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Neutron Activation Analysis of Soil Samples from Different Parts of Abuja Metropolis

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Abstract: A study was carried out on the concentrations of constituent (major, minor and trace) elements present in soil samples collected from different parts of Abuja Metropolis and their effect on the surrounding. In carrying out the analysis, the best and most convenient method being the Instrumental Neutron Activation Analysis (INAA) otherwise known as Non-Destructive Neutron Activation Analysis (NDNAA) was adopted. Soil/ Rock Samples were obtained, crushed to powdery form and samples prepared for INAA. 250mg of the samples were fed in to the nuclear reactor by means of pneumatic transfer with the aid of rabbit capsules. The irradiated samples were analyzed and the following elements identified: Al, Ti, Ca, Mg, K, Na, V, Mn, Dy, Sc, Zn, La, Sm, Co, Th, Rb, Ce, Hf, Fe, Yb, As, Eu, Lu and U. There have been higher concentrations found in the Airport Road soil than in the other soils as seen in Fe from the following results: Airport Soil (0.4212±0.014), Airport Road Soil (1.31±0.20), Aso Radio Soil (0.6641±0.017) and Karu soil (0.528±0.013); indicating that soil in that region might favour the growth of particular plants compared with soils from other region; however there was relative distribution in the overall outcome of trace and major elements. The results and technique compared with that of Oladipos who had a total of 22 elements from 7 different clay samples indeed showed that NAA is effective method of elemental analysis.

Key words: NAA (INAA · NDNAA) · Remote sensing · Soil Samples · Pneumatic transfer · Trace elements · Minor elements · Major elements

INTRODUCTION

The area of study lies within the Federal Capital Territory (FCT) of Nigeria (Fig 1). It is located between latitude 8°53'N, longitude 7°10'E and Latitude 9°14. N, longitude 7°34E. Soil is a natural resource that is frequently mistreated. Life is dependent on soil as much as it is on water and air. A nation that destroys its soils, destroys itself is a famous saying by Franklin D. Roosevelt. Nutrients required for plant development are sourced by the soil alongside micro-organisms for purification of water, retention and putrefaction of organic matter. A mixture of air, minerals, water, rock, microorganisms (protozoa, bacteria, fungi and worms and insects are vital for the wellbeing of soil. This cycle nourishes and helps keep the soil fertile.

There is virtually no where on the surface of the earth where radiations are not present, the soil inclusive. This results in the amount of radionuclides that form major part of the soil. Three ways in which Radionuclides become part of the soil are as seen in primodial radionuclides, cosmogenic radionuclides and man-made radionuclides and activities [1]. Soil macronutrients necessary for growth of crops are potassium K, magnesium Mg, phosphorus P, sulfur S and Nitrogen N. The storage capacity of the soil is vital when it comes to macronutrients.Trace elements are vital for healthy growth though needed by plants and animals in minute quantities. Trace elements of significance in agriculture consist of Boron, Iodine, Molybdenum, Cobalt, Iron, Selenium, Copper, Manganese and Zinc [2].

Interaction between diverse trace elements especially copper and manganese and prion proteins of sheep and goats is responsible for the disease condition known as Scrapie. It is a fatal transmissible spongiform (TSE) which converts the original prion proteins to its pathological form. Thus the level of trace elements in soils can be risk factors for TSEs. To further confirm this proposition, the amount of trace elements in the soil on farms with Scrapie and that without were evaluated alongside those containing higher and lower infection rates. Trace elements leves were sourced from the UKs National Soil

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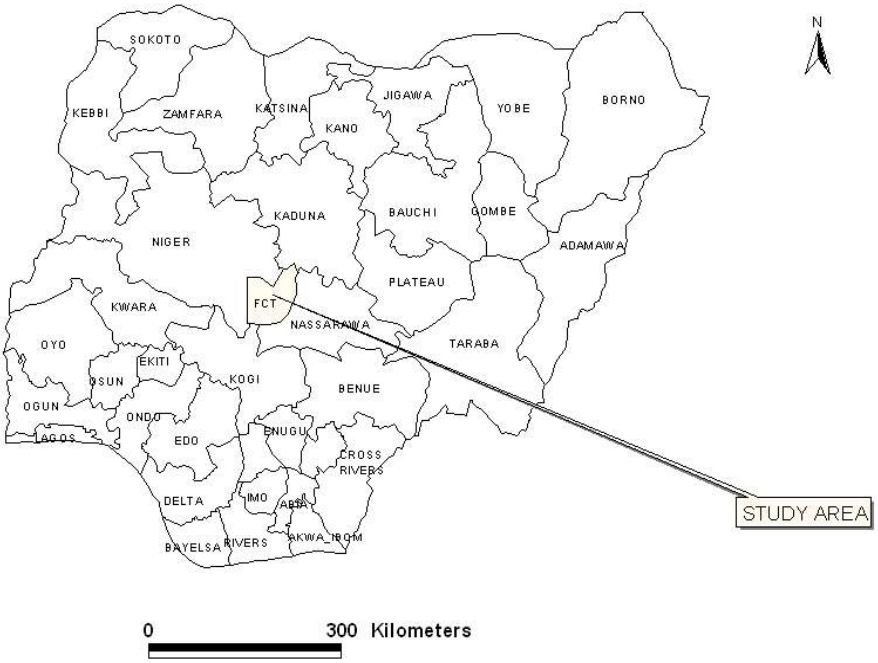

Fig. 1: Map of Nigeria showing the study area

Inventory and deficiencies reported by farmers. The outcome if the experiments proved that on farms, trace elements are risk factors for scrapie also that on regional scale the quantity of trace elements in soils is not responsible for scrapie occurrence [3].

In developing countries, the level of trace elements found in sites of electronic wastes (e-waste) recycling and disposal poses great threats to the environment and associated human health [4]. In order to appreciate the contamination level and condition, an experiment was carried out which entailed calculating the amount of trace elements in the soil, air dust and human hair amassed from e-waste recycling sites (a recycling plant and a garden recycling piece) and the reference sites in Bangalore and Chennai in India. From the result of the research carried out, it was observed that concentrations of Cu, Zn, Ag, Cd, In, Sn, Sb, Hg, Pd and Bi were higher in soil from e-waste recycling sites compared to the reference sites. The amount of Cu, Sb, Hg and Pb surpassed that stipulated by US Environmental protection agency (EPA) for some soils form e-waste sites. In the air from the e-waste recycling facility Cr, Mn, Co, Cu, In, Sn, Sb, Tl, Pb and Bi exceeded those in Chennai city. In the hair of male workers from from e-waste recycling sites, high concentrations of Cu, Mo, Ag, Cd, In, Sb, Tl and Pb were detected. The overall outcome of this experiment implies that e-waste re-cycling and its disposal could result in pollution the environment and human by some TEs, this being the premier research on TE infection at e-waste recycling sites in Banglore, India [4].

The primary objective of this work is to determine and identify the various major, minor and trace elements such as Na, K, Sc, Ti, Ga, Co, Rb, Sr, Zr, Lu, tm, Yb, Th, Gd, Eu, U, Cl, Al, Ti, Sm, Nd, Dy, Ir, Ag, Sb, La, Ba, Ce, Mo and Ho present in the rock / soil samples of Abuja metropolis. The concentrations will also be determined. Their effect on the environment such as people, animals and atmosphere will be discussed. The instrumental neutron activation analysis techniques will be employed.

Neutron Activation Technique is simply a multi element method for the trace element determinations (0.01%) even though minor and major elements may be determined some applications. G. Hevesy and Levi, developed the Analysis as far back as 1936 strictly for the analysis of Dy using isotopic source, but it did not become a practical method of analysis until the development of the nuclear reactor. Neutron Activation Technique guarantees high standard of sensitivity in detecting major components of substances even as far as determining the trace elements present in a sample of water, sand, leaf, ceramic, etc. The speed at which this occurs is also an added advantage. Currently it has become easily accessible by virtue of advanced technological developments of portable and affordable

nuclear generators. The machinery entails pneumatic systems, which conveys sample from the site of irradiation to the laboratory; it also provides radiochemical modes of separation and entirely instrumental methods. The latter makes it easy to detect an element without chemical separations even at the extreme high speeds.

The sample is exposed to a flux of activating particles such as neutrons. The emitted gamma radiation after an (n, Y) - nuclear reactions is then detected and analysed as signatures of the various elements present in the sample. Neutrons are preferred for the activation process due to the fact that most substances have high cross sections for neutrons. Gamma and other charged particles activation may be carried out in the absence of neutrons reaction or when the intensity of neutrons is very low.

The intensity of radiation from radionuclide produced by activation in the reactor is directly proportional to the quantity of resultant element present in the sample. When sample is irradiated, a range of radionuclide is produced and these need to be sorted out so that the sum of constituent elements present can be determined. This process will involve the use of standard samples with known concentrations of the analyte. Activation techniques are also carried out using the disparity in the physical properties of the constituent radionuclides such as half-life, energy and radiation type. Neutron Activation analysis could be carried out destructively on non-destructively [5].

The Instrumental Neutron Activation Analysis (INAA) technique has been widely employed for the determination of major, minor and trace elements in clays, pottery and other ceramics [6,7]. Oladipo [6] was able to identify quantitatively 22 element concentrations: Na, Mg, Al, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Rb, La, Ce, Sm, Eu, Dy, Hf, Ba, Th and U in the clays gathered from diverse lignite associated clay beds. The samples were of similar geological origin; however, have been obtained from different lignite associated clay beds. An appropriate algorithm was devised to classify the samples and the analysis proves the fact that NAA is competent in establishing noteworthy outcomes.

NAA of minor elements is an appropriate technique for the analysis of geological samples of diverse matrices. [8] Much research has been carried out on the ability of NAA to detect tiny differences in the make-up of clays having same geological origin. Oladipo's work used a 200g sample, irradiated in a reactor at a thermal neutron flux of 2 x 10^{12} ncm^{-2} s^{-1}; alongside suitable standards.

MATERIALS AND METHOD

Sample Collection: First of all different samples of Rocks and Soils were collected from different part of Abuja Metropolis such as Karu, Airport, Airport Road and Aso Radio (Katankpe Hills). Next, these samples were sent to the National Development and Metallurgical Centre (NDMC) Jos where they crushed to tiny bits. They were sent to Centre for Energy and Research Training (CERT) Zaria for analysis. The sample locations were recorded with a GPS (Global Positioning System). Topographical map of the entire study area was not available so NigeraSat-1 image of the study area was processed and the locations plotted on it in the laboratory of the National Centre for Remote Sensing, Jos, Nigeria (Fig. 2).

Quality Control: High standard of purity was taken to eliminate sample contamination. This includes the method of packaging, storage and conveyance used. It is important that the samples prepared are in powdery format so as to enable sufficient area exposure to the nuclear reactor. It could be done locally but most efficiently industrial from research centres such as NMDC Jos. The devices were fed into a machine that crushed it to powder and flakes. The powders were of the order of a few microns. The specification of the powered soil/rock sample is of the order of -35µm. This implies that after it was grinded, it was then filtered through a sieve having holes of the order of 0.035 meshes. Specification of Rock/ Soil sample powder range from -35µm or 0.035 mesh to +1mm.

Sample Preparation: This consists primarily of weighing and packaging. Any chemical treatment, which could lead to the contamination of sample by impurities from the reagents, is completely avoided as well as the surface of solid samples, cleaned to get rid of surface impurities.

The sample aliquots of the standard approximately 200 - 250 mg were weighed and wrapped in polyethylene films. The polyethylene films and rabbit capsules were cleaned by soaking in 1:1 HNO3 (nitric acid) for 3 days and washed with de-ionised water. Next, blank concentrations of all the elements of interest were investigated and using the adopted procedures and were found to be less than limits of detection [9]. The polyethylene films and rabbit capsules were soaked in 1:1 HNO3 to eliminate every contamination prior to sample irradiation.

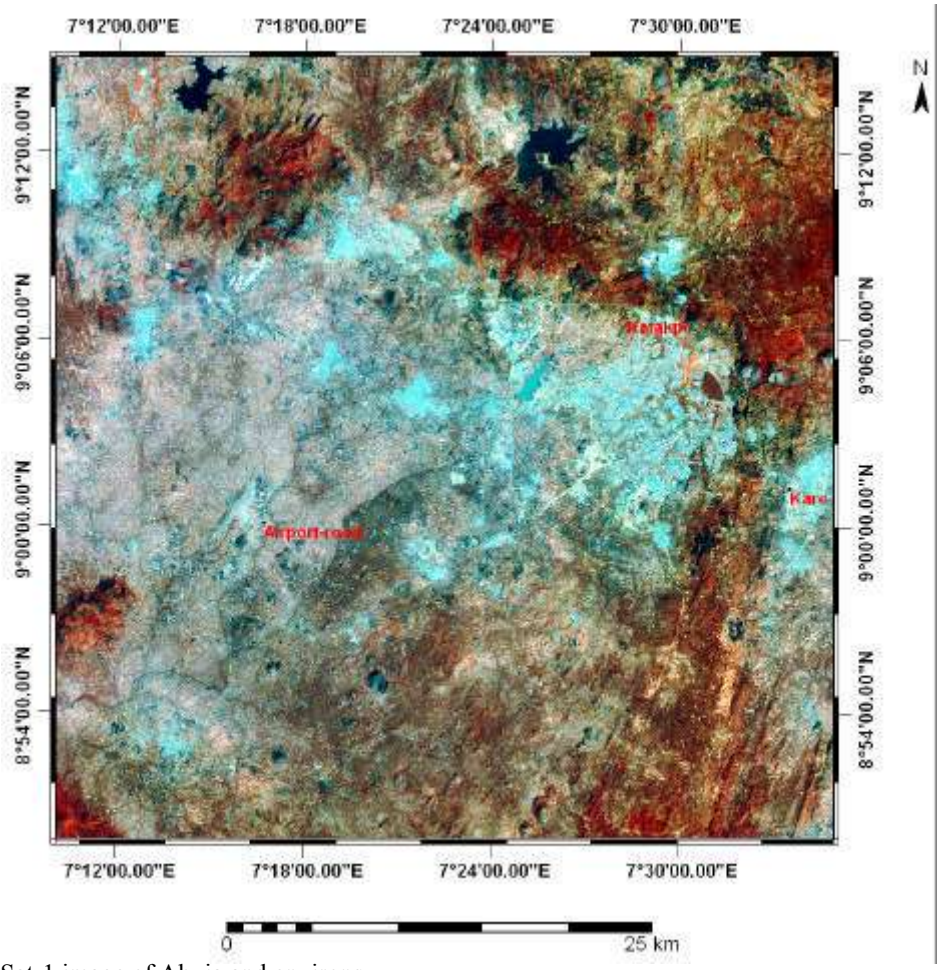

Fig. 2: NigeriaSat-1 image of Abuja and environs

Sample Analysis: In short irradiation, each of the samples were parceled, sealed in 7cm3 rabbit capsules and sent for irradiation one after the other in one of the outer irradiation channels. The neutron spectrum in the outer channel B is soft having a flux of 2.5 x 10^{1} n/cm^{2} s and irradiation period of 600s. The outer irradiation channel was chosen so as to eradicate corrections, which arise from nuclear interferences caused by threshold reactions notably Mg in the presence of Al; Al in the presence of Si; and Na in the presence of P. All these are as a result of the closeness of the inner channels of the MNS reactors to the core leading to the relatively higher ratio of fast to thermal neutrons.

The long irradiation entailed wrapping samples in polyethylene films and stack packing each inside the 7cm3 rabbit capsule and heat-sealed for irradiation. The samples are irradiated for 6hours in any of the small inner irradiation channels, which are A1, B1, B2 and B3. This enables exposure to the maximum value of thermal neutron flux of 5 x 10^{11}n/cm^{2}s. The flux is kept constant by monitoring the neutron flux reading from of a fission chamber connected to the microcomputer-controlled room. After the samples have been irradiated they are retrieved via the same pneumatic transfer of the rabbit to the control chamber where they are collected and kept in a glass chamber.

Measurement of Gamma Rays: After the short irradiation, there is a waiting time of 2 to 15 minutes, followed by the first bit of counting which was carried out for ten minutes. The samples are placed on a plexi-glass sample holder designated H2 which refers to the source detector geometry of 5cm. This is depicted as S1. The second lap of counting was also carried out for 10 minutes after irradiation and depicted as S2. The waiting period in this case is as long as 3-4 hours. Samples are counted on a plexi-glass plated denoted H1 which refers to a source detector geometry of 1cm.

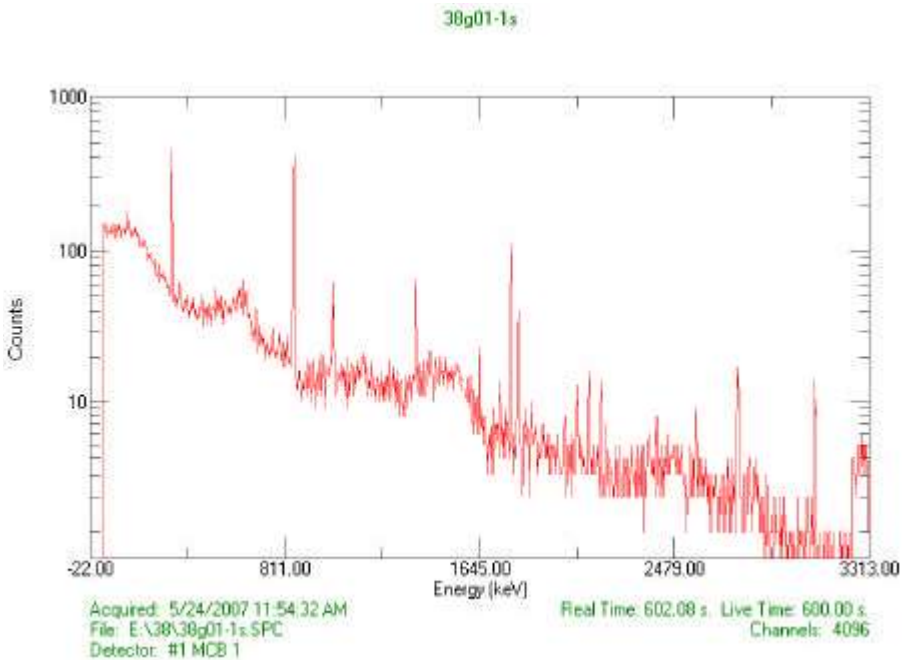

Fig. 3: 1st Irradiation

For long irradiation, the first lap of counting was carried out after a waiting period of 4-5 days for duration of 30minutes. This Long irradiation is termed L1 and is carried out using the H1 holder. The second lap of counting is carried out after a cooling period of 10-15 days for duration of 60minutes. This termed as L2 and samples counted using plexi glass holder H1.

With the aid of gamma ray spectrum software known as WINSPAN 2004, the gamma rays of product radionuclides can be identified by their energies, as well as quantitative analysis of their concentrations are obtained.

The spectrums have been acquired by virtue of the MAESTRO soft ware (Multi channel analyser). Found below is a diagram of the energy spectrum of few of the samples depicting different energy levels as displayed by the PC using the WINSPAN Software.

Radiation Protections and Management of Irradiated Samples: Safety taken into account while conducting the analysis is that of the personnel and disposal of the irradiated sample after counting is completed. There are warning light signals that automatically comes on whenever the reactor is operation or turned on. There are also the safety precautions taken by the scientists and engineers by wearing Lab coats, compulsory and strict restriction of pregnant women into the vicinity.

Approximately 250mg of the powdered sample is wrapped in polyethylene sheet and further encapsulated in a polyethylene vile and via pneumatic transfer system; it is placed inside the reactor. The operator stays in the fission chamber connected to the microcomputer-controlled room throughout the irradiation process where he operates the reactor thus shielding him from possible radiations. After irradiation, the irradiated samples and standards are retrieved via same pneumatic transfer thereby ensuring safety of personnel carrying out the analysis. Gamma dosimeters are worn to ensure monitoring of the gamma dose induced in the sample. The sample vial is only opened after dose is below $30\mu Svhr^{-1}$ and gamma–ray counting is performed. This is considered safe value. After the analysis is completed, the irradiated samples and standards are packed together in polyethylene sheets and put in a lead container for disposal.

Plots of Locations on Geological Map: The sample locations that were determined by the use of a GPS were plotted on the geological map of the study area (Fig. 4) and it was observed that the airport road sample is underlain by undifferentiated granite, migmatite and granite gneiss. The sample in Katakpe area is underlain by Migmatite and the Karo area is underlain by slate,phylite and metasiltstone. These rocks form part of the Basement

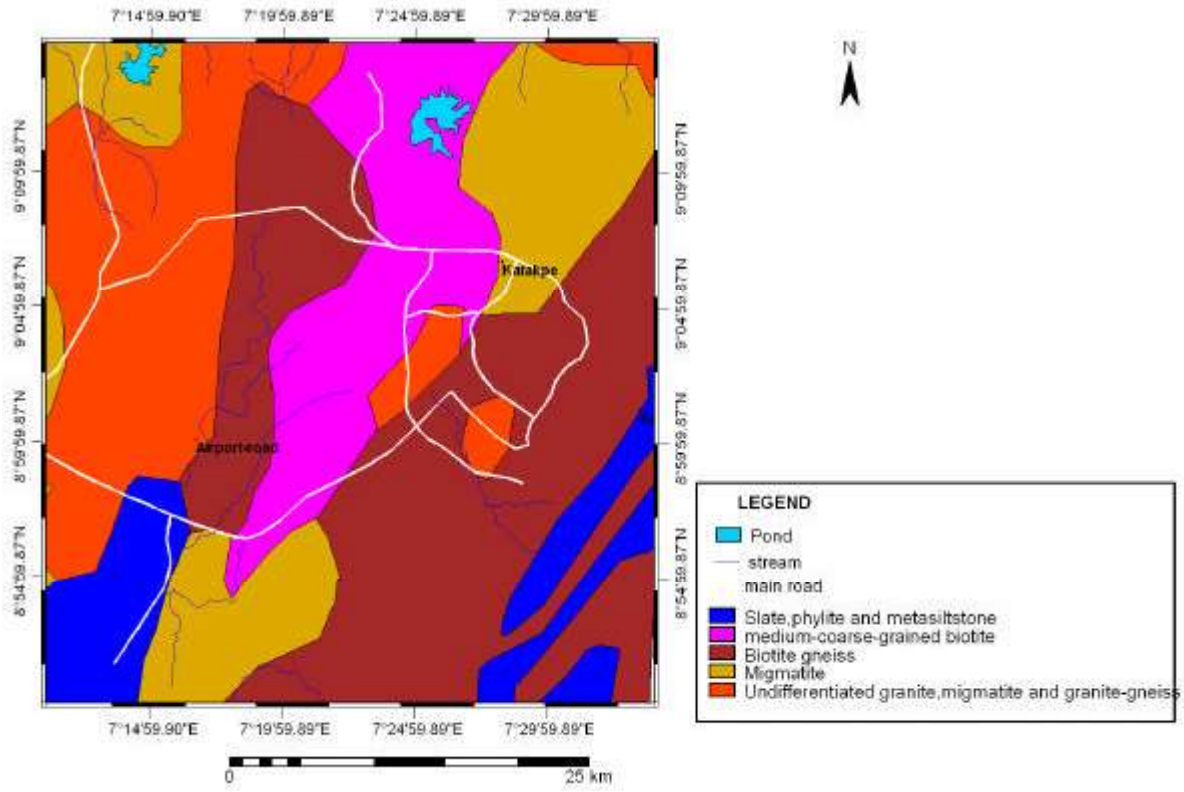

Fig. 4: Plots of locations on geological map of Abuja and environs

Complex of Nigeria. They are of Precambrian age and have been intruded by a series of granitic rocks of late Precambrian to lower Paleozoic age. These rocks have been variably metamorphosed and granitised through at least two tectono-metamorphic cycles so that they have been largely converted to migmatites and granite-gneiss. Migmatites form under extreme temperature conditions during prograde metamorphism, where partial melting occurs in pre-existing rocks. Migmatites are not crystallized from a totally molten material and are not generally the result of solid-state reactions. Migmatites are composed of a *leucosome*, new material crystallized from incipient melting and a *mesosome*, old material that resisted melting. Commonly, migmatites occur within extremely deformed rocks that represent the base of eroded mountain chains, typically within Precambrian cratonic blocks.

Migmatites often appear as tightly, incoherently folded (ptygmatic folds) dikelets, veins and segregations of light colored granitic composition called *leucosome*, within dark colored amphibole and biotite rich material called the melanosome. The light colored material has the appearance of having been *mobilized* or molten. Once enough leucosomes join up to form a network and granite is produced, the residual material is known as restite.

Gneiss is a common and widely distributed type of rock formed by high-grade regional metamorphic processes from pre-existing formations that were originally either igneous or sedimentary rocks. Gneissic rocks are usually medium to coarse foliated and largely recrystallized but do not carry large quantities of micas, chlorite or other platy minerals. Gneisses that are metamorphosed igneous rocks or their equivalent are termed granite gneisses, diorite gneisses, etc. However, depending on their composition, they may also be called garnet gneiss, biotite gneiss, albite gneiss, etc. *Orthogneiss* designates a gneiss derived from an igneous rock and *paragneiss* is one from a sedimentary rock.

RESULTS AND DATA ANALYSIS

Twenty-seven (27) elements were analysed for Karu Soil. The Table 1 shows that six elements are present as major elements. These include Al, Ti, Ca, K, Na and Fe. Mg, which constitutes a major element in soils,

Table 1: Concentrations of elements for Karu Soil, Aso Radio Soil, Airport Soil, Airport Road Soil

	Concentrations			
Elements	Karu Soil	Aso Radio Soil	Airport Soil	Airport Road Soil
Al (%)	0.3972±0.004	0.586±0.007	0.5195±0.006	BDL
Ti (ppm)	9821±756.22	5971±770.26	9160±714.48	8917±695.53
Ca (%)	0.077±0.014	0.084±0.014	BDL	BDL
Mg (ppm)	BDL	BDL	BDL	7957.0±2220.0
K (%)	0.1937±0.004	0.6196±0.076	0.25±0.005	0.211±0.003
Na (ppm)	2633±13.17	0.1628±0.001	4710±23.55	1652±9.91
V (ppm)	42.78±4.28	27.55±4.22	67.13±5.24	BDL
Mn (ppm)	615.3±3.70	526.1±3.68	571.1±3.43	334.8±2.68
Dy (ppm)	BDL	3.472±0.42	3.159±0.37	BDL
Sc (ppm)	14.39±0.63	18.18±0.49	12.09±0.90	19.00±0.61
Zn (ppm)	144.2±25.52	BDL	BDL	BDL
La (ppm)	63.90±0.58	BDL	BDL	98.99±0.89
Sm (ppm)	10.18±0.45	BDL	BDL	10.63±0.47
Lu (ppm)	BDL	13.39±3.63	BDL	BDL
Co (ppm)	22.56±1.173	BDL	23.40±1.33	19.21±1.71
Ta (ppm)	BDL	BDL	BDL	BDL
Th (ppm)	355.1±8.17	484.5±11.14	350.7±8.77	-
Rb (ppm)	116.9±15.67	180.9±27.50	129.2±20.67	84.22±19.96
Eu (ppm)	BDL	7.686±1.12	BDL	BDL
Ce (ppm)	BDL	BDL	BDL	BDL
Hf (ppm)	BDL	BDL	BDL	BDL
Fe (%)	0.528±0.013	0.6641±0.017	0.4212±0.014	1.31±0.20
Yb (ppm)	BDL	8.376±0.96	BDL	2.48±0.58
Cs (ppm)	BDL	BDL	BDL	BDL
Sb (ppm)	BDL	BDL	BDL	BDL
As (ppm)	BDL	BDL	BDL	4.439±0.32
U (ppm)	18.00±4.90	885.8±38.09	BDL	6.021±0.62
Br (ppm)	-	-	-	BDL
Ba (ppm)	-	-	-	BDL
Pa (ppm)	-	-	-	BDL
Cr (ppm)	-	-	-	BDL

was determined to be below detection limit. However, the Karu soil is enriched in Al, K and Fe. Minor elements detected include Mn, Zn and Th, while two of trace elements Hf and Sb were below detection limit. Rb was present in the Karu soil at trace concentrations. U and Co are also present. Cs however is below detection limit. In all, eleven (11) elements were below detection limit in the Karu soil.

The table also shows that six elements are present as major elements in Aso-Radio soils. These include Al, Ti, Ca, K, Na and Fe. Mg, which constitutes a major element in soils, was determined to be below detection limit. However, the Aso-Radio soil is enriched in Al, K and Fe compared with the other soils. Minor elements detected include Mn and Th, while two of trace elements Hf and Sb detected in the soil were below detection limit. Rb, U and Th were also present in the Aso Radio soil at trace concentrations. Cs and Co were however is below detection limit. In all, eleven (11) elements were below detection limit in the Aso Radio soil.

Thirty-one (31) elements were analysed for Airport Road Soil. Of these seven elements are major elements with K and Fe occurring at percentage level while Ti, Mg and Na are parts per million (ppm) levels and Ca and Al, below detection limit. Minor elements detected include Mn while two of trace elements Hf and Sb detected in the soil were below detection limit. Rb, Co and U were also present in the soil at trace concentrations. Cs was however below detection limit. In all, seventeen (17) elements were below detection limit in the Airport Road soil.

Of the twenty-seven (27) elements analysed for in the Airport Soil, fifteen (Ca, Mg, La, Zn Sm, Lu, Ta, Eu, Ce, Yb, Cs, Sb, As, U and Hf) were below detection limit. The major elements detected include Na, Mn and Ti. While Al, K and Fe occur at percentage levels, the other major elements were generally at ppm level.

DISCUSSIONS

Al, Ca, K and Fe are major elements and thus are present at percentage levels in the Airport soil, Airport road soil, Aso-radio (Katankpe) soil and Karu soil; exception of Airport soil and Airport road soil in which Ca is below detection limit. The latter also has Al below detection limit. Ti, Mg and Na are also major elements present in ppm in the soils, however, Mg is below detection limit for Airport, Aso-radio and Karu soil samples. The fact that Al and Ti elements are present in high amounts in the soil samples, shows the even distribution of these elements in the soil and thus the positive effects on plants nutrients. It is observed from the tabulated results however that the percentage of these elements in a soil type is relatively greater or lesser than the other. This is seen from the quantity of Fe in the soil, being greatest in Airport Road soil compared to the other soils. The percentage of Fe in Airport soil, Aso-radio soil, Karu soil compare with Airport Road soil is seen as follows: Aiport Soil (0.4212±0.014), Aso Radio Soil (0.6641±0.017), Karu soil (0.528±0.013) and Airport Road Soil (1.31±0.20); indicating that soil in that region might favour the growth of particular plants compared with soils from other region; however there is relative distribution in the overall outcome of trace and major elements. Rb is also present in all the soils samples and Uranium which is absent only in Airport Soil. It is observed that the concentrations of magnesium is strangely below detection limit for three of the soil samples (Airport, Aso-radio and Karu), this might not apply to other soils obtained elsewhere as observed from the results of Oladipo. Other elements that enhance the nutritional properties of the soil (since they make very good trace elements) Co and Mn are found in the soil samples, however, Co is lacking in Aso-radio soil.

Airport road soil sample has the highest number of elements below detection limit. It is also the area exposed to wind and close to a running river; it is also situated on a slope. This encourages erosion by wind and water. This is the reason for having most of the elements below detection limit. Most of the elements in soil sample from this soil type cannot be depicted by the sensitivity of the INAA technique. This could be corrected for in RNAA of XFR (X-ray Flourescence). It is observed that some elements Mg, Ti, K, Br, Na and Fe have concentrations. The advantage of these is also seen in importance of major elements such as Ferrite, Manganese and Zinc; that is Mg and Fe will definitely enhance the healthy conditions of the soil and thus favour the growth and development of Crops planted on such soils. Some elements are not available. Most results are not analysed due to the fact that the sample leaked while performing that analysis. Normally the flux is concentrated on a unit area so as to identify the elements and determine their concentration. Now if the boundary of the flux is exceeded it implies boundary not defined, it could lead to an undefined result. In this case the leakage was outside the reactor, most likely due to cooling there could have been a crack on the capsule thus affecting the results.

Oladipo's work used a 200g sample, irradiated in a reactor at a thermal neutron flux of 2 x 10 12 ncm-2 s-1; alongside suitable standards. Three diverse regimes were employed in measurements of the elements:

Short Lived Isotopes (Mg, Al, Ca, Ti, V, Mn, Ba,Eu, U): 10 minute irradiation, thirteen minutes decay and four minute count for sample (2 samples irradiated simultaneously to improve throughout). Comparing his results with this work, it is observed that Mg, Al, Ca, Ti, V, Mn, Eu and U are present in these soil samples. Ba is absent from these samples and found to be below detection limit in Airport Road soil.

Intermediate Lives Isotopes (Na, K, Mn, Dy): ten-minute irradiation, two hour decay and twenty minutes count. Comparing with this analysis, Na, K, Mn and Dy have also been identified.

Long Lived Isotopes (Sc, Cr, Fe, Co, Rb, La, Ce, Sm, Hf): Seven-hour irradiation, ten-day decay and two-hour count. Sc, Fe, Rb, La, Ce, Sm and Hf have been analysed in the four leaf samples as well as the soil. Cr is absent from the soil samples and only below detection limit in Airport road soil. Some challenges encountered include leaking of the Soil sample in the first (long) irradiation implies that the samples went beyond its boundary/ packaging. As a result no elements was identified or analysed by the gamma ray detector. The concentrations of other radionucides were not reflected

because their detection limit is far above that of Instrumental Neutron activation Analysis. Proper packaging and heat-sealing the samples before transferring by pneumatic transfer system into the reactor should be encouraged. Methods of analysis used for specific elements whose detection limit is within range example is Radiochemical Neutron Activation Analysis (RNAA) and XRF (X-ray Fourescence) should be employed.

Summary: The Neutron activation analysis of some soil samples within Abuja Metropolis, have been carried out and the following radionuclides identified as well as their concentrations determined. Twenty-four (24) elements identified are as follows: Al, Ti, Ca, Mg, K, Na, V, Mn, Dy, Sc, Zn, La, Sm, Co, Th, Rb, Ce, Hf, Fe, Yb, As, Eu, Lu and U. Others such as Sb, Cl, Br, Cs, Ta, Eu, Cr, Ba and Pa are below detection limit. Oladipo [6] was able to identify quantitatively 22 element concentrations: Na, Mg, Al, K, Ca, Sc, ti, V, Cr, Mn , Fe, Co, Rb, La, Ce, Sm, Eu, Dy, Hf, Ba, Th and U in clays gathered from diverse lignite associated clay beds. Comparing the results Oladipo obtained and that obtained in this analysis it is observed that Cr and Ba were below detection limit in the soil samples. Silicon, which is a very vital element, is not present in this sample due to the fact that it is activated by fast neutrons and as such is far below the detection limit of the INAA.

CONCLUSION

Non Destructive Neutron Activation Analysis has proved to be an effective method of analysing trace elements in Soils. More importantly is the fact that the basic major elements which is universally present in soil samples are clearly identified in percentage concentrations and ppm; as well as the key elements needed to enhance the elemental properties of soils such as Al, Fe, Zn and Mn are also found in moderate quantities.

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