Assessment of Selected Heavy Metals in Soil and *Cassia Occidentalis* in Rural Area of Jega Local Government, Kebbi State, Nigeria.

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Abstract- The soil and *Cassia occidentalis* of selected rural area of Jega Local Government were collected, digested, and analysed for some heavy metals using flame atomic absorption spectrophotometer (AA6500). The rural areas were labeled as DNG, KMB, LNG and GND for Dunbegu, Kimba, Langido and Gindi respectively. The results showed no significance difference ($p>0.05$) between the soil samples with respect to Cr, Cd and Pb and high significance difference ($p<0.05$) was observed in DNG with regards to Cu concentration. Similarly, no significance ($p>0.05$) difference was observed between plant samples in terms of Cr, Cd, and Co concentration. Cd and Co were not detected in GND and DNG respectively. Pearson correlation coefficient between plant and soil samples shows significant negative correlation between Cu and Cd at 1% and positive significant correlation between Co and Pb at 5%.

Index Terms- Cassia occidentalis, Heavy metals, Jega, Soil

I. INTRODUCTION

Soil pollutant understanding and its dependence on soil's physico-chemical properties has provides a basis for careful soil management that limits as far as possible, the negative impact of the pollutant on the ecosystem [1].

Soil contaminated with heavy metals is poor in nutrients and contribute to sub-optimal plant biomass accumulation [2]. Soil, whether in urban or rural areas, represent a major sink for metals released into the environment from a variety of activities [3]. Heavy metals are persistent contaminants of soils, coastal waters and sediments [4].

Many sources of soil pollution have been identified to include; emission of fumes and dusts containing metals that are transported in the air and eventually deposited onto soils and vegetables, effluents (industrial, domestic, etc), agricultural fertilizers and pesticides, organic manure, atmospheric pollutant from motor vehicular exhaust, industrial machines etc [5].

It is believed that greater percentage of man and animal are exposed to Heavy metal through environment, [6]. Due to their non-biodegradability; they accumulate in living organisms, thus causing various diseases and disorders even in relatively lower concentrations [7].

Cadmium accumulates in the kidney of mammals and cause kidney dysfunctions [8]. The most severe form of cadmium toxicity in humans is called "Itai-Itai" a disease condition which causes pain in the bones [9]

Lead (Pd) is a relatively stable nevertheless, when released in the air, it stays airborne for a short period, then falls to the soil and enters the food chain [10]. It (Pb) can affect many biological systems, especially nervous system [11].

Chromium (Cr) is use in melts alloys and pigments for paints, paper, rubber, tanning and other materials. Low-level exposure can irritate the skin and cause ulceration. Long-term exposure can cause kidney and liver damage and damage to the circulatory and nerve tissue. It often accumulates in aquatic life adding to the danger of eating fish that might had been exposed to highest levels of chromium [6]. It may also cause congestion and inflammation of organs [12].

Copper is an essential elements to human life but in high doses it can cause anemia, liver and kidney damages, stomach and intestinal irritation [8].

Zinc is also an essential element for the growth of much kind of organs in both plants and animals. Zinc and its compounds taken orally are relatively non-toxic, although its soluble salts in a very large doses can produced an acute gastroenteritis characterized by nausea, vomiting and diarrhea [13].

Air borne nickel pollution has been reported to cause of plants wilting and deterioration of livestock [14]. Too much nickel can be toxic. It has been reported to increased risk of respiratory infections, asthma and *sinusi* problems [15].

Nickel is an essential element for a person's health; excessive levels are considered poisonous and can cause significant health problems or even death. Cobalt dermatitis may occur but the condition is more likely from associated chrome or nickel [8].

Plants uptake of heavy metals depends on certain parameters such as; the concentration and chemical speciation of the metals in the soil solution, the movement of the metals from a bulk soil to the root by diffusion or convection, metals absorption by the root, metals translocation within the plants, pH, soil organic matter (SOM), cat ion exchange capacity (CEC) etc. [16].

II. MATERIALS AND METHODS

Materials

All the reagents used were of analytical grade (Analar) and all the glassware used, containers and tools were washed with liquid detergent first, rinsed with 20% (v/v) nitric acid and finally rinsed with deionised water. The containers and glassware were kept in an oven at 105 ^{0}C until needed. Deionised water was used throughout the work.

III. Description of the Study Area

Jega town is the head quarter of Jega local government of Kebbi state. The local government is located in the Sudan and Guinea savanna zone of the central part of the state. Jega was relatively bounded by Birnin Kebbi local government to the north, Kalgo local government to the west, Aliero local government to the east and Maiyama local government to the south.

Geographically, the areas are located within the latitude of 12^0C 11^I 24^{II} N and longitudes 40^0 23^I 50^{II} E with inhabitants that are predominantly Hausa, Gimbanawa and Fulanis. Their major occupations of the inhabitants are farming (Crop production and Animal rearing), blacksmithing, trading and other modern activities like welding, carpentering, automobile repairing with very small percentage as civil servants [17].

IV. Sampling and sample treatment

Soil Sampling

Stratified random sampling method was used. Each sampling area was divided into ten smaller units and from each unit; ten (10) samples were collected randomly at a depth range of 10-15 cm, the sample were mixed and homogenized. Cone and quartered method was used until a required (representative) sample was obtained. Clean polythene bags were used to transport the sample for Laboratory analysis [18]. The sampling areas were labeled as follows:

DNG =Dunbegu
KMB = Kimba
LNG = Langido
GND = Gindi

Plant Sampling

The plant (*Cassia occidentalis*), was also collected from the same site where the soil samples were obtained using a method described in [18,19].

Sample preparation

Soil was air dried for 5 days. Foreign and non-soil materials were removed and the soil was crushed using pestle and mortar, passed through a 1.5mm mesh sieve. Phosphorus, calcium and magnesium were determined using the methods adopted in [20, 21]. The pH was determined using the 1:2.5 soil-distilled water ratio using EL model 720 pH meter, The Walkley-Black wet oxidation method was used to determine organic carbon while ammonium acetate extraction and saturation techniques both as described in [22] were used in determining CEC, Na and K that were determined using flame photometry.

Sample digestion for heavy metals analysis

2g of air-dried and sieved soil was placed in a 150cm^3 beaker. 10cm^3 1:1HNO_3 (ie 5cm^3 water +5cm^3 conc. HNO_3) was added. And the beaker was covered with a watch glass and reflux on a hot plate for 15 minutes. The mixture was allowed to cool and 5cm^3 conc. HNO_3 was added, heated for 30 minutes. The content of the beaker was heated again for another 30 minutes without covering the beaker after adding 5cm^3 of conc. HNO_3 until the volume was reduced to 5cm^3. 2 cm^3 of deionized water + 3 cm^3 of 30% H_2O_2 was added and heated gently until effervescence was vigorously evolved. And 1 cm^3 of 30% H_2O_2 repeatedly added until effervescence subsides. 10 cm^3 of deionized water +5cm^3 of conc. HCl were also added and re-heated for 15 minutes. The contents were allowed to cooled, filtered into a 50cm^3volumetric flask and diluted to the mark with distilled water [18, 19, 23]. The filtrate was used for analysis.

The plant samples were washed several times with deionized water and oven dried at 80^0C to constant weight. The plant waslater homogenized using pestle and mortar and passed through a1.5mm sieve. 2g of the sieved plant was digested in the same way as the soil [4, 19]. The digested samples were used for metals analysis using flame atomic absorption spectrophotometer (AA6500).

The concentration of the metal was calculated using the relation below:

$$concentration\ of\ the\ metal\ (mgkg-1 = C \times V/m \times 1000)$$

Where C is the concentration in the sample extract (μgL^{-1}*),V is the volume of the sample extract, and m is the weight of the sample*

V. Statistical Analysis

Data obtained were statistically analyzed using one-way analysis of variance (ANOVA) with SPSS version 10.0 statistical packages and reported as mean ± standard error of mean of six and three replicate analysis for soil and plant respectively. The direction of the differences between the mean values was determined using LSD test at 5% level.

VI. Results and discussions

The results for physicochemical parameters and mineral elements of the soil is presented in the table 1.

Table 1: Physicochemical parameters and mineral elements of the Soil

Parameters	DNG	KMB	LNG	GND
% OM	1.48±0.01	1.69±0.00	1.41±0.03	1.45±0.06
Moisture (%)	1.5±0.01	1.5±0.02	2.0±0.09	1.0±0.05

pH	5.58±0.04	6.46±.01	6.35±0.08	6.0±0.00
CEC(%)	4.68±0.11	4.12±0.05	4.18±0.05	4.32±0.01
%N	0.042±0.00	0.035±0.00	0.028±0.00	0.039±0.00
P (mg/kg)	0.65±0.00	0.57±0.01	0.53±0.01	0.61±0.00
K (mg/kg)	1.13±0.02	1.00±0.00	1.03±0.03	1.36±0.05
Na (mg/kg)	0.70±0.00	0.43±0.01	0.35±0.01	0.65±0.02
Ca (mg/kg)	0.60±0.00	0.50±0.01	0.50±0.00	0.55±0.00
Mg (mg/kg)	0.7-±0.01	0.40±0.00	0.45±0.02	0.35±0.01

- Values were presented as mean± standard deviation of three analysis

OM = Organic Matter
CEC = Cation Exchange Capacity

The results of the heavy metals content in soil of Kimba, Gindi, Langido and Dunbegu are presented in table 2. The result indicated that there was significance (P<0.05) difference between the samples in terms of their heavy metals contents.

Table 2: Results of Heavy Metals Contents of Soil in Kimba, Langido, Gindi and Dumbegu Villages
Metals Concentration (mg/Kg)

Sample	Cr	Cd	Pb	Cu	Co	Ni	Zn
KMB	22.61±2.63^{ab}	2.23±0.67^{ab}	8.63±0.91^{abc}	0.59±0.14^{a}	23.49±1.67	4.63±0.93^{abc}	124.37±3.78
LNG	16.18±3.76^{a}	2.43±0.35^{ab}	9.51±2.01^{abc}	1.75±0.17^{a}	21.44±1.39	7.35±1.16^{bc}	48.08±0.88
GND	16.85±1.20^{a}	2.56±0.41^{ab}	8.00±0.99^{abc}	1.24±0.14^{a}	19.87±1.72	3.28±1.12^{ab}	35.72±1.85
DNG	18.96±2.90^{a}	3.07±1.00^{b}	3.09±1.03^{a}	7.70±3.11^{c}	10.68±2.46	7.57±1.33^{c}	18.18±1.13

- Values were presented as mean ± standard error of mean of six replicate analysis
- Values within the same column with different superscripts are significantly (P<0.05) different

Table 3: Results of Heavy metals Contents in Plant of Kimba, Langido, Gindi andDumbegu Villages

	Metals Concentration (mg/Kg)						
Sample	Cr	Cd	Pb	Cu	Co	Ni	Zn
KMB	3.97±1.61^{a}	1.56±0.45^{ab}	3.75±0.14	4.55±0.01	12.60±4.16^{ab}	BDL	66.63±13.08^{c}
LNG	4.31±2.46^{a}	2.14±0.28^{ab}	0.23±0.00	4.12±0.11	11.87±3.87^{ab}	11.87±o.43^{c}	50.28±0.27^{ab}
GND	6.85±1.19^{a}	BDL	0.17±0.06	5.83±0.19	11.29±3.02^{ab}	7.61±2.10^{b}	48.41±0.21^{ab}
DNG	5.67±0.90^{a}	1.94±0.21^{ab}	0.42±0.00	4.60±0.19	BDL	0.75±0.07^{a}	59.26±0.20^{bc}

- Values were presented as means ± standard error of men of three replicate analysis
- Values within the same column with different superscripts are significantly different
- BDL = Beyond Detection Limit

Table 4: Pearson Product Moment Correlation Coefficients between Metals Levels in Soil and Plant (*Cassia occidentalis*).

	Cr	Cd	Pb	Cu	Co	Ni	Zn
Cr	1						
Cd	0.137	1					
Pb	0.045	0.215	1				
Cu	0.290	-0.608**	-0.128	1			
Co	-0.162	-0.171	0.435*	0.114	1		

Ni	0.341	0.220	0.090	0.123	0.063	1	
Zn	-0.161	-0.316	-0.006	0.272	-0.188	-0.282	1

* Correlation is significant at 5% level
** Correlation is significant at 1% level

VII. Discussion

The percentage moisture contents of the soil ranges from 0.95 to 2.09. This could be attributed to the time of sampling (March/April). pH values indicated that the soil is mildly acidic. This could results in significant increases in Cd content of the soil [24]. Soil organic matter (SOM) and nitrogen content were low in all the samples and falls within the range of low fertility class. Cation Exchange Capacity (CEC) represents the total exchangeable cation held in soil. The values obtained in this work ranged between 4.08 – 4.94. Available phosphorus in the soil was very low with highest value of 6.67±0.02mg/kg. High value of P reduces the heavy metals uptake by plants [25]. The exchangeable K, Na, Ca and Mg were low in all the samples.

The chromium content was not significantly ($p>0.05$) different between KMB, LNG AND GND but the different is significant ($p<0.05$) with respect to DNG. All the samples concentration were higher than 5.02 mg/kg reported in drilling cutting dump site at Ezeogwu – Owaza, Nigeria and 230 mg/kg adopted by US EPA for soil requiring clean-up [26].

Cadmium concentration in soil was significantly ($p>0.05$) indifferent between the samples apart from DNG and also higher than 0.43 and 0.86 mg/kg set by New-York State Department for Environmental Conservation(NYS DEC) for unrestricted and residential use soil [27].

The lead concentration follows similar pattern with cadmium in the entire samples. But the values reported here are higher when compared with <0.01 mg/kg reported in literature [24].

The concentration of cobalt ranges from 8.22 to 25.16mg/kg. The high concentration of cobalt was recorded in KMB. The sources of this metal could be as a result of wearing a way of cobalt alloys, tyres, and exhaust from vehicles and generating set [28]. All the values were above the values reported [27, 31] in similar work.

The heavy metals copper, nickel and zinc in soil were within the acceptable limits set by NYS DEC [29].

The chromium concentration in *Cassia occidentalis* of all the samples are similar ($p>0.05$), but the values are lower than the corresponding values obtained from soil in each area. Congestion and inflammation of organs have been associated with chromium toxicity[30].

Cadmium is naturally non-essential toxic element and it interferes with the metabolism of some essential elements such as zinc, calcium and iron [31]. Cadmium concentration was also found to be no significance ($p>0.05$) between the samples but it is either absent or beyond the detection limit of the machine in DNG despite the excessive use of fertilizer in the area. The result was in agreement with the finding of Ozores-Hampton, *et. al.*, [32] and deviated from the results obtained by Howard *et. al*, [33] in similar works. However, cadmium has been reported to affect kidney, liver and various organs due to its ability to displaced zinc in many metallo-enzymes [34]

The concentration of lead was found to range between 0.11-3.89mg/kg in plant samples. Sample GND has the lowest concentration of 0.17±0.06mg/kg of lead despite the fact that the area is very close to the busy Jega-Yauri road. The values obtained in this work were far greater than the value obtained by [33] in similar works. Accumulation of lead in the body has been linked to several disease which includes; anaemia, kidney and CNS dysfunction [35]. The lead concentration in the range of 100 – 1000mg/kg is required to causes visible toxic effects in plants [36].

Copper concentration shows no significance ($p>0.05$) between the samples. Unlike cadmium, copper is an essential element required for the synthesis of phospholipids essential for the formation of myelin sheath in parts of respiratory enzymes. Nevertheless, copper can be harmful when taken in excess[37].

Cobalt concentration ranges from 8.00-16.76mg/kg with the highest concentration observed in sample KMB. While the cobalt was either, absent or beyond the detection limit of the machine in DNG. In addition, there was no significance ($p>0.05$) difference between the samples.

The nickel concentration is significantly ($p<0.05$) different between the samples. Comparing the results with that of the soil, it is higher. This could be due to deposition of nickel on the leaves from the vehicular exhaust.

Zinc concentrations are significantly different ($p<0.05$) between KMB and DNG with KMB having the highest concentration of 66.63±13.08mg/kg.

Results of correlation studies between the metals in soil and plant uptake showed positive correlation between the metals in almost all the metals. However, Cu and Cd showed significant negative correlation at 5%, but the correlation is not significant with Pb even though is negative. The Co correlated negatively with Cr and Cd, but significantly correlated positively with Pb at 1%. Zinc also correlated negatively with all the metals apart from Cu.

VIII. Conclusion

This work revealed that all the metals analysed were present in most of the samples both soil and plant (*Caccia occidentalis*). In addition, they metals were distributed differently in soil and plant of the samples. Also, the results revealed that there were significant ($p<0.05$) different in the distribution of some metals. While some of the metals were either, absent or beyond the detection limit of the machine in GND, DNG and KMB. The research also revealed that the area was moderately polluted when compared with the US EPA maximum concentration of the heavy metals in soil. With all the metals having lower concentration compared with the US EPA standard.

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