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MULTI ELEMENTAL ANALYSIS OF MINERAL SOIL "EWOA" USED FOR COOKING, CLOTH WASHING, ETC. IN GURAGE ZONE, SHAMENE, ETHIOPIA

T. Tessema Teklemariam[*]

A.K. Chaubey[*]

W. Tsegaye Birhanu[*]

Y.A. Ahmed[**]

M.O.A.Oladipo[*]

ABSTRACT

In Ethiopia, large percentages of the populations are engaged in farming and cattle production. Mineral soils and plants play a vital role in this population to fatten the cattle. The minerals and mineral water were mostly being used as a medicine for the cattle. Particularly in the region called Gurage Zone, Shamene-Agena farmers use a mineral soil called "Ewoa" as a mechanism to keep the flesh that can be produced from the cattle be better quality and produce qualified Milk and Milk products like butter and cheese. There were no available scientific data which gives information about the elemental composition of the mineral-soil "Ewoa". We have used the technique of instrumental neutron activation analysis (INAA) in the inner and outer irradiation channel of Nigeria Research Reactor-1 (NIRR-1), in order to determine the elemental composition of mineral soil obtained from Gurage zone, Shamene, Ethiopia. There were 28 elements identified in all the samples. The elements include Al, Fe, Ca, Ti, Na, Mg, K, Mn, Ba, Zn, V, Rb, Cr, Nd, Co, Hf, Th, Sc, La, Sm, Yb, Dy, Ta, Eu, Cs, Tb and Sb.

Keywords: INAA, Ewoa, minerals, NIRR-1.

[*] Addis Ababa University College of Natural Sciences Department of physics, Ethiopia.

[**] Center for Energy Research and Training, (CERT), ABU, Zaria, Nigeria.

1. Introduction

People living in Ethiopia particularly Gurage zone, Shamene area have been using the mineral soil called “Ewoa" as a free-choice mineral food for their cows, sheep and goats including as a cooking spice for vegetables like cabbage. The animals always go to the soil which contains “Ewoa" unless they are controlled, that means the animal themselves like to eat the soil called “Ewoa" than grazing. The people in the surrounding scatter the mineral soil over a surface of land which contains grass, so that the animals graze it without going to other places. This opens up a lot of grazing possibilities. Whenever there is a place in the field of grazing which contains “Ewoa”, it's amazing that the livestock ate all the grass around it, plus they scratch the surface of the over grazed soil to get a better concentration of the mineral. Finally they dig a hole near the spot (the point where the mineral soil concentrated more) on the ground.

Those animals which eat "Ewoa” able to graze more, look better, the milk and milk products from these animals taste good including the meat produced when the animals slaughtered. The aim of this work is to test this mineral soil using instrumental neutron activation analysis (INAA) to check for the elements present in the mineral soil (Ewoa) qualitatively and quantitatively.

Instrumental Neutron Activation Analysis (INAA) is a relatively straightforward technique for determining elemental abundances in a wide range of materials (Zeev B. Alfassi, 2000). The concentration of an element in the sample is calculated using the following equation (Zeev B. Alfassi, 2000).

$$m_x(unk) = m_x(std)\left(\frac{\left(\frac{n_\gamma}{t_c e^{-\lambda t_d}\left(1-e^{-\lambda t_c}\right)}\right)^{unk}}{\left(\frac{n_\gamma}{t_c e^{-\lambda t_d}\left(1-e^{-\lambda t_c}\right)}\right)^{std}}\right) \quad (1)$$

where: $m_x(unk)$ is the mass of the element of interest in the sample, and m_x (std) is the mass of the element in the standard or comparator both in gram, n_Υ is the count rate, the irradiated sample is measured by a detector for some time (t_c, counting time) starting at (t_d, decay time), the time gap since the end of irradiation (t_i, irradiating time).

In this work INAA is chosen for the elemental analysis of the mineral-soil samples for its multi element analysis characteristic and for its precision over other methods. In this paper, the INAA results are discussed which were achieved on determining the total element contents in the soil samples. Results for Standard reference Material Coal Fly Ash (SRM 1633b) and IAEASOIL -7 which were analyzed in the same manner as the soil-mineral samples for traceability purposes is reported.

2. Method

2.1. Sample Collection: The mineral soil is not everywhere in the region of the research area. It is only found in special places of the surrounding, even not always but during particular season of a year. For this reason the researchers unable to collect sample of the mineral soil directly by digging the ground. A soil sample taken from places those animals over graze where the mineral soil is expected highly concentrated is more of black soil than the gray powder of the mineral soil. For the purpose of getting a better concentrated sample of the mineral soil, samples were collected from three different markets, "Agena”, "Shamene”, and "Bole”. These markets are situated inside the region of the research area.

The samples were dried exposing to dry air at room temperature and powdered to get three samples for irradiation, each from different markets. The three samples were packed in polythene pocket and taken to the minister of agriculture of Ethiopia to obtain permission in order to transport them to Nigeria, Ahmadu Bello University (ABU), Center for Research and Training (CERT), where a reactor and facilities were used to irradiate the samples and count activities. The irradiation facility used at Ahmadu Bello University, CERT is The Nigeria Research Reactor-1 (NIRR-1) which is a pool-type Chinese Miniature Neutron Source Reactor (MNSR) with a nominal thermal power of 31.1 kW, with a maximum thermal neutron flux of 10^{12} neutrons m^{-2} s^{-1}. During this work, the reactor was running at half of its maximum power giving a neutron flux of $5*10^{11}$ $m^{-2}s^{-1}$ in the inner sites of irradiation and a flux of $2.5*10^{11}$ $m^{-2}s^{-1}$ in the outer irradiation sites. Samples were transferred pneumatically in to irradiation site of the reactor and retrieved from the reactor through a rabbit transfer tube with air pressure to the counting laboratory. Samples weighing 150mg - 200mg were irradiated in the system, at one of the irradiation sites. Outer sites were used for short irradiation and the inner sites were used for long irradiation. There were six irradiation sites which were situated around the reactor core one outer channel(B4) for short irradiation, one cadmium channel for Epithermal irradiation (A2), four inner channels used for long irradiations were (A1;B1;B2;B3). In this work irradiation site B4 was used for short irradiation and the cite A1 for long irradiation. Detection of gamma rays is performed using a high purity germanium detector. This is linked via a multichannel analyzer to two desktop computers with specialized software ('MAESTRO' and 'WINSPAN' programs). The irradiations of the mineral soil were in two different techniques on the basis of the half-life of the radionuclide. The first technique is to use a short irradiation (2 min), the second technique is to use a long irradiation (6 h). Multi- elemental standards called coal fly ash and IAEA SOIL – 7 were used for the purpose of quality assurance. Use of multi element standard is the easier way in INAA for the identification of elements contained and calculating the concentration of the elements in the sample (R.A.Nadkarni, etal. 1978). An energy calibration was performed with each batch of samples using two standards which put together in to the detector at the same geometry as the sample's counting geometry. The standards were Cobalt ^{60}Co and cesium ^{137}Cs. They were chosen because they provide known energy along the known energy channel.

2.2. Sample Preparation: The powder forms of the samples brought from Ethiopia were dried crushed with agate mortar to obtain a fine powder of the mineral-soil. The crushed soils were then transferred into an evaporating dish and oven dried at temperature of 100C^0 for 5 hours to allow the moisture in the mineral soil evaporate. Finally The samples were weighed between 150mg - 200mg using a Mettler Toledo balance, model AE 240, and packed in a plastic and put in pre-cleaned air tight polyethylene vials for irradiation in the NAA sample preparation laboratory. With the same procedures standard reference materials coalflyash (SRM 1633b) and SOIL 7, supplied by International Atomic Energy Agency(IAEA), Vienna, Austria, for verification and quality control purpose were prepared for analysis. The analysis of reference materials which has the same matrix with the mineral samples is one of the means by which the accuracy of the results can be assessed (M.O.A. Oladipo etal., 2012). Assessment of the results obtained from the analysis of the reference material(s) using the same technique as used for the unknown samples (being investigated) provide a means of accepting or rejecting the result on element to element basis. In other words, it will give an opportunity to know which element to accept and which are to reject.

3. Experiment

3.1. Nuclear reaction considered during the experiment: The identification of elements and their concentrations involves the detection of gamma energy of an unstable isotope of the element in the sample while it is allowed to decay with its corresponding half life. One of a stable element in a sample swallows neutron performing a well known nuclear reaction (n, ϒ) when a sample containing unknown elements with unknown concentrations is irradiated in nuclear reactor of certain thermal neutron flux. In this work samples were irradiated with thermal neutron flux, this is because the cross section of the capture reaction with thermal neutrons is very high, compared to epithermal and fast neutron capture reaction. So that the probability of an element in the sample to capture thermal neutron is very high. Irradiation of a sample with epithermal neutron flux is suitable for analysis of elements which involve high interferences with other (n, ϒ) reactions. The elemental analysis of samples with thermal neutrons is, straight forward, non destructive, more amenable compared to other systems. Hence it is called a reference method for other techniques (Zeev B. Alfassi, 2000). The method utilizes the interaction between thermal neutron and a nucleus to produce a radioactive nuclide that emits characteristic gamma rays (Eby, N. and Eby, 2008). The detection of the gamma photon emitted leads to identification of the element and determination of its concentration. During calculation of the concentration of an element in the sample in this work, not all of the gamma energies emitted during the decay of radioactive nucleus were considered. The following level schemes give example of the decay scheme of cobalt considered in the elemental analysis of the samples in this experiment.

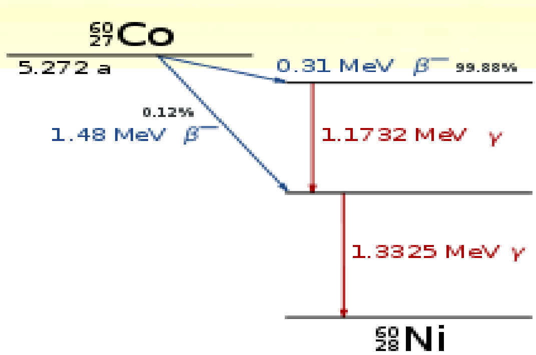

Fig 1: The decay of radioactive cobalt after thermal neutron reaction with stable isotope of cobalt. Taken from (http: //dx.doi.org/10.5772/53686).

The element cobalt (Co) is composed of 1 stable isotope, 28 radioisotopes. When we put the sample in to a flux of thermal neutrons, ^{59}Co captures one thermal neutron and becomes ^{60}Co, which is radioactive and decays by emitting two gamma energies as shown in the level scheme, fig 1 above. For the identification and concentration calculation of cobalt, a gamma with energy 1332.5 Kev only is measured. The gamma energy used in the analysis of an element is the energy which has better abundance and clearly visible independently from other energy peaks of other elements in the spectrum compared to other energies of the element. In the same manner energies and half life of elements used during the analysis in this experiment are given in the table 1 and table 2, as taken from (T. Tessema Teklemariam etal. 2014).

3.2. Irradiation: For short irradiation, each of the samples were sealed in a rabbit capsules together with the standard reference materials and put for irradiation one after the other in one of the outer irradiation sites, B4, where the thermal neutron flux was $2.5*10^{11}$ $m^{-2}s^{-1}$ using pneumatic rubber tube supported by air controlled pressure system for a duration of 120 seconds. 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 irradiation sites of the reactors to the core leading to a relatively higher ratio of fast to thermal neutrons. For long irradiation, samples were heat-sealed in a plastic one by one and put in to polyethylene vial together with standard reference materials for irradiation. The samples are irradiated for 6 hours in one of the inner irradiation channels, A1, where the thermal neutron flux was $5*10^{11}$ $m^{-2}s^{-1}$. This enables exposure to the maximum value of thermal neutron flux which was kept constant by monitoring the neutron flux reading from 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.

3.3. Counting: For the short irradiation regimes, the first round of counting was performed starting from 10-15 minutes after the end of irradiation (time of 2 minutes was irradiation time) depending on whether the activity from the irradiated sample measured by radiation survey meter is reasonably not harmful for the personnel in the counting room. The length of the counting time was 600 seconds. The second round of counting was performed for 10 minutes, starting 3 hrs - 4 hrs from the end of irradiation. Regarding the long irradiation regime, the first round of counting was carried out for 30 minutes after decay time of 4 to 5 days. The second round of long irradiation regime of counting was performed for 60 minutes after cooling time of 7 to 10 days. The choice of the cooling time and sample-detector geometry is such that the detector's dead time is less than 10%.

4. Result and Discussion

With the aid of gamma ray spectrum software known as WINSPAN 2004, the gamma rays of product radio nuclides were identified by their energies, as well as quantitative analysis of their concentrations were obtained using the energy peak information, counting, cooling and irradiating time values including the energy peak efficiency of the detector. The software was developed according to equation (1). The spectrum was directly acquired from the detector by acquisition software MAESTRO. The information was saved in a computer and made to be accessed by another computer with analysis software WINSPAN.

The quality of the analysis is controlled by analyzing the standard reference material coal fly ash (SRM 1633b) and IAEA SOIL-7. If the value analyzed from a sample of reference materials during this work for an element is in a good agreement with the certified value of the element given in the certificate of the reference material we accepted the result obtained from the analysis of the sample containing unknown amount of that element. If the element's concentrations in the certificate and in the present work not in a good agreement, we rejected the result of that element analyzed from the sample. If an element is not the member of certified group of elements in the certificate of SRM 1633b, or not available but analyzed in this work, we have used IAEA SOIL - 7 instead. The elements in the certificate of IAEA SOIL - 7 recommended with 95% interval of confidence (International Atomic Energy Agency, 2000) only were considered. The results of the analysis of the Standard Reference Material and IAEA SOIL - 7 during this work compared to the certified values in the certificate of the standards were summarized in tables 1 and 2 below.

It can be seen from the tables that the results of the concentration of the elements obtained during the present work were in a good agreement with the certified values obtained from the certificate of the standard reference material, coal fly ash (http: //www.nist.gov/srm.) as shown in table 1 and the certificate of IAEA SOIL - 7 (International Atomic Energy Agency, 2000) in table 2. The result of the analysis of IAEA SOIL - 7 during this work, as displayed in table 2, lies in the 95% confidence interval. The concentration of determined elements in the mineral-soil from Ethiopia was reported in Table-3.

Element	E_Y (Kev)	$T_{1/2}$ (second)	Present work (ppm)*	Certified value (ppm)*
Mg	1014.4	567.6	4820 ± 76	4820 ± 80
Al	1779.0	134.4	150500 ± 2500	150500 ± 2700
Ca	3084.5	523.2	15100 ± 607	15100 ± 600
Ti	320.1	345.6	7910 ± 150	7910 ± 140
V	1434.1	225	295.7 ± 3.9	295.7 ± 3.6
Mn	2113.1	$9.288*10^3$	131.8 ± 1.2	131.8 ± 1.7
Na	2754	$5.4*10^4$	2010 ± 24	2010 ± 30
K	1524.6	$4.464*10^4$	1950 ± 234	1950 ± 300
As	559.1	$9.47*10^4$	136.2 ± 0.4	136.2 ± 2.6
U	277.6	$2.038*10^5$	8.79 ± 0.34	8.79 ± 0.36
Cr	320.1	$2.393*10^6$	198.2 ± 4.4	198.2 ± 4.7
Fe	1291.6	$43.845*10^6$	77800 ± 2407	77800 ± 2300
Ba	496.3	$1.019*10^6$	709 ± 55	709 ± 27
Th	312	$2.33*10^6$	25.7 ± 0.3	25.7 ± 1.3

*ppm = parts per million.

Table 1: Coal fly ash (SRM 1633b), certified values taken from (National Institute of Standards & Technology, 2004) compared with the present work.

The samples were identified as E.Bole, E.Shamene and E.Agena in the order of sampling locations, where "E.Agena" is a code given for Ewoa from the market Agena, "E,shamene" is for the mineral Ewoa from the market Shamene, and "E.Bole" is for the mineral soil collected from the market Bole. Twenty eight (28) elements were analyzed for the mineral soil as shown in the table-3. The Table shows that eight elements Al, Fe, Ca, Ti, Na, Mg, K and Mn were present with relatively higher concentrations.

Aluminum: Aluminum was found to be more dominant element than the other elements in the present study. It varies from 63830 ppm to 59100 ppm. The lowest and highest value of this element was recorded for E.Agena and E.Bole respectively. Variation of Aluminum in the samples may be the difference in the places where the mineral soil was collected, we thought of as being the slight differences in the concentration of the element in the crust.

Element	E_γ (Kev)	$T_{1/2}$ (second)	Present work (ppm)	Recommended value (ppm)	95% confidence interval (ppm)
Dy	94.7	$8.388*10^3$	4.7 ± 0.6	3.9	3.2 - 5.3
La	1596.2	$1.45*10^5$	27.9 ± 0.1	28	27 – 29
Sm	103.2	$1.667*10^5$	5.1 ± 0.3	5.1	4.8 – 5.5
Sc	889.3	$1.197*10^6$	8.36 ± 0.07	8.3	6.9 - 9
Co	1332.5	$1.663*10^8$	8.5 ± 0.1	8.9	8.4 – 10.1
Zn	1115.6	$2.97*10^7$	106 ± 7	104	101 – 113
Rb	1076.6	$1.62*10^6$	51 ± 6	51	47 – 56
Cs	795.8	$6.5*10^7$	5.8 ± 0.3	5.4	4.9 – 6.4
Nd	91.1	$9.5*10^5$	30 ± 2	30	22 – 34
Eu	1408	$4.2*10^8$	1.3 ± 0.1	1.0	0.9 – 1.3
Tb	879.4	$2.36*10^6$	0.7 ± 0.1	0.6	0.5 – 0.9
Yb	396.3	$3.63*10^5$	1.9 ± 0.2	2.4	1.9 – 2.6
Hf	482.2	$3.66*10^6$	4.9 ± 0.2	5.1	4.8 – 5.5
Ta	1221.4	$9.94*10^6$	0.7 ± 0.1	0.8	0.6 – 1.0

Table 3: IAEA SOIL - 7, recommended values and 95% confidence intervals as given in (International Atomic Energy Agency Analytical Quality Control Service, 2000) compared with the present work.

Iron: As can be seen from Table 4, Iron(Fe) is the most concentrated element next to Aluminum in all of the samples. In the present study, its concentration ranges from 45620 ± 365 ppm to 48760 ± 390 ppm. Relatively highest concentration is obtained from a sample collected from Agena and the lowest concentration is from the sample E.Bole. It is a key element in the metabolism of almost all living organisms. In humans, it is an essential component of hundreds of proteins and enzymes (Wood, R. J. et. al. 2006). Heme is an iron-containing compound found in a number of biologically important molecules. Hemoglobin and myoglobin are heme-containing proteins. They are involved in the transport and storage of oxygen (Yip R. et al. 1996). The presence of Iron in the mineral sample is very useful for the people using the soil.

Calcium: Calcium is among the most widely distributed heavy metals in terrestrial and aquatic environment. Calcium is the most common mineral in the human body.

Element	Concentration E.Bole (ppm)	Concentration E.Agena (ppm)	Concentration E.Shamene (ppm)
Al	63830 ± 574	59100 ± 650	62230 ± 497
Fe	45620 ± 365	48670 ± 390	47550 ± 380
Ca	24550 ± 2479	28760 ± 2559	24250 ± 2449
Ti	7923 ± 594	2519 ± 571	7307 ± 540
Na	6610 ± 7	6469 ± 13	6370 ± 13
Mg	4067 ± 862	3520 ± 721	3837 ± 986
K	1511 ± 181	1632 ± 390	1645 ± 209
Mn	1377 ± 5.5	1237 ± 3.7	1369 ± 5.4
Ba	343 ± 4	329 ± 4	314 ± 5
Zn	159.7 ± 10.9	170.1 ± 10.6	176.6 ± 10.8
V	100 ± 5	91.2 ± 4.5	105 ± 5
Rb	65 ± 4	44.4 ± 1.2	71.2 ± 4

Cr	67 ± 3	69 ± 2.83	64.7 ± 2.97
Nd	59.3 ± 0.2	68.3 ± 2.6	58.4 ± 2.3
Co	16.9 ± 0.4	18.04 ± 0.4	17.12 ± 0.4
Hf	12.7 ± 0.3	13.6 ± 0.3	12.4 ± 0.3
Th	11.3 ± 0.2	11.7 ± 0.2	11.19 ± 0.25
Sc	10.5 ± 0.1	10.95 ± 0.08	10.83 ± 0.08
La	9.1 ± 0.1	8.64 ± 0.13	8.5 ± 0.13
Sm	1.2 ± 0.03	1.2 ± 0.02	1.1 ± 0.02
Yb	6.4 ± 0.18	6.4 ± 0.17	6.4 ± 0.17
Dy	5.3 ± 1.4	5.3 ± 1.4	11.1 ± 1.4
Ta	4.7 ± 0.3	4.7 ± 0.3	5.3 ± 0.3
Eu	3.3 ± 0.2	2.4 ± 0.2	2.7 ± 0.2
Cs	3.04 ± 0.07	3.3 ± 0.04	3.5 ± 0.04
Tb	2.5 ± 0.15	2.36 ± 0.15	2.4 ± 0.2

Table 4: showing concentration of elements in the samples of Ewoa.

About 99% of the calcium in the body is found in bones and teeth, while the other 1% is found in the blood and soft tissue (Weaver, C. M. and Heaney, R. P. 1999).

The mineral component of bone consists mainly of calcium and phosphate (Heaney. R. P., 2000).Thus, adequate dietary calcium is a critical factor in maintaining a healthy skeleton (Heaney. R. P., 2000), this makes use of the mineral soil as a spice is advisable to get calcium in the diet.

Titanium: Titanium is the ninth most abundant element on earth. Titanium has no known biological role. But it is not toxic (www. web elements.com/titanium/). In this study it is the fourth most concentrated element in the mineral soil.

Elements sodium, Magnesium, potassium and Manganese were the second group of elements having concentrations in the order of 10^4 ppm, in all of the samples of the mineral soil.

Sodium: Sodium helps to maintain the body's fluid balance. It is also essential for nerve trans-mission, muscle contraction and cardiac function (Sheng. H.W. 2000). Sodium is the primary determinant of extracellular fluid volume, including blood volume, a number of physiological mechanisms that regulate blood volume and blood pressure work by adjusting the body's sodium content. Its retention results in water retention and sodium loss results in water loss (Sheng. H.W.hjb fbz 2000). Sodium is the cat ion in the compound sodium chloride and in some other salts. The presence of sodium in the mineral sample makes it useful to get sodium in a food if the food contains the mineral soil.

Magnesium: The concentration of magnesium ranges from 4067 ± 862 ppm to 3520 ± 721 ppm, in the samples E.Bole and E.Agena respectively. Magnesium is involved in more than 300 essential metabolic reactions (Spencer. H. etal, 1994). For example, the metabolism of carbohydrates and fats to produce energy requires numerous magnesium dependent chemical reactions (Rude. R. K. and Shils. M. E., 2006). Magnesium is required for the active transport of ions like potassium and calcium across cell membranes. Taking the mineral soil helps to get the advantages that one can get from the element magnesium.

Potassium: Potassium is an essential dietary mineral and body's principal intracellular electrolyte. Normal body function depends on tight regulation of potassium concentrations both inside and outside of cells (Peterson L.N., 1997). Potassium is critical for nerve impulse transmission, muscle contraction, and heart function (Sheng. H.W., 2000). In this work the concentration of Potassium is found to be ranged from 1511 ± 181 ppm to 1645 ± 209 ppm, the smallest being from E.Bole and the higher concentration was from E.Shamene. This concentration may be reasonably good for the people and animals using the mineral soil.

Manganese: Essential elements activate enzymes and vitamins hence lack of them can present serious health challenges including clinical and pathological disorders in animals, plants and man. Some essential elements make vitamins work more effectively. For instance, vitamin A works best with Se and Zn while vitamin B is enriched by Se, Zn, Co, Cu, Fe and Mn. For vitamin C, the essential elements found to promote its effectiveness are Co, Cu and Se while vitamin E is activated by Fe, Mn, Se and Zn (Mindell E. and Mundis H., 2004). Hence manganese is used to control Vitamins B and E, its concentration (1377±5.5ppm to 1237±3.7ppm) in the mineral soil is acceptable and advantageous.

Zinc: Zinc is one of the most abundant essential trace metals in animals and human. The highest concentration of Zinc occurs in the eyes, male sex organs, liver and kidneys. It helps the pancreas with its digestive functions, helps metabolize carbohydrate, protein and fat, liberate vitamin A from storage in the liver and dispose of damaging free radicals (Mindell E. and Mundis H., 2004). Adding a little zinc to the diet could reduce the duration of diarrhea attack by 20-30% and could stop up to 38% of cases from ever happening at all (Fox, B.A., 1998). Zinc in the sample of Ewoa concentrates from 159.7±10.9ppm in E.Bole to 176.6±10.8ppm in E.shamene. Using of Ewoa by the people in the research area is useful and acceptable regarding to the concentration of Zinc in the sample.

Other group of elements Barium and Vanadium constitute those elements whose concentration lies in the order of 10^2 ppm in almost all of the mineral soil samples. There were other elements with minor and trace levels as shown in table 3 which has very useful roles in the animals and human development. From all the elements identified in this experiment we didn't find a heavy metal with toxic level of concentration or any other toxicity in all of the samples. Hence we saw that, the mineral soil contains more useful elements in its nature for animals and human. Since there was no chlorine in the standards (SRM-1633b and IAEA-SOIL-7) it was not analyzed, but we expect much concentration of the element because the mineral soil tastes salty.

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