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ASSESSMENT OF HEAVY METALS CONTAMINATION OF *CALATROPIS PROCERA* IN SOME PARTS OF SOKOTO CITY BASED ON CONTAMINATION FACTOR AND DEGREE OF CONTAMINATION

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ABSTRACT

Heavy metals (Cr, Fe, Mn, Pb and Zn) in the leaves and stems of *Calatropis procera* located in Ali Akilu road, Kano road and Lodge road in Sokoto City were determined by atomic absorption spectrophotometry (A.A.S.). The average concentration (C_{av}) of each heavy metal in the leaves and stems of the plants sampled from each study area was evaluated and, used for the evaluation of the respective excess concentration factor (C_{ex}) of the heavy metals in the plants. The contamination factor (C_f) for each heavy metal in the plants and the degree of contamination (C_{deg}) of the plants by the heavy metals for each study area were evaluated and assessed. The work showed that the concentration of the heavy metals (even of the same kind) varied according to the locations of the plants; the contamination factors for Fe, Mn and Zn for the plants in all the study areas were moderate ($1 < C_f < 3$); for Cr, the contamination factors were considerable ($3 < C_f < 6$) for the plants in Ali Akilu road and Kano road and was very high ($C_f > 6$) for the plants in Lodge road and; for Pb, the contamination factors were very high ($C_f > 6$) for the plants in all the study areas. The assessment of the degree of contamination revealed that for the plants in Ali Akilu road and Kano road, the degrees of contamination were considerable ($16 < C_{deg} < 32$) while for the plants in Lodge road, the degree of contamination was very high ($C_{deg} > 32$). Recommendations on the possible ways of minimizing the spread of heavy metals in the environment were also given.

Introduction

Heavy metals are defined as metals having density greater than 5g/cm^3 . This classification include transition metals and higher atomic weight metals of group III to V of the periodic table (Ademoroti, 1996). Nowadays, various activities by man such as combustion of gasoline (petrol) in internal

combustion engines, metal fabrications, charging of wet cells (accumulators), mining, smelting, refining and so on have increased the quantity and distribution of heavy metals in the atmosphere, land and water bodies (Yaro, 2010). Unlike organic contaminants, heavy metals do not undergo biological and biogeochemical

degradation and, therefore, the total concentration and ecotoxicological effects on their receptors (plants, animals and human beings) in the environment may persist for a very long period after their introduction to environment (Ogbeifun and Okieimen, 2014). The extent of this wide spread but generally diffused contamination has caused concern about the possible hazards on plants, animals and human beings (Ademoroti, 1996). When heavy metals are disposed off to farm lands, they are taken up by plants in some amounts, which may have unpleasant effects on the fruits they produce as they may be rendered unsuitable for human consumption. In some cases, they may have adverse effects on the growth and quality of the grasses, which are consumed by grazing animals. The grazing animals as well, as the fruits of plants serve as food for man. In effect, the heavy metals are passed on to man by food chain (Ademoroti, 1996). Since the persistence of heavy metals causes many biological implications in food chain and on the other hand, metals are needed in permissible trace amounts by all organisms (Bello, 1999). This paper reports the results for: the determination of concentrations of some heavy metals of interest (Cr, Fe, Mn, Pb and Zn) in the leaves and stems of *Calatropis procera*, the average concentrations in the plants and; the excess concentration (contamination) of the heavy metals in the plants. The work also reports the results for the assessment of the contamination factors for the heavy metals in the plants and the degrees of contamination of the plants by the heavy metals, with the view to highlight the general public about the resistant nature of heavy metals to undergo biological and bio-chemical degradation as well as the ecotoxicological effects of the metals on their receptors (particularly human beings) through food chain.

Materials and Methods

Collection of the Experimental Samples from the Study Areas

Fresh leaves and stems were randomly collected from different *Calatropis procera* plants located in each study area. The areas from which the samples were collected were Ali Akilu road, Kano road and Lodge road in Sokoto Metropolis.

Treatment of the Experimental Samples

Each of the samples was cut into small pieces and sun-dried for 15 days to eliminate excess water, after which it was ground using pestle and mortar. The powdered sample obtained was then sieved to a mesh size less than 250µm. The desired quantity of the sample for the analysis was obtained using coning and quarter method.

Determination of Heavy Metals by Atomic Absorption Spectrophotometry (A.A.S.) Through Dry Oxidation Process

For the determination of the heavy metals in each of the samples, 2.0g of the sample was ashed at 700°C in a muffle furnace for 5 hours. The resulting ash was dissolved in 4cm³ of 50% HCl and diluted with distilled water in 50cm³ volumetric flask and gently shaken. The solution was allowed to settle after which it was filtered off. The filtrate obtained was finally used for AAS analysis, where the relative abundance of the metals was determined using the AA-6800 SHIMAD ZU atomic absorption spectrophotometer. The AAS was switched on for 15 minutes and, for each heavy metal to be determined, the analyte's hollow cathode lamp of the AAS was stabilized for 10 minutes. The calibration curve of absorbance against analyte ions concentration for each analyte was obtained by setting the top working standard to a suitable reading and 0.00ppm.

The concentration of the heavy metals (in mg/g) for each sample was obtained using the equation adopted by Yaro (2010): Conc (mg/g) = Df x Ra.

Where Df = Dilution factor (i.e. 25cm³)

Ra = Relative abundance of the metal.

The dilution factor (Df) was obtained as follows:

$Df = \frac{\text{volume of solution of the sample (cm}^3\text{)}}{\text{used for ASS}}$

Weight of the sample used for AAS

Average Concentration of the Heavy Metals Detected in the Plants

The average concentration (Cav) of the heavy metals in the plants for each study area was evaluated as follows:

$$Cav = \left(\frac{Cle + Cst}{2} \right)$$

Where Cle = concentration of heavy metal in the leaves

Cst = concentration of heavy metal in the stems.

Estimation of Excess Concentration (Contamination) of the Heavy Metals in the Plants

The excess concentration (Cex) of the heavy metals in the plants was estimated using the following relation: $Cex = Cav - Cnat$

Where Cnat = naturally-existing concentration of heavy metals in the plant (background value).

Assessment of the Contamination factor (Cf) of the Heavy Metals in the Plants

For the evaluation of the contamination factor (Cf) for each heavy metals in the plants, the equation, $Cf = C^{10-1} / C^1_n$ adopted by Jimoh and Sabo (2013) was modified to

$Cf = Cav / Cnat$. The evaluated Cf for each metal in the plants was assessed using the following classification made by Liu *et al* (2005):

- $Cf < 1$ = low contamination factor
- $1 < Cf < 3$ = moderate contamination factor
- $3 < Cf < 6$ = considerable contamination factor

$Cf > 6$ = very high contamination

Assessment of the Degree of Contamination (Cdeg) of the Plants by Heavy Metals

Since the contamination factor described above gave only the assessment of the concentration of the individual heavy metal, it is necessary to employ the use of degree of contamination (Cdeg) in order to assess the total contamination due to the sum of concentrations of all the heavy metals in the plants. The degree of contamination was evaluated using the equation adopted by Jimoh and Sabo (2013): $Cdeg = \sum C_f$ where $\sum C_f$ = sum of the contamination factors of the heavy metals for each study area.

The degree of contamination (Cdeg) of the plants by the heavy metals for each study area was assessed using the following classifications made by Hankason (1980):

- $Cdeg < 8$ = low degree of contamination
- $8 < C_{deg} < 16$ = moderate degree of contamination
- $16 < Cdeg < 32$ = considerable degree of contamination
- $Cdeg > 32$ = very high degree of contamination

Results and Discussions

Results

The results of all the experiments and evaluations carried out in this work are presented in Tables 1to3 below. Table 1 gives the concentrations and average of the concentrations (in mg/g) of the heavy metals (i.e. Cr, Fe, Mn, Pb and Zn) in the samples Table 2 gives the average concentrations, natural concentrations and excess concentrations of the heavy metals in the plants for the three (3) study areas. Table 3 shows the contamination factors of the heavy metals and the degree of contamination of the plants by the heavy metals for the three study areas.

Table 1: Concentration of Heavy Metals in the Samples (mg/g)

Study area	Sample	Concentration of Heavy Metals				
		Cr	Fe	Mn	Pb	Zn
Ali Akilu road	leaves	3.00	22.50	37.50	27.50	5.00
	stems	2.75	37.50	42.50	30.00	5.00
	average	2.88	30.00	40.00	28.75	5.00
Kano road	leaves	1.25	12.50	20.00	2.50	2.50
	stems	4.25	35.00	42.50	67.50	5.00
	average	2.75	23.75	31.25	35.00	3.75
Lodge Road	leaves	6.25	22.50	15.00	2.50	2.50
	stems	6.25	22.50	42.50	97.50	3.00
	average	6.25	22.50	28.75	50.00	2.75

Table 2: Average Concentrations (Cav), Natural Concentrations (Cnat) and Excess Concentrations (Cex) of Heavy Metals

Study area	Concentration	Heavy metals in the plants (mg/g)				
		Cr	Fe	Mn	Pb	Zn
Ali Kilu road	Cav	2.88	30.00	40.00	28.75	5.00
	*Cnat	0.50	22.00	26.60	3.00	2.40
	Cex	2.38	10.00	13.40	25.75	2.60
Kano road	Cav	2.75	23.75	31.25	35.00	3.75
	*Cnat	0.50	22.00	26.60	3.00	2.40
	Cex	2.25	1.75	4.65	32.00	1.35
Lodge road	Cav	6.25	22.50	28.75	50.00	2.75
	*Cnat	0.50	22.00	26.60	3.00	2.40
	Cex	5.75	0.50	2.15	47.00	0.35

***Source: Bello (1999)**

Table 3: Contamination Factor (Cf) and Degree of Contamination (Cdeg) of the Plants by the Heavy Metals.

Study area	Contamination Factor (Cf) of the heavy metals					Degree of Contamination (Cdeg)
	Cr	Fe	Mn	Pb	Zn	
Ali Akilu road	5.76	1.36	1.50	9.25	2.08	19.95
Kano road	5.50	1.08	1.17	11.67	1.56	20.98
Lodge road	12.50	1.02	1.08	16.07	1.15	32.42

Discussion

The concentrations of all heavy metals (i.e Cr, Fe, Mn, Pb and Zn) determined in all the samples for all the study areas are shown in Table 1. The results (Table 1) showed highest concentration (97.50mg/g of Pb) was in the stems of the plants sampled from lodge road while the least concentration (1.25mg/g of Cr) was in the leaves of the plants sampled from Kano road. The results also showed that, with the exception of the plants in Ali Akilu road, in which the concentration of Cr in the leaves (3.00mg/g)

was higher than the concentration in the stems (2.75mg/g) and, Zn in which the concentration in the leaves (5.00mg/g) was equal to the concentration in the stems, the concentrations of the heavy metals in the plants for all the study areas were found to be higher in the stems than in the leaves. This may be attributed to the difference in the morphological and physiological natures of the leaves and stems, which make them to function differently (Yaro, 2001).

Table 2 gives the averages of the concentrations of the heavy metals in the leaves and stems, the natural concentrations and the excess concentrations of the heavy metals in the plants for the three (3) study areas. The results showed that the average concentration of each heavy metal obtained was relatively higher than the naturally-existing concentration (natural concentration in plant materials). This may be connected to the excessive use of the metals or substances containing them in our day-to-day activities. For instance, the increase in the concentration of Cr observed when compared with its natural concentration in plant materials may be associated with the extensive use of Cr in various alloys, in paints, in tannery and so on (Yaro, 2001). The high concentration of Fe in the plants may be attributed to the extensive use of pressed sheets of iron (Fe) in automobile as boring and cutting tools by mechanics in mechanical workshops, the extensive use of aluminium containers which contained iron and, the fact that soils are naturally iron-rich (Bello, 1999). The relative high concentration of Mn observed in the plants from all the study areas may be connected to the naturally-existing Mn in plant materials (Ademoroti, 1996). It could also be associated with the abundant Mn exists naturally in sedimentary and igneous rocks (Russel, 1973) and Sokoto soils consist of large amount of sedimentary and igneous rocks (Bello, 1999). The high concentration of Pb in the plants may be connected to the use of Pb in accumulators (wet cells) and in petrol (in the form of $Pb(C_2H_5)_4$ as anti knock (Ababio, 1985). The relative high concentration of Zn when compared with its naturally-existing concentration in plant materials may be associated with the use of the metal (Zn) in electroplating, manufacture of alloys and dry cells (Bello, 1999). The increase in the concentration of Zn may also be associated with the mining

activities, metal fabrications and corrosion of galvanized pipes (Henry, 1978).

The results of contamination factor (Cf) and degree of contamination (Cdeg) of the plants by the heavy metals for the 3 study areas are shown in Table 3. The Cf values shows clearly that the values of contamination factors for Fe, Mn and Zn each was greater than 1, but less than 3 for all the plants in the 3 study areas. This meant that the contamination factors for Fe, Mn and Zn were moderate ($1 < Cf < 3$) as classified by Liu *et al* (2005). The contamination factors for Cr in Ali Akilu road and Kano road each was greater than 3, but less than 6, which indicated considerable contamination factor ($3 < Cf < 6$) while for lodge road, the contamination factor for Cr was greater than 6, which indicated very high contamination factor ($Cf > 6$). These are also based on the classification made by Liu *et al* (2005). The contamination factor for Pb in the plants for each of the 3 study areas was greater than 6, which indicated very high contamination factor (Liu *et al* 2005).

The Cdeg values (Table 3) indicated that the degrees of contamination of the plants in Ali Akilu road and Kano road each was considerable ($16 < Cdeg < 32$) while in Lodge road, the degree of contamination was very high ($Cdeg > 32$). These are all based on the classification made by Hankason (1980).

Conclusion

Based on the concentrations of the heavy metals determined in the plants, which were all above the naturally-existing concentration in plant materials coupled with the contamination factors for the heavy metals, which were all above their respective low limits, it could be concluded that the plants are contaminated by the heavy metals, which could possibly be transferred to grazing animals and subsequently to human beings through food chain, which may be detrimental to human health.

Recommendations

Since the concentrations of the heavy metal in the samples analyses for all the study areas were above the naturally-existing concentrations of the heavy metals in plant materials, the following recommendations would be of great importance in preventing or minimizing the spread of heavy metal in the environment:

- Government at all levels should embark on regular inspection of industries to ensure proper disposal of wastes.
- Government at all levels should take appropriate and drastic measure on who

References

- Ababio, O. Y. (1985): New school chemistry certificate series, revised edition, Africana FEB publishers limited, Hamzet Building, 22/26 Park road, Sabon-gari, Zaria – Nigeria. Pp 444 -471.
- Ademoroti, C. M. A. (1996): Environmental Chemistry and Technology Foludex press limited, Ibadan – Nigeria. Pp 73-79.
- Bello, M. (1999): Determination of some heavy metals pollutant and their distribution around selected workshops in Sokoto metropolis. Unpublished M.Sc. Thesis in the Department of Pure and Applied Chemistry, Usmanu Danfodiyo University, Sokoto-Nigeria.
- Hankason, L. (1980): Ecological risk index for aquatic pollution control, a sedimentological approach. *Water Res*, 14: 975 - 1001
- Henry, D. F. (1978): Fundamentals of soil science, 6th edition John Wiley and Sons, New York Pp 295.
- Jimoh, W. L. O. and Sabo, Y. (2013): Assessment of heavy metals contamination in municipal dump-site compost in Kano City, Nigeria. *Biological and Environmental Sciences Journal for the Tropics (BEST)*, 10 (3): 64 – 69

ever violet the existing regulations and by-laws of environmental pollution disposal.

- Animals should not be fed with plants located by road sides.
- Emphasis should be made in undertaking researches on heavy metals.
- The use of industrial waste waters for watering vegetables should be avoided.
- The general public should be enlightened about the potential hazards associated with heavy metals and, the possible ways of minimizing the spread of heavy metals in the environment.

- Liu, W. H, Zhoa, J. Z. Ouyang, Z. Y, Solderland, L. and Liu, G. H. (2005): Impact of sewage irrigation on heavy metals distribution and contamination. Beijing, China. *Environ Int'l* 32:805-812
- Ogbeifun, D. E and Okieimen, F. E (2014): Remediation of heavy metal contaminated soil using rock phosphate. *Biological and Environmental Sciences Journal for the Tropics (BEST)*, 11 (3): 329-332
- Russel, F. W. (1973): Soils conditions and plant growth 10th Edition, Longman group limited, London. Pp 295.
- Yaro, M. N. (2001): Determination of some heavy metals from *calatropis procera* and *mangifera indica* located at Ali Akilu road, Kano road and Lodge road in Sokoto Metropolis. CHE 712 (Advanced Laboratory Practice): a course undertook in the Department of Pure and Applied Chemistry Usmanu Danfodiyo University Sokoto – University.
- Yaro, M. N. (2010): Studies on the potential biohazards of some heavy metals contents of the leaves of *Calatropis procera* and *Mangifera indica* in some parts of Sokoto City – Nigeria. *Biological and Environmental Sciences Journal for the Tropics (BEST)*; 7(2): 124 -127.