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Determination of Some Selected Trace and Alkaline Earth Metals in Soil and Plant Around Rural Bathrooms in Some Selected Communities in ESAN West Local Government Area of Edo State

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Abstract:- This study investigated the concentrations of some selected trace and alkaline earth metals (Na, K, Mg, Cu, Fe and Zn) in soil and plant around rural bathroomslocated around Ambrose Alli University, hostel (AAU hostel) Ekpoma, Ujemen and Idumebo villages, all in Esan West Local Government Area, Edo State Nigeria. The ranges of metal concentration in the soil analysed were; Na (1.28±0.11 - 3.57±0.90 mg/kg), K (4.63±0.1 - 10.05±0.00 mg/kg), Cu (0.09±0.15 - 1.01±0.01 mg/kg), Mg (14.78±0.45 - 23.90±0.09 mg/kg), Fe (0.85±0.90 - 2.52±0.32 mg/kg) and Zn (0.68±0.00 - 3.42±0.71 mg/kg). Similarly, the range of metals concentration in plant (*Talinum triangulare*); Na (5.30±0.12 - 18.90±0.12 mg/kg), K (20.42±0.13 -163.40±0.10 mg/kg), Cu (0.21±0.00 - 3.56±0.30 mg/kg), Mg (20.11±0.11 - 73.00±0.32 mg/kg), Fe (1.27±0.01 - 5.21±0.20 mg/kg) and Zn (0.43±0.11 - 1.20±0.73 mg/kg) were also recorded. The results showed that the concentration of the metals analysed were below the WHO/FAO and EU guideline standards. Pearson Correlation Coefficient, r, gave a positive correlations between the soil and plant for all the metals analysed expect for Zn. The study revealed that metal poison could result from bioaccumulation of these metals. Also, bioconcentration factor for all the metals analysed show that the plant can be used for phytoremediation purposes.

Keywords:- *Alkaline earth metals, Biocentration factor, Concentration, Talinum triangulare, Phytoremediation.*

I. INTRODUCTION

Human's activities that are associated with the use of chemicals in improving their wellbeing have immensely contributed to the widespread distribution of metals into the environment which have its attended multiple effects in the ecosystem when accumulated above the required limit.Soil acts as a sink and also as a source of pollution with the capacity to transfer pollutants to groundwater and the food chain, and then to humans and/or animals [1]. Elements have a variety of pathways by which they move through the environment. The soil-plant-animal-man pathway is of great importance to human health concerns. Because of their potential toxicity to living systems, the cycling of several trace metals through the soil-plant pathway has received much attention.Since plants are capable of taking up metals from soil, the safety, quality, and effectiveness of natural products have become questionable [2]. Jaishankar*et al*. [3] and other researchers have reported thatconsumption of plant tissues may be an important route, not only for essential dietary trace elements but also for human exposure to toxic elements. Various adverse human health effects have been linked to ingestion of toxic metals. Consequently, the symptoms of disease due to metal toxicity has been attributed to risk factors such as characteristics of the metal (concentration, form, dose, and toxicity) and individual level factors (social, health, behaviour, and physiology) [4].Contaminated vegetables can cause serious clinical and physiological problems for humans, especially when consumed in large quantities [5]. The ingestion of toxic metal contaminated food can cause both chronic and acute health effects[6].

Studies have shown that soils and plants around rural bathrooms contain different kinds and concentrations of heavy, trace and alkaline metals [7] In recent times, it has been reported that these elements accumulate and persist in soils at an environmentally hazardous levels [8]. Trace and alkaline metals concentration in soil is associated with biological and geochemical cycles.

Bathroom areas are associated with washing with chemical agents that contains so levels of surfactants. Soaps contains a positive ion, usually Na^+ or K^+, a negative ion, usually the anions of long chained carboxylic acids obtained by the hydrolysis of animal fats or vegetable oils[9]. Metallic soaps are alkali-earth or heavy metal long-chain carboxylates, which are insoluble in water but soluble in no aqueous solvents. Detergents are cleaning products derived from synthetic organic chemicals. Surfactants are mainly responsible for the cleaning action of detergents. Alkyl sulphonates (AS) are anionic surfactants widely used in household and personal cleansing application. At a concentration about 106μg/L, it is toxic to aquatic animals[9].The accumulation of trace metals around rural bathroom soils is of increasing concern due to safety issues and potential health risk, as well as its detrimental effects on soil ecosystems [10]. The presence of heavy metals at trace level and essential elements at elevated concentration do cause toxic effects if exposed to human population [11]. Food chain contamination by trace metals has become a burning issue in recent years because of their potential accumulation in biosystem through soil and plants.

The human body requires trace elements for healthygrowth, development, and proper body functioning [12], they can however be regarded as potential pollutants when they bioaccumulate and reach toxic levels [13]. Essential metals exert biochemical and physiochemical function in plants and animals. They are important constituents of several key enzymes which play important role in several oxidation and reduction reaction. Singh *et al*., [14] indicated that trace elements such as Cu, Mo and Zn are essentialelements required by humans, animals and plants in minute amounts for metabolic process. They act as catalyst or structural components of large molecules in the body and have specific making them indispensable for life and optimum health. Metals such as chromium, copper, iron, manganese, selenium and zinc have been found to be essential by medical researcher and have been proven to prevent and reverse a wide number of disease and medical conditions. Diseases such as cardiovascular gastrointestinal, genetic, kidney etc. have been known to be treated with essential trace elements.

This study assessedtheconcentration of metals (Na, K, Cu, Mg, Fe and Zn) in *Talinum triangulare* plantand soil around rural bathrooms in Ekpoma town, Esan West LGA of Edo State.

II. MATERIALS AND METHODS

2.1 Study Area

The study was conducted around bathrooms within Ambrose Alli University Hostels Ekpoma, Ujemen and Idumebo Villages all in Esan West Local Government Area, Edo State, Nigeria.

2.2 Samples Collection and Chemical Analysis

2.2.1 Soil Sampling and Digestion

Soil sampling and digestion were carried out according to Ashiq *et al*., [15] with modifications. Soil samples were collected from three sampling sites at a depth of 0-15 cm and 15-30 cm using a soil auger. Three representative composite soil samples were collected from the study area. Soil samples were stored in well labelled plastic polythene containers and then transported to the laboratory for further soil treatment and analysis. The soil samples were first, air dried at a temperature of 30 - 32 °C for 5 days. The samples were pulverized using porcelain pestle and mortar, and sieved with a 2 mm sieve to obtain fine sand fraction for various analytical determination. 1 g of fine soil sample was measured into a digestion tube and digested with 10 mL of concentrated HNO_3 and 2 ml of perchloric acid was added. [10 ml conc. HNO_3 and 2 ml of $HClO_4$ (5:1)]. Mixture was placed on a hot plate at 105 °C for one hour and then temperature was increased up to 140°C under a fume hood. After cooling, the solution was mixed and filtered through Whatman No. 42 filter paper into a 50 mL volumetric flask with distilled water. The various metal concentrations in the digest were then analysed using suitable spectrophotometric method.

2.2.2 Plant Sampling and Digestion

Plant sampling and digestion were carried out according to Ashiq *et al*., [15] with modifications. *Talinum triangulare* plant was collected for analysis from the study area, stored in polythene bags and transported to the laboratory for analysis.Plant samples were washed thoroughly with distilled water to remove any particle on the leaves of the plants. Plant samples were placed in a brown envelope and kept in the oven at 70 - 80 °C until constant dry weight was attained. The samples were then milled into a powdery form. The milled samples were passed through a 2 mm sieve and then stored in well labelled plastic polythene bags for acid digestion in order to determine the presence of metals in the samples. Digestion mixture for biological sample was a di-acid mixture. Mixture comprised concentrated HNO_3 and $HClO_4$. To one gram of plant material, 5 ml of concentrated HNO_3 was added and kept overnight. The next day, 12 ml of di-acid mixture (conc. HNO_3 +$HCLO_4$ in the ratio 3:1) was added and digested on hot plate till white reddish brown fumes of perchloric acid comes out. Plant samples slowly begin to dissolve and digest in di-acid mixture. After a few hours, plant sample dissolved completely in the digestion mixture and solution was then evaporated until only about 2 ml was left in the flask. The various metal concentrations in the digest were then analysed using suitable spectrophotometric method.

2.2.3 Mineral Analysis

Mineral analysis was carried out according to Ademoroti, [16]. Iron (Fe), Zinc (Zn), Magnesium (Mg) and Copper (Cu) were determined using Atomic Absorption Spectrophotometer (Perkin –Elmer Model 403, Norwalk CT, USA). Sodium (Na) and Potassium (K) was determined using flame photometer (Model, 405, Corning, UK).

2.3 Contamination Assessment Methods

A number of calculation methods have been used for quantifying the degree of metal enrichment or pollution in soils, sediments and dusts [17]. In this study, bioconcentration Factor (BCF) was calculated to assess the metal status in the soil.

2.3.1 Bioconcentration Factor (BCF)

Bioconcentration factor was calculated from the following equation.

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$$BCF = \frac{\text{Concentration of heavy metal in plant}}{Concentration of heavy metal in soil}$$

III. RESULTS AND DISCUSSION

3.1 Results

The results for the metal analysis in the soil and plant samples obtained for this research are reported in mean and standard deviation.

3.1.1 Heavy Metal Concentration in Soil Sample

The metal concentration level in soil samples obtained from around bathrooms in the study areas as shown in Table 1 revealed magnesium as the metal with the highest concentration for all metals analysed and represented in Figure 1, with the highest recorded from AAU hostel sample having the (23.90±0.09 mg/kg) while the least was Cu (0.09±0.15 mg/kg) recorded from Ujemen. Mean total concentrations of the elements analysed from the soil sample decreased in the order: Mg > K > Na > Fe > Zn > Cu.

Table 1: Results for metal in soil sample

S/N	METAL (mg/kg)	AAU HOSTEL	UJEMEN	IDUMEBO	EU VALUES
1	Na	1.28±0.11	3.57±0.90	2.96±0.34	-
2	K	6.10±0.18	4.63±0.1	10.05±0.00	-
3	Cu	0.14±0.10	0.09±0.15	1.01±0.01	130-140
4	Mg	23.90±0.09	14.78±0.45	18.78±0.11	-
5	Fe	0.85±0.90	2.52±0.32	1.90±0.10	-
6	Zn	0.68±0.00	3.42±0.71	0.95±0.12	300

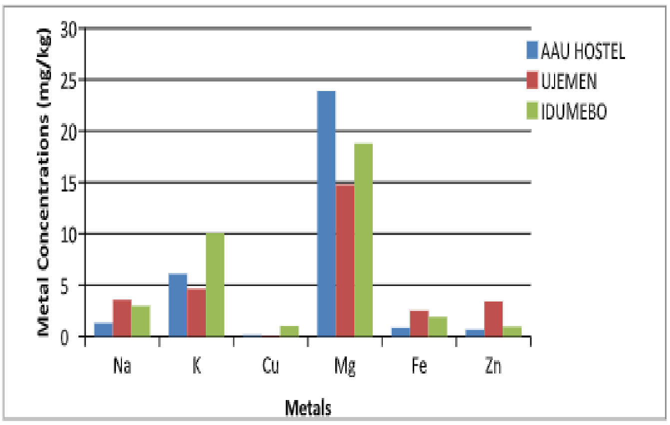

Figure 1: Metal concentrations in soil samples analysed

3.1.2 Metal Concentration in Talinum triangulare

The metal concentration level in *Talinum triangulare* sample obtained from around bathrooms area as shown in Table 2 revealed that the highest metal concentration was found in potassium (K) (163±0.10 mg/kg) from AAU hostel while the least was copper (Cu) (0.21±0.00 mg/kg) also from AAU hostel as represented in Figure 2. Mean total concentrations of the elements analysed from the soil sample decreased in the order: K > Mg > Na > Fe > Zn > Cu.

Table 2: Results for metal in plant (*Talinum triangulare*)

S/N	METAL (mg/kg)	AAU HOSTEL	UJEMEN	IDUMEBO	WHO/FAO
1	Na	5.30±0.12	10.32±0.00	18.90±0.12	-
2	K	163.40±0.10	20.42±0.13	90.45±0.81	-
3	Cu	0.21±0.00	1.72±0.90	3.56±0.30	30
4	Mg	73.00±0.32	43.67±0.14	20.11±0.11	-
5	Fe	1.27±0.01	2.34±0.55	5.21±0.20	48
6	Zn	0.43±0.11	1.20±0.73	1.10±0.12	60

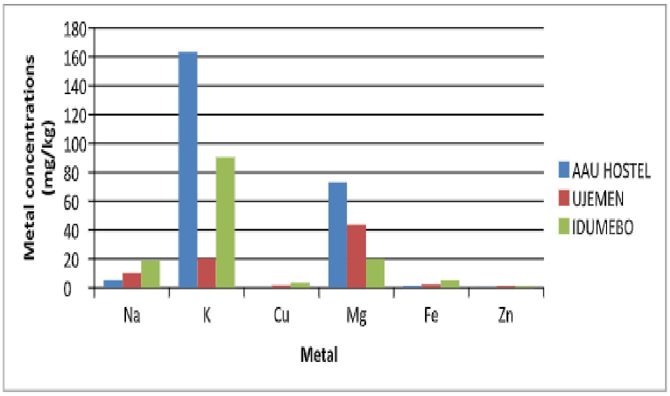

Figure 2: Metal concentrations in plant (*Talinum triangulare*) samples analysed

3.1.3 The Bioconcentration Factor (BCF)

The result for the bioconcentration factor is shown in Table 3 below.

Table 3: Results for metal bioconcentration factor

S/N	METAL (mg/kg)	AAU HOSTEL	UJEMEN	IDUMEBO
1	Na	4.14	2.89	6.39
2	K	26.72	4.41	9.0
3	Cu	1.50	19.11	5.52
4	Mg	3.05	2.95	1.07
5	Fe	1.49	0.93	2.74
6	Zn	0.63	0.35	1.16

3.1.4 The Correlation Coefficient

Correlation coefficient was used to assess the relationship that existed between the metals in the soil and plant. The Pearson Correlation Coefficient, r, was used. There were positive correlation between soil and plant for all the metals in all the investigated areas.

3.2 Discussion

Metal released into the surrounding areas of the bathroom are often bio-accumulated in the plants around these bathroom. Metal concentrations in plants vary with plant species [18]. Plant uptake of heavy metals from soil occurs either passively with the mass flow of water into the roots, or through active transport crosses the plasma membrane of root epidermal cells. Under normal growing conditions, plants can potentially accumulate certain metal ions an order of magnitude greater than the surrounding medium [19].

The ions responsible for salination are: Na^{+}, K^{+}, Ca^{2+}, Mg^{2+} and Cl^{-}. Human practices can increase the salinity of soils by the addition of salts in irrigation water and also runoff water from bathrooms with contains soap formed from the aforementioned elements. The consequential effect of soil salinity includes increased leaching of metals, especially copper, cadmium, manganese and zinc among others [20].

The major source that attributed to the concentration of sodium and potassium measured was from the soap and detergent which are produced from caustic soda (NaOH) and KOH as a major raw material for soap manufacturing and sodium citrate and sodium silicate for liquid detergents; and naturally from sodium salts. Too much sodium have identified as a risk factor for high blood pressure [9].Potassium is one of important macronutrient elements necessary for plant growth that is absorbed in the form of K^{+} ion [9].

The concentration of copper ion recorded in the soil at the study area was below the WHO/FAO [21] permissible limit as represented in Table 1. The value recorded was within the normal range required by plants in the natural soil concentration. The concentration of copper recorded in this study was lower than 47.0 mg/kg reported by Fisseha *et al*. [22] and 22.14 mg/kg by Babatunde *et al*. [23] around an oil depot at Jos in Nigeria. Higher concentration of copper can be toxic especially when leached into water body or bio-accumulated in plant which can be ingested. Contamination of drinking water with high level of copper may lead to chronic anemia. Copper accumulates in liver and brain. Copper toxicity is a fundamental cause of Wilson's disease [24].

Iron is considered the key metal in energy transformations needed for syntheses and other life processes of the cells [25]. The highest concentrations of iron in the soil and plant samples were recorded as 2.52$\pm$0.32 mg/kg at Ujemen and 5.21$\pm$0.20 mg/kg at Idumebo respectively and were below the WHO/FAO recommended level of iron as represented in Tables 1 and 2 respectively. The iron oxide that is present in soil is dependent upon the moisture content, pH,

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and oxygen content of the soil. In wet, but oxic soil conditions, the iron oxide typically would exist in the hydrated ferric oxide state [26]. The solubility of inorganic Fe in well-aerated soils is controlled by the dissolution and precipitation of Fe^{+3} oxides. As previously stated, the concentration of Fe^{+3} is related to pH, as pH increases from 4 to 8 [27]. High HCO_3 concentrations decrease the availability of Fe in calcareous soils [28].Iron is considered a plant micronutrient. Iron is absorbed by plants as the ferrous ion (Fe^{+2}), which is necessary for the formation of chlorophyll and functions in some of the enzymes of the plant's respiratory system.

Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms [29]. Zinc is an essential trace element for bacteria, plants and animals including humans.Nevertheless, higher concentrations of zinc can be toxic to the organism. However zinc deficiency might result in significant reduction in crop yields and quality. In fact, yield can even be reduced by over 20% before any visual symptoms of the deficiency occur. Anaerobic, waterlogged among other conditions are widely responsible for zinc deficiency in soil which was evident in the soil sample analysed (3.42 ± 0.71 mg/kg) as highest at Ujemen which also manifested in the plant sample analysed (1.20 ± 0.73 mg/kg). The concentrations were below permissible limit set by WHO/FAO.

Bioconcentration factor (BCF) can be used to assess a plant's potential for phytoremediation purposes. The analysis revealed that the plant around the study area have BCF values for all the metals analysed higher than 1 except for Zn (0.35) at Ujemen. Plants having BCF values less than one have limited ability to accumulate, translocate and phytoextract heavy metals [30].

In an attempt to understand the relationship between the concentrations of corresponding metals evaluated from the soil and plant sample, the Pearson Correlation Coefficient, r, was determined to be 0.46, 0.95 and 0.44 for AAU hostel, Ujemen and Idumebo respectively which were positive correlations between soil and plant for all the metals in all the investigated areas. The results of positive correlation between soil and plants have been supported by earlier research findings by [31] and [32] that, these positive relations indicate that plants take in nutritional elements from the soil through their roots. However, negative correlation gives a strong suspicion to the fact that some elements might be assimilated through other organs of the plants other than their roots. Such elemental intake may be directly through atmospheric deposition.

IV. CONCLUSION

The findings in this study shows that plant in the vicinity of bathroom has relatively high alkaline metal concentrations though are within the permissible limit. This study confirms a relationship between the concentration of metals in the plant and soils. Consequently, it can be concluded that consumption of plants around bathroom vicinity can results in bioaccumulation of these metals which could have adverse effects on animals and man that utilizes them as food. The study also revealed that, plant in this study can be subjected to further research and assessment on its phytoremediation abilities as it has bioaccumulation factor >1.

V. COMPETING INTERESTS

There is no conflict of interest

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