COMPARATIVE ANALYSIS OF TRACE ELEMENTS IN GEOMEDIA IN THE TERRESTRIAL ENVIRONMENTS OF SELECTED ECOSYSTEMS

BY

ESSEL KOFI KWEGYIR

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A project submitted to the Department of Applied Chemistry and Biochemistry, Faculty of Applied Sciences, University for Development Studies, Navrongo Campus for the award of Bachelor of Science degree in Applied Chemistry

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DECLARATION

1, ESSEL KOFI KWEGYIR, hereby declare that this work was carried out by me under the supervision of Mr. Ohene Boansi Apea and that previous submission on this topic has not been made to this University or any other institution.

Related works by others have been duly acknowledged by making references to the authors.

.....
ESSEL KOFI KWEGYIR

24/6/11
.....
DATE

CERTIFICATION

This research work has been approved as meeting the requirement of the Department of Applied Chemistry and Biochemistry, Faculty of Applied Sciences, University for Development Studies, Navrongo Campus, Ghana for the Award of BSc Honours Degree in Applied Chemistry.

..... 24/06/11

MR. OHENE BOANSI APEA DATE

(Supervisor)

..... 12/07/11

MR.LATEEF ADEBAYO OSENI DATE

(Head of Department)

....

(External Examiner) DATE

DEDICATION

I dedicate this project work to my late grandmother, Madam Ekua Kwegyirba Quagrainie. May her soul rest in perfect peace.

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My acknowledgement goes to the Almighty God for his protection and guidance throughout my three years stay on the University for Development Studies, Navrongo Campus.

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ABSTRACT

Soil samples were analyzed for minor elements and major oxides from selected districts in Upper East Region. The results indicated that vanadium, chromium and cobalt were higher in concentrations. They were found to contain 88ppm of vanadium, 695ppm of chromium and 24ppm respectively in the Kassena-Nankana district. In Paga, high levels of zinc (180.7ppm), and nickel (35.07) respectively were recorded. In Bolga, copper (Cu), Yttrium (Y), tin (Sn), cesium (Cs) and rubidium were found to contain 35.4ppm 17.5ppm, 4.9ppm and 11ppm respectively. Lanthanum was also found to be 24.5ppm. In Bongo, barium was found to be 2150ppm and was the highest. With the major oxides, Kassana-Nankana was observed to have a concentrations of 2.2515% Na_2O, 2.6% MgO and 4.74% Fe_2O_2 as the highest. Bongo registered 12.8%. Al_2O_3, 0.44% SO_3, 0.04% Cl and 4.42% K_2O as the highest. In Paga, 0.68% P_2O_5, 4.0033% CaO, 0.83% TiO_2 and 0.3467% MgO were observed to have high concentrations. Loss on ignition (L.O.I.) was high in Paga with 27.77% and low in Sandema with 18.17%.

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CHAPTER ONE

1.0 INTRODUCTION

1.1TRACE METALS CONCENTRATIONS IN SOILS

Agricultural soils accumulate trace metals, particularly copper and zinc as a result of their presence in wastes (sewage bio- solids, manures and fungicides that are applied over long periods of time (Kim *et al*, 2009)

Metals such as lead, arsenic, cadmium, copper, zinc, nickel and mercury are continuously being added to our soils through various agricultural activities such as agrochemical usage and long time application of urban sewage sludge in agricultural soils. Industrial activities such as waste disposal, waste incineration and vehicle exhaust as well as anthropogenic activities. All these sources cause accumulation of metals and mettaloids in our agricultural soils and pose threat to food safety issues and potential health risks due to soil to plant transfer of metals (Bohn, 1985).

Coexistence and persistence of heavy metals in soils as multiple contaminants and human exposure to them through ingestion of heavy metals contaminated food or uptake of contaminated drinking water can lead to their accumulation in humans, plants and animals. They can also cause detrimental effect on soil ecosystems, environment and human health due to their mobilities and solubilities which determine their speciation (Kabata-Pendias, 1992)

In some cases, the soil may be contaminated to such an extent that it may be classified as hazardous waste (Berti *et al*, 1996)

Soil contamination with heavy metal mixtures is receiving increasing attention from the public as well as government agencies particularly in developing countries. The remediation

of such soils is important because these usually cover large areas that are rendered unsuitable for agricultural and other human use (Yanez *et al*, 2002)

1.2 OBJECTIVES

1 Determination of minor elements in the soil

2 Determination of major oxides in the soil.

1.3 SCOPE OF STUDY

This research is confined to the use of soil samples. The determinations include;

1. Determination of minor elements in the soil in selected districts.
2. Determination of major oxides in the soil in selected districts.

1.4 PROBLEM STATEMENT

Trace metals accumulate in soil due to anthropogenic activities, natural disasters such as volcanic eruptions and weathering of rocks. Application of incorrect proportions of fertilizer on soils, smelting of aluminium are contributory factors to accumulation of trace metals onto the soil as well as the environment.

Industrial activities such as waste disposal, waste incineration and vehicle exhaust are all sources of trace metal accumulation in our agricultural soil. These pose threat to food safety issues and potential health risks due to soil to plant transfer of metals. It is therefore, necessary to study these trace metals, know their interactions and the dangers they pose to humans, plants, animals as well as microbes which improve soil fertility, soil texture, soil profile and other attributes.

1.5 JUSTIFICATION

There is the need to monitor these trace elements which could pose danger to the terrestrial environment biochemical processes. There is the need to monitor these trace elements and know their interactions. Then remedy found to lessen the burden or effects of the trace elements and their oxides. Trace elements play significant role in nutrition, health maintenance and illness. Studying minor elements in the soil shall enable us to know their effect on soil texture, soil fertility and soil profile.

Knowledge of these trace metals shall enable us know the quantities required for body function, utilization in the soil and the effects of indiscriminate application of fertilizer. The diseases that these minor elements may cause to humans, animals, plants and micro organisms may be acute or chronic.

Then remedy found to lessen the burden or effects of the trace elements and their oxides

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 MERITS AND DEMERITS OF TRACE METALS

Cobalt is accumulated from soils by plants which in turn become the primary source of animals .Molybdenum is a plant micronutrient and this has accelerated agricultural research. Land deficient in cobalt results in farm animals wasting away and eventually death as a result of cobalt deficiency also resulted in nkurutis of Kenya in East Africa. In U.S, it is salt sickness of Florida and bush sickness in New Zealand (Andersen, 2000)

Application of cobalt protects grazing animals. Copper applied to the same fields did increase plant yields provided copper requirements of a sheep. Copper is key to elasticity in the plant. It is an important constituents of many proteins like ascorbic acid oxidase, cytochrome oxidase, diamine oxidase and poly phenol oxidase. Copper is an important nutrient for many microbes such as *Aspergillus niger*. It controls molds and often alleviates perceived zinc deficiencies. Copper interacts with iron and manganese. It is important to root metabolism, helps form compounds and proteins as well as amino acids and host of organic compounds. It acts as a catalyst or part of enzyme systems and

prevents chlorosis. (Andersen, 2000). Copper is needed for bone formation, hemoglobin and red blood cells.It promotes healthy nerves, healthy immune system and collagen formation. It works in balance with zinc and vitamin C. Copper plays an important role in memory and brain function along with manganese, magnesium and iodine. Nuts, molasses and oats contain copper. Many enzymes incorporate a single molecule of a trace mineral such as manganese, copper, iron or zinc without which the enzyme cannot function (Fallon et al ,2001)

In Austrialia, it was discovered that black sheep grazing on copper deficient pastures turned gray. Copper is stored in humans in the liver. In cases of fever and infection, the level of iron in the blood stream drops and blood copper level rises as the copper reserves in the liver are mobilized to aid the immune system in fighting of invaders (Voison, 2003)

Signs of possible deficiencies are white hair, liver cirrhosis, allergies, parasites, hernia, anemia, hyper/hypo thyroism, arthritis,ruptured disc, iron storage disease(Walters, 2006.)

ZINC

Zinc is an essential component of many enzymes, in the dehydrogenase, proteinase and the peptide groups. It helps to make acetic acid in the root to prevent rotting. The overuse of zinc promotes the growth of many weed species (Andersen, 2000).

Zinc contributes to test weight, increased corn size, promotes corn silking, hastens maturity, chlorophyll formation, enzyme function and regulates plant growth.It is essential for corn starters (Zimmer, 2000). It stimulates plant growth prevents the occurrence of mottled leaf in citrus, white bud in corn and other disorders. Plants require zinc in the range of 3-100ppm. An excess of zinc means decreased copper availability and interference with utilization of copper and iron, resulting in anemia. Zinc disorders also result in bald patches and skin disorders (rough skin), a deficiency is created by excess of calcium. Zinc is absolutely essential for production of sperms and the need for vitamin A (Walters, 2006)

Zinc uptake by plants declines as pH increases. Manures from commercial livestock operation are frequently very good sources of zinc and copper (and sometimes boron).

Adult human body contains about 2400 mg of zinc. Zinc is mostly concentrated in the male prostrate and semen. The next most concentrated tissues are the retina of the eye, the heart, spleen, lungs, brain and adrenal glands.

Zinc deficiency leads to slow healing of wounds due to zinc's role of RNA and DNA synthesis and in the formation of many enzymes. Zinc is important in the normal immune function, protein digestion, formation of bones and teeth as it a co-factor of alkaline phosphatase (Fallon *et al* 2001).

Minor zinc deficiency in pregnant animals results in offspring with deformities such as fused and missing ribs , domed skulls. In humans, zinc deficiency can cause learning disabilities and mental retardation. Other problems are acne, boils, psoriasis, gastric ulcers(zinc is need to form digestive acid), cataracts, hypertension, infertility, loss of or poor functioning of the senses of hearing, taste, smell, weak muscles and fatigue.

Mad cow diseases and chronic wasting disease were strongly associated with soils that had very low levels of zinc and copper combined with high levels of manganese, sometimes strontium and silver are as a result of mineral imbalance (Purdey,2002)

SELENIUM

Selenium salts are toxic in large amounts, but trace amounts of the elements are necessary for cellular function in mostly, if not at all, animals, forming the active centre of the enzyme glutathione peroxidase and thioredoxin reductase which indirectly reduce certain oxidized molecules, mammals and some plants and three known deiodinase enzyme which converts one thyroid hormone to another (Mazokapakis *et al*, 2007)

Selenium requirements in plants differ by species, with some plants, it seems requiring none (Ruyle ,2009).

Certain species of plants are considered indicators of high selenium content of the soil , since they require high levels of selenium to thrive. The three main indicator plants are *Astragalus species* including some locoweeds, prince plume, woody esters and false goldenweed,*Oonopsis species (*Zane, 2008).

Selenium conducts electricity better in the light than in the dark and is used in photocells. It also exists in many non- conductive forms. It is commercially used for glassmaking, chemicals, pigments and electronics. In soils, selenium occurs most often in soluble forms such as selenite (analogous to sulfate), which are leached into rivers very easily by runoff. Natural sources of selenium include certain selenium-rich soils and selenium that has been bio-concentrated by certain plants. Anthropogenic sources of selenium include coal burns, mining and smelting of sulfide ore (Public Health Statement, 2009).

In plants, selenium occurs as a bystander mineral. Some plants accumulate selenium as a defense against being eaten by animals (Ruyle, 2009).

TOXICITY OF SELENIUM

Although, selenium is toxic if taken in excess, it is an essential trace element. Exceeding the Tolerable Upper Intake Level (T.U.I.L) of 400 microgram per day can lead to selenosis. This 400 microgram is based on a 1986 study of chinese patients who exhibited overt signs of selenosis and a follow up study on the same five people in 1992(Institute Of Medicine, 2000)

A dose of selenium as small as 5 mg per day can be fatal for many humans. Selenium is active in small quantities and has a history of causing accidental poisoning when doses supposed to be in micrograms is given by mistake in milligrams. This can cause congenital

disorder in wetland birds. People dependent on food grown from selenium deficient soils are at risk (Ohlendorf, 2003).

YTTRIUM

Yttrium compounds are used as catalysts for ethylene polymerization. As a metal, it is used on the electrodes of some high performance spark plugs (Carley, 2000).

It is also used in the manufacture of gas mantles for propane mantles as a replacement for thorium, which is radioactive. Yttrium aluminium garnet has a hardness of 8.5 and is used as a gemstone in jewelry (simulated diamond).

TOXICITY

Water soluble compounds of yttrium are mildly toxic. Yttrium compounds cause lung and liver damage, though toxicity varies with different yttrium compounds. Inhalation of yttrium citrate can cause pulmonary edema and dypsnea, while inhalation of yttrium chloride causes liver edema, pleural effusions and pulmonary hyperemia. Yttrium dust is flammable, acute exposure can cause chest pains, coughing, shortness of breath and cyanosis (O.H.S.A. contributors, 2007)

2.1.2. ENVIRONMENTAL POLLUTION AND HUMAN HEALTH

All the things around us such as plants, water, air, animals and so on make our environment.

Environmental pollution may be described as the unfavorable alteration of our surroundings attributed to the anthropogenic activities of man. Environmental pollution takes place through changes in energy patterns, radiation levels; chemical and physical constitution and

abundance of microorganisms. Pollution includes the release of materials into the atmosphere which make the air unsuitable for breathing. This harms the quality of water and soil and give out substances which damage the health of human beings, plants and animals (Chatta, 2006).

Though other environmental pollutants, odour, and noise only disturb the cell function, they can sometimes be a danger to health. The effects of pollution to our biosphere are numerous and are increasingly alarming. The pathway of impact of the environment in the human body evidently is the systems that are exposed to hazardous materials, covering the external skin and the internal respiratory and is important to note that health has direct relation to the environment.

Several diseases have a direct relation to environmental management. The environmental components involved in communicable diseases are malaria, schistosomiasis, filariasis and trypanosomiasis.

Many other ailments such as asthma and allergy are environmentally linked.

Pollution may be defined as the introduction by man into the environment of substances or energy liable to cause hazards to human health, harm to living resource and ecological systems, damage to structure or amenity or interference with legitimate use of the environment.

Pollutants have various alternative systems for their classification. Mainly pollutants are classified based on their

- Nature
- Chemical composition
- Physical state

- Properties
- Sectors of Environment
- Patterns of use as
- Use in industry as solvent
- In agriculture as fertilizer
- Pesticides in transport as lubricant and in defense as well.

2.1.3. AIR POLLUTION

The major air pollution is caused by fuel combustion in primary gases such as carbon monoxide, carbon dioxide, unburned hydrocarbons, oxides of nitrogen, sulphur dioxide and aldelydes. Reactions cause the formation of secondary derivatives in the form of peroxy acetyl nitrates, oxides of nitrogen form ozone and sulphur dioxide brings acid rain and particulate in gases form smoke, grit, dust and lead particles. God made the universe and man for some purpose has set a balance and symmetry in everything. (Schwartz J, 1997)

The environment provides man with the essential life support system which comprises air. water and land, but it also presents to man a variety of hazards which may prejudice his health.

The World Health Organization (WHO) recognizes that health is the fundamental right of every man without distinction of race, religion, political belief, economic and social conditions.

While every effort is being made to attain this concept, much remains to be done. WHO defines health as a state of physical, mental and social well being and not merely the absence

of diseases and infirmity. It represents a balanced relationship of the body and mind and complete adjustment to the total environment.

Health signifies a soundness of body and mind, but we are confronted with the difficulty of determine its relationship to disease. Health and disease must be intimately related.

For, if disease did not exist it would be irrelevant to talk about health.

2.1.4. AGRICULTURAL AND ENVIRONMENTAL IMPORTANCE OF ANIONS.

Definition: Anions are negatively charged particles capable of conducting electric current.

The types of anions formed in the soils are fluorides, chlorides, sulphates, phosphates, bromides and iodates.

Other types of anions present in the soil are hydroxyl ions, chlorates and the bicarbonates (Patel, 2007).

In water, fluorides associate with various elements present in the water, mainly with aluminum in freshwater, calcium and magnesium in seawater.

It then settles into the sediment where they are strongly attached to sediment particles. When deposited on the land, anions are strongly retained by soil forming strong associations with soil components.

Leaching removes only a small amount of anions from soils, (Blackherbals, 2001).

Anions are taken up from soil and accumulate in plants. They serve as source of nutrients to the plants and the soil. Fluorides are frequently added to drinking water supplies at approximately 1.0ppm and to tooth paste and mouth rinses to prevent dental decay. Several

medicines that contain fluoride are used for treating skin diseases example flucytosine, an antifungal and some cancers example fluouracil oil, an anti metabolite (Blackherbal, 2001).

Fluoride has been used to treat women with osteoporosis.

Fluoride is a desirable substance which can prevent or reduce dental decay and straighten bones, thus preventing bone fractures in older people.

Where fluoride level is naturally low, studies have shown higher levels of both dental caries tooth decay and fractures (WHO, 2010).

2.1.5. SOURCES OF ANIONS

Fluoride is found in vegetables, fruits, tea and other crops, although drinking water is usually the largest contributor to daily intake of fluoride. This includes other anions.

Anions are found in the atmosphere, originating from dusts of anion containing soils, from gaseous industrial wastes, from coal fires in populated areas and gases of volcanic activity. (W.H.O, 2010).

Virtually every food contains anions; plants take them up from the soil, air and earth's crust. From the soil, anions are transmitted through fine hair rootlets into the stem and to the leaves; plants absorb more anions from sandy than from clay soil and from wet and acid soils than from dry alkaline soils (Waldbott, 1997).

Anions are found in pesticides and in inorganic compounds such as cryolite (Na_3AlF_6), fluorapatite (Ca_5Po_4F) and other phosphate rocks. Anions are also found in phosphate fertilizer application areas and in rich soils from farming. They are also found in minerals, also in natural and fresh waters and from groundwater sources especially, sources of animal feed lots, septic systems urban drainage or decaying plant material. (ATSDR, 1993).

2.1.6. TRACE ELEMENTS

Trace elements are metals and elements that are needed in very small amounts. Examples are iodine, cobalt, molybdenum selenium, vanadium, nickel chromium, tin, fluorine, silicon and arsenic. The elements of major importance in order of decreasing numerical abundance are hydrogen (H), carbon (C) oxygen (C), nitrogen (N), Phosphorus (P) and sulphur(S).Certain metal ions are also important and include Na^{+}, K^{+}, Mg^{2+}, Ca^{2+}, Zn^{2+} and Fe^{2+} or Fe^{3+} (Zubay, 1995).

Trace elements are also known as trace minerals. They are needed in only a few milligrams(mg) or microgram(mcg) per day.

2.1.6 IMPORTANCE OF TRACE ELEMENTS

Although minerals comprise of only a fraction of total body weight, they are cruel for many body functions including transporting oxygen, normalizing the nervous system and growth simulation as well as maintaining and repair of bones and tissues

- Chromium aids in glucose metabolism and helps regulate blood sugar by potentiating insulin and serving as a component of glucose tolerance factor. In alloys and pigments.
- Cobalt promotes the formulation of red blood cells and server as a component of vitamin B_{12}. Used in fertilizers in porcelain and glass. As alloys of various steels or iodine is required by the thyroid hormone to support metabolism. As disinfectant in swimming pools and potable waters.
- Molybdenum contributes to normal growth and development and is a key component in many enzyme systems involved in detoxification.

- Selenium is an essential component of a key antioxidant enzyme, necessary for normal growth and development, plays role in detoxification of heavy metals such as mercury. Also in the production of antibodies by the immune system is a component of teeth.

There are more benefits than these, so it is certainly easy to see that minerals play an important role in health. Many inorganic elements have been Identified in tissues' of man, animals, fungi, bacteria and dietary components and the importance of many of them in biological processes have been established.

Natural foods and feeds soil and water supplies may have sufficient quantities of the elements to satisfy requirements. Purified diets have been most helpful. (Miller *et al*, 1988).

Fluorine has been found to acid in the prevention of dental cavities and in animal metabolism. Arsenic, chromium, silicon, tin and vanadium in purified diets are known to have specific physiological functions (Miller, 1988).

Higher levels of these trace metals could be harmful and may result in various diseases.

Vanadium is used in steel alloys and as a catalyst in the production of sulfuric acid and synthetic rubber. Laboratory and epidemiological evidence suggests that vanadium may play a beneficial role in prevention of heart diseases. It may be an essential trace element for some algae and microorganisms.

2.1.7. CHARACTERIZATION OF TRACE METALS

2.1.8. Fluoride is characterized by SPADNS colorimetric method. The colorimetric method is based on the reaction between fluoride reacts with the dye lake, dissociating a portion of it into a colorless complex anion (ZrF_6^{2-})the dye.

As the amount of fluoride increases, the color becomes progressively lighter (Lenore, 1998).

2.1.9. IODINE BY LEUCO CRYSTAL VIOLET METHOD

Mercuric chloride added to aqueous elemental iodine solutions causes' essentially complete hydrolysis of iodine and production of hypoiodous acid.

Leuco crystal violet (N,N-dimethylaniline) reacts instantaneously with hypoiodous acid to form crystal violet red. (Lenore 1998).

2.2.0 TRACE ELEMENTS IN SOIL IN SELECTED DISTRICTS

The trace elements found in the selected Districts are vanadium chromium, cobalt, nickel, arsenic and tin.

Vanadium (v) is the first element in Group VB in the periodic table. The average abundance of (V) in the earth is crust is 136ppm. In soil it ranges from 15 to 110ppm

In streams it averages about 0.9ug/L and in ground waters it is generally less than 0.1mg/L (Lenore, 1998).

Chromium on the average abundance of the earth's crust is 122ppm. In soils it ranges from 11 to 22ppm in streams, it averages about 1ug/L.

COBALT: The average abundance of cobalt in the earth's crust is 29ppm. In soils, it is 1.0 to 14ppm, in streams, it is 0.2ug/L, and in ground waters, it is 1to 10ug/L it occurs only sparingly in ores, usually as the sulphide or the arsenide.

NICKEL: The average abundance of nickel in the earth's crush is 1.2ppm, in soils, it is 2.5ppm, in streams, it is 1ug/L and in ground waters it is less than 0.1mg/L.

ARSENIC: The average abundance of arsenic in the earth's crust is 1.8ppm, in soils, it is 5.5 to 13ppm. In streams, it is less than 2ug/L. In groundwater, it is generally less than 100mg/L naturally. It occurs naturally in sulphide minerals such as pyrite.

TIN: The average abundance of tin in the earth's crust is 8.1ppm, in soils, it is 13ppm. In streams, it is 0.1ug/L and in ground waters, it is less than 0.1mg/L. Tin is mostly found in the mineral cassiterite (SnO_2), in association with granite rocks. (Lenore, 1998). Virtually every food contains anions; plants take them up from the soil, air and earth's crust. From the soil, anions are transmitted through fine hair rootlets into the stem and to the leaves; plants absorb more anions from sandy than from clay soil and from wet and acid soils than from dry alkaline soils (Waldbott, 1997).

Anions are found in pesticides and in inorganic compounds such as cryolite (Na_3AlF_6), fluorapatite (Ca_5Po_4F) and other phosphate rocks. Anions are also found in phosphate fertilizer application areas and in rich soils from farming. They are also found in minerals, also in natural and fresh waters and from groundwater sources especially, sources of animal feed lots, septic systems urban drainage or decaying plant material. (ATSDR, 1993).

CHAPTER THREE

3.0. MATERIALS AND METHOD

3.1. SAMPLING

The sampling areas selected include Kassena-Nankana East, Kassena West Districts, Bolgatanga municipality, Bongo district and Kassena-Nankana districts. These areas were were divided into five sampling points. These are Bolgatanga Ministries, Bolgatanga estate, Navrongo Dam , Paga, Sawaba, Bolga, Bongo and Sandema. The sampling points were cleared of all weeds and debris and soil samples were collected to a depth of 30 cm deep from each point.The samples were then bagged into polyethylene bags and were sent to the laboratory for analyses.

3.1.1. SAMPLE PREPARATION

The samples were air dried. The dried samples were crushed to break lumps.Stones and debris were then removed from the soil samples. Samples free of debris were ground to passed through a 2mm sieve, bagged and were sent for laboratory analysis.

3.1.2 X-RAY FLUORESCENCE ANALYSIS

Exactly 4.0 g of the soil was weighed and 0.9 g of Fluxana Licowax C Micropowder PM (Hoechstwax). The soil sample and the fluxana were transferred into a sample cap. The sample was then homogenized in a homogenizer which is automated at a frequency of 15 rev/sec for 3 min.

Fluxana bound tightly to the soil and a pellet was formed. A presser was used to press the pellets at a pressure of about 8 tons and a shape of a coin developed. The samples were then placed in a sample compartment in batches the X-Ray Fluorescence (XRF) Spectrometer in

order to determine the minor elements and the major oxides present in the soil. This process takes about 8 hrs and the results were read from the computer.

3.1.3 COLLECTION OF GIS DATA

Soil samples were collected to a depth of 30cm deep and the locations or way points for each sample was noted by the use of Geographical Processing System (GPS)

3.1.4 LIST OF INSTRUMENTS

- Analytical balance, SARTORIUS, BD BL 200
- X-Ray Fluorescence Spectrometer

  Homogenizer

LIST OF CHEMICALS

Fluxana Licowax C Micropowder

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

MINOR ELEMENTS (ppm)

ELEMENT	V	Cr	Co	Ni	Cu	Zn	Ga	As	Rb	Sr	Pb	Bi	Y
PAGA	59.67	619	16	35.07	34	180.7	6.733	0.8	50.067	196.53	14.33	5.03	14.667
BOLGA	94	262.4	15.5	13.8	35.4	179.5	15	2.9	148	396	91	0.85	17.5
SANDEMA	76.33	233	16	11.17	18.73	152.7	15	16	*82.42*	*770.3*	37.33	0.73	15.667
ZUARUNGU	70.67	149.7	16.67	14.37	35.03	149.7	11.13	1.7	*42.1*	*286*		0.73	14.333
BOLGA ESTATE	70.5	588.5	15.5	13.9	32.5	132.5	13.5	1.15	*86.65*	*404.5*	51	0.8	12
BOLGA MINISTRIES	67.33	246.2	15.33	14.03	23.97	85.67	13	2.33	115.13	597.33	28	0.73	15
KASSENA NANKANA	88	695	24	14.85	23.5	36.5	14.5	0.65	26.2	320	8.9	0.55	17
BONGO	46	442	17	13.2	21.3	81	15	0.7	179	951	34	0.7	13

Table 4.1

MINOR ELEMENTS (ppm)

ELEMENT	Zr	Nb	Sn	Cs	Ba	La	Th	U	Ta	Ce
PAGA	517.66	8.9	5.73	1.66	697.67	10.4	13.3	8.93	4.5	30.33
BOLGA	738.5	10.65	11	4.9	1887	24.5	17	14	4.6	94.5
SANDEMA	997	10.6	5.9	3.1	1853.3	12.33	17	10.6	4.7	31
ZUARUNGU	779.66	7.53	3.96	2.36	410	9	12	8.8	4.6	26.33
BOLGA ESTATE	632	7.75	5.65	2.85	1094	11	12.5	12	4.3	43
BOLGA MINISTRIES	711.33	11.2	4.8	2.76	1450	14.7	14	11.93	4.3	56
KASSENA NANKANA	379	6.6	2.85	1.25	420	11.25	7.4	6.5	4.4	24.55
BONGO	176	12	5.9	2.9	2150	21	15	13	4.3	72

Table 4.2

MAJOR OXIDES (%)

TOWN	ELEMENT	Al_2O_3	CaO	Cl	Fe_2O_3	K_2O	L.O.I.	MgO	MnO	Na_2O	P_2O_5	S_1O_2	SO_3	TiO_2
PAGA	MEAN	8.38	4.00	0.03	3.5	1.15	27.77	2.18	0.35	1.33	0.68	49.85	0.34	0.83
BOLGA	MEAN	12.29	1.245	0.03	3.685	2.98	24.25	1.79	0.075	2.265	0.42	52.69	0.32	0.58
SANDEMA	MEAN	12.32	0.95	0.03	3.17	4.03	18.17	1.82	0.06	2.037	0.27	56.24	0.32	0.7
ZUARUNGU	MEAN	9.15	1.49	0.02	3.61	1.29	27.4	2.24	0.07	2.39	0.42	51.11	0.35	0.57
BOLGA STC	MEAN	11.48	1.055	0.03	3.265	3.005	19.3	1.88	0.075	2.33	0.43	56.83	0.37	0.475
BOLGA MINISTRIES	MEAN	10.18	3.39	0.03	3.44	3.33	25.18	1.76	0.07	1.86	0.34	49.36	0.43	0.65
KASSENA NANKANA	MEAN	11.35	2.74	0.025	4.74	0.925	24.65	2.6	0.11	2.515	0.195	46.34	0.27	0.625
BONGO	MEAN	12.8	1.72	0.04	3.53	4.42	24.1	1.74	0.05	1.96	0.58	48.61	0.44	0.77

Table 4.3: Major Oxides of some selected districts in Upper East Region

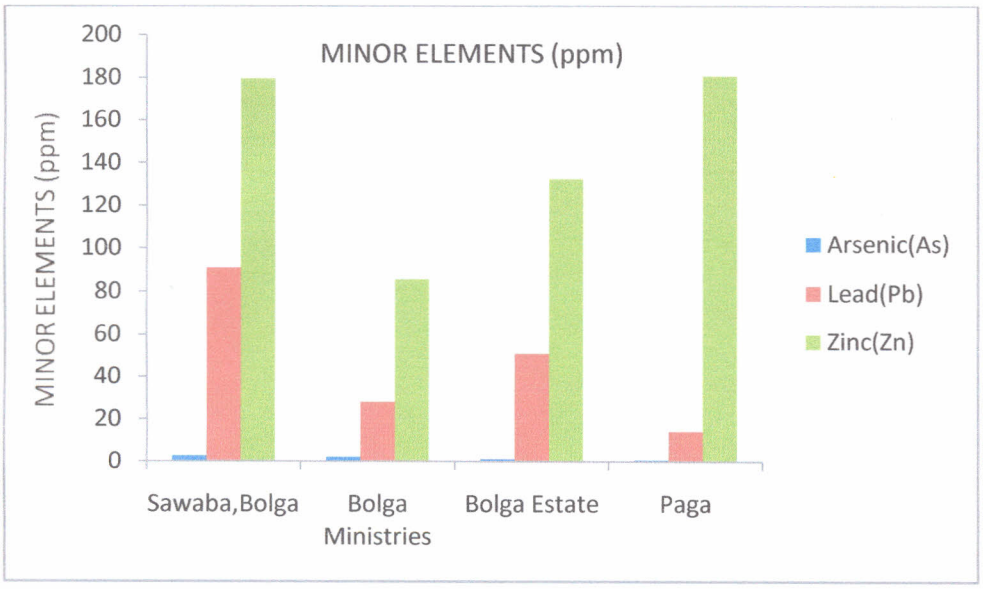

Figure 4.1: Minor Elements (As, Pb and Zn) for Bolga Municipality and Kassena Nankana West District

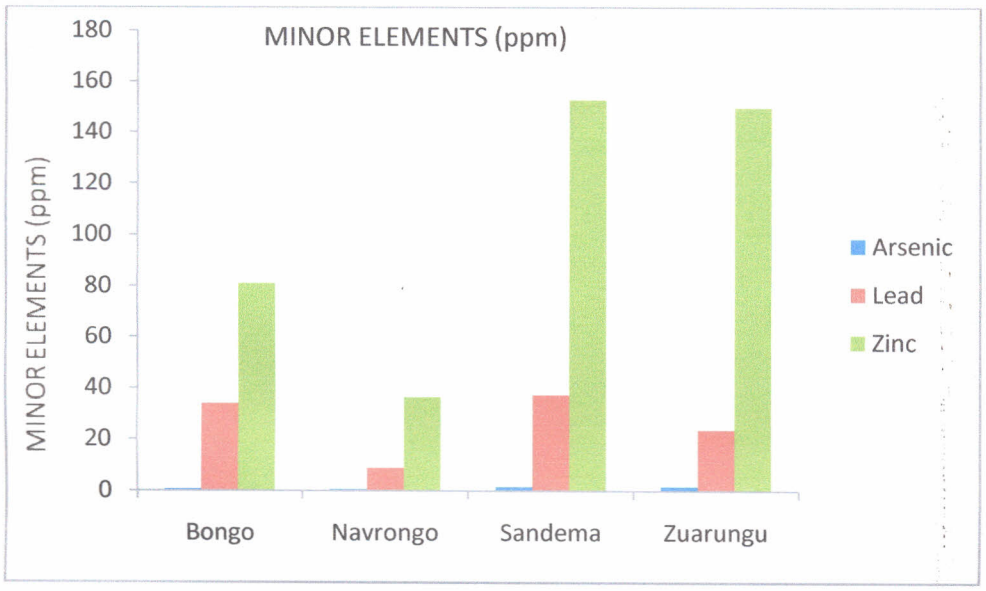

Figure 4.2: Minor Elements (As, Pb and Zn) for Bongo, Kassena Nankana East ,Builsa Districts and Bolga Municipality

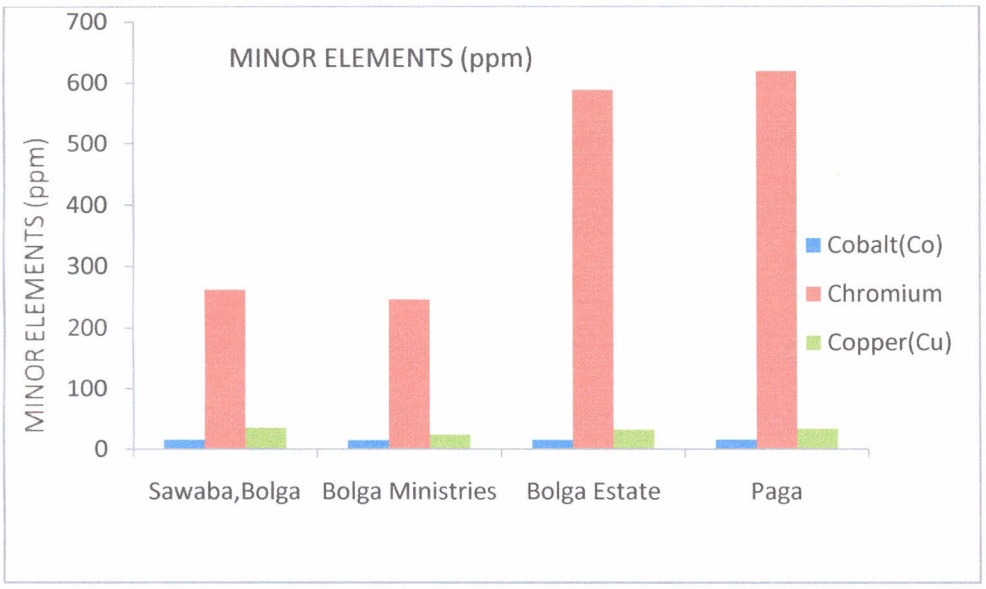

Figure 4.3: Minor Elements (Co, Cr and Cu) for Bolga Municipality and Kassena Nankana West District

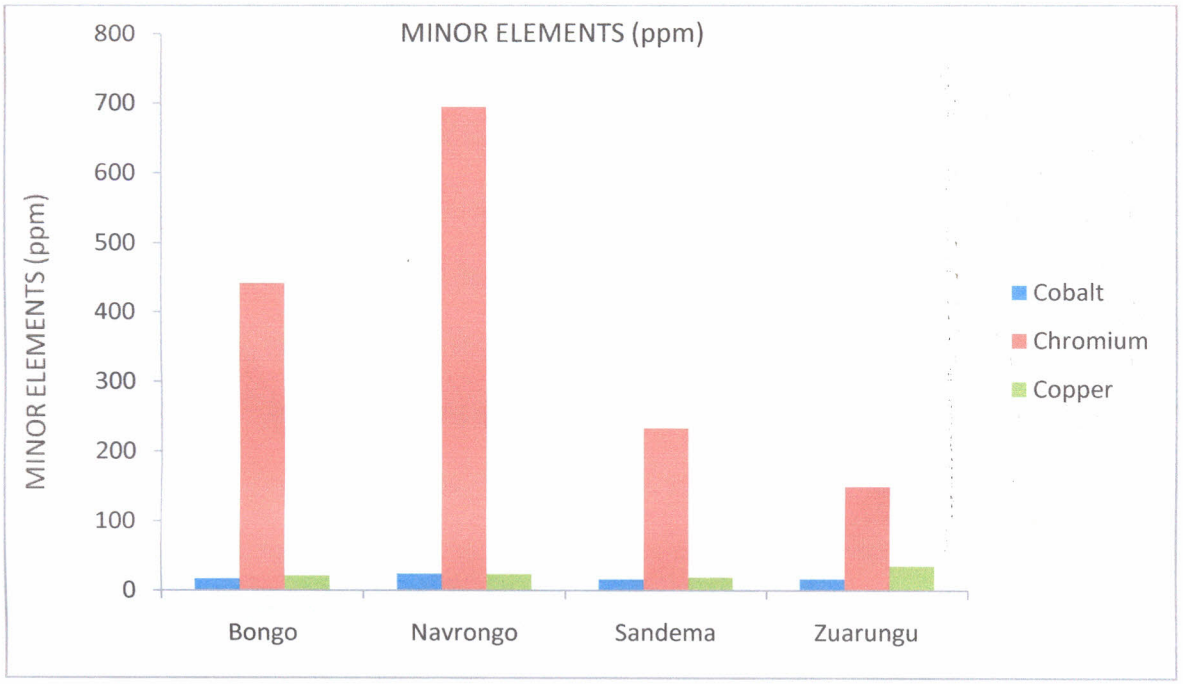

Figure 4.4 Minor Elements (Co, Cr and Cu) for Bongo, Kassena Nankana East Districts and Bolga Municipality.

DISCUSSION

MINOR ELEMENTS

The results of the analysis shows that arsenic, barium, chromium, strontium, zirconium and so on were present in the sample at varying concentrations. The samples from all the districts contained the same elements occurring at various degrees of varying concentration.

The following harmful or toxic trace elements were also observed to be present in the sample from all the districts. They are cobalt, chromium, thorium, uranium, yttrium, and so on. The results of the analyses revealed that the soils from all the districts contain varying amounts of radioactive elements. Some of these radioactive elements are cobalt, chromium, thorium and uranium.

KASSENA NANKANA WEST DISTRICT

In Kassena –Nankana West district, that is Paga, barium (Ba) was the highest element with concentration, 697.67ppm followed by chromium (Cr) 619ppm. The next was zirconium (Zr) with concentration 517.7ppm. Strontium (Sr) and zinc (Zn) followed with 196.5ppm and 180.7ppm respectively. Vanadium(V), 59.67ppm, rubidium(Rb), 50.07ppm, nickel(Ni), 35.07ppm, copper(Cu), 34ppm, cerium(Ce), 30.33ppm, cesium(Cs), 1.67ppm, cobalt(Co), 16ppm, bismuth(Bi), 5.03ppm, uranium(U), 8.93ppm, thorium(Th), 13.3ppm, tantalum(Ta), 7.07ppm, tin(Sn), 5.73ppm and arsenic(As), 0.8ppm were low in concentrations. Hafnium (Hf), 10.57ppm, lead (Pb), 14.33ppm, gallium (Ga), 6.73ppm, lanthanum (La), 10.4ppm, niobium (Nb), 8.9ppm and yttrium, 14.67ppm were also low in concentrations.

At Navrongo Dam, which is under the Kassena-Nankana East District, chromium concentration was noted to have high 695ppm concentration. Barium concentration was noted to be 420ppm, whilst zirconium and strontium were observed to be 379ppm and 320ppm respectively. The concentrations of other minor elements were found to be low.

KASSENA- NANKANA EAST DISTRICT

Sandema was observed to have high rates of zirconium, strontium, chromium and barium with 997ppm for zirconium, 770ppm for strontium, 233ppm for chromium and 180ppm for barium. The remaining minor elements being ,vanadium, thorium, uranium, niobium, lanthanum, yttrium, gallium, hafnium, tin, cerium, cobalt and so on were observed to have concentrations of 59.67ppm, 13.3ppm, 8.9ppm, 8.9ppm, 10.4ppm, 14.7ppm, 6.7ppm, 10.6ppm, 5.7ppm, 30.3ppm and 3.6ppm respectively.

BOLGA MUNICIPALITY

BOLGA

In Bolga, that is Sawaba, barium concentration was the highest giving a value of 1887ppm. Zirconium concentration was observed to be 738.5ppm, while strontium was noted to be 770ppm and chromium 233ppm in concentration. The remaining minor elements were noted to be 2.9ppm, 4.9ppm, 11ppm, 13.8ppm, 15ppm in concentrations and so on.

BOLGA ESTATE

From the table 4.1, barium was observed to be very high with concentration 1094ppm, followed by zirconium with concentration 632ppm. Chromium and strontium concentrations were noted to

be 588.5ppm and 404.4ppm respectively. The remaining minor elements were found to be very low with concentrations 1.15ppm, 2ppm, 11ppm, 12ppm and 12ppm.

BOLGA MINISTRIES

From the data on table 4.1 generated from the soil samples at Bolga ministries, barium was observed to have the highest concentration 1450ppm, zirconium, 711ppm and strontium 597.3ppm The other minor elements were found to have concentrations .as low as 2.3ppm(Arsenic), tin,4.8ppm, niobium,11.2ppm, gallium,13ppm and nickel, 14.03ppm.

BONGO DISTRICT

From the table, barium was noted to have concentration of 2150ppm which was the highest in the district. Strontium and chromium were observed to have concentrations 951ppm and 412ppm respectively. The other minor elements from the table were observed to have low values.

BOLGA MUNICIPALITY-ZUARUNGU

From table 4.1, zirconium was noted to be 779.6ppm, barium was observed to be 410ppm and strontium 286ppm. The other minor elements were observed to be low in concentrations..

In Navrongo, which is also under Kassena-Nankana East, chromium was noted to be 695ppm, barium, 420ppm, zirconium was 397ppm. From Examination of Water and Waste water (Clesceri et al 1998), the average abundance of chromium in the soil ranges from 11-22ppm and in the earth's crust, it is 122ppm. So in effect, all the chromium content in the soils higher or lower than the reference range are considered to be high or low in concentrations.

Also, the average abundance of vanadium in the soil from the same source, (Clesceri *et al*, 1998) is 15-110ppm, so all vanadium content in the soil analyzed above or below this range are considered high or low. The average abundance of cobalt in the earth's crust is 29ppm and that in the soil is 1.0-14ppm, so, all the soil samples analyzed which were above or below this range are considered high or low in concentrations.

The average abundance of nickel in the earth's crust is1.2ppm, in soils, it is 2.5ppm. It implies that all the soils in the analyzed in the district which had concentrations were above or below this range are high or low in concentrations.The average abundance of arsenic in the earth's crust is 1.8ppm and in soils, it is 5.5ppm-13ppm. It is an indication that all soil samples analyzed in these selected districts which fell below or above this range is noted to be high or low in concentrations.

The average abundance of tin in the earth's crust is 8.1ppm, in soils, it is 13ppm. It therefore, suggests that the soil samples analyzed in the selected district found to be above or below this range is observed to be high or low in concentrations.

.UPPER EAST REGION

In Up per East region, barium was o bserved to have highest concentration of 6 89ppm and strontium concentration was noted to be 460ppm. The other minor elements were found to have low concentrations as.

Some of the elements analyzed in the soil were observed to be radioactive and some are cobalt, chromium, gallium, strontium, thorium and uranium.

METALS	METTALOIDS
Thorium, vanadium, nickel, copper	Arsenic
Uranium, zinc, rubidium, yttrium	
Strontium, gallium, chromium	
Cobalt, zirconium, niobium.	
Tin, cerium, barium, lanthanum	
Hafnium and tantalum	

MAJOR OXIDES (%)

BONGO DISTRICT

From table 4.2, at Vea in the Bongo district, the concentrations of the selected major oxides were observed have concentrations of Al_2O_3 to be 12.8%, P_2O_5, 0.58%, SO_3, 0.44%, MnO, 0.05% and Fe_2O_3, 3.53%

PAGA

From table 4.2, the observed concentrations were as following; Al_2O_3, 8.38%, P_2O_5, 0.68%, SO_3, 0.34%, MnO, 0.35% and Fe_2O_3, 3.5%.

BUILSA DISTRICT (SANDEMA)

In Sandema, the observed concentrations were Al_2O_3, 12.3%, P_2O_5, 0.27%, SO_3, 0.32%, MnO ,0.06% and Fe_2O_3,3.17%.

KASSENA – NANKANA DISTRICT (NAVRONGO)

From table 4.2, the concentrations of the major oxides were 11.35%Al_2O_3, P_2O_5, 0.58%, SO_3, 0.44% , MnO, 0.05% and Fe_2O_3, 3.53%.

BOLGATANGA MUNICIPALITY

SAWABA, BOLGA

In Bolga Sawaba, it was observed that concentrations for major oxides were Al_2O_3, 12.29%, P_2O_5, 0.42%, SO_3, 0.32%, MnO, 0.08% and Fe_2O_3, 3.69%.

In Bolga Estates, concentrations were observed to be Al_2O_3, 11.48% P_2O_5, 0.43%, SO_3, 0.38%, MnO, 0.08% and Fe_2O_3, 3.27%.

BOLGA MINISTRIES

In Bolga ministries, the concentrations of the major oxides were Al_2O_3, 10.18%, P_2O_5, 0.34%, SO_3, 0.44%, MnO, 0.07% and Fe_2O_3, 3.44%

ZUARUNGU

In Zuarungu, which is also under Bolga Municipality, the concentrations of the major oxides were Al_2O_3, 9.15%, P_2O_5, 0.42%, SO_3, 0.35%, MnO, 0.07% and Fe_2O_3, 3.61%.

The toxic elements in soils are arsenic, selenium, niobium, tantalum and manganese. From figure 4.1, in Sawaba, Bolga Municipality, zinc was observed to be greater in concentration, 179.5ppm than lead, 91ppm then arsenic 2.9ppm in concentration. At Bolgatanga Ministries, zinc was observed to be higher in concentration, 85.67ppm than lead which was observed to be 91ppm which was also observed to be higher than arsenic, 2.3ppm.

At Bolgatanga Estate, zinc was observed to have 132.5ppm in concentration than lead which was in turn observed to be 51ppm and was observed to greater than arsenic, 1.15ppm in concentration.

At Paga, zinc was observed to have higher concentration of 180.7ppm than lead, 14.3ppm followed by arsenic with concentration of 0.8ppm. Zinc was noted to have had a higher concentration, 179.5ppm than Bolga Estate, 132.5ppm, Bolga Ministries, 85.67ppm and Paga, 180.7ppm.

From figure 4.2, zinc was observed to have a higher concentration in Bongo, 81ppm than lead, 34ppm and arsenic, 0.7ppm. In Navrongo, which is under Kassena- Nankana district, zinc was noted to be highest in concentration, 36.5ppm, than lead, 8.9ppm which was also observed to be higher than arsenic, 0.65ppm.

In Sandema, which is under Builsa district, zinc was observed have the highest concentration of 152.7ppm than lead, 37.3ppm which was also noted to be higher than arsenic, 1.6ppm.

In Zuarungu, under Bolga Municipality, zinc was noted to have greatest concentration. of 149.7ppm than lead, 23.7ppm and arsenic, 1.7ppm. Zinc was observed to have highest concentration in Sandema, than in Zuarungu, 152.7ppm and Navrongo 36.5ppm.

From figure 4.3, chromium was note to have the highest concentration, 262.4ppm than copper, 34ppm and cobalt, 15.5ppm At Bolga Ministries, chromium was observed to be 246.2ppm , higher than copper, 24ppm and cobalt, 15.3ppm.

At Bolga Eststes, chromium was noted to highest in concentration, 588.5ppm than copper, 32.5ppm and cobalt 15.5ppm. In Paga, chromium was noted to be highest with 619ppm than copper, 34ppm and cobalt, 16ppm. Chromium was highest in Bolga Estates, 588.5ppm than in Bolga Ministries, 246.2ppm and Sawaba, Bolga, 262.4ppm.

From figure 4.4, chromium was noted to be the highest in concentration, 695ppm in Navrongo than in Bongo, 442ppm, Sandema, 233ppm and Zuarungu, 149.7ppm.In Bongo, chromium was noted to be 442ppm which was the highest concentration than copper, 21.3ppm and cobalt, 17ppm. In Navrongo, chromium, was noted to be 695ppm, highest than cobalt, 24ppm and copper, 23.5ppm. In Sandema, chromium was noted to be highest, 233ppm higher than copper, 18.7ppm and cobalt, 15ppm.

CONCLUSION

In conclusion, in Kassena-Nankana West district, being Paga, barium was higher with697.67ppm followed by chromium with 619ppm.Then, zirconium with 517.7ppm. vanadium, rubidium, nickel, copper, cerium, cobalt, bismuth, uranium, tantalum, tin and arsenic zirconium, 379ppm and strontium registered 320ppm. The remaining minor elements were observed strontium concentration of 196.5ppm and zinc concentration of 180ppm respectively. The other minor elements were observed to have low concentration of the remaining minor elements.

At Kassena- Nankana East, that is Sandema, zirconium was 997ppm and was the hi ghest. Strontium was the second highest with 770ppm. Chromium and barium were 233ppm and 180ppm respectively. The other minor elements were found to be low in concentrations.

At Bolga municipality, that is Bolga, barium was highest with 1887ppm, zirconium registered 738.5ppm. Strontium was also found to be 396ppm, whilst chromium content in the soil from this municipality was found to be 262.4ppm. The remaining minor elements such as vanadium, rubidium, nickel, copper, cerium, cobalt, bismuth, uranium tantalum, tin and arsenic registered low levels.

At Bolga estates, barium, zirconium, chromium, strontium were higher in this order. With barium having 1094ppm, zirconium was 632ppm. That of chromium was 588.5ppm and strontium 404.4ppm.

At Bolga ministries, barium was high with 1450ppm, zirconium 711ppm and strontium 597.3ppm. The other elements present in the soil samples were found to be low.

In Bongo district, barium was 2150ppm, strontium, 951ppm and chromium, 412ppm.

With the major oxides, Al_2O_3 in Bongo was observed to have concentration 12.8% and lowest in Paga with concentration 8.4%.

P_2O_5 was high in Paga with concentration of 0.68% and low in Sandema with concentration of 0.27%.

SO_3 was high in Bongo with 0.44% and low in Bolga and Sandema with both districts having the same value of 0.32%. MnO was high in Paga with 0.35% and low in Bongo with 0.05%. Fe_2O_3 was high in Bolga with with approximately 3.7% and low in Sandema with 3.17%. In Upper East region, barium was observed to have concentration of 689ppm and strontium 460ppm.

RECOMMENDATION

Total trace metals and mineral oxides concentrations of soils and sediments do not necessarily indicate toxicity and bioavailability of elements in any given ecosystems. Thus, it is recommended that speciation, bioavailability and bioaccumulation studies be carried out to ascertain the extent to which this data can be used to discuss environmental impact issues.

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Preset Sample Data

Sample Name:	**A**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.2536	±	0.0035	%
16	S	1780	±	13	ppm
17	Cl	416.7	±	5.5	ppm
22	Ti	0.4595	±	0.0018	%
23	V	46.0	±	4.8	ppm
24	Cr	442.2	±	3.2	ppm
27	Co	16.9	±	2.3	ppm
28	Ni	13.2	±	0.6	ppm
29	Cu	21.3	±	0.7	ppm
30	Zn	80.9	±	0.9	ppm
31	Ga	14.8	±	0.5	ppm
32	Ge	1.3	±	0.2	ppm
33	As	0.7	±	0.3	ppm
34	Se	0.5	±	0.2	ppm
35	Br	2.4	±	0.2	ppm
37	Rb	179.3	±	1.2	ppm
38	Sr	951.1	±	2.5	ppm
39	Y	13.3	±	0.5	ppm
40	Zr	975.6	±	2.4	ppm
41	Nb	11.6	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	3.2	±	0.3	ppm
50	Sn	5.9	±	0.3	ppm
51	Sb		<	1.5	ppm
52	Te	4.5	±	0.4	ppm
53	I	3.4	±	1.1	ppm
55	Cs	2.9	±	1.3	ppm
56	Ba	> 2150	±	6	ppm
57	La	21.0	±	2.5	ppm
58	Ce	71.8	±	3.3	ppm
73	Ta		<	4.3	ppm
74	W	4.2	±	0.5	ppm
80	Hg		<	0.9	ppm
81	Tl	1.3	±	0.2	ppm
82	Pb	34.2	±	0.6	ppm
83	Bi	0.7	±	0.2	ppm

Minor Elements

90	Th	15.3	±	0.8	ppm
92	U	13.0	±	1.9	ppm

Sum of concentration 40.52 %

Major Oxides

11	Na2O	1.96	±	0.17	%
12	MgO	1.742	±	0.074	%
13	Al2O3	12.18	±	0.06	%
14	SiO2	48.61	±	0.08	%
15	P2O5	0.5812	±	0.0081	%
16	SO3	0.4446	±	0.0034	%
19	K2O	4.421	±	0.010	%
20	CaO	1.716	±	0.006	%
25	MnO	0.05206	±	0.00037	%
26	Fe2O3	3.531	±	0.005	%

Sum 75.24 %

Preset Sample Data

Sample Name:	**B**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.0779	±	0.0029	%
16	S	952	±	10	ppm
17	Cl	294.4	±	4.7	ppm
22	Ti	0.4753	±	0.0016	%
23	V	120.3	±	5.7	ppm
24	Cr	552.9	±	3.2	ppm
27	Co	36.1	±	3.0	ppm
28	Ni	93.1	±	1.4	ppm
29	Cu	33.5	±	0.8	ppm
30	Zn	47.8	±	0.7	ppm
31	Ga	13.9	±	0.4	ppm
32	Ge	1.0	±	0.2	ppm
33	As	0.6	±	0.2	ppm
34	Se		<	0.3	ppm
35	Br	0.5	±	0.1	ppm
37	Rb	26.2	±	0.5	ppm
38	Sr	264.6	±	1.3	ppm
39	Y	19.7	±	0.4	ppm
40	Zr	181.1	±	1.0	ppm
41	Nb	6.7	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	1.2	±	0.2	ppm
50	Sn	2.0	±	0.2	ppm
51	Sb	1.6	±	0.2	ppm
52	Te		<	1.5	ppm
53	I		<	1.5	ppm
55	Cs	0.8	±	0.6	ppm
56	Ba	360.3	±	2.8	ppm
57	La	15.7	±	2.4	ppm
58	Ce	42.7	±	3.0	ppm
73	Ta		<	5.0	ppm
74	W	2.3	±	0.4	ppm
80	Hg		<	0.9	ppm
81	Tl		<	0.6	ppm
82	Pb	7.8	±	0.5	ppm
83	Bi	0.5	±	0.2	ppm

Minor Elements

90	Th	7.1	±	0.6	ppm
92	U	6.3	±	0.8	ppm

Sum of concentration 36.88 %

Major Oxides

11	Na2O	1.98	±	0.18	%
12	MgO	3.082	±	0.079	%
13	Al2O3	11.46	±	0.06	%
14	SiO2	41.00	±	0.07	%
15	P2O5	0.1785	±	0.0068	%
16	SO3	0.2377	±	0.0025	%
19	K2O	0.8033	±	0.0041	%
20	CaO	2.851	±	0.007	%
25	MnO	0.1796	±	0.0006	%
26	Fe2O3	6.601	±	0.007	%

Sum 68.38 %

Preset Sample Data

Sample Name:	C	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1030	±	0.0037	%
16	S	1217	±	12	ppm
17	Cl	301.8	±	5.0	ppm
22	Ti	0.4041	±	0.0015	%
23	V	40.5	±	4.3	ppm
24	Cr	220.5	±	2.1	ppm
27	Co	17.7	±	2.1	ppm
28	Ni	11.5	±	0.5	ppm
29	Cu	13.9	±	0.6	ppm
30	Zn	17.3	±	0.5	ppm
31	Ga	11.2	±	0.4	ppm
32	Ge	0.9	±	0.1	ppm
33	As	0.8	±	0.3	ppm
34	Se		<	0.3	ppm
35	Br	1.4	±	0.1	ppm
37	Rb	72.4	±	0.8	ppm
38	Sr	299.0	±	1.3	ppm
39	Y	15.1	±	0.4	ppm
40	Zr	732.7	±	1.9	ppm
41	Nb	11.6	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag	2.6	±	0.3	ppm
48	Cd	2.0	±	0.2	ppm
50	Sn		<	1.0	ppm
51	Sb		<	1.5	ppm
52	Te		<	1.5	ppm
53	I	3.8	±	0.9	ppm
55	Cs	2.9	±	1.1	ppm
56	Ba	1167	±	4	ppm
57	La	6.1	±	2.2	ppm
58	Ce	26.5	±	2.8	ppm
73	Ta		<	3.4	ppm
74	W	2.3	±	0.3	ppm
80	Hg		<	0.8	ppm
81	Tl	0.7	±	0.2	ppm
82	Pb	19.6	±	0.5	ppm
83	Bi		<	0.6	ppm

Minor Elements

90	Th	10.4	±	0.7	ppm
92	U	8.8	±	1.3	ppm

Sum of concentration	42.25 %

Major Oxides

11	Na2O	2.51	±	0.18	%
12	MgO	1.921	±	0.074	%
13	Al2O3	10.16	±	0.06	%
14	SiO2	60.42	±	0.09	%
15	P2O5	0.2360	±	0.0086	%
16	SO3	0.3038	±	0.0029	%
19	K2O	2.689	±	0.007	%
20	CaO	0.8674	±	0.0040	%
25	MnO	0.05805	±	0.00034	%
26	Fe2O3	2.549	±	0.004	%

Sum	81.70 %

Preset Sample Data

Sample Name:	**D**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1377	±	0.0036	%
16	S	1481	±	13	ppm
17	Cl	351.7	±	5.1	ppm
22	Ti	0.4155	±	0.0017	%
23	V	101.6	±	5.6	ppm
24	Cr	137.3	±	2.3	ppm
27	Co	20.6	±	2.5	ppm
28	Ni	13.5	±	0.6	ppm
29	Cu	23.9	±	0.8	ppm
30	Zn	367.3	±	1.9	ppm
31	Ga	15.9	±	0.5	ppm
32	Ge	1.0	±	0.2	ppm
33	As	47.3	±	0.8	ppm
34	Se		<	0.4	ppm
35	Br	2.1	±	0.2	ppm
37	Rb	192.1	±	1.3	ppm
38	Sr	866.9	±	2.4	ppm
39	Y	13.4	±	0.6	ppm
40	Zr	751.2	±	2.1	ppm
41	Nb	9.7	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	3.0	±	0.3	ppm
50	Sn	6.3	±	0.3	ppm
51	Sb	6.0	±	0.3	ppm
52	Te	4.2	±	0.4	ppm
53	I		<	1.5	ppm
55	Cs	3.8	±	1.4	ppm
56	Ba	> 2288	±	6	ppm
57	La	11.4	±	2.5	ppm
58	Ce	48.8	±	3.2	ppm
73	Ta		<	4.5	ppm
74	W		<	3.5	ppm
80	Hg		<	1.0	ppm
81	Tl	1.8	±	0.3	ppm
82	Pb	70.0	±	0.8	ppm
83	Bi		<	0.9	ppm

Minor Elements

90	Th	19.5	±	0.8	ppm
92	U	16.5	±	2.1	ppm

Sum of concentration 43.35 %

Major Oxides

11	Na2O	2.30	±	0.19	%
12	MgO	1.787	±	0.078	%
13	Al2O3	12.43	±	0.06	%
14	SiO2	52.63	±	0.08	%
15	P2O5	0.3154	±	0.0082	%
16	SO3	0.3699	±	0.0031	%
19	K2O	5.112	±	0.011	%
20	CaO	1.145	±	0.005	%
25	MnO	0.09305	±	0.00047	%
26	Fe2O3	4.289	±	0.006	%

Sum 80.47 %

Preset Sample Data

Sample Name:	**E**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1589	±	0.0036	%
16	S	1440	±	12	ppm
17	Cl	343.9	±	4.9	ppm
22	Ti	0.2903	±	0.0013	%
23	V	67.2	±	4.5	ppm
24	Cr	647.7	±	3.5	ppm
27	Co	16.0	±	2.1	ppm
28	Ni	14.5	±	0.6	ppm
29	Cu	31.3	±	0.8	ppm
30	Zn	133.5	±	1.1	ppm
31	Ga	12.9	±	0.4	ppm
32	Ge	0.8	±	0.2	ppm
33	As	1.0	±	0.4	ppm
34	Se		<	0.3	ppm
35	Br	3.2	±	0.2	ppm
37	Rb	87.3	±	0.8	ppm
38	Sr	411.4	±	1.6	ppm
39	Y	11.9	±	0.4	ppm
40	Zr	610.7	±	1.7	ppm
41	Nb	7.4	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	2.2	±	0.2	ppm
50	Sn	5.6	±	0.3	ppm
51	Sb	3.9	±	0.3	ppm
52	Te		<	1.5	ppm
53	I	4.4	±	0.9	ppm
55	Cs	3.7	±	1.2	ppm
56	Ba	1126	±	4	ppm
57	La	10.6	±	2.3	ppm
58	Ce	44.7	±	3.0	ppm
73	Ta		<	4.6	ppm
74	W	3.7	±	0.5	ppm
80	Hg		<	0.8	ppm
81	Tl	0.6	±	0.2	ppm
82	Pb	50.2	±	0.7	ppm
83	Bi		<	0.7	ppm

Minor Elements

90	Th	11.8	±	0.7	ppm
92	U	11.4	±	1.4	ppm

Sum of concentration	41.40	%

Major Oxides

11	Na2O	2.81	±	0.18	%
12	MgO	1.927	±	0.074	%
13	Al2O3	11.24	±	0.06	%
14	SiO2	54.50	±	0.08	%
15	P2O5	0.3642	±	0.0083	%
16	SO3	0.3597	±	0.0030	%
19	K2O	2.943	±	0.008	%
20	CaO	1.356	±	0.005	%
25	MnO	0.08630	±	0.00044	%
26	Fe2O3	3.259	±	0.005	%

Sum	78.85	%

Preset Sample Data

Sample Name:	F	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1599	±	0.0040	%
16	S	1396	±	13	ppm
17	Cl	265.1	±	4.7	ppm
22	Ti	0.2901	±	0.0012	%
23	V	75.7	±	4.3	ppm
24	Cr	80.2	±	1.4	ppm
27	Co	15.0	±	2.0	ppm
28	Ni	13.1	±	0.6	ppm
29	Cu	32.7	±	0.8	ppm
30	Zn	71.7	±	0.8	ppm
31	Ga	11.6	±	0.4	ppm
32	Ge	0.8	±	0.2	ppm
33	As	2.2	±	0.3	ppm
34	Se		<	0.3	ppm
35	Br	2.0	±	0.1	ppm
37	Rb	40.0	±	0.6	ppm
38	Sr	295.6	±	1.3	ppm
39	Y	14.0	±	0.4	ppm
40	Zr	975.3	±	2.2	ppm
41	Nb	6.9	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	1.4	±	0.2	ppm
50	Sn	2.8	±	0.2	ppm
51	Sb	1.8	±	0.2	ppm
52	Te	1.1	±	0.3	ppm
53	I	1.9	±	0.8	ppm
55	Cs		<	1.5	ppm
56	Ba	351.5	±	2.6	ppm
57	La	5.1	±	2.1	ppm
58	Ce	28.9	±	2.7	ppm
73	Ta		<	4.5	ppm
74	W	4.1	±	0.5	ppm
80	Hg		<	0.8	ppm
81	Tl	0.5	±	0.2	ppm
82	Pb	15.2	±	0.5	ppm
83	Bi		<	0.6	ppm

Minor Elements

90	Th	12.0	±	0.7	ppm
92	U	7.8	±	1.0	ppm

Sum of concentration	42.10 %

Major Oxides

11	Na2O	2.17	±	0.18	%
12	MgO	2.274	±	0.077	%
13	Al2O3	9.975	±	0.056	%
14	SiO2	60.97	±	0.09	%
15	P2O5	0.3665	±	0.0092	%
16	SO3	0.3485	±	0.0031	%
19	K2O	1.235	±	0.005	%
20	CaO	0.9778	±	0.0037	%
25	MnO	0.06057	±	0.00032	%
26	Fe2O3	3.920	±	0.005	%

Sum	82.30 %

Preset Sample Data

Sample Name:	G	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.0740	±	0.0031	%
16	S	1030	±	10	ppm
17	Cl	278.9	±	4.3	ppm
22	Ti	0.3888	±	0.0013	%
23	V	75.0	±	4.7	ppm
24	Cr	995.6	±	3.9	ppm
27	Co	12.3	±	1.7	ppm
28	Ni	33.8	±	0.8	ppm
29	Cu	16.5	±	0.6	ppm
30	Zn	27.8	±	0.6	ppm
31	Ga	10.6	±	0.4	ppm
32	Ge	0.7	±	0.1	ppm
33	As		<	0.5	ppm
34	Se		<	0.3	ppm
35	Br	0.4	±	0.1	ppm
37	Rb	27.0	±	0.5	ppm
38	Sr	275.7	±	1.3	ppm
39	Y	12.7	±	0.4	ppm
40	Zr	340.3	±	1.3	ppm
41	Nb	6.6	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	1.6	±	0.2	ppm
50	Sn	3.3	±	0.3	ppm
51	Sb		<	1.5	ppm
52	Te		<	1.5	ppm
53	I		<	1.5	ppm
55	Cs		<	1.5	ppm
56	Ba	591.4	±	3.2	ppm
57	La	11.7	±	2.4	ppm
58	Ce	32.8	±	2.9	ppm
73	Ta		<	3.7	ppm
74	W	1.9	±	0.3	ppm
80	Hg		<	0.8	ppm
81	Tl		<	0.6	ppm
82	Pb	10.2	±	0.4	ppm
83	Bi	0.7	±	0.2	ppm

Minor Elements

90	Th	7.9	±	0.6	ppm
92	U	5.9	±	0.8	ppm

Sum of concentration	34.80	%

Major Oxides

11	Na2O	2.16	±	0.18	%
12	MgO	2.076	±	0.069	%
13	Al2O3	8.660	±	0.051	%
14	SiO2	47.34	±	0.07	%
15	P2O5	0.1695	±	0.0071	%
16	SO3	0.2572	±	0.0025	%
19	K2O	1.086	±	0.004	%
20	CaO	1.283	±	0.004	%
25	MnO	0.07054	±	0.00039	%
26	Fe2O3	3.593	±	0.005	%

Sum	66.69	%

Preset Sample Data

Sample Name:	**H**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1043	±	0.0033	%
16	S	1212	±	11	ppm
17	Cl	257.7	±	4.2	ppm
22	Ti	0.3194	±	0.0012	%
23	V	66.5	±	4.2	ppm
24	Cr	64.1	±	1.5	ppm
27	Co	15.1	±	2.0	ppm
28	Ni	10.3	±	0.5	ppm
29	Cu	17.4	±	0.6	ppm
30	Zn	67.7	±	0.8	ppm
31	Ga	14.8	±	0.4	ppm
32	Ge	0.9	±	0.2	ppm
33	As	0.4	±	0.2	ppm
34	Se		<	0.3	ppm
35	Br	2.1	±	0.1	ppm
37	Rb	53.6	±	0.7	ppm
38	Sr	470.4	±	1.7	ppm
39	Y	15.0	±	0.4	ppm
40	Zr	1109	±	2	ppm
41	Nb	8.1	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	1.8	±	0.2	ppm
50	Sn	3.8	±	0.3	ppm
51	Sb		<	1.5	ppm
52	Te		<	1.5	ppm
53	I	3.8	±	0.9	ppm
55	Cs	1.2	±	0.9	ppm
56	Ba	981.5	±	4.0	ppm
57	La	10.9	±	2.4	ppm
58	Ce	12.0	±	2.3	ppm
73	Ta		<	3.7	ppm
74	W	3.2	±	0.4	ppm
80	Hg		<	0.8	ppm
81	Tl	0.8	±	0.2	ppm
82	Pb	14.2	±	0.5	ppm
83	Bi		<	0.6	ppm

Minor Elements

90	Th	11.4	±	0.6	ppm
92	U	7.4	±	1.1	ppm

Sum of concentration 37.63 %

Major Oxides

11	Na2O	1.92	±	0.17	%
12	MgO	1.804	±	0.071	%
13	Al2O3	11.55	±	0.05	%
14	SiO2	50.82	±	0.08	%
15	P2O5	0.2390	±	0.0075	%
16	SO3	0.3027	±	0.0027	%
19	K2O	1.780	±	0.006	%
20	CaO	1.377	±	0.004	%
25	MnO	0.05584	±	0.00032	%
26	Fe2O3	2.664	±	0.004	%

Sum 72.52 %

Preset Sample Data

Sample Name:	I	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1091	±	0.0043	%
16	S	1171	±	12	ppm
17	Cl	295.1	±	5.3	ppm
22	Ti	0.5300	±	0.0019	%
23	V	60.3	±	5.2	ppm
24	Cr	497.6	±	3.5	ppm
27	Co	11.9	±	1.9	ppm
28	Ni	9.7	±	0.5	ppm
29	Cu	14.9	±	0.6	ppm
30	Zn	22.9	±	0.6	ppm
31	Ga	13.7	±	0.4	ppm
32	Ge	1.2	±	0.2	ppm
33	As	0.6	±	0.3	ppm
34	Se		<	0.3	ppm
35	Br	2.2	±	0.1	ppm
37	Rb	166.0	±	1.2	ppm
38	Sr	704.1	±	2.2	ppm
39	Y	18.7	±	0.6	ppm
40	Zr	1131	±	3	ppm
41	Nb	13.6	±	0.4	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	3.6	±	0.3	ppm
50	Sn	5.6	±	0.3	ppm
51	Sb	5.4	±	0.3	ppm
52	Te	5.0	±	0.4	ppm
53	I	5.3	±	1.1	ppm
55	Cs	4.3	±	1.4	ppm
56	Ba	> 2290	±	6	ppm
57	La	14.8	±	2.5	ppm
58	Ce	31.9	±	3.0	ppm
73	Ta		<	3.9	ppm
74	W	2.1	±	0.3	ppm
80	Hg		<	0.9	ppm
81	Tl	1.7	±	0.2	ppm
82	Pb	27.9	±	0.6	ppm
83	Bi		<	0.7	ppm

Minor Elements

90	Th	19.7	±	0.8	ppm
92	U	17.4	±	2.0	ppm

Sum of concentration	47.58	%

Major Oxides

11	Na2O	1.89	±	0.18	%
12	MgO	1.873	±	0.083	%
13	Al2O3	12.98	±	0.06	%
14	SiO2	65.28	±	0.10	%
15	P2O5	0.2500	±	0.0098	%
16	SO3	0.2925	±	0.0031	%
19	K2O	5.185	±	0.011	%
20	CaO	0.3178	±	0.0040	%
25	MnO	0.03420	±	0.00033	%
26	Fe2O3	2.567	±	0.004	%

Sum	90.67	%

Preset Sample Data

Sample Name:	J	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.2215	±	0.0040	%
16	S	1431	±	13	ppm
17	Cl	429.0	±	5.7	ppm
22	Ti	0.4254	±	0.0016	%
23	V	84.5	±	5.3	ppm
24	Cr	457.7	±	3.2	ppm
27	Co	13.2	±	2.0	ppm
28	Ni	14.7	±	0.6	ppm
29	Cu	33.1	±	0.8	ppm
30	Zn	144.6	±	1.2	ppm
31	Ga	14.6	±	0.5	ppm
32	Ge	1.4	±	0.2	ppm
33	As	4.3	±	0.6	ppm
34	Se		<	0.4	ppm
35	Br	5.5	±	0.2	ppm
37	Rb	156.4	±	1.1	ppm
38	Sr	674.5	±	2.1	ppm
39	Y	16.8	±	0.6	ppm
40	Zr	803.7	±	2.1	ppm
41	Nb	11.6	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	3.1	±	0.3	ppm
50	Sn	8.0	±	0.3	ppm
51	Sb	5.2	±	0.3	ppm
52	Te	4.1	±	0.4	ppm
53	I	4.1	±	1.1	ppm
55	Cs	3.9	±	1.3	ppm
56	Ba	1830	±	5	ppm
57	La	24.8	±	2.6	ppm
58	Ce	89.8	±	3.4	ppm
73	Ta		<	5.0	ppm
74	W	4.1	±	0.6	ppm
80	Hg		<	1.0	ppm
81	Tl	1.7	±	0.2	ppm
82	Pb	72.4	±	0.8	ppm
83	Bi		<	0.8	ppm

Minor Elements

90	Th	17.3	±	0.8	ppm
92	U	14.3	±	1.9	ppm

Sum of concentration	43.47	%

Major Oxides

11	Na2O	2.36	±	0.19	%
12	MgO	1.851	±	0.081	%
13	Al2O3	12.59	±	0.06	%
14	SiO2	54.38	±	0.09	%
15	P2O5	0.5075	±	0.0092	%
16	SO3	0.3573	±	0.0032	%
19	K2O	4.054	±	0.009	%
20	CaO	1.255	±	0.005	%
25	MnO	0.07502	±	0.00042	%
26	Fe2O3	4.156	±	0.005	%

Sum	81.59	%

Preset Sample Data

Sample Name:	**K**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.4198	±	0.0041	%
16	S	1523	±	12	ppm
17	Cl	350.7	±	4.8	ppm
22	Ti	0.5339	±	0.0017	%
23	V	58.1	±	5.5	ppm
24	Cr	288.5	±	2.4	ppm
27	Co	18.6	±	2.2	ppm
28	Ni	18.0	±	0.6	ppm
29	Cu	33.1	±	0.7	ppm
30	Zn	102.9	±	0.9	ppm
31	Ga	9.5	±	0.4	ppm
32	Ge	0.8	±	0.1	ppm
33	As	0.6	±	0.2	ppm
34	Se		<	0.3	ppm
35	Br	3.9	±	0.1	ppm
37	Rb	37.2	±	0.6	ppm
38	Sr	164.2	±	1.0	ppm
39	Y	19.1	±	0.4	ppm
40	Zr	559.6	±	1.6	ppm
41	Nb	11.7	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	2.5	±	0.2	ppm
50	Sn	8.2	±	0.3	ppm
51	Sb	2.7	±	0.3	ppm
52	Te		<	1.5	ppm
53	I	2.5	±	0.8	ppm
55	Cs		<	1.5	ppm
56	Ba	439.9	±	2.9	ppm
57	La	8.2	±	2.2	ppm
58	Ce	17.1	±	2.5	ppm
73	Ta		<	4.5	ppm
74	W	3.3	±	0.4	ppm
80	Hg		<	0.8	ppm
81	Tl	0.9	±	0.2	ppm
82	Pb	18.1	±	0.5	ppm
83	Bi	0.4	±	0.1	ppm

Minor Elements

90	Th	11.5	±	0.7	ppm
92	U	6.9	±	1.0	ppm

Sum of concentration 37.63 %

Major Oxides

11	Na2O	0.58	±	0.11	%
12	MgO	2.133	±	0.072	%
13	Al2O3	8.703	±	0.053	%
14	SiO2	52.96	±	0.08	%
15	P2O5	0.9620	±	0.0094	%
16	SO3	0.3803	±	0.0031	%
19	K2O	1.130	±	0.005	%
20	CaO	2.643	±	0.006	%
25	MnO	0.08073	±	0.00040	%
26	Fe2O3	3.346	±	0.005	%

Sum 72.91 %

Preset Sample Data

Sample Name:	L	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.2902	±	0.0040	%
16	S	1743	±	14	ppm
17	Cl	319.0	±	4.9	ppm
22	Ti	0.3376	±	0.0013	%
23	V	76.9	±	4.8	ppm
24	Cr	132.5	±	1.8	ppm
27	Co	15.8	±	2.1	ppm
28	Ni	17.3	±	0.7	ppm
29	Cu	42.0	±	0.9	ppm
30	Zn	271.6	±	1.5	ppm
31	Ga	12.2	±	0.4	ppm
32	Ge	1.0	±	0.2	ppm
33	As	1.8	±	0.4	ppm
34	Se		<	0.3	ppm
35	Br	3.6	±	0.2	ppm
37	Rb	46.9	±	0.7	ppm
38	Sr	311.0	±	1.4	ppm
39	Y	15.6	±	0.4	ppm
40	Zr	572.9	±	1.7	ppm
41	Nb	8.3	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	2.7	±	0.2	ppm
50	Sn	4.0	±	0.3	ppm
51	Sb	3.3	±	0.3	ppm
52	Te		<	1.5	ppm
53	I	2.6	±	0.8	ppm
55	Cs	2.0	±	0.9	ppm
56	Ba	475.8	±	2.9	ppm
57	La	11.7	±	2.3	ppm
58	Ce	26.7	±	2.7	ppm
73	Ta		<	5.1	ppm
74	W	2.6	±	0.5	ppm
80	Hg		<	0.8	ppm
81	Tl	0.9	±	0.2	ppm
82	Pb	40.0	±	0.6	ppm
83	Bi		<	0.7	ppm

Minor Elements

90	Th	12.1	±	0.7	ppm
92	U	10.8	±	1.2	ppm

Sum of concentration 40.56 %

Major Oxides

11	Na2O	2.65	±	0.18	%
12	MgO	2.430	±	0.078	%
13	Al2O3	10.87	±	0.06	%
14	SiO2	52.55	±	0.08	%
15	P2O5	0.6649	±	0.0092	%
16	SO3	0.4351	±	0.0034	%
19	K2O	1.576	±	0.005	%
20	CaO	2.085	±	0.006	%
25	MnO	0.08682	±	0.00039	%
26	Fe2O3	4.143	±	0.005	%

Sum 77.50 %

Preset Sample Data

Sample Name:	**M**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1875	±	0.0033	%
16	S	2596	±	15	ppm
17	Cl	297.1	±	4.7	ppm
22	Ti	0.3266	±	0.0016	%
23	V	75.9	±	5.4	ppm
24	Cr	59.5	±	1.9	ppm
27	Co	15.0	±	2.1	ppm
28	Ni	12.4	±	0.6	ppm
29	Cu	24.9	±	0.7	ppm
30	Zn	94.8	±	1.0	ppm
31	Ga	12.6	±	0.4	ppm
32	Ge	0.9	±	0.2	ppm
33	As	1.9	±	0.4	ppm
34	Se	0.4	±	0.2	ppm
35	Br	10.1	±	0.2	ppm
37	Rb	117.3	±	1.0	ppm
38	Sr	817.5	±	2.3	ppm
39	Y	13.4	±	0.5	ppm
40	Zr	596.5	±	1.9	ppm
41	Nb	9.6	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	3.0	±	0.3	ppm
50	Sn	5.4	±	0.3	ppm
51	Sb		<	1.5	ppm
52	Te	3.9	±	0.4	ppm
53	I	4.3	±	1.0	ppm
55	Cs		<	1.5	ppm
56	Ba	1353	±	5	ppm
57	La	12.6	±	2.4	ppm
58	Ce	51.2	±	3.1	ppm
73	Ta		<	4.4	ppm
74	W	3.8	±	0.5	ppm
80	Hg		<	0.9	ppm
81	Tl	1.3	±	0.2	ppm
82	Pb	29.1	±	0.6	ppm
83	Bi		<	0.7	ppm

Minor Elements

90	Th	13.5	±	0.7	ppm
92	U	11.6	±	1.6	ppm

Sum of concentration	35.87	%

Major Oxides

11	Na2O	1.67	±	0.16	%
12	MgO	1.602	±	0.069	%
13	Al2O3	8.571	±	0.049	%
14	SiO2	40.56	±	0.07	%
15	P2O5	0.4295	±	0.0075	%
16	SO3	0.6483	±	0.0037	%
19	K2O	2.740	±	0.008	%
20	CaO	6.034	±	0.011	%
25	MnO	0.07805	±	0.00044	%
26	Fe2O3	3.394	±	0.005	%

Sum	65.73	%

Preset Sample Data

Sample Name:	**N**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.2582	±	0.0040	%
16	S	1415	±	13	ppm
17	Cl	333.4	±	5.2	ppm
22	Ti	0.3776	±	0.0016	%
23	V	103.2	±	5.5	ppm
24	Cr	66.8	±	1.9	ppm
27	Co	18.2	±	2.4	ppm
28	Ni	12.9	±	0.6	ppm
29	Cu	37.7	±	0.9	ppm
30	Zn	214.4	±	1.4	ppm
31	Ga	14.8	±	0.5	ppm
32	Ge	1.4	±	0.2	ppm
33	As	1.5	±	0.6	ppm
34	Se	0.6	±	0.2	ppm
35	Br	4.1	±	0.2	ppm
37	Rb	139.7	±	1.2	ppm
38	Sr	724.9	±	2.2	ppm
39	Y	17.7	±	0.6	ppm
40	Zr	672.5	±	2.0	ppm
41	Nb	9.3	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	4.0	±	0.3	ppm
50	Sn	14.1	±	0.4	ppm
51	Sb	6.1	±	0.3	ppm
52	Te		<	1.5	ppm
53	I	5.6	±	1.1	ppm
55	Cs	5.9	±	1.4	ppm
56	Ba	> 1944	±	6	ppm
57	La	23.6	±	2.6	ppm
58	Ce	99.3	±	3.5	ppm
73	Ta	4.8	±	1.5	ppm
74	W	3.5	±	0.6	ppm
80	Hg		<	1.0	ppm
81	Tl	1.9	±	0.3	ppm
82	Pb	110.1	±	0.9	ppm
83	Bi		<	0.9	ppm

Minor Elements

90	Th	16.7	±	0.9	ppm
92	U	17.1	±	2.0	ppm

Sum of concentration	41.73	%

Major Oxides

11	Na2O	2.17	±	0.19	%
12	MgO	1.732	±	0.079	%
13	Al2O3	11.99	±	0.06	%
14	SiO2	51.01	±	0.08	%
15	P2O5	0.5917	±	0.0091	%
16	SO3	0.3534	±	0.0031	%
19	K2O	4.183	±	0.010	%
20	CaO	1.112	±	0.005	%
25	MnO	0.09239	±	0.00045	%
26	Fe2O3	4.709	±	0.006	%

Sum	77.94	%

Preset Sample Data

Sample Name:	O	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.3957	±	0.0043	%
16	S	1551	±	13	ppm
17	Cl	415.3	±	5.5	ppm
22	Ti	0.5685	±	0.0020	%
23	V	45.6	±	6.5	ppm
24	Cr	572.2	±	3.8	ppm
27	Co	16.8	±	2.3	ppm
28	Ni	53.4	±	1.1	ppm
29	Cu	52.4	±	1.0	ppm
30	Zn	410.7	±	1.9	ppm
31	Ga	9.1	±	0.4	ppm
32	Ge	1.1	±	0.2	ppm
33	As	1.3	±	0.3	ppm
34	Se		<	0.3	ppm
35	Br	3.8	±	0.2	ppm
37	Rb	41.1	±	0.6	ppm
38	Sr	446.8	±	1.7	ppm
39	Y	20.4	±	0.4	ppm
40	Zr	526.6	±	1.7	ppm
41	Nb	11.6	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	3.2	±	0.3	ppm
50	Sn	10.9	±	0.3	ppm
51	Sb	4.4	±	0.3	ppm
52	Te		<	1.5	ppm
53	I	4.0	±	0.9	ppm
55	Cs		<	1.5	ppm
56	Ba	517.4	±	3.1	ppm
57	La	7.1	±	2.2	ppm
58	Ce	14.8	±	2.4	ppm
73	Ta		<	5.9	ppm
74	W		<	3.8	ppm
80	Hg		<	0.9	ppm
81	Tl	0.9	±	0.2	ppm
82	Pb	26.9	±	0.6	ppm
83	Bi		<	0.7	ppm

Minor Elements

90	Th	12.5	±	0.7	ppm
92	U	7.5	±	1.0	ppm

Sum of concentration 40.15 %

Major Oxides

11	Na2O	1.06	±	0.15	%
12	MgO	2.338	±	0.077	%
13	Al2O3	7.792	±	0.053	%
14	SiO2	49.25	±	0.08	%
15	P2O5	0.9068	±	0.0098	%
16	SO3	0.3873	±	0.0033	%
19	K2O	1.238	±	0.006	%
20	CaO	8.087	±	0.014	%
25	MnO	0.08285	±	0.00049	%
26	Fe2O3	3.558	±	0.005	%

Sum 74.70 %

Preset Sample Data

Sample Name:	P	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.2202	±	0.0042	%
16	S	1573	±	13	ppm
17	Cl	342.4	±	5.1	ppm
22	Ti	0.2842	±	0.0013	%
23	V	73.6	±	4.5	ppm
24	Cr	529.1	±	3.2	ppm
27	Co	14.8	±	2.1	ppm
28	Ni	13.3	±	0.6	ppm
29	Cu	33.7	±	0.8	ppm
30	Zn	131.2	±	1.1	ppm
31	Ga	13.7	±	0.4	ppm
32	Ge	1.3	±	0.2	ppm
33	As	1.3	±	0.4	ppm
34	Se		<	0.3	ppm
35	Br	2.3	±	0.1	ppm
37	Rb	86.0	±	0.8	ppm
38	Sr	397.7	±	1.5	ppm
39	Y	12.3	±	0.4	ppm
40	Zr	652.7	±	1.8	ppm
41	Nb	8.1	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	3.2	±	0.3	ppm
50	Sn	5.7	±	0.3	ppm
51	Sb	4.6	±	0.3	ppm
52	Te		<	1.5	ppm
53	I		<	1.5	ppm
55	Cs	2.0	±	1.0	ppm
56	Ba	1062	±	4	ppm
57	La	11.3	±	2.3	ppm
58	Ce	41.1	±	3.0	ppm
73	Ta		<	4.7	ppm
74	W	2.3	±	0.4	ppm
80	Hg		<	0.9	ppm
81	Tl	1.7	±	0.3	ppm
82	Pb	52.3	±	0.7	ppm
83	Bi		<	0.7	ppm

Minor Elements

90	Th	12.9	±	0.7	ppm
92	U	12.6	±	1.4	ppm

Sum of concentration 42.30 %

Major Oxides

11	Na2O	1.85	±	0.18	%
12	MgO	1.828	±	0.080	%
13	Al2O3	11.72	±	0.06	%
14	SiO2	58.16	±	0.09	%
15	P2O5	0.5046	±	0.0096	%
16	SO3	0.3927	±	0.0033	%
19	K2O	3.068	±	0.008	%
20	CaO	0.7495	±	0.0039	%
25	MnO	0.05630	±	0.00036	%
26	Fe2O3	3.272	±	0.005	%

Sum 81.59 %

Preset Sample Data

Sample Name:	Q	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1478	±	0.0036	%
16	S	1767	±	13	ppm
17	Cl	341.7	±	5.0	ppm
22	Ti	0.4043	±	0.0017	%
23	V	91.8	±	5.9	ppm
24	Cr	355.5	±	3.2	ppm
27	Co	16.7	±	2.3	ppm
28	Ni	15.5	±	0.7	ppm
29	Cu	27.2	±	0.8	ppm
30	Zn	1292	±	4	ppm
31	Ga	14.2	±	0.5	ppm
32	Ge	1.1	±	0.2	ppm
33	As	3.7	±	0.6	ppm
34	Se	0.5	±	0.2	ppm
35	Br	3.5	±	0.2	ppm
37	Rb	151.3	±	1.1	ppm
38	Sr	749.8	±	2.2	ppm
39	Y	15.4	±	0.6	ppm
40	Zr	686.7	±	2.0	ppm
41	Nb	11.2	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	3.7	±	0.3	ppm
50	Sn	7.0	±	0.3	ppm
51	Sb	6.6	±	0.3	ppm
52	Te	5.0	±	0.4	ppm
53	I	4.8	±	1.1	ppm
55	Cs	2.4	±	1.2	ppm
56	Ba	1623	±	5	ppm
57	La	11.7	±	2.4	ppm
58	Ce	55.8	±	3.1	ppm
73	Ta		<	5.0	ppm
74	W		<	6.4	ppm
80	Hg		<	1.0	ppm
81	Tl	2.0	±	0.3	ppm
82	Pb	75.3	±	0.8	ppm
83	Bi		<	0.8	ppm

Minor Elements

90	Th	16.0	±	0.8	ppm
92	U	14.2	±	1.9	ppm

Sum of concentration	39.54	%

Major Oxides

11	Na2O	1.05	±	0.14	%
12	MgO	1.711	±	0.078	%
13	Al2O3	11.02	±	0.06	%
14	SiO2	46.19	±	0.08	%
15	P2O5	0.3386	±	0.0082	%
16	SO3	0.4411	±	0.0033	%
19	K2O	3.644	±	0.009	%
20	CaO	4.305	±	0.009	%
25	MnO	0.06641	±	0.00043	%
26	Fe2O3	4.081	±	0.005	%

Sum	72.84	%

Preset Sample Data

Sample Name:	R	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.0921	±	0.0040	%
16	S	1186	±	11	ppm
17	Cl	248.7	±	4.7	ppm
22	Ti	0.2748	±	0.0012	%
23	V	56.2	±	4.3	ppm
24	Cr	837.0	±	3.8	ppm
27	Co	11.9	±	1.9	ppm
28	Ni	10.9	±	0.5	ppm
29	Cu	13.5	±	0.6	ppm
30	Zn	24.9	±	0.5	ppm
31	Ga	14.5	±	0.4	ppm
32	Ge	1.3	±	0.2	ppm
33	As	0.7	±	0.2	ppm
34	Se	0.4	±	0.2	ppm
35	Br	1.7	±	0.1	ppm
37	Rb	26.2	±	0.5	ppm
38	Sr	375.3	±	1.5	ppm
39	Y	13.6	±	0.4	ppm
40	Zr	804.1	±	2.0	ppm
41	Nb	6.5	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag	3.4	±	0.3	ppm
48	Cd	2.8	±	0.2	ppm
50	Sn	3.7	±	0.3	ppm
51	Sb	2.9	±	0.3	ppm
52	Te		<	1.5	ppm
53	I	3.8	±	0.9	ppm
55	Cs	1.7	±	0.9	ppm
56	Ba	480.2	±	3.0	ppm
57	La	6.5	±	2.2	ppm
58	Ce	6.1	±	1.7	ppm
73	Ta		<	3.6	ppm
74	W	1.9	±	0.3	ppm
80	Hg		<	0.8	ppm
81	Tl	1.3	±	0.2	ppm
82	Pb	10.1	±	0.4	ppm
83	Bi	0.8	±	0.2	ppm

Minor Elements

90	Th	7.7	±	0.6	ppm
92	U	6.7	±	0.9	ppm

Sum of concentration	42.02 %

Major Oxides

11	Na2O	3.05	±	0.19	%
12	MgO	2.117	±	0.079	%
13	Al2O3	11.24	±	0.06	%
14	SiO2	57.68	±	0.09	%
15	P2O5	0.2111	±	0.0092	%
16	SO3	0.2960	±	0.0029	%
19	K2O	1.045	±	0.005	%
20	CaO	2.629	±	0.006	%
25	MnO	0.04140	±	0.00033	%
26	Fe2O3	2.880	±	0.004	%

Sum	81.18 %

Preset Sample Data

Sample Name:	**S**	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1514	±	0.0039	%
16	S	1768	±	14	ppm
17	Cl	277.5	±	4.9	ppm
22	Ti	0.4229	±	0.0018	%
23	V	74.9	±	5.6	ppm
24	Cr	425.5	±	3.4	ppm
27	Co	16.9	±	2.3	ppm
28	Ni	11.4	±	0.6	ppm
29	Cu	18.6	±	0.7	ppm
30	Zn	30.8	±	0.6	ppm
31	Ga	13.7	±	0.5	ppm
32	Ge	1.3	±	0.2	ppm
33	As	0.5	±	0.3	ppm
34	Se	0.8	±	0.2	ppm
35	Br	6.8	±	0.2	ppm
37	Rb	170.5	±	1.2	ppm
38	Sr	946.1	±	2.6	ppm
39	Y	15.8	±	0.6	ppm
40	Zr	1002	±	3	ppm
41	Nb	12.3	±	0.4	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	4.5	±	0.3	ppm
50	Sn	6.3	±	0.3	ppm
51	Sb		<	1.5	ppm
52	Te	5.5	±	0.4	ppm
53	I	5.5	±	1.1	ppm
55	Cs	5.7	±	1.5	ppm
56	Ba	> 1943	±	6	ppm
57	La	19.0	±	2.5	ppm
58	Ce	76.7	±	3.3	ppm
73	Ta	6.3	±	1.5	ppm
74	W	3.2	±	0.4	ppm
80	Hg		<	1.0	ppm
81	Tl	1.9	±	0.2	ppm
82	Pb	34.7	±	0.6	ppm
83	Bi	0.4	±	0.1	ppm

Minor Elements

90	Th	17.7	±	0.8	ppm
92	U	15.3	±	2.1	ppm

Sum of concentration	41.18	%

Major Oxides

11	Na2O	2.22	±	0.18	%
12	MgO	1.799	±	0.078	%
13	Al2O3	10.96	±	0.06	%
14	SiO2	50.27	±	0.08	%
15	P2O5	0.3469	±	0.0088	%
16	SO3	0.4414	±	0.0034	%
19	K2O	4.229	±	0.010	%
20	CaO	2.382	±	0.007	%
25	MnO	0.06361	±	0.00042	%
26	Fe2O3	3.731	±	0.005	%

Sum	76.44	%

Preset Sample Data

Sample Name:	T	Dilution Material:	HWC
Description:		Sample Mass (g):	4.0000
Method:	Geo-4013	Dilution Mass (g):	0.9000
Job Number:	000	Dilution Factor:	0.8163
Sample State:	Pressed tablet, 32 mm	Sample rotation:	No
Sample Type:	Preßtablette	Date of Receipt:	01/12/2011
Sample Status:	A A A A A X	Date of Evaluation:	01/13/2011

Results

The error is the statistical error with 1 sigma confidence interval

Minor Elements

15	P	0.1851	±	0.0039	%
16	S	1378	±	12	ppm
17	Cl	270.9	±	4.5	ppm
22	Ti	0.2910	±	0.0012	%
23	V	58.5	±	4.2	ppm
24	Cr	236.1	±	2.0	ppm
27	Co	19.2	±	2.3	ppm
28	Ni	12.7	±	0.6	ppm
29	Cu	30.4	±	0.8	ppm
30	Zn	104.7	±	0.9	ppm
31	Ga	9.4	±	0.4	ppm
32	Ge	0.9	±	0.2	ppm
33	As	1.1	±	0.3	ppm
34	Se	0.4	±	0.2	ppm
35	Br	2.4	±	0.1	ppm
37	Rb	39.4	±	0.6	ppm
38	Sr	251.4	±	1.2	ppm
39	Y	13.2	±	0.4	ppm
40	Zr	791.4	±	2.0	ppm
41	Nb	7.4	±	0.3	ppm
42	Mo		<	1.0	ppm
47	Ag		<	0.8	ppm
48	Cd	2.5	±	0.2	ppm
50	Sn	5.1	±	0.3	ppm
51	Sb		<	1.5	ppm
52	Te		<	1.5	ppm
53	I	3.6	±	0.8	ppm
55	Cs	3.6	±	1.1	ppm
56	Ba	402.1	±	2.7	ppm
57	La	9.9	±	2.3	ppm
58	Ce	22.5	±	2.7	ppm
73	Ta		<	4.5	ppm
74	W	3.9	±	0.5	ppm
80	Hg		<	0.8	ppm
81	Tl	1.1	±	0.2	ppm
82	Pb	16.3	±	0.5	ppm
83	Bi	0.9	±	0.2	ppm

Minor Elements

90	Th	11.9	±	0.7	ppm
92	U	7.6	±	1.0	ppm

Sum of concentration	37.11	%

Major Oxides

11	Na2O	2.38	±	0.18	%
12	MgO	2.198	±	0.072	%
13	Al2O3	7.907	±	0.052	%
14	SiO2	53.44	±	0.08	%
15	P2O5	0.4241	±	0.0089	%
16	SO3	0.3442	±	0.0029	%
19	K2O	1.188	±	0.005	%
20	CaO	1.124	±	0.004	%
25	MnO	0.06442	±	0.00034	%
26	Fe2O3	3.102	±	0.004	%

Sum	72.17	%

DISTRICT SAMPLING AND WAY POINTS

District	Sampling points		Way Point(North)	Way point(East)
Bolga 1	Sawaba	30 P	0735415	1192672
Bolga 2	Sawaba	30 P	0735410	1192684
Bolga 3	Sawaba	30 P	0735431	1192682
Bolga 4	Sawaba	30 P	0735441	192685
Bolga 5	Sawaba	30 P	0735415	1192707
Bolga	Bolga Ministries 1	30 P	0734481	1194327
	Bolga Ministries 2	30 P	0734490	1194330
	Bolga Ministries 3	30 P	0734507	1194357
	Bolga Ministries 4	30 P	0734572	1194308
	Bolga Ministries 5	30 P	0734562	1194305
	Bolga – STS yard 1	30 P	0731437	1192039
	Bolga – STC yard 2	30 P	0734442	1192035
	Bolga – STC yard 3	30 P	0734450	1191929
	Bolga - STC 4 yard	30 P	0734455	1191924
	Balga - STC yard 5	30 P	0731442	1191922
Kassena -	Kassena Nankana Dam	30 P	07085131	1203838
Nankana				
	(KND1)			
	KND 2	30 P	0708537	1203831
	KND 3	30 P	0708539	1203821
	KND 4	30 P	0708538	1203813
	KND 5	30 P	0708540	1203802
	Near the border corn mill	30 P	0705312	1216261
PAGA	Near paga 1			

	Border point paga 2	30 P	0705410	1216275
	Paga 3	30 P	0705314	1216020
	Paga 4	30 P	0706216	121590
	Paga 5	30 P	0705150	1216030
Builsa	Sardema (S1)	30 P	0691352	1189881
	S 2	30 P	0691104	1189103
	S 3	30 P	0685760	1185806
	S 4	30 P	0687760	1184615
	S 5	30 P	0692577	1190642
Bolga	Zuarungu(Z1) (Water Reservoir area)	30 P	0741513	1193899
	Z 2			
	Zuarungu Cooperative Farmer Association	30 P	0741530	1193983
	Zuarungu Health center (ZHC)	30 P	0741258	1193799
	Zuarungu Muslin House (ZMH)	30 P	0741435	1193930
	Zuarungu Taxi Rank (ZTR)	30 P	0741387	1193908
Bongo	Bongo 1	30 P	0739752	1206835
	Bongo 2	30 P	0739964	1206737
	Vea	30 P	0735156	1201844
	Bongo 4	30 P	0739755	1206833
	Bongo 5	30 P	0739755	1206836

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**GEOLOGICAL SURVEY DEPARTMENT**													
2	**X-RAY FLUORESCENCE LABORATORY RESULTS**													
3														
4	**MAJOR OXIDES(%)**													
5	**ELEMENT**	**Na_2O**	**MgO**	**Al_2O_3**	**S_1O_2**	**P_2O_5**	**SO_3**	**Cl**	**K_2O**	**CaO**	**TiO_2**	**MnO**	**Fe_2O_3**	**L.O.1**
6	**LOCATION**													
7	**PAGA 2**	0.58	2.13	8.7	52.96	0.96	0.38	0.04	1.13	2.64	0.89	0.08	3.35	26.2
8	**PAGA 4**	2.16	2.08	8.66	47.34	0.17	0.26	0.03	1.09	1.28	0.65	0.07	3.59	32.7
9	**PAGA 5**	1.06	2.34	7.79	49.25	0.91	0.39	0.04	1.24	8.09	0.95	0.08	3.56	24.4
10	**B1**	2.36	1.85	12.59	54.38	0.25	0.29	0.03	1.78	1.38	0.53	0.06	2.66	27.1
11	**B5**	2.17	1.73	11.99	51.01	0.59	0.35	0.03	4.18	1.11	0.63	0.09	4.71	21.4
12	**S1**	1.89	1.87	12.98	65.28	0.25	0.29	0.03	5.19	0.32	0.88	0.03	2.57	8.5
13	**S4**	1.92	1.8	11.55	50.82	0.24	0.3	0.03	1.78	1.38	0.53	0.06	2.66	27.1
14	**S5**	2.3	1.79	12.43	52.63	0.32	0.37	0.04	5.11	1.15	0.69	0.09	4.29	18.9
15	**ZMH**	2.65	2.43	10.87	52.55	0.66	0.44	0	1.58	2.09	0.56	0.09	4.14	22.1
16	**ZMH**	2.38	2.2	7.91	53.44	0.42	0.34	0.03	1.19	1.12	0.49	0.06	3.1	27.4
17	**ZTR**	2.16	2.08	8.66	47.34	0.17	0.26	0.03	1.09	1.28	0.65	0.07	3.59	32.7
18	**B-STC4**	2.81	1.93	11.24	54.5	0.36	0.36	0.03	2.94	1.36	0.48	0.09	3.26	20.7
19	**B-STC5**	1.85	1.83	11.72	58.16	0.5	0.39	0.03	3.07	0.75	0.47	0.06	3.27	17.9
20	**BM1**	2.22	1.8	10.96	50.27	0.35	0.44	0.03	4.23	2.38	0.71	0.06	3.73	22.9
21	**BM3**	1.67	1.6	8.57	40.56	0.43	0.65	0.03	2.74	6.03	0.54	0.08	3.39	33.7
22	**BM4**	1.05	1.71	11.02	46.19	0.34	0.44	0.03	3.64	4.31	0.67	0.07	4.08	26.5
23	**BM5**	2.51	1.92	10.16	60.42	0.24	0.3	0.03	2.69	0.87	0.67	0.06	2.55	17.6
24	**KND1**	3.05	2.12	11.24	51.68	0.21	0.3	0.02	1.05	2.63	0.46	0.04	2.88	18.4
25	**KND2**	1.98	3.08	11.46	41	0.18	0.24	0.03	0.8	2.85	0.79	0.18	6.6	30.9
26	**BG**	1.96	1.74	12.18	48.61	0.58	0.44	0.04	4.42	1.72	0.77	0.05	3.53	24.1