel and manufacturing industries.

MATERIALS AND METHOD

Sample collection

Soil samples; these were collected from there different locations (Akwuke, Ngwo and Udi) in three different local Government area in Enugu state and the soil sample were collected from a depth of 15-30cm using a metal auger and transferred into prewashed polyethylene nylon bag to avoid contamination. Water sample; well water sample were collected from three different locations (Akwuke, Ngwo and Udi), according to the method recommended by [5] and Tate, [6]. According to the method, two litres plastic container was rinsed with detergent and rinsed with the sample to be collected at least three times before samples are finally collected and stored in 1ml HCl to avoid microbial growth. Food cultivars; leafy vegetables and tubers were collected from three different location (Akwuke,Udi and Ngwo)in three different Local Government Area in Enugu State, with the consent of the owners of the farm, and the tubers were also collected from their storage bans with the consent of the farmers .

Sample preparation

Preparation of soil samples: After collection, samples were brought to the laboratory and initial treatment was given for the preservation and further analysed according to the following methods. The soil samples collected from the selected areas were initially treated by adopting the method recommended by [7]. According to this method, samples were air dried in sun light for a day. Then the samples were finally dried in oven at 105^{oC} till a constant weight was acquired. Then about half of each sample was passed through 0.5mm nylon mesh sieve. Then soil samples were repacked with the complete labeling and preserved for further analysis.

DIGESTION OF SAMPLES

Digestion of soil samples

Soil samples were dried at 105^{oC} and sieved with 100 mesh (152um Bs screen 410). 1g of the dried soil sample was weighed into a labeled 100ml conical flask and 20ml of mixture of concentrated HCL and concentrated HNO_3 (1:1) were added and well shaken. The solution was kept overnight after which it was filtered through with whatman N0.1 filter paper formerly leached by pouring cupious quantity of dilute HNO_3 on the filter paper while in the funnel. The clear solution obtained was made up to 100ml using a standard flask and transferred into a plastic bottle [8]. The sample solutions were analyzed at various wavelengths for each metal using Varian AA240 Atomic Absorption Spectrophotometer according to the method of APHA [9].

Digestion of water sample

Well water sample was collected with 2L polyethylene cans which were leached with a 1:1 HCL and water and rinsed with distilled de-ionized water [10]. The samples were concentrated by evaporating 500ml of water sample to about 100ml followed by addition of 1ml concentrated HCL and digesting until volume was about 15-20ml. this was later transferred into an acid-rinsed polyethylene bottle prior to analysis. Heavy metals were determined with AAS AA240, according to American Public Health Association (1995).

Phosphate Determination

Phosphate was measured using Standard Method 4500-P B.5 and 4500-PE (APHA; 1998). **Procedure:** Exactly 100ml of the homogenized and filtered sample was pipetted into a conical flask. The same volume of distilled water (serving as control) was also pipetted into another conical flask. 1ml of 18M H_2SO_4 and 0.89g of ammonium persulphate were added to both conical flasks and gently boiled for 1½ hrs, keeping the volume of 25-50cm^3 with distilled water. It was then cooled; one drop of phenolpthelein indicator was added and after neutralized to a faint pink color with the 2M NaOH solution. The pink color was discharged by drop wise addition of 2M HC1, and the solution made up to 100ml with distilled water. For the colorimetric analysis, 20ml of the sample was pipetted into test tubes, 10ml of the combined reagent added, shaken and left to stand for 10mins before reading the absorbance at 690nm on a spectrophotometer, using 20ml of distilled water plus 1ml of the reagent as reference.

Methods for Calibration

Standard phosphate solution: 219.5 mg of dried AR potassium hydrogen phosphate was dissolved in distilled water and made up to 1000ml, where 1ml = 50.0μg. of phosphate. 10ml of the stock solution was made up to 1000ml to give 1ml - 0.05 mg. Standards of strength ranging from 0 (blank) to 0.05mg/L at intervals of 0.05mg is prepared by diluting the stock with distilled water.

Conc. of sample = $\dfrac{\text{Abs of sample x conc of std}}{\text{Abs of Std}}$

Chloride Determination

Chloride analyzed according to APHA standard method (APHA; 1998).

Procedure:

A 100ml of the clear sample was introduced using pipette into an Erlenmeyer flask and the pH adjusted to 7-10 with either H_2SO_4 or NaOH solution. Then 100ml of K_2CrO_4 indicator solution was added with standard solution of $AgNO_3$ in a permanent reddish brown colouration. The $AgNO_3$ titrant was standardized and a reagent blank established. A blank of 0.2-0.3ml is usual for the method Calculation

Chloride cone = Titre value (x) x 10 =10xmg/l

Sulphate Determination

Sulphate analysed according to APHA standard method (APHA; 1998).

Procedure:

A 250cm^3 of the water sample was evaporated to dryness on a dish. The residue was moisten with a few drop of concentrated. HC1 and 30cm^3 distilled water was added. This was boiled and men filtered.

The dish was rinsed and the filter paper washed with several portions, of distilled water and both filterate and washings added together. This was heated to boiling and then 10cm^3 of 10% BaCb solution was added, drop by drop with constant stirring. The mixture was digested for about 30minutes, filtered and the filter paper washed with warm distilled water. It was then ignited, cooled and weighed in an already weighed crucible.

Calculation: $Mg/dm^3 SO_4^{2-}$ = mg $BaSO_4$ x 411.5cm^3 of water sample

Nitrate Determination

Nitrate is determined using PD303 UV spectrophotometer (APHA, 1998)

Procedure

A known volume (50ml) of the sample was pipette into a poecelain dish and evaporated to dryness on a hot water bath. 2ml of phenol disulphonic acid was added to dissolve the residue by constant stirring with a glass rod. Concentrated solution of sodium hydroxide and distilled water was added with stirring to make it alkaline. This was filtered into a Nesslers tube and made up to 50ml with distilled water, the absorbance was read at 410nm using a spectrophotometric after the development of color. The standard graph was plotted by taking concentration along X - axis and the spectrophotometeric readings (absorbance) along Y-axis. The value of nitrate was found by comparing absorbance of sample with the standard curve and expressed in mg/1.

Conc, of sample $= \dfrac{\text{Abs of sample x Conc, of std}}{\text{Abs of Std}}$

RESULTS
HEAVY METAL CONCENTRATION IN SOIL FROM THE STUDY AREAS

Result of heavy metal levels in soil from coal mining communities in Enugu State showed that Mn, Pb and Cd levels in soil from Akwuke were significantly higher ($p < 0.05$) when compared to Udi and Ngwo, while Cr level inNgwo was

significantly highest (p<0.05), followed by Akwuke and Udi. Ni level were below detectable level in soil from all the communities (Table 1)

Table 1: Heavy Metal Level in Soil

Trace Metals(μg/g)	Udi	Ngwo	Akwuke	WHO/EPA (μg/l)
Mn	330.00 ± 0.01^c	430.00 ± 0.01^b	450.00 ± 0.01^a	630.00
Cr	130.00 ± 0.01^c	430.00 ± 0.01^a	330.00 ± 0.01^b	100.00
Pb	280.00 ± 0.01^b	220.00 ± 0.01^c	330.00 ± 0.01^a	85.00
Cd	10.00 ± 0.10^b	20.00 ± 0.01^b	120.00 ± 0.01^a	5.2.00
Ni	0.00 ± 0.01^a	0.00 ± 0.01^a	0.00 ± 0.01^a	100.00

Values are mean ± standard deviation of triplicate determination

Values in the same row bearing the same superscript letters are not statistically significant at P<0.05.

HEAVY METAL CONCENTRATION IN WATER FROM THE STUDY AREAS

Result of heavy metal levels in water from coal mining communities in Enugu State showed that Mn, Pb, Cr and Cd levels in water from Akwuke were significantly higher (p<0.05) when compared to Ngwo and Udi, while Ni level in well water from Ngwo was significantly highest (p<0.05) followed by Akwuke and least was Udi (Table 2).

Table 2: Heavy Metal Level in well water from coal mining communities

Trace Metal(μg/g)	Udi	Ngwo	Akwuke	WHO/EPA (μg/l)
Mn	380.00 ± 0.01^c	540.00 ± 0.01^b	590.00 ± 0.01^a	50.00
Cr	0.00 ± 0.01^c	60.00 ± 0.01^b	90.00 ± 0.01^a	50.00
Pb	270.00 ± 0.01^b	200.00 ± 0.01^c	280.00 ± 0.01^a	10.00
Cd	10.00 ± 0.10^b	10.00 ± 0.01^b	20.00 ± 0.01^a	10.00
Ni	0.00 ± 0.01^a	30.00 ± 0.01^a	10.00 ± 0.01^b	1.00

Values are mean ± standard deviation of triplicate determination

Values in the same row bearing the same superscript letters are not statistically significant at P<0.05

DISCUSSION

Heavy metal levels in soil of the three communities followed the trend Akwuke>Ngwo>Udi. Higher level of Mn, Pb and Cd observed in Akwuke soil over other communities could be attributed to anthropogenic and mining activities that took place in this area, and the use of fertilizer sources. The result of the study revealed that the concentrations of these metals in the soil of the three communities studied is within the permissible limit in agricultural soil [11]. High levels of heavy metal in agricultural soil may lead to increased metal uptake in plant which may have adverse health implication in humans that depends on them for food.The heavy metal levels in well water followed the same trend as observed in soil. However Mn, Cr and Pb levels in well water from the three locations were above [12] permissible limit of 0.05mg/l, 0.05mg/l, and 0.01mg/l for Mn, Cr and Pbrespectively. The high level of these metals in well water could be attributed to anthropogenic sources as well as underground water pollution due to leaching of these metals in the soil to underground water. The level of heavy metals above the permissible limit renders the water unsafefor both domestic and industrial use. Thus consumption of well water from these communities may increase the heavy metal load of the system and result in gastro entireties and abdominal pains.

CONCLUSION

This study revealed high concentration of manganese, lead, chromium,cadmium and nickel in water samples in the three studied area Akwuke, Ngwo and Udi,all in Enugu State. Though concentrations of these heavy metals were not high in any of the soil samples, butwere high when compared to WHO/FAO well water especially in Udi and Ngwo community.

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