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Chemical Analyses of Leave Samples of Tomato, Groundnut and Melon as Economic Crops for Successful Reclamation at Itakpe Iron Ore Mine, Kogi State, Nigeria

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Abstract: A critical assessment of the suitability of tomato, groundnut and melon as economic crops for successful reclamation at Itakpe iron ore mine, Kogi State, Nigeria had been carried out. This was with the aim of determining their suitability for post-mining agricultural land-use. Over a six months period (April-September, 2006) tomato, groundnut and melon seeds were planted on three farms, two of which were within the mines environment. The 2 farms that were 100 and 200 m from the mine were amended with poultry dropping at the rate of 200 g $3kg^{-1}$ of soils. The third farm which was about 300 m from the mine, where mining effect was negligible, was used as control without any poultry dropping addition. Leaves of the three crops were collected, predigested and analyzed for their chemical properties. The results shows that in the three farms, the extractable micronutrients, such as Calcium, Magnesium and Potassium were within the range of 210- 1,000 ppm, 210- 6,000 ppm and 1,710- 25, 000 ppm, respectively.The results also revealed that plant samples from the farms within the mines environment contained higher level of heavy metals compared to that of the third farm, although not in harmful quantity. Also, none of the plant could survive on the mined-out soil without application of poultry droppings.

Key words: Reclamation, mined-out, poultry, leaves, micronutrients, extractable, exchangeable

INTRODUCTION

As part of surface mining activities topsoil and plant material are usually removed before mining operations begins (Holmberg, 1980). They are stored for a later use in a manner conducive to protect the primary root medium from contamination and erosion. It also enhances its productivity. Although the majority of damage to soil structure emanate from the way the material is handled. It is further exacerbated during the storage period (Scullion, 1994). Systematic handling and storage practices can protect physical, chemical and microbiological characteristics of the soil while it is in storage and after it has been redistributed onto the degraded area (Mccormack, 2005). Scullion (1994) found decreases in the organic matter responsible for stabilizing soil structures in the stored topsoil, also there are little structural stability deterioration in topsoil stockpiled. The most immediate effect of stripping soil is compaction caused by a combination of the passage of the earth moving equipment and shear force during lifting (Ramsay, 1996). As the soil is made increasingly compact, the volume occupied by gas and available water declines rapidly. A loss in aggregate stability results, as was demonstrated by Scullion (1994) represents a large decrease in the ability of the soil to provide adequate aeration for plant growth and drainage. During storage, there are chemical changes caused by compaction of the soil. Here, the supply of oxygen to soils has been cut off leading to the development of anaerobic condition during the first three months (Ramsay, 1996). This phenomenon usually leads to a number of important changes in the soil chemistry. During the course of storage, most of the nitrogen which would become available for plants growth in the undisturbed soils accumulated in this form. Nitrogen accumulated is then liable to be lost on re-spreading.

The change in redox potential is accompanied by a fall in pH and an increase in the availability of certain metals, such as manganese, copper and zinc (Scullion, 1994). This can bring further problems of toxicity for the surviving organisms. Sulphides are then produced as a result of anaerobic metabolism, resulting in the production of metal sulphide precipitates and giving the soil a characteristic dark grey or black coloration. Also, there are some biological changes such as significant and rapid changes in the living component of the soil during the course of storage. It occurs in two major phases as a result of linked phenomena. Initially because of the large amount of organic materials, such as fungal hyphae, plant roots and soil animals, killed by the soil lifting process,

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there is rapid and large increase in the numbers of bacterial throughout the storage (Ramsay, 1996). This is followed by a period where the numbers of bacterial decline as these reserves are exhausted, until numbers found in reference areas are reached. Numbers of fungi decline immediately, so also total microbial biomass. The fungal biomass is providing organic and inorganic substrates for the bacterial explosion.

Reclamation of derelict land: Derelict land is a land so damaged by mining or industrial or other development that is incapable of beneficial use without treatment while reclamation is a process by which previously unsuitable land is returned to a state whereby some use may be made of it (ASTM, 1987). It is also includes those states that stabilize mined land in an environmental sense. Hence reclamation is integral to a total plan for erosion and sediment control (Birch and Harris, 1999). Reclamation is an act or process of transforming a derelict land into its original, natural productive or better conditions. It involves consideration of the physical, chemical, biological and hydrologic characteristic of land prior to, during and after mining operations and each kind of dereliction is likely to require certain techniques in reclamation which are peculiar to its own particular problem. It is not a simple operations supplementing mining, rather it is a series of integrated operations that begins with initial mine planning, continues through the extraction phase and does not end until the new, post mining land use begins (Adepoju and Flemming, 1987). Reclamation of a mined land has to be planned before construction or mining work starts. Arrangements have to be made in advance so that materials needed for a good reclamation are set aside from the first day of the work (Rimmer and Alan, 2003). McCormack (2005) opined that of greater importance than any other factor in achieving successful reclamation of surface mined land is the nature of the soil left at the surface after mining. The nature of this soil determines the choices available for plant species. Exhaustive planning and comprehensive collection of data are essential to make reclamation an economically viable venture. Spoil material analysis is very important in determining a practical reclamation plan to utilize. This would reveal toxic material and it's unsuitability for reclamation purpose. Spoil material evaluation could prevent such environmentally hazardous and economically devastating effect. Physical and laboratory analyses are the most reliable means for spoil evaluation (Meritt, 2003). A variety of valuable tests, colour, content and type and pH- are used for determining potential toxicity problems for toxic spoil material by indiscriminate placement of acid. Producing strata may be alleviated by pre-mine test such as these and also a thorough geo-chemical laboratory analysis of overburden strata (Despard, 1994). The restoration of the mined-land to its original fertility could only be done when the present content of the spoil is known and then there could be additional nutrients to cater for the deficiencies. This becomes imperative where the mined land is to be restored for crop production, since plants require certain amount of nutrients to survive.

Geology of the study area: The Itakpe Iron-ore deposit is located within gneiss- migmatite-quarzite unit of the Nigeria basement complex. Olade (1998), Annor and Freeth (1995) noted that the dominant lithologic unit in the area is the granodiorite-tonalite gneiss, overlain by a sequence of low grade metasedments and intruded by granodioritite and granitic rocks. The main rock types identified include granite gneiss, amphibolites, quartzite, schist's, granite and pegmatite. Olade (1998) discussed the geology of the deposit and identifies two types of quartzite in the area: Ferruginous and non-ferruginous. The ferruginous quartzite occurs as magnetite-rich and hematite rich bends and lenses about 10-60 m wide in alternation with gneiss. The non ferruginous quartzite is rare in the Itakpe but constitute the bulk of the rocks on its southern edge. Three main ore bodies have been delineated which comprises a group of ferruginous quartzite bends or lenses. All ore bodies crop out at the surface or are capped by thin overburden. The northern ore body occurs at the northern flank of the ridge. It has a strike length of 400 m and a length of 200 m along dip direction with thicknesses ranging from 60-30 m. The control ore body extends along strike for 200 m and it increases in thickness from west to east. Two small ore lenses 35 and 15 m thick coalesce to form the main ore body which is approximately 10 m wide. The southern ore body dips steeply to the south and extend along strike for about 500 m with a thickness of approximately 15 m it is width is about 40 m. The deposit is hard and aggressive with a bulk density of 3.7tonnes/km^3 (Olade, 1998). Various test carried out on the Itakpe deposit confirmed the amenability of the Itakpe Ore for the production of concentrates and super concentrates required by Ajaokuta Steel Plant and the Delta Steel Plant, respectively. This finding was a major factor that influences the sitting of the Ajaokuta Steel Plant, 56km away from Itakpe. The average chemical composition of a typical Itakpe Iron Ore is shown in Table 1.

The objective of this study, is to determine the suitability of economic crops such as tomato, groundnut and melon as indicators of successful reclamation in an iron ore mined-out area.

Table 1: Average chemical composition of typical Itakpe iron ore

Component	(%)
Fe_2O_3 (Hematite)	30.88
Fe_3O_4 (Magnetite)	19.90
SiO_2	42.05
CaO	1.25
Al_2O_3	3.20
TiO_2	0.17
MgO	0.35
P	0.095
S	0.03
CO_2	0.38
H_2O	0.41
Na_2	0.52
K_2O	0.64
Pb	0.005
Zn	0.007
Cu	0.005

Sources: Mines Laboratory, NIOMCO Itakpe

MATERIALS AND METHODS

Description of the study area: Itakpe is located along Okene- Lokoja road in Kogi state which is in North Central part of Nigeria. The climate is a forest savanna type of vegetation which consists of scattered trees, shrub and tall grass. The monthly average temperature range is between 25 and 30°C in July/August and 34-36°C in February/March. Humidity is high, varying from 80% in July/August to 60% in January/February. The major stream, River *Pompom* flow eastwards towards river Niger, likewise the Osara River. Drainage pattern in the area may be said to be radiant because of the hilly landscape that is prominent. Majority of the inhabitants of the settlement around the study area are the Ebiras, with few Bassa people and nomadic Fulanis. Agriculture is the major activities of the inhabitants of the study area. They cultivate some economic food crops, such as cassava, melon, groundnut, yam, tomatoes, millet and cowpea. Some people carry out fishing activities around River Osara and the nomadic Fulanis, always carry their herds of cow to graze around the area.

Leave sample from the study area: Over a six months period, seeds of tomato, melon and groundnut were planted on two experimental farms and one control farm for the purpose of this study. The two experimental farms that were 100 and 200 m from the mine were amended with poultry dropping at the rate of 200 g $3kg^{-1}$ of soils. The third farm which was about 300 m from the mine, where mining effect was negligible, was used as control without any poultry droppings addition. Representative leaves samples of tomato; melon and groundnut were collected from farms A, B and C. The leave samples were the youngest but fully matured leaves and label APT, APM and APG for tomato, melon and groundnut leaves at farm A, respectively. BPT, BPM and BPG for farm B while CPT, CPM and CPM is for farm C in the same order. Leaves of tomato, groundnut and melon from the three farms were collected, predigested and analyzed for their chemical properties.

Laboratory analyses: Leaves samples collected were dried in the oven at 65°C to a constant weight. They were grinded to a fine state in a mortal and kept in label polythene bag for laboratory analysis. One gram of grinded sample was weighted into a crucible and heated in a furnace at the temperature of 550°C for 3 h for complete ashing. The ash was then dissolved in 10% Hydrochloric acid (Hcl) and filtered into 50 mL standard flask using filter paper and it was made to mark with distilled water and pour into a bottle for chemical analysis.

Plant analyses: Plant Science Laboratory of Department of Crop, Soil and Pest Management (CSP) and Chemistry laboratory of the Department of Industrial Chemistry of Federal University of Technology, Akure were used for the plant analysis of this study. The major extracting and analytical tests were carried out at the Plant Science Laboratory of CSP except the flame emission and atomic absorption spectrometry tests which were done at the Chemistry laboratory. Macronutrients such as nitrogen, Phosphorus, Potassium, Calcium, Magnesium and plant micronutrients were determined from the plant samples.

Determination of leaf nitrogen: Leaf nitrogen contents were determined using the ASTM 6187-97 procedures. Table 2-4 show the nitrogen content of the crop from the study farms. Similar tables were prepared for all other parameters that were determined such as leave phosphorous, extractable Calcium, Magnesium, Potassium, Manganese, Iron, Copper and Zinc. The average (mean) values of these parameters were determined for three farms as shown in Fig. 1-9.

Determination of leaf phosphorus: The following method was used to determine the phosphorous content of leave sample from the study area. Ten milliliters of sample solution was pipetted into 50 mL standard flask. Twenty milliliters of 0.1m EDTA with 10 mL of vanado- molybdate solutions were added and diluted to volume, mixed and allowed to stand for 10 min. Absorbance of this was determined at 470 mm. Phosphorus was determined from the calibration curve obtained by taking 0, 2, 4, 6, 8, 10 mL of the 50 ppm stock solution of phosphorus which was diluted to 50 mL in a volumetric flask. The absorbance of standard was read and the graph of absorbance was plotted against the concentration.

Table 2: Nitrogen (%) content of tomato leaves from the study farms

	1ST	2ND	3RD	Mean	Min	Max
FA	2.08	2.11	2.11	2.10	2.08	2.11
FB	2.17	2.21	2.16	2.18	2.16	2.21
FC	2.30	2.32	2.34	2.31	2.30	2.34

Table 3: Nitrogen (%) content of melon leaves from the study farms

	1ST	2ND	3RD	Mean	Min	Max
FA	2.23	2.26	2.26	2.25	2.23	2.26
FB	2.48	2.52	2.50	2.50	2.48	2.52
FC	2.55	2.59	2.60	2.58	2.55	2.60

Table 4: Nitrogen (%) content of groundnut leaves from the study farms

	1ST	2ND	3RD	Mean	Min	Max
FA	3.30	3.25	3.35	3.3	3.25	3.35
FB	3.36	3.33	3.36	3.35	3.33	3.36
FC	3.50	3.54	3.52	3.52	3.50	3.54

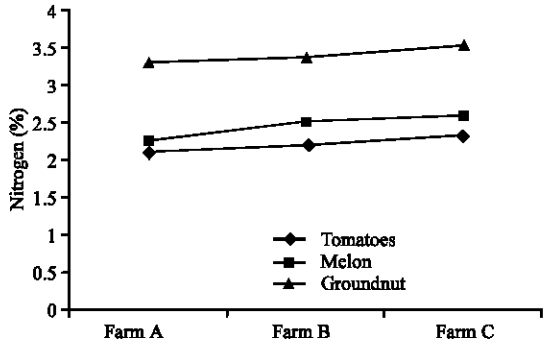

Fig. 1: The nitrogen content of leave sample from the three experimental farms

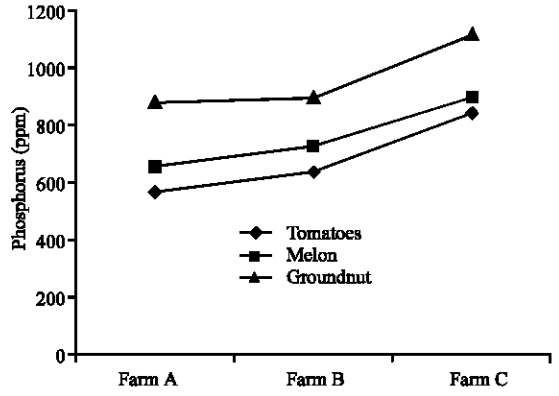

Fig. 2: The phosphorus content of leave sample from the three experimental farms

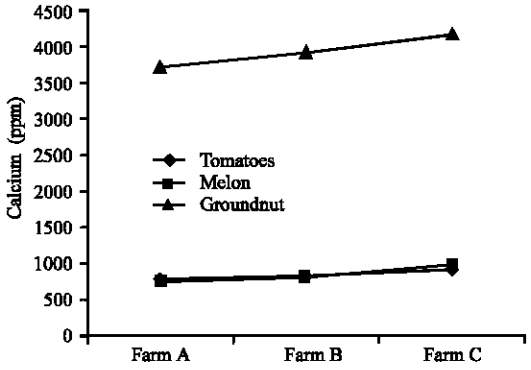

Fig. 3: The calcium content of leave sample from the three experimental farms

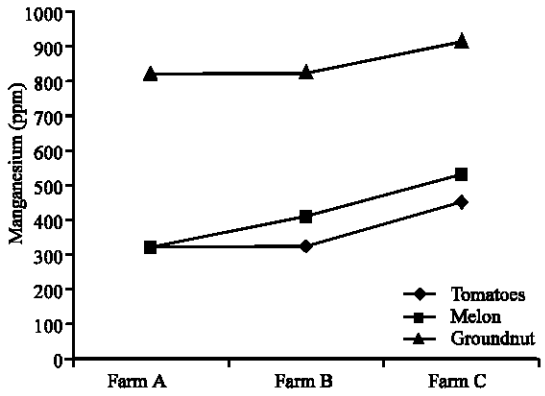

Fig. 4: The magnesium content of leave sample from the three experimental farms

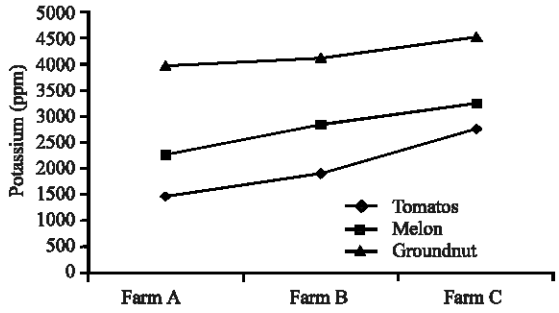

Fig. 5: The potassium content of leave sample from the three experimental farms

Determination of leaf calcium and magnesium: The value of (Ca++ and Mg++) was first obtained as follows: 10 mL of the extracted solution used for phosphorus was pipetted into 250 mL conical flask. Five drops of 2% Kcn, 5 drops of OH and CH2Hcl and 5 drops of erichrome black T indicator were added. The resulting solution was titrated with 0.0lm EDTA and deep blue and point resulted from a wine red colour. The titre value was recorded for Ca++ and Mg++. To obtain Ca++ alone, 10 mL of sample was pipetted into 250 conical flask. Five drops of 2% Kcn, Five drops of OH.NH2Hcl and a little quantity of a mixture aleserine power indicator were added. The solution was titrated with 0.01m EDTA from wine red to deep end blue point. The titre value was recorded for calcium alone. Mg^{++} was then obtained by subtracting Ca^{++} from the value obtained for (Ca++ and Mg++).

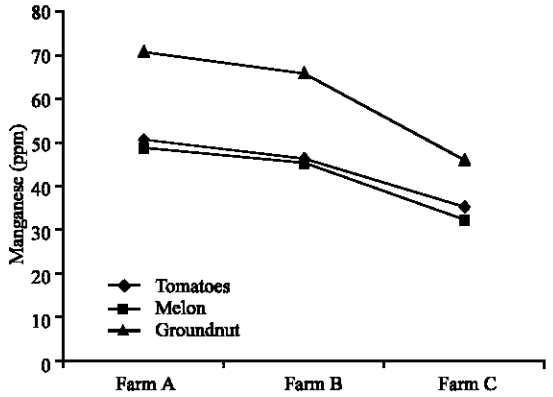

Fig. 6: The manganese content of leave sample from the three experimental farms

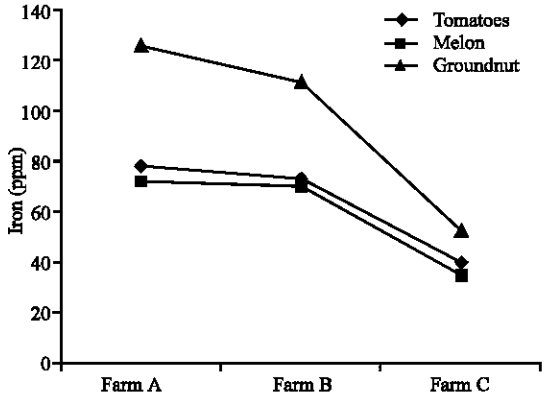

Fig. 7: The iron content of leave sample from the three experimental farms

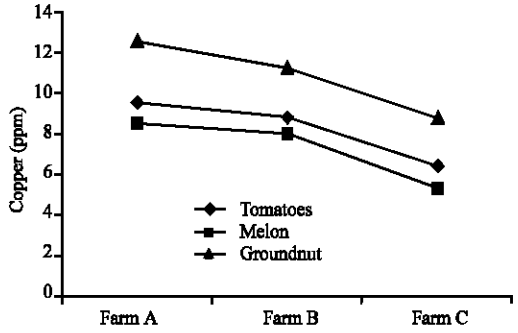

Fig. 8: The copper content of leave sample from the three experimental farms

$$\%Ca^{++} = \frac{T \times 0.01}{100} \times \frac{V_1}{V_2} \times \frac{100}{W} \times \frac{40}{1} \quad (1)$$

Determination of leaf potassium: Potassium chloride was used to prepare standards for potassium Sodium,

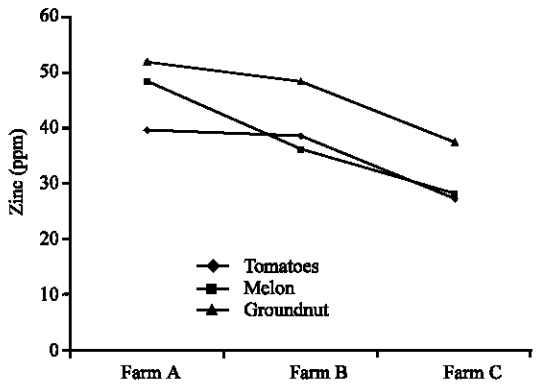

Fig. 9: The zinc content of leave sample from the three experimental farms

standard stock solution. To prepare 1000 ppm from KCl the quantity of KCl can be calculated as:

$$\frac{\text{Molecular mass of KCl}}{\text{Atomic mass of K}} = \frac{58.5}{21} = 2.5434\text{g} \quad (2)$$

Therefore, 2.5434 KCl were dissolved in distilled water and diluted to 1 L to give 1000 ppm by making 400cm to 1000 mL with distilled water. Potassium was determined by taking 0, 5, 10, 20 and 40 cm^3 out of the 1000 dm^{-1} solution of potassium chloride and diluting to 100 cm^3 in a volumetric flask. The standard solutions were run in a flame photometer and their emission recorded.

Determination of Mn, Zn, Fe, Cu in leaves: Atomic Absorption Spectrometry (AAS) method was used. The spectrometry described the measurement of the amount light absorb by the sample at a specified wavelength. A series of standard solutions of the elements were made by weighing 0.5g of ground plant material (Oven dry) into a 125 mL flask, 4 mL of perceleric acid, 15 mL concentrated HNO_3 and 2 mL concentrated H_2SO_4 under a fume hood. The absorbance of each solution was measured in an atomic absorption in spectrophotometer and plotted to provide a calibrated curve.

RESULTS AND DISCUSSION

Leaf analysis of crops grown on the farms in the study area: The crops plant analyses provide immediate diagnosis of nutrients deficiency, toxicity or imbalance (Brady and Weir, 1999). It serves as a supplemental tool to soil texts.

Nitrogen in plant: Table 2-4 and Fig. 1 shows the nitrogen content of tomato, melon and groundnut that were grown on the farms in the study area. According to Ramsay (1996) the figure shows that the nitrogen content in both tomato and melon leaves in the farms was lower than the general sufficient (required) range of 2.76- 3.5%, while the nitrogen in groundnut leaf was within this sufficient range. However, the values of nitrogen content increase with increasing distance from the mines.

Phosphorous and extractable micronutrients in plant: The results of the leaves analyses for Phosphorous and extractable micronutrients are shown for tomatoes, melon and groundnut in Fig. 2-5. Figure 2 shows that the Phosphorus content of the three leaves samples was within the sufficient range of 250-4,000 ppm and, the values increased with increase in distance from the mines (Brady *et al*., 1999). As indicated in Fig. 2, these values were higher in Groundnut, followed by melon, then tomato. As shown in Fig. 3-5 the extractable micronutrients, such as Calcium, Magnesium and Potassium were within the sufficient range of 210- 1,000 ppm, 210- 6,000 ppm and 1,710- 25, 000 ppm, respectively (Ramsay, 1996). This may be due to the application of N.P.K fertilizer to the soil in the study area over a long period of time. Also, the soil alkalinity in the experimental farms could be a factor as it usually favours the presence or availability of exchangeable bases.

Exchangeable bases in plant: Figure 6-9 shows that the values of metal exchangeable bases increased with increasing distance from the mines in the order melon>groundnut>tomato. As shown in Fig. 7, the plants recorded the highest value of Iron content among the heavy metal and it is within the critical values of 21- 250 ppm (McCormack, 2005). Figure 6-9 show that other heavy metals such as manganese, copper and zinc were found to be within the critical value of 20-150, 6.0- 20 and 20-70 ppm, respectively and it recorded the values in this order groundnut>melon>tomato (McCormack, 2005). Lead was not detected at all in the leave samples.

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CONCLUSION

In this study, the suitability of tomato, groundnut and melon as economic crops for successful reclamation at Itakpe iron ore mine, Kogi State, Nigeria had been discussed. The aim was to determine their suitability for post-mining agricultural land-use. Over a six months period (April-September, 2006) tomato, groundnut and melon seeds were planted on three farms, two of which were within the mines environment. They were 100 and 200 m from the mine. The third farm was about 300 mfrom the mine, where mining effect is negligible. Leaves of the three crops were collected, predigested and analyzed for their chemical properties. The results shows that the three experimental farms the extractable micronutrients, such as Calcium, Magnesium and Potassium were within the sufficient range of 210- 1,000 ppm, 210- 6,000 ppm and 1,710- 25, 000 ppm, respectively (Ramsay, 1996) The results also revealed that plant samples from the farms within the mines environment contained higher level of heavy metals compared to that of the third farm, although not in harmful quantity. Also, none of the plant could survive on the mined-out soil without application of poultry droppings.

REFERENCES

Adepoju, S.O. and G. Flemming, 1987. Pre-mine Baseline Data: An Essential Tool in Reclamation Colliery Wastes. Proc. 2nd International Symposium on Reclamation and Treatment and Utilization of Coal Mining Wastes. University of Nottingham, U.K. Elsevier Publ., pp: 471- 473.

Annor, A.E. and S.J. Freeth, 1995. Thermo tectonic Evolution of the Basement Complex around Okene, Nigeria with Special Reference to Deformation Mechanism, Macmillan Publisher's, Lagos, pp: 269-281.

American Society for Testing and Material (ASTM), 1987. Standard Specification, pp: 2974- 2987, 6187-6197.

Brady, N.C. and R.R. Weir, 1999. The Nature and Properties of Soil. 12th Edn. Prentice Hall, New Jersey, pp: 8-9.

Birch, P. and J.A. Harris, 1999. Land Reclamation and Restoration. Cambridge University Press, Cambridge, pp: 125-130.

Despard, T.L., 1994. Avoid Soil Problems through Overburden Analysis use, North Eastern Forest Experimental Station. Oxford University Press, UK., pp: 12-18.

Holmberg, G.V., 1980. Vegetation Establishment on Abandoned Coal Mined Land. Am. Soc. Agric. Eng. Trans. General Edn., 23: 117-120.

McCormack, D.E., 2005. Soil Reconstruction: Selecting Plant Materials for Placement in Mine Reclamation: Mining Congress J., 62: 32- 36.

Merritt, R.D., 2003. Coal Overburden-Geological, Characteristics and Pre- mine Planning. Noyes Data Corporation, USA., pp: 42-45.

Olade, M.A., 1998. General Features of Precambrian Iron Ore Deposit and its Environment at Itakpe Ridge Okene, Nigeria. Macmillan Publisher's, pp: 1-9.

Ramsay, W.J.H., 1996. Bulk Soil and Plant Handling for Quarry Restoration. Prentice Hall, New Jersey, pp: 30-95.

Rimmer, D.L. and Y. Alan, 2003. Land Reclamation after Coal Mining Operations. Oxford University Press, UK., pp: 73-75.

Scullion, J., 1994. Restoring Farmland after Coal: The Bryngwyn Project, British Coal. Open Cast Executive Mansfield Publishers, UK., pp: 15-17.