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Determinations of Some Selected Heavy Metals and Elements in Soil of the College's Farm, College of Agriculture, Maiduguri, North – Eastern Nigeria

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Abstract: This study focuses on the ecosystem – ecological, environmental Pedology determined of some selective heavy metals and elements in soil of the college's farm, College of Agriculture, Maiduguri, Nigeria. Soils were sampled, and collected as described by the method of Ashiq et al, (2013) and analysed by the methods described by AOAC (1990). Results obtained revealed that, the soil sampled found to contained heavy metals and element in moderate amount of mean concentration values in milligrams per gram (mg / g), the element and metals determined were; potassium (K) element had the highest level with the mean concentration of 15 mg / g, and then followed by cadmium (Cd) 9 mg / g, copper (Cu), iron (Fe) and nickel (Ni) had 1 mg / g each, lead (Pb) had the value of 0.4 mg / g in mean concentration level, while manganese (Mn) had 0.3 mg / g, and finally zinc (Zn) had the mean concentration level of 0.1 mg / g of soil. The magnitude of concentration levels of the heavy metals and elements determined in the soils of the college's irrigation farm in sequential ascending order was; K > Cd > Cu, Fe and Ni > Pb > Mn > Zn. Also in consideration of their concentration levels in terms of mean percentage (%) amongst the metals and elements determined; K had 54%, Cd had 32%, Fe and Ni had 5% each, Cu had 2%, Mn and Pb had I% each, and finally Zn had 0.5%, i.e. the highest in mean concentration levels was potassium (K), the least was zinc and it is not contaminated by the metals and the elements determined as well respectively. Human activities have dramatically changed the 10 metres position and organization of the soil. The industrial and mining activates in an increased concentration of heavy metals in soil. How plants and soil microorganisms cope with this situation. It is recommended that further study needs to be carried out in order to ascertain, assess and state the heavy metals and elements mean concentration levels in soil of the said study area, and all farms at large.

Keywords: College's Farm, Concentration, Element, Heavy Metal, Mean Value, Soil

1. Introduction

Human activities affect and cause climate change, the ecosystem–environmental ecology; have dramatically changed the composition and organization of soil. Such as industrial and urban wastes, agricultural applications and also mining activities inclusively resulted in an increased concentration of heavy metals in soils, which rendered many soils in some farms have been contaminated with heavy metals and pollutants in some countries, and the College's farm, Maiduguri will not be different, which are unhealthy to plant growth and development in them or expose them to health risks due to these metals accumulation in their tissues (bioaccumulation), and they contained harmful physical, chemical and biological agents in higher concentration levels and when these plants were fed by herbivores animals will cause environmental impacts; health risk effects.

Soil may be defined as a natural body of loose unconsolidated material which constitutes a thin layer several metres deep on the earth surfaces. It is derived from weathered parent rock materials and decaying organic matter and is composed of solid particles with liquids and or gasses occupying the spaces between the particles [3, 17, 25]. Soil is an indispensable agricultural resource which nourishes and provides mechanical supports for growing plants [4, 18]. Soil is considered the "skin of the earth" with interfaces between the lithosphere, hydrosphere, atmosphere and biosphere [6, 8]. Soil is the mixture of minerals, organic matter, gasses, liquids and a myriad of organisms that can support plant life. It is a natural body that exists as part of the pedosphere and it performs four important functions; Soil is a medium for plant growth, a means of water storage, supply and purification, a modifier of the atmosphere and it is habitat for organisms and creation of a habitat for other organisms. Soil consists of a solid phase (mineral and organic matter) as well as a porous phase that holds gasses and water [17–19, 25].

Soils are often treated as a three state system and soil is the end product of the influence of the climate, relief (elevation, orientation and slope of terrain), biotic-activities (organisms) and parent materials (original minerals) interacting over time. Soil continually undergoes development by way of numerous physical, chemical biological processes, which include weathering with associated erosion. Most soils have a density of between 1 to 2 g / cm^3. Little of soil of the planet earth is older than the Pleistocene and none is older than the Cenozoic [6, 12, 19].

Soil science has two main branches of study; the Edaphology and Pedology. Pedology is focused on the formation, description (morphology) and classification of soils in their natural environment, whereas Edaphology is concerned with the influence of soils on organisms. Soil is referred to as regolith, or loose rock material that lies above the "soil geology". It is commonly referred to as "earth". As soil resources serve as a basic food security, the international community advocates for its sustainable and responsible use through different types of soil governance [6, 8, 9, 12]. Soil formation, or paedogenesis, is the combined effect of the physical, chemical, biological and anthropogenic processes working on soil parent material. Soil is said to be formed when organic matter has accumulated and colloids are washed down ward, leaving deposits of clay, humus, iron oxide, carbonate and gypsum. These constituents are moved from one level to another by water and animal activities. As a result, layers (horizons) form in soil profile. The alteration and the movement of material within a soil cause the formation of distinctive soil horizons [6, 10, 17].

The mineral material from which a soil form is called parent material, rock, whether its origin is igneous, sedimentary, or metamorphic, is the source of all soil mineral materials and the origin of all plant nutrients with the exceptions of nitrogen, hydrogen and carbon. As the parent material is chemically and physically weathered, transported, deposited and precipitated, it is transformed into a soil [4, 10, 19]. Out of the one hundred and twelve (112) elements in nature, about eighty (80) are metals, most of which are found only in trace amounts in the biosphere and biological materials. Some metals or metal - like elements which do give rise to well organised toxic effects in man and his ecological associates [3, 7, 9, 25]. These elements include; arsenic, antimony, beryllium, cobalt, chromium, lead, manganese, nickel, e.t.c, [11, 20]. These metals have been known to be toxic to man for centuries, and their carcinogenic activities have also been reviewed by Meittinien [11, 20].

The aim of this study is to determine some selective heavy metals and elements in soil of the college's farm, College of Agriculture, Maiduguri, North – eastern Nigeria. Human activities have dramatically changed the 10 metres position and organization of soil, the industrial and mining activates also caused an increased in concentration of heavy metals in soil. How plants and soil microorganisms cope with this situation, and with advance of science, technology, and engineering and Nano – fields of science, technology and engineering innovations modern sophisticated science laboratory techniques developed for the analysis of contaminated soil with heavy metals, trace elements in soil environment, salinity effects of soil environment, biological pollution, especially microbiological contaminants, soil fungi, heavy metals polluted plants, Insecticides and Herbicide on plants, pests and soil analysis, etc.

2. Materials and Methods

2.1. Study Area and Location

The study was conducted in the College's farm, College of Agriculture, Maiduguri, Borno state of Nigeria. Maiduguri shares local boundaries with Konduga, Jere and Mafa LGAs. It has an area land mark of 300 square kilometres (300 km^2), which lies between latitude 12°N to 13°N and longitude 13° E to 15° E respectively [13]. It has an estimated population of 629, 486 people, out of which 340,809 are males and 288,977 are females [21]. The vegetation is of semi – arid zone and climatic condition in this area is of a hot dry season (27°C to 42°C), and an annual rainfall of 500 mm to 600 mm has been recorded [13].

2.2. Materials Used

Materials (apparatus and reagents) used in this research

study were of high grade, AOAC standard reagents and analytical techniques. Standard Operation Procedures was strictly being observed.

2.2.1. Apparatus

Plastic tray, ceramic pistle and mortar, soil auger, polythene bags, plastic buckets and bowls, plastic cutting knife and spatula, clean white cotton piece of cloth, sterile absorbable cotton wool, plastic sieve, crucible dishes, reagent bottles (various types), measuring cylinders and flasks (50 mls, 100 mls, 250 mls, 500 mls, 1000 mls) large mouth brown bottles, sample bottles, Whatman filter paper (No. 1), hand gloves, hot air oven, Muffle furnace, Homogenizer machine, weighing balance, Analytical balance, Atomic Absorption Spectrophotometer (AAS) and Flame photometer.

2.2.2. Reagents

Tap water, distilled water, deionised water, Hydrogen hypochlorite (bleaching solution), HCl and KOH of known molarity and concentration, Kheldahl reagents and AOAC standard reagents.

2.3. Methods

Soil were sampled, and collected as described by the method of Ashiq *et al* [3] and analysed by the methods described by AOAC [2].

2.3.1. Sampling and Samples Collection

About 6:30 AM, 20.5 kg of soil samples in the college's farm were collected with the aid of a stainless steel tube auger at the depths of 10 cm to 15 cm, 15 cm to 30 cm, 30 cm to 45 cm, 45 cm to 60 cm, at different portions of the various stations A, B, C, D and E. It was then transferred into the air tight polythene bags separately and brought to the laboratory. In the laboratory, it were pooled together, thoroughly mixed and air dried at room temperature. 5 g of the pooled, mixed and air dried soil sampled was removed from the whole soil samples and then oven dried at 40°C for 48 hours in Hot air oven, removed and cooled. It was then crushed to fine powder by using homogenizer and sieved to pass through a 2 mm nylon sieve. The fine powder was then dispensed into brown plastic bottles and ready for analysis.

2.3.2. Soil Sampled Analysis

It was ashed, digested and analysed for the presence and determined the queried heavy metals and element by using AAS as described by Ashiq *et al*, [3] and the methods described by AOAC, [2].

2.4. Data Analysis

The data obtained from this research study were subjected to statistical tools of analysis using percentage, mean for the measurement of central tendency, and standard deviations for measurement of dispersion and or discrepancy within the variables being obtained and its' significance, as described by Stroud and Booth [26].

3. Results

The results obtained from the research study on the determinations of some selected heavy metals and elements in soil of the college's irrigation farm, Maiduguri is shown in the tables below:

The table 1 showed the results of analysed soil sampled out of the college's irrigation farm that the mean concentration levels of heavy metals and element that were determined. It revealed that K had the mean concentration level of 15.0 milligram per gram (mg / g), Cd had 9.0 mg / g, Cu had 0.57 mg / g, Iron had 1.31 mg / g, Mn had 0.34 mg / g, Ni had 1.27 mg / g, Pb had 0.4 mg / g, and finally Zn had 0.13 m g / g respectively.

In the table 2, it showed the results of the analysed soil sampled out of the college's irrigation farm that the percentage (%) of mean concentration levels of the heavy metals and elements that determined. It revealed that K had the mean concentration of 54%, Cd had 32%, Cu had 2%, Fe had 5%, Mn had 1%, Ni had 4%, Pb had 1% and Zn had 0.5%.

Table 1. *Mean Concentration Values of the Soil Sampled from College's Irrigation Farm.*

Sample Trial		**Mean Concentration Values (mg / g)**							
Type		**Cd**	**Cu**	**Fe**	**K**	**Mn**	**Ni**	**Pb**	**Zn**
	1st	9.0	0.57	1.31	15.0	0.34	1.27	0.4	0.13
Farm's Soil	2nd	9.1	0.57	1.30	15.1	0.34	1.26	0.39	0.13
	3rd	9.0	0.56	1.30	15.1	0.34	1.27	0.4	0.13
T (M ± ST Dev)		27 (9 ± 0.1)	2 (1 ± 0.01)	4 (1 ± 0.01)	45 (15 ± 0.1)	1 (0.3 ± 0)	4 (1 ± 0.01)	1.2 (0.4 ± 0.01)	0.4 (0.1 ± 0)

Keys: mg = milligram, / = per, g = gram, Cd = Cadmium, Cu = Copper, Fe = Iron, Mn = Manganese, Ni = Nickel, Pb = Lead, Zn = Zinc, T = Total, M = mean, ± = Plus or Minus, ST Dev = Standard deviation.

Table 2. *Mean Percentage of Concentration Values of the Soil Sampled from College's Irrigation Farm.*

Sample Trial		**Mean Concentration Values (%)**							
Type		**Cd**	**Cu**	**Fe**	**K**	**Mn**	**Ni**	**Pb**	**Zn**
Farm's Soil	1st	32.12	2.03	4.78	53.53	1.21	4.53	1.43	0.46
	2nd	32.3	2.02	4.61	53.57	1.21	4.47	1.38	0.46
	3rd	32.03	1.99	4.63	53.74	1.21	4,51	1.42	0.46
T (M ± ST Dev)		96.5 (32 ± 0.1)	6 (2±0.02)	14 (5 ± 0.04)	161 (54 ± 0.1)	4 (1 ± 0)	14 (5 ± 0.03)	4 (1 ± 0.03)	1 (0.5 ± 0)

Keys:% = Percentage, Cd = Cadmium, Cu = Copper, Fe = Iron, Mn = Manganese, Ni = Nickel, Pb = Lead, Zn = Zinc, T = Total, M = mean, ± = Plus or Minus, ST Dev = Standard deviation.

4. Discussions

Climate change impacts such as unpredictable and changing seasonal weather variation, etc, in warm and humid region where soil dose not freeze, climate directly affects the rate of leaching. Soil is said to be formed when detectable layers of clays, organic colloid carbonates, or soluble salts had been removed down ward. Wind moves sand and smaller particles especially in the arid regions where there are little plants covering the type soil and amount of precipitation influence soil formation by affecting the movement of ions and particle through the soil, and aid in the development of different soil profile. Human activities affect and cause climate change, the ecosystem – environmental ecology; have dramatically changed the composition and organization of soil. Such as industrial and urban wastes, agricultural application and also mining activities inclusively resulted in an increased concentration of heavy metals in soil, which rendered many soils in some farms have been contaminated with heavy metals and pollutants in some countries, and the College's farm, Maiduguri will not be different. Okoronkwo et al, [23] who reported that implication of polluted soil with heavy metals is one of the risk and health factors that affects human and animal through the bioaccumulations of metals.

Consumption of food crops grown on soil that is been contaminated with heavy metals is a major food chain route for human exposure which was also reported by Ashiq *et al*, [3]; Fischbein, [11] and NIOSH, [22]. It was reported by some researchers such as Alloway *et al*, [1]; Bhata, [5]; Huges et al, [16] and Okoronkwo *et al*, [23] that the distribution of heavy metals in plant body depends upon availability and concentration of heavy metals in soils as well as particular plant species and its population.

These heavy metals such as cadmium, lead, nickel, e.t.c, increase in their recommended concentration are unhealthy to the plants growth and tend to develops in them or expose them to health risks due to these metals accumulation in their tissues (bioaccumulation), and they contained harmful physical, chemical and biological agents in higher concentration levels and when herbivores animals fed on these plants, they tend to bio - accumulates them in their body tissue and as a result of over concentration levels of heavy metals which cause lethal effect or mortality or morbidity may occur, and then the dead body of the animal concern will decomposed and release the metals into the soil which will cause adverse environmental impacts, when such environment is been polluted with heavy metals from the industrial waste, human activities such as mining; it will cause health risk effects if not been rapidly addressed.

As a result of these problems, a research study was conducted in such a way that, the data obtained would be serving as baseline data and focuses on the determination of some selected heavy metals and elements in the soils of the college's irrigation farm. The results obtained revealed that the mean concentration levels of the determined heavy metals and elements which were presented in milligram per gram of the soil sampled in the irrigation farm. The study revealed that potassium (K) element had the highest level with the mean concentration of 15 mg / g, and then followed by cadmium (Cd) with the mean concentration level of 9 mg / g. The mean concentration levels of copper (Cu), iron (Fe) and nickel (Ni) was that each had 1 mg / g respectively. Lead (Pb) had the value of 0.4 mg / g in mean concentration level, while manganese (Mn) had the mean concentration level of 0.3 mg / g, and finally zinc (Zn) had the mean concentration level of 0.1 mg / g of soil. The magnitude of concentration levels of the heavy metals and elements determined in soils of the college's irrigation farm in sequential ascending order was K > Cd > Cu, Fe and Ni > Pb > Mn > Zn. Also in consideration of their concentration levels in terms of mean percentage (%) amongst the metals and elements determined; K had 54%, Cd had 32%, Fe and Ni had 5% each, Cu had 2%, Mn and Pb had 1% each, and finally Zn had 0.5%, i.e., the highest in mean concentration levels was potassium (K), the least was zinc respectively. 0.03). The study revealed that the college's irrigation farm soils had higher percentage and rich in K and much of Cd, had lesser Fe, Cu, Ni, Mn and Pb, and had the least amount of Zn mean concentration level. Hence, it was concluded that the soils of the college's irrigation farm is rich in the determined minerals salt, both macro and micro elements and it is not contaminated by the metals and elements determined as well.

According to Gwana *et al*, (2017) who stated that those recent years, changes in climate have caused some impacts on human systems and natural across all bodies. For instance soil environment or ecosystem pollutions, it cause some problems to agriculture and food security, especially in fields of irrigation and fisheries sector and with these climate changes impacts, such as unpredictable and changing seasonal weather variation etc, is causing lower crops yields and animals production, especial the fish production and some vegetables. Climate change is occurring as a result of the earth's atmosphere due to human activities generating excess amount of green house gases. This in general terms, climate change occurs as a result of imbalance between incoming and outgoing radiation in the earth's atmosphere.

On the other hand, the human activities such as the industrial wastes (e.g., heavy metal) disposal and agricultural practice and its applications of fertilizers, pesticides, herbicides, etc, and because of its potential impacts on the hydrologic cycle and severe weather event climate is expected to have caused enormous effects on human health, including on the burden and distribution of many infectious diseases, such as poisoning with the exposed and concentrated heavy metals exposed to and contaminated the soil, in this case not only the human being been affected but also the biodiversity of the soil, this is in conformity with the works of Watt et al, [27]; Qais et al, [24]; Gwana et al, [14]. High levels of concentration values of these heavy metals in the soils may cause immediate poisonous in the animals and plants through bioaccumulations. All plants require the same basic nutrients, but plants differ in the way they respond to nutrient availability. Plants, some are

selective on absorption or intake of mineral metals, it depend on the species or varieties, and if animal fed on these edible plants, especially man, high levels in the body can be or cause immediate poisonous, or can result in long – term health problems and thereby results to mortality, morbidity or both as the case may be involved.

5. Conclusion

Soil is indispensable agricultural resources which nourishes and provides supports for growing plants. Soil is defined as natural body of loose unconsolidated material which constitutes a thin layer several metres deep on the earth's surface, derived from weather parent rocks material, decaying organic matter and it composed of solid particles with liquid and gasses occupying the space between the particles. Climate change impacts such as unpredictable and changing seasonal weather variation, etc, in warm and humid region where soil does not freeze, climate directly affects the rate of leaching. Soil is said to be formed when detectable layers of clays, organic colloid carbonates, or soluble salts had been removed down ward. Soil formation or paedogenesis is the combined effect of the physical, chemical, biological and anthropogenic processes working on soil parent material. Soil is said to be formed when organic matter has accumulated and colloids are washed down ward, leaving deposits of clay, humus, iron oxide, carbonate and gypsum. These constituents are moved from one level to another by water and animal activities.

As a result, layers (horizons) formed in soil profile. The alteration and the movement of material within a soil cause the formation of distinctive soil horizons. The mineral material from which a soil forms is called parent material, rock, whether its origin is igneous, sedimentary, or metamorphic, is the source of all soil mineral materials and the origin of all plant nutrients with the exceptions of nitrogen, hydrogen and carbon. As the parent material is chemically and physically weathered, transported, deposited and precipitated, it is transformed into a soil.

As a result of these problems, study was conducted on the determinations of some selected heavy metals and elements in soils of the college's irrigation farm. The results obtained revealed that the mean concentration levels of the determined heavy metals and elements which were presented in milligram per gram of the soil sampled in the irrigation farm. It revealed that the college's irrigation farm soils had higher percentage and rich in K and much of Cd, had lesser Fe, Cu, Ni, Mn and Pb, and had the least amount of Zn mean concentration level. Hence, it was concluded that the soils of the college's irrigation farm is rich in minerals salt, both macro and micro elements and it is not contaminated by the heavy metals and elements determined as well.

Recommendations

Based on the results obtained and the information revealed from this research study, we recommend further intensive study need to be carried out on the soil minerals (both macro and micro elements and the 20 heavy metals) in this area in order to ascertain, assesses and states the heavy metals and elements in soil environment of the said study area.

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