Evaluation Of Baseline Geochemical Data Of Soils From Zaria By Inaa Using Nigeria Research Reactor-1 (Nirr-1)

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ABSTRACT: Source profile of chemical elements is important for determination of natural baseline and anthropogenic input into soil characteristics. Undisturbed soils from Zaria and environ were analyzed for Al, K, Fe, Mn, Rb, Ta, Br, Sc, Cr, Co, Cs, Ba, La, Dy, Eu and Lu using Instrumental Neutron Activation Analysis (INAA) Technique. Analysis of the data revealed that concentration of these elements increases with depth indicating that natural sources account for the distribution pattern. Specifically, soil in areas underlain by igneous rocks contain higher concentrations of Al and Dy in the 0-15 cm and K, Mn, Rb and La in 15-30 cm depth than soil in areas underlain by metamorphic rocks. The broad variations in elemental concentration in the Zaria soil is attributed to differences in parent rock chemistry and constituent minerals, local variations in Eh-pH conditions of the environment and continued alterations by other soil forming factors.

Keywords: Source profile, INAA, soil forming factor, bio-accumulative toxic pollutants, geochemical baseline data

1. INTRODUCTION

Weathering of rocks is a complex series of physical processes and chemical reactions that convert various parent minerals to more stable mineral forms. It is a major soil forming factor which allows redistribution (enrichment or dispersion) of chemical elements from geologically disparate areas [1]. Depending on the impact of land use, human induced activities are also considered a factor of soil formation [2]. In the recent time, concern engendered by the possibility of detrimental effects on the health of humans, animals and vegetation due to chemicals in the environment has been growing. Economic and population growth are increasing rapidly and are thus exacerbating such problems as land degradation and pollution resulting from uncontrolled, intensive agriculture and over-cropping. These problems have impacts on the chemistry of the soil and the sustainability of its life-support systems. Historically, we depend on the local environment for our food and water supply. There is a general practice to use plants for preparation of herbal medicines for the management and treatment of various ailments. Specifically, *Azadirachta indica* – (Bedi), *Acacia nilotica* (Bagaruwa), *khaya senegalensis* (madaci), *parkia clappertoniana* (Dorawa) are harvested by herbalists and researchers for the treatment of malaria, typhoid fever, cough and respiratory diseases respectively. Though metal concentrations in plant vary with plant species, contaminated soil can influence the metal uptake by plants grown on them [3, 4] Local environmental deficiencies in essential trace elements such as iodine and selenium can result in endemic diseases caused by insufficient quantities of such elements in the daily diet. Lack of iodine, for example, causes a host of medical conditions grouped together as iodine deficiency disorders ranging from manifestly obvious goiters to mental retardation and cretinism. Some elements that are essential, such as selenium and molybdenum can also be toxic. These potentially harmful inorganic elements can build up in the food chain to levels that are harmful to ecosystem health and, therefore, are considered to be part of persistent, bio-accumulative and toxic pollutants. Background level coupled with data on plant uptake, toxicity and transport of trace elements in soils are important in making policy decisions regarding the application rates of organic and inorganic fertilizers and pesticide to agricultural and or forested lands. However, there has been no broad base documented baseline data on potentially toxic elements in the soil in Zaria. Most studies on heavy metal and trace element pollution have focused on industrial or agricultural (cultivated) areas. It is expedient to have basic knowledge of background elemental concentrations of soils on which the above mentioned plants are grown. The only way to assess the extent and effect of these problems on a regional scale is to identify changes in the levels of chemical elements in the soil. In order to identify such changes it is essential to have a detailed knowledge of the variations in the present background levels of constituent elements. The present work, therefore, is devoted to determination of the source profiles of undisturbed soil in Zaria. The overall objectives of the study are to prepare database, and to document the concentration and distribution of chemical elements in soil from Zaria. The database can then be used as a geochemical baseline against which future human-induced or natural changes to chemistry of the land surface may be recognized and measured.

2. MATERIAL AND METHODS

A number of analytical techniques such as atomic absorption spectroscopic technique, X-ray fluorescence spectrometry and neutron activation analysis are often employed in the analysis of soil samples. Instrumental neutron activation analysis (INAA) offers sensitivities that are superior to those attainable by these other methods, on the order of parts per million or better. For this work, Instrumental Neutron Activation Analysis (INAA) was employed in view of its sensitivity, relative simplicity, inherent selectivity, precision and accuracy amongst other merits.

2.1 Sampling and Sample Preparation

Undisturbed soil samples were collected from six different locations namely Bassawa, Kufena, Tsibiri, Palladan, Kamphaghi and Kudingi. The choice of sampling location was predicated on the geology and the need to ensure that the samples were collected at the sites underlain by map-able major rock units. At each location, three sampling sites were selected. Soil samples were collected at depths of 0-15 cm and 15-30 cm from the surface using soil auger and plastic trowel. The samples collected at same depth interval from the same sampling location were then combined together to obtain sub-composite samples and stored in clean polyethylene bags. The sub-composite samples from same depth interval at each sampling site were subsequently mixed together to obtain composite sample and systematically labeled to reflect the sampling location and depth. For example, composite sample collected from Bassawa sampling location at the depth of 0-15 cm was labeled BS-15. Further details on the soil samples are provided in Table 1.

Table 1: Soil sampling location and underlying parent materials

Sample Identification	Underlying Rock	Sampling Sites Co-ordinates	Sampling Depth (cm)	Sampling Location
PD-15	Older granite	N11^o 8.609'	0-15	Palladan
PD-30	Older granite	E007^{o}41.006' E1ev. 674 m	15-30	Palladan
KF-15	Older granite	N11^{o}8. 613' E7^{o}40.993'	0-15	Kufena
KF-30	Older granite	Elev. 673 m	15-30	Kufena
TS-15	Undifferentiated Schist with subordinate Amphibolites	N11^{o}9.907 ' E7^{o}40.843'	0-15	Tsibiri
TS-30	Undifferentiated Schist with subordinate Amphibolites	Elev. 655 m	15-30	Tsibiri
BS-15	Laterite	N11^{o}5. 015' E7^{o}39.071'	0-15	Bassawa
BS-30	Laterite	Elev. 676 m	15-30	Bassawa
KD-15	Biotite Gneiss	N11^{o}5. 131' E7^{o}39.071'	0-15	Kudingi
KD-30	Biotite Gneiss	Elev. 686 m	15-30	Kudingi
KP-15	Laterite	N11^{o}10.395' E007^{o}36.860'	0-15	Kamphaghi
KP-30	Laterite	Elev. 702 m	15-30	Kamphaghi

The soil samples were air-dried in a dust free environment for 7days. Each of the 36 composite samples was spread on a tray and subjected to repeated coning and quartering process to obtain laboratory sample, which to a reasonable extent is representative of the composite sample. A portion of the laboratory sample was then ground to finer particles using agate mortar and pestle and thereafter passed through stainless steel sieve with an aperture of 75 µm and labeled accordingly. The agate mortar and pestle were always washed, dried and cleaned with de-ionized water and Acetone before a new sample was pulverized in order to avoid inter-sample (cross) contamination. Approximately 240 mg of each -75 µm particle size fraction was weighed into polyethylene sachet and sealed for subsequent irradiation with thermal neutrons from Nigeria Research Reactor-1 (NIRR-1). A certified reference material (Soil-7) was also prepared in the same way as the soil samples for the purpose of quality control.

2.2 Sample Irradiation

The soil samples and certified reference material were irradiated using the NIRR-1 facility located at the Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria. The reactor was operated at its peak power of 31 kW corresponding to a thermal neutron flux of 1×10^{12} n cm^{-2} s^{-1} in the inner channel. Two irradiation schemes were adopted based on half-life of product nuclide. For elements with short-lived activation products, the samples were irradiated in an outer irradiation channel 'B4' where the neutron spectrum is 'soft' while for elements with long-lived activation products, the samples were irradiated in an inner irradiation channel 'B3' where the thermal neutron flux is maximum. This is to take advantage of the maximum value of thermal neutron flux in the inner channel.

2.3 Spectral Acquisition and Analysis

Measurement of induced radioactivity was performed using PC-based gamma-ray spectrometry according to the procedure developed by [5]. The multi-purpose gamma-ray analysis software WinSPAN [6] was used for peak identification and quantitative evaluation. The certified reference material, Soil-7 which was treated under similar condition as the unknown samples was used for quality control material to validate the result. Nuclear parameters of the radionuclides of interest to this work along with necessary experimental conditions are provided in Table 2 below.

Table 2: Nuclear parameters of the radionuclides of interest along with necessary experimental conditions

Element	Radionuclides	Half=life	Gamma[7] Line (keV)	Conditions
Al	^{28}Al	2.23m	1778.8	A
As	^{76}As	26.3h	559.1	c, d
Ba	^{131}Ba	11.7d	496	D
Ca	^{49}Ca	8.72m	3084	A
Co	^{60}Co	5.27y	1173, 1332	D
Cr	^{51}Cr	27.7d	320	D
Cs	^{134}Cs	2.06y	604, 796	D
Dy	^{165}Dy	2.35h	94.7	B
Eu	^{152}Eu	12.4y	121.8, 1407.9	D
Fe	^{59}Fe	44.6d	1099. 1291.6	D
Hf	^{181}Hf	42.4d	482	D
K	^{42}K	12.36h	1524.7	b, c
La	^{140}La	40.23h	487.6, 1596	c,d
Mg	^{27}Mg	9.5m	1014	A
Mn	^{56}Mn	2.582h	846.6, 1811	C
Na	^{24}Na	15.03h	1368, 2754	B
Rb	^{86}Rb	18.65d	1076.6	D
Sb	^{122}Sb	2.72d	564	c, d
Sc	^{46}Sc	83.8d	889, 1120	d
Sm	^{153}Sm	46.5h	103	d
Ta	^{182}Ta	115d	1221	d
Th	^{233}Pa	27.0d	311.9	d
Ti	^{51}Ti	5.76m	320	a
U	^{239}Np	2.35d	106, 277.6	c
V	^{52}V	3.76m	1434	a

a = (tirr = 1min, tdecay =<5% dead time, tcount = 10min, geometry = 5cm)
b = (tirr= 1min, tdecay = 120-180 min, tcount = 10 min, geometry = 1 cm)
c = (tirr= 6h, tdecay=3-4d, tcount = 30 min, geometry = 5 cm)
d= (tirr= 6 h, tdecay =9-10 d, tcount= 1h, geometry = 1 cm)

3   RESULTS AND DISCUSSION

Concentration of sixteen (16) elements, namely Al, Mn, K, Fe, Dy, Br, La, Sc, Cr, Co, Rb, Cs, Ba, Eu, Lu, and Sb in Zaria soils was determined by INAA. The analytical data are presented as mean values with the absolute standard deviations in Table 3. The reliability of the analytical results was checked using IAEA Soil-7 reference materials. The analytical data reveal that while most elements in the soil samples from the six locations have similar values, certain elements are present in high concentration in soil underlain by specific rock type. For example, soil samples collected at 0-15 cm from site underlain by older granite and biotite gneiss (Site-A) contain Al and Dy at much lower level than soil samples collected from the site underlain by undifferentiated Schist with subordinate Amphibolites and Younger Laterite (Site-B).

Table 3: Major, Minor and trace element concentration in Zaria soils (values are in ppm)

Element	PD-15	PD-30	KF-15	KF-30	KD-15	KD-30
A l	4.12 ± 0.05	5.26 ± 0.05	6.97 ± 0.07	BDL	BDL	BDL
Mn(ppm)	347.20 ± 3.47	284.8 ± 2.85	483.1 ± 3.86	354.70 ± 0.31	218.90±1.97	241.20±2.17
K	3.37± 0.41	4.24 ± 0.44	2.66 ± 0.47	3.16 ± 0.14	4.30 ± 0.40	BDL
Fe	1.84±0.12	2.52 ± 0.14	2.15 ± 0.13	2.39 ± 0.13	2.30 ± 0.10	2.8 ± 0.20
Dy	4.30 ± 0.71	BDL	10.11 ± 1.07	BDL	BDL	BDL
As	BDL	BDL	BDL	BDL	BDL	BDL
Br	BDL	BDL	2.3 ± 0.53	BDL	BDL	2.6 ± 0.60
La	44.53 ± 2.94	149.90 ± 9.74	46.24 ± 3.05	168.90 ± 10.97	93.00 ± 5.00	114 ± 7.00
Sc	3.91 ± 0.21	5.82 ± 0.30	5.07 ± 0.26	4.99 ± 0.25	4.70 ± 0.20	4.9 ± 0.30
Cr	14.40 ± 3.21	36.16 ± 5.50	19.38 ± 3.37	29.61 ± 4.65	37.7 ± 5.40	36.0 ± 6.00
Co	4.51 ± 0.83	6.82 ± 1.29	6.58 ± 0.80	5.20 ± 1.18	6.20 ± 0.80	5.8 ± 0.60
Zn	39.85 ± 9.01	51.60 ± 12.64	BDL	BDL	91.00±11.00	52.0 ± 7.00
Rb	135.70 ± 19.13	299.90 ±26.40	141.8 ± 17.29	269.90 ± 21.32	BDL	363 ± 26.00
Cs	1.96 ± 0.53	4.89 ± 0.74	BDL	4.13 ± 0.71	5.50 ± 0.70	6.5 ± 0.80
Ba	875.8 ± 112.10	899.6 ± 108.85	899.6± 105.25	845.5 ± 107.38	606.00 ± 70	521 ± 81.00
Eu	BDL	2.52 ± 0.38	BDL	1.58 ± 0.44	BDL	1.7 ± 0.30
Lu	BDL	BDL	BDL	BDL	0.76 ± 0.14	0.7 ± 0.10
Sb	0.60 ± 0.12	0.65 ± 0.19	BDL	BDL	BDL	BDL

Table 3: *Contd.*

| Element	KP-15	KP-30	BS-15	BS-30	TS-15	TS-30
A l	BDL	3.78 ± 0.07	BDL	BDL	BDL	BDL
Mn(ppm)	180.1± 1.80	1167.1±1.84	177.0±1.95	147.9±1.63	218.7±2.62	213.4±2.13
K	NA	0.82 ±0.05	1.58 ± 0.99	1.49±942.48	3.90 ± 0.40	2.78 ± 0.23
Fe	4.1 ± 0.20	4.1 ± 0.20	2.85 ± 0.15	3.50 ± 0.19	1.89 ± 0.11	1.69 ± 0.15
Dy	BDL	BDL	BDL	BDL	BDL	BDL
Br	BDL	1.4 ± 0.20	2.71 ± 0.28	1.98 ± 0.30	BDL	BDL
La	NA	59.0 ± 4.00	56.69± 3.68	58.30± 3.79	1.83 ± 0.41	37.82 ± 2.46
Sc	11.70± 0.60	11.2 ± 0.60	7.92 ± 0.40	11.12± 0.56	6.79 ± 0.34	7.47 ± 0.37
Cr	51.0 ± 7.00	47.0 ± 7.00	63.24± 8.79	43.49± 6.26	21.54± 3.73	27.22 ± 4.16
Rb	68.0 ± 18.00	63.0 ± 15.00	133.9±14.99	125.7±16.47	242.8±20.15	205.9±23.68
Cs	4.2 ± 0.70	3.2 ± 0.60	4.52 ± 0.69	5.87 ± 0.75	4.35 ± 0.75	6.13 ± 0.71
Ba	244 ± 62.00	BDL	527.7±88.65	364.8±76.97	599.1±82.67	493 ± 76.91
Eu	1.8 ± 0.30	1.5 ± 0.40	1.29 ± 0.24	BDL	BDL	1.48 ± 0.38
Lu	0.8 ± 0.10	0.8 ± 0.20	BDL	BDL	BDL	BDL
Sb	BDL	BDL	BDL	BDL	BDL	BDL
Th	27.6 ± 3.60	25.4 ± 3.40	20.04±2.91	22.68±3.00	11.95±1.59	16.22±2.14

It could also be observed that soil collected from Site-B are enriched in Sc and Cr relative to those from site-A. In addition, soil samples collected from 15-30 cm depth from Site-A are characterized by higher concentrations of K, La, Rb and Mn than those collected from Site-B while Sc and Co was found to be high in soils collected from the Site-B. The soil underlain by Biotite Gneiss has the highest concentration of K, Rb, and Br as shown in Figure 2, while soils underlain by Older Granite have the highest concentrations of Dy, Eu, Sb, Al and Ba. By contrast, highest values of Sc, Fe, and Cr were obtained in the area underlain by undifferentiated Schist with subordinate Amphibolites. The lowest average concentration of Fe, Eu, La and Cr and highest value of Co were found in the soils underlain by Younger Laterite. The marked difference in the level of elemental concentration between the sites studied is probably due to the differences in the major rock forming minerals constituents of the parent materials from which the soils were formed. However, there is no observable significant difference in the concentration of elements in the soils collected from the same rock type.
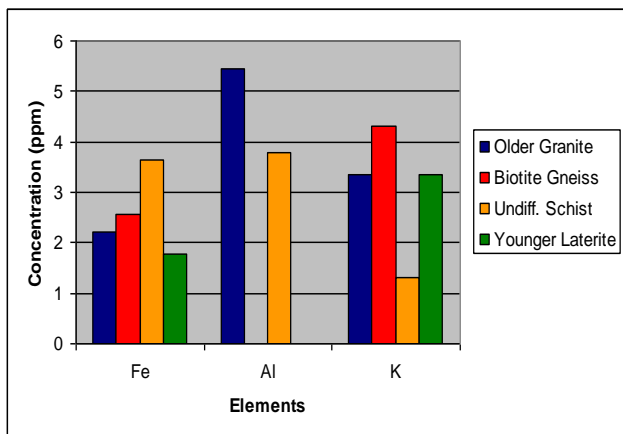
(a)
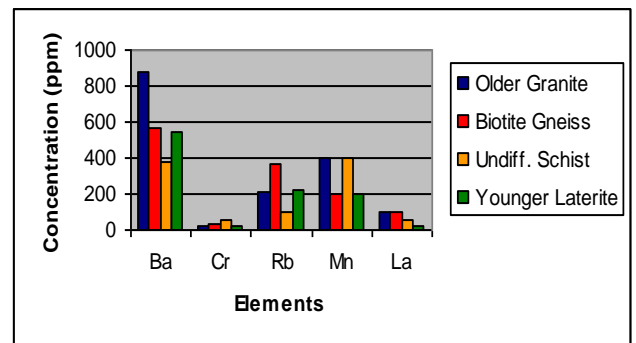
(b)
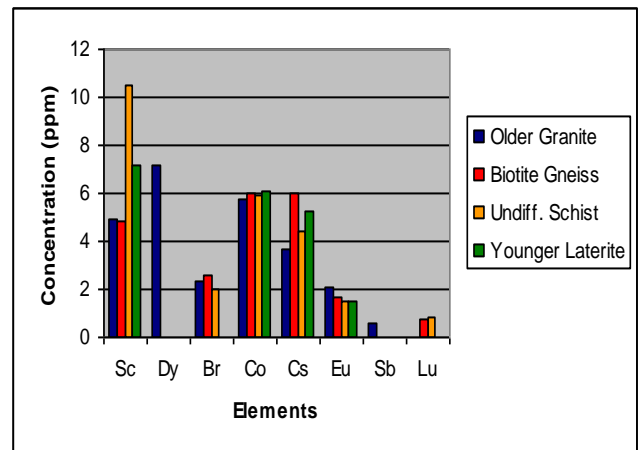
(c)

Figure 2 *(a,b,c): Histogram of mean concentrations of selected major, essential and non-essential trace elements in soils from Zaria*

It has been observed that concentration of elements will decrease with distance from the source [8]. According to [9] and [10] short-range variability in concentration due to

wind and water redistribution are possible in contaminated areas. In the study area, however, the concentration profiles for most of the elements determined increases with depth indicating that natural sources, particularly, parent material accounts for the distribution pattern. Concentration of Cs and La tends to increase with depth which may be due to capillary action of fluctuating water table level [11]. The concentrations of these elements are relatively high in soil sample within 0 – 15 cm from the surface. In samples KP-15 and KP-30, the concentration of Lu, Fe, and Sc was observed to be relatively constant. Similar trends have been observed in the soils supporting medicinal plants in the eastern region of Ghana by [12] and in lake sediments in Laguna Chica de San Pedro by [13]. Estimation of crustal enrichment factor (EF$_{crust}$) has commonly been used as a first step in attempting to evaluate the contribution of crustal and non-crustal sources of trace elements [14]. According to [15] and [16], the crustal enrichment factor is defined as follows:

$$EF_{crust} = \frac{\left(\dfrac{C_E}{C_{Fe}}\right)_{sample}}{\left(\dfrac{C_E}{C_{Fe}}\right)_{crust}} \qquad (1)$$

where

EF_{crust} = crustal enrichment factor.

$\left(\dfrac{C_E}{C_{Fe}}\right)_{sample}$ = ratio of elements and Fe concentration of the sample.

$\left(\dfrac{C_E}{C_{Fe}}\right)_{crust}$ = ratio of elements and Fe concentration of a background.

EF_{crust} value of 0.5 – 1.5 indicates that the elements are entirely from the crustal materials or natural processes whereas EF_{crust} value greater than 1.5 suggests that the source is more likely to be anthropogenic [17]. The crustal enrichment factors (EF_{crust}) of the elements was determined for all the soils samples in the study area using Fe as conservative tracer (Table 4).

Table 4: *Crustal Enrichment Factors (* EF_{crust} *) of the elements in Zaria soil*

Eleme	Al	Mn	Dy	K	Br	La	Sc	Cr	Co	Cs	Ba	Eu	Lu	Sb	Rb
PD-15	1.01	0.97	1.35	2.39	-	1.95	0.54	0.40	0.72	1.40	2.86	-	-	5.77	2.18
PD-30	0.94	0.58	-	2.11	-	4.80	0.59	0.72	0.80	2.55	2.14	2.53	-	4.57	3.51
KF-15	1.47	1.54	2.73	1.55	1.29	1.73	0.60	0.46	0.90	-	2.51	-	-	-	1.94
KF-30	-	0.76	-	1.66	-	5.69	0.53	0.63	0.64	2.27	2.12	1.67	-	-	3.33
KD -15	-	0.49	-	2.35	-	3.26	0.57	0.83	0.79	3.13	1.58	-	1.95	-	-
KD -30	-	0.44	-	-	1.13	3.28	0.44	0.65	0.61	3.04	1.11	1.54	1.48	-	3.80
KP-15	-	2.00	-	-	-	-	0.72	0.63	0.16	1.34	0.36	1.11	1.15	-	0.49
KP-30	0.42	0.00	-	0.25	0.42	1.16	0.69	0.58	0.11	1.02	-	0.92	1.15	-	4.53
BS-15	-	0.32	-	0.70	1.16	1.6	0.70	1.12	0.69	2.07	1.11	1.14	-	-	1.38
BS-30	-	0.22	-	0.53	0.69	1.34	0.80	0.63	0.63	2.20	0.13	-	-	-	0.14
TS-15	-	0.01	-	2.59	-	0.08	0.91	0.58	-	0.68	0.26	-	-	-	0.30
TS-30	-	0.01	-	2.07	-	1.8	1.12	0.82	1.07	4.76	1.75	2.21	-	-	3.59

The analytical data from the present study shows that Al, Mn, Br, Sc, Cr, Co, Ba and Lu were within normal range for tropical soil. Antimony has the highest EF_{crust} with an average value of 5.17 (Table 5). The contrast in the values may be due to the difference in the magnitude of input of each element into the soil and/or the difference in the removal rate from the soil [18].

Table 5: *Mean values of* EF_{crust} *for the elements in Zaria soil*

Element	Mean ± SD	Element	Mean ± SD
Al	0.96±0.43	Co	0.65±0.26
Mn	0.61±0.63	Cs	2.22±0.84
Dy	2.04±0.98	Ba	1.45±0.98
K	1.62±0.84	Eu	1.59±0.59
Br	0.94±0.37	Lu	1.43±0.38
La	2.43±1.74	Sb	5.17±0.85
Sc	0.68±0.14	Rb	2.29±1.58
Cr	0.67±0.19		

Correlation analysis was employed in estimation of the extent to which any two elements are associated or vary together using the approach of the Pearson product- moment correlation coefficient. Correlation matrix for all elements determined is presented in Table 6.

Table 6: Correlation coefficient of major, minor and elements in Zaria soils

Element	Al	K	Mn	Fe	Br	La	Sc	Cr	Co	Rb	Cs	Ba	Eu	Lu	Sb
Al	1.00														
K	0.32	1.00													
Mn	-0.44	-0.49	1.00												
Fe	-0.48	-0.74	0.37	1.00											
Br	1.00	0.60	-0.81	-0.78	1.00										
La	0.04	0.27	-0.05	0.15	0.35	1.00									
Sc	-0.46	-0.80	0.23	0.82	-0.74	-0.32	1.00								
Cr	-0.40	-0.56	0.02	0.74	0.05	0.17	0.64	1.00							
Co	0.25	-0.48	0.26	-0.12	-0.67	-0.18	-0.04	0.06	1.00						
Rb	0.33	0.84	-0.36	-0.50	0.62	0.56	-0.66	-0.32	0.15	1.00					
Cs	0.79	0.08	-0.47	-0.06	0.60	0.17	0.02	0.20	0.34	0.50	1.00				
Ba	0.80	0.51	0.84	-0.65	0.14	0.35	-0.82	-0.62	0.25	0.34	-0.47	1.00			
Eu	1.00	0.77	-0.16	-0.04	-0.09	0.61	-0.23	-0.29	-0.03	0.41	0.08	0.45	1.00		
Lu	-	-1.00	0.45	0.72	-1.00	-0.97	0.84	0.88	-0.26	-1.00	-0.93	-0.65	-0.19	1.00	
Sb	1.00	1.00	-1.00	1.00	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-	1.00

A number of significant inter-element correlations are revealed in the soil samples. All the elements were strongly correlated with Sb ($r^2 = 1.00$) while significant positive correlation also exist between K-Br, K-Rb, K-Eu, Fe-Sc, Fe-Lu, La-Eu, K-Ba, Mn-Ba, Sc-Cr, Sc-Lu, Cr-Lu and Rb-Cs. Al exhibit positive correlation with Br, Cs, Ba, and Eu while negative correlation was observed between the following pairs of elements K-Lu, Mn-Sb, La-Lu, Rb-Lu, Cs-Lu and Ba-Lu at P<0.05 (5% significance level). The implication of these patterns of element association is that formation of complexes by these elements within the soil strata could influence the presence of any given element. A A good correlation between As, Co, Cr, Cu, Ga, Mn, Ni and Se and Al and Fe in surface soils of Poland was found by [12]. The authors concluded that levels of most elements were mainly controlled by minerals present in those soil. F-test, which is also known as variance ratio test was employed in order to check whether there is significance difference between the mean concentration of the elements determined in the soils underlain by different rock types. From the results the P-value is 2.17 which is higher than 0.05. The results show that at 5 % significance level, there is no significant variation in trace elements contents in the soils from all the sampling locations thus suggesting that there was no anthropogenic input to the soil chemistry as of now. The element distribution patterns simply reflect the broad chemistry of the parent materials. Elements were released from rocks into the soil profile through weathering. Since this is a long-term process, obviously elemental concentrations would hardly change provided the concentrations were not influenced by anthropogenic activities. Descriptive statistics of range, arithmetic mean, minimum and maximum concentrations and Max/Min ratio, skewness and kurtosis are summarized in Table 7.

Table 7: Descriptive statistics of some of the constituent elements in soil from Zaria

Element	Range	Minimum	Maximum	Max./Min.	Mean	Skewness	Kurtosis
Al (%)	3.19	3.78	6.97	1.84	5.03	1.02	-0.07
K (%)	3.48	0.82	4.30	5.25	2.83	-0.40	-1.05
Mn (%)	0.10	0.01	0.12	12.00	0.03	2.82	8.59
Fe (%)	2.41	1.69	4.10	2.42	2.68	0.77	-0.53
Dy	5.81	4.30	10.11	2.35	7.21	-	-
Br	1.31	1.40	2.71	1.94	2.20	-0.90	0.04
La	167.07	1.83	168.90	92.29	75.47	0.72	-0.19
Sc	7.79	3.91	11.70	2.99	7.13	0.73	-1.01
Cr	48.84	14.40	63.24	4.39	35.56	0.37	-0.23
Co	5.20	2.30	7.50	3.26	5.89	-1.62	3.05
Rb	300.00	63.00	363.00	5.76	186.33	0.48	-0.79
Cs	4.54	1.96	6.50	3.32	4.66	-0.58	0.26
Ba	655.60	244.00	899.60	3.69	625.10	-0.10	-1.12
Eu	1.23	1.29	2.52	1.95	1.70	1.75	3.71
Lu	0.10	0.70	0.80	1.14	0.77	-1.19	0.44
Sb	0.05	0.60	0.65	1.08	0.63	-	-

The range of the contents of the elements determined in this work shows that Ba, Rb and La have the highest range while Al and Sb have the highest and lowest concentration respectively. Lanthanum presents a high Max/Min ratio (92.29) and this may be related to analytical uncertainties. The rest of the elements show no significant Max/Min ratios thus suggesting that the variation of elemental concentration in soil does not differ substantially from one locality to another; moreover it indicates a regional character. Most of the element shows skewness less than one indicating that the element exhibit normal distribution.

4   CONCLUSION

Major and trace elements constituent and distribution pattern in soil from Zaria and environ have been investigated using instrumental neutron activation analysis (INAA). The elements determined are Al, Ba, Br, Co, Cr, Cs, Dy, Eu, Fe, K, La, Lu, Mn, Rb, Sb and Sc. As expected Al, K, Mn and Fe are present as major constituents while the concentration of Dy, Br, La, Sc, Cr, Rb, Cs, Co, Ba, Eu, Lu and Sb was found to be at a trace level. The crustal enrichment factor (EF_{crust}) computed for the soils suggest that Al, Mn, Br, Sc, Cr, Co, Ba and Lu are not enriched in Zaria soils and are therefore geochemical expression of the bedrock lithology. However, Dy, K, La, Cs, Eu, Sb and Rb are found to have high EF_{crust} and therefore, apart from the parent bedrock materials external natural source such as dust-laden harmattan wind that predominantly affect the study area from November to February year-in year-out could contribute to concentration level of these elements. The descriptive statistics of element data show that Ba, Rb and La have the highest range while Al and Sb have the highest and lowest concentration in all the soil samples. Lanthanum presents a high Max/Min ratio of 92.29 and this value may be related to the analytical uncertainties. The rest of the elements show no significant Max/Min ratios thus indicating that the variation of elemental concentration in the soil do not differ substantially from one locality to another. Most of the elements show skewness less than one indicating normal distribution of the elements.

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