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Assessment of Heavy Metals Concentration as an Index of Environmental Pollution in Mechanic Village, Avu, Owerri West LGA Imo State.

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ABSTRACT
Theassessment of heavy metals concentration and some physicochemical properties of soil in Mechanic village Avu, owerri were carried out. The samples were collected at the points A, B and C at depths of 5cm, 10cm and 15cm at each point, alongside an unpolluted site point D. Results showed that the concentration of Lead (Pb) ranges from1.30±0.06, 1.40±0.10 to 1.33±0.40 for Stations A, B and C respectively, Cadmium (Cd) ranges from 1.43±0.11, 1.42±0.22 to 1.56±0.30 respectively, Chromium (Cr) ranges from 3.10±0.06, 3.12±0.63 to 3.40±0.06 respectively, Zinc (Zn) ranges from 31.30±0.16, 30.30±1.57 to 29.90±0.91 respectively, while Iron (Fe) ranges from 19.99±0.04, 22.31±2.24 to 20.89±1.24. The results showed that the concentration of these metals were within the range of WHO and FEPA except in the case of chromium whose values was above FEPA permissible limit and cadmium that had a higher concentration above permissible limit for WHO and FEPA. Furthermore, the pollution index showed that the soil has a considerable contamination factor which may increase with time due to the anthropogenic activities which frequently takes place in the mechanic village. The physicochemical parameters, pH and electrical conductivity showed that the soil is slightly acidic with the presence of some ionic salts with high mobility.

Keywords: Heavy metals, physicochemical parameters, permissible limit, pollution index, contamination factor,

I. INTRODUCTION

Heavy metals are generally referred to as those metals which possess a specific density of more than 5g/cm^3 and adversely affect the environment and living organisms [1]. They are important constituents for plants and humans, when present only in small amount. Some micronutrient elements may also be toxic to both animals and plants at high concentrations. For instance, copper (Cu), chromium (Cr), molybdenum (Mo), nickel (Ni), selenium (Se) or zinc (Zn). Other trace elements such as arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb) are toxic even at small concentrations [2]. Heavy metals, being persistent and non-biodegradable, can neither be removed by normal cropping nor easily leached by rain water [3]. They might be transported from soil to ground waters or may be taken up by plants, including agricultural crops. For this reason, the knowledge of metal-plant interactions is also important for the safety of the environment [2].

There has been increasing interest in determining heavy metal levels in public food supplied. However, their concentration in bio-available form is not necessarily proportional to the total concentration of the metal [4] [5].

The quality of ecosystem becomes altered, when heavy metals find their way, somehow, into it through human and natural activities. These activities are one of the most pressing concerns of urbanization in developing countries like Nigeria, which result in the problem of solid, liquid and toxic waste management. Such waste may be toxic or radioactive [6].

Most plants and animals depend on soil as a growth substrate for their sustained growth and development. In many instances the sustenance of life in the soil matrix is adversely affected by the presence of deleterious substances or contaminants. The entry of the organic and inorganic form of

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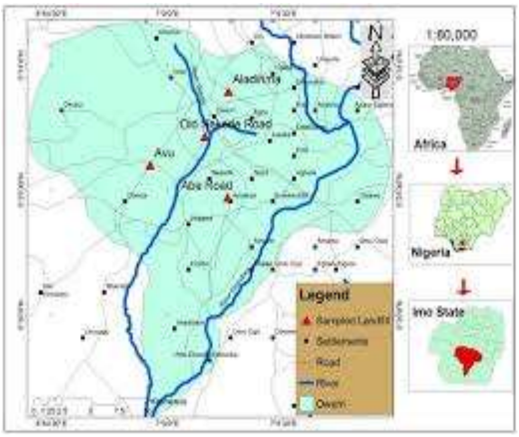
contaminants results from disposal of industrial effluents [7]. The source of the organic and inorganic elements of the soil of contaminated area was mainly from unmindful release of untreated effluent on the ground [8]. The contamination of soils with heavy metals or micronutrients in phytotoxic concentrations generates adverse effects not only on plants but also poses risks to human health [9].

Afterwards, the consumption of contaminated vegetables constitutes an important route of heavy metal exposure to animals and humans [10]. Abandoned waste dumpsites have been used extensively as fertile grounds for cultivating vegetables, though research has indicated that the vegetables are capable of accumulating high levels of heavy metals from contaminated and polluted soils.

II. EXPERIMENTATION

Sample / Study Area

The mechanic village in Avu was chosen for the present study, Avu is a village in Owerri west Local Government Area of Imo state. The mechanic village is an industrial cluster where the repairs of automobiles are carried out. The town is located along Port Harcourt Road with Latitude of 5.44°N and Longitude 6.96°E. Owerri West LGA has population of about 140,100. It has an area of 295Km^2 with a density of 474.9/Km^2.



Sample collection

The soil test samples were collected using Random sampling at three different points; A, B and C in the mechanic village at various depths such as 5cm, 10cm and 15cm respectively while the control sample point D was collected from an area where neither car repair, industrial, commercial nor auto-mechanic activities are carried out with the aid of a spatula that has been pre-cleaned with concentrated nitric acid in order to prevent sample contamination prior to analysis.

Sample preservation

The collected samples were preserved in a clean polyethene/cellophane bag and were correctly labeled as shown below before transporting it to the laboratory for analysis.

Test samples

Stations Depths

A Samples (A1 for 5cm, A2 for10cm and A3 for15cm)

B Samples (B1 for 5cm, B2 for 10cm and B3 for 15cm)

C Samples (C1 for 5cm, C2 for 10cm and C3 for 15cm)

Control Sample

Sample D (From a mean depth = 10cm)

Sample pre-treatment

The soil samples were allowed to air dry for 24 hours and were sieved into fine particles using a 2mm mesh sieve. The fine soil particles were then taken to the laboratory for preparation.

Heavy metals Analysis

Standard solutions of Lead, Cadmium and Chromium were prepared at different concentrations using analytical grade reagents from their stock solutions. The solutions were aspirated into the AAS and the hollow cathode lamp of the various metals having resonance lines were used as radiation source. The absorbance readings of the metals were recorded. The calibration curve of the metals was gotten by plotting a graph of the absorbance against concentration which gives a straight line graph according to Beer-Lambert Law.

The digested soil samples were also analyzed using the AAS as described above. The absorbance readings of the samples were recorded and their various concentrations were extrapolated from the calibration curves of the metals.

Determination of pH

The pH of the various soil samples was determined using the pH meter.

The pH meter was turned ON and allowed to stabilize for about 15mins, thereafter it was calibrated with buffer solutions of pH 7 and 4. The various soil samples were poured into a clean beaker containing distilled water, then the pH of each soil sample was determined by immersing the glass electrode into the sample and the readings were taken.

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Determination of Electrical Conductivity

The Electric conducometer (EC) was used to determine the conductivity of the soil samples.

The electric conductometer (EC) was turned ON and allowed to stabilize for about 15mins, thereafter it was calibrated with 0.01M of NaCl. The various soil samples were poured into a clean beaker containing distilled water, then conductivity of each soil sample was determined by immersing the glass electrode into the sample and the readings were noted for stable values in µs/cm.

Environmental Pollution Indices

Contamination Factor (Cf)

In this study, the concentration of the control samples is taken to represent the pre-industrial concentration. Contamination factor (Cf) can be used to differentiate between the metals originating from anthropogenic activities and those from natural processes and to assess the degree of anthropogenic influence [11]. Five contamination categories of contamination factor are recognized. High CF values suggest strong anthropogenic influence.

$$Cf = \frac{C_{sample}}{C_{background}} \quad (1)$$

Where;

Cf = Contamination factor

C_{sample} = Concentration of heavy metals from polluted sites

$C_{background}$ = Concentration of heavy metals from unpolluted sites (Control)

Categories of Contamination factor (Cf)

Range	Category
Cf<1	Low contamination factor
1<Cf<3	Moderate Contamination factor
3<Cf<6	Considerable contamination factor
6<Cf	Very high contamination factor

Pollution Load Index

The PLI is obtained as a contamination factor (CF) of each metal with respect to the natural background value in the soil.

$$PLI = [CF_1 \times CF_2 \times CF_3 \times \ldots \times CF_n]^{1/n} \quad (2)$$

Where;

Cf = Contamination factor each metal

n = number of metals analyzed

Enrichment Factor (EF)

Enrichment factor (EF) was used in the study to assess the relative contributions of natural and anthropogenic heavy metal inputs to soil. EF has also been used to indicate the degree of pollution or contamination or both. Data from samples taken from the control site were used to establish metal-normalizer relationships to which the data generated from various mechanic workshops are compared. According to this technique, metal concentrations were normalized to the textural characteristic of soil. Most commonly used reference elements include Sc, Mn, Al and Fe [12].

In this study, Fe was chosen as the geo-chemical normalizer because of its conservative nature.

EF is defined as:

$$EF = (X/Fe)soil \times (X/Fe)background \quad (3)$$

Where;

$(X/Fe)soil$ = ratio of heavy metal (X) to Fe in the soil from mechanic village

$(X/Fe)background$ = Control value of the metal-Fe ratio.

Categories of Enrichment factors (EF)

Range	Category
EF<1	No Enrichment
EF<3	Minor Enrichment
EF = 3-5	Moderate Enrichemnt
EF = 5-10	Moderately Severe Enrichment
EF = 10-25	Severe Enrichment
EF = 25-50	Very severe Enrichment
EF>50	Extremely severe Enrichment

Geo-accumulation Index

The geoaccumulation index (I-geo) was used to quantify the extent of heavy metal contamination associated with the soils from the various mechanic workshops. The Igeo values were calculated using the expression [19]:

$$Igeo = \log_2\left(\frac{Cm}{1.5Bn}\right) \quad (4)$$

Where;

Cm = Measured total concentration of metals in soils (mg/kg)

Bn = Geochemical background (Control) values (mg/kg)

1.5 = the background (Control) matrix correction factor due to lithogenic effects

Categories of Geoaccumulation index (I-geo)

Range	Category
<0	Unpolluted
0 – 1	Unpolluted to moderately
1 – 2	Moderately polluted
2 – 3	Moderately polluted to highly polluted
3 – 4	Highly polluted
4 – 5	Highly polluted to very highly polluted
>5	Very highly polluted

Quantification of Anthropogenic metal (%QoC)
The quantification of anthropogenic concentration of metal employs the concentration in the control samples to represent the lithogenic metal [13].

$$\%QoC = \frac{X - X_c}{X} \times 100 \quad - \quad - \quad (5)$$

Where;
X = Average concentration of the metal in the soil under investigation
Xc = Average concentration of the metal in the control sample

Statistical Analysis
All analysis was done in triplicate with values expressed as Mean±SEM (Standard Error of the mean) which were calculated using Microsoft Excel 2003. Two-way Analysis of Variance (ANOVA) with and without replication was carried out with Excel 2003 and SPSS version 21.0 with a significant level ($p<0.05$) to check for the difference between treatments.

III. RESULTS AND DISCUSSION

Table 4: Heavy metals concentration of soil (Test and Control Sample)

Heavy metals (mg/kg)	STATIONS			
	A	B	C	D
Pb	1.30±0.06	1.40±0.10	1.33±0.40	0.07±0.01
Cd	1.43±0.11	1.42±0.22	1.56±0.29	0.04±0.00
Cr	3.10±0.06	3.12±0.63	3.40±0.06	0.61±0.02
Zn	31.30±0.16	30.30±1.57	29.90±0.91	16.57±0.04
Fe	19.99±0.04	22.31±2.25	20.89±1.24	16.06±0.01

Values are expressed as Mean±SE

Pollution Indices

Table 5: Metal pollution indices

Heavy metals (mg/kg)	Mean values	WHO standard (mg/kg)	FEPA standard (mg/kg)	CONTROL	Pollution Indices EF	Cf	I-geo	QoC
Pb	1.34±0.03	`85	2-200	0.07±0.01	0.001	19.14	1.11	94.78
Cd	1.47±0.05	`0.8	0.01-0.7	0.00±0.00	0.00	0.00	0.00	0.00
Cr	3.21±0.10	`100	1-1000	0.61±0.02	0.01	5.29	0.55	81.10
Zn	30.50±0.42	50	10-300	16.57±0.04	1.96	1.84	0.09	45.67
Fe	21.06±0.68		7000-550000	16.06	1.31	1.31	-0.06	23.72
					PLi=	3		

Physicochemical Analysis

Table 6: Physicochemical Parameters of Soils (Test and Control)

Parameters	STATIONS			
	A	B	C	D
EC	4.24±0.08	4.20±0.17	4.12±0.12	1.66±0.70
pH	4.22±0.17	4.23±0.09	4.26±0.17	5.27±0.14

Values are expressed as Mean±SEM, D = Control sample

The result of the mean values of the heavy metals in different stations which were collected at random showed that station A, B and C has the following metals in degree of abundance Zn>Fe>Cr>Cd>Pb. The result from each station also indicated that the 5cm depth for all the station has the highest concentration of heavy metals which indicates that the metals are mostly seen at the top layer of the soil than the inner depth.

Lead (Pb)

The mean concentration value of Lead from the soil was found at the range of 1.34±0.030mg/kg. The WHO and FEPA permissible limits for Lead was found to be 85mg/kg and 2-200mg/kg respectively. Hence the value of Lead in the soil was below the permissible limit for WHO and FEPA. The unpolluted site revealed a mean value of 0.07±0.01mg/kg which is lower than both WHO and FEPA permissible limit.

However from the pollution indices, the Enrichment factor (EF) was found to be 0.01 which indicates no enrichment, the contamination factor (Cf) was found to be 19.14 which indicates a very high contamination, the geo-accumulation (I-geo) was found to be 1.11 which indicates a moderate pollution hence the value of Quantification of Anthropogenic metal (%QoC) was found to be 94.78 which is higher than other heavy metals. This implies that the mechanic village is highly polluted with lead which is attributed to the availability of Lead in spent engine and transmission oil usually disposed on the grounds of the mechanic village.

Cadmium (Cd)

The mean concentration value of Cadmium in the soil ranges from 1.47±0.05mg/kg. Meanwhile Cadmium (Cd) was not detected in the control sample. The WHO and FEPA permissible limits for soil are 0.8 and 0.01-0.70mg/kg respectively. The result shows that Cadmium (Cd) exceeds the WHO and FEPA permissible limits. However, the pollution indices were not detected for Cadmium owing to its absent in the control sample.

Chromium (Cr)

The mean concentration value of Chromium was 3.21±0.10mg/kg. This value fell within the range of the permissible limit for WHO and FEPA which are 100mg/kg and 1-1000mg/kg respectively.

The pollution indices showed that its Enrichment factor (EF) was 0.01 which indicates that there were no Enrichment, the contamination factor (Cf) was 5.29 which indicates that there was a considerable contamination, The geo-accumulation factor (I-geo) was 0.55 which indicates that the metal is unpolluted with a close to moderate pollution. However, it was found the soil is contaminated with Chromium due its high value of Quantification of Anthropogenic metal (%QoC) that was found to be 81.10.

Zinc (Zn)

The mean concentration value of Zinc was found to be 30.50±0.42mg/kg. This value is below the WHO limit but within the range of FEPA whose permissible limits are 50-3000mg/kg and 10-300mg/kg respectively. The Enrichment factor for Zinc was found to be 1.96 indicating enrichment, the Contamination factor (Cf) was 1.84 indicating a moderate contamination, the geo-accumulation factor (I-geo) was 0.09 which indicates that the metal is unpolluted with a close to moderate pollution, the soil is moderately polluted with Zinc since its Quantification of Anthropogenic metal (%QoC) was found to be 45.67.

Iron (Fe)

The mean concentration value shows that Iron in the soil was found to be 21.06±0.68mg/kg which was below the WHO and FEPA permissible limits of 3000-500000mg/kg and 7000-550000mg/kg respectively. The pollution indices on Iron showed that it has an Enrichment factor (Ef) of 1.31 indicating that the enrichment is minor, the contamination factor (Cf) was 1.31 indicating a moderate contamination, the geo-accumulation is 0.06 which indicates that soil is unpolluted with

Iron, this corroborates with the use of Iron (Fe) as normalizer for enrichment factor. However the Quantification of Anthropogenic metal (%QoC) gave 23.73 indicating a very minor contamination that can be neglible.

Hence the overall pollution index calculated from the pollution load index (PLI) gave 3.00 which imply a considerable contamination of heavy metals in the soil.

The physicochemical investigation shown in table 9 showed stability in the electrical conductivity and pH as shown in figure 4.8. The electrical conductivity for the three stations A, B and C were found to be 4.24±0.083, 4.20±0.171 and 4.12±0.117 respectively, this indicates the presence of ions of with high mobility. The pH value for the three stations A, B and C were found to be 4.22±0.174, 4.23±0.091 and 4.26±0.167 respectively. The pH values indicate that soil is slightly acidic.

IV. CONCLUSION

In conclusion, the heavy metal analysis revealed that the concentration of the metals were within the range of WHO and FEPA except in the case of lead whose value was above FEPA permissible limit and Cadmium that gave a higher concentration above its permissible limit for WHO and FEPA.

Hence from the pollution index, it was found that the soil has a considerable contamination factor which will definitely increase with time due to the anthropogenic activities which frequently takes place in the mechanic village. Above all the metals analysed, it was found that the soil is highly contaminated with lead and Chromium.

The contamination of lead is attributed to its availability in most of the materials used in the mechanic village such as Engine oils, gasoline's, Sprays, paints, batteries etc while the contamination of chromium is attributed to the burning of oil and coal, petroleum from ferro-cromate refractory material, pigment oxidants, catalyst, chromium steel, fertilizers, oil well drilling and metal plating tanneries.

The physiochemical analysis proves presence of ionic salts with high mobility owing to the fact that the soil is slightly acidic.

COMPETING INTEREST

Authors have declared no competing interest exist.

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