SPECIATION OF TRACE ELEMENTS IN SELECTED MEDICINAL PLANTS FROM NYAMIRA COUNTY (KENYA)

BY

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Declaration

This thesis is my original work and has not been submitted to any university for the award of any degree

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DEDICATIONS

This work is dedicated to my family: wife Moraa, daughters Sharon, Zylene, Vivian, son Dan Junior, my mother Kerubo, my late father Nyanchama Okiega and the users of the herbal medicine in Nyamira County.

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ABSTRACT

In this study medicinal plants used by herbalist in Nyamira County, Kenya were evaluated and characterized for their elemental species. Experienced herbalists and the medicinal plants they use to treat different diseases were assessed. Elemental species in medicinal plants were determined and correlated to the diseases they treat. A questionnaire was administered to four hundred herbalists in four Sub-Counties, Borabu, Ekerenyo, Manga and Nyamira that comprise Nyamira County. Seventy six herbalists in each sub-county were randomly selected using the questionnaires. The herbalists were established by mapping their clinics using geographical position system (GPS). A total of three hundred and four medicinal plants were sampled from the herbalists and analyzed for various trace and macro elements. The questionnaires were analyzed to establish the demographics and social status of the herbalists, the predominant diseases treated and medicinal plants used by the herbalists. Total levels of magnesium, copper, zinc, iron, manganese and chromium in the medicinal plants were determined by flame Atomic absorption spectrometry using acetylene at 2000ºC and inductively coupled plasma- mass spectrometry. Sequential Extractions was used to fractionate iron, chromium, manganese, zinc and copper in the medicinal plants. One hundred and sixty herbalists were found to treat predominantly malaria and diabetes and with high treatment success rates. Twelve medicinal plants were used to treat diabetes and ten medicinal plants were found to treat malaria. A total of 19 medicinal plants were used in the treatment of malaria and diabetes. The four mostly used medicinal plants to treat malaria with 100% usage were *Aloe vera*, *Clerodendrum myricoides, Toddalia asiatica* and *Warburgia ugandensis* while those used to treat diabetes were *Bidens pilosa, Solanum indicum, Magnifera indica* and *Erythrina abyssinica.* The macro elements found in the medicinal plants were calcium, magnesium, potassium and phosphorus whose concentration ranges were 2.4 to 39.04 g/Kg, 0.43 to 6.23 g/Kg, 3 to 59 g/Kg and 0.29 to 5.90 g/Kg respectively. The trace elements in the medicinal plants were zinc, copper, manganese, chromium and iron. The highest zinc level of 123.00 mg/Kg was found in *Solanum mauense* while the lowest level, 3.90 mg/Kg was found in *Acacia hockii*. The highest copper level of 29.00 mg/Kg was found in *Bidens pilosa* while the lowest level, 1.56 mg/Kg was found in *Acacia hockii.* The highest manganese level of 2990 mg/Kg was found in *Croton macrostachyus* while the lowest, 18.20 mg/Kg was in *Acacia hockii.* The highest chromium level of 3.20 mg/Kg were in *Solanum mauense* and *Clerodendrum myricoides* while the lowest, 0.04 mg/Kg was in *Acacia hockii* among the medicinal plants from Nyamira County. The iron levels in the medicinal plants (*Carissa edulis, Clerodendrum myricoides, Melia azedarach, Toddalia asiatica*) ranged from 1150 to 4700 mg/Kg. The results of the sequential extraction showed that the easily bioavailable fraction (EBF) of iron, chromium, manganese, zinc and copper, ranged from 0.2 to 0.4%, 6.7 to 13.8 %, 4.1 to 10%, 2.4 to 10.2% and 3.2 to 12.0 % while the potentially bioavailable fraction (PBF) ranged from 1.6 to 1.9%, 50.1 to 67.6 %, 32.2 to 48.7%, 23.0 to 41.1 % and 34.6 to 53.1% respectively. *Acacia hockii* had 4.47 mg/Kg of iron while *Melia azedarach* had 67.454 mg/Kg of iron extracted. 0.12 mg/Kg of chromium, 83.35 mg/Kg of manganese, 2.42mg/Kg of zinc and 2.53 mg/Kg of copper were extracted from *Warburgia ugandensis*. 1.75 mg/Kg of chromium from *Solanum mauense,* 745.63 mg/Kg of manganese from *Croton macrostachyus,* 29.31 mg/Kg of zinc from *Solanum mauense* and 7.12mg/Kg of copper from *Bidens pilosa* were extracted. Molecular size fractionation of elemental characterization showed that the percentage distribution across the fractions (<3 kDa, 3 kDa-10 kDa, 10 kDa-0.45 μm and 0.45μm-5 μm) was strongly dependent on the specific element. *Bidens pilosa, Croton macrostachyus, Ultrica dioica and Solanum mauense* which were used to treat diabetes by at least eighty percent (80%) of the herbalists in

Nyamira County were found to be rich in chromium, magnesium, manganese, copper and zinc. *Melia azedarach, Aloe vera, Clerodendrum myricoides* and *Tabernaemontana stapfiana* which were used to treat malaria by at least ninety percent (90%) of the herbalists had bioavailale iron levels ranging from 67.454 to 11.053 mg/Kg. This is evidence that the herbalists are able to manage malaria and diabetes by use of their choice medicinal plants.

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List of Abbreviations

AAS- Atomic Absorption Spectrometry

BCR- Bureau Community of Reference

BMP Borabu Medicinal Plant

Da- Daltons

DNA- Deoxyribonucleic acid

E_1- Ground State Energy Level

E_2- Excited State Energy Level

EBF Easily Bioavailable Fraction

EMP Ekerenyo Medicinal Plant

ESI-MS- Electro Spray Ionization- Mass Spectrometry

FAAS- Flame Atomic Absorption Spectrophotometry

GTF Glucose Tolerance Factor

HPLC – High Performance Liquid Chromatography

ICP-MS - Inductively Coupled Plasma Mass Spectrometry

IUPAC- International Union of Pure and Applied Chemistry

h- Planck’s Constant

HIV- Human Immunodeficiency Virus

HPLC-ICP-MS - High Performance Liquid Chromatography Inductively Coupled Plasma Mass Spectrometry

HPLC-ESI-MS - High Performance Liquid Chromatography Electrospray Ionization- Mass Spectrometry.

ICP-OES - Inductively Coupled Plasma Optical Emission Spectroscopy

MMP Manga Medicinal Plant

NACOSTI- National Commission of Science, Technology and Innovation of Kenya

NMP Nyamira Medicinal Plant

PAD - Pulsed Amperometric Detection

PBF Potentially Bioavailable Fraction

PPM- Parts Per Million

RNA- Ribonucleic acid

SADC- South African Development Community

WHO- World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Trace elements are essential in the biochemical activities in the bodies of both fauna and flora as components of enzymes, hormones, antioxidants and in detoxification mechanism. Some elements are toxic while others are important to living organisms when taken (Lobinski & Szpunar, 1999; Templeton *et al*., 2000; Sadia *et al*., 2011). The influence of elements in the body depends on the ligands attached to them (Szpunar, 2000). For instance Cr (III) ions are more useful to man than Cr (VI) (Shu *et al.*, 2006). The measurements of the fractions or oxidation states of elements provide the information on the active species which is not given from total trace element determinations (Chery, 2003, Kokkotov *et al*., 2009).

Macro elements taken for body development are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, sodium, magnesium, calcium and chlorine. In addition trace elements such as manganese, iron, cobalt, copper, zinc, molybdenum, selenium, chromium and nickel (Shu *et al*, 2006) are essential in trace amounts (a few parts per million). Diseases like diabetes and cancer are managed by very expensive commercial drugs. There are cases where herbal medicines cure certain diseases, but when organic compounds are isolated, their activity disappears or is reduced. It is therefore possible that their activity is enhanced by their complex nature with metal ions (Akbarov & Aripkhodzhaeva, 2000). Most of these trace elements find their way into the plants by absorption through the roots. Animals get their trace element supply by feeding on the plants, food supplements or the drugs (Shu *et al*., 2006). The deficiency of the trace elements in the diets is manifested by the diseases or symptoms which differ from organism to organism and they also affect various functions in bodies of organisms.

Manganese is used in the synthesis of enzymes, metalloenzymes, hormones and proteins in both fauna and flora (Ansari *et al*., 2004, Dobson *et al*., 2004).

Selenium is an essential nutrient for most biological organisms. At low concentrations selenium acts as an antioxidant which assists in reducing the availability of free radicals and other reactive substances such as Vitamin E. Selenium deficiencies have been correlated with an increased cancer rate in some regions of the world (Gomez-Ariza et al., 1998; Kariuki, 2000; Kariuki & Kariuki, 2004; Shu *et al*., 2006,). Selenium input into the organism increases the detoxification mechanisms. At elevated concentrations selenium can act as a teratogen, mutagen, induces cirrhosis of the liver and decreases reproductive efficiency (Shu *et al*., 2006).

Zinc plays a central role in antioxidant mechanisms and zinc deficiency can cause detrimental oxidative stress (Singh *et al*., 2009). Zinc has also been shown to be a potent antagonist for the lead levels in the human body (Mogwasi *et al*., 2013). Chromium, iron and zinc are essential nutrients and their deficiencies in the diet are known to perturb physiological functions and to contribute to diseases such as diabetes, anaemia and diarrhea. As a result the use of Cr-Fe-and Zn- enriched nutritional supplements is widespread (Hendler & Rorvik; 2001; Caruso and Montes-Bayon, 2003).

Trace element supplementation has been achieved by use of salts such as sulphates and chlorides. However, recent research has indicated an enhancement of the element bioavailability when it is used in the form of chelates with amino acids or peptides (Queralt *et al*., 2005). Zinc has also been shown to be important for immunity, metabolic harmony, antioxidant, in addition it lowers the chronic inflammatory status (Weber & Konieczynski, 2003).

Copper has a vital importance in many biological systems and it is used for many industrial, agriculture and domestic purposes. Copper nutrient is important to fauna at normanal levels but is harmaful at high concentrations; therefore its determination in medicinal plants, food, environmental and industrial samples is very important. In milk, a high copper content contributes to accelerated lipid oxidation (Zaidi *et al*., 2004).

Medicinal herbs are widely used for curative and prevention of diseases. Trace elements may be responsible for the medicinal properties, but depending on their concentration and bioaccessibility, they can exert toxic effects as well (Abdalla *et al*., 1993; Weber & Konieczynski, 2003). In any case, these elements show high biological interest, because some of them support growth and others can be toxic to man (Kokkotov *et al*., 2009). Previous studies on medicinal plants in Africa have mainly focused on determination of total elemental contents but not on elemental speciation analysis (Ogata et al., 2009; Okorol, *et al*., 2012).

There are several methods for herbal medicine preparation. One of the common methods is by boiling the plant parts (Piero *et al*, Muregi *et al*., 2004; Adongo *et al*., 2012). The second method is by soaking the plants in cold or warm water and the infusion used either internally or externally. The third method is by burning the plant part and the ash applied to the affected area or consumed. The knowledge of the levels of trace elements in medicinal herbs and their aqueous extract, their ashes and organic extracts will enhance effective use of these herbs in treatment of various diseases.

Kigen *et al* (2013) reviewed the status of use of traditional medicine in Kenya and revealed that there is need to research on herbal medicine as the information available is possessed by the aged population. This will facilitate the documentation on herbal medicine for future reference and research.

The traditional methods of making the aqueous extract may only be extracting a small fraction of these elements leading to not fully reaching efficacy potential. There is no defined dosage of herbal medicine for specific ailments (Muregi *et al*., 2004) neither is there standard content of herbal plants. If the concentration and speciation of such elements is well known, appropriate dosage could be prescribed.

This study determined total concentration and speciation of trace elements in some medicinal plants from Nyamira County. ICP-MS and AAS instruments were used for determination of total element concentration in the plants after digestion. Bureau Community of Reference (BCR) sequential extraction method was employed on plant extracts to fractionationate (characterize) some selected trace element species.

1.2 Statement of the problem

Medicinal plants have been used in the treatment and management of a number of diseases in human beings (Hendler & Rorvik, 2001; Weber & Konieczynski, 2003; Adongo *et al*., 2012; Ammar *et al*., 2012; Piero *et al*., 2012; Mabona& Vuuren, 2013). There exists a relationship between malnutrition and infectious diseases, the two largest health problems to man. Primary deficiencies of certain essential elements have been recognized as a major contributor to a number of common chronic illnesses (Hendler & Rorvik, 2001). Study has shown that trace element deficiency in man and animals brings about reduced immunity (Spears, 2000; Fraker & King, 2001). Medicinal herbs are known to contain organic molecules and in organic elements (Adongo *et al*., 2012). The study on medicinal herbs has mainly focused on active organic molecules present; leaving out essential elements some of which are known to enhance the activity of organic compounds by complexing with them (Ammar *et al*., 2012). Furthermore, traditional methods of aqueous extractions may result in extracts with low amounts of bioactive molecules (Kokwaro, 1993; Oduola *et al*., 1998). This could mean that the aqueous extract contains mainly immune boosting trace elements as they act in very low concentrations which may be responsible for their therapeutic property. People have developed a store of empirical information concerning the therapeutic values of local plants (Kokwaro, 2009; Nelvana & Mohomoodally, 2014). However information on chemical composition of trace elements has been insufficient making it difficult to prescribe appropriate dosages. High concentrations of some elements in medicnal plants could lead to their accumulation in the body if administered in significantly high doses. Knowledge of the total concentration and speciation of the trace elements in plants will assist in prescribing the appropriate dosage. The plants used for disease treatement were investigated in order to determine their chemical compositions. Some side-effects from consumption of herbal medicine could result from lack of knowledge on their chemical composition since high concentrations of trace elements are toxic (Kokwaro, 1993; Lozak *et al*., 2002; Naga Raju *et al*., 2013; Khan *et al*.,2013; Liu *et al*., 2015). The levels and speciation of trace elements in medicinal plants have not been determined in Nyamira County. The results obtained from this research will lead to effective safe use of medicinal plants. This will be achieved by investigating the levels and speciation of the selected elements in the medicinal plants.

1.3 Research Questions

i) What is the distribution of herbalists in Nyamira County?

ii) Which medicinal plants are used in Nyamira County?

iii) What diseases are predominantly treated by herbalists in Nyamira County?

iv) What are the total concentrations of trace elements in medicinal plants from Nyamira County?

v) What species do these trace elements exist in medicinal plants?

vi) What is the effect of herbal preparation protocols on the elemental species present in the medicine taken by the patients?

1.4 Main Objective

To determine the total amount and fractional species of trace elements in selected medicinal plants used in Nyamira County.

1.4.1 Specific Objectives

The specific objectives were to:

i. Identify the medicinal plants used to treat two predominant diseases treated (managed) by herbalists in Nyamira County.

ii. Determine the concentration of macro elements in the selected medicinal plants.

iii. Determine the concentration of trace elements in the selected medicinal plants.

iv. Determine the fractions of selected trace elements in the medicinal plants.

v. Correlate the bioavailable elemental species with medicinal properties of the plants.

1.5 Justification

Most studies done on medicinal plants have emphasized on natural products for their bioactivity. Some medicinal plants are used in ash form after combustion of organic matter. The ashes have been shown to cure diseases and this could be due to the presence of metals and metal compounds. The fractional species of metals in the medicinal plants were determined and related to therapeutic properties. The speciation form determines the bioavailability and therapeutic effect of the elements in their intended use. Herbalists do not administer medicinal plants based on bioavailable element quantities. The elements including trace elements present, their bioavailable species and quantities taken in the medicinal plants are not known. This study will generate this information, the basis of which the herbalists will be able to select the relevant herbal plants for certain ailments and their suitable dosages.

1.6 Significance of the Study

The medicinal plants mostly used in Nyamira County were identified in this study with the aim of encouraging the residents to conserve these plants and the knowledge about their therapeutic properties. The information on the specific compounds in which the elements exist in medicinal plants was elucidated. The information will be used to come up with the most efficacious medicinal plants in terms of trace element levels for the treatment of specific diseases. The findings will guide the formulation of better policies of utilizing medicinal plants to avoid toxic effects or over use. The findings of this study will have impact on:

a) Conservation of medicinal plants and knowledge about their therapeutic properties

b) Detailed data on the range of elemental contents in currently used medicinal plants will help to avoid overdosage or underdosage.

c) Characterization of elemental molecular species may help to identify the active ingredients of the medicinal plants.

1.7 Scope of the Study

The total concentration and speciation of some elements in medicinal plants from Nyamira County was determined. Medicinal plant species, their location and the different elements in given plant species were compared for total contents of selected elements. Correlations of the identified elemental species with the known therapeutic properties of the individual medicinal plants were done.

1.8 Limitations of the Study

The limitation was that only common used medicinal plants used by herbalists were studied.

1.9 Assumptions

The assumptions taken were that

i) The herbalists identified the medicinal plants accurately.

ii) There are trace elements in medicinal plants.

iii) Trace elements are responsible for the therapeutic properties of the medicinal plants.

CHAPTER TWO

LITERATURE REVIEW

2.1 Medicinal Plants

Medicinal plants are used for therapeutic purposes or precursors for drug synthesis. Abou-Arab and Abou Donata, (2001) reported a need for research, development, documentation, utilization and promotion of traditional medicine in developing countries. Most people in developing countries use complentary medicine in disease management due to low toxicity and possession bioactive compounds and low cost (Carson, 1986; Omulokoli *et al*., 1997; WHO 2000a; WHO, 2000b; Muregi *et al*., 2004; Slavica *et al*., 2005; Charlotte *et al*., 2008; Pirzada *et al.,* 2009; Jimoh *et al*., 2010; Kimani *et al.*, 2011; Jena & Gupta, 2012). Omolo *et al.* (1997) reported the total and extractable iron species in eight eastern African medicinal plants used in the management of anaemia while Kariuki *et al.* (2014) reported that *Erithrina abyssinica, Solanum aculeastrum, Carissa edulis, Croton megalocarpus* and *Myrica salicifolia* extracts by the Maasai people in Kenya had anti bacterial activity on *Staphylococcus aureus, Escherichia coli, Pseudomonas aeregenosa, Salmonella typhi* and *Krebsiella pneumonaie.* This means that the plants contain bioactive compounds which can be used in the management of the ailments.

In the management of malaria conventional medicine has been combined with alternative medicine to overcome resistance (Phillipson and Wright, 1991; Omulokoli *et al*., 1997; WHO, 2000a; WHO 2000b; Muregi *et al*., 2004). Although combinations of conventional drugs and conventional and alternative medicine have been applied in the management of drug resistant malaria, asthma and typhoid (Oduola *et al*., 1998), the effect of the trace elements on the efficacy of the herbal drugs on the treatment of malaria, typhoid, diabetes and asthma is not known. Onguéné *et al.* (2013) reviewed anti- malarial compounds from the African medicinal plants and revealed that most African medicinal plants were rich in bioactive compounds of malaria. Most traditional medicine and Natural Health Products in Africa are not regulated and may contain poisonous compounds (Colebunders *et al.,* 2003; Peters *et al*., 2004; Edward *et al*., 2005). This requires the medicines to be analyzed regularly to guard against possible poisoining.

Mabona & Vuuren (2013) reviewed medicinal plants phytochemistry and toxicity of plants used in treatment of skin diseases in South Africa and revealed that they had antimicrobial, anti-inflammatory, and wound healing properties. Ammar *et al.* (2012) reported that anti-diabetic plants of Sudan had high concentrations of K, Ca, Cr, Mn, Cu and Zn which fit well with the attribution of these elements to stimulate insulin action.

Medicinal plant extracts are prescribed by doctors as a supplementary treatment of day to day ailments caused by civilization. The supplements contain bioactive compounds as flavonoids, alkaloids, tannins, glycosides, sugars, organic acids, and other substances (Mabona and Vuuren, 2013). They also contain micro elements such Mn, Zn, V, Co, Fe, V, Zn, Cu Ti, Se, and Mo involved in synthesis and metabolism in the body (Herber & Stoeppler, 1994; Lindskong, 1997; Taylor *et al*., 1998; Paul & Garg, 2007). Consequently, there is only little knowledge on theraupeutic influence of the mico elements in the medicinal plants. Influence could be possibly binding to pharmacologically active substances, or by influencing bioavailability or the pharmacokinetics of the bioactive compound.

Adedapo *et al.* (2011) reported that the *Bidens pilosa* leaf extracts of acetone, water and methanol were bioactive on both the Gram+/- *Bacillus cereus, Staphylococcus epidermidis, Staphylococcus aureus, Micrococcus kristinae, Etreptococcus pyrogens, Escherischia coli, Salmonella pooni* and *Serratia marcescens* (Kariuki *et al* ., 2014).

Plants growing in soils contaminated with metals accumulate higher levels of metals than those growing in the normal soils. The rate of the uptake of the metals depends on several factors that include soil conditions, age, species and physiological adaptations (Bako & Daudu, 2007). Plants have several mechanisms of dealing with high metal levels. If plants with high levels of metals are taken as herbal medicine they can intoxicate the microbes, destroying them. This cures some ailments but as more of herbal medicine is taken the trace elements can bioaccumulate and their toxic effects in human body can manifest themselves at relatively higher levels (Caruso and Montes-Bayon, 2003; Hullenbusch *et al*., 2006). World health organization (WHO)(2000a) has given the permissible limits of the various trace elements in the consumed medicinal herbs for different countries (African states) as: chromium (2 mg/Kg), manganese (44.6 to 339 mg/Kg), iron (261 to 1239 mg/Kg), cobalt (0.14 to 0.48 mg/Kg), nickel (1.63 mg/Kg), copper (20 to 150 mg/Kg), zinc (27.4 mg/Kg), cadmium (0.3 mg/Kg), mercury (0.1 mg/Kg) and lead (10 mg/Kg). Adongo *et al.* (2012) reported Zn, Mg and Fe levels anti diabetic plants to be from 6.00-164.00 mg/Kg, 1.45-9.54 mg/Kg and 0.67-4.29 mg/Kg, respectively in Chuka. Maobe *et al.* (2013) reported chromium (0.567 to 2.035 mg/Kg), manganese (3.254 to 17.33 mg/Kg), iron (0.967 to 6.067 g/Kg), cobalt (0.967 to 6.067 mg/Kg), nickel (0.589 to 1.60 mg/Kg), copper (0.305 to 1.44 mg/Kg), zinc (0.989 to 1.833 mg/Kg), cadmium (0.035 to 0.206 mg/Kg), mercury (0.0024 to 0.00838 mg/Kg) and lead (0.25 to 0.407 mg/Kg) levels in anti diabetic plants from Kisii (Kenya). Piero *et al*. (2012) reported the levels of Fe, Zn, Pb, Mg, Cr, Cu, Ni, Mn, Mo and Sr in anti diabetic medicinal plants to vary from 281.0 ± 2.6 to < 1 µg/g in *Bidens pilosa, Erythrina abyssinica, Aspilia pluriseta, Strychnos henningsii* and *Carissa edulis.*

Alikwe *et al.* (2014) reported the levels of minerals and phytochemical composition of *Bidens pilosa* from Nigeria to be Na; 0.54±0.3 mg/100g, Ca:0.39±0.14 mg/100g, Mg:0.23± 0.46

mg/100g, P:0.31± 0.1 mg/100g, K: 1.21± 0.1 mg/100g,Cu: 12.6±0.3 mg/100g, Mn:22.0±0.01 mg/100g, Zn: 45.20±0.02 mg/100g, Fe:789.00± 0.02 mg/100g, Tannins:0.08± 0.23 mg/100g, Saponins: 0.896±0.5 mg/100g, Phenols: 0.206±0.10 mg/100g and Alkaloids: 1.29±0.50 mg/100g. Mtunzi *et al.* (2012) reported the levels of iron in *Ibhubezi* to be 3.47±0.01 g/Kg, zinc and copper in wonder cure to be 2.71±0.30 mg/100g and 0.20±0.06 mg/100g respectively while those of lead and cadmium were in very low amounts in all the medicinal plant products studied. Onguene *et al.* (2013) did a review of anti malarial activities of various compounds and suggested that further work must be done on those medicinal plants which were shown to be very active against malaria from literature while Masako & Yoshiyuki (2006) reported that the suspension and boiling extract of dried powder of the aerial parts of *Bidens pilosa* from Japanese island of Miyako had anti-inflammatory and anti-allergic properties in experimental diseases. There are two major reasons for monitoring the levels of elements in medicinal plants. The first reason is to assess the levels of environmental contamination by toxic metals while the second reason is that exotic herbal remedies, especially those of Asian origin which have toxic metals (Manzoor & Mahmood, 2011). Some diseases and the medicinal plants which treat them are given in the Table 2.1

Table 2.1: Diseases and Medicinal Plants.

Disease	Medicinal Plant
Skin disease	*Senna didymolbotrya*
Eye disease	*Markhamia platycalyx*(leaves), *Erythrina abyssinica*(stem bark)
Coughs	*Croton macrostachyus* (leaves)
Skin rushes	*Croton macrostachyus* (leaves)
Venereal disease	*Croton macrostachyus*(leaves), *Erythrina abyssinica*(stem bark)
Malaria	*Croton macrostachyus* (leaves) *Euphorbia candelabrum*(stem bark) *Erythrina abyssinica* (stem bark)
Diabetes	*Bidens pilosa,Ultrica dioica,Solanum mauense*

Source: Kokwaro, 1993

2.2 Macro elements

Macro elements are those that are required in the human body in large amounts. They include potassium, sodium, phosphorus, calcium, magnesium, sulphur, aluminium, silicon, carbon, nitrogen and hydrogen. They are essential in the synthesis of the various structures and organs in the body as well as some biochemical functions. Potassium and sodium are essential in the transmission of nerve impulses useful for the communication in the mammalian body (Taylor *et al.,* 1998). The recommended upper daily intakes of potassium for adult males are 3.8 g and 2.8 g for females daily (Australian government National Health and Medical Council, 2002).

High concentrations of Ca are also important in muscles system and heart functions. It also plays a role in hormone secretion and control of protein activities (Taylor *et al.,* 1998; Baron *et al*., 1999; Holt *et al*., 1999a; Lipkin & Newmark, 1999; Holt *et al*., 1999b; Raju *et al*., 2013; Anna *et al*., 2013). The recommended upper daily intake of calcium for adult is 2.5 g (Australian government National Health and Medical Council, 2002). Magnesium is involved in glucose homeostasis and metabolism. Magnesium also plays a role in the release of insulin and the maintenance of the pancreatic β-cells (Piero *et al*., 2012). Magnesium is essential in the synthesis of bones and teeth (Taylor *et al*., 1998). Piero *et al*.(2012) reported the levels of Magnesium as 1021.4 ± 6.3 mg/ Kg in *Erthrina abyssinica*, 791.7 ± 1.2 mg/ Kg in *Catha edulis*, 865.5 ± 2.8 mg/Kg in *Strychnos heningsii*, 823.6± 2.3 mg/Kg in *Aspilia pluriseta* and 879.7±3.1 mg/Kg in *Bidens pilosa* in the Kenyan antidiabetic plants. Magnesium is involved metabolism of glucose and in the release of insulin (Akhuemokhan *et al*., 2010; Piero *et al*., 2012). This makes magnesium to be used in the management of diabetes. The recommended daily intakes of magnesium for adult males are 400-420 mg and 310-320 mg for females (Australian government National Health and Medical Council, 2002). Phosphorus is useful in the synthesis of atps which is an energy reservoir in the body. Konieczynski & Wesolowski (2007 a) reported that several botanical species of medicinal plants from Poland had substantial phosphorus levels. Sulphur and nitrogen are used in the protein synthesis (Hough *et al*., 1989; Taylor *et al*., 1998).

2. 3 Trace elements

Trace elements are involved in biological functions as enzymes or cofactors for various processes. Many organic compounds used in medicine are activated or biotransformed by metal ions including metalloenzymes or indirect effect on metal ion metabolism (Taylor *et al*., 1998). The phamaceutical activites of organometallic compounds depend on their structure which will enable them to be transported in the tissues easily to react with the target pathogens (Peter *et al*., 2004; Edward *et al*., 2005).

Adequate intake of vitamins and trace elements promote immune functions by affecting the innate T-cell-mediated immune response and adaptive antibody response (Taylor *et al*., 1998). Peters *et al*. (2004) reported that vitamins C&E, selenium, copper, and zinc had a potential to counteract damage caused by reactive oxygen species to cellular tissues and modulate immune cell function through regulation of redox-sensitive transcription factors and affect production of cytokines and prostaglandins. Edward *et al*., (2005) further reported that adequate intake of vitamins B_6, folate, B_{12}, C, D, E, and of selenium, zinc, copper, and iron supports a Th1 cytokine-mediated immune response with sufficient production of proinflammatory cytokines. This maintains an effective immune response and avoids a shift to an anti-inflammatory Th2 cell-mediated immune response and an increased risk of extracellular infections. This means inadequate intake of vitamins and minerals may lead to suppressed immunity which predisposes the human body to infections and aggravates malnutrition.

Iron

It is a component of haemoglobin and facilitates the oxidation of carbohydrates, protein and fat, thereby controlling body weight, which is very important factor in diabetes (Li & Deng, 2003; Khan *et al*, 2008). Iron is found at the active centre of many biological molecules in living organisms. Iron in animals exists in complex forms bound to protein, either as porphyrin or heme compounds. It is also a component of many enzymes. A 100 g of human body contains around 4 g of iron and three-quarters is in the form of haemoglobin (Carson, 1986).

Iron deficiency leads to low haemoglobin levels and thus anaemia. Women, because of menstruation, and children, because of their enhanced requirement for growth, are particularly susceptible to anaemia (Carson, 1986; Maolin *et al*., 2007). During reproductive years adult women lose an average of 20 mg iron monthly as a result of menstruation and approximately 800 mg for each pregnancy. These losses are in addition to an approximately 1 mg daily from extoliation of intestinal epithelial cells (Bratter & Schramel, 1980).

Iron deficiency in the world's population can be overcome easily through dietary intake. Daily iron requirements are 10 mg for adult males, 15 mg for female, 30 mg for pregnant females and 6-12 mg for children. Iron dietary sources include liver, fish, spinach and whole grains (Clarkson & Rowson, 1999). The iron content of most feed ingredients is highly variable, reflecting differences in soil and climatic conditions. Its level in herbage plants is basically determined by the species and environmental conditions of its habitat (Reddy & Jose, 2013).

A wide range of iron chelators inhibit ribonucleotide reductase and this is the reason for cytotoxic properties of such molecules as tropolone (Abrams & Murrer, 1993). Some iron chelators also function as free radical scavengers, for instance, hydroxyurea which inhibits the enzyme activity. The ability of iron chelators to inhibit ribonucleotide reductase has led to several proposals for therapeutic application. Anti-malarial activity of desferrioxamine has been demonstrated in a range of plasmodium species in rats and man (Ferguson, 1990). Malaria is a worsening problem worldwide and the introduction of an iron chelator to control such infection is a novel approach, and as chelation is particularly critical at the late trophozoite stage, it may prove possible to limit treatment to relatively short time periods (Carson, 1986). Conditions of iron overload have been observed in humans and include those in idiopathic hemochromatosis (genetic disorder in which excessive iron is absorbed), transfusion hemosiderosis and in humans who consume diets containing as much as 200 mg iron per day. Kumar *et al.* (2003) reported iron concentration in most medicinal herbs to be above 500 µg/g except *arjuna, red sandal* and *tulsi* which had levels of 160 µg/g to 324 µg/g. Majolagbe *et al*. (2013) reported the levels of iron in *Sorghum bicolor* and the leaves of *Hibiscus sabdariffa* from Southern Nigeria to be 188.7 mg/g and 69.7 mg/g respectively.

Some components of the food and herbal medicine such as calcium, zinc, polyphenols, vegetable protein or phytates can inhibit the absorption of iron while nutrients as vitamin C, citric, lactic or malic acid increase its absorption(Hurell and Egli, 2010; Wessling, 2014). Feeding on meat, fish and poultry can also increase non-haem iron absorption from plant foods consumed and hence its bioavailability (Hurell and Egli, 2010; Murray-Kolbe and Beard, 2010; Aggett, 2012; Reddy & Jose, 2013; Wessling, 2014). Unlike other inhibitors of iron absorption, calcium might reduce the bioavailability of both nonheme and heme iron.

The absorption of iron depends on the diet of an individual (Hurell and Egli, 2010; Aggett, 2012). These means that the iron absorbed must be low than the bioavailable forms of iron in the medicinal plants and also depending on zinc content in the diets of an individual. Iron enhances oxidation of carbohydrates, protein and fat in the process inhibiting diabetes in the individual (Khan *et al*, 2008). Recommended daily iron intakes for adult males are 6-8 mg and 8 mg for females (Australian government National Health and Medical Council, 2002).

Lukose *et al.* (2013) synthesized and did structural chacterization of metal complexes of Fe(III), Co(III) and Mn(III) with 4-N-(2-thienylidene)aminoantipyrine, 2,3-dimethyl-1-phenyl [2-pyrrolyl)methylene]aminoantipyrine,2,3-dimethyl-1-phenyl4[(3isatiaylidene)]aminoantipyrine and 2,3-dimethyl-1-phenyl-4- [(3-indoyl))methylene]aminoantipyrine and reported that the complexes had higher antibacterial propertiies than free ligands against four pathogens namely *Staphylococcus aureus, Bacillus substilis, Escherichia coli* and *Klebsiella pneumonia*. Konieczynski & Wesolowski (2007b) working on the water extractable forms of iron reported that substantial amounts of iron were extracted from the various fruits showing that water extracts obtained from the fruits of the plants may deliver potentially bioavailable form of iron to the consumer. Konieczynski *et al.* (2007) reported that the total and extractable iron (II) in selected herbs collected from natural areas from Northern Poland was positively related.

Manganese

Manganese is an essential trace element nutrient in humans. The functional value of manganese is as a lewis acid and catalyst for oxidation. Manganese is important for several enzymatic and biochemical processes some of which regulate the blood sugar (Abdalla, *et al*., 1993; Christianson &Ferke, 1999; Devereaux *et al*., 2000). However, in excessive amounts it is a toxic substance. Manganese occurs in relatively constant amounts in tissues and organs of both plants and animals, and is especially concentrated in the reproductive organs (Grossman & Wendel, 1985; Akbarov& Aripkhodzhaeva, 2000). It was first recognized as an essential mineral element for growth and reproduction in mice and rats in 1931. Interest in manganese nutrition was greatly stimulated a few years later by the discovery that a deficiency of this element was largely responsible for the crippling disease of chickens known as *perosis* (Pennington &Young, 1991). Soil manganese concentration/levels range from less than 1 ppm to as much as 7000 ppm with an average of 500 to 600 ppm (Pennington & Young, 1991). The two most important oxidation states in biological systems are +2 and +3. Liver, bones, pancreas and kidney have relatively high levels while muscles have very little metal levels. The skeleton accounts for about 25 per cent of total body manganese (Berman, 1980). This reserve, however is not readily used when dietary intake is low. The oral absorption of manganese into the body is naturally slow and is transported in blood serum by ß-globulin (Berman, 1980). Excess intake is generally reflected in excess concentrations in hair, but deficient intakes are not consistently reflected in lower levels (Grimble, 1994). Its absorption apparently occurs equally well throughout the length of the small intestine (Berman, 1980). It competes directly with cobalt and iron for binding sites, thus excess iron or cobalt could be antagonistic. Absorbed manganese may either remain free or rapidly become bound to α2-macro-globulin before traversing the liver to enter the systemic circulation where it becomes oxidized to the manganic state or become bound to transferrin (Grimble, 1994). Basgel&Erdemoglu (2006) observed an increase in liver manganese when dietary manganese was elevated. It activates many enzymatic reactions associated with the metabolism of organic acids, carbohydrates, nitrogen and phosphorus. It is part of several enzymes such as arginase, pyruvate and carboxylase which are required for protein and energy metabolism in mucopolysaccharide formation (Herber & Stoeppler, 1994). There are few manganese metalloenzymes (Sappey, 1994). Some manganese complexes cure certain allergic syndromes (Beck *et al.*, 2001). The element also plays a role in immunological and insulin function (Ajit *et al.,* 1999; Dobson *et al*., 2004). Its deficiency or toxicity can affect brain function (Bratter &

Schramel, 1980; Abrams & Murrer, 1993). Humans with convulsive disorders, including epileptics, showed whole blood manganese concentrations significantly below level of 0.15 mg/day (Bratter & Schramel, 1980).

The human requirement for manganese is estimated to be 2.0 to 5.0 mg/day for adults and 0.3 to 3.0 mg daily for infants and children (Bratter & Schramel, 1980). Meat and fish are generally low in manganese, approximately 5-15 ppm while milk is 20-40 µg/l. Its deficiency in human reduces uptake of vitamin K (Berman, 1980; Bratter & Schramel, 1980). Clinical signs of deficiency include inability to elevate depressed clotting proteins in response to vitamin K, hypocholesterolemia, slowed growth of hair and nails, weight loss and reddening of hair and beard. A number of studies have been done in medicinal herbs to determine the level of manganese in them. Lozak and co workers (2002) reported manganese levels to be 188 mg/kg in mint leaves while Basgel &Erdemoglu (2006) reported it to range from 23 mg/kg to 244 mg/kg in various medicinal herbs. Basgel and Erdemoglu (2006) reported in another study ranges of manganese of 4.30-49.1 mg/Kg in infusions *Foeniculum vugare* and *Rosa caninae* while Anna *et al.* (2013) reported levels of 72.50 mg/Kg in the Brazilian teas. Kokwaro (1993) reported that *Erythrina abyssinica* is known to treat the highest number of diseases among the herbs containing high levels of manganese in Kenya. In that work the aqueous extracts obtained from the herb (*Erythrina abyssinica)* had the highest levels of iron, manganese and zinc which could enhance the body resistance against many diseases. Choudhury *et al.* (2008) reported the levels of manganese to range between 26.7-250 µg/g in antdiabetic herbs. Kofi *et al.* (2010) reported the concentration of manganese to be 1455 µg/g in *R. vomitoria*, 1190 µg/g in *G.sylvesre* and 556 µg/g in *V.africana*.

Zinc

Zinc is an essential trace element to humans and under normal conditions about 1-2 mg of zinc are required daily (Berman, 1980). Zinc bioavailability from food ranges from 10 to 40 per cent. About 5 to 10 per cent of the dietary zinc intake is absorbed and this depends on the age, content of zinc in the body and the dietary composition. Zinc and insulin concentrations in the pancreas change in the same direction in a variety of situations in humans (Ansari *et al*., 2004). Zinc plays vital roles in insulin biosynthesis, storage, and secretion (Bode *et al*., 1992). Zinc deficiency is associated with a number of metabolic disturbances including impaired glucose tolerance, insulin degradation, and reduced pancreatic insulin content (Ansari *et al*., 2004). It also improves glycaemia, and a restored zinc status in type 2 diabetes may counteract the deleterious effects of oxidative stress, thereby helping to prevent complications associated with *diabetes mellitus* (Bode *et al*., 1992; Ansari *et al*., 2004). Phytates and fibers decrease zinc absorption while zinc deficient organisms show a tremendous increase in zinc absorption (Eleanor & Mary, 1984). High concentrations are found in the male reproductive system, muscles, bone, liver, kidney, pancreas, thyroid and endocrine glands. The cause of zinc deficiency in man include excessive intake of cereal food with high phytate and fiber contents, which renders the zinc ingested unavailable for absorption. Zinc deficiency in animals and humans is manifested as growth retardation, impaired development functions, malabsorption syndrome, renal and liver diseases (Neve, 1996). Zinc functions mainly as an essential co-factor (an activator of enzymes) or structural component for over 70 enzymes in body cells (Eleanor & Mary, 1984). A number of enzymes including alkaline phosphate, alcohol dehydrogenase, carboxyl peptidate, glutamic dehydrogenase, leucine amino peptidase, RNA polymerase and DNA polymerase are zinc dependent (Neve, 1996). Humans and birds exhibit gross bone disorders, poor wound healing and susceptibility to infections due to zinc deficiency (Berman, 1980; Fraker and King, 2001).

Zinc deficiency during pregnancy results in congenital malformations of the embryo particularly by affecting growth of proliferating tissues. The consequences of more subtle metabolic interactions, as in cirrhosis, and the basis of genetic or teratological defects have not been examined widely and offer rich investigative opportunities (Berman, 1980). Zinc also plays an important role as antioxidant that helps limit the oxidation of low-density lipoprotein cholestrol and thereby helps to prevent coronary artery disease (Neve, 1996).

Individuals with HIV who take in diets rich in zinc have been found to maintain weight and experience fewer opportunistic infections (Kumar *et al.*, 2003). Animal sources of zinc include oysters and other sea foods, liver, meat and eggs. Whole grains also supply a significant amount of zinc (Eleanor & Mary, 1984). Zinc boosts the body's immunity, Lewis acid–type catalyst as well as avital role in insulin function (Vallee & Galdes, 1984; Williams, 1987; Cotton & Wilkinson, 1988 ; Silverman & Lindskog, 1988; Christianson & Lipscomb, 1989; Hough *et al*., 1989; Bode *et al*., 1992; Vallee & Auld 1993; Huheey *et al.*, 1993; Kiefer *et al*., 1993; Ippolito & Christianson, 1994; Lovejoy *et al*., 1994; Klabunde *et al*., 1996; Lindskog, 1997; Butler, 1998; Christianson & Cox, 1999; Rathore & Upadhyay, 2013).

Symptoms of acute toxicity include decreased blood concentration of high-density lipoprotein (HDL), the form of lipoprotein thought to be protective against heart disease (Berman, 1980). Excess zinc levels are also associated with vomiting, dehydration, electrolyte imbalance, abdominal pain, lethargy, dizziness and muscular in coordination (Mogwasi *et al*., 2013). Kumar *et al.* (2003) reported the levels of zinc to be in the range from 26.5 μg/g to 56.9 μg/g in *Pragya-peya* and *Aagya-ghas* herbal drinks respectively. Zinc participates in insulin synthesis, secretion and sotrage and thereby controlling diabetes (Bode *et al*., 1992; Ansari *et al*., 2004).The recommended daily intakes of zinc for a dults are 14 mg for males and 8 mg for females (Australian government National Health and Medical Council, 2002).

Chromium

Chromium occurs in oxidation states of +2, +3 and +6 in human bodies. However, its most stable oxidation state in these systems is +3 (Anderson, 1989). It is one of the least toxic metals at low concentration and is essential for fat and carbohydrate metabolism in mammals, forming part of the glucose tolerance factor (Lukaski, 1999). In 1957 Schwarz and Mertz extracted from pork kidney a compound they called GTF, which restored impaired glucose tolerance in rats; with chromium identified as the active component (Vartika *et al*., 2014). It appears to be an essential trace element because it potentiates insulin action (Cohen *et al.,* 1995). Chromium is essential in the functioning of the body as a glucose tolerance factor. It is also used for insulin signaling for biological role and thus sugar metabolism and diabetes (Chen *et al*., 1993).

Absorption of chromium ranges from less than 0.4% to 2.5% of the amount consumed and the remainder is excreted in the faeces. Chromium works with insulin metabolism of sugar in the human body. Maintenance of blood sugar is achieved by the active agent (glucose tolerance factor) made of chromium bound with nicotinic acid. Chromium is required in trace amounts to increase the sensitivity of the body to insulin for efficient use of excess glucose. Vitamin C and B enhances the absorption of chromium (Paul *et al*., 2007). Cr (III) complexes by way of the glucose tolerance factor (GTF) bring about the management of diabetes (Yang *et al*., 2006). The levels of chromium in the medicinal plants studied must be playing a vital role in the management of diabetes. The use of *Bidens pilosa* and *Ultrica dioica* among the many herbal plants in the management of diabetes could be attributed to the chromium in the medicinal plants (Adongo *et al.,* 2012). Vartika *et al.* (2014) reported the effect of chromium (Cr) of increased antioxidant potential and production of anticancer alkaloids vincristine and vinblastine in *C. roseus* leaves.

Offenbacher & Pi-Sunyer (1988) hypothesized that chromium forms a complex between insulin and insulin receptors that facilitates the insulin-tissue interaction. They reported that suboptimal chromium intake in humans led to detrimental changes in glucose, insulin and glucagons of subjects with slightly impaired glucose tolerance. Deficiencies may be as a result of inadequate dietary intake and bioavailability as in over refined junk foods, increased body losses and intravenous feeding, anxiety, fatigue and in addition to impaired glucose tolerance factor (Lukaski, 1999; Vartika *et al*., 2014). There is evidence that tissue level of chromium decline with increasing age, pregnancy and in malnourished children (Offenbacher & Pi-Sunyer, 1988). Food sources of chromium include eggs, beef, brewer's yeast, green pepper, apples, bananas, spinach and molasses. It is suggested that human requirements for chromium can be met by typical plant food concentrations (Hathcock, 1997). Analysis done on various medicinal herbs has shown low levels of chromium. Garcia *et al.* (2000) reported the presence of chromium in spices and aromatic herbs to be higher than that in other foods and beverages. Anna *et al*. (2013) reported the total content of chromium of 0.56 to 2.74 mg/ Kg among the Brazilian teas. Castro (1998) reported chromium values of 2.20 $\pm$0.88 μg/g in different aromatic plants which are used in the treatment of diabetes.

Vanadium

Vanadium is a trace element which occurs in oxidation states +4 and +5 in human beings (Srivastava, 2000). The function of vanadium is the protection of the system against injury of tissues and in the formation of enzymes. Deficiencies cause reduced growth, impaired reproduction and survival of young, impaired tooth and borne metabolism (Singh *et al*., 2009). Vanadium is essential in the functioning of the body as a glucose tolerance factor. It is also used for insulin signaling for biological role and thus sugar metabolism and diabetes (Chen *et al*., 1993; Chakraborty *et al*., 1995a; Chakraborty *et al*., 1995b). It is widely distributed in nature, occurring in many flora and fauna. Vanadium deficiency is known to reduce wing and tail feather growth in chicks consuming a diet containing less than 10 ppb Vanadium (National Research Council, 1994). Adequate vanadium in humans leads to well build healthy bones and teeth (Mohammad *et al*., 2001). It has significance in the treatment of cardiovascular disease (Cohen *et al*., 1995) as well as treatment of cancer (Narla *et al*., 2000). It may also act as an enzyme cofactor in the form of vanadyl in metabolism of the hormones, glucose, lipids and teeth but no specific biochemical function has been identified (Cohen *et al.,* 1995; Srivastava, 2000; Kanna *et al*.,2003). Recommended daily intake for vanadium is 1 mg/day to 4 mg/day (Srivastava, 2000). The main sources of vanadium in the diet include oat straw, peas, liver, fish, mushrooms and corn (Clarkson & Rowson, 1999). Srivastava, (2000) reported the levels of vanadium in Fats, oils, fresh fruits and vegetables to range from 1 to 5 ppb. It is relatively toxic, with a threshold level near 10-20 mg/day or 10-20 ppm of diet (Clarkson & Rowson, 1999). Kumar *et al.* (2003) reported vanadium concentration from 0.5 μg/g to 5.2 μg/g in medicinal herbs while Basgel and Erdemoglu (2006) reported 0.9 μg/g to 7.6 μg/g. A study done by Katherine *et al.*(2009) reavealed that 3-hydroxy-2-methyl-4-pyrone, bis(ethylmaltolato) oxovanadium(IV) (BEOV), bis(maltolato)oxovanadium(IV) (BMOV) and 2-ethyl-3-hydroxy-4-pyrone had potential to manage *diabetes mellitus*.

Nickel

Nickel is also involved in the production and action of some hormones, optimal growth, healthy skin, bone structure and in iron metabolism. It is required for metabolism of glucose, lipids, hormones and cell membrane. Nickel complexes of sulfadimethoxine, sulfadiazine, sulfamerazine and sulfamethazine have been shown to have antibacterial activity against

Staphylococcus aureus, Escherichia coli, Klesiella pneumonia, Enterococcus faecalis and *Pseudomonas aeruginosa* (Papish *et al*., 2006).

Plants are the main dietary source of nickel and they include peas, dried beans, chocolate, nuts and oats. Daily dietary intakes for nickel are estimated to be 100 micrograms (Onianwa *et al*., 2000).

The symptoms of Nickel deficiency include depressed growth, reproductive changes, altered lipid and glucose levels in the blood, changes in skin color, coarse hair, hormone imbalance, a bnormal bone growth, malfunction of liver, poor absorption of iron, altered calcium and vitamin B_{12} metabolism (Agarwal *et al*., 2005).

Dietary excess of nickel is not common, though toxicity symptoms have been observed with nickel contact and inhalation of nickel fumes. Some people are believed to be nickel sensitive. Excess Nickel intak increase risk of cancers of the lung, nose and larynx and is also associated with respiratory ailments such as asthma and bronchitis. Bone development, shortness of breath, dizziness and reduced body immunity are some of the other conditions associated with excess nickel in the body (Chen *et al*., 1993).

Cobalt

Cobalt occurs in oxidation states +2 and +3 in living organisms.Cobalt is found in the coenzyme B_{12}, which is important for the transfer of alkyl groups from one molecule to another in the body. It has been shown to affect growth and metabolism of plants and animals depending on the concentration and status of cobalt in the organism. Cobalt interacts with other elements to form complexes (Agarwal *et al*., 2005). The cytotoxic and phytotoxic activities of cobalt and its compounds depend on the physico-chemical properties of the complexes, including their electronic structure, ion parameters (charge-size relations) and coordination. The competitive absorption and mutual activation of associated metals influence the action of cobalt on various phytochemical reactions (Narla *et al*., 2000).

Two sites of action of Co^{2+} are found in mitochondrial respiration since it induces different responses toward different substrates like α-keto glutarate and succinate. Vitamin B_{12} is a cobaloxime, a cobalt complex containing a glyoxime ligand and is one of the naturally occurring organometallic complexes (Prasain *et al*., 2004; Naga *et al*., 2007; Lukose *et al*., 2013). Vitaimin B_{12} is a cofactor for a number of enzymes which are isomerases as methyl transferases or dehalogenases. Others include nitrile hydratase, prolidase, glucose isomerase, methylmalonyl-CoA carboxytransferase, aldehyde decarbonylase, lysine-2,3-aminomutase, bromoperoxidase and methionine aminopeptidase (Ammar *et al*., 2012). The Co^{3+} ion in vitamin B_{12} is stabilized by a chelating tetradentate macrocycle known as a corrin in which the four nitrogen atoms are located in equatorial positions in the octahedral geometry. Co(III) is also found in certain cobalt-porhyrin containg proteins. A number of complexes of cobalt have shown antibacterial and anti virial activity (Chang & Ragan, 2011).

The interaction of cobalt with other metals mainly depends on the concentration of the metals. For example, high levels of Co^{2+} induce iron deficiency in plants and suppress uptake of Cd by roots and it also interacts synergistically with Zn, Cr, and Sn (Lukose *et al*., 2013). The beneficial effects of cobalt include retardation of senescence of leaf, increase in drought resistance in seeds and regulation of alkaloid accumulation in medicinal plants.

Chang *et al*. (2010) reviewed a number of complexes of cobalt which were found to have antibacterial and antiviral activities. Among these complexes were cobalt bis (1, 2-carbollides) which are used as HIV-1 in hibitors. The selenium organometallic complexes of cobalt were also shown in the same review to be having antibacterial activities. The recommended daily intake of cobalt is 0.13 mg and only about 50% is absorbed from that digested (Basgel and Erdemogl, 2006). Carboxylate complexes icorporating Copper, Manganese and Cobalt metal centre inhibit the growth of Candida albicans (Michael et al., 2000). This means that those medicinal plants which had high cobalt levels could be used for therapeutic activities for the control of bacterial and viral infections.

Copper

The metalloenzyme copper protect the body against the damage of physiological functions of reactive oxygen species in mammals which include neurodegenerative, diabetes, inflammatory or carcinogenetic related processes (Rosas *et al*., 1995; Goodman *et al*., 2004; Kowol *et al.,* 2010). Copper is an essential trace element to human life, but in high doses it can cause anaemia, liver and kidney damage and stomach and intestinal irritation. The Cu, Zn-SOD enzyme, which is the organism's first line of antioxidant defence, contains a bimetallic active site with zinc (II) and copper (II) bridged by deprotonated imidazole.

Radka *et al*. (2012) reported promising SOD-mimic activity (IC_{50} = 8.67–41.45 μM) of dimeric perchlorate Cu(II) complexes$[Cu_2(\mu\text{-}HLx)_4(ClO_4)_2](ClO_4)_2$ and benzyl-substituted derivatives of N6-benzyladenine (HLx) in the treatment of diseases connected with the oxidative stress. Additionally, the pharmaceutical potential of complexes involving methoxy-benzyl-derived N6-benzyladenines was confirmed in the antidiabetic activity against alloxan-induced diabetes in vivo (Radka *et al*., 2012; Kowol *et al.,* 2010).

Copper is involved in the oxidation of Fe^{2+} to Fe^{3+} during haemoglobin formation. It's an important catalyst for iron absorption. Copper deficiency may be a risk factor for cardiovascular disease. When overt copper deficiency occurs symptoms include neutropenia, cardiac disorders, osteoporosis and anaemia. Kowol *et al.* (2010) reported that organic bound metals are potentially bioavailable during the acid rain as well as the carbonates of Cu, Zn, Pb and Fe in Ultrica dioica from the soil in Poland. This resulted in higher accumulation of those elements in medicinal plants collected from natural states. A review done by Saba *et al.* (2014) revealed that complexes of vanadium, zinc, copper, chromium, cobalt, molybdenum and tungsten to be effective anti- diabetic agents. This means that those medicinal plants which had substantial amounts of these elements could be used in the management of diabetes mellitus. Copper is a critical functional component of a number of essential enzymes known as cuproenzymes which perform the following physiological functions known to be copper-dependent; plays a critical role in cellular energy production by catalyzing the reduction of molecular oxygen to water, making the enzyme to generate an electrical gradient used by the mitochondria to create the vital energy-storing molecule, ATP (Bharti & Singh, 2009). It forms part of enzymes which are essential for the formation of strong and flexible connective tissue. This maintains the integrity of connective tissue in the heart and blood vessels and also plays a role in bone formation. Cuproenzymes help in mobilization of iron from storage sites. A number of reactions essential to normal function of the brain and nervous system are catalyzed by cuproenzymes. The cuproenzyme, tyrosinase, is required for the formation of the pigment melanin which plays a role in the pigmentation of the hair, skin, and eyes (Turnlund, 2006). The total content of 9.40-16.70 mg/100g of copper was reported by Anna *et al.* (2013) among the Brazilian teas. 24 mg/100g was reported by Adeolu *et al.* (2011) in a study done in South Africa.Copper is essential in bringing about immunity in the human body as well as involved in homeostasis and iron metabolism (Sappey, 1994; Queralt *et al*., 2005; Edward *et al*., 2005; Kokkotov *et al*., 2009; Iakovidis *et al*., 2011). Iakovidis and co workers (2011) reported the use copper complexes in medicine anti-inflammatory drugs with reduced side effects. Masako and Yoshiyuki, (2006) reported the use of copper complexes as antimicrobial, antiviral, anti-inflammatory, antitumor agents, enzyme inhibitors, or chemical nucleases.

The availability of Cu in the medicinal plants plays a number of roles in treatment of ailments. In the treatment of bone related ailments such as arthritis, paining and swollen joints, Cu as a mineral is important. It also assists in healing of wounds and treating lung related ailments such as coughs and colds because it boosts body immunity according to Failla and Hopkins (1998).

Average daily copper intake for adults is estimated at 1.6 µg from air, 20 µg from drinking water and 28 µg from food (Okoro *et al.,* 2012). Turnlund (2006) synthesised, characterized and biologically comparatively studied the antibacterial copper complexes with heterocyclic sulfonamides and reported that complexes of $[Cu(L)_2].H_2O$ and $[Cu(L)2(H_2O)_4].n\ H_2O$ with five-membered heterocyclic rings were more active than the free sulfonamides while the pyrimidine, pyridine and pyridazine complexes were more active than the free ligands. He further tested this lipophicity behavoiur and superoxide dismutase-like activity showing that the [Cu (sulfamethoxazol)$_2(H_2O)_4]$. $3H_2O$ presented the highest antimicrobial potency and a superoxide dismutase-like activity comparable with pharmacological active compounds. All the compounds were active against *Staphylococcus aureus* and *Escherichia coli*. Availabilty of copper in medicinal plants plays the role of treatment of anumber of ailments such as bone diseases and joint aches, healing wounds, lung diseases by boosting the body's immunity (Failla &Hopkins, 1998).The upper recommended daily intakes of copper for adult males are 1.7 mg and 1.20 mg for females (Australian government National Health and Medical Council, 2002).

Selenium

Selenium plays a role in reproduction, thyroid hormone metabolism, DNA synthesis, and protection tissues from oxidative damage and infection (Gomez-Ariza *et al*., 1998; Kariuki, 2000; Brown &Arthur, 2001; Sunde, 2012). Selenium exists as inorganic and organic forms in the body (Kaiuki&Kariuki, 2004; Sunde, 2006; Davis, 2012; Terry and Diamond, 2012). The daily recommended daily allowances of selenium are as shown in table 2.2.

Table 2.2: Recommended Dietary Allowances (RDAs) for Selenium.

Age	Male	Female	Pregnancy	Lactation
Birth to 6 months	15 µg *	15 µg *		
7 months–3years	20 µg *	20 µg *		
4–8 years	30 µg	30 µg		
9–13 years	40 µg	40 µg		
14–18 years	55 µg	55 µg	60 µg	70 µg
19–50 years	55 µg	55 µg	60 µg	70 µg
51+ years	55 µg	55 µg		

*Adequate Intake (AI) Source: Institute of Medicine, 2000

The major food sources of selenium in the diet are breads, grains, meat, poultry, fish, and eggs (Anderson, 1989 & 1993; Kariuki, 2000; Chun *et al*., 2010). The amount of selenium in medicinal plants depend on selenium in the soil, soil pH, organic matter in the soil, and whether the selenium is in a form that is amenable for plant uptake (Burk *et al*., 2006; Thomson *et al*., 2008; Rayman, 2012; Sunde, 2012).

Selenium deficiency produces biochemical changes that might predispose people to additional stresses to develop certain illnesses such as Keshan disease, male infertility and Kashin-Beck disease (Institute of Medicine, 2000; Beck *et al*.,2001; Gromer *et al*., 2005; Chun *et al*., 2006; Rayman, 2008; Chen, 2012; Jirong *et al*., 2012).

Because of its effects on DNA repair, apoptosis, and the endocrine and immune systems as well as other mechanisms, including its antioxidant properties, selenium might play a role in the prevention of cancer (Grossman & Wendel, 1985; Grimble, 1994; David, 1994; Kariuki&Kariuki, 2004; Brinkman *et al*., 2006; Hullenbusch et al., 2006; Sunde, 2006; Kupka *et al*., 2009; Lu& Holmgren, 2009; Lobanov *et al*., 2009; Antal *et al*., 2010; Chen, 2012).

Kupka *et al*. (2009) reported an inverse association between selenium statuses and the risk of colorectal, prostate, lung, bladder, skin, esophageal, and gastric cancers. Selenoproteins have been shown to help prevent the oxidative modification of lipids, reducing inflammation and preventing platelets from aggregating (Davis, 2012; Rayman, 2012). Flores-Mateo *et al*., 2006) reported that people with lower selenium concentrations had a higher risk of coronary heart disease while Bleys *et al*. (2008) and Bleys *et al*. (2009) reported that higher selenium concentrations are associated with an increased risk of cardiovascular disease. These mean selenium supplements could reduce the risk of cardiovascular disease or deaths associated with cardiovascular disease.

Antal *et al.* (2010) reported the levels of selenium in Romania to be 60$\pm$8.7 µg/kg, 58$\pm$7.7 µg/kg in the leaves, 54$\pm$6.3 µg/kg in subterranean parts, 35$\pm$5.0 µg/kg in flowers and inflorescences and 12$\pm$8 µg/kg in fruits of the medicinal plants. Selenium is essential in twenty-five proteins and enzyme systems where it is incorporated as selenocysteine at the active sites (Brown & Arthur, 2001). The uptake of selenium in man is subjected to a genetic control. Among selenium containing enzymes, of special importance are glutathione peroxidases which reduce the accumulation of peroxides and hydroperoxides and deiodinases which intervene in the metabolism of of the thyroid hormones (Gromer *et al*., 2009). Seleproteinns P, the major plasma protein which defends the body against oxidative injuries and plays a part in the detoxification of mercury (Lobanov, 2001). Selenoprotein W is used for the health cardiac and skeletal muscles (Ream *et al*., 2001); selenoprotein 15 which has a chemopreventive role (Gladyshev, 2001). Selenoprotein R acts as a stereospecific methionine sulfoxide reductase (Krykov *et al*., 2002), while selenoprotein N functions catalytically in redox process involving thiols as electron donors (Lu and Holmgren, 2009). Limited amounts of selenium in the body brings about a number of diseases such as fatal cardimyopthy, muscular dystrophy, inflammatory-degenerative deterioration of articulations, cancer, immune system deficiencies and decline in the thyroid function (Anderson,1993; Annke *et al*., 2002). Clinical applications of selenium supplementation include avariety of acute diseases or chronic conditions associated with increased oxygen radical production (septicemia, acute pancreatitis, chronic lyphedema, endemic hemorrhagic fever, an autoimmune thyroiditis) (David, 1994; Berger and Chiolero, 2007; Steinbrenner& Sies, 2009), AIDS, cancer (lung, gastric, intestinal, prostate, and breast) as well as cardiovascular and rheumatic disease (Miron and Stanescu, 2003; Sunde, 2006 Kupka *et al*., 2009; Rayman, 2009). The daily requirement for selenium in humans (WHO, 1996) is 40µg Se/day. The high tolerable level of daily selenium intake was set at 400µg Se/day.

The most common clinical signs of chronically high selenium intakes are hair and nail loss or brittleness, lesions of the skin and nervous system, nausea, diarrhea, skin rashes, mottled teeth, fatigue, irritability, and nervous system abnormalities (Kariuki &Kariuki, 2004).

Molybdenum

Molybdenum is an important trace element in metalloenzymes active sites. Molybdenum along with tungstein helps sulphur, selenium, and chlorine compounds in the body metabolism. It plays a crucial role in the structural formation of certain enzymes involved redox reactions (Hille &Massey, 1985; Barber et al., 1987; Burris, 1991; Stiefel, 1993; Doring & Schulzke, 2010). Molybdenum in different forms possesses insulin mimetic properties and hence it’s used in the treatment of diabetes. Sodium molybdate and its complex compounds such as cis-MoO_2L_2 were found to reduce the levels of blood glucose significantly and also free fatty acids (Howard and Rees, 1996; Burgess and Lowe, 1996; Kisker et al., 1997; Butler et al., 1999; Campbell, 1999; Lord *et al*., 1999; Mendel &Bittner, 2006). Combination of molybdenum and ascorbic acid exhibited significant insulin-like activities and also cardio protective effects (Einsle et al., 2002; Hille, 2002; Williams and Fraústo da Silva, 2002; Yandulov and Schrock, 2003; MacDonald *et al*., 2006). The Mo in enzymes exist in +7, +5 or +4 oxidation states in which it performs different functions (Mendel and Bittner, 2006; Morozkina and Zvyagilskaya, 2007; Hu et al., 2008; Zhang and Gladyshev, 2008; Hernandez et al., 2009). Ogata *et al.* (2009) reported that molybdenum complexes were anti cancerous against pancreatic cancer and gastric cancer. Upper recommended daily intakes of molybdenum for adults 45 μg (Australian government National Health and Medical Council, 2002).

Boron

Boron is essential to human life as an antiseptic, antifungal and antiviral (Pirzada *et al*., 2010). Sekhon, (2013) reported that boron-containing drug have a potential for treatment o fhuman African trypanosomiasis, malaria and Chagas disease and several protease inhibitors exert anti-tumour activity *in vivo* and potently induce apoptosis in tumour cells *in vitro*, including those resistant to conventional chemotherapeutic agents.

The chelated complexes of V, Cr, Cu, Mn, Zn, or Ni exhibited bioctivities against antineurodegenerative, anticancer, antioxidant, antimicrobial, anti-inflammatory, and antidiabetic diseases (Berger & Chiolero, 2007; Prachayasittikul *et al.,* 2013). The complexes of these essential elements could be used in the treatment of a number of ailments affecting the human beings (Prachayasittikul *et al.,* 2013).

2.4 Trace Element Speciation

The term speciation refers to the specific chemical state or binding form of elements for example different oxidation states, different inorganic or organometallic compounds or complexes with organic ligands. It draws attention to the distinction between measuring the total elemental levels and those of the different fractions (Singh *et al*., 2009). Nriagu (1983) defines speciation as all the possible chemical forms of a metal that may occur in different environments, while Florence (1983) defines it as the determination of individual chemical forms of an element which together make up total concentration of the element in a sample. Many elements and substances exist in food and medicinal plants in a variety of physico-chemical forms. These different forms (species) exhibit different physical, chemical and biochemical properties. Unless the chemical distribution of the trace element is known, predictions cannot be made about its effects on the living organisms (Zaidi *et al*., 2004).

Metal speciation is a process of evaluating the biochemistry and beneficial or toxic aspects of an element. The uptake, accumulation, transport and interaction of metals and metalloids in nature are influenced by their speciation (Singh *et al*., 2009). Complete characterization of a metal in environmental and biological system involves the determination of its fractional species, oxidation state and associated organic ligands (Zaidi *et al*., 2004). Speciation analysis challenges are low concentration of the analytes and potential instability of the target (Singh *et al*., 2009). The international union for Pure and Applied Chemistry (IUPAC) defines speciation analysis as the analytical activity of identifying and measuring the quantities of one or more individual chemical species in a sample (chemical species are specific forms of an element defined as to fractional, isotopic composition, electronic or oxidation state, and/or complex or molecular structure). Speciation analysis is therefore the process leading to the identification and determination of the different chemical and physical forms of an element existing in a sample. In practice speciation deals with specifying the transformation and/or the distribution of species or the analytical activity to identify chemical species and measure their distribution (Moldovan *et* *al*., 2004). Metal speciation deals with the determination of the concentrations of the elemental forms that makes it possible for the attainment of new data to foresee the absorption of the element. Bioavailability of an element indicates the ratio of the nutrient that is absorbed and used by the organism. Techniques of chemical speciation determination, such as Sequential Extraction can assist in the evaluation of the bioavailabilty of minerals in medicinal plants.

2.5 Analytical Methods

2.5.1 Elemental Analysis

Prior to determination of total metal contents in plants the samples are typically dried, ground and digested using either wet ashing in a microwave system, or dry ashing in a muffle furnace with subsequent uptake in acidic solution. The obtained digest can then be analysed by multi-element detection techniques like Inductive Coupled Plasma Mass Spectroscopy (ICP-MS), Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) or Atomic Absorption Spectrophotometer (AAS) (Xudong *et al*., 2011). Sensitivity of ICP-MS is better than ICP-OES and therefore this technique will be mainly applied for determination of elemental contents in medicinal plants this study.

Aqueous extracts, partly containing buffers or organic solvents like methanol, have been used in many studies for extraction of elemental species from biological samples. Hyphenated techniques offer flexible approaches for characterization of elemental species in complex biological matrices. Various liquid chromatographic methods, for example Size Exclusion Chromatography, Ion Exchange Chromatography, are suitable for separation of elemental species which are detected using ICP-MS and ESI-MS (Lobinski & Szpunar, 1999; Templeton *et al*., 2000; Kokkotov *et al*., 2009).

Medicinal plants contain considerable amounts of mineral constituents such V, Co, K, Ca, Mg, Mn, Cr, Fe and Zn which are involved in activation of enzymes, synthesis and metabolism of biomolecules and in immunity whose metal species in the plants is not known. Consequently, there is only little knowledge on their pharmacological influence on medicinal plants. Such influence could be through metal binding to pharmacologically active substances, or by influencing bioavailability, pharmacokinetics, or side effects of the drug (Weber and Konieczynski, 2003). Weber and Konieczynski (2003) reported a good correlation between detection of Mg, Mn and Pulsed Amperometric Detection (PAD), which is selective for carbohydrates on speciation of Mg, Mn and Zn in extracts of medicinal plants. The respective molecular weight of carbohydrate species was in the range of approximately 300–600 daltons (Da). The distribution of zinc species (detectable only in the *Betula* extract) is totally different from that of Mg and Mn species. For zinc, many species are detected were the (poly) phenols in which zinc was involved complexation (Szpunar, 2000).

Inductively Coupled Plasma- Mass Spectrometry (ICP-MS)

ICP-MS is powerful element analysis technique with detection limits, at ng kg^{-1} level. The aerosol formed by the introduction system is desolvated in the plasma; the molecules are then atomized and ionized. The ionization occurs through the interaction, collisions between the argon atoms and its electrons, partly free in this plasma and the analyte (Chery, 2003).

The inductive coupled plasma source is called a tourch. It consists of three concentric quartz tubes through which streams of argon flow at atotal rate between 11 and 17 litres per minute. The diameter of the largest tube is about 2.5 cm. Surrounding the top of this tube is a water cooled induction coil that is powered by a radio-frequency generator which is capable of producing 2KW of power at 27MHz. Ionization of the flowing gas is intiated by a spark from a Tesla coil. The resulting ions and their associated electrons, then interact with the fluctuating magnetic field produced by the induction coil. This nteraction causes the ions and electrons within the coil to flow in the closed annular paths bringing about ohmic heating as a consequence of their resistance to this movement.

The temperature of the plasma formed is high enough to require thermal isolation from the outer quartz cylinder. This isolation is achieved by flowing argon tangentially around the walls of the tube at a rate of 5 to 15 litres per minute. The tangential argon flow cools the inside walls of the centre tube and centres the plasma radially.

The sample is carried into the hot plasma at the head of the tubes by argon flowing at 0.3 to 1.5 litres per minute through the central quartz tube. The sample may be an aersol, a thermally or spark generated vapour or fine powder. The sample is nebulized by the flow of argon, and the resulting finely divided droplets are carried into the plasma. Another method of introducing the liquid and solid samples into the plasma is by electrothermal vapourization. The sample is vapourized in a furnace. The vapour formation occurs on an open graphite rod. The vapour is carried into a plasma torch by a flow of argon. Electrothermal vapourization coupled with a plasma torch offers the microsampling capabilities and low detection limit of electothermal furnaces while maintaining the wide linear working range, the freedom from interference and multielement capabilities.

The interface between the atmospheric pressure and the low pressure, lower than 1 mPa is necessary to ensure a collision-free transmission of the ions i.e, long enough free paths. This interface consists of two coaxial cones with a tiny opening at their vertex, with their axis in the direction of the plasma plume. Part of the gas coming out of the plasma is allowed to go further, gas consisting of ions, neutral molecules and electrons. At each step of the ion transmission a vacuum pump is installed.

The pump expels a way all neutral molecules. After the two cones, when the sampling of the plasma gas is achieved, the ionized atoms are focused by an electrostatic lens, which in the case of negative mode also deflects anions and electrons. Only cations are transported to the filtering device of the instrument, a joined magnetic and electric sector field or a quadrupole (Willard *et al*., 1993). The dynamic electromagnetic field that is present in the quadrupole has the capacity to bring at the exit of the device only ions with a specific mass-to-charge ratio; other ratios are simply destabilized and expulsed from a stable trajectory. The selected ions then leave the quadrupole to migrate towards the detector, in most cases an electron multiplier (Chery, 2003).

One advantage of ICP-MS is its high sensitivity for elements (Szpunar, 2000). This however, suffers from spectral interferences, i.e. the formation of ions with the same nominal mass as the analyte. The matrix, in which the element is present, plays an essential role in the position of the plasma plume, the ionization equilibrium and the charge distribution, so that a calibration with the same matrix is preferable. Some vital trace elements such as iron or vanadium are interfered by polyatomic ions. ICP-MS instruments are not stable over a long period of time, which makes mandatory the use of an internal reference or of periodical external standardization (Szpunar, 2000).

Atomic Absorption Spectrophotometry (AAS)

Atomic Absorption Spectrometry is a powerful tool for heavy metal analysis in biological and environmental samples. It provides a total metal content of the sample. When electromagnetic radiation is incident onto a vapor of metallic atoms, the atoms interacts with light radiation of their own specific resonance wavelengths resulting in absorption of radiation. Upon absorption of radiation, the atoms are transformed from a low energy state (ground state) characterized by

E_1 to a higher energy state (excited state) characterized by E_2. The transition E_1 to E_2 results from the absorption of radiation of frequency, ν given by the equation:

$$\nu = \frac{E_2 - E_1}{h} \text{ -------------------------------------- (I)}$$

Where *h* is Plank's Constant (Skoog and Leary, 2000).

The excited atoms may revert back to ground state by emitting radiation of the same frequency. The transitions are due to absorption of radiation from an external source. The measurement of the radiation absorbed in such a transition forms the basis of AAS (Dulsik, 1999; Skoog and Leary, 2000). Radiation source should emit stable, intense radiation of the resonance wavelength of the element to be determined and should guarantee high signal- to- noise ratio. The radiation sources commonly used in AAS are the hollow cathode lamps consisting of the test element and the gaseous discharge lamps (arc lamps).

A solution of the sample is converted to a mist of finely divided droplets by a jet of a compressed gas. The flow of the gas then carries the sample into a heated region where a tomization occurs. The first step of atomization involves desolvation in which the solvent is evaporated to produce a finely divided solid molecular aerosol. Dissocxiation of molecules leads to formation of an atomic gas. The atoms inturn are dissociated into ions and electrons. The molecules, atoms and ions are all excitedin the heated medium producing molecular and atomic emission spectra. The atomizers convert the metal ions in the liquid sample to atomic vapor. Air-acetylene and nitrous oxide-acetylene flames are commonly used, although electrically heated graphite atomizers are also used for special analytical work. Nebulizers convert the liquid samples into small droplets before the sample enters the atomizer. This is achieved by use of a gas moving at high velocity. Monochromator on the other hand selects a given absorption line from spectral lines emitted from the light source or background emission from the flame. The most common monochromators in AAS are prisms and gratings. Gratings have the advantage of constant performance throughout the electromagnetic spectrum and are often used. However, prisms have higher performance in the ultraviolet region (Skoog and Leary, 2000). The photomultiplier tube detector is used in most modern instruments. In the photomultiplier tube, there is an evacuated envelope, which contains a photocathode, a series of dynodes, which amplify the optical signals at the anode. A photon from the monochromator strikes the photocathode and dislodges an electron which is then accelerated to dynode one. The accelerated electron in turn ejects two or more electrons from dynode one. These electrons are accelerated to dynode two, three and so on resulting in the ejection of more and more electrons which eventually reach the anode as an amplified electron current. The amplified electron current from the photomultiplier tube is then fed to an electrical amplifier, which is then read out on an analogue or digital display. Most modern instruments are interfaced to a computer processor (Skoog and Leary, 2000).

Table 2.3: Atomic absorption spectrophotometer conditions for some metal analysis.

Metal	Wavelength(nm)	IEO	Slit setting(nm)	Detection limit (µg/g)	Linear range (µg/g)	Flow rate
Chromium	425.37	25 97	0.3	0.002	0.005-0.1	2000
Iron	248.33	30(18) 6	0.3	0.005	0.3-10.0	1700
Vanadium	437.9	25 97	0.2	0.008	0.2-10	2000
Copper	324.75	15 80	0.2	0.04	0.2-5	2000
Manganese	279.48	20 62	0.2	0.005	1.0-7.0	2000
Magnesium	285.20	25 67	0.3	0.001	0.1-0.5	2000
Zinc	213.86	15 (13)	0.2	0.003	0.3-3.0	1000
Lead	283.3	30(18) 6	0.2	0.01	1-20	2000
Cadmium	228.8	15 (13)	0.2	0.05	0.2-5	2000

Source: Willrad *et al*., 1993

2.5.2 Trace Element Speciation

The species of the elements in biological systems are sperated by various techniques which include size exclusion, ion exchange, reversed-phase chromatography and sequential extraction and the fractional species are then detected by AAS or ICP-MS techniques.

Reversed Phase Chromatography

The stationary phase is made of hydrophobic bonded C_8 or C_{18} functional groups while the eluent is a polar in nature. Eluent strength of various solvents in reverse chromatography is the reverse of the eluotropic series. Thus water is the weakest eluent and n- hexane the strongest due to their polarity. Methanol and acetonitrile with low ultraviolet cutoff points, low viscosity and availability in high purity are the most popular organic solvents (Dulsik, 1999).

Selectivity arises as a consequence of non polar size differences, that is, non polar surface areas of solutes. Hydrophobic forces reduction can be effected by adding any miscible organic solvent to water (Szpunar, 2000). The effect will be larger with less polar solvents and with greater concentration. The added organic modifier improves the seperation of organic homologs (Skoog and Leary, 2000; Szpunar, 2000).

In resolving functional group differences the organic modifier is used as the polar group selectivity is dependent on the organic solvent used. The use of mobile phases made of water, methanol and tetrahydrofuran control the selectivity of solutes particularly with different functionalities (Willard *et al*., 1993). When the mixture contains components having a wide difference in polarity, the capacity of separation column has to be increased by using gradient elution. In reversed mode, solvent gradients are generated by a decrease in the polarity of the eluent during the separation (Szpunar, 2000; Moradkhani *et al*., 2012).

Adjusting pH allows inorganic solutes to be separated. Ion suppression is useful for weak acids and bases separations at pH 2-8. Relatively high buffer concentration is maintained in order to facilitate a rapid establishment of the protonic equilibria and to avoid asymmetrical peaks or band splitting due to the slowness of the secondary equilibria involved in the chromatographic process. At low pH perchloric acid is used (Dulsik, 1999). Strong acids and bases can be handled by forming ion pair (a coulombic association species formed between two ions of opposite electrical charge) with a suitable counter ion; ionic or ionizable compounds are converted to electrically neutral compounds and therefore partitioned into respective non polar phase. A large organic counter ion added to the mobile phase forms a reversible ion –pair complex with ionized sample; this complex behaves as electrically neutral and non polar (lipophilic) compound (Szpunar, 2000). The extent to which the ionized sample and counter ion form an ion-pair complex affects the degree to which the retention is increased (Skoog and Leary, 2000). The adjustment of the pH so that the sample is present in ionic form and choosing a strongly ionic counter ion of opposite charge with very lipophilic group attached and the situation can be represented as:

$Solute^{\pm}$ + counter ion $\mp$ = $Solute^{\pm}$ + counter ion $\mp$ (Skoog and Leary, 2000; Szpunar, 2000).

Ion Exchange HPLC

The stationary phase consists of two components: the polymer matrix attached functional groups and the functional groups are permanently bonded ionic groups with their counter ions of opposite charge. It's particularly adapted to the analysis of ionized and ionizable compounds through charge-charge interactions (Skoog and Leary, 2000; Szpunar, 2000).

Some ion exchangers have negatively charged groups and are used for exchanging cationic species; others are designed for exchanging anionic species and are provided with positively charged groups. The most commonly used functional groups are sulphonate type for cation exchange and the quarternary amine type for anion exchange. Sulphonate exchangers are strongly acidic exchangers because they have the properties of strong acids when in the H-form. Quartenary ammonium exchangers are strongly basic because when in the OH-form, their properties are similar to those of a strong base (Willard *et al*., 1993). Both functional groups are totally dissociated; therefore their exchange capacity, which is the number of the functional groups available for exchange per mass unit of exchanger, is constant and not subject to change with pH (Skoog and Leary, 2000; Moradkhani *et al*., 2012).

There are some exchangers whose functional groups have weak acidic or basic properties. Thus carboxyllate group carried by an exchanger permits the exchange of cationic species only when the pH is high enough to permit the dissociation of the –COOH site. For the same reason a ternary amine has exchanging properties only when in an acidic medium, because its functional groups are then carrying a positive charge, a proton having been bound to the nitrogen atom. In addition to their weak acid character, some functional groups have chelating properties towards some metallic cations. These exchangers have considerable affinity for heavy metal cations and to a lesser extent for alkaline earth cations (Skoog and Leary, 2000).

The limitation of conventional ion chromatography is that of detectors. Ion chromatography solves this by using an additional suppressor column downstream from the separator column. The suppressor column strips cut out or neutralizes the ions of eluent and leaves only the species of interest passing through the conductance cell. In the anion analysis, the anion ion-exchanger column is followed by a cation exchanger suppressor column (Moradkhani *et al*., 2012). On entering the suppressor column, the eluting base is removed by acidic resin:

$resin–H^+ + Na^+ + OH^- \rightarrow resin\text{-}Na^+ + H_2O$

on the separating anions are converted to their acids:

$resin\text{-}H^+ + M^+ + A^- \rightarrow resin\text{-}M^+ + H^+ + A^-$

which flow through the suppressor column into the conductivity cell of the instrument where they are monitored. The ratio C_B/C_A (specific capacity of suppressor bed/ specific capacity of the separator bed) must be as large as possible to maximize the number of ions that can be removed from the eluent stream before the capacity of the suppressor bed is saturated. These requirements are met by using resins with high degree of cross-linking in the suppressor column while using special low capacity resins in the separator column (Willard *et al*., 1993). The choice of eluent revolves about balancing eluting power and eluent concentration with the selectivity of the sample ions in the separator resin. To ensure sufficient residence time in the separator column one should select an eluting ion that has about the same affinity for the resin as does the sample ions (Moradkhani *et al*., 2012).

Size Exclusion Chromatography

Size exclusion chromatography is also called gel permeation chromatography and is a non interactive mode of separation. The particles of the column packing have various size pores and pore networks, so that the solute molecules are retained or excluded depending on their hydrodynamic volumes i.e their size and shape. The stationary phase effects separation according to molecular weight (Skoog and Leary, 2000).

As the sample passes through the column, the solute molecules are sorted by the pores of the packing material. Very large molecules cannot enter many of the pores and will penetrate (permeate) less into the comparatively open regions of the packing and thus are excluded, will travel mostly around the packing and elute at the velocity of the mobile phase. Very small molecules, diffusing into many of the pores accessible to them, both the flowing mobile phase and the stationary solvent trapped within the pores. With a larger column volume at their disposal, small molecules exit the column last. Between these two extremes, the intermediate – size molecules can permeate some pores but not others and suffer retardations in their movement down the column exiting at intermediate times (Moradkhani *et al*., 2012). A column packed with porous particles can be regarded as being a column of variable path length; it is short column for solute molecules of molecular dimensions greater than average pore size of the column packing, whereas it is along column for solute molecules smaller than the pore size of the packing. Compounds in polar mobile phase such as water or water- methanol are chromatographed using a relatively non polar stationery phase i.e porous silica gel surface modified chemically bonded by hydrocarbon chains (C_4-C_{18}) (Szupnar, 1999).

Squential Extraction Procedure for Speciation of Trace Elements

The sequential extraction scheme for metals byBureau Community of Reference (BCR) partitions in biological amd chemical systems is divided into four fractions: exchangeable, reducible, oxidizable and residual fractions (Oyeyiola *et al*., 2009; Uduma and Jimoh, 2013).

Exchangeable fraction:

This deals with separation of those metal fractions which are bound to biological or chemical systems by weak adsorption to the sample particles. Changes in ionic strength of the water affect the adsorption-desorption or ion exchange processes resulting in the uptake or release of metals at organic matrix/water interface

Reducible fraction

The netal fractions bound to iron/ manganese oxide released under reducing (anoxic) conditions. These conditions are obtained by 0.01M hydroxylamine hydrochloride in 25% (v/v) acetic acid at room temperature.

Oxidizable fraction

Organic bound metal fractions are oxidized to be released. This is achieved by heating the sample using 30% H_2O_2 in 0.02 M HNO_3 for a total of 5 hours at 85°C followed by extraction into 3.2 M ammonium acetate in 25 % (v/v) nitric acid added to prevent readsorption of metals by oxidized organic material.

Residual fraction

This fraction contains naturally occurring minerals which hold metals within their crystalline matrix. These metal fractions are released by digestion with HNO_3/HCl (aqua regia) for about 4 hours.

Ultrafiltration

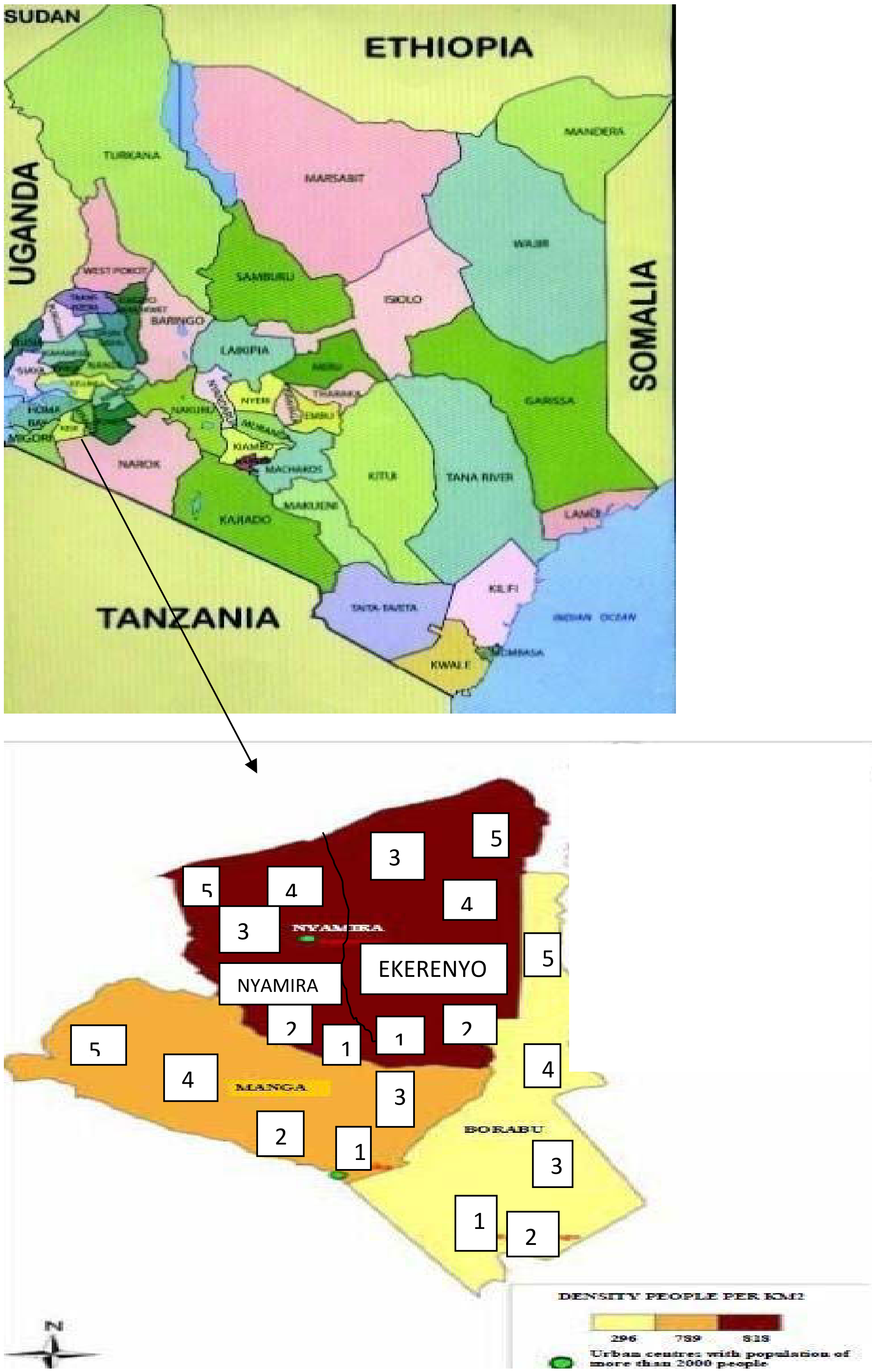
This is a separation technique for different molecular weight compounds. The primary basis for separation is molecular size, although the permeability of a filter medium can be affected by chemical and molecular properties of the sample. Ultrafiltration can only separate molecules which differ by atleast an order of magnitude in size. Molecules of similar size cannot be separated by ultrafiltration. The aim of ultrafiltration is to maximize recovery of solutes of interest but there many membrane charactereristics that affect this goal. Ultrafiltration membranes are rated according to the molecular weight cut off (MWCO). MWCO indicates the most dissolved macromolecules with molecular weights higher than MWCO will be retained. Ultrafiltration membrane with stated MWCO should retain (reject) atleast 90% of globular solute of that molecular weight in Daltons (Ogata *et al*., 2009). The selected cut-off should be well below the molecular weight of the solute to be retained. When the solutes are to be exchanged the cut-off should be above that of passing solute. A lower MWCO increases rejection but decreases the filtration rate for the same membrane material. Retention and compound recovery are afunction of factors such as molecular shape and size, sample concentration and composition. Another factor affecting the retention is the potential for the membrane fouling, or concentration polarization. This occurs when there is an accumulation of the retained solute on the surface of the membrane. At high concentration, a gel layer may form that can act as a secondary membrane.

CHAPTER THREE

METHODOLOGY

3.1 Nyamira County

Nyamira County lies between latitudes 0^0 $30^{//}$ and 0^0 $45^{//}$ South and longitudes 34^0 $45^{//}$ and 35^0 $00^{//}$ East. The County has an area of 879 square kilometers, with a population of 624,834 (Kenya Census, 2009). It has two topographical zones lying between 1500 and 1800M above sea level and dissected by several ridges and hills. The climate of the County is the highland equatorial type which enables it to receive high reliable rainfall that is well distributed throughout the year, with an average annual rainfall of 2000mm. However, there are two rainy seasons, the long rainy season that occurs between April-June, and the short rainy season between October- December. Soils are generally ferruginous, with relatively high cation exchange capacity that supports the growth of variety of the flora. Borabu, Ekerenyo, Manga, and Nyamira Sub Counties which make Nyamira County have rich forest reserves containing many different medicinal plants (Kenya Census, 2009). The map of Nyamira County showing the sampling sites is given on Fig 1 below.



Scale 1: 250,000

Figure 1: Map of the sampling sites of Nyamira County

3.2 Survey of Herbalists

3.2.1 Sample Size and samling of Herbalists

Four hundred herbalists registered at the Nyamira County cultural office were interviewed using a coded questionnaire (Appendix I) and the herbalists in each sub county randomly selected. The sample size was calculated on prevalence of 5%, d=0.05 at a confidence level 0f 95% (Daniel 1999).

$$N= \frac{Z^2P(1-P)}{d^2}$$

The Z value which was used to calculate the sample size was 1.96, giving a sample size of 73 but a sample size of herbalists from each sub county were selected by rotary random sampling based on their use of the identified medicinal plant and the success of treatment of their patients. The selected herbalists and the places where the medicinal plants were collected from were identified by geographical position system ordinates (GPS).

3.2.2 Administration of Questionnaire

The purpose of the study was explained to the herbalists in herbal clinics before administering the questionnaire. The designed, coded questionnaires were administered to willing herbalists in five areas in each Sub County and who were allowed to fill the questionnaire on their own. The filled questionnaires were collected after two weeks and analyzed statistically.

3.2.3 Analysis of Questionnaire

The coded questionnaires were collected and analysed by SPSS package. Those questionnaires which had atleast 80% responses filled were used for the selection of the herbalists. The most important responses used were; the most predominantly treated diseases, popular herbalists, most commonly used medicinal plants and the protocols used for preparation of medicine from the plants. The quality of the answers to the questionnaire, their popularity in treatment and the use of selected plants for the treatment of the selected diseases were used as a criterion of choice of the herbalists to be selected for sampling of herbal medicine. The herbalists were requested to provide one kilogram of the dry unpowdered medicinal plant species.

3.3 Collection of Medicinal Plants

Herbal medicinal were sampled from the herbalists interviewed in Nyamira County between February 2014 and June 2014. The plant samples collected were botanically identified, washed with deionised water to remove soil and other adsorbed material, placed in polythene paper, sealed, air-dried under shade and ground using a wooden pestle and mortar (for all the samples) to avoid contamination. The ground samples of the medicinal plants were placed in polythene paper, sealed, labelled and stored. This was done with ultimate care to ensure that there was no contamination during collection, transportation and storage of the herbal plants, whereby each plant was collected and stored separately. Each sample was placed in a transparent polythene bag, labeled and stored in a cool dry area until it was analyzed. Confirmation of the identity of the medicinal plants was done at the University of Nairobi Herbarium.

3.4 Instruments and Apparatus

The manufacturer and the model of the instruments used in analysis are given in Table 3.1

Table 3.1: Manufacturer and models of instruments.

Instrument	Manufacturer	Model
FAAS	Shimadzu, Japan	AA-6300
ICP-MS	Agilent Technologies, Japan	ICP-MS Agilent 7500A series
Micro wave	CEM, Germany	MARS 5

3.5 Reagents, Chemicals and Reference Materials

The analar chemicals which were used in the analysis are given in table 3.2

Table 3.2: Chemicals.

Chemical	Manufacturer	Percentage concentration	Specific gravity
Hydrochloric acid	Sigma	36%	1.18
Nitric acid	Sigma	70%	1.41
Acetic acid	Sigma	99.6	1.048
Sulphuric acid	Sigma	99.8	1.84
Percloric acid	Sigma	7o%	1.18
Hydrogen peroxide	Sigma	99.9%	
Ammonium acetate	Merck	99%	
Hydroxylamine hydrochloride	Merck	99%	
Manganese sulphate	Sigma	99%	
Potassium dichromate	Sigma	99%	
Nickel metal	Sigma	99%	
Iron fillings (Metal)	Sigma	99%	
Cadmium sulphate	Merck	99%	
Cobalt metal	Sigma	99%	
Zinc sulphate	Sigma	99%	
Mercury chloride	Merck	99%	
Molybdenum oxide	Merck	99%	
Ammonium iron sulphate	Merck	99%	
Sodium molbdate	Sigma	99%	
Magnesiusm sulphate	Sigma	99%	
Copper sulphate	Merck	99%	
Lead nitrate	Sigma	99%	
Calcim carbonate	Sigma	99%	

All the reagents used were of analar grade suitable for trace element analysis. The glassware used were soaked in 5% nitric acid and rinsed thoroughly with double-distilled deionised water after each use and dried overnight in an oven at 80^{o}C.

3.6 Analytical Procedures

3.6.1 Preparation of working solutions

Standard stock solutions of iron, cobalt, copper, nickel, chromium, manganese, molybdenum, zinc, cadmium, magnesium, potassium, aluminium and calcium were serially diluted to give the working solutions.

3.6.2 Preparation of Chemical Reagents

0.1M hydroxylamine hydrochloride and 0.1 m acetic acid

Working solutions of 0.1 m hydroxylamine hydrochloride and 0.1 m acetic acid were made by serial dilutions of their stock solutions.

8 M Hydrogen Peroxide

100V hydrogen peroxide stock analytical grade (A.R) hydrogen peroxide solution was used.

1 M Ammonium Acetate

77.08 g of A.R ammonium acetate crystals were dissolved in double distilled deionised water to make one litre of 1 M ammonium acetate solution.

Aqua Regia

Stock A.R nitric acid and Stock A.R hydrochloric acid were mixed in the ratio of 1:3 to give aqua regia.

3.7 Procedure for Determination of Total Elements by FAAS

Sample preparation- wet digestion

Homogenized 1.0 g of powdered plant sample was weighed into a 100 cm^3 of Pyrex beaker which had been washed with 0.1 M HNO_3 and rinsed with distilled water. Aliquots of 4 cm^3 of Perchloric acid, 25 cm^3 concentrated HNO_3 and 2 cm^3 concentrated H_2SO_4 were added. The mixture was mixed, initially heated at low heat of about 60 °C and then on a hot plate under an acid fume-hood, the heating was continued until dense white fumes appeared. The boiling mixture was heated for two minutes afterward to remove most of the acids from it which could corrode the FAAS metallic parts during the analysis. An aliquot of 50 cm^3 of distilled water was added after cooling to room temperature and boiled further for a half minute on the hot plate. The solution was allowed to cool and filtered using Whatman No. 42 filter paper into 100 cm^3 volumetric flask. Distilled water was added to the mark and the filtrate analyzed for iron, zinc, lead, cadmium, copper, manganese, magnesium and chromium using FAAS. Each sample was analyzed in tetracate (n=4) to test for homogeneity and analytical reproducibility. A solution of known concentration of sodium (5 mg/Kg) was run using the FAAS machine at intervals of running ten samples to ensure that the results were reproducicible.

3.8 Microwave digestion

Aliquots of approximately 70 mg of the plant samples were digested in tetracate using 2 cm^3 of nitric acid and 1 cm^3 of hydrogen peroxide in a closed vessel microwave system at 160°C. Complete digestion of the organic matrix was achieved with occasionally adding silicate chips. The digestion solution was transferred to calibrated polystyrene sample vials and made up to 10 cm^3 with deionised water. Blank digestions, digestions of plant reference materials (NIST1515-apple leaves), (NIST 1547-peach leaves) and natural water refence material (NIST 1640a) were treated in the same way.

3.9 Hot water extraction

Approximately 150 mg of ground plant material mixed with 40 cm^3 deionised water in a glass beaker was covered by a watch glass and heated for 6 minutes to boiling temperature, boiled further for 6 minutes. After cooling to room temperature the mixture was transferred to a polypropylene tube and shaken for 13 h in the dark on a horizontal orbital shaker at 100 revolutions per minute. Loss of water due to evaporation was compensated by topping up with deionised water to 40 cm^3. The plant suspensions were filtered through 0.45 µm syringe filters to obtain clear extracts for analysis.

3.10 Sequential (ultra-) filtration

Hot water extractions were prepared from homogeneous mixture of *Bidens pilosa* and *Tabermontana stapfiana* (obtained by mixing 1 gm of powdered plant species from the four sub counties for each species) as described above (n=4). In addition extractions of the same plant samples were performed by shaking with deionised water at room temperature in the dark for 13 hours without any heating. The obtained extracts were first filtered using a 5 µm syringe filter. An aliquot of the filtrates was then filtered again through 0.45 µm syringe filters. An aliquot of this second filtrate was subjected to ultrafiltration through 10 kDa membrane using Amicon filtration units at a speed of 14000 g. An aliquot of the third filtrate was finally subjected to ultrafiltration through 3 kDa membrane using Amicon filtration units at a speed of 14000 g. The ultrafiltration units were pre-cleaned by filtration of 0.5% nitric acid and deionised water prior to filtration of the samples following previous work. The filtrates were analysed by ICP-MS as described below. The elemental molecular species content were related to the solid plant material. In addition to the <3 kDa fraction, the size fraction 3 kDa-10 kDa, 10 kDa-0.45 µm and 0.45 µm-5 µm molecular species were calculated as difference of contents in the respective filtrates.

3.11 Procedure for Determination of Total Elements by ICP-MS

Total contents of 36 elements (B, Mg, Al, P, K, S, Si, As, Hg, Zr, Se,Ca, Ti, V, Cr, Fe, Mn, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Nb, Mo, Cd, Ba, Nd, Sm, Gd, Er, Yb, Tl and Pb) were determined in the digested solutions of the plant samples using inductively coupled plasma mass spectrometry.

The instrument was equipped with a micromist nebuliser and double pass spray chamber. Quantification was performed by external calibration using Rh as the internal standard. NIST 1640a natural water reference material was analysed for quality control. Hot water extracts and filtrates obtained from sequential filtration were analysed in the same way.

3.12 Determination of Trace Element Species by Sequential Extraction Procedures

The extractions were carried out in four steps as:

Step 1: Exchangeable

An aliquot of 40 cm^3 of 0.1 M acetic acid was added to 1.0 g of ground plant sample in a 250 cm^3 flat bottom flask. The flask was shaken for 16 hours at room temperature on a flask shaker at 400 rpm. The solution was filtered and the filtrate was analyzed for Cr, Fe, Mn, Cu and Zn using FAAS.

Step 2: Reducible

The residue from step 1 was washed with 20 cm^3 of deionised water by shaking for 15 minutes and then filtered. The supernatant liquid was discarded without any loss by discarding. The washed residue was stirred in a 250 cm^3 conical flask by adding 40 cm^3 of 0.1 M hydroxylamine hydrochloride solution and was adjusted to pH 2.0 with nitric acid. The mixture was shaken for 16 hours at room temperature. The extract was filtered and analyzed for Cr, Fe, Mn, Cu and Zn using FAAS.

Step 3: Oxidizable

The residue from step 2 was washed with 20 cm^3 of deionised water. 10 cm^3 of 8 M hydrogen peroxide solution was carefully added to the residue in small aliquots to avoid losses. The flask content was digested at room temperature for 1 hour with occasional manual shaking. The flask was placed on a water bath and heated at 85 ^{o}C to evaporate to near dryness. A second aliquot of 10 cm^3 of hydrogen peroxide was added to the residue and digestion procedure was repeated. An aliquot of 50 cm^3 of 1.0 M ammonium acetate solution (adjusted to pH 2 with nitric acid) was added to the moist residue. The mixture was shaken and filtered. The filtrate was analyzed for Cr, Mn, Cu and Zn using FAAS.

Step 4: Residual

The residue from step 3 was washed with 20 cm^3 of deionised water. An aliquot of 5 cm^3 of distilled water and 12 cm^3 of aqua-regia solution was added to the residue and evaporated to near dryness on an electric heater. The procedure was repeated using 8 cm^3 aqua- regia solution. 20 cm^3 of 0.1 M nitric acid was then added in small aliquots to the residue and filtered. The filtrate was analyzed for Cr, Fe, Mn, Cu and Zn using FAAS.

3.13 Analysis of Data

The results obtained from the questionnaires (age of herbalists, educational level of herbalists, use of medicinal plants and success of treatments) were analyzed using SPSS program while the results obtained from laboratory procedures were analyzed using Excel program. Descriptive analyses were conducted for all questionnaire information and on the medicinal plant elemental concentrations.

The relationships between the medicinal plant elemental concentrations and the independent variables were determined by correlation coefficient and linear regression where applicable. Linear regression equations were used for the the determination of the total and bioavailable quantities of the elements in the medicinal plants. The relationship between total levels of the elements, the Sub Counties and the plant species were analyzed by t-test and correlations coefficients. The bionomial t-test was carried out to determine wheter the medicinal plant and the Sub County from which the medicinal plant was collected contributed significantly to the levels of the trace elements in the medicinal plants. A parametric statistical test (student's t-test) was applied to test different study questions. An-α value of 0.05 was adopted as the critical level for all statistical testing giving a 95% confidence level.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The information which was given to the responses to the questionnaire followed by presentation of laboratory results of macro and trace elements in the selected medicinal plants from Nyamira County are presented in tables and figures, statistically analyzed and then discussed.

4.1.1 Herbalists

One Hundred andfive, ninenty five one hundred and seven and ninenty three herbalists registered in the Nyamira County cultural from Borabu, Ekerenyo, Manga and Nyamira respectively were interviewed. The responses to the questionnaire to the herbalists were analysed and presented in Table 4.1

Table 4.1: Results of Survey.

Number of herbalists	**Sub County**				
	Borabu	**Ekerenyo**	**Manga**	**Nyamira**	**Total**
Business registration	85	88	77	78	328
Treating malaria	84	82	93	78	337
Treating diabetes	81	81	82	83	327
Treating >30 patients per week	84	80	86	86	336
Using A, C, E, I, K, N, O, P, R & S to treat malaria	84	80	78	84	326
Using A, B, D, F, G, H, I, J, L, M, Q&S to treat diabetes	88	76	82	78	324
With >5 years of practice	84	76	78	80	318

Eighty two percent of the herbalists' reigistered in Nyamira County had their business registerd with business licence. Eighty four percent of the herbalists interviewed were found to be treating malaria while 82% were found to be treating diabetes. Eighty four percent of the herbalists were found to be treating more than thirty patients per week. Eighty two percent of the herbalists were found to be treating malaria using A, C, E, I, K, N, O, P, R & S medicinal plants while 81% of the herbalists were found to be treating diabetes using A, B, D, F, G, H, I, J, L, M, Q & S medicinal plants in Nyamira County.

4.1.2 Age Distribution of Herbalists

The herbalists recruited in the Sub Counties were found to be distributed in different age groups as shown in Table 4.2.

Table 4.2: Distribution of the herbalists in different age groups.

Age group (Years)	**Number of herbalists**				**TOTAL**
	BORABU	**NYAMIRA**	**EKERENYO**	**MANGA**	
Less than 40	17	-	17	-	**34**
41-50	25	39	26	27	**117**
51-60	27	-	27	25	**79**
Above 60	36	56	37	41	**170**
TOTAL	**105**	**95**	**107**	**93**	**400**

The age of the herbalists in the study ranged from 20 to 96 years. Sixty three herbalists in Borabu, fifty six from Ekerenyo, sixty four from Manga sixty six herbalists in Nyamira were were in the age groups of 51-60 and above 60years. Sixty two percent of the herbalists in Nyamira County were above the age of 50 years and this necessitates the preservation of the herbal knowledge for the future generation and the use of the herbal medicine to evolve the treatment of malaria and diabetes.

4.1.3: Level of Education

The educational levels of the herbalists were distributed as shown in Table 4.3

Table 4.3: Educational level of herbalists.

Educational level	Number of herbalists				TOTAL
	BORABU	NYAMIRA	EKERENYO	MANGA	
UNEDUCATED	30	26	26	23	**105**
Primary	55	42	58	41	**196**
High School	20	27	23	29	**99**
Above high school	-	-	-	-	**0**
TOTAL	**105**	**95**	**107**	**93**	**400**

Seventy five percent of the herbalists recruited had education level of lower than high school level. This means that most herbalists had little knowledge on the chemical composition and how the herbal medicine functions in the human body. Therefore the information on the trace element composition and their bioavailability from the medicinal plants should be passed on to them by thorough investigation on the herbal medicine. On the other hand the majority of those who had not gone to school were elderly and the knowledge they possessed on herbal medicine should be documented and be preserved.

4.1.4 Experience of practice of the herbalists

The years of experience the herbalists in Nyamira County were distributed as shown in Table 4.4

Table 4.4: Years of practice of the herbalists.

Years of practice	Number of herbalists				TOTAL
	BORABU	NYAMIRA	EKERENYO	MANGA	
< 1 Year	-	-	-	-	**0**
1-5 Years	17	-	10	-	**27**
6- 10 Years	34	44	39	37	**154**
> 10 Years	54	51	58	56	**219**
TOTAL	**105**	**95**	**107**	**93**	**400**

Ninety three percent of the herbalists had above six years of practice. Fifty one percent of herbalists in Borabu and fifty four percent from Ekerenyo and Manga and sixty percent of herbalists from Nyamira had above 10 years of practice. This means that most of the herbalists had enough knowledge on the herbal medicine.

4.1.5 Herbal knowledge

The mode the herbalists acquired the herbal knowledge was investigated and presented in Table 4.5.

Table 4.5: Source of herbal knowledge.

source	Number of herbalists				TOTAL
	BORABU	NYAMIRA	EKERENYO	MANGA	
a)Family induction	37	43	36	40	**156**
b)Induction	42	36	45	45	**168**
c)Training	26	16	26	8	**76**
TOTAL	**105**	**95**	**107**	**93**	**400**

Eighty one percent of the herbalists in Nyamira County acquired herbal knowledge through induction. Twenty five percent of herbalists in Borabu and Manga, seventeen percent of herbalists in Ekerenyo and nine percent of herbalists from Nyamira acquired their herbal knowledge through training. This means only seventeen percent of the herbalists are scientifically trained on the use of the herbal medicine and the rest should be given this information.

4.1.6 Medicinal plants used Nyamira County

The medicinal plants use informed by the herbalists in Nyamira County was investigated. Their botanical names, the common local names, the parts of the plants used for treatment, the diseases the plants treat, the procedure for preparation of the herbal medicine and percentage use are presented in Table 4.6.

Table 4.6: Medicinal Plants Used to Treat Specific Ailments in Nyamira County.

Botanical Name Local Name: (Family) (Plant code)	Part(s) of plant	Diseases treated by plant by > 80% of herbalists	Preparation procedure	% use
Warburgia ugandensis Sprague. Local Name: Esoko (Canellaceae) (A)	Stem bark, roots and ash	Malaria, diabetes, pneumonia, typhoid, headache, asthma, and anaemia	3 Kg of plant part boiled in 5 L of water and 250 ml of extract taken twice for 3 weeks for malaria or for 3 months for diabetes.	100
Solanum indicum L. Omorobo (Solanaceae) (B)	Roots, leaves and ash	Gonorrhea, wounds, boils, anaemia, diabetes, wounds, and bleeding.	3 Kg of plant part boiled in 5 L of water and 250 ml of extract taken twice for 3 months. For boils and wounds the leaves crushed and applied on affected area.	80
Toddalia asiatica L. Ekenagwa ekiegarori (Rutaceae) (C)	Roots and ash	Malaria, diabetes, gonorrhea, pneumonia, typhoid, heart disease, cancer and asthma.	3 Kg of plant part boiled in 5 L of water and 250 ml of extract taken twice for 3 months.	100

Table 4.6: Continued

Erythrina abyssinica Bak.f. Omotembe (Fabaceae) (D)	Roots, stem bark and ash	Diabetes, gonorrhea, allergy, cancer, coughs and fever.	3 Kg of plant part boiled in 5L of water and 250 ml of extract taken twice for 3 months.	100
Senna didymobotrya Fresen. Omobeno (Fabaceae) (E)	Leaves and ash	Malaria, pneumonia, skin disease, constipation, worms, fever, chicken pox, athlete's foot and swellings on the skin.	4 Kg of plant part boiled in 5 L water and 250 ml of extract taken thrice for 3 weeks.	100
Vernonia auriculifera Hiern. Omosabakwa (Asteraceae) (F)	Roots, leaves and ash	Diabetes, pneumonia, coughs and fever.	3 Kg of plant part boiled in 5 L of water and 250 ml of extract taken twice for 3 months	80
Plectranthus barbatus Andr. Omoroka (Lamiaceae) (G)	Buds, roots and ash	Worms, diarrhea, diabetes and stomachache	2 Kg of plant boiled in 5 L of water and 250 ml of extract taken twice for 3 months.	90
Ultrica dioica L. Rise (Ultriaceae) (H)	Leaves	Diabetes, cancer, stomachache, Asthma, anaemia, chestaches and boils.	3 Kg of plant boiled in 5 L of water and 250 ml of extract taken two times daily for three months with goat soup.	100
Croton macrostachyus De wild Omosocho (Euphorbiacea) (I)	Roots, leaves and ash	Malaria, diabetes, typhoid, diarrhea, bleeding, anaemia, cancer	3 Kg of plant part boiled in 5 L of water and 250 ml of extract taken for 3 months and for bleeding leaf extract applied on affected area.	95
Bidens pilosa L. Ekemogamogia (Asteraceae) (J)	Leaves and ash	Diabetes, worms, gonorrhea, cancer	1 Kg of plant boiled in 5l of water 250 ml of extract taken twice for 3 months.	100
Melia azedarach L. Omwarubaine (Meliaceae) (K)	Leaves	Malaria, STIS and typhoid, anaemia	3 Kg of leaves are boiled in 5 L of water and 250 ml of extract taken daily with goat soup for one month.	100

Table 4.6: Continued.

Solanum mauense Bitter. Ekeng'eta mbori (Solanaceae) (L)	Whole plant	Diabetes, children diseases, malaria, cancer	3 Kg of plant boiled in 5 L of water and 250 ml of extract taken two times daily for three months with goat soup.	100
Magnifera indica L. Riembe (Anacardiaceae) (M)	Leaves and ash	Diabetes, constipation, burns and scalds.	3 Kg of plant boiled in 5l water and 250 ml of extract taken twice for 3 months.	80
Acacia hockii De wild Omokonge (Fabaceae) (N)	Roots, stem bark and ash	Diarrhea, malaria and fungal infection	5 Kg of Plant part boiled in 5L of water and 250 ml of extract taken thrice for 3 weeks.	85
Acacia abyssinica Benth. Omonyenya (Fabaceae) (O)	Roots, stem bark and ash	Malaria, gonorrhea and joints ache	4 Kg of plant part boiled in 5 L of water and 250 ml of extract taken thrice for 3 weeks	82
Clerodendrum myricoides Hoscht. Omonyasese (Lamiaceae) (P)	Roots , leaves, and ash	Malaria, gonorrhea, diabetes, typhoid, amoeba, stomachache, worms,	2 Kg of plant boiled in 5 L of water for 2 hrs and 250 ml of extract taken twice for 3 months.	97
Carissa edulis Forssk. (Apocynaceae) Omonyangatetia (Q)	Roots and ash	Malaria, typhoid, gonorrhea, diabetes, cancer and asthma.	2 Kg of plant part boiled in 5 L of water and 250 ml of extract taken twice for 3 months.	83
Tabernaemontana stapfiana Britten. Omobondo (Apocynaceae) (R)	Leaves	Malaria, anaemia and fevers.	3 Kg of Leaves boiled in 5 L of water and 250 ml of extract taken two times daily for three weeks.	
Aloe vera Omogaka (Xanthorrhoeaceae) (S)	Leaves	Malaria, asthma, diabetes, cancer, skin diseases and typhoid	3 Kg Leaves boiled in 5 L of water and 250 ml of extract taken twice for 3 weeks for malaria and for three months for other ailments.	100

The popularity of the use of the medicinal plant was determined by the percentage of herbalists who administered a particular medicinal plant. The medicinal plants which were administered by

70% of herbalists in Nyamira County were selected and used in this study. The medicinal plants were used treat different diseases. The two diseases predominantly treated by by herbalists were malaria and diabetes. The medicinal plants which were used to treat malaria by more than 80% of the herbalists were *Warburgia ugandensis, Toddalia asiatica, Senna didymobotrya, Croton macrostachyus, Melia azedarach, Acacia abyssinica, Acacia hockii, Clerodendrum myricoides, Carissa edulis, Tabernaemontana stapfiana and Aloe vera.* The medicinal plants which were used for the treatment of diabetes by more than 80% of the herbalists to treat diabetes were *Warburgia ugandensis, Solanum indicum, Toddalia asiatica, Erythrina abyssinica, Vernonia auriculifera, Plectranthus barbatus, Ultrica dioica, Croton macrostachyus, Solanum mauense, Clerodendrum myricoides, Carissa edulis* and *Aloe vera.*

The medicnal plants which were used to treat malaria and diabetes were *Warburgia ugandensis, Toddalia asiatica, Croton macrostachyus, Carissa edulis* and *Aloe vera.* In the treatment for malaria the medicinal plants were prepared by boiling in water and two glasses of extracts taken twice daily for three weeks while in the treatment for diabetes the two glasses of extracts from the medicinal plants are taken twice daily with goat soup for three months. The absorption conditions for the malaria treating agents appear to be different from those of the diabetic treating agents. The malarial treating agents are enhanced in the polar conditions while the diabetic treating agents are enhanced in the less polar conditions according to how the medicinal plants are administered.

4.1.7Sources of herbal medicine

Ninenty, eighty five, ninenty nine and eighty one herbalists from Borabu, Ekerenyo, Manga and Nyamira respectively obtained their herbal medicine from the forests close to their residence.

4.1.8 Conservation of the resources

Eighty five, seventy eight, ninenty two and eighty herbalists from Borabu, Ekerenyo, Manga and Nyamira respectively were involved in the conservation of the natural resources. The conserved the trees to ensure a continuous supply of the medicinal and this could ensure that the resources may be available for the future generations.

4.1.9 Season with the highest number of patients

Sixty seven percent of herbalists in Nyamira County received the highest number of patients in the rainy season. This could be attributed the the suitable environmental conditions for the bleeding habitats for the pathogens which then cause diseases to man.

4.1.10 Success of treatment

The number of patients who came back to the herbalists to thank the herbalists after the treatment was determined and the results are presented in Table 4.7.

Table 4.7: Success of treatment.

		Borabu	Ekerenyo	Manga	Nyamira
Malaria	Total number of patients treated in session	840	848	968	1040
	Number of patients with success	403	407	581	603
Diabetes	Total number treated in session	132	112	128	124
	Number of patients with success	24	20	12	16

Forty eight percent of malaria patients treated in Borabu and Ekerenyo, 60% of those in Manga and 58% of those from Nyamira registered success in their treatment. Eighteen percent of patients treated for diabetes in Borabu and Ekerenyo, 9% of patients from Manga and 13% of patients from Nyamira were treated successful after the treatment session. The herbalists treated malaria more successfully than diabetes. Ninety nine percent of the herbalists were obtaining the medicinal plants they used in their treatment from the forests where they lived.

Nineteen medicinal plants were found to treat malaria and diabetes. Forty herbalists in each Sub County were found to treat malaria and diabetes using the 19 medicinal plants and they found to have more than 40% of the patients treated cured. They were selected and requested to supply one kilogram of dry sample of one medicinal plant species. The elemental levels in medicinal plants were determined.

4.2 The Total Levels of Elements in the Medicinal Plants

The levels of manganese, copper, chromium and zinc in nineteen commonly used medicinal plants of Borabu, Ekerenyo, Manga and Nyamira of Nyamira County, Kenya determined by AAS and ICP-MS. The AAS analysis was carried out in Kenya while the ICP-MS was done in Germany .An overview of the analysed medicinal plant species with their abbreviations (A to S) is given in Tables of results of each Sub County. ICP-MS results were backed up by analysis of plant reference materials NIST 1515 (apple leaves) and NIST 1547 (peach leaves). Recoveries (corrected for moisture) were 97% for Mn, 98% for Cu and 95% for Zn in NIST 1515 (6.1% moisture) and 103% for Mn, 113% for Cu and 107% for Zn in NIST 1547 (6.4% moisture).

4.2.1 Levels of macroelements in medicinal plants

The levels of the macroelements in the medicinal plants from Borabu, Ekerenyo, Manga and Nyamira Sub Counties determined by ICP-MS are presented in Table 4.8

Table 4.8: Macroelement levels in medicinal plants from the Sub Counties.

Element	Sub County	Amounts of element in g/kg						
		Mg	Al	Si	P	S	K	Ca
A	B	1.00±0.10	0.43±0.07	0.80±0.20	0.71±0.06	1.90±0.20	16.70±1.00	12.00±2.00
	E	1.02±0.10	0.53±0.07	0.78±0.20	0.81±0.06	1.91±0.20	16.72±1.01	12.03±2.00
	M	0.86±0.03	0.48±0.02	0.98±0.03	0.68±0.03	2.30±0.10	14.70±0.60	10.40±0.40
	N	0.86±0.02	0.19±0.01	0.38±0.02	0.54±0.04	1.50±0.20	12.60±0.50	11.20±0.20
B	B	0.67±0.01	2.19±0.06	1.20±0.20	1.30±0.20	3.00±1.00	12.00±2.00	3.14±0.07
	E	0.64±0.01	2.09±0.06	1.23±0.20	1.32±0.20	3.30±1.00	12.01±2.00	3.11±0.07
	M	0.78±0.02	1.47±0.04	1.30±0.20	1.65±0.03	4.60±0.40	20.20±0.50	2.40±0.04
	N	0.94±0.02	2.40±0.03	1.40±0.20	1.85±0.04	2.50±0.20	9.50±0.50	5.30±0.06
C	B	0.60±0.01	1.06±0.07	1.29±0.04	0.45±0.04	2.40±0.30	6.20±0.80	18.00±1.00
	E	0.61±0.01	1.02±0.07	1.26±0.04	0.43±0.04	2.42±0.30	6.23±0.80	18.04±1.01
	M	0.66±0.02	1.70±0.09	1.25±0.07	0.49±0.01	1.60±0.30	6.20±0.10	15.40±0.30
	N	0.64±0.02	1.71±0.09	1.23±0.07	0.47±0.01	1.62±0.30	6.23±0.10	15.41±0.30
D	B	0.44±0.01	0.42±0.01	1.20±0.20	0.36±0.06	2.10±0.20	3.00±0.50	9.00±0.30
	E	0.43±0.01	0.41±0.01	1.21±0.20	0.26±0.06	2.08±0.20	3.00±0.50	9.02±0.30
	M	1.10±0.06	1.15±0.07	1.70±0.30	1.12±0.06	2.90±0.30	14.00±0.70	15.40±0.80
	N	1.07±0.04	1.27±0.04	1.20±0.20	0.80±0.10	2.90±0.30	11.00±0.20	26.60±0.30
E	B	3.80±0.1	0.45±0.01	0.78±0.07	2.60±0.10	1.60±0.30	13.80±0.40	9.40±0.20
	E	3.82±0.1	0.43±0.01	0.76±0.07	2.64±0.10	1.61±0.30	13.82±0.42	9.40±0.20
	M	3.42±0.04	0.65±0.01	1.06±0.03	3.54±0.05	3.70±0.40	17.20±0.30	14.60±0.20
	N	3.10±0.10	0.55±0.02	0.82±0.03	2.25±0.04	2.20±0.30	10.60±0.40	12.30±0.20
F	B	2.61±0.02	0.32±0.01	0.83±0.03	5.80±0.10	1.50±0.40	35.90±0.50	8.00±0.10
	E	2.41±0.02	0.28±0.01	0.84±0.03	5.82±0.10	1.45±0.40	35.94±0.51	8.04±0.10
	M	3.14±0.04	0.41±0.01	1.02±0.05	5.81±0.07	3.10±0.40	38.80±0.50	6.24±0.02
	N	2.64±0.10	0.36±0.01	0.85±0.06	5.90±0.10	3.00±0.40	37.00±2.00	7.50±0.10
G	B	4.91±0.09	2.24±0.07	1.60±0.20	1.94±0.04	3.00±0.60	33.00±2.00	20.40±0.40
	E	4.71±0.09	2.14±0.07	1.64±0.20	1.92±0.04	3.30±0.60	33.03±2.00	20.40±0.42
	M	3.74±0.03	1.04±0.01	1.20±0.20	2.23±0.03	2.60±0.30	49.80±0.40	15.40±0.10
	N	4.30±0.20	1.25±0.05	1.30±0.20	3.20±0.20	2.70±0.20	40.00±2.00	13.40±0.50
H	B	6.20±0.40	3.14±0.06	1.40±0.10	5.50±0.80	5.00±1.00	36.00±6.00	39.00±1.00
	E	6.23±0.40	3.24±0.06	1.43±0.10	5.54±0.80	5.02±1.00	36.04±6.05	39.04±1.01
	M	5.80±0.10	2.95±0.06	1.90±0.30	5.20±0.10	5.00±0.20	31.30±0.70	36.90±0.80
	N	5.50±0.20	1.08±0.09	1.20±0.10	4.40±0.20	4.03±2.00	29.00±2.00	39.00±1.00
I	B	5.00±0.40	1.21±0.06	1.60±0.30	2.10±0.30	3.30±0.20	20.00±3.00	27.60±1.00
	E	5.03±0.40	1.24±0.06	1.62±0.30	2.13±0.30	3.31±0.20	20.03±3.01	27.62±1.00
	M	3.70±0.10	1.00±0.03	1.30±0.10	4.10±0.10	3.70±0.10	32.40±0.80	10.60±0.30
	N	4.32±0.05	1.52±0.05	1.30±0.30	3.51±0.05	3.00±1.00	20.00±1.00	15.30±0.20
J	B	3.80±0.20	6.00±0.20	1.60±0.50	3.10±0.40	3.20±0.30	26.00±4.00	11.90±0.30
	E	3.83±0.20	6.03±0.20	1.54±0.50	3.12±0.40	3.24±0.30	26.02±4.04	11.94±0.30
	M	4.40±0.06	3.12±0.05	1.80±0.30	4.07±0.08	3.70±0.20	31.60±0.50	11.80±0.20
	N	4.70±0.20	2.50±0.10	1.40±0.30	3.80±0.20	2.30±0.70	37.00±2.00	13.50±0.30
K	B	2.00±0.20	1.00±0.10	1.10±0.10	2.19±0.05	3.00±0.20	11.60±0.50	10.00±1.00
	E	2.02±0.20	1.02±0.10	1.12±0.10	2.17±0.05	3.04±0.20	11.61±0.51	10.02±1.01
	M	2.13±0.05	0.26±0.01	0.97±0.06	2.21±0.04	3.60±0.10	14.80±0.40	12.40±0.40
	N	2.60±0.10	1.90±0.10	1.11±0.07	2.80±0.10	2.00±0.40	17.50±0.70	16.60±0.50
L	B	1.88±0.09	4.00±0.20	1.20±0.06	3.30±0.20	3.70±0.90	46.00±3.00	9.90±0.60
	E	1.83±0.09	4.02±0.20	1.22±0.06	3.32±0.20	3.68±0.90	46.01±3.20	9.92±0.62
	M	2.78±0.07	5.00±0.10	2.00±0.50	5.40±0.20	4.80±0.20	42.00±1.00	11.10±0.30
	N	2.60±0.20	4.60±0.40	1.40±0.40	4.30±0.60	4.00±1.00	35.00±5.00	9.20±0.20

B –Borabu E- Ekerenyo M- Manga N-Nyamira

Table 4.8: Continued.

Element	Sub county	Amounts of element in g/kg						
		Mg	**Al**	**Si**	**P**	**S**	**K**	**Ca**
M	B	1.77±0.04	0.24±0.01	1.70±0.3	1.34±0.04	1.60±0.30	9.50±0.80	8.80±0.20
	E	1.72±0.04	0.23±0.01	1.71±0.30	1.24±0.04	1.61±0.30	9.50±0.84	8.84±0.20
	M	1.83±0.07	0.28±0.01	1.91±0.30	1.59±0.06	1.92±0.06	10.70±0.50	8.80±0.30
	N	1.79±0.03	0.38±0.02	1.52±0.20	1.32±0.06	1.90±0.10	8.90±0.50	9.20±0.20
N	B	1.05±0.02	0.32±0.01	0.65±0.02	0.48±0.02	1.00±0.05	6.90±0.20	23.20±0.60
	E	1.04±0.02	0.27±0.01	0.64±0.02	0.44±0.02	1.01±0.05	6.92±0.20	23.23±0.61
	M	2.29±0.10	0.13±0.01	0.20±0.01	0.35±0.01	1.80±0.60	5.00±0.20	19.10±0.50
	N	2.20±0.03	0.12±0.01	0.19±0.02	0.29±0.03	1.00±0.04	4.20±0.20	21.40±0.30
O	B	1.89±0.04	0.60±0.01	0.76±0.07	0.37±0.01	1.02±0.04	5.10±0.20	18.30±0.60
	E	1.86±0.04	0.56±0.01	0.74±0.07	0.39±0.01	1.03±0.04	5.14±0.20	18.31±0.62
	M	0.49±0.02	0.47±0.02	0.70±0.04	0.89±0.02	3.00±0.20	11.10±0.60	19.70±0.60
	N	1.82±0.03	0.77±0.02	0.82±0.04	0.35±0.03	2.00±0.15	5.00±0.20	16.70±0.20
P	B	2.51±0.07	0.94±0.07	1.17±0.02	2.00±0.20	3.00±0.90	20.00±2.00	12.50±0.70
	E	2.61±0.07	0.92±0.07	1.27±0.02	2.10±0.20	3.02±0.90	20.03±2.00	12.51±0.72
	M	2.90±0.10	4.10±0.20	1.90±0.30	0.88±0.04	2.50±0.30	12.10±0.70	29.00±2.00
	N	1.25±0.01	1.00±0.02	0.94±0.05	1.09±0.02	1.20±0.10	7.80±0.30	12.50±0.10
Q	B	1.41±0.04	2.59±0.07	1.10±0.10	0.66±0.02	1.93±0.09	9.80±0.40	24.90±0.70
	E	1.44±0.04	2.56±0.07	1.13±0.10	0.64±0.02	1.93±0.09	9.83±0.40	24.93±0.73
	M	0.68±0.01	2.16±0.06	1.50±0.10	1.84±0.03	3.20±0.30	9.60±0.20	10.30±0.20
	N	0.67±0.01	2.14±0.06	1.50±0.10	1.82±0.03	3.22±0.30	9.70±0.20	10.10±0.20
R	B	1.96±0.03	0.55±0.02	0.72±0.08	2.00±0.20	2.30±0.70	8.00±0.70	7.00±0.20
	E	1.93±0.03	0.53±0.02	0.74±0.08	2.04±0.20	2.33±0.70	8.01±0.70	7.04±0.20
	M	1.85±0.07	0.61±0.02	0.67±0.04	2.26±0.07	2.80±0.20	9.00±0.40	4.70±0.10
	N	1.86±0.10	1.11±0.09	0.89±0.04	1.88±0.10	2.00±0.30	6.90±0.30	7.30±0.40
S	B	4.20±0.50	1.50±0.1	1.20±0.2	1.30±0.10	1.90±0.70	47.00±5.00	47.00±3.00
	E	4.24±0.50	1.51±0.1	1.24±0.2	1.32±0.10	1.91±0.70	47.02±5.00	44.04±3.02
	M	4.60±0.10	1.49±0.04	1.33±0.09	1.62±0.03	2.50±0.20	59.0±2.00	47.20±0.70
	N	5.26±0.09	1.50±0.10	1.37±0.04	2.20±0.20	2.70±0.30	59.00±7.00	44.50±1.00

B –Borabu E- Ekerenyo M- Manga N-Nyamira

Magnesium

The mean level of magnesium in Borabu ranged from 0.44±0.01 to 6.20±0.40 g/kg. The seven anti diabetic medicinal plants from Borabu found to be rich in magnesium were *Ultrica dioica* (6.2 g/kg), *Croton macrostachyus* (5 g/kg), *Plectranthus barbatus* (4.91 g/kg), *Aloe vera (*4.2 g/kg) *Bidens pilosa* (3.8 g/kg), *Veronia auriculifera* (2.6 g/kg) and *Clerodendrum myricoides* (2.51 g/kg). The levels of magnesium in medicinal plants from Ekerenyo ranged from 0.43±0.01 to 6.23±0.40 g/kg. The seven anti diabetic medicinal plants from Ekerenyo found to be rich in magnesium were *Ultrica dioica (*6.23 g/kg), *Croton macrostachyus* (5.03 g/kg), *Plectranthus* *barbatus* (4.71 g/kg), *Aloe vera (*4.24 g/kg) *Bidens pilosa* (3.83 g/kg), *Veronia auriculifera* (2.41 g/kg) and *Clerodendrum myricoides* (2.61 g/kg). The levels of magnesium in medicinal plants from Manga ranged from 0.49±0.02 to 5.80±0.10 g/kg. Seven anti diabetic medicinal plants from Manga found to be rich in magnesium were *Ultrica dioica (*5.8 g/kg), *Aloe vera (*4.6 g/kg), *Bidens pilosa* (4.4 g/kg), *Plectranthus barbatus* (3.74 g/kg), *Croton macrostachyus* (3.7 g/kg), *Veronia auriculifera* (3.41 g/kg) and *Clerodendrum myricoides* (2.90 g/kg). The levels of magnesium in medicinal plants from Nyamira ranged from 0.64±0.02 to 5.50±0.20 g/kg. Six anti diabetic medicinal plants from Nyamira found to be rich in magnesium were *Ultrica dioica (*5.5 g/kg), *Aloe vera (*5.26 g/kg) *Bidens pilosa* (4.7 g/kg), *Croton macrostachyus* (4.32 g/kg), *Plectranthus barbatus* (4.30 g/kg) and *Veronia auriculifera* (2.64 g/kg). The highest mean level of magnesium in all the study areas was in *Ultrica dioica with an average* of 5.93g/kg. The levels of magnesium were statistically significant from silicon, potassium and calcium in Nyamira (Appendix XXXVIII), from all other macroelements except phosphorus and sulphur in Borabu (Appendix XXXIX) and Manga (Appendix XXXXI) and phosphorus, sulphur and iron in Ekerenyo (Appendix XXXX) ($P<0.05$). The levels of magnesium in the medicinal plants in different Sub Counties were not statistically significant from one another ($P<0.05$) (Appendix XXXIIa).

Most medicinal plants must be supplying the bioavailable magnesium levels within the recommended levels and are safe to be taken. The four anti diabetic medicinal plants from Nyamira County rich in magnesium were *Ultrica dioica*, *Croton macrostachyus*, *Plectranthus barbatus* and *Bidens pilosa*.

Aluminium

The mean level of aluminium in Borabu ranged from 0.24±0.01 to 6.00±0.20 g/kg. The medicinal plants from Borabu with high levels of aluminum were *Bidens pilosa* (6.0 g/kg), *Ultrica dioica* (3.14g kg), *Carissa edulis* (2.59 g/kg), *Plectranthus barbatus* (2.4 g/kg), *Solanum indicum* (2.19 g/kg) and *Solanum mauense* (4.0 g/kg). The levels of aluminium from Ekerenyo ranged from 0.23±0.01 to 6.03±0.20 g/kg. The medicinal plants from Ekerenyo with high levels of aluminum were *Bidens pilosa* (6.03g/kg), *Ultrica dioica* (3.24 g kg), *Carissa edulis* (2.56 g/kg), *Plectranthus barbatus* (2.14 g/kg), *Solanum indicum* (2.09 g/kg) and *Solanum mauense* (4.02 g/kg). The levels of aluminium in medicinal plants from Manga ranged from 0.13±0.01 to 5.00±0.10 g/kg. The medicinal plants from Manga with high levels of aluminum were *Solanum mauense* (5.0 g/kg), *Clerodendrum myricoides* (4.1 g/kg), *Bidens pilosa* (3.12 g/kg), *Ultrica dioica* (2.95 g/kg), *Carissa edulis* (2.16 g/kg) and *Toddalia ascitica* (1.7 g/kg). The levels of aluminium in medicinal plants from Nyamira ranged from 0.12±0.01 to 4.60±0.40 g/kg. The medicinal plants from Nyamira with high levels of aluminum were *Solanum mauense* (8.6 g/kg), *Bidens pilosa* (2.5 g/kg), *Solanum indicum* (2.4 g/kg), *Carissa edulis* (2.14 g/kg) and *Toddalia ascitica* (1.71 g/kg). The highest mean levels of aluminium were in *Bidens pilosa* from Borabu and Ekerenyo while *Solanum mauense* had the highest mean levels in Manga and Nyamira. The levels of aluminium in the medicinal plants were statistically significant from all other macro elements except for silicon, phosphorus and iron in all Borabu (Appendix XXXIX) and Nyamira (Appendix XXXVIII) and silicon and iron in Ekerenyo (Appendix XXXX) and Manga (Appendix XXXXI) ($P<0.05$). The levels of aluminium in the medicinal plants in Sub Counties were not statistically different from one another ($P<0.05$) (appendix XXXXII b). The four medicinal plants from Nyamira County that had high levels of aluminium were *Bidens pilosa*, *Ultrica dioica*, *Carissa edulis* and Plectranth*us barbatus.*

Silicon

The mean level of silicon in Borabu ranged from 0.65±0.02 to 1.70±0.3 g/kg. The medicinal plants from Borabu with high levels of silicon were *Magnifera indica* (1.7 g/kg), *Bidens pilosa*

(1.6 g/kg), *Plectranthus barbatus* (1.6 g/kg), *Croton macrostachyus* (1.6 g/kg), *Ultrica dioica* (1.4 g/kg) *and Toddalia asciatica* (1.29 g/kg). The levels of silicon in medicinal plants from Ekerenyo ranged from 0.64±0.02 to 1.71±0.30 g/kg. The medicinal plants from Ekerenyo with high levels of silicon were *Magnifera indica* (1.71 g/kg), *Plectranthus barbatus* (1.64 g/kg), *Croton macrostachyus* (1.62 g/kg), *Bidens pilosa* (1.54 g/kg), *Ultrica dioica* (1.43 g/kg) and *Clerodendrum myricoides* (1.27 g/kg). The levels of silicon in medicinal plants from Manga ranged from 0.20±0.01 to 1.91±0.30 g/kg. The medicinal plants form Manga with high levels of silicon were *Magnifera indica* (1.91 g/kg), *Ultrica dioica* (1.9 g/kg), *Clerodendrum myricoides* (1.9 g/kg), *Bidens pilosa* (1.8 g/kg), *Erythrina abyssinica* (1.7 g/kg) and *Carissa edulis* (1.5 g/kg). The levels of silicon in medicinal plants from Nyamira ranged from 0.19±0.02 to 1.52±0.20 g/kg. The medicinal plants from Nyamira which were found to be rich in silicon were *Magnifera indica* (1.52 g/kg), *Carissa edulis* (1.5 g/kg), *Solanum indicum* (1.4 g/kg), *Bidens pilosa* (1.4 g/kg), *Solanum mauense* (1.4 g/kg), *Aloe vera* (1.37 g/kg), *Croton macrostachyus* (1.3 g/kg) and *Plectranthus barbatus* (1.3 g/kg). The highest mean level of silicon was in *Magnifera indica* (1.71g/kg) while the lowest was in *Acacia hockii* (0.42g/kg) in all the Sub Counties. The levels of silicon in medicinal plants were statistically significant from all other macro elements except aluminium and iron in all the study areas (Appendix XXXVIII -Appendix XXXXI) ($P<0.05$). The levels of silicon in the medicinal plants were statistically not different from one another in the Sub Counties ($P<0.05$) (Appendix XXXXIIIc). The four medicinal plants from Nyamira County with high levels of silicon were *Magnifera indica* (1.71 g/kg), *Bidens pilosa* (1.59 g/kg), *Solanum mauense* (1.46 g/kg) and *Plectranthus barbatus* (1.44 g/kg).

Phosphorus

The mean phosphorus levels in Borabu ranged from 0.36±0.06 to 5.80±0.10 g/kg. The medicinal plants from Borabu found to be rich in phosphorus were *Veronia auriculifera* (5.8 g/kg), *Ultrica* *dioica* (5.5 g/kg), *Solanum mauense* (3.3 g/kg), *Bidens pilosa* (3.1 g/kg), *Senna didymolbotrya* (2.6 g/kg) and *Melia azedarach* (2.19 g/kg). The phosphorus levels in medicinal plants from Ekerenyo ranged from 0.26±0.06 to 5.82±0.10 g/kg. The medicinal plants from Ekerenyo found to be rich in phosphorus were *Veronia auriculifera* (5.82 g/kg), *Ultrica dioica* (5.54 g/kg), *Solanum mauense* (3.32 g/kg), *Bidens pilosa* (3.12 g/kg), *Senna didymolbotrya* (2.64 g/kg) and *Melia azedarach* (2.17 g/kg). The levels of phosphorus in medicinal plants from Manga ranged from 0.35±0.01 to 5.81±0.07 g/kg. The medicinal plants from Manga found to be rich in phosphorus were *Veronia auriculifera* (5.81 g/kg), *Solanum mauense* (5.4 g/kg), *Ultrica dioica* (5.2 g/kg), *Croton macrostachyus* (4.1 g/kg), *Bidens pilosa* (4.07 g/kg) and *Senna didymolbotrya* (3.54 g/kg). The levels of phosphorus in medicinal plants from Nyamira ranged from 0.29±0.03 to 5.90±0.10 g/kg. The medicinal plants from Nyamira found to be rich in phosphorus were *Veronia auriculifera* (5.9 g/kg), *Solanum mauense* (4.3 g/kg), *Ultrica dioica* (4.4 g/kg), *Bidens pilosa* (3.8 g/kg), *Croton macrostachyus* (3.51 g/kg) and *Plectranthus barbatus* (3.2 g/kg). The highest mean level of phosphorus was *Vernomia auriculifera* (5.833 g/kg) in Nyamira County. The levels of phosphorus were statistically significant from silicon, potassium and calcium in Borabu (Appendix XXXIX) and Nyamira (Appendix XXXVIII) and from the other elements except magnesium and iron in Ekerenyo (Appendix XXXX) and Manga (Appendix XXXXI) ($P<0.05$). The levels of phosphorus in the medicinal plants in the Sub Counties were not statistically different from each other ($P<0.05$) (Appendix XXXXII d). These results are comparable to that of Anna *et al.* (2013) who reported the levels of phosphorus to be from 2.37 - 5.48 g/kg among the Brazilian teas and infusions. Phosphorus in the human body plays arole in the synthesis of bones and teeth, nucleic acids, ATP and phospholipids in membranes (Taylor *et al*., 1998). The four medicinal plants from Nyamira County rich in phosphorus were *Veronia* *auriculifera* (5.833 g/kg), *Ultrica dioica* (5.16 g/kg), *Solanum mauense* (4.08 g/kg), and *Bidens pilosa* (3.522 g/kg). These mean that most of the medicinal plants supply the bioavailable phosphorus levels within the recommended levels and are safe to be taken.

Sulphur

The mean level of sulphur in Borabu ranged from 1.00±0.05 to 5.00±1.00 g/kg. The medicinal plants from Borabu found to be rich in sulphur were *Ultrica dioica* (5 g/kg), *Solanum mauense* (3.7g/kg), *Bidens pilosa* (3.2 g/kg), *Croton macrostachyus* (3.3 g/kg), *Solanum indicum* (3 g/kg), *Clerodendrum myricoides* (3 g/kg), *Melia azedarach* (3 g/kg) and *Plectranthus barbatus* (3 g/kg). The levels of sulphur in medicinal plants from Ekerenyo ranged from 1.01±0.05 to 5.02±1.00 g/kg. The medicinal plants from Ekerenyo found to be rich in sulphur were *Ultrica dioica* (5.02 g/kg), *Solanum mauense* (3.68g/kg), *Bidens pilosa* (3.24 g/kg), *Croton macrostachyus* (3.3 1 g/kg), *Solanum indicum* (3.3 g/kg) *Plectranthus barbatus* (3.3 g/kg), *Melia azedarach* (3.04 g/kg) and *Clerodendrum myricoides* (3.02 g/kg). The levels of sulphur in medicinal plants from Manga ranged from 1.80±0.60 to 5.00±0.20 g/kg. The medicinal plants from Manga found to be rich in sulphur were *Ultrica dioica* (5 g/kg), *Solanum mauense* (4.8g/kg), *Solanum indicum* (4.6 g/kg), *Bidens pilosa* (3.7 g/kg), *Croton macrostachyus* (3.7 g/kg), *Melia azedarach* (3.6 g/kg), *Carissa edulis* (3.2 g/kg) and *Veronia auriculifera* (3.1 g/kg). The levels of sulphur in medicinal plants from Nyamira ranged from 1.00±0.04 to 4.03±2.00 g/kg. The medicinal plants from Nyamira found to be rich in sulphur were *Ultrica dioica* (4.3 g/kg), *Solanum mauense* (4 g/kg), *Carissa edulis* (3.22 g/kg), *Croton macrostachyus* (3 g/kg) and *Veronia auriculifera* (3.0 g/kg). The highest mean level of sulphur was in *Ultrica dioica* while the lowest was in *Acacia hockii* in all the Sub Counties. The levels of sulphur were statistically significant from phosphorus and magnesium in Borabu (Appendix XXXIX) and Nyamira (Appendix XXXVIII) and from the other elements except magnesium in Ekerenyo (Appendix

XXXX) and Manga (Appendix XXXXI) (P<0.05). The levels of sulphur in the medicinal plants in the Sub Counties were not statistically different from one another (P<0.05) (appendix xxxxii e). Sulphur in the human body is used in the synthesis of proteins and many other organic compounds such as coenzyme A (Taylor *et al*., 1998). The four medicinal plants from Nyamira County rich in sulphur were *Ultrica dioica* (4.83 g/kg), *Solanum mauense* (4.05 g/kg), *Croton macrostachyus* (3.33 g/kg) and *Bidens pilosa* (3.11 g/kg).

Potassium

The mean level of silicon in Borabu ranged from 3.00±0.50 to 47.00±5.00g/kg. The anti diabetic medicinal plants from Borabu found to be rich in potassium were Aloe vera (47 g/kg), Solanum mauense (46 g/kg), Ultrica dioica (36 g/kg), Veronia auriculifera (35.9 g /kg), Plectranthus barbatus (33 g/kg) and Bidens pilosa (26 g/kg). The levels of potassium from Ekerenyo ranged from 3.00±0.50 to 47.02±5.00 g/kg. The anti diabetic medicinal plants from Ekerenyo found to be rich in potassium were Aloe vera (47.02 g/kg), Solanum mauense (46.01 g/kg), Ultrica dioica (36.04 g/kg), Veronia auriculifera (35.94 g /kg), Plectranthus barbatus (33.03 g/kg) and Bidens pilosa (26.02 g/kg). The levels of potassium in medicinal plants from Manga ranged from 5.00±0.20 to 59.0±2.00 g/kg. The anti diabetic medicinal plants from Manga found to be rich in potassium were Aloe vera (59 g/kg), Plectranthus barbatus (49.8 g/kg), Solanum mauense (42 g/kg), Veronia auriculifera (38.8 g /kg), Croton macrostachyus (32.4 g/kg), Bidens pilosa (31.6g/kg) and Ultrica dioica (31.3g/kg). The levels of potassium in medicinal plants from Nyamira ranged from 4.20±0.20 to 59.00±7.00 g/kg. The anti diabetic medicinal plants from Nyamira found to be rich in potassium were Aloe vera (59.4 g/kg), Plectranthus barbatus (40 g/kg), Solanum mauense (35 g/kg), Veronia auriculifera (37 g /kg), Bidens pilosa (37 g/kg) and Ultrica dioica (29 g/kg). The highest mean level of potassium was highest in Aloe vera in all the Sub Counties. The levels of potassium were statistically significant from all other macro elements except calcium in all the Sub Counties (Appendix XXXVIII- Appendix XXXXI) ($P<0.05$).The levels of potassium in the medicinal plants in different Sub Counties were not statistically significant from one another ($P<0.05$) (Appendix XXXII f).

These means most of the medicinal plants could be supply the bioavailable potassium levels within the recommended levels and are safe to be taken. The anti diabetic medicinal plants from Nyamira County which contained substantial amounts of potassium include *Aloe vera* (59.11 g/kg), *Solanum mauense* (42.25 g/kg), *Plectranthus barbatus* (38.96 g/kg), *Veronia auriculifera* (36.91 g/kg), *Ultrica dioica* (33.09 g/kg), *a*nd *Bidens pilosa* (29.91 g/kg).These plants are used in the management of diabetes by the herbalists in Nyamira County.

Calcium

The mean level of calcium in Borabu ranged from 3.14±0.07 to 39.00±1.00 g/kg. The medicinal plants from Borabu found to be rich in calcium were *Aloe vera* (47 g/kg), *Solanum mauense* (46 g/kg), *Ultrica dioica* (39 g/kg), *Ultrica dioica* (39 g/kg) and *Plectranthus barbatus* (33 g/kg). The levels of calcium in medicinal plants from Ekerenyo ranged from 3.11±0.07 to 39.04±1.01 g/kg. The medicinal plants from Ekerenyo found to be rich in calcium were *Aloe vera* (44.04 g/kg), *Ultrica dioica* (39 g/kg), *Croton macrostachyus* (27.62 g/kg), *Acacia abyssinica* (23.23g/kg) and *Plectranthus barbatus* (20.4 g/kg). The levels of calcium in medicinal plants from Manga ranged from 2.40±0.04 to 36.90±0.80 g/kg. The medicinal plants from Manga found to be rich in calcium were were *Aloe vera* (47.2 g/kg), *Solanum mauense* (46 g/kg), *Ultrica dioica* (39 g/kg), *Ultrica dioica* (36 g/kg), *Clerodendrum myricoides* (29 g/kg), *Acacia abyssinica* (19.7g/kg) and *Acacia hockii* (19.1 g/kg). The levels of calcium in medicinal plants from Nyamira ranged from 5.30±0.06 to 39.00±1.00 g/kg. The medicinal plants from Nyamira found to be rich in calcium were *Aloe vera* (44.5 g/kg), *Ultrica dioica* (39 g/kg), *Erythrina abyssinica* (26.6 g/kg), *Acacia abyssinica* (21.4 g/kg), *Acacia hockii* (16.7 g/kg) and *Melia* *azedarach* (16.6 g/kg). The highest mean level of calcium was in *Ultrica dioica* and the lowest was in *Solanum indicum* in all the Sub Counties. The levels of calcium in the medicinal plants were statistically significant from all other macro elements except potassium in all the Sub Counties (Appendix XXXVIII- Appendix XXXXI) ($P<0.05$). The levels of calcium in the plants were statistically not different from one another in the different Sub Counties ($P<0.05$) (Appendix XXXXII g). The medicinal plants in Nyamira County which had high levels of calcium were *Ultrica dioica* (38.25 g/kg), *Aloe vera* (45.69 g/kg), *Acacia hockii* (.21.68 *g/*kg) *Carissa edulis* (18.65 g/kg), *Acacia abyssinica* (18.25 g/kg), *Plectranthus barbatus* (17.4 g/Kg) and *Clerodendrum myricoides* (16.63 g/kg). The levels of calcium in the medicinal plants reported in this study are similar to those reported by Adongo *et al*. (2012) ranging from 0.21 to 78 g/ kg in the medicinal plants used in Chuka, Kenya. These mean that most of the herbal medicinal could supply the bioavailable calcium levels within the recommended levels and are safe to be taken.

4.2.3 The Levels of Trace Elements in Medicinal Plants

The results of total trace elements in the medicinal plants from Borabu, Ekerenyo, Manga and Nyamira Sub Counties determined by ICP-MS are presented in figures 6a – 24 b.

Trace element Concentration in Warburgia ungandesis stem bark

Figure 2a shows trace element B….Zr and Figure 2b shows Ga…Yb levels in *Warburgia ugandensis*.

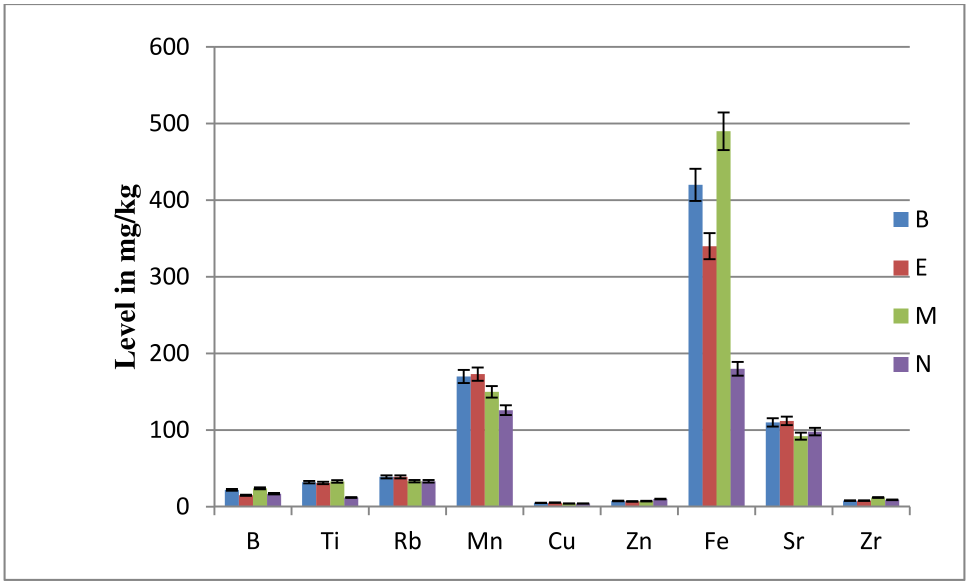


Figure 2a: Total trace element levels in *Warburgia ungandesis*

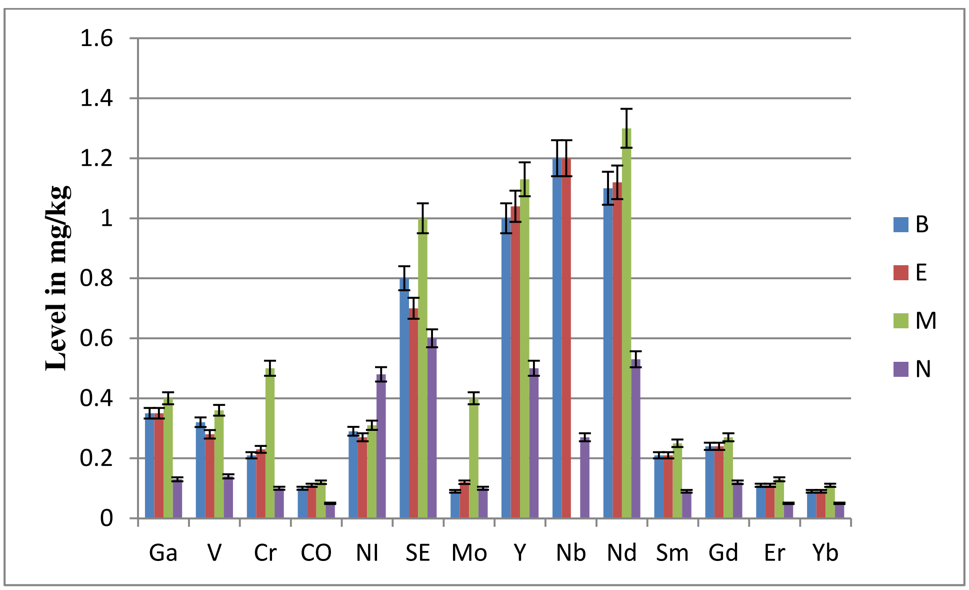


Figure 2b: Total trace Element levels in *Warbugia ugandensis*

Warbugia ugandensis had iron levels of 420, 340, 490 and 180 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Warbugia ugandensis* had manganese levels of 170.00, 173.00, 150.00 and 126.00 mg/kg and strontium levels of 110.00, 112.00, 92.00 and 98.00 mg/kg in *Warbugia ugandensis* respectively from Borabu, Ekerenyo, Manga and Nyamira. The other elements which were substantial in the medicnal plant were Se, Y, Nb and Nd. The levels of the other elements were generally low in *Warburgia ugandesis* as shown in figures 6a and 6b. The iron level in the medicinal plant accounts for its use in the management of malaria as it facilitates the erythrocyte synthesis destroyed by the plasmodium parasites while that of manganese enables it to manage diabetes. The medicinal plant can be used against a number of other ailments as it has substantial amounts of selenium and niobium.

Trace element concentration in *Solanum indicum* leaves

Fig 3(a) shows trace element B….Zr and Fig 3(b) shows Ga…Yb levels in *Solanum indicum*.

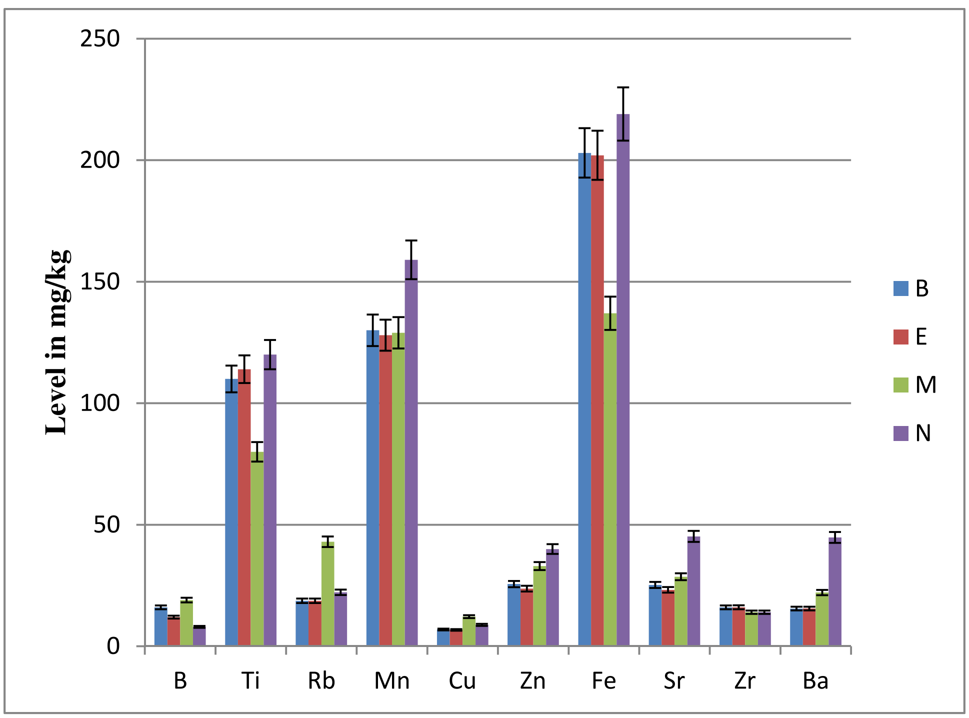


Figure 3a: Total trace element levels in *Solanum indicum*

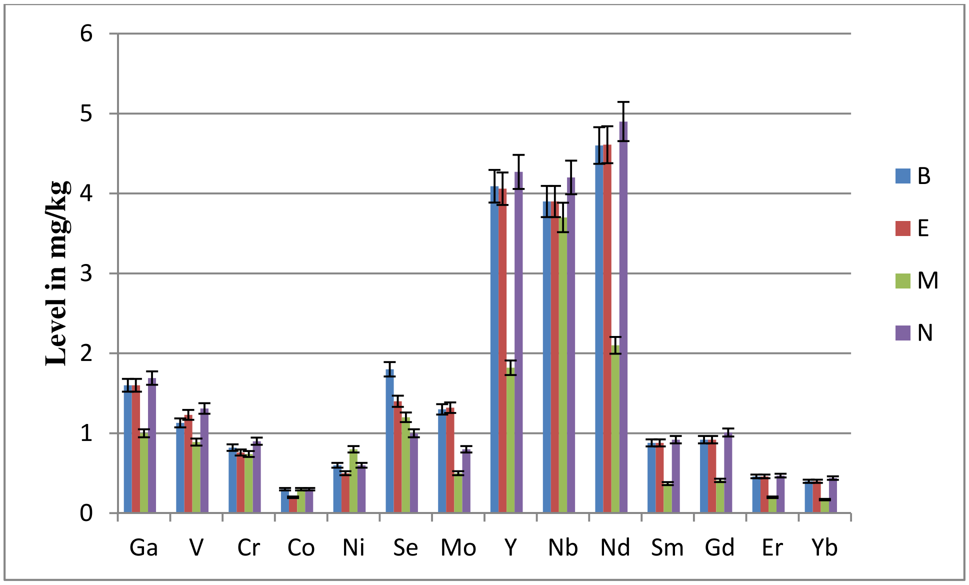


Figure 3b: Total trace element levels in *Solanum indicum*

Solanum indicum contains the highest concentration of yttrium amongst the nineteen medicinal plants with the mean level of 4.09, 4.06, 1.82 and 4.27 mg/kg from Borabu, Ekerenyo, Manga and Nyamira. *Solanum indicum* had zinc levels of 108, 103, 123 and 82 mg/kg, gallium levels of 1.7, 1.71, 0.92 and 1.8 mg/kg, vanadium levels of 1.2, 1.3, 0.8 and 1.41 mg/kg, selenium levels of 1.86, 1.42, 1.36 and 0.98 mg/kg, niobium levels of 3.89, 3.87, 3.68 and 4.25 mg/kg and neodymium levels of 4.5, 4.52, 2.2 and 4.82 mg/kg respectively from Borabu, Ekerenyo, Manga and Nyamira. It is rich in Fe, Y, V, Nb, Mn, Ti, Cr, V, Se, Mo, Nd, Ga, Nb, Ni and Co. The fact that the medicinal plant is rich in immune boosting trace elements shows that it can be used to boost the immunity of patients. The medicinal plant is used to manage diabetes as it is rich in zinc, chromium, vanadium and manganese, which have been shown to low the blood sugar levels (Kumar *et al*., 2003). Our results compare well with that reported by Kumar *et al.* (2003) of 0.5-5.2 µg/g in medicinal plants.

Trace element concentration in *Toddalia asciatica* roots

The total mean levels of the trace elements in roots of *Toddalia asciatica* are presented in figures 4a and 4b.

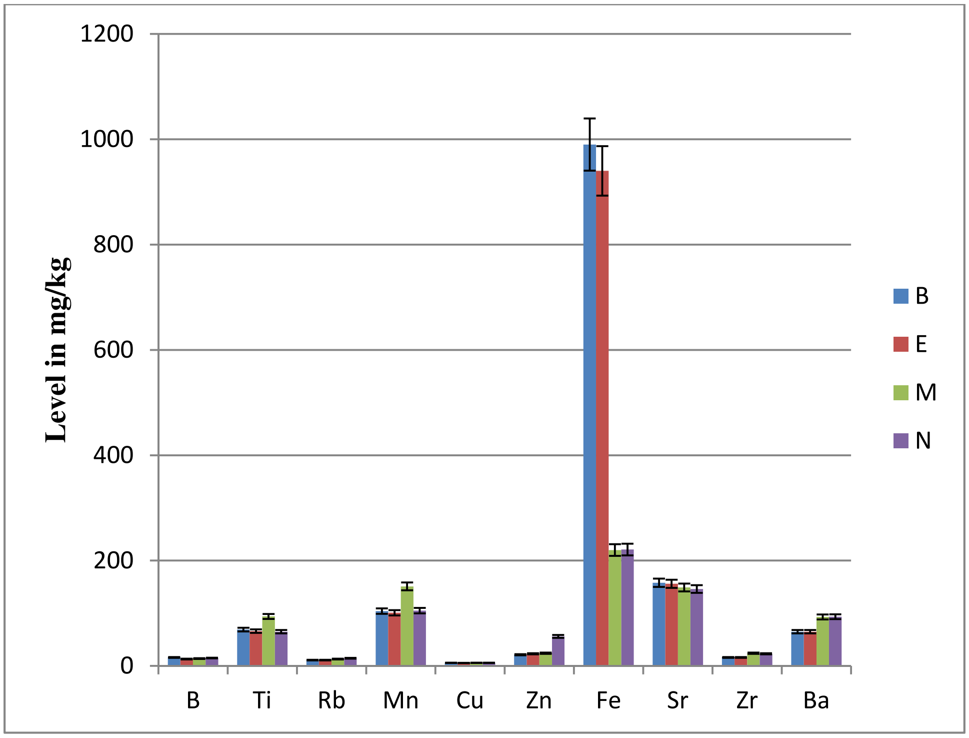


Figure 4a: Total trace element levels in *Toddalia asciatica*

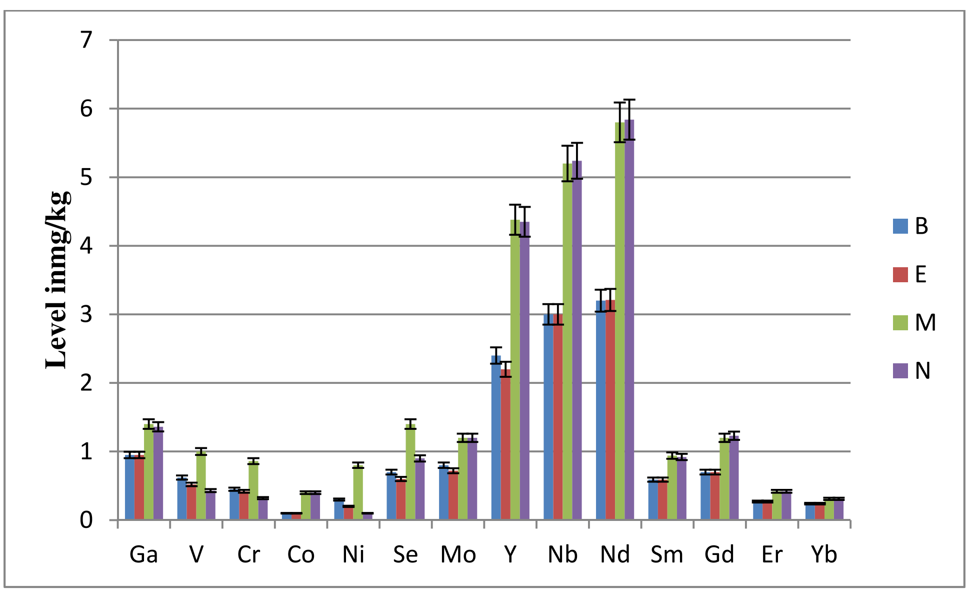


Figure 4b: Total trace element levels in *Toddalia asciatica*

The element which was in highest concentration in *Toddalia asciatica* was iron with concentrations of 990, 940, 220 and 221 mg/kg from Borabu, Ekerenyo, Manga and Nyamira. *Toddalia asciatica* had gallium levels of 0.91, 0.92, 1.45 and 1.44 mg/kg, yttrium levels of 2.4, 2.25, 4.31 and 4.3mg/kg, niobium levels of 3.0, 3.01, 5.31 and 5.3 mg/kg, neodymium levels of 3.2, 3.21, 5.81 and 5.82 mg/kg and gadolinium levels of 0.78, 0,79, 1.22 and 1.24 mg/kg respectively from Borabu, ekerenyo, Manga and Nyamira. The other elements which were substantial in the plant were Ti, Mn, Zn, Sr, Ba, Co, Cr, V, Ni, Mo, Yb, Sm and Er. The medicinal plant contains immune boosting trace elements and may be used to boost the body's immunity. The medicinal plant is used in the treatment of malaria and diabetes among other ailments by the herbalists of Nyamira County.

Trace element concentration in *Erythrina abyssinica*

The total mean levels of the trace elements in stem bark of *Erythrina abyssinica* are presented in figures 5a and 5b.

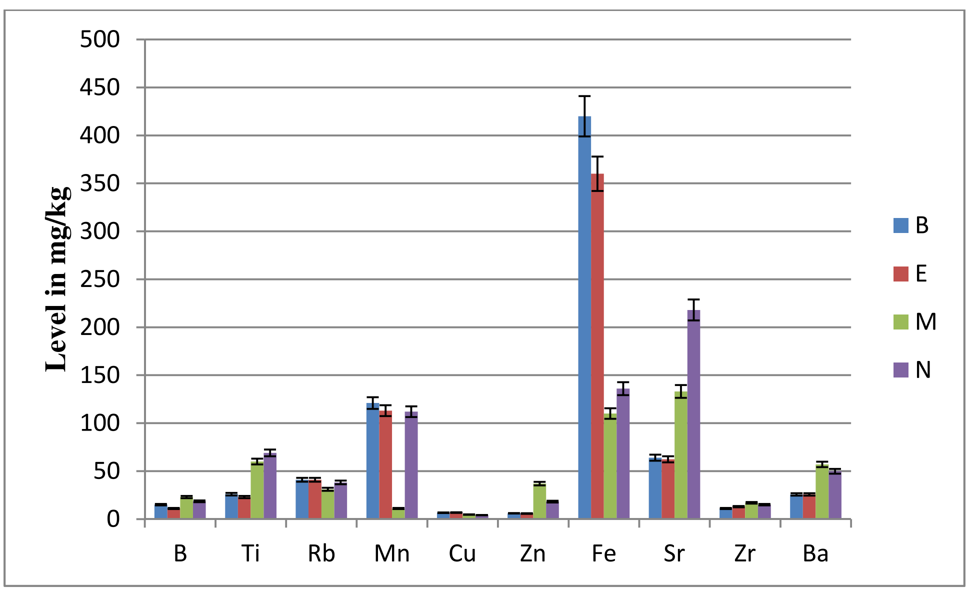


Figure 5a: Total trace element levels *in Erythrina abyssinica*

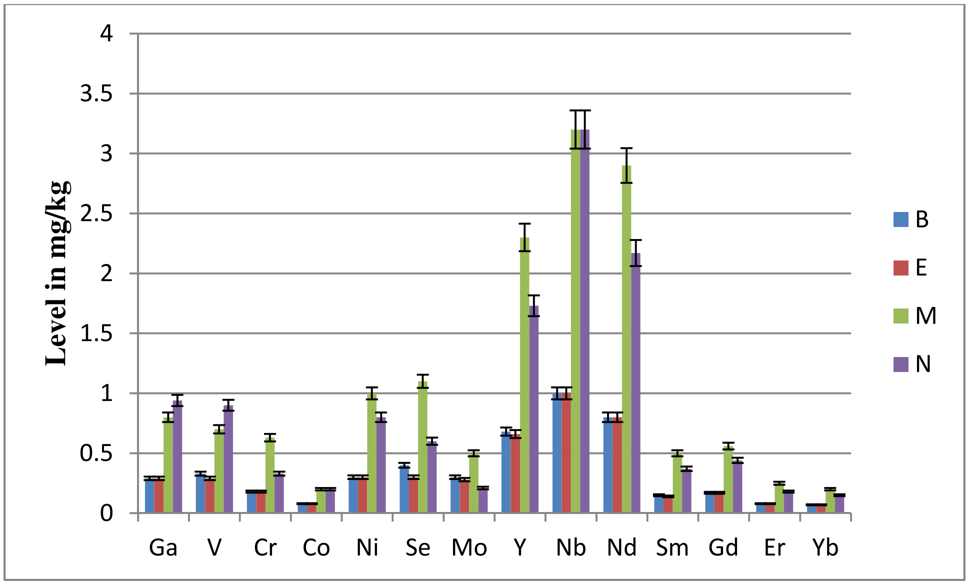


Figure 5b: Total trace element levels *in Erythrina abyssinica*

Erythrina abyssinica had niobium levels of 1.00, 1.00, 3.20 and 3.20 mg/kg and strontium levels of 54, 54.1, 132 and 210 mg/kg from Borabu, Ekerenyo, Manga and Nyamira. It had relatively high amounts of Ti, Mn, Zn, Ba, Ga, Co, Se, Cr, V, Nd, Y, Ni, Mo, Yb, Sm, Gd, and Er as shown in figures 9 a&b . The medicinal plant has a high elemental content which could be an indicator of its wide therapeutic application. The medicinal plant is used in the management of diabetes as it has high levels of elements reported to lower the blood sugar levels and it can also be used as an immune booster.

Trace element concentration in *Senna didymolbotrya*

The total mean levels of the trace elements in the leaves of *Senna didymolbotrya* are presented in figures 6a and 6b.

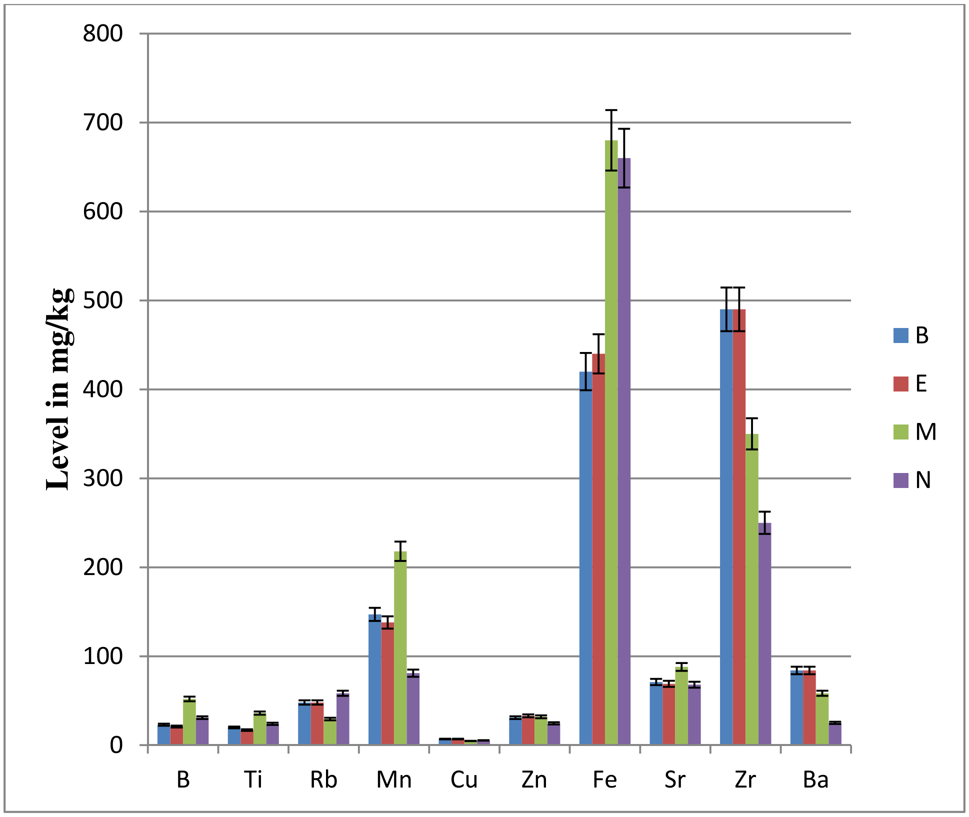


Figure 6a: Total trace element levels in *Senna didymolybotrya*

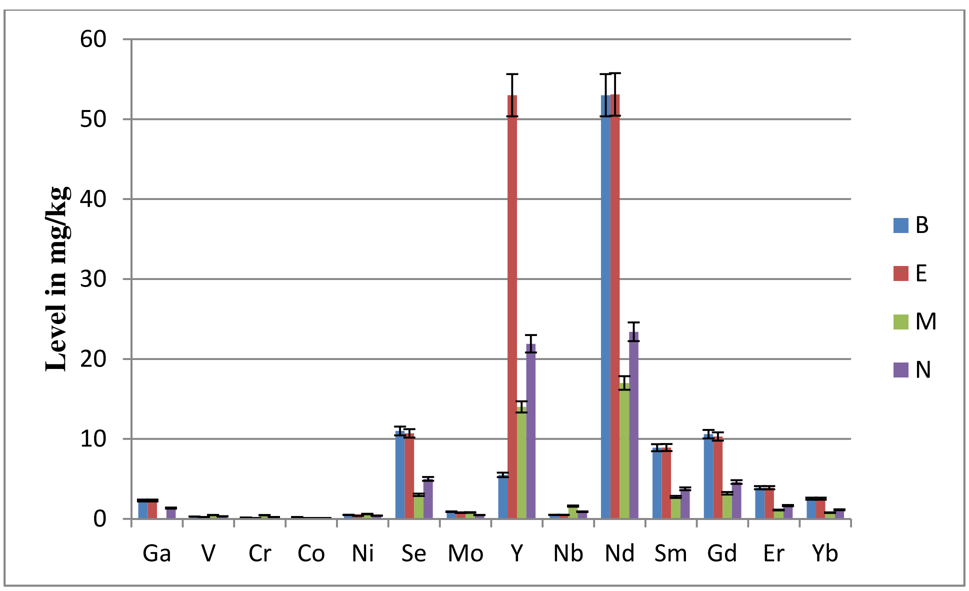


Figure 6b: Total trace element levels in *Senna didymolybotrya*

Senna didymolbotrya had the highest Yttrium levels of 5.50, 53.00, 14.00 and 21.90 mg/kg and that of neodymium of 53.00, 53.10, 17.00 and 23.40 mg/kg from Borabu, Ekerenyo, Manga and

Nyamira among the nineteen medicinal plants. *Senna didymolbotrya* had selenium levels of 11, 10.93 and 5 mg/kg, zirconium levels of 490, 490, 350 and 250 mg/kg, samarium levels of 8.9, 8.92, 2.75 and 3.76 mg/kg, gadolinium levels of 10.6, 10.3, 3.2 and 4.6 mg/kg, and erbium levels of 3.9, 3.9, 1.1 and 1.65 mg/kg from Borabu, Ekerenyo, Manga and Nyamira. The plant had substantial levels of Fe, B, Rb and Ba. The high level of iron in the medicinal plant allows it to be efficacious in the treatment of malaria in Nyamira County.

Trace element Concentration in *Veronia auriculifera* leaves

The total mean levels of the trace elements in the leaves of *Veronia auriculifera* are presented in figures 7a and 7b.

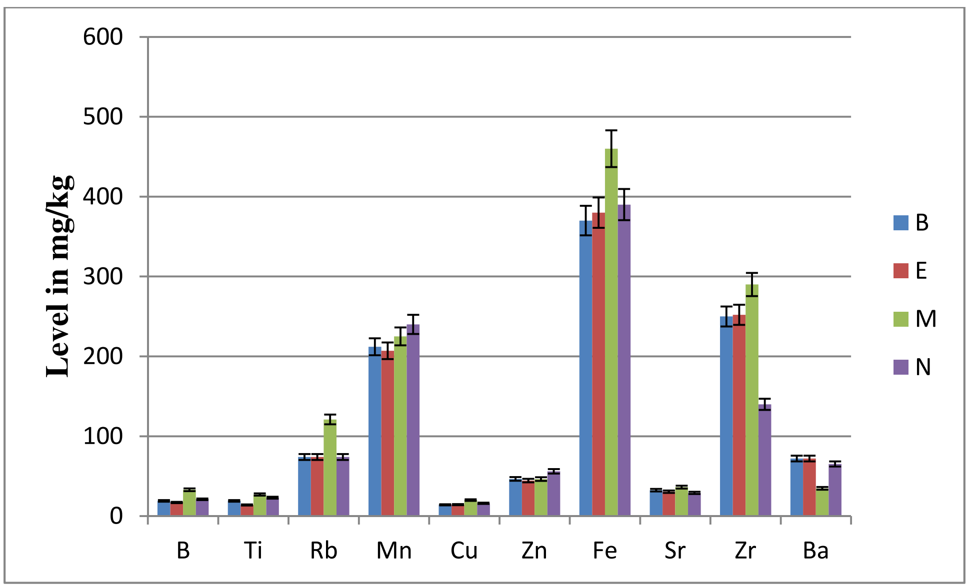


Figure 7a: Total trace element levels in *Veronia auriculifera*

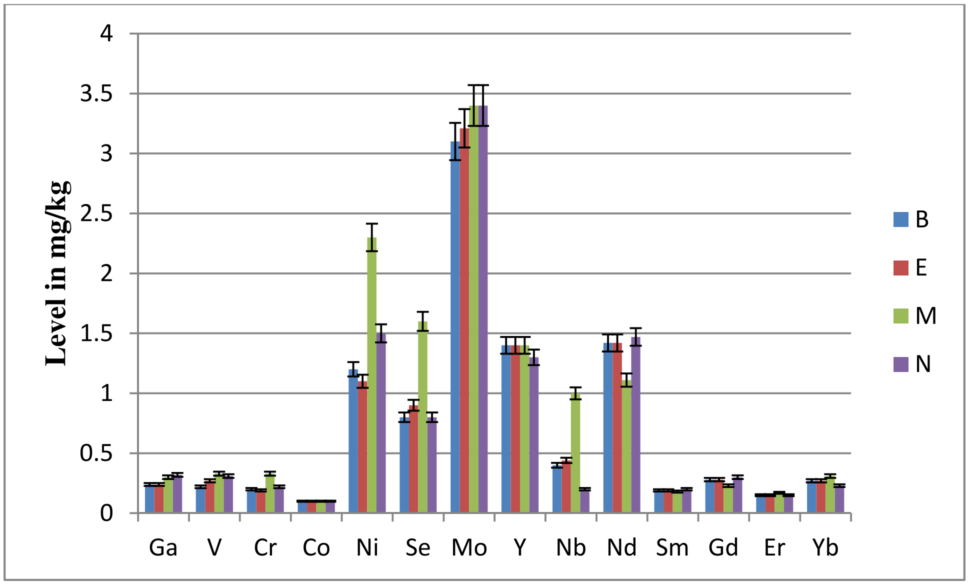


Figure 7b: Total trace element levels in *Veronia auriculifera*

Veronia auriculifera leaves had the highest levels of molybdenum of 3.10, 3.21, 3.40 and 3.40 mg/kg from Borabu, Ekerenyo, Manga and Nyamira Sub Counties. *Veronia auriculifera* leaves had copper levels of 14.2, 14.3, 20.1 and 16 mg/kg, zinc levels of 56, 53, 60 and 68 mg/kg, rubidium levels of 74, 74, 121 and 75 mg/kg and zirconium levels of 250, 252, 290 and 140 mg/kg respectively from Borabu, Ekerenyo, Manga and Nyamira. The medicinal plant was rich in the trace elements and indication that it be used in the treatment of several ailments. It is rich in the immune boosting trace elements and hence it can be use to boost the immunity. It has high levels of Cr, Mn, Zn, Se, Ni, Nd, V and Mo which make it to be used as an anti diabetic plant by herbalists in Nyamira.

Concentration of trace elements in Plectranthus barbatus

The total mean levels of the trace elements in the leaves of *Plectranthus barbatus* are presented in figures 8a and 8b.

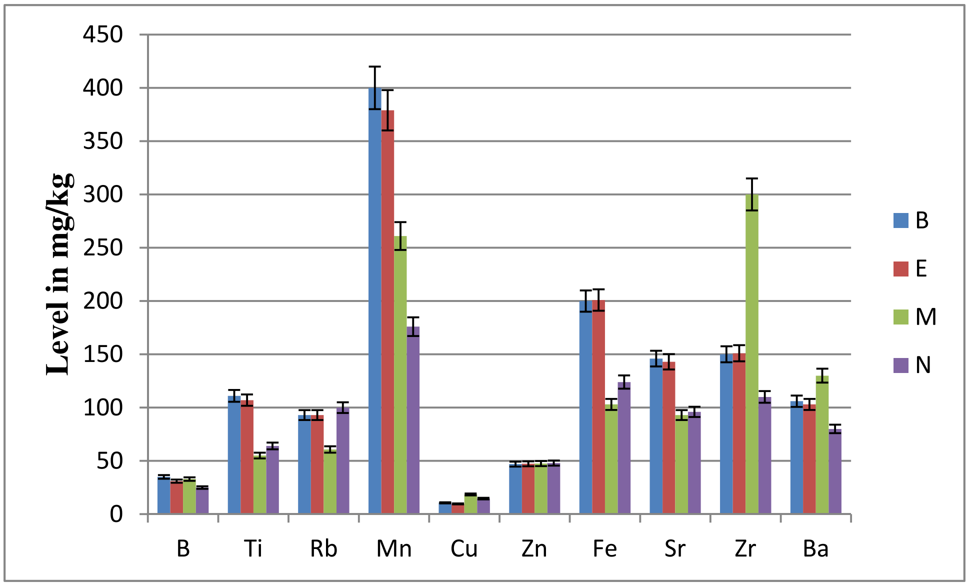


Figure 8a: Total trace element levels in *Plectranthus barbatus*

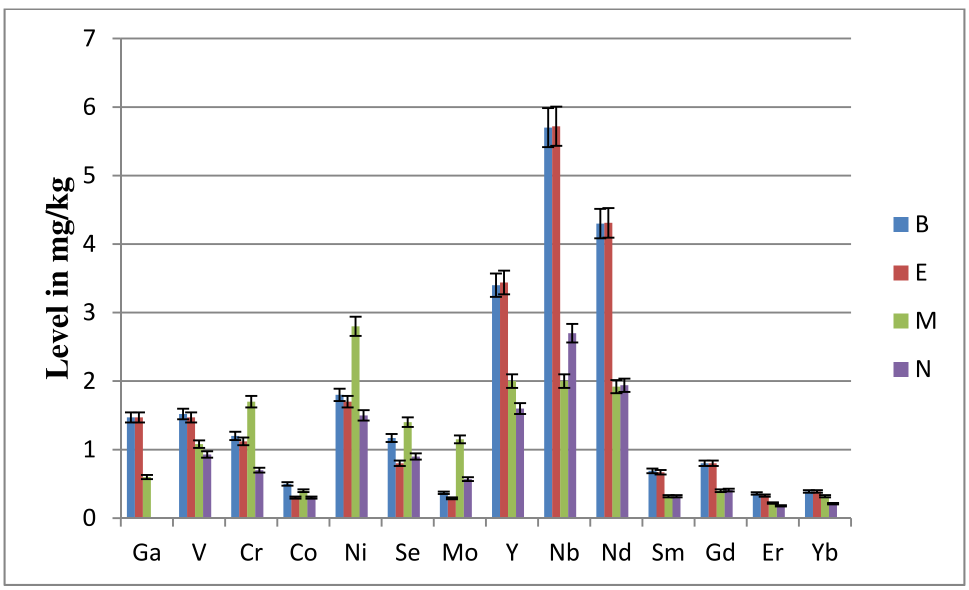


Figure 8b: Total trace element levels in *Plectranthus barbatus*

Plectranthus barbatus had highest manganese concentration of 400.00, 379.00, 261.00 and 176.00 mg/kg from Borabu, Ekerenyo, Manga and Nyamira among the nineteen medicinal plants. *Plectranthus barbatus* had nickel levels of 1.8, 1.75, 2.88 and 1.5 mg/kg, copper levels of 10.7, 10.2, 18.5 and 14.6 mg/kg, rubidium levels of 93, 93, 60.7 and 100 mg/kg, zirconium levels of 150, 149.8, 300 and 110 mg/kg and barium levels of 106, 103, 130 and 80 mg/kg respectively from Borabu, Ekerenyo, Manga and Nyamira. The other elements with substantial levels were B, Ti, Zn, Sr, Zr, Ga, V, Co, Cr, Se, Nd, Y and Nb. *Plectranthus barbatus* is rich in Zn, V and Cr which have been shown to control the blood sugar levels in the management of diabetes (Choudhury *et al*., 2008). The medicinal plant is used in the management of diabetes by herbalists in Nyamira County.

Concentration of trace elements in *Ultrica dioica* leaves

The total mean levels of the trace elements in the leaves of *Ultrica dioica* are presented in figures 9a and 9b.

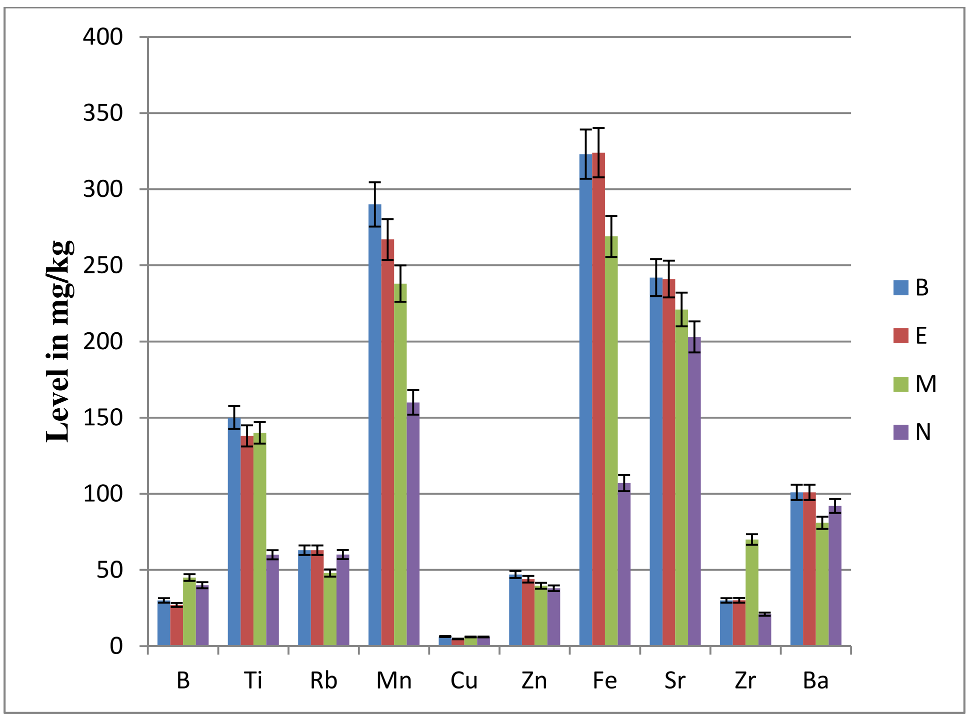


Figure 9a: Total trace element concentration in *Ultrica dioica*

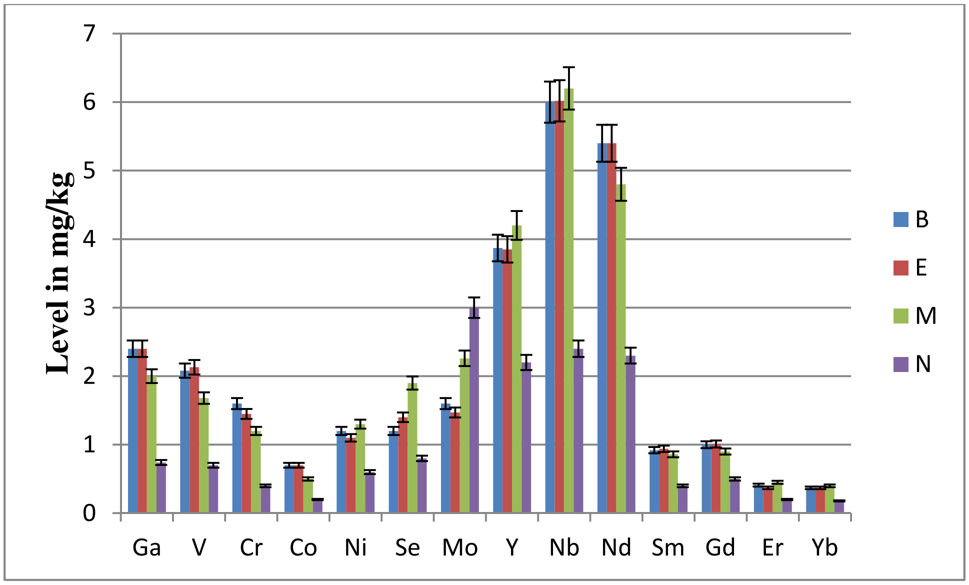


Figure 9b: Total trace element concentration in *Ultrica dioica*

The concentration of strontium was the highest in *Ultrica dioica* with levels of 242.00, 241.00, 221.00 and 203.00 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Ultrica dioica* had vanadium levels of 2.08, 2.13, 1.73 and 0.81 mg/kg, chromium levels of 1.6, 1.45, 1.23 and 0.42 mg/kg, cobalt levels of 0.74, 0.73, 0.47 and 0.27 mg/kg, molybdenum levels of 1.6, 1.32, 2.26 and 3.0 mg/kg, niobium levels of 6, 6.02, 6.2 and 6.1 mg/ kg and gallium levels of 2.4, 2.4, 2.08 and 2.08 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. The other elements which were in high concentration in the plant were Mn, B, Ti, Zn, Ba, Ni, Se, Nd, Sm and Gd. The high level of trace elements in the plant shows that it can be taken to boost the body's immunity, for management of diabetes and other ailments.

Concentration of trace elements in *Croton macrostachyus* leaves

The total mean levels of the trace elements in the leaves of *Croton macrostachyus* are presented in figures 10a and 10b.

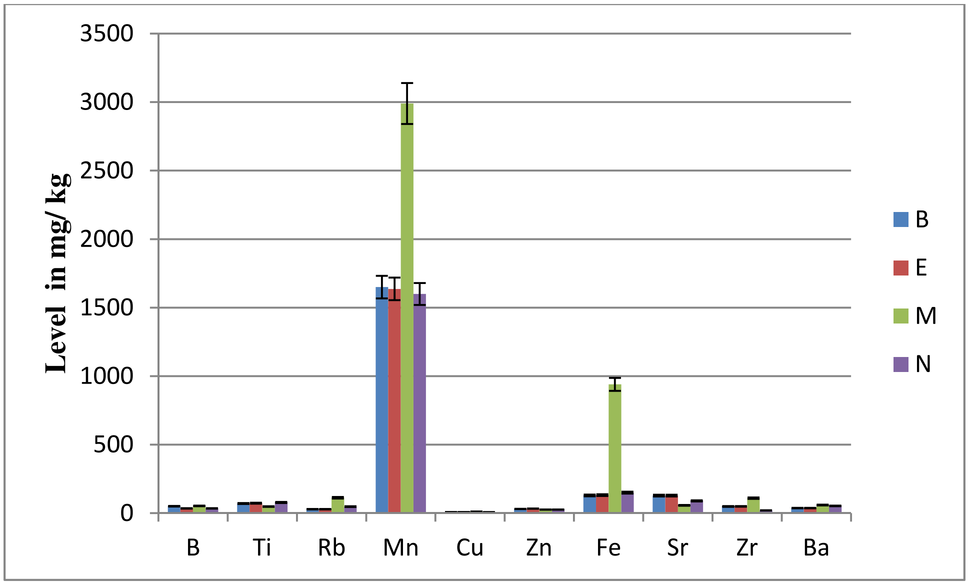


Figure 10a: Total trace element concentration in *Croton macrostachyus*

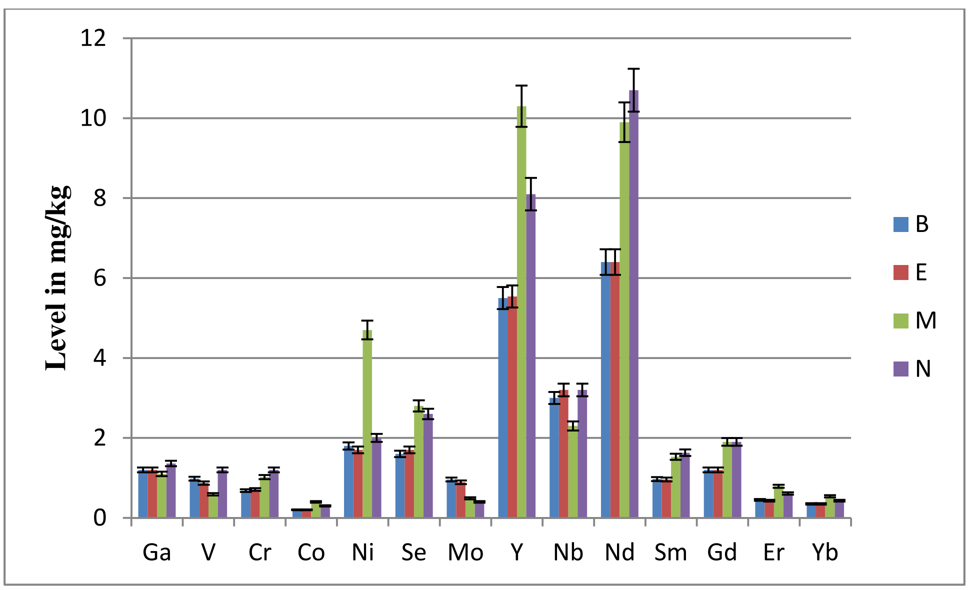


Figure 10b: Total trace element concentration in *Croton macrostachyus*

Croton macrostachyus had the highest levels of manganese among all the nineteen medicinal plants of 1650.00, 1637.00, 2990.000 and 1600.00 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Croton macrostachyus* had nickel levels of 1.8, 1.78, 4.64 and 2.0 mg/kg, selenium levels of 1.6, 2.8, 2.8 and 2.6 mg/kg, yttrium levels of 5.5, 5.54, 10.3 and 8.9 mg/kg, neodymium levels of 6.4, 6.31, 9.9 and 10.7 mg/kg, gadolinium levels of 1.2, 1.2, 1.9 and1.9

mg/Kg and erbium levels of 0.45, 0.43, 0.45 and 0.61 mg/kg from Borabu, Ekerenyo, Manga and Nyamira.The other elements which were high in the plant include Ga, V, Cr, Nb and Sm. *Croton macrostachyus* is found to be effective for curing colds, coughs as well as enhancing the body's resistance against diseases where trace elements like manganese, chromium, vanadium and selenium are responsible. The high levels of manganese, chromium and vanadium in the medicinal plant make it efficacious in the treatment of diabetes.

Concentration of trace elements in *Bidens pilosa* aerial parts

The total mean levels of the trace elements in the aerial parts of *Bidens pilosa* are presented in figures 11a and 11b.

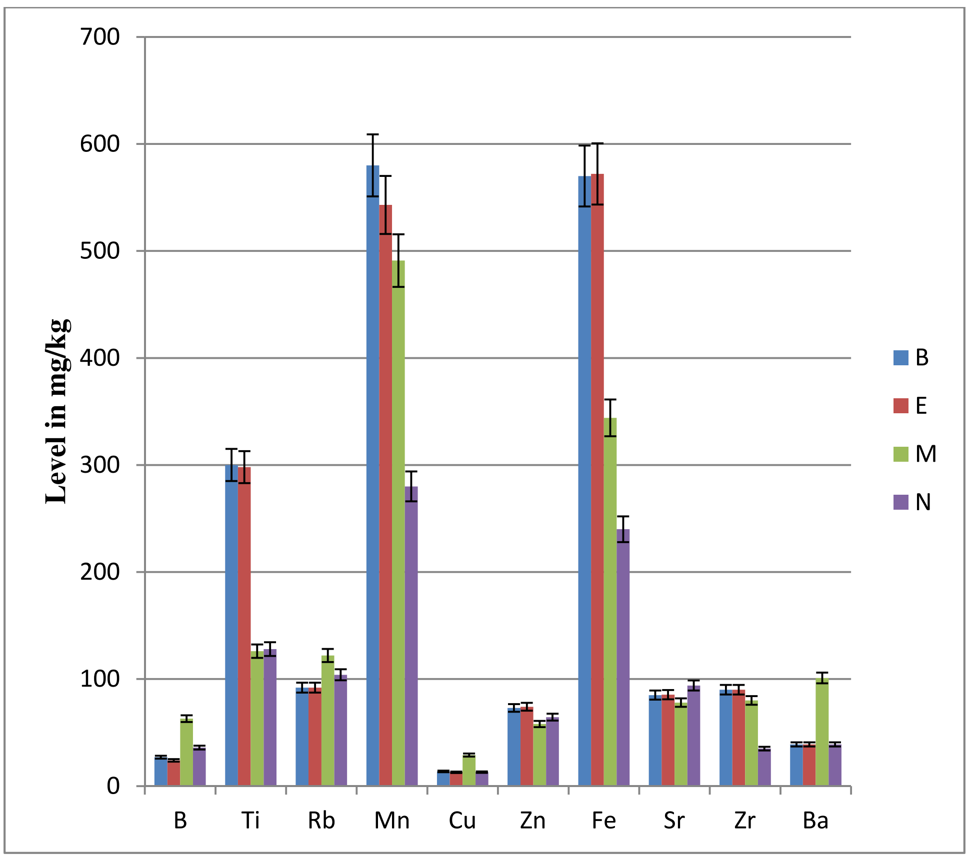


Figure 11a: Total trace element concentration in *Bidens pilosa*

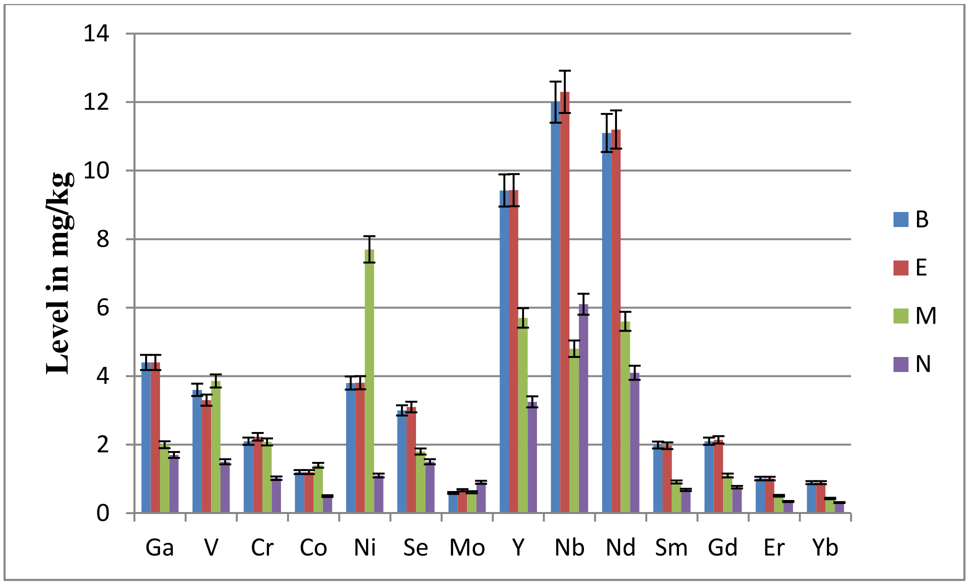


Figure 11b: Total trace element concentration in *Bidens pilosa*

Bidens pilosa had the highest concentrations of vanadium and chromium of the nineteen plants of 3.60, 3.30, 3.86 and 1.5 mg/kg and 2.10, 2.23, 2.08 and 1.02 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Bidens pilosa* had titanium levels of 300, 298, 127 and 128 mg/kg, manganese levels of 580, 540, 491 and 281 mg/kg, cobalt levels of 1.21, 1.22, 1.42 and 0.56 mg/kg, nickel levels of 3.8, 3.81, 7.7 and 1.21 mg/kg, zinc levels of 73, 74.1, 58 and 64.4 mg/kg, copper levels of 13.7, 12.9, 29 and 13 mg/kg, rubidium levels of 92, 92, 122 and 104 mg/kg, niobium levels of 12, 12.3, 4.8 and 6.1 mg/kg, yttrium levels of 9.42, 9.43, 5.7 and 3.6 mg/kg, neodymium levels of 11.1, 11.2, 5.6 and 3.98 mg/kg, samarium levels of 1.99, 1.97, 0.9 and 0.86 mg/kg, gadolinium levels of 2.1, 2.14, 1.1 and0.76 mg/kg, erbium levels of 1.01,1.01, 0.51 and 0.45 mg/ kg, ytterbium levels of 0.89, 0.89, 0.43 and 0.31 mg/kg and gallium levels of 4.4, 4.4, 2.01 and1.91 mg/kg from Borabu, Ekerenyo, Manga and Nyamira. The other elements which were in high concentration were Sr, Zr, Ba, Se Sm and Gd. *Bidens pilosa* is rich in immune boosting trace elements and is used to enhance the body's immunity. *Bidens pilosa* is theurapeutically used for the treatment of diabetes by herbalists in Nyamira as it contain the blood sugar lowering trace elements such as Cr, Zn,Mn and V.

The total content of zinc in Bidens pilosa of 73, 74.1, 58 and 64.4 mg/Kg in Borabu, Ekerenyo, Manga and Nyamira respectivlely in our study compares well with that of 51 mg/100g of zinc were reported by Adeolu Adedapo *et al.* (2011), in a study done in South Africa. Rathore & Upadhyay (2013) reported the levels of zinc in *Azadirachta indica* to be 21.3 µg/g from India. Raju *et al.* (2013) reported the levels of zinc to range from 13.4-79.5 µg/g in the anticancer herbal plants. The presence of zinc in these plants correlates with the use of the medicinal pant such as in the treatment of cancer since it was observed that there is direct correlation between cancer and zinc defiency (Rosas *et al*., 1995; Narla *et al*., 2000; Raju *et al*., 2007). Owing to antagonistic property, zinc probably reduces the absorption of copper which is a cancer promoting agent (Goodman *et al*., 2004). Administering zinc through the anticancer medicinal plants also supplements some amount of copper. Since copper is antagonistic to zinc, whatever amount of copper which enters the body is possibly prevented from being absorbed by the relatively high zinc amounts. In view of the protective aspect of zinc against carcinogenesis, the medicinal plants with considerable amounts of zinc can be used for the treatment and management of cancer (Selinus *et al*., 2005).

Concentration of trace elements in *Melia azadarach* leaves

The total mean levels of the trace elements in the leaves of *Melia azadarach* are presented in figures 12a and 12b.

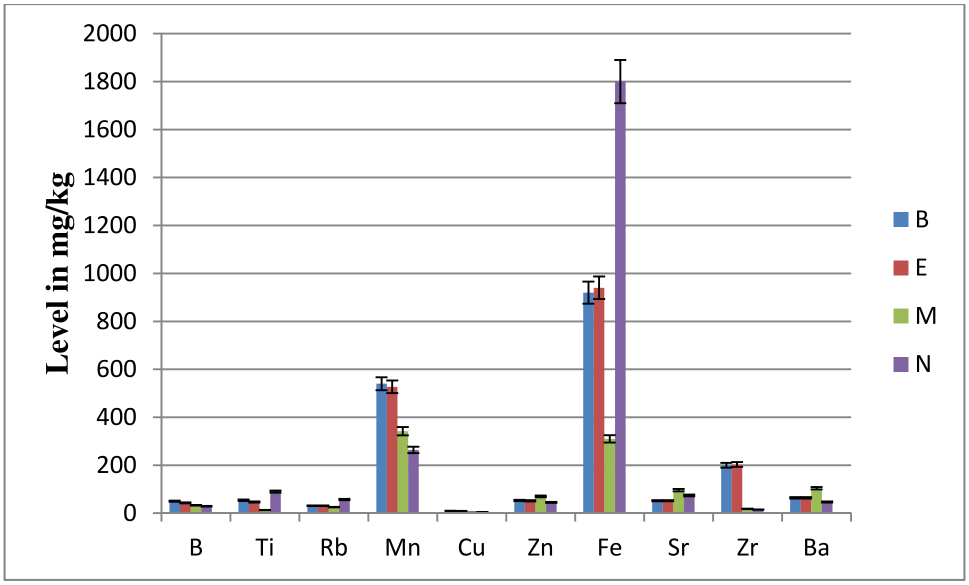


Figure 12a: Total trace element levels in *Melia azedarach*

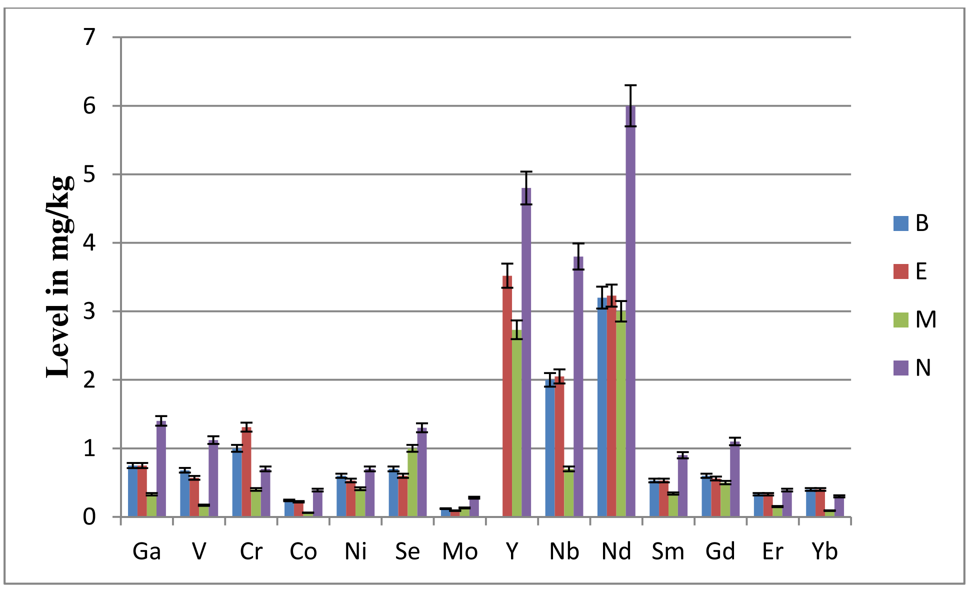


Figure 12b: Total trace element levels in *Melia azedarach*

Melia azadarach leaves are rich in iron with levels of 920, 940, 310 and 1800 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Melia azadarach* had zirconium levels of 200, 203, 45 and 42 mg/kg, manganese levels of 560, 550, 350 and 280 mg/kg, gallium levels of 0.8, 0.81, 0.4 and 1.41 mg/kg, chromium levels of 1, 1.21, 0.4 and 0.61 mg/kg, selenium levels of 0.73, 0.7, 0.9 and 1.2 mg/kg, niobium levels of 2,.0, 2.0, 0.64 and 3.81 mg/kg and neodymium levels of 3.2, 3.2, 3.0 and 6.0 mg/kg respectively from Borabu, Ekerenyo, Manga and Nyamira. The other elements which were in substantial amounts were yttrium, samarium and gadolinium. The other elements had mean concentration of below 1mg/Kg. *Melia azadarach* is rich in iron and can be efficacious in the management of anemia and malaria. The levels of iron obtained are comparable with those obtained in South Africa by Adedapo *et al.* (2011) of 986 mg/100g in *Biden pilosa* and 255 mg/100g in *Chenopodium album*. In another study done by Alikwe (2014) it was reported that the levels of iron in *Bidens plosa* in Nigeria was 789± 0.1 mg/kg. This means trace elements activated the therapeutic activity of natural products in the medicinal plants boosting their curative activity. The iron in the medicinal plants enhances the synthesis of the erythrocytes as the natural products in the medicinal plants destroyed the plasmodium parasites and are used in the treatment of malaria.

Concentration of trace elements in *Solanum mauense* aerial parts

The total mean levels of the trace elements in *Solanum mauense* aerial parts are presented in figures 13a and 13b.

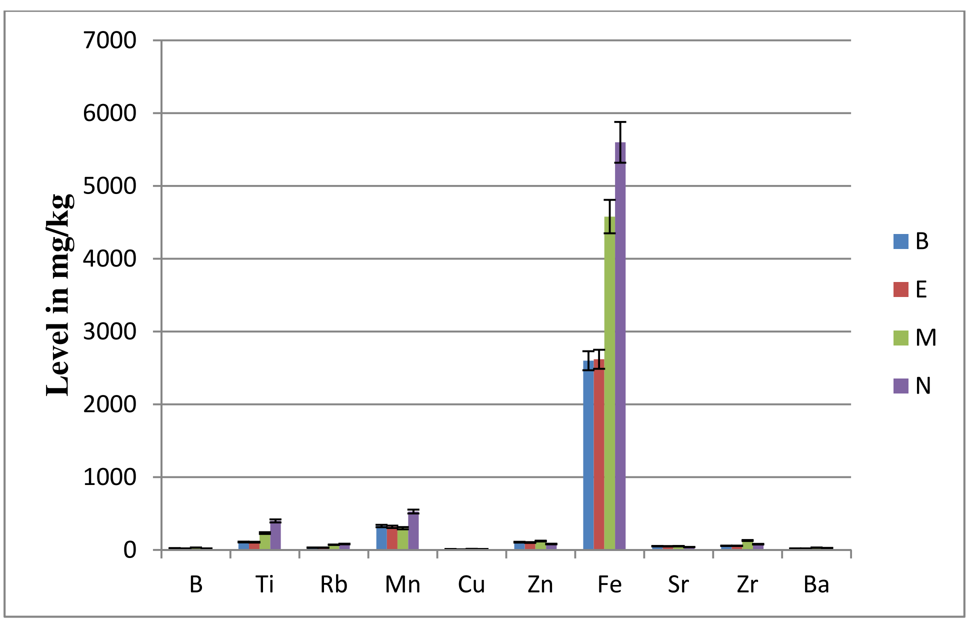


Figure 13a: Total trace element levels in *Solanum mauense*

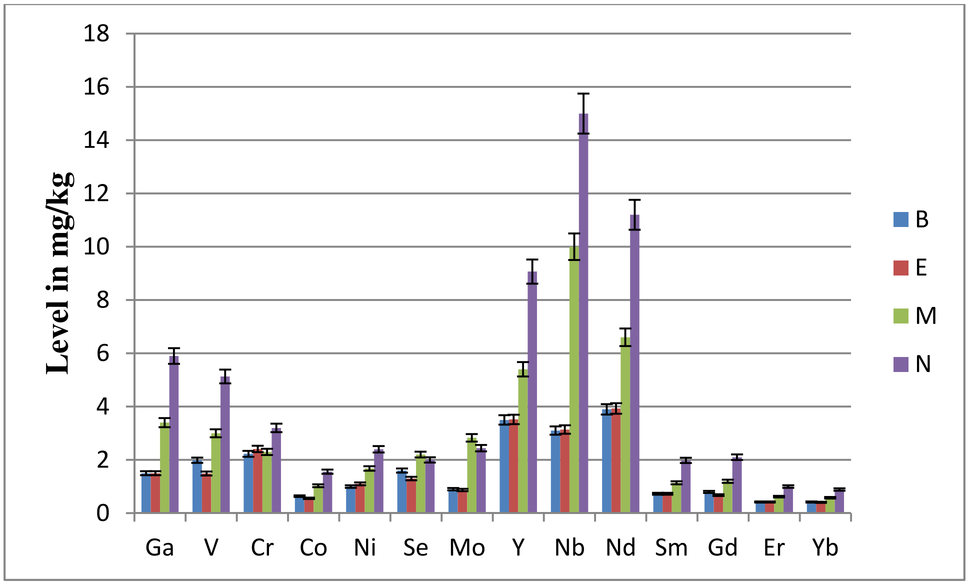


Figure 13b: Total trace element levels in *Solanum mauense*

Solanum mauense aerial parts had the highest iron levels of 2600, 2620, 4580 and 6000 mg/kg, chromium levels of 2.23, 2.41, 2.3 and 3.2mg/kg, niobium levels of 3.10, 3.14, 10.00 and 15.00 mg/kg, zinc levels of 108, 103, 123, 82 mg/kg while neodymium levels of 3.90 mg/kg, 3.93, 6.60 and 11.20 mg/kg among the nineteen plants from Borabu, Ekerenyo, Manga and Nyamira. *Solanum mauense* had vanadium levels of 1.99, 1.49, 3.0 and 5.13 mg/kg, cobalt levels of 0.64, 0.56, 1.03 and 1.56 mg/kg, selenium levels of 1.6, 2.2, 2.2 and 2.0 mg/kg, yttrium levels of 3.8, 3.8, 5.4 and 9.07 mg/kg and ytterbium levels of 0.42, 0.41, 0.58 and 0.89 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. The other elements rich in *solanum mauense* were Ga, Ni, Mn and Mo (Fig 17). The medicinal plant has high amount of immune boosting trace elements and can be efficacious in enhancing the body's immunity. The plant is rich in iron and can be efficacious in managing malaria and anemia. The plant is also rich in vanadium, chromium and manganese and it can be used to manage diabetes.

Concentration of trace elements in *magnifera indica* leaves

The total mean levels of the trace elements in *magnifera indica* leaves are presented in figures 14a and 14b.

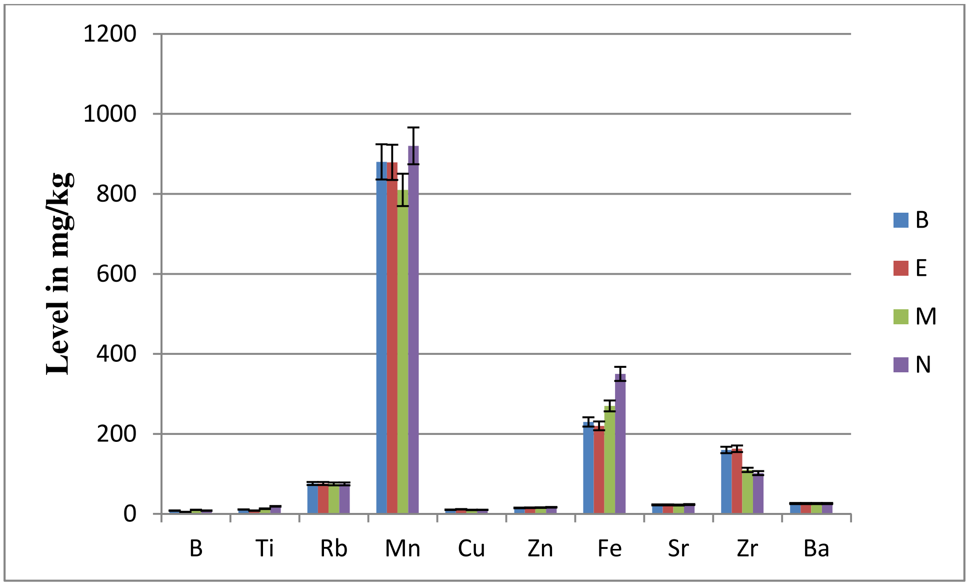


Figure 14a: Total trace element levels in *Magnifera indica*

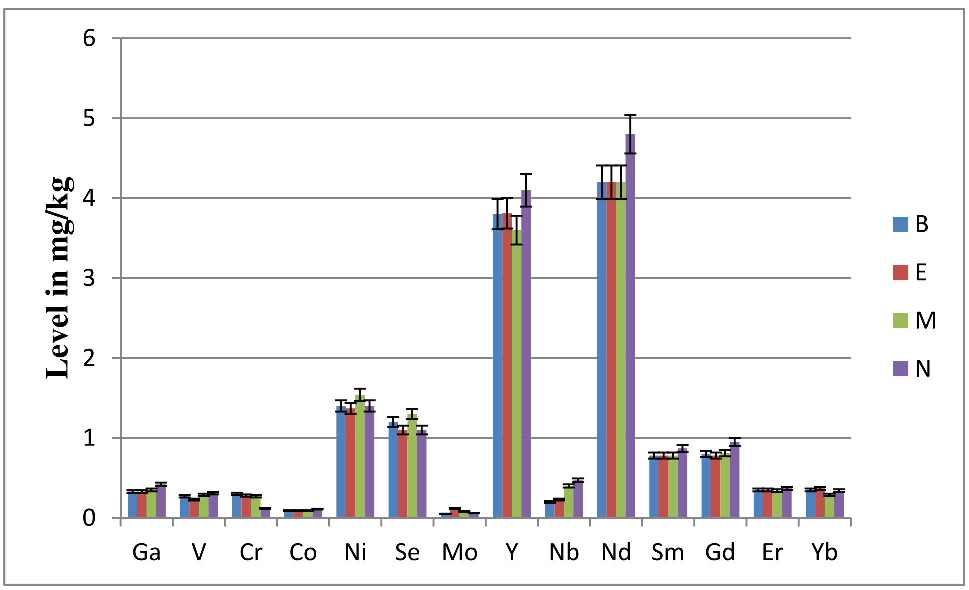


Figure 14b: Total trace element levels in *Magnifera indica*

Magnifera indica had high levels of manganese of 880.00, 879.00, 810.00 and 920.00 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Magnifera indica* had nickel levels of

1.3, 1.31, 1.4 and 1.3mg/kg, selenium levels of 1.2, 1.1, 1.3 and 1.1 mg/kg, yttrium levels of 3.8, 3.8, 3.6 and 4.1 mg/kg, neodymium levels of 4.2, 4.21, 4.2 and 4.8 mg/kg, copper levels of 10, 11.4, 10 and 10.2 mg/kg, rubidium levels of 76, 76, 75 and 75 mg/kg and zirconium levels of 160, 163, 110 and 102 mg/kg respectively from Borabu, Ekerenyo, Manga and Nyamira. The other elements which were in high amounts in *Magnifera indica* were V, Cr, Sm, Gd, Yb and Er as shown in figure 18. *Magnifera indica* can be used in the management of diabetes due its high manganese levels. The high levels of manganese could be due to the association of iron and manganese and adherence of soil particles rich in iron as the soils of Nyamira County are rich in iron. The high levels of manganese in the medicinal plants may be used in the management of diabetes. These results are similar to that of 115 mg/100g reported by Adedapo *et al.* (2011) in a study done in South Africa among the medicinal plants.

Trace element concentrations in Acacia hockii stem *bark*

The total mean levels of the trace elements in *Acacia hockii stem bark* are presented in figures 15a and 15b.

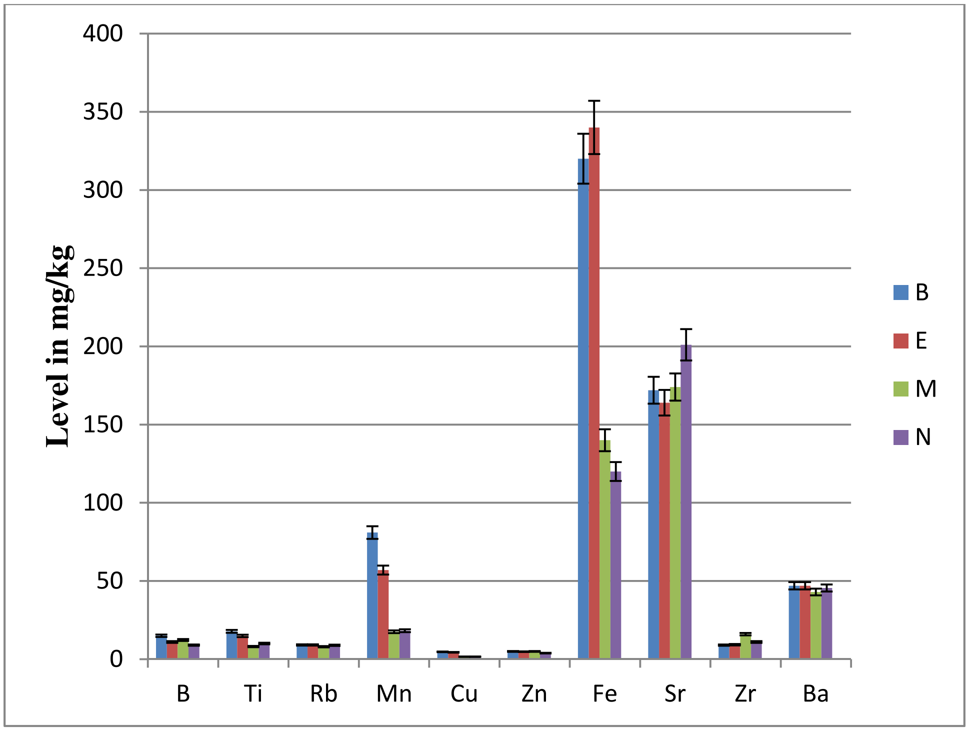


Figure 15a: Total element levels in *Acacia hockii*

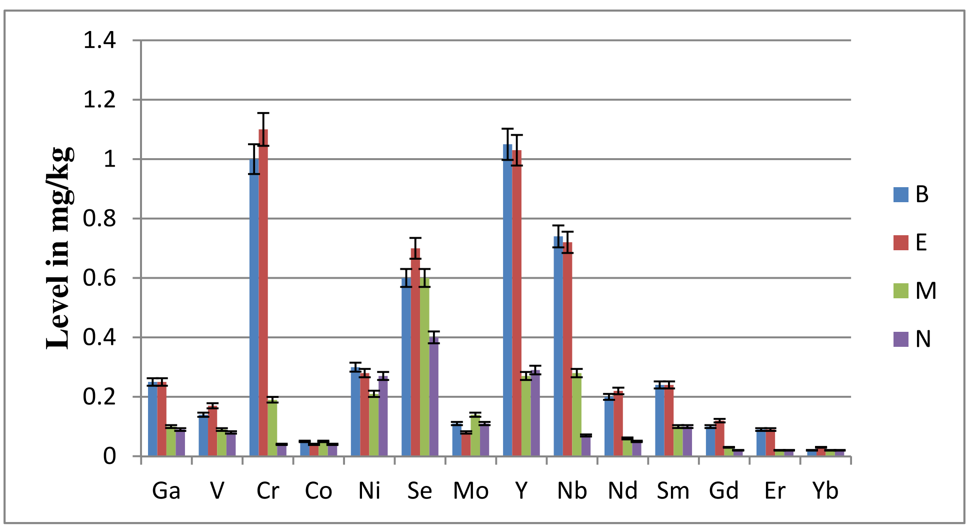


Figure 15b: Total element levels in *Acacia hockii*

Acacia hockii contained generally low elemental levels with iron having highest levels of 320, 340,140 and 120 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. The other elements in substantial amounts were Sr, Cr, Nb, Se and Y in figure 19. Due to the high iron levels it may be used in the management of malaria and anemia. The high chromium levels in the plant can enable it to be used as an anti diabetic plant.

Concentration of trace elements in *acacia abyssinica* (stem bark)

The total mean levels of the trace elements in *Acacia abyssinica stem bark* are presented in figures 16a and 16b.

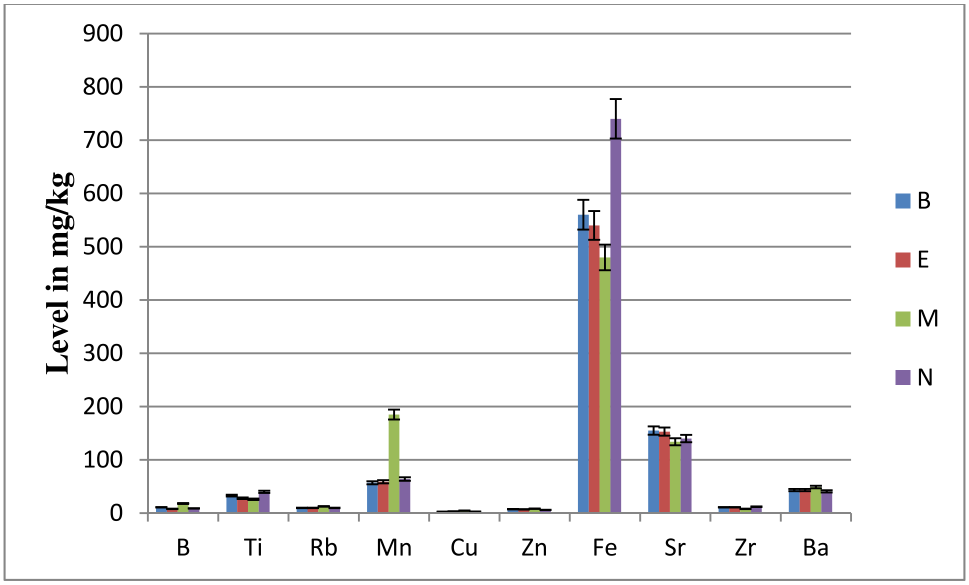


Figure 16a: Total trace element levels in *Acacia abyssinica*

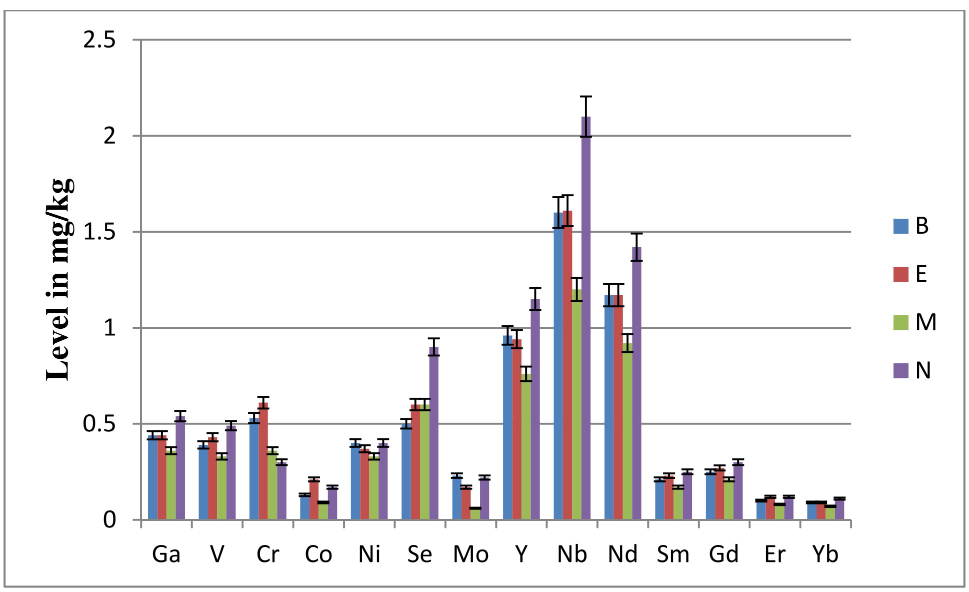


Figure 16b: Total trace element levels in Acacia abyssinica.

Acacia abyssinica had high amount of iron of 560, 540, 480 and 740 mg/kgfrom Borabu, Ekerenyo, Manga and Nyamira respectively. *Acacia abyssinica* had niobium levels of 1.52, 1.52, 1.25 and 2.17 mg/kg, strontium levels of 172, 164,174 and 201 mg/kg and neodymium levels of 1.22, 1.22, 0.95 and 1.45 mg/kg respectively from Borabu, Ekerenyo, Manga and Nyamira. Other elements in high levels were Er, Se, Gd and Y as shown in figure 20. *Acacia abyssinica* may be used in the treatment of malaria and anemia due its high iron levels.

Concentration of trace elements in *Clerodendrum myricoides* (root bark)

The total mean levels of the trace elements in *Clerodendrum myricoides root bark* are presented in figures 17a and 17b.

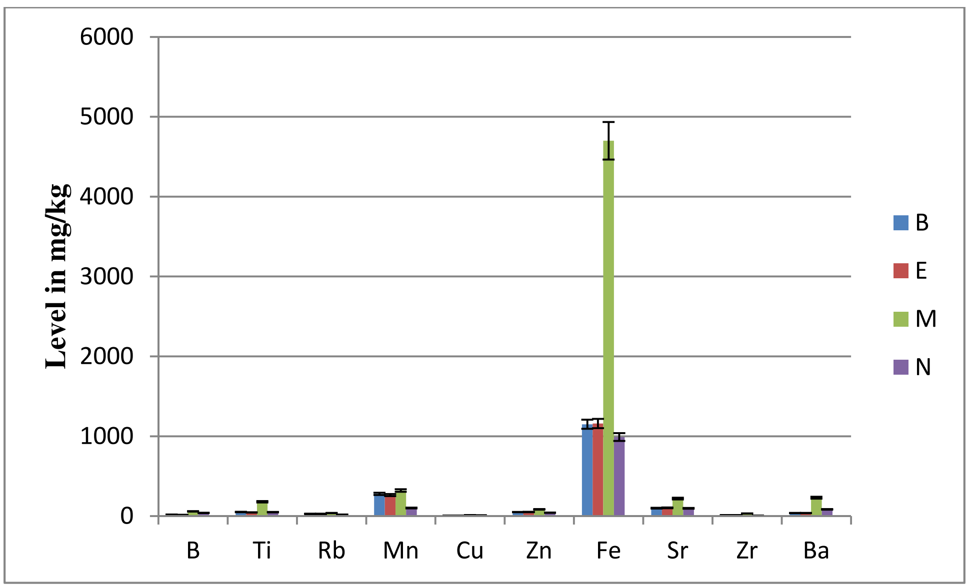


Figure 17a: Total trace element levels in *Clerodendrum myricoides*

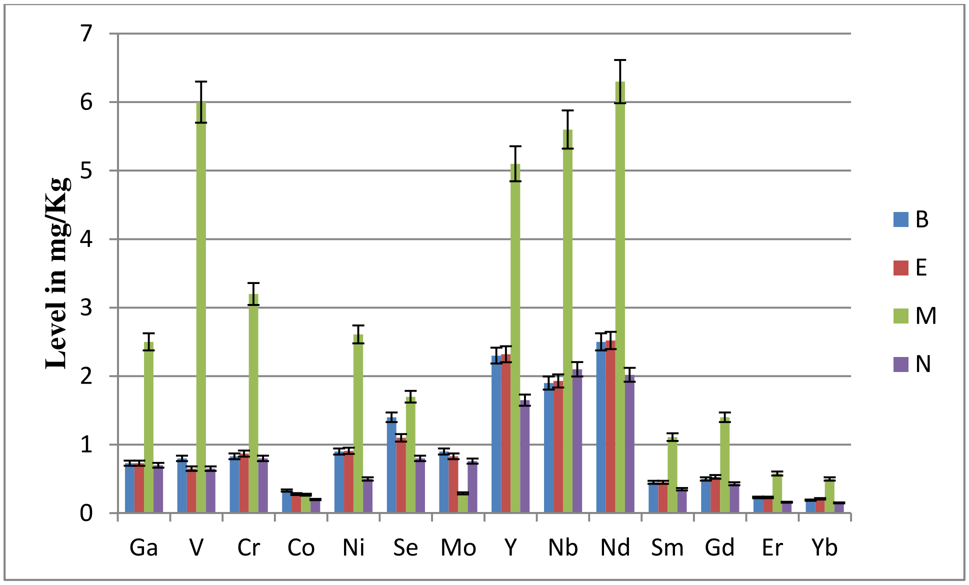


Figure 17b: Total trace element levels in *Clerodendrum myricoides*

Clerodendrum myricoides contains high levels of iron of 1150, 1160, 470 and 990 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Clerodendrum myricoides* had vanadium levels of 0.9, 0.81, 6.0 and 0.8 mg/kg, chromium levels of 0.92, 0.94, 3.2 and 0.91 mg/kg, selenium levels of 1.24, 1.0, 1.8 and 0.8 mg/kg, yttrium levels of 2.2, 2.2, 5.1 and 1.62 mg/kg, niobium levels of 1.85, 1.90, 5.7and 2.1 mg/kg and neodymium levels of 2.5, 2.5, 6.3 and 2.0 mg/Kg respectively from Borabu, Ekerenyo, Manga and Nyamira. Other elements which were in high concentration were Mo, Sm, Gd, Ga and Ni as shown in figure 21 above. *Clerodendrum myricoides* may be used in the management of malaria and diabetes due to the presence of high levels of iron and chromium in it. Total nickel content reported here is comparable to that reported by Anna *et al*. (2013) of 3.03 to 8.84 mg/kg in the Brazilian teas. Nickel plays an essential role in the production of insulin in human bodies and hence is essential in the management of diabetes (Onianwa *et al.,* 2000; Khan *et al*., 2013).

Concentration of trace elements *Carissa edulis* (root bark)

The total mean levels of the trace elements in *Carissa edulis root bark* are presented in figures 18a and 18b.

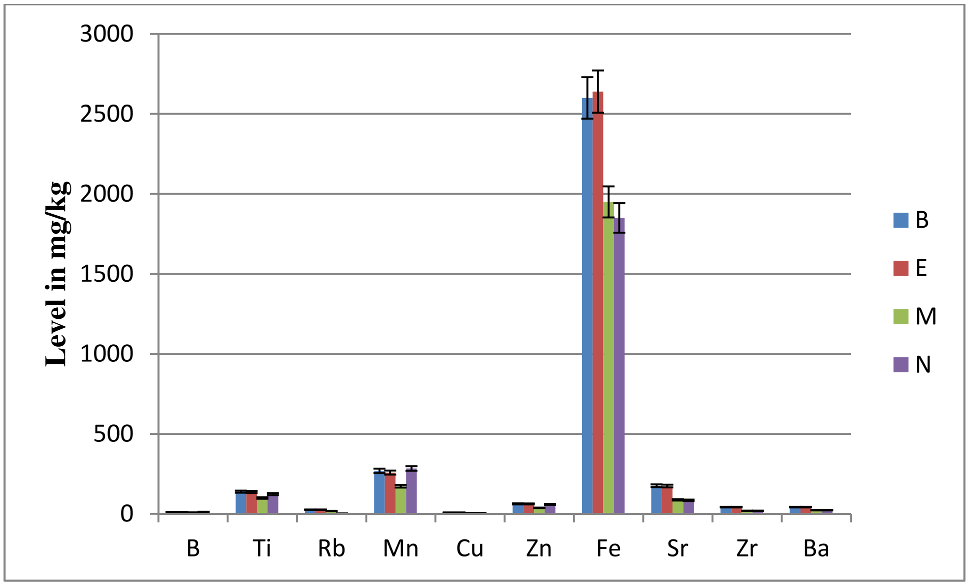


Figure 18a: Total trace element levels in *Carissa edulis*

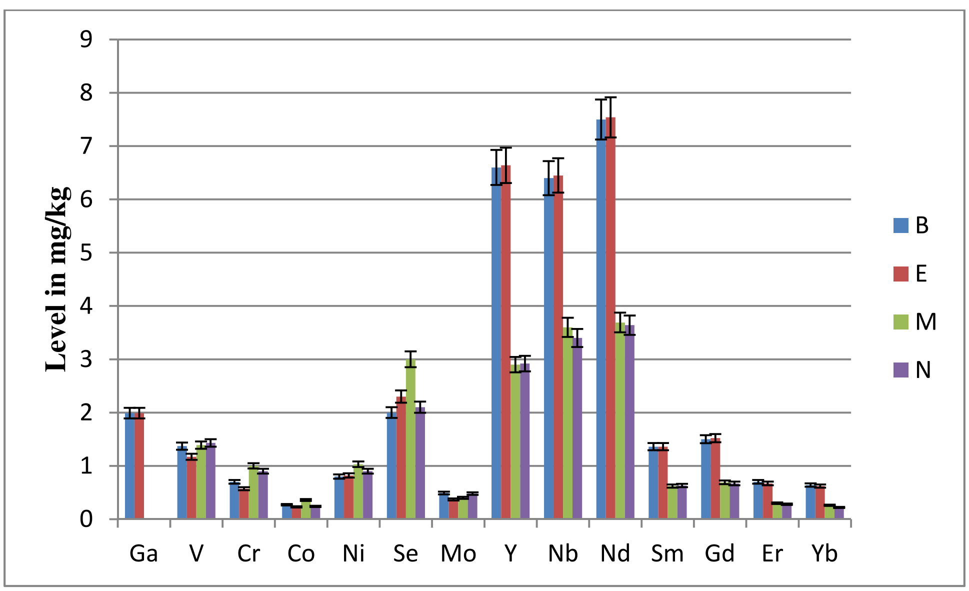


Figure 18b: Total trace element levels in *Carissa edulis*

Carissa edulis had high iron concentration of 2600, 2640, 1950 and 1850 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Carissa edulis* had vanadium levels of 1.41, 1.1, 1.42 and 1.43 mg/kg, selenium levels of 2.0,3.0, 3.0 and 2.1 mg/kg, yttrium levels of 6.6, 6.64, 2.9 and 2.9 mg/kg, niobium levels of 6.4, 6.45, 3.4 and 3.41 mg/Kg, samarium levels of 1.36, 1.36, 0.54 and 0.55 mg/kg, gadolinium levels of 1.5, 1.52, 0.8 and 0.81 mg/Kg and neodymium levels of 7.5, 7.54, 3.72 and 3.7 mg/kg respectively from Borabu, Ekerenyo, Manga and Nyamira. The other elements which were in high concentration in *Carissa edulis* were Ga, Cr, Ni, Er and Yb as shown in figure 22 a&b above. *Carissa edulis* may be used in the management of malaria due its high iron content. It may also be used in the management of diabetes due high vanadium and chromium content in it.

Concentration of trace elements in *Tabernaemontana stapfiana leaves*

The total mean levels of the trace elements in *Tabernaemontana stapfiana leaves* are presented in figure 19a and figure 19b.

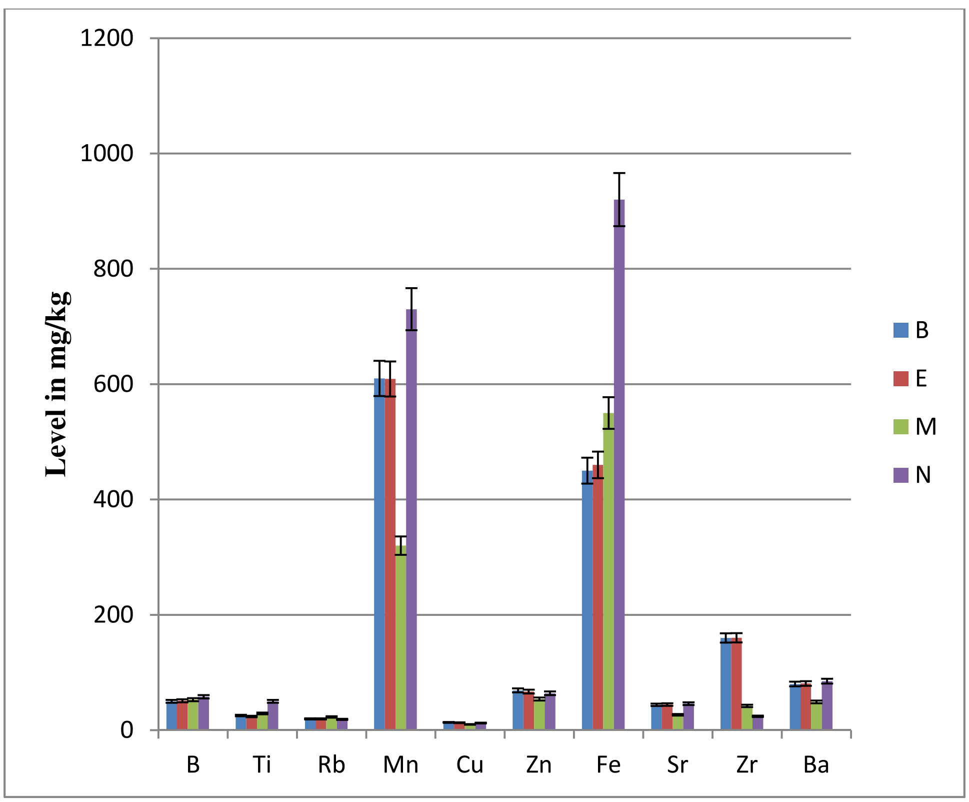


Figure 19a*: Total trace element levels in *Tabernaemontana stapfiana*

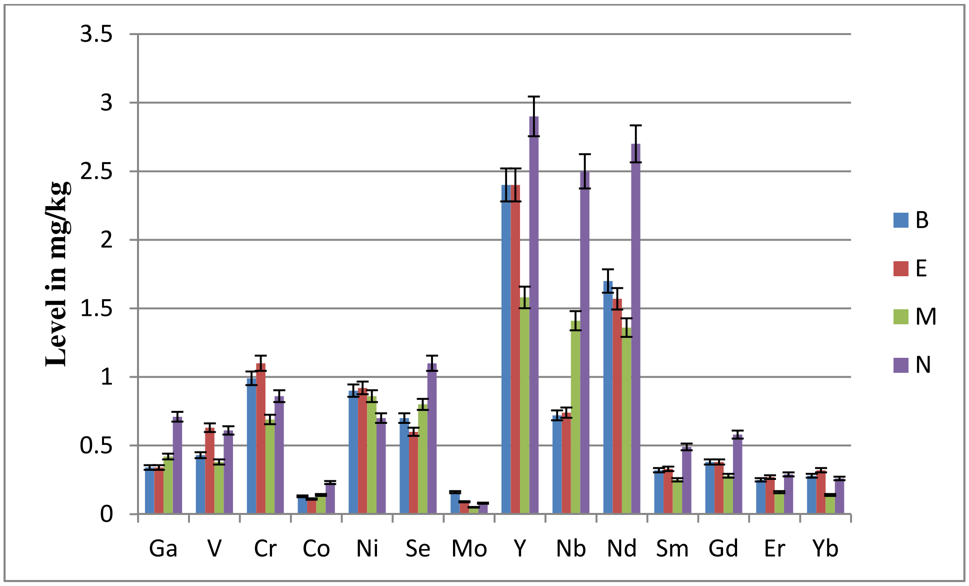


Figure 19b: Total trace element levels in *Tabernaemontana stapfiana*

Tabernaemontana stapfiana had high iron levels of 450, 460, 550 and 920 mg/kg from Borabu, Ekerenyo, Manga and Nyamira respectively. *Tabernaemontana stapfiana* had boron levels of 49, 51, 59 and 63 mg/kg and zirconium levels of 160, 160, 50 and 43 mg/kg respectively from Borabu, Ekerenyo, Manga and Nyamira. Other elements which were in high concentration in the plant are Mn, Cr, Ni, Se, Y, Nb and Nd as shown in figure 23 a&b above. *Tabernaemontana stapfiana* may be used in the management of malaria due its high iron level. Due to the high levels of chromium and manganese the medicinal plant may be used to manage diabetes.

Concentration of trace elements in *Aloe vera*

The total mean levels of the trace elements in *Aloe vera leaves* are presented in figures 20a and 20b.

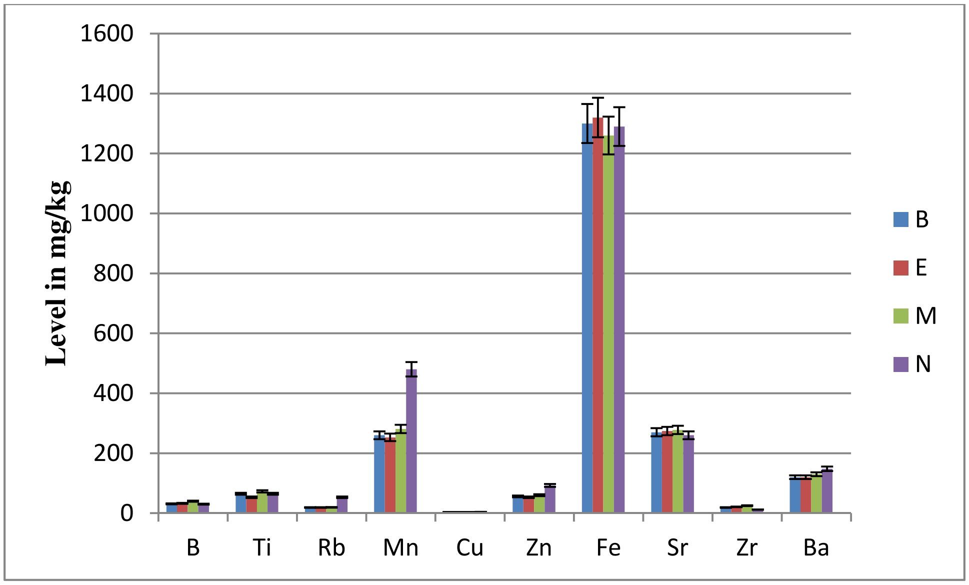


Figure 20a: Total trace element concentration levels in *Aloe vera*

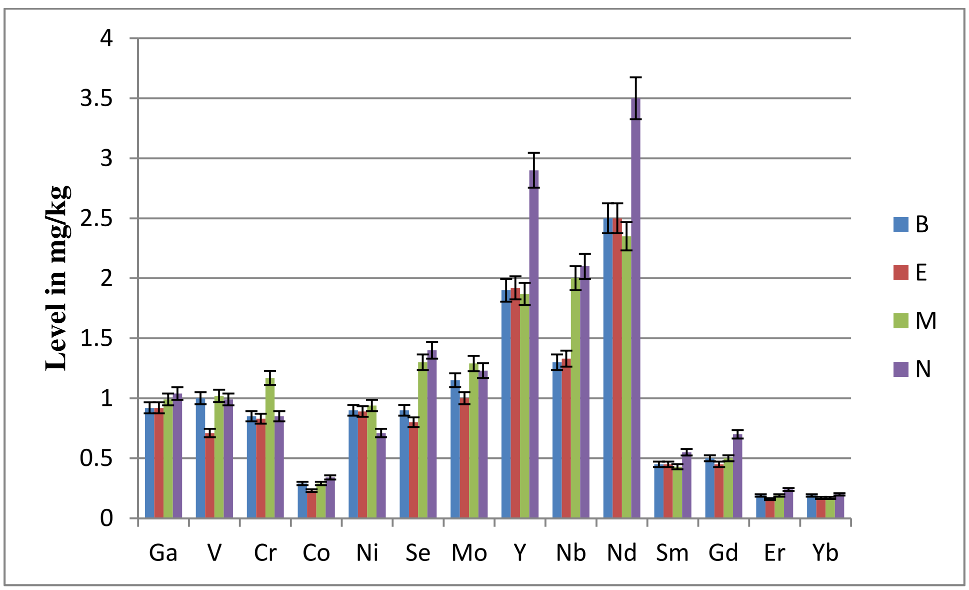


Figure 20b: Total trace element concentration levels in *Aloe vera*

Aloe vera had highest strontium levels of 270,274,278 and 260 mg/kg and barium levels of 120,120, 130 and 148 mg/kg among the nineteen medicinal plants from Borabu, Ekerenyo, Manga and Nyamira respectively. *Aloe vera* had iron levels of 1300, 1320, 1260 and 1290 mg/kg, molybdenum levels of 1.15,1, 1.29 and 1.23 mg/kg, zinc levels of 56, 53, 60 and 92.6

mg/Kg respectively from Borabu, Ekerenyo, Manga and Nyamira. Other elements which were in high amounts were Mn, Ga, V, Ni, Cr, Se, Nb, Y and Nd as shown in figures 24a and 24b above. *Aloe vera* may be used in the treatment of malaria and anemia due its high iron content. It may also be used in the management of diabetes as it contains high levels of manganese, vanadium and chromium. The results obtained here on the total content of strontium in medicinal plants are higher than those reported elsewhere by Anna *et al*. (2013) of 31.6-55.4 mg/Kg among the Brazilian teas while similar to those reported by Raju et al. (2013) in the Indian medicinal plants.

Arsenic, Cadmium, Mercury, Thallium and Lead

Arsenic levels ranged from <0.001 to 0.02±0.01 mg/Kg, cadmium from <0.002 to 0.03±0.01 mg/Kg, thallium from <0.001 to 0.03, mercury from <0.001 to 0.02 mg/Kg and lead from <0.003 to 1.02±0.08 mg/Kg in the medicinal plants in all the Sub Counties. Arsenic, cadmium, thallium, mercury and lead levels in the medicinal plants were low. Results of the levels of toxic elements are similar to those of Korfali *et al.* (2013) and Manzoor & Manmood (2011) which reported the levels of Pb (1.1-10.3 μg/g) > Cd (nd-1.7) in medicinal herbs of Lebanon and Pakistan respectively. This means that the curative activity of the medicinal plants may be brought about by the immunological activity of the trace element in them. The natural products in the medicinal plants bring about the inhibitory effects on the pathogens as the essential elements enhance the recovery.

The total levels of the most trace elements in the medicinal plants were statistically different from one another (Appendix XXII-XXV) while that of the elements between the Sub Counties were not statistically different from each other (Appendix XXXII-XXXV) (P<0.05).

Chromium, manganese, zinc and copper bioavailability in *Solanum mauense , Bidens pilosa, Carissa edulis, Ultrica dioica, Plectranthus barbatus, Aloe vera, Croton macrostachyus,* *Clerodendrum myricoides, Warburgia ungandensis ,Erithyrina abyssinica, Vernonia auriculifera* and *Magnifera indica* which were medicinal plants used in the management of diabetes and that of iron in *Melia azedarach, Toddalia asiatica, Croton macrostachyus, Clerodendrum myricoides, Aloe vera, Tabernaemontana stapfiana, Acacia hockii, acacia abyssinica, Senna didymobotrya* and *Warburgia ungandensis* the medicinal plants used in the management of malaria from Nyamira County *were* determined and presented in section 4.5.

4.2.4 Correlation Coefficient r and t- test of Trace Elements

The correlation coefficient, r and t- test for the comparision of some elements in four Sub Counties are presented in Table 4. 9

Table 4.9: Correlation coefficient, r and t- test for the comparison of the various elements in the Sub Counties.

element	Borabu/Nyamira		Nyamira/ Ekerenyo		Borabu/Ekerenyo		Borabu/Manga		Ekerenyo/Manga		Manga /Nyamira	
	R	t-test	R	t-test	R	t-test	R	t-test	R	t-test	R	t-test
B	0.743	0.919	0.779	0.565	0.987	0.493	0.823	0.905	0.812	0.964	0.817	0.913
Ti	0.425	0.876	0.431	0.766	0.998	0.874	0.546	0.843	0.512	0.945	0.612	0.787
V	0.523	0.952	0.425	0.748	0.985	0.766	0.724	0.854	0.523	0.937	0.679	0.827
Cr	0.693	0.487	0.703	0.442	0.987	0.916	0.843	0.542	0.482	0.964	0.861	0.497
Fe	0.506	0.889	0.502	0.861	0.999	0.969	0.674	0.776	0.784	0.986	0.682	0.594
Mn	0.932	0.775	0.938	0.839	0.999	0.932	0.892	0.721	0.843	0.994	0.879	0.706
Co	0.482	0.945	0.435	0.721	0.988	0.758	0.543	0.864	0.784	0.964	0.497	0.789
Ni	0.459	0.803	0.478	0.807	0.999	0.955	0.492	0.742		0.889	0.547	0.674
Cu	0.858	0.898	0.823	0.973	0.981	0.853	0.867	0.823	0.812	0.968	0.845	0.803
Zn	0.844	0.869	0.838	0.811	0.998	0.945	0.894	0.812	0.956	0.899	0.874	0.764
Se	0.894	0.583	0.898	0.659	0.997	0.928	0.854	0.623	0.804	0.993	0.868	0.842
Mo	0.853	0.644	0.843	0.542	0.996	0.855	0.832	0.643	0.564	0.983	0.816	0.596

When the levels of trace elements in *Solanum mauense, Bidens pilosa, Ultrica dioica, Plectranthus barbatus, Aloe vera, Croton macrostachyus, Vernonia auriculifera, Magnifera* *indica, Melia azedarach, Tabernaemontana stapfiana* and *Senna didymobotrya* in which the leaves are used for theurapeutic action from four Sub Counties were compared the differences were found not to be statistically different (df =18, t= 2.878) (Appendix XXXXIII). Levels of the elements in the Sub Counties had positive correlations ranging from 0.459 to 0.999 which close to one which is the expected value. The consumption these medicinal plants from any one of the Sub County will have similar theurapeutic effect.

4.2.5 Comparison of the Concentration Levels of Trace Elements in the Medicinal Plants

The binomial analysis of the levels of the twelve trace elements which have been reported to have theurapeutic effect in the human body in the eleven medicinal plants used in section 4.2.2.1 was done and the results are given in Tables 4.10-4.13.

Table 4.10: t-test values for comparison of the trace element in medicinal plants from Borabu.

	B	Ti	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Se	Mo
B	1											
Ti	-3.097*	1				.		.				
V	8.001*	4.656*	1				.					
Cr	8.071*	4.636*	1.012	1					.			
Fe	-4.479*	-4.546*	-4.554*	-4.553*	1							
Mn	-4.122*	-3.476*	-4.320*	-4.321*	3.336*	1						
Co	8.175*	4.658*	4.790*	5.846*	4.554*	4.326*	1					
Ni	8.032*	4.638*	-.343	-.984	4.553*	4.323*	-4.849*	1				
Cu	5.954*	4.207*	-9.766*	-9.781*	4.532*	4.251*	-10.418*	-10.638*	1			
Zn	-2.620	2.481	-6.339*	-6.334*	4.480*	3.899*	-6.358*	-6.289*	-5.397*	1		
Se	7.527*	4.558*	-1.285	-1.473	4.549*	4.309*	-2.574	-1.223	6.876*	6.108*	1	
Mo	7.966*	4.617*	.858	.439	4.552*	4.320*	-2.576	1.081	9.867*	6.284*	1.705	1

* Correlation significant at 0.05 level (2-tailed).

Correlations of boron with the other trace elements which have been reported to have theurapeutic effect were found to be significant with other elements except with zinc. The levels of titanium were found to be statistically different with other elements except with zinc. The levels of vanadium were found to be statistically significant with iron, manganese, cobalt, copper and zinc. The differences in levels of chromium were found to not be statistically significant with nickel, selenium and molybdenum. The differences in the levels of iron were found to be statistically different from all the elements. The differences in the levels of manganese were found to be statistically different with all other elements. The differences in the levels of cobalt were found not to be statistically different except with selenium and molybdenum. The levels of nickel were found to be statistically different with copper and zinc. The differences in the levels of copper and zinc were found to be statistically different from other elements in Borabu Sub County ($p<0.01$ df = 18).

Table 4.11: t-test values for comparison of the trace elements in medicinal plants from Ekerenyo.

	B	**Ti**	**V**	**Cr**	**Fe**	**Mn**	**Co**	**Ni**	**Cu**	**Zn**	**Se**	**Mo**
B	1											
Ti	-3.050*	1										
V	6.872*	4.418*	1									
Cr	6.916*	4.398*	.092	1								
Fe	-4.493*	-4.561*	-4.558*	-4.557*	1							
Mn	-4.159	-3.527*	-4.321*	-4.321*	3.318*	1						
Co	7.017*	4.424*	4.927*	5.437*	4.558*	4.327*	1					
Ni	6.873*	4.403*	-.908	-.732	4.557*	4.323*	-4.874*	1				
Cu	4.765*	3.969*	-9.609*	-9.514*	4.535*	4.254*	-10.288*	-10.471*	1			
Zn	-3.236*	2.259	-6.447*	-6.453*	4.484*	3.912*	-6.474*	-6.416*	-5.462*	1		
Se	6.459*	4.331*	-1.341	-1.322	4.554*	4.310*	-2.541	-1.147	6.904*	6.237*	1	
Mo	6.840*	4.383*	.724	.683	4.556*	4.321*	-2.390	1.176	9.851*	6.398*	1.674	1

* Correlation significant at 0.5 level (2-tailed).

Correlations of boron with the other essential elements were found to be significant from the other elements. The levels of titanium were found to be statistically different from other elements except with zinc. The levels of vandiunm were found to be statistically significant from iron, manganese, cobalt, copper and zinc. The differences in levels with chromium were found to be statistically significant from iron, cobalt and copper.The differences in the levels of iron were found to be statistically different from all elements. The differences in the levels of manganese was found to be statistically different from all elements .The differences in the levels of cobalt were found to be statistically different from all elements except with selenium and molybdenum. The levels of nickel were found to be statistically different from copper and zinc. The differences in the levels of copper and zinc were found to be statistically different in Ekerenyo Sub County ($p<0.01$, df= 18).

Table 4.12: t-test values for comparison of the trace elements in medicinal plants from Manga.

	B	Ti	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Se	Mo
B	1											
Ti	-2.304	1										
V	7.435*	3.843*	1									
Cr	6.302*	4.878*	2.301	1								
Fe	-4.624*	-5.957*	-4.328*	-4.738*	1							
Mn	-4.284*	-3.114*	-4.118*	-3.922*	3.216*	1						
Co	8.563*	4.189*	4.328*	3.476*	3. 898*	3.784*	1					
Ni	7.289*	4. 286*	0.376	-1.835	3.698*	3.473*	-5.868*	1				
Cu	5. 752*	3. 363*	-7.847*	-7.489*	3.947*	3.782*	-8.389*	-7.317*	1			
Zn	-3.294*	2.120	-7.353*	-7.145*	3.899*	3.421*	-7.371*	-6.573*	-6.283*	1		
Se	7.943*	3.876*	-1.245	-2.537	3.874*	3.747*	-4.641*	-1.579	6.423*	6.678*	1	
Mo	7.573*	3.847*	0.347	-0.899	3.987*	3.687*	-2.320	0.045	7.893*	7.432*	1.128	1

* Correlation significant at 0.05 level (2-tailed).

Correlations of most elements in Manga were found to significant to each other except boron with titanium , titanium with zinc, vanadium with chromium,nickel selenium and molybdenum, cobalt with molybdenum, nickel with selenium and molybdenum and selenium with molybdenum. The elements which were not stastically different from each other were obtained from the same source by the medicinal plants.

Table 4.13: t-test values for comparison of the trace elements in medicinal plants from Nyamira.

	B	Ti	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Se	Mo
B	1											
Ti	-2.704	1										
V	7.535*	3.983*	1									
Cr	7.702*	3.978*	2.701	1								
Fe	-3.924*	-3.987*	-3.988*	-3.988*	1							
Mn	-3.564*	-2.944*	-3.798*	-3.802*	3.126*	1						
Co	7.763*	3.981*	3.658*	3.986*	3.988*	3.804*	1					
Ni	8.238*	3.826*	0.276	-2.035	3.866*	3.469*	-5.805*	1				
Cu	5.570*	3.633*	-7.587*	-7.894*	3.970*	3.728*	-8.069*	-7.513*	1			
Zn	-3.191*	2.144	-7.208*	-7.213*	3.911*	3.358*	-7.211*	-6.678*	-6.287*	1		
Se	7.509*	3.921*	-1.218	-2.566	3.985*	3.794*	-4.350*	-1.593	6.579*	6.996*	1	
Mo	7.623*	3.953*	0.348	-0.779	3.986*	3.796*	-2.660	0.075	7.866*	7.185*	1.396	1

* Correlation significant at 0.05 level (2-tailed).

Correlations of boron with the other trace elements were found to be significant with other elements except with titanium. The levels of titanium were found to be statistically different from other elements except zinc. The levels of vanadium were found to be statistically significant from iron, manganese, copper and zinc. The differences in levels of chromium were found to be statistically significant from iron, manganese, cobalt, copper and zinc. Manganese and iron were found to be statistically different from all the other elements. The differences in the levels of cobalt with other elements were found to be statistically different except from molybdenum. The levels of nickel were found to be statistically different from copper and zinc. The differences in the levels of copper and zinc with other elements were found to be statistically different while selenium was not statistically different from other elements except cobalt in Nyamira Sub County ($p<0.01$, $df=18$). The t-test used to predict the sources of trace elements to the medicinal plants. The trace elements which were statistically significant from each other had different sources from which the medicinal plants obtained them from while those which were not statistically significant had a common source.

4.2.6 Interaction Trace Elements

Interaction of the trace elements in the Sub County plants were determined and given in Tables 4.14-4.17.

Table 4.14: Correlations coefficient (r) between trace elements in medicinal plants from Borabu.

	B	**Ti**	**V**	**Cr**	**Fe**	**Mn**	**Co**	**Ni**	**Cu**	**Zn**	**Se**
Ti	094										
V	.168	.970		.							
Cr	.303	.733	.837								
Fe	.093	.988	.988	.79							
Mn	.574	.104	.157	.112	.089						
Co	.190	.927	.978	.836	.954	.132					
Ni	.264	.758	.780	.560	.740	.505	.799				
Cu	.365	.279	.309	.274	.277	.389	.339	.617			
Zn	.402	.515	.630	.732	.590	.153	.613	.445	.519		
Se	-.033	.045	.038	-.117	.054	-.057	.117	.063	.016	.060	
Mo	-.045	.045	.121	-.007	.129	-.087	.163	.141	.243	.233	.084

The concentration levels of the trace elements in the eleven medicinal plants whose leaves are used for theurapeutic action from Borabu positively correlated to each other except selenium which had an inverse correlation with most elements. This means that the amount of selenium was influenced by the amount of other elements in the plants.

Table 4.15: Correlations coefficient (r) between trace elements in medicinal plants from Ekerenyo.

	B	Ti	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Se
Ti	.090										
V	.194	.965									
Cr	.342	.665	.753								
Fe	.096	.982	.983	.736							
Mn	.567	.101	.134	.117	.064						
Co	.147	.915	.963	.776	.952	.099					
Ni	.272	.765	.790	.551	.746	.487	.796				
Cu	.302	.212	.233	.180	.171	.415	.206	.574			
Zn	.458	.519	.578	.723	.593	.168	.565	.494	.453		
Se	-.013	.069	.038	-.136	.068	-.048	.102	.067	.025	.082	
Mo	-.029	.519	.092	-.082	.099	-.085	.111		.123	.191	.061

Medicinal plant trace elements eleven medicinal plants whose leaves are used for theurapeutic action from Ekerenyo had a positive correlation except selenium and molybdenum which was negatively correlated with boron, chromium and manganese. These mean that the amount of selenium and molybdenum were influenced by the levels of boron, chromium and manganese in the medicinal plants.

Table 4.16: Correlations coefficient (r) between trace elements in medicinal plants from Manga.

	B	Ti	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Se
Ti	.084										
V	.163	.870		.							
Cr	.203	.673	.917								
Fe	.071	.953	.638	.831							
Mn	.494	.214	.133	.127	.043						
Co	.187	.867	.798	.696	.874	.242					
Ni	.334	.698	.870	.590	.630	.395	.731				
Cu	.331	.221	.343	.219	.237	.429	.352	.437			
Zn	.433	.534	.657	.728	.587	.187	.573	.385	.489		
Se	-.027	.125	.064	-.107	.053	-.037	.121	.067	.026	.049	
Mo	-.042	.043	.134	-.012	.133	-.078	.161	.161	.183	.252	.078

The trace element concentrations in the eleven medicinal plants whose leaves are used for theurapeutic action from Manga had a positively correlation to each other except selenium and molybdenum which had an inverse correlation with boron, chromium and manganese. This means that the amount of selenium and molybdenum in the plants were influenced by the amount of boron, chromium and manganese in the plants.

Table 4.17: Correlations coefficient (r) between the trace elements in medicinal plants from Nyamira.

	B	Ti	V	Cr	Fe	Mn	Co	Ni	Cu	Zn	Se
Ti	-.002										
V	.031	.992									
Cr	.205	.949	.966								
Fe	.014	.997	.994	.953							
Mn	.274	.139	.200	.329	.152						
Co	.071	.966	.963	.936	.953	.180					
Ni	.119	.613	.663	.685	.618	.674	.654				
Cu	.295	.313	.324	.384	.309	.233	.338	.681			
Zn	.400	.551	.543	.613	.551	.116	.588	.387	.494		
Se	.196	.165	.187	.213	.205	.241	.165	.148	-.010	.092	
Mo	.129	.340	.332	.291	.332	.207	.389	.342	.413	.457	-.068

The amounts of the trace element in eleven medicinal plants whose leaves are used for theurapeutic action from Nyamira Sub County positively correlated with each other except selenium which correlated negatively with molybdenum. This means that the level of molybdenum was influenced by the levels of selenium while those of selenium were influenced by those of molybdenum and copper in the plant. These results are similar to those reported by Konieczynski *et al.* (2007) of iron levels in medicinal plants from Poland which positively correlated to that of Cu, Cr, and Mn in the plants and negatively with Ca and Sr.

The elements which showed strong positive correlation between them (high positive value) had a similarity in the sources while those which revealed a negative correlation was a reflection of uncommon sources in each Sub County.

4.3 Bioavailablity of Trace Elements in Medicinal Plants

Exchangeable (easily bioavailable fraction, EBF) reducible and oxidizable (potentially bioavailable fraction, PBF) and residual fractions of iron, chromium, manganese, zinc and copper were determined in triplicates in anti malarial (*Melia azedarach, Toddalia asiatica, Croton macrostachyus, Clerodendrum myricoides, Aloe vera, Tabernaemontana stapfiana, Acacia hockii, acacia abyssinica, Senna didymobotrya* and *Warburgia ungandensis*) and anti diabetic (*Solanum mauense , Bidens pilosa, Carissa edulis, Ultrica dioica, Plectranthus barbatus, Aloe vera, Croton macrostachyus, Clerodendrum myricoides, Warburgia ungandensis ,Erithyrina abyssinica, Vernonia auriculifera* and *Magnifera indica*) plants respectivelyThe bioavailable (EBF+PBF) mass of each element in the 2 g of the medicinal plant and the mass of the medicinal plant required to provide the recommended daily intake (RDI) of each element were calculated for male (m) and female adults (f) in grammes are presented in Tables 4.17 and 4.18.

Bioavailability of Iron in Medicinal Plants

The various forms of iron extracted sequentially, the bioavailable forms, the daily intake and the mass required to provide required daily intake (RDI) for the male (m) and female (f) adults are given in the Table 4.18.

Table 4.18: Species of iron in medicinal plants used to treat malaria.

Medicinal Plant	Exchangeable	Reducible	Oxidizable	Residual	Sum of the fraction	Bioavailable	Daily intake	Mass to provide RDI	EBF %	PBF %
Tabernaemontana stapfiana	2.027±0.46	5.2753±1.5	3.75±0.41	561.6387±4.5	572.691	11.053	0.088	45.46	0.35	1.58
Acacia abyssinica	1.145±0.24	5.659±2.4	3.098±1.1	500.499±3.2	510.401	9.902	0.053	232.2	0.22	1.72
Acacia hockii	0.781±0.34	2.709±0.1	0.982±0.1	234.653±4.1	239.125	4.472	0.036	425	0.33	1.54
Melia azedarach	8.611±1.3	47.934±6.5	10.909±3.8	3099.414±8.4	3166.868	67.454	0.54	25.63	0.27	1.86
Senna didymobotrya	1.635±0.1	6.041±1.3	1.983±0.2	480.654±3.5	490.313	9.659	0.078	49.63	0.33	1.64
Warburgia ungandensis	0.775±0.03	4.334±1.4	1.976±0.4	363.836±4.1	370.921	7.085	0.056	285	0.21	1.7
Croton macrostachyus	3.529±1.21	16.195±3.6	6.974±1.2	1301..557±5.5	1328.255	26.698	0.214	74.75	0.27	1.74
Clerodendrum myricoides	2.710±0.35	15.916±2.3	5.506±1.4	1120.634±9.2	1145.14	24.506	0.1896	84.4	0.24	1.87
Aloe vera	3.495±1.83	15.395±2.2	5.232±1.4	1265.818±8.1	1289.94	24.122	0.192	83.33	0.27	1.6
Toddalia asiatica	4.157±1.21	24.835±2.2	8.481±4.3	1705.514±44	1742.987	37.473	0.276	57.98	0.24	1.91

An individual takes two tea spoons of the medicinal plant in a glass of water in the morning and in the evening. The patients are given about 2 g of medicinal plants daily which supplies 0.54 mg of iron in case of *Melia azedarach* and 0.036 mg of iron when *Acacia hocki* is taken. These means to supply iron within the recommended levels for adult males and females should take 25.63 g of *Melia azedarach* and 42.5g of *Acacia hockii.* The medicinal plants supply different amounts of iron to the body as shown in Table 4.18. The exchangeable, reducible and the oxidisable forms of iron constitute the bioavailable species of iron to the consumer of the medicinal plant.

The residual species were more than reducible species which were more than the oxidizable species while the exchangeable species of iron were low in medicinal plants. The four medicinal plants with high levels of iron easily bioavailable fraction (EBF) were *Melia azedarach, Toddalia asiatica, Croton macrostachyus* and *Aloe vera* with 8.611, 4.157, 3.529 and 3.495 mg/kg respectively. When these plants are taken the above levels of iron is easily availed for absorption into the body. The four medicinal plants with high potentially bioavailable fraction (PBF) of iron were *Melia azedarach, Toddalia asiatica, Croton macrostachyus and Clerodendrum myricoides* with 58.843, 33.316, 23.169 and 21.422 mg/kg respectively. These amounts of iron may be availed to the human body provided the metabolism of the medicinal plants in the human body have similar reduction or oxidation strength (conditions) as those applied in the sequential extraction. The information on the species of the metal in the medicinal plant is essential in order to explain its importance in man. Iron bioavavailable fractions compared well with those reported by Omolo *et al*. (1997) in Kenya but were higher than those reported by Majolagbe et al. (2013) in Nigerian medicinal plants. Bioavailable fractions depended on the extraction solvent, plant part used and the species of the plant (Li &Deng (2004). Koniecynski *et al.* (2007) revealed that +2 oxidation state of iron extracted by water can be a source of bioavailable form of iron for human beings.

The trends in decreasing order of various fractions of iron are residual > reducible > oxidizable > exchangeable species in the medicinal plants. Large iron fractions are strongly bound to plant tissues. Effectiveness of various medicinal plants under similar conditions in blood-building and hence management of malaria and anemia based on the bioavailable fractions of iron is *Melia azedarach > Toddalia asiatica > Croton macrostachyus > Clerodendrum myricoides > Aloe vera > Bidens pilosa >Tabernaemontana stapfiana > Acacia abyssinica > Senna didymobotrya > Warburgia ungandensis > Acacia hockii.* The four medicinal plants with high bioavailable levels of iron were *Melia azedarach, Toddalia asiatica, Croton macrostachyus and Aloe vera.*

Bioavailibilty of chromium, manganganese, zinc and copper

The mass of the fractional species of chromium, manganese, zinc and copper elements which have been shown to regulate blood sugar in the anti diabetic medicicinal plants from Nyamira County were sequentially determined, their daily intake and the mass of the plant required to provide RDI determined are given in Table 4.19.

Table 4.19: Species of Cr, Mn, Zn and Cu in medicinal plants used to treat diabetes.

Medicinal Plant	Trace element	Exchangeable(mg/kg)	Reducible (mg/kg)	Oxidizable (mg/kg)	Residual (mg/kg)	Sum of the fraction (mg/kg)	Bioavailable(mg/kg)	Daily intake(mg/kg) Cr in µg	Mass to provide RDI(g)	EBF %	PBF %
Warburgia ugandensis	Cr	0.018±0.010	0.066±0.020	0.036±0.01	0.053±0.01	0.173	0.120	0.96	72.8m 52.08f	10.4	59.0
	Mn	12.492±1.300	52.055±3.210	18.803±1.310	70.348±3.100	153.698	83.350	0.6668	16.5m 15f	8.1	46.1
	Zn	0.196±0.03	1.734±0.23	0.495±0.03	5.609±0.8	8.034	2.425	0.0194	140m 82.5f	2.4	27.8
	Cu	0.176±0.020	1.833±0.700	0.527±0.030	1.911±0.300	4.447	2.536	0.02028	231.6m 163.5f	4	53.1
Vernonia auriculifera	Cr	0.019±0.010	0.072±0.010	0.042±0.02	0.064±0.010	0.197	0.133	1.04	67.3m 48.08f	9.6	57.9
	Mn	12.612±2.100	54.495±6.100	17.722±1.200	82.652±4.100	167.481	84.829	0.6786	16.2m 14.7f	7.5	43.1
	Zn	1.511±0.31	9.142±1.01	1.708±0.11	34.759±1.33	47.12	12.361	0.09888	27.2 m 16.18f	3.2	23.0
	Cu	0.454±0.010	3.926 ±1.100	1.638±0.090	4.995±0.400	11.013	6.018	0.04814	70.6m 49.9f	4.1	50.5
Carissa edulis	Cr	0.091±0.020	0.485±0.021	0.214±0.080	0.464±.01	1.254	0.790	6.32	11.1m 7.9f	7.3	55.7
	Mn	20.207±4.000	65.777±1.600	36.151±1.800	194.656±4.900	269.555	122.135	0.977	11.3m 10.2f	7.5	37.8
	Zn	3.529±1.020	18.309±2.210	6.082±1.020	31.447±2.310	59.367	27.920	0.22336	12.53m 7.16f	5.9	41.1
	Cu	0.893±0.010	1.982 ±0.410	1.093±0.200	3.473±0.500	7.441	3.968	0.03174	107.1m 75.6f	12.0	41.3

Table 4.19: Continued.

Medicinal Plant	Trace element	Exchangeable(mg/kg)	Reducible (mg/kg)	Oxidizable (mg/kg)	Residual (mg/kg)	Sum of the fraction (mg/kg)	Bioavailable(mg/kg)	Daily intake(mg/kg) Cr in µg	Mass to provide RDI(g)	EBF %	PBF %
Solanum indicum	Cr	0.092±0.01	0.324±0.04	0.124±0.06	0.213±0.03	0.753	0.54	4.3	13.4m 10.2f	12.2	59.0
	Mn	18.453±3.981	76.866±4.87	41.794±5.23	187.217±6.87	324.24	137.023	2.321	4.32m 3.12f	5.7	46.1
	Zn	1.461±0.981	10.673±2.98	3.286±1.02	20.183	35.6	15.42	0.1842	15.24m 13.61f	4.1	27.8
	Cu	0.464±0.02	4.134±0.41	2.514±0.56	4.012±1.02	11.124	7.112	0.0496	68.2m 45.4f	4.2	53.1
Ultrica dioica	Cr	0.098±0.010	0.442±0.010	0.245±0.030	0.305±0.061	1.090	0.785	6.28	11.2m 7.95f	8.99	57.9
	Mn	23.020±1.800	78.21±2.100	40.907±1.200	102.631±5.200	244.768	142.137	1.1372	9.7m 8.8f	9.4	43.1
	Zn	3.713±1.210	11.289±1.230	6.047±1.200	21.100±1.100	42.149	21.049	0.1684	14.63m 9.5f	8.8	23.0
	Cu	0.829±0.020	2.587±0.300	1.341±0.060	3.314±0.200	8.071	4.757	0.03806	89.3m 63.1f	10.3	50.5
Croton macrostachyus	Cr	0.078±0.010	0.382±0.031	0.103±0.030	0.257±0.08	0.820	0.563	4.5	15.6m 11.1f	9.5	59.5
	Mn	93.854±18.400	492.861±23.400	158.916±14.00	879.899±10.300	1625.530	745. 631	5.965	1.85m 1.7f	5.8	36.6
	Zn	1.181±0.040	5.919±1.410	3.812±1.040	18.854±1.200	29.766	10.912	0.0873	32.5m 18.33f	4.0	39.2
	Cu	0.660±0.020	2.091±0.200	1.009±0.030	3.372±1.400	7.132	3.760	0.03008	113.02m 79.8f	9.3	59.8

Table 4.19: Continued.

Medicinal Plant	Trace element	Exchangeable(mg/kg)	Reducible (mg/kg)	Oxidizable (mg/kg)	Residual (mg/kg)	Sum of the fraction (mg/kg)	Bioavailable(mg/kg)	Daily intake(mg/kg) Cr in µg	Mass to provide RDI(g)	EBF %	PBF %
Bidens pilosa	Cr	0.135±0.013	0.752±0.041	0.344±0.005	0.539±0.012	1.770	1.231	9.84	7.1m 5.1f	8.3	67.6
	Mn	50.072±5.420	152.793±12.100	57.180±6.000	218.154±6.400	478.199	260.045	2.0804	5.3m 4.8f	10.6	43.8
	Zn	4.041±1.120	12.709±2.210	7.654±1.240	44.768±2.100	69.172	24.404	0.19524	14.34m 8.198f	5.8	29.4
	Cu	1.194±0.120	4.424±1.040	1.502±0.060	5.028±1.310	12.148	7.120	0.05696	59.7m 42.1f	9.8	48.8
Magnifera indica	Cr	0.078±0.02	0.432±0.04	0.186±0.06	0.231±0.08	0.927	0.696	4.52	11.2m 9.6f	8.4	66.7
	Mn	10.432±2.11	58.323±3.221	26.566±3.12	158.999±5.83	254.32	95.321	0.842	13.3m 11.4f	4.1	33.4
	Zn	2.321±0.96	10.734±3.1	5.155±1.89	25.03	43.24	18.21	0.124	21.86m 20.4f	5.4	36.7
	Cu	0.283±0.06	1.434±0.12	0.625±0.08	1.873±0.24	4.215	2.342	0.0137	241.2m 165.4f	6.7	48.8
Solanum mauense	Cr	0.254±0.021	0.915±0.022	0.581±0.021	0.807±0.03	2.557	1.750	14	4m 3.6f	9.9	58.5
	Mn	16.799±2.400	107.866±18.000	53.643±3.900	213.664±5.700	391.972	178.308	1.4264	7.7m 7f	4.3	41.2
	Zn	4.305±1.080	17.263±1.110	7.749±1.400	67.342±2.700	96.659	29.317	0.23454	11.94m 6.82f	10.2	38.2
	Cu	0.321±0.030	3.062±1.040	1.768±0.400	4.777±1.340	9.928	5.151	0.0412	85.5m 58.2f	3.2	48.7

Table 4.19: Continued.

Medicinal Plant	Trace element	Exchangeable(mg/kg)	Reducible (mg/kg)	Oxidizable (mg/kg)	Residual (mg/kg)	Sum of the fraction (mg/kg)	Bioavailable(mg/kg)	Daily intake (mg/kg) Cr in µg	Mass to provide RDI(g)	EBF %	PBF %
Clerodendrum myricoides	Cr	0.045±0.010	0.276±0.031	0.112±0.010	0.234±0.02	0.667	0.433	3.46	20.2m 14.5f	6.7	58.2
	Mn	9.046±2.300	67.301±12.000	14.839±1.100	128.010±5.200	219.196	91.186	0.7294	15.1m 13.7f	4.1	37.5
	Zn	2.228±0.100	12.143±1.010	5.668±1.080	27.515±1.800	47.554	20.039	0.16032	17.47m 9.98f	4.7	37.5
	Cu	0.399±0.020	2.343±0.300	1.025±0.010	3.085±0.43	6.852	3.767	0.03014	112.8m 79.6f	5.8	49.2
Aloe vera	Cr	0.094±0.020	0.338±0.021	0.144±0.003	0.261±0.02	0.837	0.576	4.6	15.2m 10.9f	11.2	57.6
	Mn	18.755±1.900	98.134±13.200	57.951±1.900	176.104±4.800	350.944	174.840	1.3988	7.9m 7.2f	5.3	44.5
	Zn	3.456±1.040	14.400±1.900	7.880±1.210	40.16±2.030	62.450	25.736	0.20588	13.6m 7.77f	5.5	35.7
	Cu	0.270±0.010	0.959±0.020	0.605±0.020	1.687±0.240	3.521	1.834	0.01468	231.6m 163.5f	7.7	44.4
Plectranthus barbatus	Cr	0.100±0.030	0.363±0.041	0.134±0.040	0.396±.020	0.993	0.597	4.78	14.7m 10.5f	10.1	50.1
	Mn	25.371±1.010	74.147±2.300	36.766±2.100	187.584±5.700	323.868	136.284	1.0902	10.1m 9.2f	7.8	34.2
	Zn	1.271±0.300	9.180±1.410	3.789±1.040	32.617±1.330	46.857	14.240	0.11392	24.58m 14.04f	2.7	27.7
	Cu	0.771±0.020	2.898±0.300	1.082±0.030	6.767±1.810	11.518	4.751	0.038	89.5m 63.1f	6.7	34.6

The residual species were more than reducible fraction which was more than the oxidizable fraction while the exchangeable species of chromium, manganese, zinc and copper were low amounts in each medicinal plant.

Chromium

High percentage amount of chromium were extracted despite its low concentration in the medicinal plants. The highest percentage of 72.06 % was extracted in *Ultrica dioica* and the lowest of 60.08% was extracted in *Plectranthus barbatus.* Most medicinal plants had percentage of extractable form of chromium of between 67- 70%. The four medicinal plants with high easily bioavailable fraction (EBF) of chromium were *Solanum mauense, Bidens pilosa, Plectranthus barbatus and Ultrica dioica* with 0.254, 0.135, 0.100 and 0.098 mg/kg respectively. This amount of chromium is available for intake into the body when the medicinal plants are consumed. The four medicinal plants with high PBF of chromium were *Solanum mauense, Bidens pilosa, Carissa edulis and Ultrica dioica* with 1.496, 1.096, 0.699 and 0.687 mg/kg. The PBF form of chromium may be availed to the body provided the enzymatic processes during uptake and metabolism of the medicinal plants in the human body achieve similar reduction or oxidation conditions as applied in the sequential extraction. The amount of chromium bioavailed from the medicinal plants may be lower than the calculated amount. The patients are given about 2 g of the medicinal plants daily in the concotion which supplies 14 µg of chromium from *Solanum mauense* and 0.96 µg from *Warburgia ungandensis.* To supply chromium within the recommended levels for males they should take 4 g of *Bidens pilosa* and 72.8 g of *Warburgia ungandensis* while the females should take 3.6 g of Bidens pilosa and 52.08 g of *Warburgia ungandensis* daily. The amount of chromium available to the body daily when 2g of the medicinal plants taken twice a day are *Solanum mauense* (14 µg), *Bidens pilosa* (9.84 µg), *Carissa edulis* (6.32 µg), *Ultrica dioica* (6.28 µg), *Plectranthus barbatus* (4.78 µg), *Aloe vera* (4.6 µg), *Magnifera indica* (4.52 µg), *Croton macrostachyus(4.5 µg), Solanum indicum (4.3 µg), Clerodendrum myricoides* (3.46 µg), *Vernonia auriculifera* (1.04 µg) and *Warburgia* *ungandensis* (0.96 µg). Most medicinal plants as administered by herbalists in Nyamira County provide the recommended daily intake of chromium and hence the give the right dosage.

The four medicinal plants used in the management of diabetes with high bioavailable levels of chromium were *Solanum mauense, Bidens pilosa, Plectranthus barbatus and Ultrica dioica.*

Manganese

The highest percentage amount of mangesese was extracted in *Ultrica dioica* 58.7% and the lowest percentage of 41.6% was in *Clerodendrum myricoides.* The four medicinal plants with high EBF of manganese were *Croton macrostachyus, Bidens pilosa, Plectranthus barbatus* and *Ultrica dioica with* 93.854, 50.072, 25.371 and 23.02 mg/kg respectively. The four medicinal plants with high levels of manganese in PBF were *Croton macrostachyus, Bidens pilosa, Solanum mauense* and *Aloe vera* with 651.777, 209.973, 161.509 and 156.085 mg/kg. The conditions used during PBF extraction are partially achieved in the human body meaning that the amounts of manganese bioavailable from these fractions are much less. The patients take 5.965 mg from *Croton macrostachyus* and 0.6668 mg from *Warburgia ungandensis* of manganese daily. To supply manganese within the recommended levels 1.85 g of *Croton macrostachyus* and 16.5 g of *Warburgia ungandensis* should be taken by males while females should take 1.7 g of *Croton macrostachyus and* 15 g *of Warburgia ungandensis.* The amount of manganese taken by patients from anti diabetic medicinal plants daily are *Croton macrostachyus* (5.97 mg), *Solanum indicum* (2.32 mg), *Bidens pilosa* (2.08 mg), *Solanum mauense* (1.43 mg), *Aloe vera* (1.40 mg), *Ultrica dioica* (1.14 mg), *Plectranthus barbatus* (1.09 mg), *Carissa edulis* (0.98 mg), *Magnifera indica* (0.84 mg), *Clerodendrum myricoides* (0.73 mg), *Vernonia auriculifera* (0.679 mg) and *Warburgia ungandensis* (0.667 mg). The amount of each medicinal plant to be taken if it were to be taken as the only source of manganese to the human body or for purposes of suplemmentation is as shown in table 4.20. Most of the anti diabetic medicinal plants from Nyamira County may supply the bioavailable levels of manganese within the recommended levels and are safe to be used.

Zinc

The percentage amount of zinc bioavailable in the medicinal plants ranged from 26.23 to 49.94%, with the highest percentage being in *Ultrica dioica* and the lowest in *Vernonia auriculifera.* The four medicinal plants with high levels of zinc in the EBF were *Solanum mauense, Bidens pilosa, Ultrica dioica* and *Carissa edulis* with 4.305, 4.041, 3.713 and 3.529 mg/kg. The EBF levels of zinc are absorbed by the body when the medicinal plants are consumed. The four medicinal plants with high PBF of zinc were *Solanum mauense, Carissa edulis, Aloe vera* and *Bidens pilosa* with 25.012, 24.391, 22.28 and 20.363 mg/kg. Since the PBF conditions are rather high the amount of zinc availed to the body from PBF is low from the medicinal plant. The patients take in 0.2345 mg from *Solanum mauense* and 0.0194 mg from *Warburgia ungandensis* of zinc daily. To supply the recommended zinc levels males should take 11.94 g of *Solanum mauense* and 41.4 g of *Warburgia ungandensis* while the females should take 6.82 g of *Solanum mauense and* 23.6 *g of Warburgia ungandensis.* The four medicinal plants which release high zinc amounts daily are *Solanum mauense* (0.23 mg), *Carissa edulis* (0.22 mg), *Aloe vera* (0.21 mg) and *Bidens pilosa* (0.2 mg).

The four medicinal plants used by herbalists in Nyamira for the management of diabetes with high bioavailable fractional species of zinc were *Solanum mauense, Bidens pilosa, Ultrica dioica* and *Carissa edulis.* Most medicinal plants are supplying the bioavailable levels of zinc within the recommended levels and are safe to beadmnistered by herbalists

Copper

The percentage amount of copper in the medicinal plants ranged between 34.6 to 59.8%, with highest in *Solanum indicum* (59.8%) and the lowest in *Plectranthus barbatus* (34.6%). Most medicinal plants had between 44 -49% of their copper content bioavalable to the consumer. The four medicinal plants with high EBF of copper were *Bidens pilosa, Carissa edulis, Ultrica dioica* and *Plectranthus barbatus* with 1.194, 0.893, 0.829 and 0.771 mg/kg respectively. The four medicinal plants with high PBF of copper were *Solanum indicum, Bidens pilosa, Vernonia auriculifera and Solanum mauense* with 6.648, 5.926, 5.564 and 4.83 mg/kg respectively. The PBF of copper is availed provided the enzymatic processes during uptake and metabolism of the medicinal plants in the human body achieve similar reduction or oxidation conditions as applied in the sequential extraction. The patients take in 0.05696 mg from Bidens *pilosa* and 0.0137 mg from Magnifera *indica* of copper daily. To supply copper within the recommended levels 59.7 g of *Bidens pilosa* and 241.2 g of *Magnifera indica* should taken daily males while females should take 42.2 g of *Bidens pilosa* and 165.4 *g* of *Magnifera indica.* The four anti diabetic medicinal plants which releasd high amounts of copper daily were *Bidens pilosa* (0.057 mg), *Solanum indicum* (0.05 mg), *Vernonia auriculifera* (0.048 mg) and *Solanum mauense* (0.041 mg).

Saba *et al.* (2014) revealed that complexes of vanadium, zinc, copper, chromium, cobalt, molybdenum and tungsten were effective antidiabetic agents. This means that those medicinal plants that had substantial amounts of these or some of these elements could be used in the management of diabetes mellitus.

The four medicinal plants with high bioavailable fractional species of copper were *Bidens pilosa, Carissa edulis, Ultrica dioica* and *Plectranthus barbatus.*

4.4 Hot Water Extraction

Cluster analysis (single linkage, Euclidean distances) of elements according to their percentage of extraction efficiencies from 19 medicinal plants from Borabu and Nyamira using hot water extraction were done and results are given in figures 25 and 26.

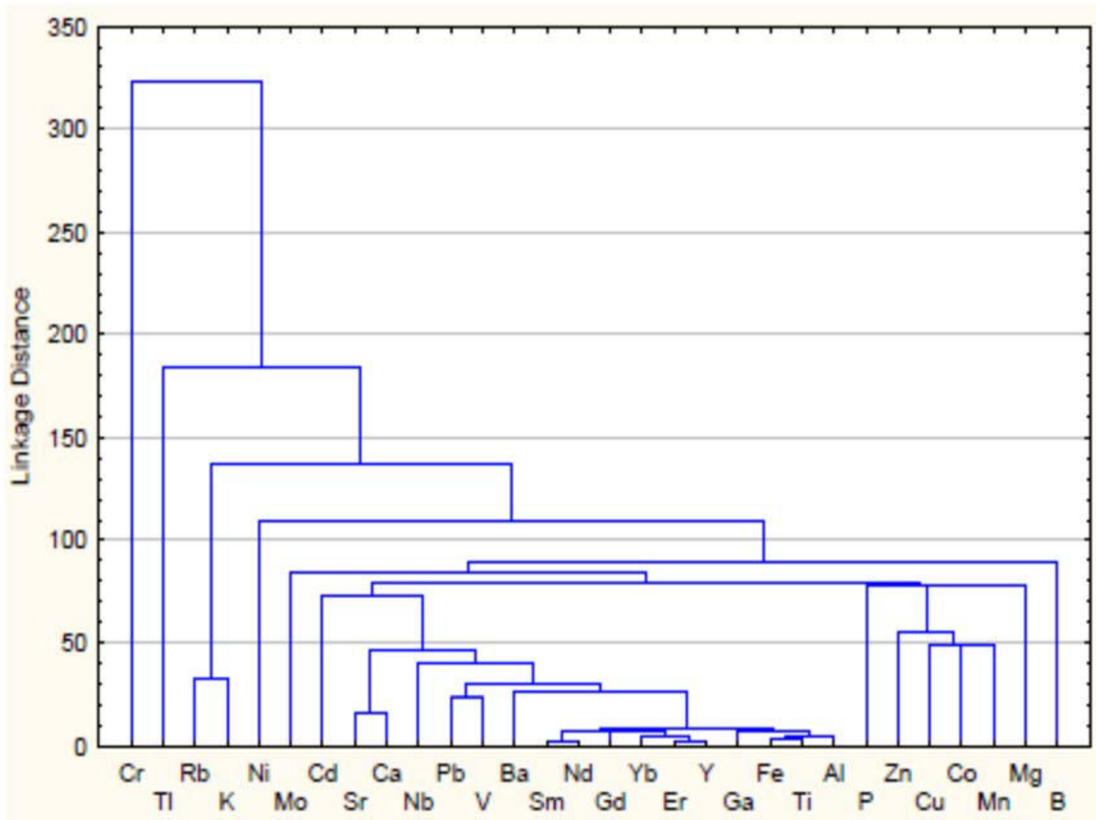


Figure 21: Cluster analysis (single linkage, Euclidean distances) of elements according to their percentage extraction efficiencies from 19 medicinal plants from Borabu (BMP) using hot water extraction

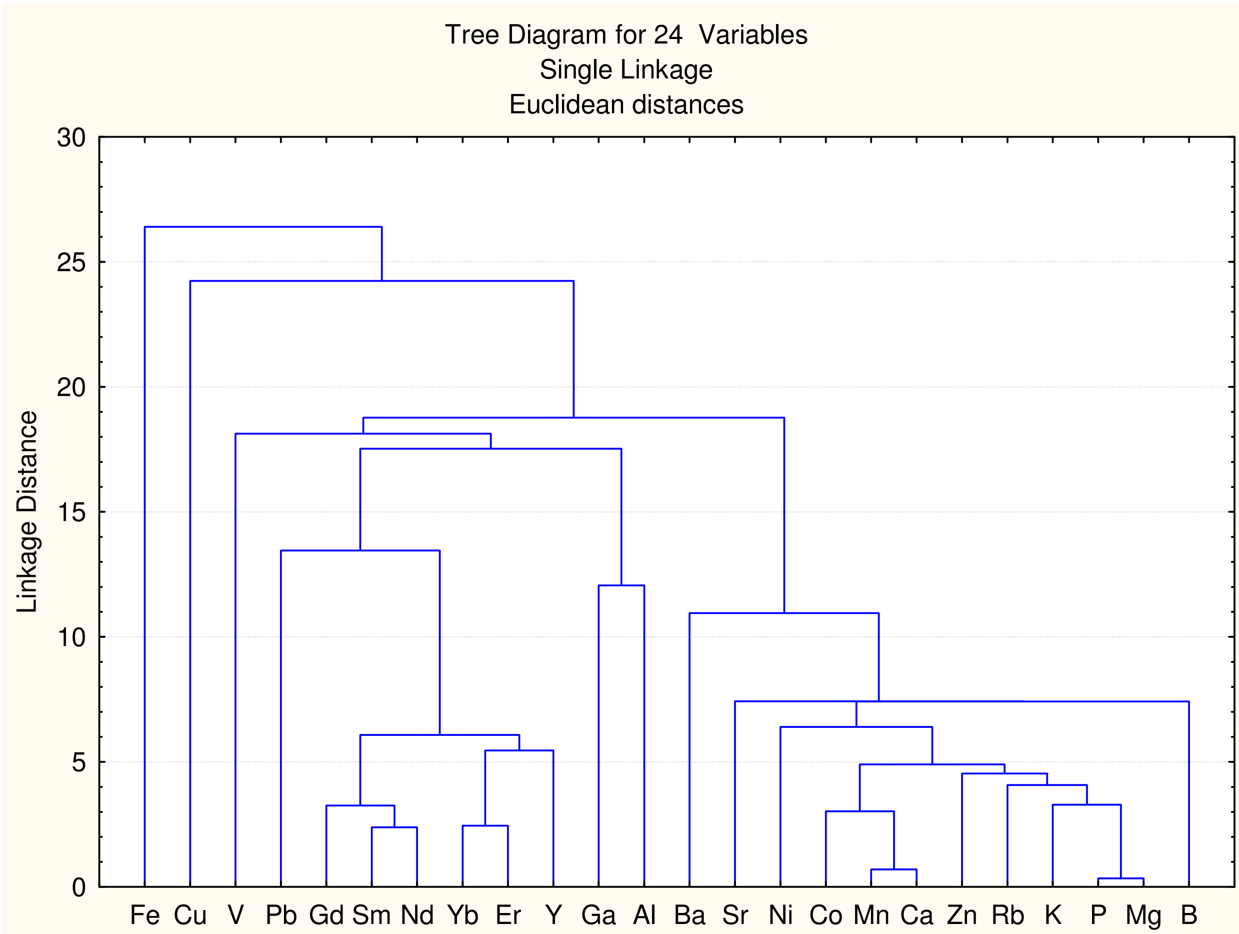


Figure 22: Cluster analysis (single linkage, Euclidean distances) of elements according to their percentage extraction efficiencies from 19 medicinal plants from Nyamira (NMP) using hot water extraction

The determined total elemental concentrations are important to estimate maximum intake of metals from herbal medicine. However, depending on the actual process for preparation of the medicine from the collected plants the uptake may be (much) lower. The most frequently applied procedure is boiling and soaking of the plants in water (Musila *et al*., 2014). In our study an aliquot of the ground plants was mixed with water, shortly boiled and then soaked overnight with shaking followed by filtration (0.45 µm) and elemental analysis by ICP-MS. Using this protocol the water extractable elemental fraction was determined for the plants from Borabu. The resulting extraction efficiencies were calculated as percentage ratio of the water soluble fraction and the total elemental contents. For most elements the water extractable fraction is strongly dependent on the plant species as indicated by about 10-fold difference in minimum and maximum extractable fraction. These results demonstrate that not only the total element contents of the plants are important for estimation of therapeutic or toxic effects but also the actual protocol for preparation of the medicine which is then consumed by the patient may significantly affect elemental intake. When comparing the mean extraction efficiencies obtained from the 19 medicinal plants, less than half of the analysed elements, i.e. B, Mg, P, K, Mn, Co, Ni, Cu, Zn, Rb, Mo, Cd and Tl, exceed 20% using our experimental conditions. Those elements are mostly essential and supposed to support therapy in case of mineral deficiency apart from Cd and Tl elements. Due to the low total contents of Cd and Tl near the limit of detection(Cd-0.0001mg/kg, Tl-0.0002mg/kg) the relatively high water solubility seems not critical in these plants, however in case of increased uptake of Cd or Tl from contaminated soil this would be of significant concern. Overall the extractable fraction is strongly dependent on the respective element, for example low amounts of Al and Pb are detected in the aqueous extract which reduces the amount of these metals, while those elements that have been shown to theurapeutic like Mg, Cu and Zn are extracted in much higher percentage. This is confirmed and shown by cluster analysis of the extraction efficiencies of 30 elements for the 19 medicinal plants from Borabu (Figure 26). Cr and Tl are special cases with most extracted concentrations below 0.0003 mg/kg and 0.0002mg/kg for Cr and Tl, the remaining elements with low extraction efficiencies are clustered together in the centre, while the above mentioned elements with higher extraction efficiencies form additional clusters. The hot water extraction is an efficient way to improve the ratio of beneficial to toxic elemental contents prior to administration of the herbal medicine to the patient. This is because those elements which have been reported to have high theurapeutic values are extracted in high amounts in the hot water while those that have no theurapeutic values are extracted more in the cold water.

4.5: Size-fractionation of Extracted Elemental Species using Sequential Filtration

A four step sequential filtration procedure resulting in the following size fractions as described in the experimental section 3.10: <3 kDa, 3 kDa-10 kDa, 10 kDa-0.45 µm and 0.45µm-5 µm for Mg, Mn, Co, Ni, Zn, V, Cu, Y, Al and Fe were determined and presentd in figures27 a& 27 b.

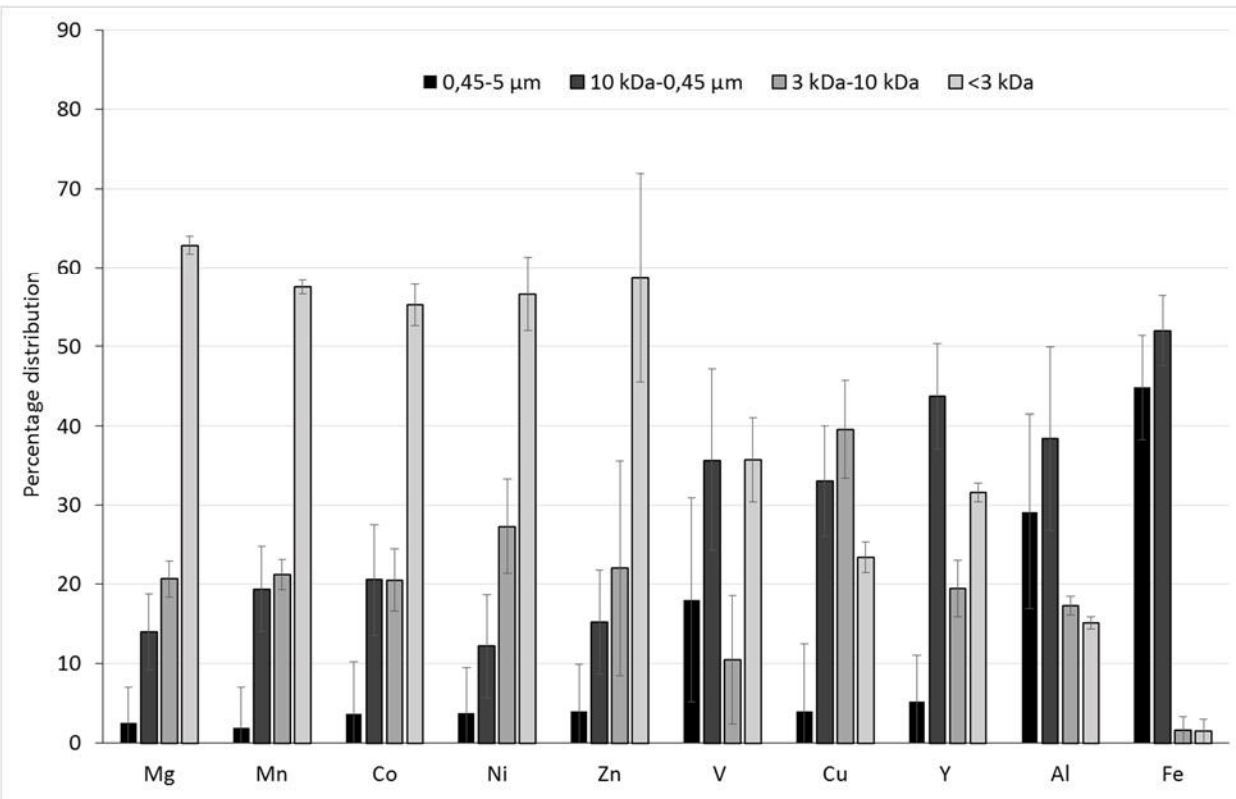


Figure 23a: Sequential filtration results for elements in *Bidens pilosa*

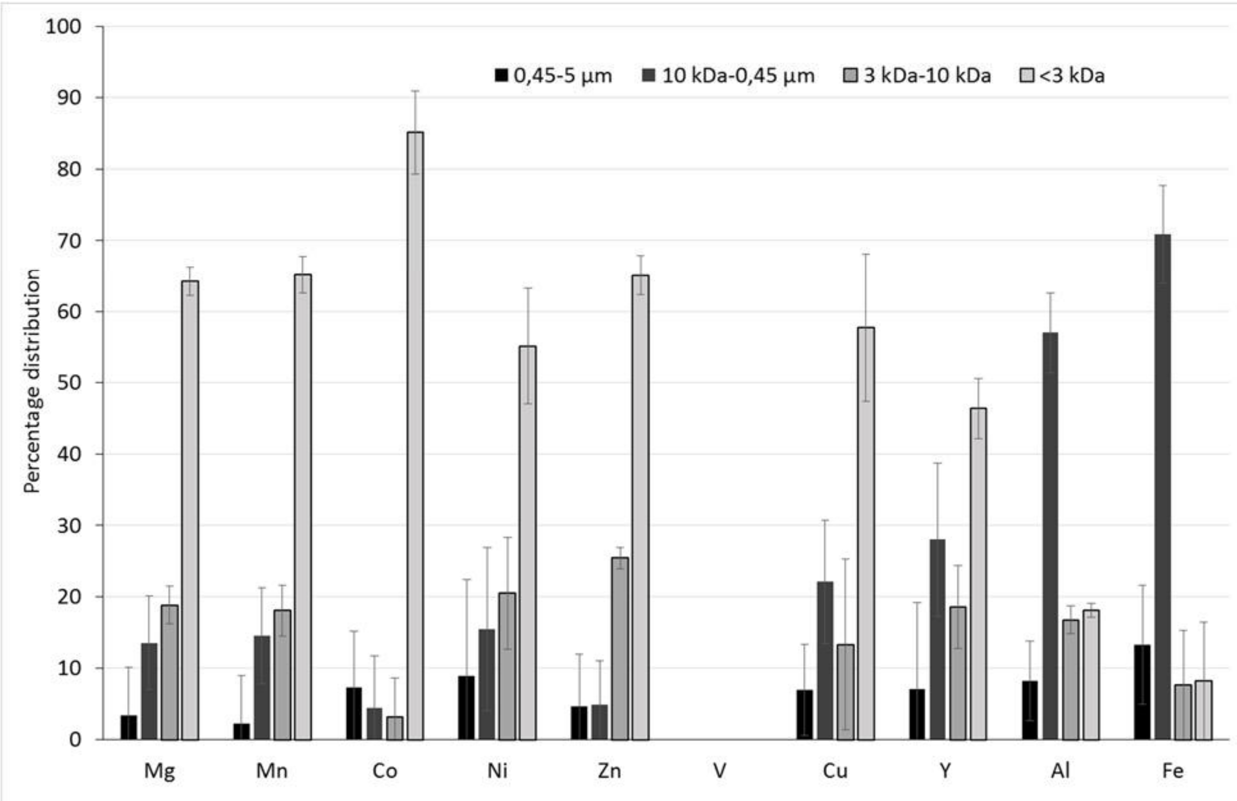


Figure 23b: Sequential filtration results for elements in *Tabernaemontana stapfiana*

The determination of the total extracted elemental contents improved the estimation of elemental intake during therapy with herbal medicine. The molecular forms of the extracted elemental species are still largely unknown and therefore detailed understanding of the molecular mechanism of the potential therapeutic effects of the plant derived elemental species is not available. Hyphenated techniques (that means combining a separation step with subsequent online elemental and molecular detection) have been applied in many studies related to food or nutritional supplements, for example for the identification and quantification of arsenic species in algal extracts (Khouzam *et al*., 2012, Nischwitz & Pergantis, 2012). Critical aspects of the separation of elemental species for example by liquid chromatographic techniques are the recovery from the column and the stability of the species during separation. In particular for complex mixtures of mostly unknown elemental species, as present in the herbal extracts investigated in this study, development and validation of hyphenated speciation techniques was a big challenge (Michalke *et al*., 2013). Ultrafiltration with offline elemental detection technique for size fractionation of elemental species minimises the problems associated with species stability and recovery. In addition the filtration techniques are often faster and fractions of the size-separated species are obtained without dilution for further analysis with complementary techniques (Nischwitz *et al.,* 2010). Therefore, a sequential extraction method was established and applied to selected plants extracts (i.e *Bidens pilosa* an anti diabetic and *Tabernaemontana stapfiana* an anti malarial medicinal plant).

The average recoveries of the cold extracts compared to the hot extracts were 90% with standard deviation 23% for *Bidens pilosa* and 100% with standard deviation 21% for *Tabernaemontana stapfiana* based on the <5 μm filtrates compared to the total amounts of the elements determined by ICP-MS. Only in few elements the difference in the extracted contents between cold and hot water treatment exceeded 40%: V, Cr and Mo were less soluble in cold water for *Bidens pilosa* (recoveries 53%, 60% and 38%) while Cu was more soluble in cold water for *Bidens pilosa* (recovery 161%). This effect was lower or absent for *Tabernaemontana stapfiana* based extracts. This indicates that the heating step during extraction has for most elements either a beneficial effect by increasing the extracted contents and improves safety of the herbal medicine due to disinfection of potential microbiological contamination of the water or plant material. The mean relative standard deviations across the 30 monitored elements obtained from triplicate extraction using hot or cold water are 5.0% and 6.6% for *Bidens pilosa* and slightly higher at 9.0% and 7.0% for *Tabernaemontana stapfiana* based due to the lower concentrations in this sample.

The hot water extracts were subjected to 4-step sequential filtration procedure resulting in the following size fractions as described in the experimental section: <3 kDa, 3 kDa-10 kDa, 10 kDa-0.45 µm and 0.45µm-5 µm. Elemental analysis of the fractions clearly showed that the percentage distribution of species in these fractions dependent on element. The results for selected elements are summarised in Figure 29a. Mg, Mn, Co, Ni, and Zn were mainly (>55%) present as low molecular mass species (< 3kDa) with minor percentage of higher molecular mass species. In case of V, Cu and Y more species were in the fractions 3 kDa-10 kDa fraction or the 10 kDa-0.45 µm for *Bidens pilosa*. For Al and Fe the highest percentage of species was found in the fractions >10 kDa. Cluster analysis of the size fractionation of *Bidens pilosa* shows the outstanding distribution for Fe, Cu and V. All rare earth elements show very similar fractionation profile and most remaining elements join the group of predominantly low molecular weight species (Figure29 a & b). This molecular size fractionation provides characterization of the predominant elemental species present in the plant extracts (Mitharwal *et al*., 2013).

Regarding V the concentrations in *Tabernaemontana stapfiana* extracts were 0.0004mg/kg. However, in *Bidens pilosa* the size fractionation resulted in more than 60% vanadium species with molecular weight more than 3 kDa. This result is contrary to the numerous studies focusing on the synthesis of low molecular weight insulin-mimetic drugs for oral treatment of diabetes. Possibly the plant derived high molecular weight vanadium species are poorly resorbed and not relevant. However, there is also the possibility that these natural forms of vanadium are advantageous for gastro-intestinal uptake and thus could support regulation of blood glucose levels with fewer side effects compared to current synthetic vanadium containing candidate drugs.

4.6 Correlation of the Bioavailable Trace elements in Medicinal Plants with their Uses

The amount of bioavailable forms per Kg of the medicicinal plants are used to determine the daily intakes of the elements and the results are presented in Table 4.20a-4.20c.

Table 4.20: Bioavailable Trace elements and the use of medicinal plants.

	Medicinal Plant	Bioavailable level of elements (mg/kg)	Daily intake(mg/kg) for Cr(ug)	Diseases treated by herbalist using plant
1	*Warburgia ugandensis*	Fe:7, Cr:0.1 Mn:83, Zn:2.4, Cu: 2.5	Fe:0.06,Cr:0.096,Mn: 0.67,Zn:0.02, Cu:0.02	Malaria,diabetes,Gonorrrhea,syphilis,impotence, worms, asthma, pneumonia, typhoid, headache and anaemia
2	*Toddalia asiatica*	Fe:7.2 Cr:1.2 Mn:451 Zn:21.2 Cu:3.8	Fe:0.28,Cr:8.30, Mn:5.81, Zn:0.24,Cu:0.02	Malaria,diabetes,Gonorrrhea,syphilis, pneumonia, typhoid, heart disease and cancer
3	*Erythrina abyssinica*	Fe: 6.3 Cr:1.2 Mn:546 Zn:23.4 Cu:5.3	Fe:0.04 Cr:8.24 , Mn: 6.23 , Zn: 0.24 ,Cu:0.03	Malaria,diabetes,Gonorrrhea,syphilis, allergy, gonorrhea and cancer
4	*Vernonia auriculifera*	Fe:2.4, Cr:0.1, Mn:85, Zn:12, Cu:6	Fe:0.03,Cr:1.04,Mn:0.68, Zn:0.10,Cu:0.05	Diabetes, pneumonia,
5	*Plectranthus barbatus*	Fe:4.2 Cr:0.6 Mn:136, Zn:14, Cu:5	Fe:0.06 ,Cr:4.78, Mn:1.09, Zn:0.11, Cu:0.04	Gonorrhea, Worms, diarrhea, diabetes and stomachache
6	*Ultrica dioica*	Fe:8.11 Cr:0.79 Mn:142 Zn:14 Cu:5	Fe: 0.08, Cr:6.28, Mn:1.13, Zn:0.17, Cu: 0.04	Diabetes, cancer, stomachache, Asthma and anaemia

Table 4.20: Continued.

	Medicinal Plant	Bioavailable level of elements (mg/kg)	Daily intake(mg/kg) for Cr(ug)	Diseases treated by herbalist using plant
6	*Croton macrostachyus*	Fe:26Cr:0.6 Mn:746Zn:10 Cu:4	Fe:0.21, Cr:4.5, Mn:5.96,Zn:0.09 , Cu:0.03	Malaria, Coughs, Venerial diseases, Bleeding, diabetes, typhoid, diarrhea, anaemia, cancer, wounds and blood circulation.
7	*Bidens pilosa*	Fe:18 Cr:1 Mn:260,Zn:24, Cu:7	Fe:0.15, Cr:9.84, Mn:2.08, Zn:0.19, Cu:0.06	Diabetes, mouth rash in kids, malaria, worms, gonorrhea, cancer, athletes foot, eye inflammation freshcut and coughs
8	*Melia azedarach*	Fe: 67, Cr:0.1 Mn:76 Zn:1.8 Cu:1.1	Fe:0.54,Cr: 0.23 Mn:1.03 Zn:0.06, Cu:0.03	Malaria, diarrhoea, dysentry, cough, asthma, STIS, typhoid, anaemia tuberculosis and headache.
9	*Solanum mauense*	Fe:8.1, Cr:2 Mn:178,Zn:29, Cu:5	Fe: 0.08 Cr:14, Mn: 1.43, Zn:0.23, Cu:0.04	Diabetes, children diseases, malaria and cancer
10	*Clerodendrum myricoides*	Fe:24 Cr:0.4 Mn:91, Zn: 20,Cu:4	Fe: 0.19, Cr: 3.46 , Mn: 0.73, Zn:0.16 ,Cu:0.03	Malaria, gonorrhea, typhoid, amoeba, stomachache, worms, syphilis, pneumonia, colds and flu
11	*Carissa edulis*	Fe:10,Cr:0.8, Mn:122Zn:28, Cu:4	Fe:0.09 Cr: 6.32, Mn: 0.98, Zn: 0.22 ,Cu:0.03	Malaria, diabetes, gonorrrhea, syphilis, typhoid and cancer.
12	*Tabernaemontana Stapfiana*	Fe:11, Cr:0.7, Mn: 303,Zn:31 Cu:7	Fe: 0.9, Cr:5.48 , Mn:2.43, Zn:0.25,Cu:0.06	Malaria and anaemia
13	*Aloe vera*	Fe:24, Cr:0.6, Mn:174, Zn:26, Cu:2	Fe: 0.19,Cr: 4.6, Mn: 1.40, Zn:0.21,Cu:0.02	Malaria, diabetes, Gonorrrhea, syphilis, pneumonia, local hair lotion, asthma, cancer, skin diseases, typhoid, dysentry and diarrhea.

Table 4.20: Continued.

	Medicinal Plant	Bioavailable level of elements (mg/kg)	Daily intake(mg/kg) for Cr(ug)	Diseases treated by herbalist using plant
15	Magnifera indica	Fe:7, Cr:0.70 Mn:95, Zn:18.2, Cu: 2.3	Fe:0.01,Cr:4.52,Mn :0.84,Zn:0.12, Cu:0.01	Malaria,diabetes,Gonorrrhea, syphilis,impotence, worms, asthma, pneumonia, typhoid, headache and anaemia
16	*Acacia hockii*	Fe:4.4 Cr:1.2 Mn:31 Zn:11.2 Cu:3.8	Fe:0.33,Cr:8.30, Mn:5.81, Zn:0.24,Cu:0.02	Malaria,diabetes,Gonorrrhea, syphilis, pneumonia, typhoid, heart disease and cancer
17	*Acacia abyssinica*	Fe: 9.9 Cr:1.2 Mn:5 Zn:13.4 Cu:2.3	Fe:0.22 Cr:0.14 , Mn: 0.23 , Zn: 0.24 ,Cu:0.03	Malaria, ,Gonorrrhea,syphilis, allergy, gonorrhea and cancer
18	Solanum indicum	Fe:2.4, Cr:0.54, Mn:137, Zn:15.4, Cu:7.1	Fe:0.02,Cr:4.3,Mn: 2.32, Zn:0.18,Cu:0.05	Diabetes, pneumonia,coughs
19	Senna didymolbo trya	Fe:9.7 Cr:0.6 Mn:12, Zn:6, Cu:3	Fe:0.33 ,Cr:0.18, Mn:1.09, Zn:0.11, Cu:0.04	Gonorrhea, skin diseases, malaria

Four medicinal plants which contain high amount of chromium, manganese, copper and zinc when taken are *Solanum mauense, Bidens pilosa, Croton macrostachyus* and *Ultrica dioica.* These medicinal plants were used in the management of diabetes by 100% of herbalists in Nyamira County. These plants had high bioavailable amounts of Cr, Mn, Zn and Cu. It is likely that these medicinal plants may have wide pharmacological applicabilition. The fact that the plants are rich in immune boosting trace element compounds they may boost the immunity of patients suffering from various ailments. They are used in the management of diabetes since they have been shown to contain high zinc, chromium and manganese level which reduces blood sugar levels of diabetic patients (Kumar *et al.,* 2003). There was a relationship between the medicinal plants application and their bioavailble elemental amount. The medicinal plants can be more efficacious if the worked out masses of the each medicinal plants may be used to provide the recommended elements (Tables 19-20).

The four medicinal plants which contain high iron level were *Melia azedarach, Toddalia asiatica, Croton macrostachyus and Aloe vera were.* These medicinal plants are used by the herbalists in Nyamira County in the management of malaria. The iron in the medicinal plants is used in the synthesis of the erythrocytes which are destroyed by the plasmodium parasites. The medicinal plants have been shown to contain natural products (Muregi *et al*., 2004) that destroy the parasites hence curing the malaria.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Out of the four hundred questionnaires administered in Nyamira County to the herbalists three hundred and four herbalists had more than five years of experience, treated more than thirty patients per week, used herbal medicine from forests in their residence, were involved in conserving natural resources and treated diseases in the order malaria, diabetes, diarrhea, pneumonia and gornorrhea. These herbalists were found to prevalently treat two diseases i.e malaria and diabetes using ten and twelve identified medicinal plants respectively. The medicinal plants used by ninenty percent of herbalists to treat malaria were *Warburgia ugandensis, Senna didymobotrya, Acacia* abyssinica, *Croton macrostachyus, Toddalia asiatica, Clerodendrum myricoides, Aloe vera Tabernaemontana stapfiana, Melia azedarach, Acacia hockii* while those used to treat diabetes were *Plectranthus barbatus, Magnifera indica, Bidens pilosa, Warburgia ugandensis, Croton macrostachyus, Erythrina abyssinica, Toddalia asiatica, Carissa edulis, Vernonia auriculifera, Aloe vera, Ultrica dioica, Solanum mauense and Solanum indicum.* The four medicinal plants used to treat malaria with 100% usage were *Aloe vera*, *Clerodendrum myricoides, Toddalia asiatica* and *Warburgia ugandensis* while those used to treat diabetes were *Bidens pilosa, Solanum indicum, Magnifera indica* and *Erythrina abyssinica.*

The two methods used to analyze the elements were flame atomic absorption spectrophotometry (FAAS) and inductive coupled plasma- mass spectrometry (ICP-MS).

The macro elements found in the medicinal plants were calcium, magnesium, potassium phosphorus, aluminium, sulphur and silicon whose concentration ranged from 2.4 to 39.04 g/Kg, 0.43 to 6.23 g/Kg, 3 to 59 g/Kg and 0.29 to 5.90 g/Kg, 0.24 to 8.6g/kg ,1.0 to 5.02 g/kg and 0.46 to 1.71 g/kg respectively. The total concentration of each macroelement in the medicinal plants differed from each other, though the differences of the elements in the different Sub Counties were not statistically different.

The trace elements in the medicinal plants were Fe, Cr, Mn, Zn, Cu, Nd, Sm, Er, Pb, Cd, As Tl, Hg, Nb, Zr, Ga, Rb, Y, Yb, Ba, Gd, Sr, V, Ti, Se, B, Co, Mo, and Ni. The levels of these elements were statistically signicant from each other in the medicinal plants but the differences in elements in the Sub Counties were not statically diferrent. The levels of some theurapeutic elements ranged as follows boron(8.00- 58.00 mg/ kg), titanium(10.00-400.00mg/ kg), vanadium(0.09-6.00mg/kg), cobalt(0.04-1.56mg/Kg), nickel(0.2-3.81mg/kg), molybdenum(0.08-3.21mg/kg), niobium(0.07±0.-15.00mg/kg) selenium(0.04-11.00mg/kg). The highest zinc level of 123.00 mg/Kg was found in *Solanum mauense* while the lowest level, 3.90 mg/Kg was found in *Acacia hockii*. The highest copper level of 29.00 mg/Kg was found in *Bidens pilosa* while the lowest level, 1.56 mg/Kg was found in *Acacia hockii.* The highest manganese level of 2990 mg/Kg was found in *Croton macrostachyus* while the lowest, 18.20 mg/Kg was in *Acacia hockii.* The highest chromium level of 3.20 mg/Kg were in *Solanum mauense* and *Clerodendrum myricoides* while the lowest, 0.04 mg/Kg was in *Acacia hockii* among the medicinal plants from Nyamira County. The iron levels in the medicinal plants (*Carissa edulis, Clerodendrum myricoides, Melia azedarach, Toddalia asiatica*) ranged from 1150 to 4700 mg/Kg.

The exchangeable species provided the easily bioavailable fraction (EBF) of the element which is available for absorption into the body. The results of the sequential extraction showed that the easily bioavailable fraction (EBF) of iron, chromium, manganese, zinc and copper, ranged from 0.2 to 0.4%, 6.7 to 13.8 %, 4.1 to 10%, 2.4 to 10.2% and 3.2 to 12.0 % while the potentially bioavailable fraction (PBF) ranged from 1.6 to 1.9%, 50.1 to 67.6 %, 32.2 to 48.7%, 23.0 to 41.1 % and 34.6 to 53.1% respectively. *Acacia hockii* had 4.47 mg/Kg of iron while *Melia azedarach* had 67.454 mg/Kg of iron extracted. 0.12 mg/Kg of chromium, 83.35 mg/Kg of manganese, 2.42mg/Kg of zinc and 2.53 mg/Kg of copper were extracted from *Warburgia ugandensis*. 1.75 mg/Kg of chromium from *Solanum mauense,* 745.63 mg/Kg of manganese from *Croton macrostachyus,* 29.31 mg/Kg of zinc from *Solanum mauense* and 7.12mg/Kg of copper from *Bidens pilosa* were extracted.

Molecular size fractionation of elemental chacterization showed that the percentage distribution across the fractions (<3 kDa, 3 kDa-10 kDa, 10 kDa-0.45 µm and 0.45µm-5 µm) was strongly dependent on the specific element.

Hundred percent of the herbalists used the ten medicinal plants to treat malaria and twelve medicinal plants to treat diabetes. Three medicinal plants namely *Carissa edulis*, *Aloe vera* and *Clerodendrum Myricoides* were used by the herbalists to treat both malaria and diabetes.

It was established that the antidiabetic medicinal plants had high quantities of the trace elements whose compounds are associated with glucose lowering effects such as magnesium, calcium, zinc, manganese, copper and chromium. On the other hand it was established that the antimalarial plants had substantial bioavaible form of iron. The antimalarial potential of the plants could be due to the presence of iron in the plants among other factors. This demonstrates that the herbalists are able to manage malaria and diabetes by use of their choice medicinal plants.

5.2 Recommendation from the study

It is recommended that

- The oxidation states of the elements in the medicinal plants be determined.
- Plants have efficacy to treat the diseases and one should carry out a study to establish the optimum dosage for the medicinal plants required to treat the specific diseases.
- The specific organic theurepeutic compounds (anti malarial and anti diabetic) in the medicinal plants should be determined.
- Further investigations are required for detailed species identification, for example by analysis of the obtained fractions by HPLC separation online with elemental and molecular detection.

CHAPTER SIX

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APPENDICES

Appendix I

QUESTIONNAIRE ON MEDICINAL PLANTS

Introduction

The information requested for in this questionnaire is purely for research purposes. The information given will be treated with all the confidentiality required. Please give us the required information as accurately as possible. The researcher seeks to find out the curative value and speciation of trace elements in medicinal plants used in Nyamira County for the treatment of various diseases. Either tick the correct response with a cross (x) or write a precise response on the questions asked. Thank you.

A) Bio data

i) Name: ___________________________ Age: ________yrs Sex__________

Village _________ **Sub** location ___________Location:___________ Division___________

ii) Educational level (a) Primary ( ) (b) High school ( ) (c) University ( ) (d) Other ( )

iii) Is your business registered? State:

Business name;_______________

Business license;__________________

Practitioner license;______________________

iv) How did you acquire the herbalist's knowledge? (a) Through family induction ( ) (b) induction ( ) (c) training ( )

(B) General information

1) How long have you been practising? (a) Less than one year ( ) (b) 1-5 years ( ) (c) 5- 10 years

( ) (d) Above 10 years ( )

2) On average how many patients do you treat per week? _____________________________

3) Which diseases have you been treating? (a) Malaria ( ) (b) Diabetes ( ) (c) Gonorrhea ( ) (d) Pneumonia ( ) (e) Diarrhea ( ) (f) others

4) If one of your answers to question (3) is (f) specify the disease(s)?

____

____

5) Give the order of two prevalently treated diseases?

(a)Malaria/Diabetes ( ) (b)Malaria/Pneumonia( ) (c)Diabetes/Gonorrhea( ) (d)Gonorrhea/Diarrhea( )

6) Fill the following table on the plants used to treat the diseases given:

Disease	Plants used for treatment	plant part used	Preparation of the medicine	Packaging of medicine	Dispensing of the medicine	Dosage
Malaria	*Warbugia ugandesis* (Esoko)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Croton machrostachyus (Omosocho)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Senna didymobotrya (Omobeno)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Clerodendrum myricoides (Omonyasese)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Toddalia asiatica (Ekenagwa ekiegarori)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Ajunga remota (Omonyantira)	Roots ( )				
		Stem bark ( )				
		Leaves				

		( )				
	Ekebergia capensis (Omonyamari)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Stephania abyssinica (Omotabararia)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Acacia hockii (Omokonge)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Leucas calostachys (Ekemwa)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Melia azedarach (Omwarubaine)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Tabernaemontana stapfiana (Omobondo)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
Diabetes	*Warbugia ugandensis* (Esoko)	Roots ( )				
		Stem bark ( )				
		Leaves				

		( )				
	Croton machrostachyus (Omosocho)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Bidens pilosa (Ekemogamogia)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Magnifera indica (Riembe)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Solanum indicum (Omorobo)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Solanum mauense (Ekengeta mbori)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Vernonia auriculifera (Omosabakwa)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Carissa eduli (Omonyangatetia)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				

	Erythrina abyssinica (Omotembe)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Urtica dioica (Rise)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
	Plectranthus barbatus (Omoroka)	Roots ( )				
		Stem bark ( )				
		Leaves ( )				
Other diseases		Roots ( )				
		Stem bark ( )				
		Leaves ( )				
		Roots ( )				
		Stem bark ( )				
		Leaves ( )				
		Roots ( )				
		Stem bark ( )				
		Leaves ( )				
		Roots ( )				

7) What season do you receive the highest number of patients? (a) Rainy season ( ) (b) Dry season ( )

8) Do you conserve the natural resource? (a) Yes ( ) (b) No ( )

8) How do you acquire the herbal plants you use for treatment? (a) from the forests near residence( ) (b) bought from the market( )

9) How many patients come back to thank you after the treatment session? _____________

APPENDIX II

PAGE 2

THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Richard Mogwasi
of (Address) University of Nairobi
P.O.Box 30197-00100, Nairobi.
has been permitted to conduct research in

Location
District
Nyamira County

On the topic: Speciation analysis of selected Elements in selected medicinal plants from Nyamira County.

for a period ending: 31st October, 2016.

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Research Permit No. *NACOSTI/RCD/12B/013/60*
Date of issue *30th September, 2013*
Fee received *KSH. 2000*

Applicant's Signature

For: Secretary
National Commission for Science Technology & Innovation

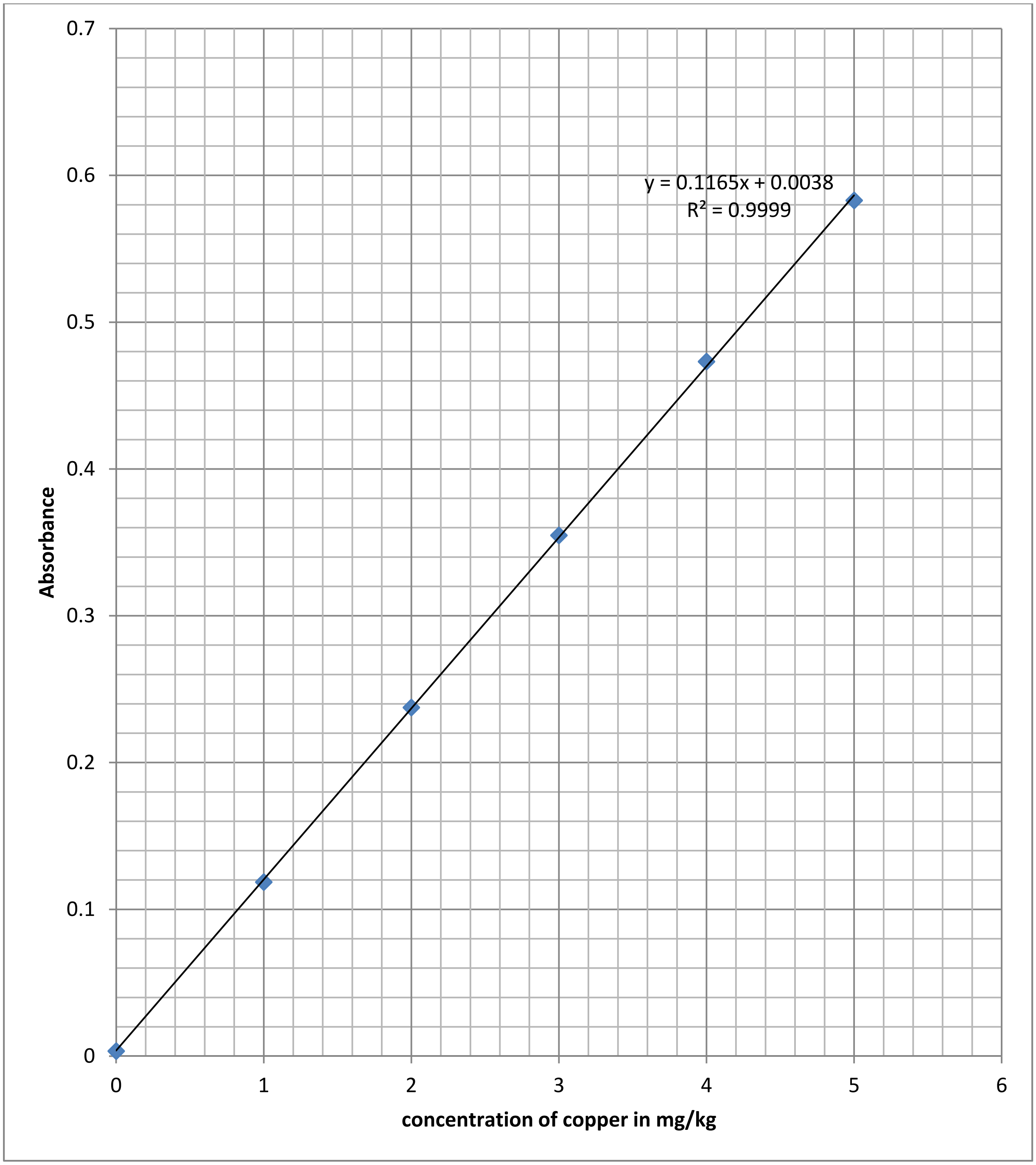
APPENDIX III

Questionnaire Analysis

Aspect	Category	Borabu	Ekerenyo	Manga	Nyamira
1) Age groups of herblists	Less than 40	17	-	17	-
	41-50	25	39	26	27
	51-60	27	-	27	25
	Above 60	36	56	37	41
2)Educational level	Uneducated	30	26	26	23
	Primary	55	42	58	41
	High school	20	27	23	29
3)Registration of business	Yes	85	88	77	78
	No	20	7	30	15
4)Herbal knowledge	Family induction	37	43	36	40
	induction	42	36	45	45
	Training	26	16	26	8
5)Years of practice	<1 yr	-	-	-	-
	1-5yrs	17	-	10	-
	6-10yrs	34	44	39	37
	>10yrs	54	51	58	56
6)Patients treated per week	<20	10	3	11	3
	20-30	11	12	10	4
	31-40	50	43	53	41
	>40	34	37	33	45
7)Diseases treated	Malaria	84	82	93	78
	Diabetes	81	81	82	83
	Gonorhoea	16	13	17	10
	Pneumonia	30	10	13	21
	Diarrhea	11	15	17	23
8)Other diseases treated	Cancer	3	7	4	7
	Syphilis	11	12	15	9
	AIDS	3	4	6	7
9)Two prevalently diseases treated	a)malaria/ diabetes	95	76	91	85
	b)Malaria/pneumonia	2	2	1	2
	c)Diabetes/gonorhea	-	5	5	2
	d)Gonorrhea/diarrhea	8	12	10	4
10) Medicinal plants usage (%)	Warburgia ugandensis	100	100	100	100
	Solanum indicum	100	90	90	90
	Toddalia asciatica	100	90	95	92
	Erythrina abyssinica	98	95	100	95
	Senna didymolbotrya	100	90	85	90
	Croton macostachyus	100	100	100	90
	Ultrica dioica	100	100	100	100
	Ajunga remota	10	30	40	45

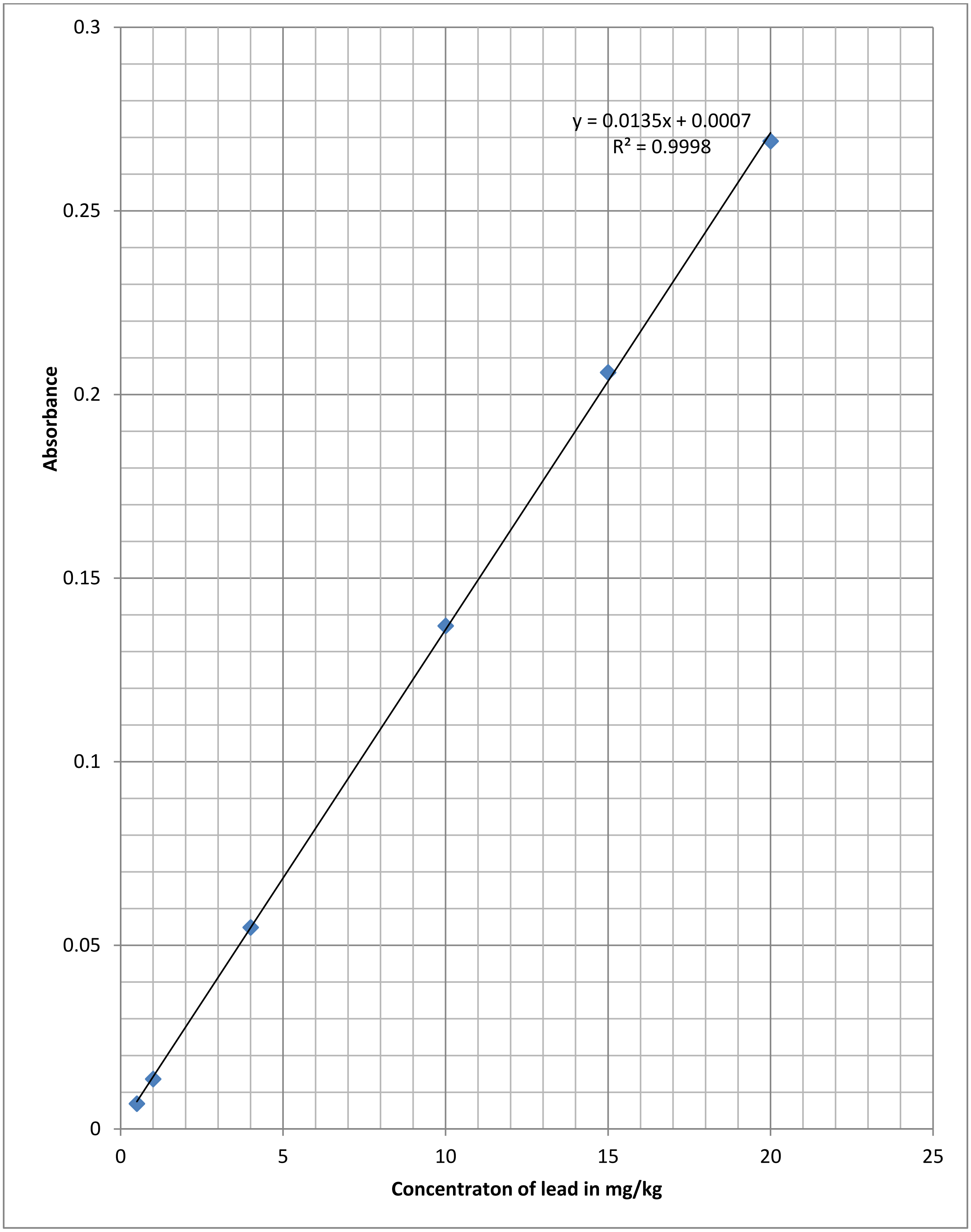
	Ekebergia capensis		15	50	25	30
	Stephania abyssinica		40	30	20	38
	Tabernaemontana stapfiana		100	90	95	85
	Bidens pilosa		90	100	100	100
	Magnifera indica		90	85	92	98
	Veronica auriculifera		100	90	87	90
	Clerodendrum myricoides		97	100	87	94
	Carissa edulis		87	97	98	100
	Plectranthus barbatus		87	100	100	98
	Acacia abyssinica		87	84	91	98
	Acacia hockii		82	97	89	90
	Solanum mauense		87	98	93	87
	Melia azedarach		100	100	100	100
	Aloe vera		100	100	100	100
11)Source of herbal medicine	Collected from forests near residence		90	87	99	81
	Bought from market		15	8	18	12
12) Conserving natural resources	Yes		85	78	92	80
	No		20	17	13	13
13) Season with highest number of patients	Rainy		67	62	71	66
	Dry		38	33	36	27
14) Success of tretatment	malaria	No of patients in session	840	848	968	1040
		sucess	403	407	581	603
	diabetes	No of patients in session	132	112	128	124
		sucess	24	20	12	16

Appendix IV



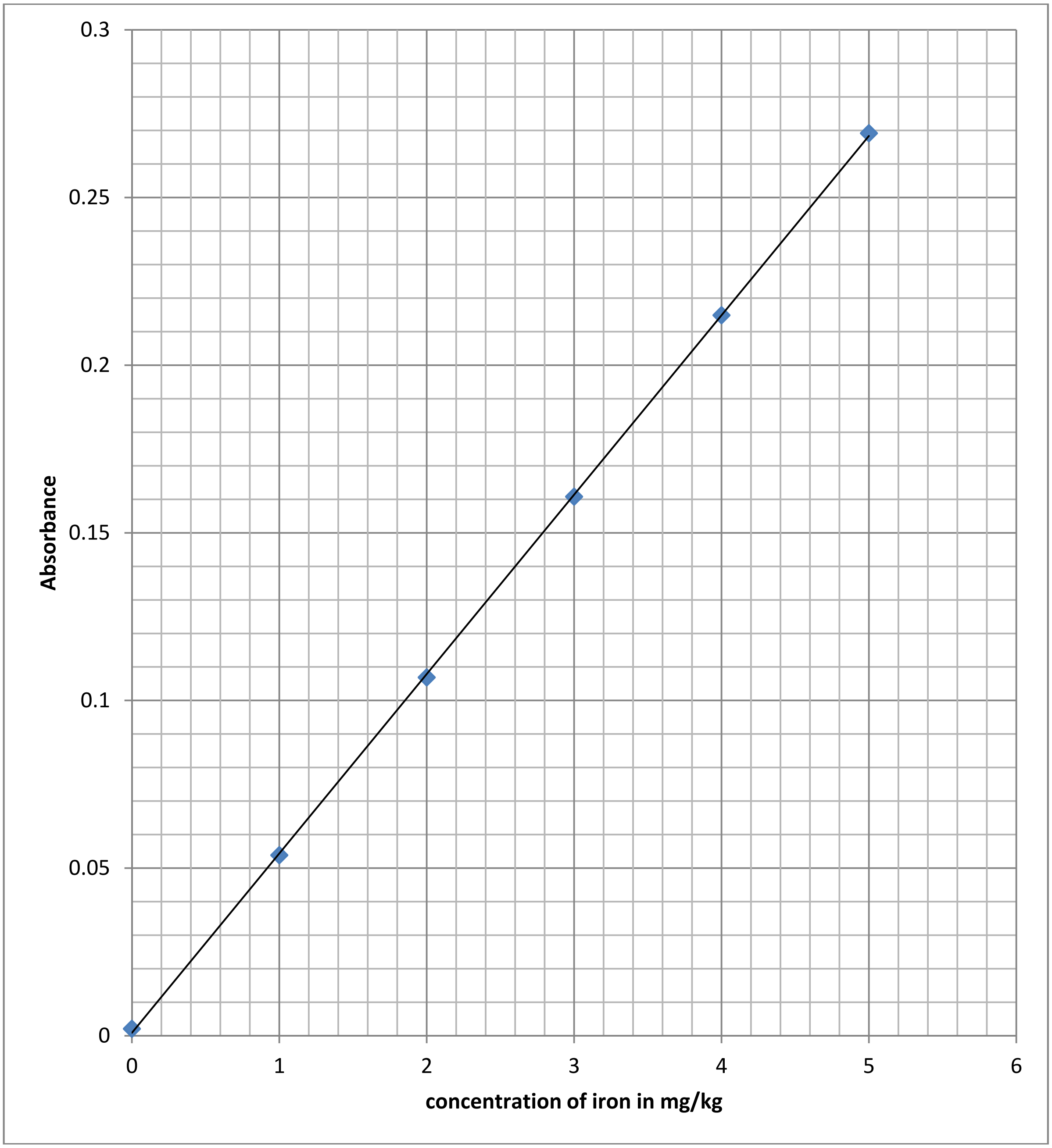
Calibration curve for copper

APPENDIX V



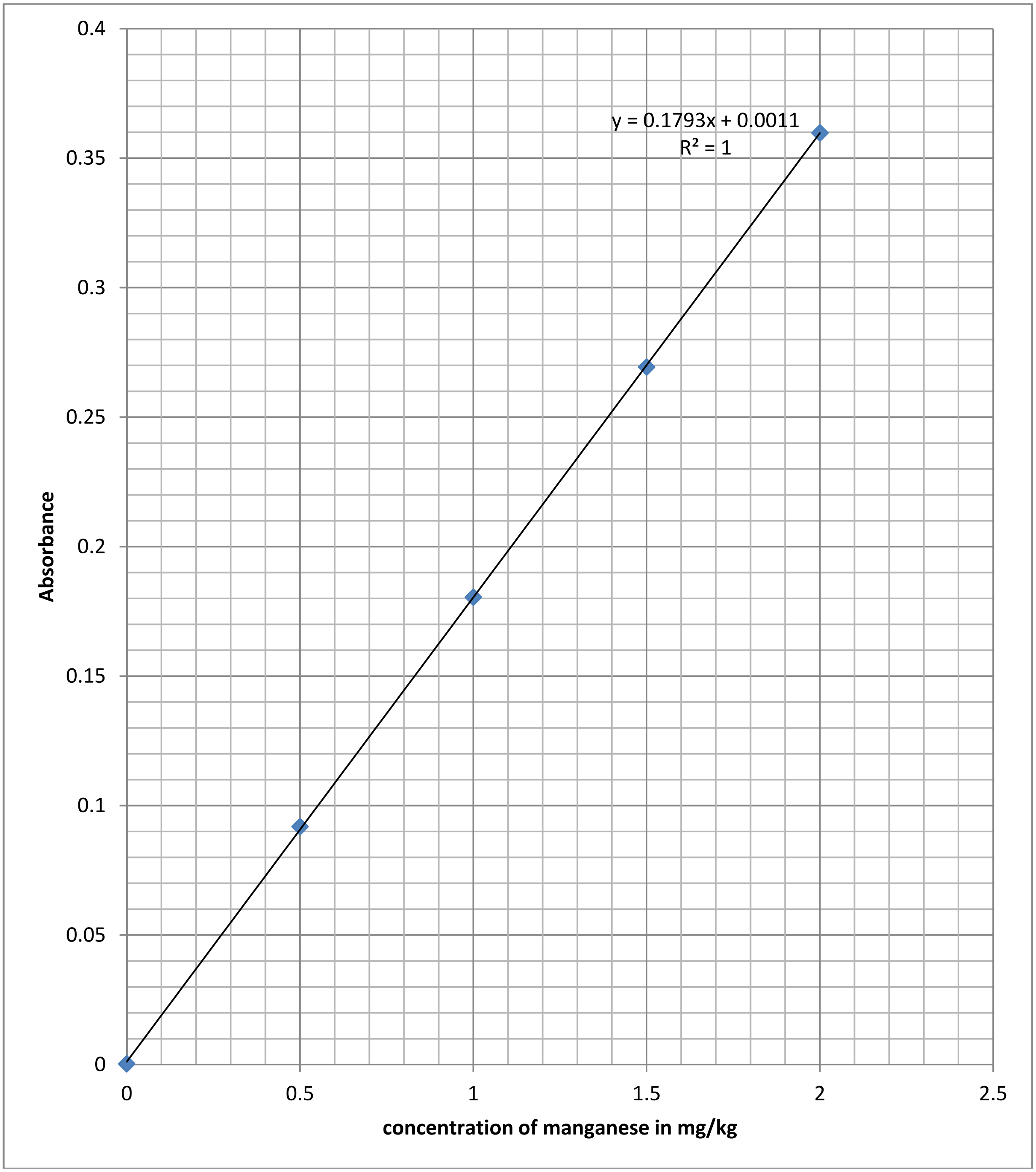
Calibration curve of lead

APPENDIX VI



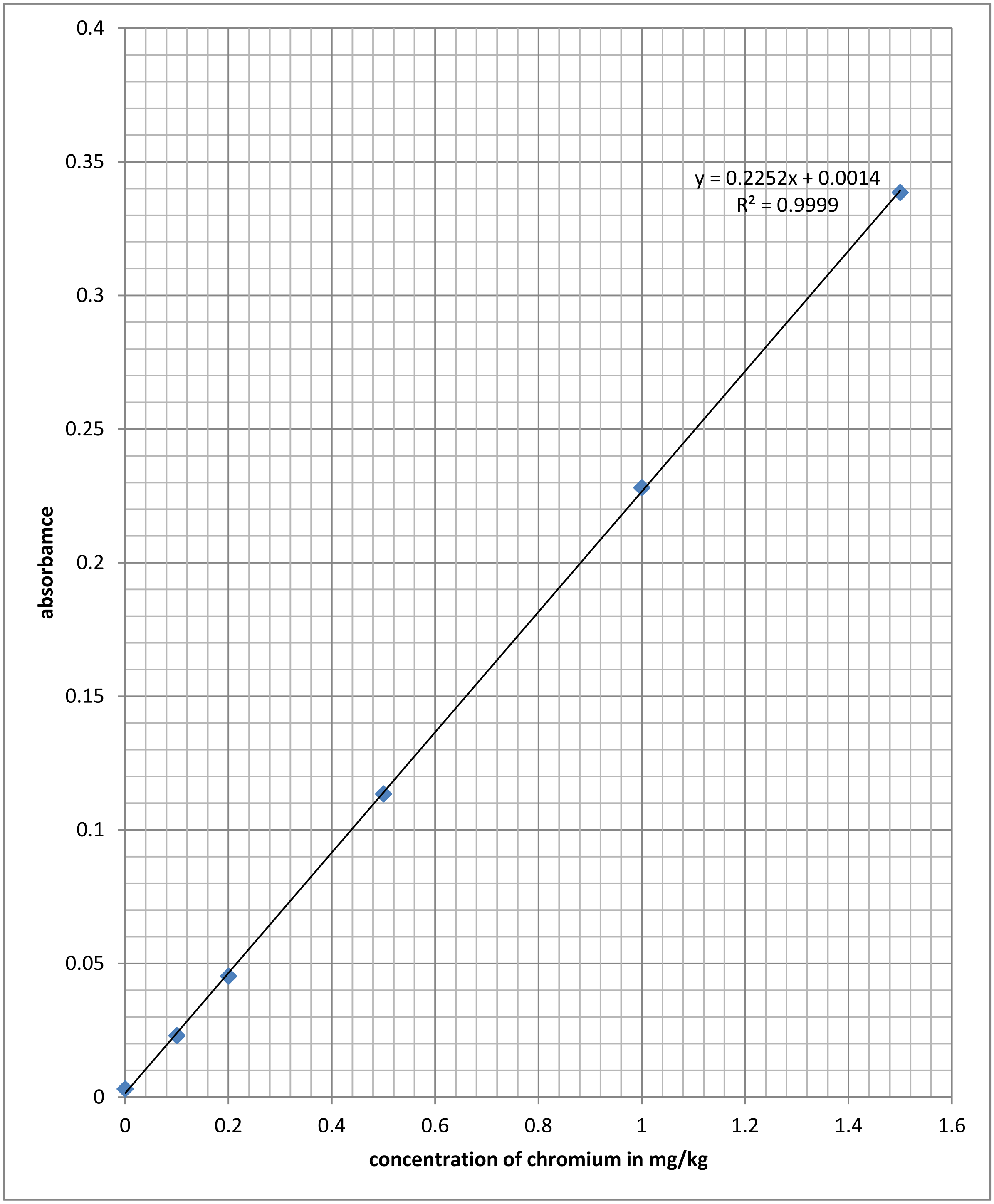
Calibration curve of iron

APPENDIX VII



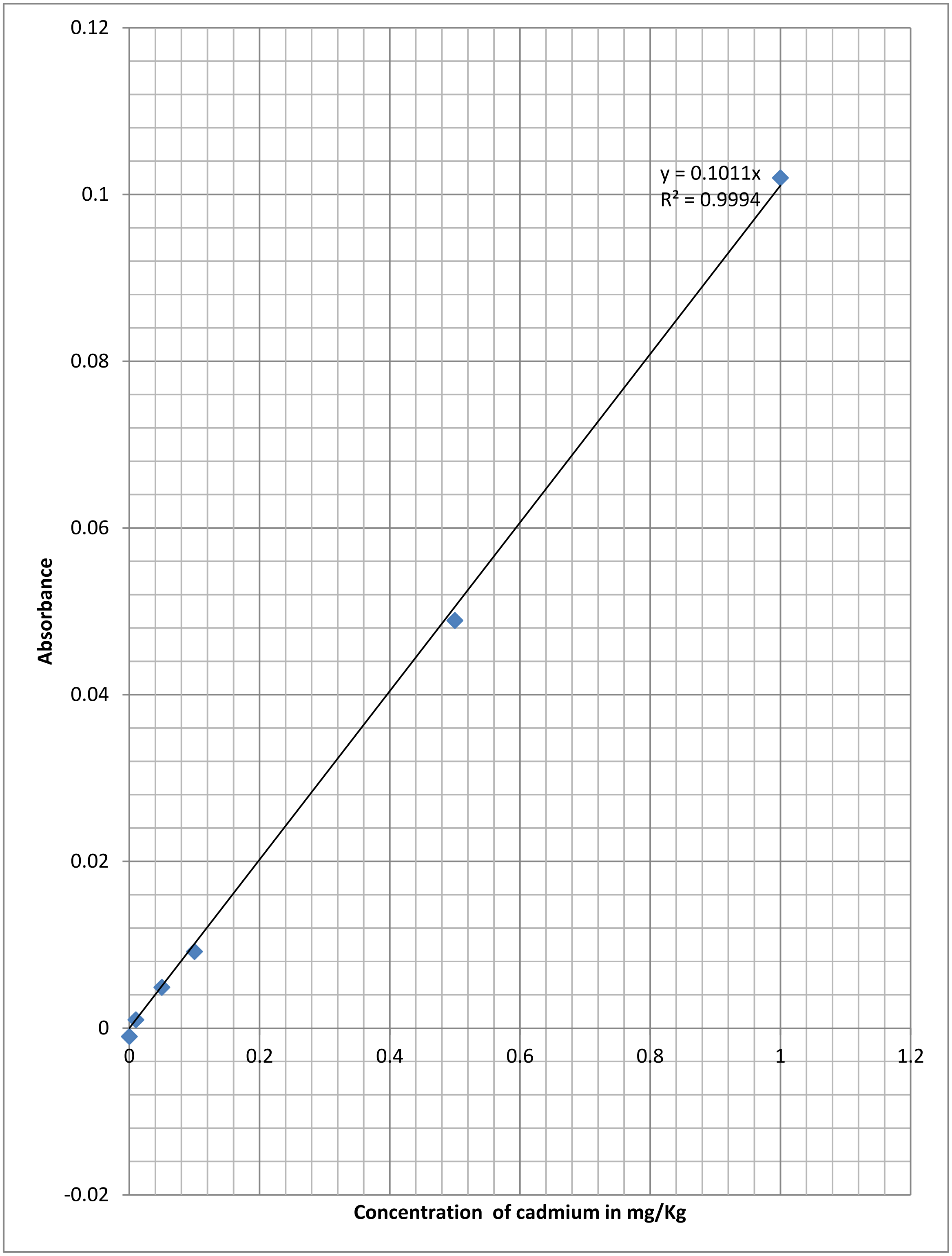
Calibration curve of Manganese

APPENDIX VIII



Calibration curve of chromium

APPENDIX IX



Calibration curve for cadmium

APPENDIX X

TABLE 4.21: RESULTS OF TOTAL TRACE ELEMENTS IN MEDICINAL PLANTS FROM SUB COUNTIES DETERMINED BY AAS

SPECIMEN	Sub county	Concentration in mg/Kg							
		Fe	Cu	Zn	Mg	Cr	Cd	Mn	Pb
A	B	464.00±2.37	4.72±0.21	7.35±1.074	960 ±84	0.206±0.03	Nd	168.01±9.12	Nd
	E	453.21±2.3	4.71±0.36	6.31±0.81	965±96	0.21±0.04	Nd	168.12±3.33	Nd
	M	484.24±10.2	3.72±0.2	7.14±0.3	860±30	0.42±0.1	Nd	145.9±5	Nd
	N	175.76±5.03	3.73±0.25	9.853±1.167	850±22	0.1±0.02	Nd	123.089±10.4	Nd
B	B	2045.15±5.37	6.13±1.01	24.83±3.134	664±10	0.812±0.06	Nd	127.88±8.46	Nd
	E	2013.04±2.32	6.34±0.48	22.93±2.43	648±8	0.73±0.03	Nd	124.32±1.83	0.08±0.06
	M	1357.34±28.4	11.4±0.4	31.4±2	780±20	0.73±0.1	Nd	119.6±3	1.0±0.1
	N	2100±8.33	8.55±1.70	38.71±2.13	932±18	0.9±0.03	0.02±0.01	155.193±2.04	Nd
C	B	985.76±6.20	5.53±0.2	20.799±2.082	600±7	0.44±0.02	0.03±0.01	102.90±6.11	Nd
	E	983.43±3.34	5.22±0.53	22.42±3.36	560±8	0.38±0.06	Nd	96.14±2.33	0.09±0.03
	M	2194.56±194.1	5.87±0.05	23.1±1	660±20	0.83±0.07	Nd	141.4±9	0.4±0.1
	N	2208.2±4.2	7.20±2.50	55.80±4.50	565±12	0.22±0.04	Nd	98.40±6.30	Nd
D	B	418.06±1.20	6.17±0.31	5.84±1.093	441±8	0.17±0.01	0.02±0.01	120.66±8.21	Nd
	E	411.12±2.33	6.43±0.24	5.30±0.35	384±7	0.11±0.03	Nd	103.31±1.98	Nd
	M	1069.12±60.13	4.37±0.2	35.8±1	1100±60	0.61±0.04	Nd	103.6±5	0.27±0.04
	N	1238.74±15.09	4.15±0.40	17.78±1.15	1212±35	0.33±0.02	0.02±0.01	111.34±5.14	Nd
E	B	421.57±3.94	6.41±1.06	30.74±3.81	3802±95	0.15±0.02	Nd	144.30±3.44	Nd
	E	413.09±3.33	6.542±1.02	31.12±3.43	3764±85	0.10±0.03	Nd	131.23±2.33	Nd
	M	1069.12±60.13	4.37±0.2	35.8±1	1100±60	0.61±0.04	Nd	103.6±5	0.27±0.04
	N	631.37±2.38	4.83±0.14	24.04±1.37	3094±85	0.22±0.04	0.03±0.02	80.70±9.60	Nd
F	B	367.26±3.86	13.92±2.32	45.74±5.92	2604±18	0.2±0.02	Nd	209.75±6.92	Nd
	E	357.03±2.33	13.43±1.23	42.53±4.31	2503±15	0.17±0.04	Nd	204.41±5.33	Nd
	M	453.34±9.27	17.9±0.4	45.3±0.8	3140±40	0.29±0.01	0.04±0.01	223±2	Nd
	N	423.21±8.41	14.93±0.27	51.12±2.83	2635±95	0.22±0.03	Nd	238.31±4.12	Nd
G	B	2054.55±9.04	9.90±1.177	46.95±4.84	4906±84	1.2±0.04	Nd	397.82±8.00	Nd
	E	2118.12±1.33	8.81±0.4	46.33±3.33	4923±95	1.08±0.0	Nd	367.23±6.33	0.27±0.

			6			5			06
	M	1028.36±6.34	17.5±0.4	46.3±0.8	3740±30	1.53±0.1	Nd	241±7	Nd
	N	1134.39±3.80	14.95±1.5	47.77±2.45	43263±182	0.7±0.01	Nd	173.79±3.61	Nd
H	B	3287.83±8.23	5.79±1.25	45.92±6.69	6164±380	1.56±0.06	0.02±0.01	285.90±8.46	0.15±0.04
	E	3283.31±1.33	4.32±0.38	42.91±2.33	6207±380	1.27±0.08	Nd	259.53±4.83	1.03±0.23
	M	2690.14±48.34	5.6±0.5	37.9±0.8	5800±100	1.1±0.02	Nd	228±6	1.2±0.2
	N	1156.44±2.50	5.71±1.3	36.63±3.58	5480±205	0.4±0.02	Nd	158.38±3.36	Nd
I	B	1184.37±0.38	7.76±1.50	30.67±4.18	5002±390	0.64±0.03	Nd	1637.49±16.2	0.54±0.08
	E	1207.23±3.33	8.11±1.23	32.64±2.33	5060±390	0.58±0.04	0.02±0.01	1623.12±10.33	Nd
	M	934±30.56	11.4±0.8	24.9±0.5	3700±100	1.01±0.05	0.03±0.01	2979±90	1.02±0.1
	N	1582.39±5.05	4.82±0.23	25.43±4.34	4318±50	1.2±0.04	Nd	1589.10±14.12	1.01±0.12
J	B	5630.08±28.7	12.72±1.03	71.56±7.49	3801±186	2.08±0.07	Nd	578.71±9.86	1.17±0.82
	E	5567.43±5.33	12.35±1.42	72.81±5.36	3801±185	2.19±0.33	Nd	534.13±5.32	1.07±0.23
	M	3425.16±38.2	28.7±6	54.8±3	4400±60	2.03±0.2	0.02±0.01	491.1±7	1.07±0.1
	N	2362.31±4.74	11.34±0.87	62.82±6.64	4704±205	1.02±0.03	Nd	275.89±8.96	Nd
K	B	1004.30±7.8	8.94±1.5	52.23±6.27	1896±201	1±0.03	Nd	532.8±10.43	Nd
	E	923.23±4.33	9.24±1.24	50.72±4.58	2015±180	1.18±0.13	0.04±0.02	519.31±5.33	0.59±0.12
	M	308.94±10.34	2.29±0.1	68.3±2	2130±50	0.32±0.2	Nd	341.4±7	Nd
	N	1756.36±8.95	3.88±0.15	44.64±6.06	2604±103	0.7±0.02	Nd	258.83±2.14	1.11±0.81
L	B	2696.54±7.69	9.06±1.63	107.49±9.94	1881±86	2.22±0.06	Nd	327.76±9.36	0.58±0.17
	E	2709.24±2.36	8.41±0.64	101.15±6.33	1845±75	2.24±0.33	0.03±0.01	307.31±4.33	0.49±0.03
	M	4576.24±95.45	14.7±0.3	121.2±3	2780±70	2.12±0.2	Nd	300.3±10	1.19±0.1
	N	7562.30±5.05	11.82±1.49	81.49±4.07	2546±206	3.2±0.05	Nd	518.16±3.86	0.18±0.01
M	B	236.08±3.924	10.17±1.41	14.56±2.72	1764±40	0.3±0.02	0.02±0.01	873.36±11.12	Nd
	E	169.32±3.21	10.42±0.36	14.61±1.33	1715±33	0.23±0.08	Nd	872.42±5.34	Nd
	M	265.25±8.86	9.7±0.4	14.8±0.8	1830±70	0.25±0.03	Nd	808±30	Nd
	N	341.64±4.74	8.97±0.26	15.45±1.57	1745±30	0.12±0.01	0.03±0.01	917.74±10.42	Nd
N	B	316.10±2.601	4.47±1.46	4.32±1.42	1045±18	1.0±0.01	0.03±0.02	81.53±8.6	Nd
	E	276.41±3.31	4.31±0.23	4.51±0.83	1024±15	1.03±0.06	Nd	53.64±1.33	Nd
	M	132.65±4.33	1.46±0.04	4.3±0.8	2290±100	0.17±0.03	Nd	17.2±0.5	Nd
	N	113.28±3.21	0.96±0.12	3.48±0.53	2184±36	0.042±0.01	0.02±0.01	17.39±1.20	Nd

O	B	550.01±9.35	2.26±0.13	6.63±1.45	1860±40	0.51±0.02	0.02±0.01	54.01±4.884	Nd
	E	614.21±2.23	3.22±0.24	6.73±0.81	1854±41	0.43±0.04	Nd	56.38±1.43	Nd
	M	468.36±10.4	3.96±0.2	7.34±0.5	490±20	0.32±0.06	Nd	185.2±5	Nd
	N	684.48±3.76	2.50±0.10	5.24±0.48	1820±34	0.3±0.02	Nd	62.90±4.80	Nd
P	B	1197.02±14	6.25±1.50	49.97±2.83	2506±65	0.8±0.03	0.03±0.01	278.63±6.95	1.11±0.12
	E	1242.42±5.83	5.51±0.33	48.52±1.33	2515±75	0.67±0.03	Nd	258.14±2.33	Nd
	M	4654.89±194.82	13.7±0.5	82.3±4	2900±100	2.82±0.2	Nd	318±9	0.72±0.09
	N	985.40±5.06	8.61±0.17	41.48±4.56	1243±10	0.8±0.02	Nd	99.96±8.89	Nd
Q	B	2635.48±17.33	7.13±1.40	61.20±5.83	1410±37	0.73±0.04	Nd	264.86±7.89	Nd
	E	2529.12±6.76	8.10±0.48	60.7±2.33	1415±35	0.53±0.04	0.02±0.01	249.81±2.43	0.21±0.03
	M	1945.11±40.42	5.9±0.1	35.59±0.5	680±10	0.87±0.2	Nd	171.8±3	Nd
	N	2578.2±8.4	6.40±0.85	54.60±2.50	4475±204	2.4±0.3	Nd	274.80±5.20	0.10±0.08
R	B	451.01±4.920	13.23±2.95	67.27±6.84	1962±30	0.97±0.04	0.03±0.01	608.68±10.0	Nd
	E	409.31±2.43	12.32±1.34	65.81±3.33	1932±26	1.04±0.08	0.03±0.01	603.52±3.48	Nd
	M	550.36±20.24	9.7±0.3	52.9±1	1850±70	0.59±0.07	0.03±0.01	318.4±10	Nd
	N	854.07±2.89	12.20±1.15	62.82±5.09	1836±105	0.86±0.05	Nd	724.89±10.32	0.08±0.04
S	B	1243.22±9.41	2.99±0.33	55.84±5.02	4186±45	0.86±0.05	Nd	254.49±8.84	Nd
	E	1303.31±4.52	3.21±0.63	52.42±4.48	4124±485	0.67±0.06	Nd	247.10±2.38	0.53±0.21
	M	1246.84±30.24	3.57±0.07	60.2±1	4600±100	0.97±0.09	Nd	280.1±9	Nd
	N	1313.60±3.72	3.88±0.91	91.63±2.95	5242±79	0.85±0.04	Nd	438.35±5.95	Nd

Appendix XI

Table 4.22 a: Total trace element concentration in medicinal plants from the Sub Counties

Element / Sample	Sub county	B	Ti	Ga	V	Cr	Rb	Mn	Co	Ni	Cu	Zn	Se	Mo	Cd	Fe
		Mean Concentration in mg/Kg														
A	B	22.00± 2.00	32.00 ±4.00	0.35 ±0.04	0.32 ±0.04	0.21 ± 0.07	39.00±5.00	170.00± 20.00	0.10± 0.02	0.29± 0.06	5.00 ± 0.90	7.50 ± 0.90	0.80 ± 0.50	0.09 ± 0.05	Nd	420 ±70
	E	15.00±4.00	31.00 ±3.00	0.35 ±0.04	0.28 ±0.03	0.23 ±0.06	39.00±5.00	173.00±17.00	0.11±0.02	0.27±0.04	5.30 ±0.80	6.90 ±0.80	0.70 ±0.30	0.12 ±0.04	Nd	340 ±70
	M	24.00±4.00	32.00 ±2.00	0.40±0.03	0.36 ±0.01	0.50 ±0.10	33.30±0.90	150.00±5.00	0.12±0.02	0.31±0.03	4.20 ±0.20	7.30 ±0.30	1.00 ±0.50	0.40 ±0.04	Nd	490 ±10
	N	17.00±2.00	12.00 ±2.00	0.13 ±0.02	0.14 ±0.01	0.10 ±0.06	33.20±0.70	126.00±2.00	0.05±0.01	0.48±0.05	4.20 ±0.40	10.00±0.40	0.60 ±0.40	0.10 ±0.01	Nd	180 ±10
B	B	16.00± 1.00	110.00± 2.00	1.60 ±0.10	1.13 ± 0.03	0.82 ± 0.10	18.70±0.20	130.00± 2.00	0.30± 0.02	0.62± 0.09	6.90 ± 0.50	25.60± 0.40	1.80 ± 0.60	1.30 ± 0.30	Nd	2030±70
	E	12.00±3.00	114.00±4.00	1.6± 0.10	1.23 ±0.03	0.76 ±0.1	18.70±0.20	128.00±1.00	0.27±0.03	0.57±0.06	6.70 ±0.30	23.70±0.20	1.40 ±0.40	1.32 ±0.20	Nd	2020±70
	M	19.00±3.00	80.00 ±10.00	1.08±0.04	0.89 ±0.05	0.74 ±0.10	43.00±1.00	129.00±3.00	0.30±0.01	0.86±0.06	12.20±0.40	33.00±2.00	1.20 ±0.60	0.50 ±0.20	Nd	1370±30
	N	8.00 ±2.00	120.00±1.000	1.69 ±0.05	1.31 ±0.06	0.90 ±0.09	22.20±0.40	159.00±2.00	0.33±0.01	0.60±0.08	8.80 ±0.50	40.00±1.00	1.00 ±0.70	0.80 ±0.06	Nd	2190±60
C	B	16.00±1.00	69.00 ± 8.00	0.95 ±0.06	0.62 ±.03	0.45 ±0.30	11.00±0.20	104.00± 2.00	0.18±..02	0.30± 0.01	5.80 ± 0.09	21.30±2.00	0.70 ±0.40	0.80 ± 0.30	Nd	990 ±50
	E	13.00±1.00	66.00 ±7.00	0.95 ±0.06	0.52 ±0.04	0.42 ±0.02	11.00±0.20	101.00±3.00	0.14±0.02	0.28±0.02	5.60 ±0.09	23.10±3.00	0.60 ±0.06	0.72 ±0.40	Nd	940 ±50
	M	14.00±2.00	94.00 ±5.00	1.45±0.06	1.00 ±0.10	0.86 ±0.07	13.00±0.30	151.00±9.00	0.33±0.03	0.88±0.06	5.97 ±0.05	24.10±1.00	1.40 ±0.60	1.20 ±0.20	Nd	2200±200
	N	15.00±3.	65.00 ±5.00	1.36 ±0.0	0.43 ±0.0	0.32 ±0.0	14.60±0.	105.00±3.0	0.43±0	0.10±0	5.80 ±0.7	56.00±4.	0.90 ±0.6	1.20 ±0.1	Nd	221

		00		4	5	3	50	0	.01	.02	0	00	0	0		0±200
D	B	15.00±0.80	26.00±3.00	0.29±0.04	0.33±0.02	0.18±0.08	4.10±0.10	121.00±3.00	0.08±0.01	0.31±0.04	6.60±0.20	6.00±0.30	0.40±0.10	0.30±0.20	Nd	420±10
	E	11.00±1.00	23.00±3.00	0.29±0.04	0.29±0.01	0.13±0.06	4.10±0.10	113.00±4.00	0.06±0.01	0.33±0.05	6.70±0.30	5.80±0.40	0.30±0.20	0.28±0.03	0.09±0.02	360±10
	M	23.00±3.00	60.00±6.00	0.88±0.08	0.70±0.05	0.63±0.04	31.00±1.00	111.00±5.00	0.22±0.02	1.08±0.04	4.70±0.20	37.00±1.00	1.10±0.50	0.50±0.20	Nd	1100±60
	N	18.50±2.00	69.00±8.00	0.94±0.06	0.9±0.03	0.33±0.03	38.20±0.50	112.00±1.00	0.22±0.01	0.85±0.06	4.10±0.05	18.20±0.40	0.60±0.40	0.21±0.04	Nd	1360±30
E	B	23.00±3.00	20.00±3.00	2.30±0.10	0.28±0.01	0.15±0.02	48.00±1.00	147.00±2.00	0.20±0.01	0.50±0.10	6.90±0.30	31.00±2.00	11.00±1.00	0.90±0.04	Nd	420±10
	E	21.00±2.00	17.00±4.00	2.30 0.10	0.23±0.02	0.11±0.02	48.00±1.00	138.00±5.00	0.14±0.03	0.43±0.20	6.91±0.30	33.00±4.00	10.70±1.10	0.78±0.05	Nd	440±10
	M	52.00±5.00	36.00±2.00	1.12±0.04	0.48±0.02	0.45±0.02	29.40±0.30	218.00±2.00	0.15±0.01	0.68±0.03	4.79±0.05	31.90±0.70	3.00±1.00	0.80±0.50	Nd	680±10
	N	31.00±4.00	24.00±4.00	1.35±0.09	0.32±0.03	0.22±0.03	58.40±0.80	81.00±1.00	0.14±0.01	0.40±0.03	5.40±0.06	24.50±1.00	5.00±1.00	0.47±0.09	Nd	660±20
F	B	19.00±2.00	19.00±2.00	0.24±0.02	0.20±0.02	0.20±0.01	74.00±1.00	212.00±4.00	0.13±0.01	1.20±0.20	14.20±0.40	46.50±0.80	0.80±0.07	3.10±0.20	0.02±0.01	370±20
	E	17.00±2.00	14.00±2.00	0.24±0.02	0.27±0.03	0.19±0.08	74.00±1.00	207.00±3.00	0.11±0.04	1.17±0.10	14.30±0.50	44.50±0.80	0.90±0.06	3.21±0.30	Nd	380±20
	M	33.00±2.00	27.00±6.00	0.34±0.02	0.33±0.02	0.33±0.01	121.00±2.00	225.00±2.00	0.13±0.01	2.32±0.08	20.10±0.40	46.30±0.80	1.60±0.70	3.40±0.10	Nd	460±10
	N	21.00±4.00	23.00±7.00	0.32±0.03	0.31±0.05	0.22±0.02	74.00±2.00	240.00±3.00	0.15±0.01	1.50±0.03	16.00±0.20	53.00±3.00	0.80±0.40	3.40±0.10	Nd	390±20
G	B	35.00±3.00	111.00±5.00	1.47±0.0	1.52±0.07	1.20±0.20	93.00±2.	400.00±9.00	0.52±0.02	1.80±0.20	10.70±0.20	47.00±2.00	1.10±0.09	0.37±0.03	Nd.	2000±7

				7			00									0
	E	31.00±3.00	107.00±3.00	1.47±0.07	1.47±0.06	1.12±0.30	93.00±2.00	379.00±8.00	0.37±0.04	1.75±0.10	9.70±0.20	47.30±1.00	0.80±0.08	0.29±0.02	Nd	2010±70
	M	33.00±2.00	55.00±3.00	0.67±0.02	1.08±0.04	1.7±0.10	60.70±0.60	261.00±7.00	0.41±0.02	2.88±0.06	18.50±0.40	47.50±0.80	1.40±0.60	1.15±0.05	Nd	1030±10
	N	25.00±3.00	64.00±3.00	0.87±0.04	0.93±0.04	0.70±0.09	100.00±4.00	176.00±7.00	0.32±0.02	1.50±0.2	14.60±0.40	48.00±3.00	0.90±0.30	0.57±0.05	Nd	1240±50
H	B	30.00±4.00	150.00±20.00	2.40±0.10	2.08±0.08	1.60±0.20	63.00±3.00	290.00±10.00	0.74±0.09	1.20±0.10	6.30±0.10	47.00±1.00	1.20.±0.02	1.60±0.09	Nd	3230±90
	E	27.00±5.00	138.00±18.00	2.40±0.10	2.13±0.08	1.45±0.20	63.00±3.00	267.00±7.00	0.73±0.01	1.15±0.20	4.70±0.30	43.90±3.00	1.40±0.01	1.47±0.08	Nd	3240±90
	M	45.00±1.00	140.00±6.00	2.08±0.05	1.68±0.05	1.2±0.02	48.00±1.00	238.00±6.00	0.58±0.02	1.30±0.05	6.00±0.50	39.60±0.80	1.90±0.60	2.26±0.04	Nd	2690±50
	N	40.00±5.00	60.00±6.00	0.74±0.05	0.7±0.07	0.40±0.02	60.10±1.00	160.00±10.00	0.24±0.02	0.60±0.2	6.00±0.50	38.00±0.60	0.80±0.50	3.00±0.20	Nd	1070±100
I	B	51.00±3.00	71.00±5.00	1.20±0.20	0.98±0.05	0.68±0.10	29.20±0.90	1650.00±40.00	0.27±0.03	1.80±0.10	8.20±0.30	31.00±3.00	1.60±0.05	0.96±0.03	Nd	1300±100
	E	34.70±3.00	73.00±5.00	1.20±0.20	0.87±0.04	0.71±0.20	29.20±0.90	1637.00±41.00	0.23±0.01	1.78±0.10	8.40±0.03	33.20±5.00	1.70±0.04	0.89±0.02	Nd	1320±100
	M	53.00±2.00	48.00±3.00	1.15±0.04	0.59±0.02	1.02±0.05	113.00±3.00	2990.000±90.00	0.47±0.01	4.70±0.20	12.10±0.80	26.20±0.50	2.80±0.50	0.49±0.03	0.02	940±30
	N	35.00±2.00	78.00±7.00	1.36±0.06	1.2±0.06	1.20±0.05	47.90±0.70	1600.00±2.00	0.36±0.02	2.00±0.40	7.20±0.30	26.00±2.00	2.60±0.90	0.40±0.03	0.02±0.01	1500±60
J	B	27.00±2.00	300.00±20.00	4.40±0.30	3.60±0.10	2.10±0.10	92.00±3.00	580.00±30.00	1.21±0.03	3.80±0.20	13.70±0.10	73.00±0.80	3.00±0.70	0.67±0.02	Nd	5700±300
	E	24.00±1.	298.00±22.	4.40±0.3	3.30±0.2	2.23±0.1	92.00±3.	543.00±34.	1.22±0	3.81±0	12.90±0.	74.10±0.	3.10±0.5	0.59±0.0	Nd	5720±3

		00	00	0	0	0	00	00	.03	.03	09	70	0	3		00
	M	63.00±2.00	126.00±10.00	2.04±0.04	3.86±0.07	2.08±0.20	122.00±2.00	491.00±7.00	1.42±0.02	7.70±0.20	29.00±6.00	58±3	1.80±0.60	0.61±0.05	Nd	3440±40
	N	36.00±4.00	128.00±7.00	1.70±0.10	1.5±0.07	1.02±0.09	104.00±3.00	280.00±10.00	0.51±0.02	1.10±0.20	13.00±0.10	64.40±1.00	1.50±0.50	0.90±0.10	0.02±0.01	2400±100
K	B	50.00±5.00	54.00±10.00	0.75±0.05	0.68±0.03	1.00±0.20	31.00±3.00	540.00±80.00	0.24±0.05	0.60±0.10	9.80±0.60	53.00±0.30	0.70±0.07	0.12±0.04	0.02±0.01	920±90
	E	43.00±6.00	47.00±10.00	0.75±0.05	0.57±0.03	1.31±0.30	31.00±3.00	527.00±82.00	0.22±0.04	0.53±0.10	9.50±0.50	51.70±4.00	0.60±0.40	0.09±0.03	0.03±0.01	940±90
	M	33.00±2.00	13.00±1.00	0.33±0.01	0.17±0.01	0.40±0.20	25.30±0.60	342.00±7.00	0.06±0.01	0.41±0.03	2.90±0.10	70.00±2.00	1.00±0.50	0.13±0.01	Nd	310±10
	N	29.00±3.00	90.00±8.00	1.40±0.10	1.12±0.1	0.70±0.2	57.00±3.00	264.00±10.00	0.39±0.03	0.70±0.30	4.7±0.40	45.00±5.00	1.30±0.60	0.28±0.06	Nd	1800±100
L	B	24.00±3.00	110.00±10.00	1.50±0.06	1.99±0.02	2.23±0.10	32.00±2.00	330.00±40.00	0.64±0.01	1.00±0.09	9.20±0.10	108.00±9.00	1.60±0.80	0.90±0.10	Nd	2600±200
	E	21.00±3.00	107.00±11.00	1.50±0.06	1.49±0.03	2.41±0.10	32.00±2.00	319.00±43.00	0.56±0.01	1.10±0.08	8.70±0.08	103.00±7.00	1.30±0.60	0.87±0.20	Nd	2620±200
	M	33.00±1.00	233.00±10.00	3.47±0.06	3.00±0.10	2.3±0.20	73.00±2.00	300.00±10.00	1.03±0.03	1.68±0.04	15.70±0.30	123.00±3.00	2.20±0.40	2.83±0.05	Nd	4580±100
	N	22.00±3.00	400.00±30.00	5.90±0.50	5.13±0.1	3.20±0.1	82.90±0.90	529.00±20.00	1.56±0.03	2.40±0.10	12.50±0.20	82.00±0.90	2.00±0.80	2.44±0.04	Nd	6000±500
M	B	8.00±3.00	11.00±0.90	0.33±0.03	0.27±0.02	0.30±0.02	76.00±1.00	880.00±20.00	0.09±0.01	1.40±0.10	10.40±0.10	15.10±0.40	1.20±0.03	0.05±0.03	Nd	230±10
	E	5.00±1.00	8.00±1.00	0.33±0.03	0.23±0.02	0.28±0.03	76.00±1.00	879.00±17.00	0.09±0.02	1.37±0.09	11.40±1.2	15.30±0.50	1.10±0.08	0.12±0.02	Nd	220±10
	M	10.20±0.70	13.00±1.00	0.35±0.	0.29±0.01	0.27±0.03	75.00±3.	810.00±30.00	0.09±0.01	1.54±0.08	10.00±0.40	15.80±0.80	1.30±0.50	0.08±0.01	Nd	270±10

				03			00									
	N	8.00±1.00	19.00±2.00	0.42±0.04	0.31±0.03	0.12±0.01	75.00±1.00	920.00±20.00	0.11±0.01	1.40±0.30	10.20±0.30	16.50±0.90	1.10±0.30	0.06±0.003	Nd	350±10
N	B	15.00±2.00	17.80±0.90	0.25±0.03	0.14±0.02	1.00±0.01	9.10±0.10	81.00±1.00	0.05±0.01	0.30±0.10	4.70±0.10	5.00±1.00	0.60±0.03	0.11±0.03	Nd	320±10
	E	11.00±2.00	14.90±0.90	0.25±0.03	0.17±0.03	1.10±0.010	9.10±0.10	57.00±4.00	0.04±0.01	0.28±0.10	4.4±0.10	4.80±0.30	0.70±0.02	0.08±0.02	Nd	340±10
	M	12.30±0.80	8.10±0.90	0.10±0.01	0.09±0.007	0.19±0.03	8.00±0.30	17.50±0.50	0.05±0.01	0.21±0.03	1.56±0.04	5.00±0.80	0.60±0.40	0.14±0.03	Nd	140±10
	N	9.00±2.00	10.00±3.00	0.09±0.02	0.08±0.02	0.04±0.01	8.90±0.20	18.20±0.20	0.04±0.01	0.27±0.10	1.6±0.40	3.90±0.60	0.40±0.30	0.11±0.005	Nd	120±10
O	B	11.00±1.00	33.00±2.00	0.44±0.04	0.39±0.05	0.53±0.04	9.80±0.20	57.00±1.00	0.13±0.03	0.40±0.10	2.70±0.10	7.40±0.80	0.50±0.08	0.23±0.06	Nd	560±20
	E	8.00±2.00	28.00±3.00	0.44±0.04	0.43±0.05	0.61±0.05	9.80±0.20	59.00±2.00	0.21±0.05	0.37±0.07	3.40±0.20	7.10±0.90	0.60±0.04	0.17±0.05	Nd	540±20
	M	18.00±1.00	26.00±2.00	0.36±0.02	0.33±0.02	0.36±0.06	12.60±0.40	185.00±5.00	0.09±0.02	0.33±0.04	4.60±0.20	8.40±0.50	0.60±0.50	0.06±0.02	Nd	480±10
	N	9.00±1.00	40.00±10.00	0.54±0..03	0.49±0.03	0.30±0.07	9.80±0.10	64.00±2.00	0.17±0.01	0.40±0.07	2.80±0.02	6.20±0.80	0.90±0.60	0.22±0.09	Nd	740±20
P	B	20.00±3.00	51.00±7.00	0.73±0.04	0.80±0.07	0.83±0.03	28.00±2.00	279.00±20.00	0.33±0.03	0.90±0.10	6.90±0.30	50.00±2.00	1.40±0.20	0.90±0.20	Nd	1150±50
	E	16.00±4.00	46.00±8.00	0.73±0.04	0.65±0.08	0.87±0.30	28.00±2.00	263.00±22.00	0.28±0.03	0.91±0.10	5.80±0.30	51.20±4.00	1.10±0.10	0.83±0.1	Nd	1160±50
	M	59.00±4.00	180.00±20.00	2.50±0.10	6.00±0.20	3.20±0.20	38.00±2.00	320.00±9.00	2.07±0.05	2.61±0.09	14.3±0.50	84.00±4.00	1.70±0.40	0.29±0.04	0.02	4700±200
	N	41.00±3.00	49.00±2.00	0.70±0.07	0.65±0.02	0.80±0.05	19.10±0.20	102.00±1.00	0.2±0.01	0.50±0.04	8.90±0.09	42.00±0.90	0.80±0.50	0.76±0.06	Nd	990±20

Q	B	12.00±2.00	139.00±8.00	1.99±0.07	1.37±0.05	0.70±0.05	26.50±0.80	269.00±8.00	0.27±0.03	0.80±0.10	7.60±0.30	63.00±2.00	2.00±0.50	0.49±0.05	Nd	2600±100
	E	11.00±2.00	137.00±9.00	1.99±0.07	1.17±0.05	0.57±0.07	26.50±0.80	258.00±6.00	0.23±0.06	0.82±0.06	8.20±0.40	62.30±1.00	2.30±0.30	0.37±0.04	Nd	2640±100
	M	9.70±0.70	99.00±9.00	1.44±0.03	1.39±0.04	1.00±0.20	18.30±0.20	173.00±3.00	0.36±0.02	1.03±0.05	5.9±0.10	37.90±0.50	3.00±0.50	0.40±0.03	Nd	1950±40
	N	13.00±1.00	124.00±24.00	1.32±0.04	1.43±0.1	0.90±0.01	15.60±1.20	284.00±2.00	0.24±0.02	0.90±0.01	7.40±0.08	59.00±1.00	2.10±0.70	0.48±0.04	0.03±0.02	1850±40
R	B	50.00±3.00	25.30±2.00	0.34±0.02	0.43±0.04	0.99±0.06	19.60±0.80	610.00±60.00	0.13±0.01	0.90±0.10	13.60±0.60	69.00±2.00	0.70±0.05	0.16±0.01	0.02±0.01	450±20
	E	51.00±2.00	23.80±2.00	0.34±0.02	0.63±0.06	1.10±0.04	19.60±0.80	609.00±63.00	0.11±0.03	0.92±0.20	12.90±0.50	67.00±2.00	0.60±0.04	0.09±0.01	0.03±0.01	460±20
	M	53.00±2.00	29.00±6.00	0.42±0.07	0.38±0.02	0.69±0.07	22.90±0.60	320.00±10.00	0.14±0.02	0.86±0.05	10.0±0.30	54.00±1.00	0.80±0.50	0.05±0.02	0.01	550±20
	N	58.00±8.00	50.00±10.00	0.71±0.07	0.61±0.03	0.86±0.03	18.70±0.90	730.00±30.00	0.23±0.01	0.70±0.30	12.4±0.60	64.00±4.00	1.10±0.60	0.08±0.04	0.03±0.01	920±60
S	B	31.00±5.00	65.00±7.00	0.92±0.10	1.00±0.10	0.85±0.10	19.00±2.00	260.00±20.00	0.29±0.04	0.90±0.20	3.80±0.20	56.00±7.00	0.90±0.05	1.15±0.10	Nd	1300±100
	E	33.00±3.00	53.00±8.00	0.92±0.10	0.71±0.09	0.83±0.20	19.00±2.00	253.00±23.00	0.23±0.02	0.89±0.30	3.70±0.20	53.00±8.00	0.80±0.03	1.00±0.08	Nd	1320±100
	M	40.00±2.00	73.00±6.00	0.99±0.05	1.02±0.03	1.17±0.09	19.50±0.40	281.00±9.00	0.29±0.02	0.94±0.06	3.67±0.07	60.00±1.00	1.30±0.40	1.29±0.03	Nd	1260±30
	N	30.00±1.00	65.00±9.00	1.04±0.05	0.99±0.07	0.85±0.2	53.00±1.00	480.00±40.00	0.34±0.03	0.71±0.07	4.40±0.40	92.60±3.00	1.40±0.70	1.23±0.05	Nd	1290±70

Table 4.22 b: Total trace element concentration in medicinal plants from the Sub Counties

Element	Subcounty	Sr	Y	Zr	Nb	Ba	Nd	Sm	Gd	Er	Yb	Tl	Hg	As	Pb
Sample		Mean Concentration in mg/Kg													
A	B	110.00±20.00	1.00±0.20	8.00±1.00	1.20±0.20	21.00±3.00	1.10±0.20	0.21±0.04	0.24±0.06	0.11±0.02	0.09±0.02	0.03±0.01	Nd	Nd	Nd
	E	112.00±20.00	1.04±0.20	8.00±1.00	1.20±0.20	21.42±3.00	1.12±0.20	0.21±0.04	0.24±0.06	0.11±0.02	0.09±0.02	0.03±0.01	Nd	Nd	Nd
	M	92.00±3.00	1.13±0.05	12.00±2.00	1.80±0.20	19.00±0.50	1.30±0.07	0.25±0.01	0.27±0.04	0.13±0.01	0.11±0.01	0.03±0.01	Nd	Nd	Nd
	N	98.00±2.00	0.50±0.01	9.00±2.00	0.27±0.06	17.80±0.30	0.53±0.02	0.09±0.01	0.12±0.02	0.05±0.01	0.05±0.01	0.03±0.01	Nd	Nd	Nd
B	B	25.20±0.60	4.09±0.06	16.00±0.70	3.90±0.60	15.50±0.20	4.60±0.20	0.88±0.02	0.92±0.09	0.46±0.01	0.40±0.03	Nd	Nd	Nd	Nd
	E	23.20±0.60	4.06±0.06	16.03±0.70	3.90±0.60	15.52±0.20	4.61±0.20	0.88±0.02	0.92±0.09	0.46±0.01	0.40±0.03	0.02±0.01	Nd	0.03±0.01	Nd
	M	28.60±0.70	1.82±0.07	14.00±0.70	3.70±0.70	22.10±1.00	2.10±0.10	0.37±0.01	0.41±0.05	0.20±0.01	0.17±0.02	0.02±0.01	Nd	Nd	Nd
	N	45.20±0.80	4.27±0.04	14.00±3.00	4.20±0.50	44.80±0.60	4.90±0.2	0.92±0.02	1.01±0.09	0.47±0.02	0.44±0.01	0.02±0.01	0 Nd	Nd	0.03±0.01
C	B	158.00±5.00	2.40±0.20	16.00±2.00	3.00±0.20	65.00±2.00	3.20±0.20	0.59±0.04	0.70±0.10	0.27±0.01	0.24±0.03	Nd	Nd	Nd	1.01±0.05
	E	156.00±5.00	2.20±0.20	16.00±2.00	3.00±0.20	65.03±2.00	3.21±0.20	0.59±0.04	0.70±0.10	0.27±0.01	0.24±0.03	Nd	Nd	0.03±0.01	Nd
	M	149.00±3.00	4.38±0.08	24.00±3.00	5.20±0.40	93.00±2.00	5.80±0.20	0.94±0.03	1.20±0.20	0.42±0.02	0.31±0.02	Nd	Nd	0.02	Nd
	N	146.00±3.00	4.35±0.08	23.00±3.00	5.24±0.40	93.40±2.00	5.84±0.20	0.92±0.03	1.23±0.20	0.42±0.02	0.31±0.02	0.03±0.01	Nd	Nd	Nd

D	B	64.00±2.00	0.68±0.03	11.00±3.00	1.00±0.07	25.70±0.70	0.80±0.03	0.15±0.01	0.17±0.03	0.08±0.01	0.07±0.01	Nd	Nd	Nd	Nd
	E	62.30±2.00	0.66±0.03	13.00±3.00	1.00±0.07	25.74±0.70	0.80±0.03	0.14±0.01	0.17±0.03	0.08±0.01	0.07±0.01	Nd	Nd	Nd	Nd
	M	133.00±6.00	2.30±0.10	17.00±0.37	3.20±0.50	57.00±3.00	2.90±0.20	0.50±0.02	0.56±0.09	0.25±0.02	0.20±0.01	Nd	Nd	Nd	Nd
	N	218.00±5.00	1.73±0.05	15.00±1.00	3.20±0.20	49.80±0.40	2.17±0.07	0.37±0.01	0.44±0.07	0.18±0.01	0.15±0.01	Nd	0.02	Nd	Nd
E	B	71.00±1.00	5.50±2.00	490.00±70.00	0.50±0.01	84.00±1.00	53.00±2.00	8.90±0.30	10.6o±0.60	3.90±0.10	2.53±0.06	Nd	Nd	0.03±0.01	Nd
	E	69.00±1.00	53.00±2.00	490.00±72.00	0.50±0.01	84.00±1.00	53.10±2.00	8.92±0.30	10.30±0.60	3.90±0.10	2.53±0.06	0.03±0.01	Nd	Nd	Nd
	M	88.00±1.00	14.00±0.20	350.00±90.00	1.60±0.30	58.40±0.60	17.00±0.50	2.75±0.03	3.20±0.40	1.11±0.02	0.78±0.04	0.03±0.01	Nd	0.02	Nd
	N	68.00±1.00	21.90±0.30	250.00±50.00	0.91±0.04	25.10±0.30	23.40±0.7	3.76±0.05	4.60±0.40	1.65±0.04	1.14±0.04	Nd	Nd	Nd	Nd
F	B	32.50±0.50	1.40±0.10	250.00±80.00	0.40±0.01	72.00±1.00	1.42±0.06	0.19±0.01	0.28±0.09	0.15±0.01	0.27±0.04	0.03±0.01	0.02	Nd	Nd
	E	30.50±0.50	1.400±0.10	252.00±80.00	0.44±0.01	72.04±1.00	1.42±0.06	0.19±0.01	0.28±0.09	0.15±0.01	0.27±0.04	0.03±0.01	Nd	Nd	Nd
	M	36.30±0.50	1.40±0.10	290.00±80.00	1.00±0.20	34.70±0.60	1.11±0.05	0.18±0.01	0.23±0.05	0.17±0.02	0.31±0.06	Nd	0.02	Nd	Nd
	N	29.00±0.50	1.30±0.20	140.00±30.00	0.20±0.02	65.30±0.90	1.47±0.07	0.20±0.01	0.30±0.10	0.15±0.03	0.23±0.06	0.03±0.01	Nd	Nd	0.40±0.01
G	B	146.00±4.00	3.40±0.10	150.00±20.00	5.70±0.50	106.00±3.00	4.30±0.20	0.69±0.03	0.80±0.02	0.36±0.02	0.39±0.04	Nd	Nd	Nd	Nd
	E	143.00±4.00	3.44±0.10	151.00±20.00	5.72±0.50	103.00±3.00	4.31±0.20	0.67±0.03	0.80±0.02	0.33±0.02	0.39±0.04	Nd	0.02	Nd	Nd

	M	93.00±1.00	2.00±0.10	300.00±80.00	2.00±0.20	130.00±3.00	1.92±0.06	0.32±0.01	0.40±0.10	0.22±0.02	0.32±0.06	0.03±0.01	Nd	Nd	Nd
	N	96.00±4.00	1.60±0.10	110.00±30.00	2.70±0.20	80.00±3.00	1.94±0.08	0.32±0.01	0.41±0.06	0.18±0.01	0.21±0.02	Nd	Nd	Nd	1.02±0.05
H	B	242.00±7.00	3.87±0.10	30.00±6.00	6.00±1.00	101.00±4.00	5.40±0.30	0.92±0.02	1.00±0.10	0.41±0.02	0.37±0.05	Nd	Nd	0.02±0.01	1.02±0.09
	E	241.00±7.00	3.85±0.10	30.04±6.00	6.02±1.00	101.00±4.00	5.40±0.30	0.94±0.02	1.01±0.10	0.37±0.02	0.37±0.05	Nd	Nd	Nd	1.02±0.08
	M	221.00±4.00	4.20±0.10	70.00±10.00	6.20±0.60	81.00±2.00	4.80±0.20	0.86±0.02	0.90±0.10	0.45±0.01	0.40±0.02	Nd	Nd	Nd	0.03
	N	203.00±7.00	2.20±0.10	21.00±4.00	2.40±0.4	92.00±3.00	2.30±0.20	0.40±0.03	0.50±0.10	0.20±0.01	0.18±0.01	Nd	Nd	Nd	Nd
I	B	128.00±3.00	5.50±0.10	49.00±7.00	3.00±0.30	37.00±2.00	6.40±0.20	0.97±0.03	1.20±0.20	0.45±0.02	0.35±0.01	0.03±0.01	Nd	Nd	Nd
	E	128.03±3.00	5.54±0.10	49.40±7.00	3.20±0.30	37.00±2.00	6.40±0.20	0.96±0.03	1.20±0.20	0.43±0.02	0.35±0.01	Nd	0.02	Nd	Nd
	M	57.00±2.00	10.30±0.30	110.00±30.00	2.30±0.30	60.00±2.00	9.90±0.40	1.53±0.05	1.90±0.30	0.79±0.03	0.54±0.03	0.03±0.01	Nd	Nd	Nd
	N	90.00±2.00	8.10±0.10	20.00±1.00	3.20±0.50	53.00±0.50	10.70±0.50	1.63±0.04	1.90±0.30	0.61±0.02	0.43±0.02	0.02±0.01	Nd	0.02±0.01	Nd
J	B	85.00±2.00	9.42±0.09	90.00±20.00	12.00±2.00	39.00±1.00	11.10±0.30	1.99±0.03	2.10±0.20	1.01±0.01	0.89±0.08	Nd	0.02	0.02±0.01	1.01±0.04
	E	85.40±2.00	9.43±0.09	90.07±20.00	12.30±2.00	39.00±1.00	11.20±0.30	1.97±0.03	2.14±0.20	1.01±0.01	0.89±0.08	Nd	Nd	0.03±0.01	1.01±0.5
	M	78.00±1.00	5.70±0.10	80.00±20.00	4.80±0.60	101.00±2.00	5.60±0.20	0.91±0.02	1.10±0.20	0.51±0.01	0.43±0.02	Nd	Nd	Nd	0.02
	N	94.00±2.00	3.25±0.09	35.00±5.00	6.10±0.40	39.00±1.00	4.10±0.20	0.68±0.03	0.76±0.07	0.34±0.01	0.31±0.01	Nd	0.02	Nd	1.01±0.05

K	B	52.00 ±6.00	3.50. ±0.7	200.00±20.00	2.00 ±0.40	64.00 ±7.00	3.20 ±0.40	0.53 ±0.07	0.60 ±0.10	0.33 ±0.07	0.40 ±0.02	Nd	Nd	Nd	0.72 ±0.3
	E	52.00 ±6.00	3.52 ±0.7	203.00±20.00	2.05 ±0.40	64.00 ±7.00	3.23 ±0.40	0.53 ±0.07	0.56 ±0.10	0.33 ±0.07	0.40 ±0.02	Nd	Nd	Nd	Nd
	M	96.00 ±2.00	2.73 ±0.04	18.00 ±3.00	0.70 ±0.20	104.00±2.00	3.00 ±0.10	0.34 ±0.01	0.50 ±0.02	0.15 ±0.01	0.09 ±0.01	Nd	Nd	Nd	Nd
	N	74.00 ±3.00	4.80 ±0.30	15.00 ±2.00	3.80 ±0.10	47.00 ±1.00	6.00 ±0.40	0.90 ±0.05	1.10 ±0.20	0.39 ±0.03	0.30 ±0.02	Nd	Nd	Nd	Nd
L	B	53.00 ±5.00	3.50 ±0.30	58.00 ±4.00	3.10 ±0.20	22.00 ±2.00	3.90 ±0.50	0.73 ±0.08	0.80 ±0.10	0.42 ±0.03	0.42 ±0.05	Nd	0.02	Nd	0.66 ±0.1
	E	51.00 ±5.00	3.52 ±0.30	58.30 ±4.00	3.14 ±0.20	22.00 ±2.00	3.93 ±0.50	0.73 ±0.08	0.68 ±0.10	0.42 ±0.03	0.41 ±0.05	Nd	Nd	0.03	Nd
	M	53.00 ±1.00	5.40 ±0.10	130.00±30.00	10.00±1.00	32.20 ±0.50	6.60 ±0.20	1.14 ±0.03	1.20 ±0.10	0.62 ±0.01	0.58 ±0.04	Nd	Nd	Nd	0.01
	N	41.30 ±0.50	9.07 ±0.08	80.00 ±10.00	15.00±2.00	27.70 ±0.40	11.20±0.30	1.98 ±0.05	2.10 ±0.20	1.00 ±0.03	0.89 ±0.07	Nd	0.02	0.03 ±0.01	1.01 ±0.04
M	B	22.50 ±0.70	3.80 ±0.07	160.00±30.00	0.20 ±0.01	26.00 ±0.70	4.20 ±0.20	0.78 ±0.04	0.80 ±0.10	0.35 ±0.01	0.35 ±0.04	Nd	Nd	Nd	Nd
	E	22.52 ±0.70	3.81 ±0.07	163.00±30.00	0.23 ±0.01	26.00 ±0.70	4.20 ±0.20	0.78 ±0.04	0.78 ±0.10	0.35 ±0.01	0.37 ±0.04	0.03 ±0.01	Nd	Nd	0.03 ±0.01
	M	22.10 ±0.70	3.60 ±0.20	110.00±20.00	0.40 ±0.10	26.00 ±1.00	4.20 ±0.20	0.78 ±0.04	0.81 ±0.09	0.34 ±0.02	0.29 ±0.02	0.02 ±0.01	Nd	Nd	Nd
	N	23.40 ±0.50	4.10 ±0.10	102.00±9.00	0.47 ±0.05	26.00 ±1.00	4.80 ±0.20	0.87 ±0.05	0.95 ±0.09	0.37 ±0.02	0.34 ±0.02	0.03 ±0.01	Nd	Nd	Nd
N	B	172.00±5.00	1.05 ±0.05	9.00± 1.00	0.74 ±0.07	47.00 ±1.00	1.08 ±0.07	0.20 ±0.01	0.24 ±0.04	0.10 ±0.01	0.09 ±0.01	0.02 ±0.01	0.02	Nd	Nd
	E	164.00±5.00	1.03 ±0.05	9.30± 1.00	0.72 ±0.07	47.00 ±1.00	1.08 ±0.07	0.22 ±0.01	0.24 ±0.04	0.12 ±0.01	0.09 ±0.01	0.03 ±0.01	Nd	Nd	Nd

	M	174.00±4.00	0.27±0.01	16.00±3.00	0.28±0.07	43.00±1.00	0.33±0.02	0.06±0.01	0.10±0.04	0.03±0.01	0.02±0.01	0.02±0.01	Nd	Nd	Nd
	N	201.00±4.00	0.29±0.02	11.00±3.00	0.07±0.01	45.50±0.90	0.35±0.02	0.05±0.01	0.10±0.04	0.02±0.01	0.02±0.01	0.02±0.01	Nd	Nd	Nd
O	B	155.00±5.00	0.96±0.02	11.00±3.00	1.60±0.3	43.40±0.90	1.17±0.05	0.21±0.01	0.25±0.04	0.10±0.01	0.09±0.01	0.03±0.01	Nd	Nd	0.66±0.09
	E	153.00±5.00	0.94±0.02	11.04±3.00	1.61±0.3	43.40±0.90	1.17±0.05	0.23±0.01	0.27±0.04	0.12±0.01	0.09±0.01	Nd	0.02	Nd	Nd
	M	134.00±2.00	0.76±0.03	8.00±1.00	1.20±0.1	49.10±0.90	0.92±0.05	0.17±0.01	0.21±0.05	0.08±0.02	0.07±0.01	Nd	0.01	Nd	Nd
	N	140.00±2.00	1.15±0.03	12.00±1.00	2.10±0.20	41.00±1.00	1.42±0.06	0.25±0.01	0.30±0.04	0.12±0.01	0.11±0.01	Nd	Nd	Nd	Nd
P	B	100.00±8.00	2.30±0.20	11.00±2.00	1.90±0.10	39.00±3.00	2.50±0.30	0.45±0.04	0.50±0.08	0.23±0.02	0.19±0.03	Nd	0.02	Nd	0.09±0.04
	E	104.00±8.00	2.32±0.20	11.30±2.00	1.93±0.10	39.00±3.00	2.52±0.30	0.45±0.04	0.53±0.08	0.23±0.02	0.21±0.03	Nd	Nd	0.02	Nd
	M	220.00±10.00	5.10±0.10	33.00±5.00	5.60±0.70	230.00±20.00	6.30±0.20	1.11±0.03	1.40±0.30	0.58±0.02	0.50±0.02	Nd	0.01	0.01	Nd
	N	97.00±1.00	1.65±0.03	6.00±2.00	2.10±0.30	83.50±0.80	2.02±0.07	0.35±0.02	0.43±0.08	0.16±0.01	0.15±0.01	Nd	Nd	Nd	Nd
Q	B	176.00±6.00	6.60±0.20	42.00±9.00	6.40±0.40	42.00±1.00	7.50±0.30	1.36±0.04	1.50±0.10	0.70±0.02	0.64±0.02	Nd	0.02	Nd	Nd
	E	174.00±6.00	6.64±0.20	42.07±9.00	6.45±0.40	42.00±1.00	7.54±0.30	1.36±0.04	1.52±0.10	0.67±0.02	0.62±0.02	Nd	Nd	0.03	Nd
	M	87.90±0.80	2.90±0.05	19.00±3.00	3.60±0.30	23.20±0.40	3.69±0.09	0.62±0.02	0.69±0.09	0.30±0.01	0.26±0.01	Nd	0.02	Nd	Nd
	N	84.93±0.80	2.92±0.05	19.30±3.00	3.40±0.30	23.20±0.40	3.64±0.09	0.63±0.02	0.67±0.09	0.28±0.01	0.22±0.01	Nd	Nd	0.03±0.01	Nd

R	B	44.00±2.00	2.40±0.20	160.00±10.00	0.72±0.06	80.00±3.00	1.70±0.10	0.32±0.02	0.38±0.07	0.25±0.02	0.28±0.04	Nd	Nd	Nd	Nd
	E	44.30±2.00	2.40±0.20	160.30±10.00	0.74±0.06	81.00±3.00	1.57±0.10	0.33±0.02	0.38±0.07	0.27±0.02	0.32±0.04	Nd	Nd	Nd	Nd
	M	26.60±0.60	1.58±0.04	42.00±2.00	1.41±0.10	49.00±1.00	1.36±0.05	0.25±0.01	0.28±0.04	0.16±0.01	0.14±0.01	Nd	Nd	Nd	Nd
	N	46.00±2.00	2.90±0.10	24.00±6.00	2.50±0.20	85.00±3.00	2.70±0.10	0.49±0.03	0.58±0.07	0.29±0.01	0.26±0.02	Nd	Nd	Nd	Nd
S	B	270.00±20.00	1.90±0.20	19.00±5.00	1.30±0.20	120.00±10.00	2.50±0.30	0.45±0.05	0.50±0.1	0.19±0.01	0.19±0.02	Nd	0.02	0.02±0.01	Nd
	E	274.00±20.00	1.92±0.20	21.00±5.00	1.33±0.20	120.00±10.00	2.50±0.30	0.45±0.05	0.45±0.1	0.16±0.01	0.17±0.02	Nd	Nd	Nd	Nd
	M	278.00±4.00	1.87±0.05	25.00±6.00	2.00±0.30	130.00±2.00	2.35±0.08	0.43±0.02	0.50±0.10	0.19±0.02	0.17±0.02	Nd	Nd	Nd	Nd
	N	260.00±10.00	2.90±0.20	12.00±2.00	2.10±0.20	148.00±4.00	3.50±0.30	0.55±0.04	0.70±0.2	0.24±0.02	0.20±0.03	Nd	Nd	Nd	Nd

Nd – below the detection limit

APPENDIX XII

Paired Samples Test for Trace elements in Nyamira Sub County

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1	B vs Ti	-58.9279	95.10668	21.81897	-104.7678	-13.0879	-2.701	18	.015
Pair 2	B vs V	27.6511	16.51192	3.78809	19.6926	35.6095	7.299	18	.000
Pair 3	B vs Cr	28.0349	16.29719	3.73883	20.1800	35.8899	7.498	18	.000
Pair 4	B vs Mn	-299.7963	378.88324	86.92178	-482.4122	-117.1804	-3.449	18	.003
Pair 5	B vs Co	28.3779	16.42534	3.76823	20.4611	36.2947	7.531	18	.000
Pair 6	B vs Cu	27.5189	16.71490	3.83466	19.4626	35.5753	7.176	18	.000
Pair 7	B- Ni	19.5232	17.71396	4.06386	10.9853	28.0610	4.804	18	.000
Pair 8	B vs Zn	-7.7016	23.00398	5.27748	-18.7891	3.3860	-1.459	18	.162
Pair 9	B vs Ga	27.5637	16.37923	3.75765	19.6691	35.4582	7.335	18	.000
Pair 10	B vs Se	27.2121	16.30577	3.74080	19.3530	35.0712	7.274	18	.000
Pair 11	B vs Rb	-18.1911	31.77950	7.29072	-33.5083	-2.8738	-2.495	18	.023
Pair 12	B vs Sr	-79.0595	70.98209	16.28441	-113.2717	-44.8472	-4.855	18	.000
Pair 13	B vs Y	24.5926	16.28961	3.73709	16.7413	32.4440	6.581	18	.000
Pair 14	B vs Zr	-19.4700	64.78530	14.86277	-50.6955	11.7555	-1.310	18	.207
Pair 15	B vs Nb	25.5832	16.57714	3.80306	17.5932	33.5731	6.727	18	.000
Pair 16	B vs Mo	27.8474	16.36437	3.75424	19.9600	35.7347	7.418	18	.000
Pair 17	B vs Ba	-28.1647	29.53346	6.77544	-42.3994	-13.9301	-4.157	18	.001
Pair 18	B vs Nd	23.9174	16.39375	3.76098	16.0158	31.8189	6.359	18	.000
Pair 19	B vs Sm	27.9075	16.33176	3.74676	20.0359	35.7792	7.448	18	.000
Pair 20	B vs Gd	27.7747	16.29226	3.73770	19.9221	35.6274	7.431	18	.000
Pair 21	B vs Er	28.3324	16.38819	3.75971	20.4336	36.2313	7.536	18	.000
Pair 22	B vs Yb	28.3943	16.40651	3.76391	20.4866	36.3020	7.544	18	.000
Pair 23	B vs Tl	28.6418	16.45123	3.77417	20.7126	36.5711	7.589	18	.000
Pair 24	Ti vs V	86.5789	91.29060	20.94350	42.5783	130.5796	4.134	18	.001
Pair 25	Ti vs Cr	86.9628	91.75911	21.05098	42.7364	131.1893	4.131	18	.001
Pair 26	Ti vs Mn	-240.8684	387.76413	88.95919	-427.7647	-53.9721	-2.708	18	.014
Pair 27	Ti vs Co	87.3058	92.09137	21.12721	42.9192	131.6924	4.132	18	.001
Pair 28	Ti vs Ni	86.4468	91.87355	21.07724	42.1652	130.7285	4.101	18	.001
Pair 29	Ti vs Cu	78.4511	90.30079	20.71642	34.9275	121.9746	3.787	18	.001
Pair 30	Ti vs Zn	51.2263	85.38248	19.58809	10.0733	92.3794	2.615	18	.018
Pair 31	Ti vs Ga	86.4916	91.27514	20.93995	42.4984	130.4848	4.130	18	.001
Pair 32	Ti vs Se	86.1400	92.12988	21.13604	41.7348	130.5452	4.076	18	.001
Pair 33	Ti vs Rb	40.7368	90.69819	20.80759	-2.9783	84.4520	1.958	18	.066
Pair 34	Ti vs Sr	-20.1316	126.92908	29.11953	-81.3094	41.0463	-.691	18	.498
Pair 35	Ti vs Y	83.5205	91.64283	21.02431	39.3501	127.6910	3.973	18	.001
Pair 36	Ti vs Zr	39.4579	115.09646	26.40494	-16.0168	94.9326	1.494	18	.152

Pair 37	Ti vs Nb	84.5111	89.21293	20.46685	41.5118	127.5103	4.129	18	.001
Pair 38	Ti vs Mo	86.7753	92.07944	21.12447	42.3944	131.1561	4.108	18	.001
Pair 39	Ti vs Ba	30.7632	103.47048	23.73776	-19.1080	80.6343	1.296	18	.211
Pair 40	Ti vs Nd	82.8453	91.30273	20.94628	38.8388	126.8518	3.955	18	.001
Pair 41	Ti vs Sm	86.8354	92.18184	21.14797	42.4052	131.2656	4.106	18	.001
Pair 42	Ti vs Gd	86.7026	92.20609	21.15353	42.2607	131.1445	4.099	18	.001
Pair 43	Ti vs Er	87.2603	92.28786	21.17229	42.7790	131.7416	4.121	18	.001
Pair 44	Ti vs Yb	87.3222	92.29605	21.17417	42.8369	131.8075	4.124	18	.001
Pair 45	Ti vs Tl	87.5697	92.36358	21.18966	43.0519	132.0876	4.133	18	.001
Pair 46	V vs Cr	.3839	.52892	.12134	.1290	.6388	3.164	18	.005
Pair 47	V vs Mn	-327.4474	383.43115	87.96514	-512.2553	-142.6395	-3.722	18	.002
Pair 48	V vs Co	.7268	.80774	.18531	.3375	1.1162	3.922	18	.001
Pair 49	V vs Ni	-.1321	.95589	.21930	-.5928	.3286	-.602	18	.554
Pair 50	V vs Cu	-8.1279	5.29705	1.21523	-10.6810	-5.5748	-6.688	18	.000
Pair 51	V vs Zn	-35.3526	27.81986	6.38231	-48.7614	-21.9439	-5.539	18	.000
Pair 52	V vs Ga	-.0874	.45132	.10354	-.3049	.1302	-.844	18	.410
Pair 53	V vs Se	-.4389	1.29155	.29630	-1.0615	.1836	-1.481	18	.156
Pair 54	V vs Rb	-45.8421	30.20543	6.92960	-60.4007	-31.2836	-6.615	18	.000
Pair 55	V vs Sr	-106.7105	68.79806	15.78336	-139.8701	-73.5509	-6.761	18	.000
Pair 56	V vs Y	-3.0584	4.77951	1.09650	-5.3621	-.7548	-2.789	18	.012
Pair 57	V vs Zr	-47.1211	63.07785	14.47105	-77.5236	-16.7185	-3.256	18	.004
Pair 58	V vs Nb	-2.0679	2.20129	.50501	-3.1289	-1.0069	-4.095	18	.001
Pair 59	V vs Mo	.1963	1.21227	.27811	-.3880	.7806	.706	18	.489
Pair 60	V vs Ba	-55.8158	32.76705	7.51728	-71.6090	-40.0226	-7.425	18	.000
Pair 61	V vs Nd	-3.7337	5.21447	1.19628	-6.2470	-1.2204	-3.121	18	.006
Pair 62	V vs Sm	.2565	1.20764	.27705	-.3256	.8385	.926	18	.367
Pair 63	V vs Gd	.1237	1.34443	.30843	-.5243	.7717	.401	18	.693
Pair 64	V vs Er	.6814	1.05936	.24303	.1708	1.1920	2.804	18	.012
Pair 65	V vs Yb	.7433	1.03667	.23783	.2436	1.2429	3.125	18	.006
Pair 66	V vs Tl	.9908	1.08473	.24885	.4680	1.5136	3.981	18	.001
Pair 67	Cr vs Mn	-327.8313	383.34046	87.94433	-512.5955	-143.0671	-3.728	18	.002
Pair 68	Cr vs Co	.3429	.43055	.09878	.1354	.5505	3.472	18	.003
Pair 69	Cr vs Ni	-.5160	.92031	.21113	-.9596	-.0724	-2.444	18	.025
Pair 70	Cr vs Cu	-8.5118	5.51112	1.26434	-11.1681	-5.8555	-6.732	18	.000
Pair 71	Cr vs Zn	-35.7365	27.82880	6.38436	-49.1496	-22.3235	-5.598	18	.000
Pair 72	Cr vs Ga	-.4713	.60559	.13893	-.7631	-.1794	-3.392	18	.003
Pair 73	Cr vs Se	-.8228	1.09612	.25147	-1.3512	-.2945	-3.272	18	.004
Pair 74	Cr vs Rb	-46.2260	30.23739	6.93693	-60.8000	-31.6520	-6.664	18	.000
Pair 75	Cr vs Sr	-107.0944	68.69505	15.75973	-140.2044	-73.9845	-6.795	18	.000
Pair 76	Cr vs Y	-3.4423	4.76283	1.09267	-5.7379	-1.1467	-3.150	18	.006
Pair 77	Cr vs Zr	-47.5049	63.05175	14.46506	-77.8949	-17.1150	-3.284	18	.004
Pair 78	Cr vs Nb	-2.4518	2.61897	.60083	-3.7141	-1.1895	-4.081	18	.001
Pair 79	Cr vs Mo	-.1876	.98754	.22656	-.6636	.2884	-.828	18	.419
Pair 80	Cr vs Ba	-56.1997	32.59145	7.47699	-71.9083	-40.4911	-7.516	18	.000
Pair 81	Cr vs Nd	-4.1176	5.22288	1.19821	-6.6349	-1.6002	-3.436	18	.003

Pair 82	Cr vs Sm	-.1274	.94192	.21609	-.5814	.3266	-.590	18	.563
Pair 83	Cr vs Gd	-.2602	1.09650	.25155	-.7887	.2683	-1.034	18	.315
Pair 84	Cr vs Er	.2975	.69222	.15881	-.0362	.6311	1.873	18	.077
Pair 85	Cr vs Yb	.3594	.65202	.14958	.0451	.6736	2.402	18	.027
Pair 86	Cr vs Tl	.6069	.69972	.16053	.2696	.9442	3.781	18	.001
Pair 87	Mn vs Co	328.1742	383.53224	87.98833	143.3176	513.0308	3.730	18	.002
Pair 88	Mn vs Ni	327.3153	383.39514	87.95688	142.5247	512.1058	3.721	18	.002
Pair 89	Mn vs Cu	319.3195	383.52990	87.98779	134.4640	504.1750	3.629	18	.002
Pair 90	Mn vs Zn	292.0947	378.28215	86.78388	109.7686	474.4209	3.366	18	.003
Pair 91	Mn vs Ga	327.3600	383.36013	87.94885	142.5863	512.1337	3.722	18	.002
Pair 92	Mn vs Se	327.0084	383.41289	87.96095	142.2093	511.8075	3.718	18	.002
Pair 93	Mn vs Rb	281.6053	377.90901	86.69827	99.4590	463.7516	3.248	18	.004
Pair 94	Mn vs Sr	220.7368	408.13540	93.63268	24.0219	417.4518	2.357	18	.030
Pair 95	Mn vs Y	324.3889	382.76013	87.81120	139.9045	508.8734	3.694	18	.002
Pair 96	Mn vs Zr	280.3263	389.62286	89.38561	92.5341	468.1185	3.136	18	.006
Pair 97	Mn vs Nb	325.3795	383.19526	87.91102	140.6853	510.0737	3.701	18	.002
Pair 98	Mn vs Mo	327.6437	383.66834	88.01955	142.7215	512.5659	3.722	18	.002
Pair 99	Mn vs Ba	271.6316	383.57012	87.99702	86.7567	456.5065	3.087	18	.006
Pair 100	Mn vs Nd	323.7137	382.35325	87.71785	139.4253	508.0021	3.690	18	.002
Pair 101	Mn vs Sm	327.7038	383.39328	87.95645	142.9142	512.4935	3.726	18	.002
Pair 102	Mn vs Gd	327.5711	383.37807	87.95296	142.7887	512.3534	3.724	18	.002
Pair 103	Mn vs Er	328.1287	383.52153	87.98587	143.2773	512.9802	3.729	18	.002
Pair 104	Mn vs Yb	328.1906	383.53617	87.98923	143.3321	513.0491	3.730	18	.002
Pair 105	Mn vs Tl	328.4382	383.59299	88.00227	143.5523	513.3241	3.732	18	.002
Pair 106	Co vs Ni	-.8589	.77281	.17730	-1.2314	-.4865	-4.845	18	.000
Pair 107	Co vs Cu	-8.8547	5.49092	1.25970	-11.5013	-6.2082	-7.029	18	.000
Pair 108	Co vs Zn	-36.0795	28.12550	6.45243	-49.6355	-22.5234	-5.592	18	.000
Pair 109	Co vs Ga	-.8142	.92664	.21259	-1.2608	-.3676	-3.830	18	.001
Pair 110	Co vs Se	-1.1658	1.00089	.22962	-1.6482	-.6834	-5.077	18	.000
Pair 111	Co vs Rb	-46.5689	30.37383	6.96823	-61.2087	-31.9292	-6.683	18	.000
Pair 112	Co vs Sr	-107.4374	68.61814	15.74208	-140.5103	-74.3645	-6.825	18	.000
Pair 113	Co vs Y	-3.7853	4.81504	1.10465	-6.1060	-1.4645	-3.427	18	.003
Pair 114	Co vs Zr	-47.8479	63.02355	14.45859	-78.2243	-17.4715	-3.309	18	.004
Pair 115	Co vs Nb	-2.7947	2.96201	.67953	-4.2224	-1.3671	-4.113	18	.001
Pair 116	Co vs Mo	-.5305	.91326	.20952	-.9707	-.0903	-2.532	18	.021
Pair 117	Co vs Ba	-56.5426	32.59945	7.47883	-72.2551	-40.8302	-7.560	18	.000
Pair 118	Co vs Nd	-4.4605	5.30431	1.21689	-7.0171	-1.9039	-3.666	18	.002
Pair 119	Co vs Sm	-.4704	.82402	.18904	-.8675	-.0732	-2.488	18	.023
Pair 120	Co vs Gd	-.6032	.99907	.22920	-1.0847	-.1216	-2.632	18	.017
Pair 121	Co vs Er	-.0455	.39888	.09151	-.2377	.1468	-.497	18	.625
Pair 122	Co vs Yb	.0164	.31265	.07173	-.1343	.1671	.229	18	.821
Pair 123	Co vs Tl	.2639	.28858	.06620	.1249	.4030	3.987	18	.001
Pair 124	Ni vs Cu	-7.9958	4.91104	1.12667	-10.3628	-5.6287	-7.097	18	.000
Pair 125	Ni vs Zn	-35.2205	28.34500	6.50279	-48.8824	-21.5587	-5.416	18	.000
Pair 126	Ni vs Ga	.0447	1.17844	.27035	-.5233	.6127	.165	18	.870
Pair 127	Ni vs Se	-.3068	1.24604	.28586	-.9074	.2937	-1.073	18	.297

Pair 128	Ni vs Rb	-45.7100	30.40726	6.97590	-60.3658	-31.0542	-6.553	18	.000
Pair 129	Ni vs Sr	-106.5784	68.71528	15.76437	-139.6981	-73.4587	-6.761	18	.000
Pair 130	Ni vs Y	-2.9263	4.89525	1.12305	-5.2857	-.5669	-2.606	18	.018
Pair 131	Ni vs Zr	-46.9889	63.00102	14.45343	-77.3545	-16.6234	-3.251	18	.004
Pair 132	Ni vs Nb	-1.9358	2.92354	.67071	-3.3449	-.5267	-2.886	18	.010
Pair 133	Ni vs Mo	.3284	1.26853	.29102	-.2830	.9398	1.129	18	.274
Pair 134	Ni vs Ba	-55.6837	32.58661	7.47588	-71.3899	-39.9774	-7.448	18	.000
Pair 135	Ni vs Nd	-3.6016	5.35340	1.22815	-6.1818	-1.0213	-2.933	18	.009
Pair 136	Ni vs Sm	.3886	1.15420	.26479	-.1677	.9449	1.467	18	.159
Pair 137	Ni vs Gd	.2558	1.30887	.30028	-.3751	.8866	.852	18	.405
Pair 138	Ni vs Er	.8135	.91741	.21047	.3713	1.2557	3.865	18	.001
Pair 139	Ni vs Yb	.8754	.88790	.20370	.4474	1.3033	4.297	18	.000
Pair 140	Ni vs Tl	1.1229	.85464	.19607	.7110	1.5348	5.727	18	.000
Pair 141	Cu vs Zn	-27.2247	28.38895	6.51287	-40.9078	-13.5417	-4.180	18	.001
Pair 142	Cu vs Ga	8.0405	5.47459	1.25596	5.4019	10.6792	6.402	18	.000
Pair 143	Cu vs Se	7.6889	5.61751	1.28875	4.9814	10.3965	5.966	18	.000
Pair 144	Cu vs Rb	-37.7142	30.09685	6.90469	-52.2204	-23.2080	-5.462	18	.000
Pair 145	Cu vs Sr	-98.5826	71.16442	16.32624	-132.8828	-64.2825	-6.038	18	.000
Pair 146	Cu vs Y	5.0695	7.58144	1.73930	1.4153	8.7236	2.915	18	.009
Pair 147	Cu vs Zr	-38.9932	62.46385	14.33019	-69.0998	-8.8865	-2.721	18	.014
Pair 148	Cu vs Nb	6.0600	5.48114	1.25746	3.4182	8.7018	4.819	18	.000
Pair 149	Cu vs Mo	8.3242	5.51002	1.26409	5.6685	10.9800	6.585	18	.000
Pair 150	Cu vs Ba	-47.6879	32.71379	7.50506	-63.4554	-31.9204	-6.354	18	.000
Pair 151	Cu vs Nd	4.3942	7.90609	1.81378	.5836	8.2048	2.423	18	.026
Pair 152	Cu vs Sm	8.3844	5.66569	1.29980	5.6536	11.1151	6.451	18	.000
Pair 153	Cu vs Gd	8.2516	5.73790	1.31637	5.4860	11.0172	6.268	18	.000
Pair 154	Cu vs Er	8.8093	5.58825	1.28203	6.1158	11.5027	6.871	18	.000
Pair 155	Cu vs Yb	8.8712	5.56987	1.27782	6.1866	11.5557	6.942	18	.000
Pair 156	Cu vs Tl	9.1187	5.55852	1.27521	6.4396	11.7978	7.151	18	.000
Pair 157	Zn vs Ga	35.2653	27.66762	6.34739	21.9299	48.6006	5.556	18	.000
Pair 158	Zn vs Se	34.9137	28.20844	6.47146	21.3177	48.5097	5.395	18	.000
Pair 159	Zn vs Rb	-10.4895	28.38667	6.51235	-24.1714	3.1925	-1.611	18	.125
Pair 160	Zn vs S r	-71.3579	75.72568	17.37266	-107.8565	-34.8593	-4.107	18	.001
Pair 161	Zn vs Y	32.2942	28.28378	6.48874	18.6619	45.9266	4.977	18	.000
Pair 162	Zn vs Zr	-11.7684	66.80082	15.32516	-43.9654	20.4285	-.768	18	.452
Pair 163	Zn vs Nb	33.2847	26.90399	6.17220	20.3174	46.2520	5.393	18	.000
Pair 164	Zn vs Mo	35.5489	27.81590	6.38140	22.1421	48.9558	5.571	18	.000
Pair 165	Zn vs Ba	-20.4632	31.08909	7.13233	-35.4476	-5.4787	-2.869	18	.010
Pair 166	Zn vs Nd	31.6189	28.23163	6.47678	18.0117	45.2262	4.882	18	.000
Pair 167	Zn vs Sm	35.6091	28.21600	6.47320	22.0094	49.2088	5.501	18	.000
Pair 168	Zn vs Gd	35.4763	28.21030	6.47189	21.8794	49.0732	5.482	18	.000
Pair 169	Zn vs Er	36.0340	28.24287	6.47936	22.4214	49.6466	5.561	18	.000
Pair 170	Zn vs Yb	36.0959	28.23190	6.47684	22.4886	49.7032	5.573	18	.000
Pair 171	Zn vs Tl	36.3434	28.28934	6.49002	22.7084	49.9784	5.600	18	.000
Pair 172	Ga vs Se	-.3516	1.27314	.29208	-.9652	.2621	-1.204	18	.244

Pair 173	Ga vs Rb	-45.7547	30.06602	6.89762	-60.2461	-31.2634	-6.633	18	.000
Pair 174	Ga vs Sr	-106.6232	68.86322	15.79831	-139.8142	-73.4321	-6.749	18	.000
Pair 175	Ga vs Y	-2.9711	4.52744	1.03867	-5.1532	-.7889	-2.860	18	.010
Pair 176	Ga vs Zr	-47.0337	62.87544	14.42461	-77.3387	-16.7287	-3.261	18	.004
Pair 177	Ga vs Nb	-1.9805	2.14135	.49126	-3.0126	-.9484	-4.032	18	.001
Pair 178	Ga vs Mo	.2837	1.25975	.28901	-.3235	.8909	.982	18	.339
Pair 179	Ga vs Ba	-55.7284	32.77669	7.51949	-71.5263	-39.9306	-7.411	18	.000
Pair 180	Ga vs Nd	-3.6463	4.95077	1.13579	-6.0325	-1.2601	-3.210	18	.005
Pair 181	Ga vs Sm	.3438	1.12038	.25703	-.1962	.8839	1.338	18	.198
Pair 182	Ga vs Gd	.2111	1.22995	.28217	-.3818	.8039	.748	18	.464
Pair 183	Ga vs Er	.7687	1.09073	.25023	.2430	1.2945	3.072	18	.007
Pair 184	Ga vs Yb	.8306	1.09610	.25146	.3023	1.3589	3.303	18	.004
Pair 185	Ga vs Tl	1.0782	1.20231	.27583	.4987	1.6577	3.909	18	.001
Pair 186	Se vs Rb	-45.4032	30.29043	6.94910	-60.0027	-30.8036	-6.534	18	.000
Pair 187	Se vs Sr	-106.2716	68.84296	15.79366	-139.4528	-73.0903	-6.729	18	.000
Pair 188	Se vs Y	-2.6195	3.91674	.89856	-4.5073	-.7317	-2.915	18	.009
Pair 189	Se vs Zr	-46.6821	62.36916	14.30847	-76.7431	-16.6211	-3.263	18	.004
Pair 190	Se vs Nb	-1.6289	3.19023	.73189	-3.1666	-.0913	-2.226	18	.039
Pair 191	Se vs Mo	.6353	1.45765	.33441	-.0673	1.3378	1.900	18	.074
Pair 192	Se vs Ba	-55.3768	32.87526	7.54210	-71.2222	-39.5315	-7.342	18	.000
Pair 193	Se vs Nd	-3.2947	4.43003	1.01632	-5.4299	-1.1595	-3.242	18	.005
Pair 194	Se vs Sm	.6954	.39163	.08985	.5067	.8842	7.740	18	.000
Pair 195	Se vs Gd	.5626	.37040	.08498	.3841	.7412	6.621	18	.000
Pair 196	Se vs Er	1.1203	.70595	.16196	.7801	1.4606	6.917	18	.000
Pair 197	Se vs Yb	1.1822	.81177	.18623	.7909	1.5735	6.348	18	.000
Pair 198	Se vs Tl	1.4297	1.03707	.23792	.9299	1.9296	6.009	18	.000
Pair 199	Rb vs Sr	-60.8684	81.60839	18.72225	-100.2024	-21.5344	-3.251	18	.004
Pair 200	Rb vs Y	42.7837	29.81831	6.84079	28.4117	57.1556	6.254	18	.000
Pair 201	Rb vs Zr	-1.2789	54.71475	12.55242	-27.6506	25.0927	-.102	18	.920
Pair 202	Rb vs Nb	43.7742	29.67968	6.80899	29.4691	58.0794	6.429	18	.000
Pair 203	Rb vs Mo	46.0384	30.06504	6.89739	31.5475	60.5293	6.675	18	.000
Pair 204	Rb vs Ba	-9.9737	45.30190	10.39297	-31.8085	11.8611	-.960	18	.350
Pair 205	Rb vs Nd	42.1084	29.65959	6.80438	27.8130	56.4039	6.188	18	.000
Pair 206	Rb vs Sm	46.0986	30.30188	6.95173	31.4935	60.7036	6.631	18	.000
Pair 207	Rb vs Gd	45.9658	30.27007	6.94443	31.3761	60.5555	6.619	18	.000
Pair 208	Rb vs Er	46.5235	30.40106	6.97448	31.8706	61.1763	6.671	18	.000
Pair 209	Rb vs Yb	46.5854	30.40341	6.97502	31.9314	61.2393	6.679	18	.000
Pair 210	Rb vs Tl	46.8329	30.48921	6.99470	32.1376	61.5282	6.695	18	.000
Pair 211	Sr vs Y	103.6521	70.15832	16.09542	69.8369	137.4673	6.440	18	.000
Pair 212	Sr vs Zr	59.5895	110.99923	25.46497	6.0896	113.0894	2.340	18	.031
Pair 213	Sr vs Nb	104.6426	69.26965	15.89155	71.2557	138.0295	6.585	18	.000
Pair 214	Sr vs Mo	106.9068	68.58832	15.73524	73.8483	139.9654	6.794	18	.000
Pair 215	Sr vs Ba	50.8947	58.36471	13.38978	22.7638	79.0256	3.801	18	.001
Pair 216	Sr vs Nd	102.9768	70.36642	16.14316	69.0613	136.8924	6.379	18	.000
Pair 217	Sr vs Sm	106.9670	68.82821	15.79027	73.7929	140.1411	6.774	18	.000

Pair 218	Sr vs Gd	106.8342	68.86118	15.79784	73.6442	140.0242	6.763	18	.000
Pair 219	Sr vs Er	107.3919	68.68124	15.75656	74.2886	140.4952	6.816	18	.000
Pair 220	Sr vs Yb	107.4538	68.66508	15.75285	74.3583	140.5493	6.821	18	.000
Pair 221	Sr vs Tl	107.7013	68.54286	15.72481	74.6647	140.7379	6.849	18	.000
Pair 222	Y vs Zr	-44.0626	59.63979	13.68231	-72.8081	-15.3172	-3.220	18	.005
Pair 223	Y vs Nb	.9905	5.32971	1.22272	-1.5783	3.5594	.810	18	.428
Pair 224	Y vs Mo	3.2547	4.97784	1.14200	.8555	5.6540	2.850	18	.011
Pair 225	Y vs Ba	-52.7574	34.23662	7.85442	-69.2589	-36.2558	-6.717	18	.000
Pair 226	Y vs Nd	-.6753	.73940	.16963	-1.0316	-.3189	-3.981	18	.001
Pair 227	Y vs Sm	3.3149	4.02129	.92255	1.3767	5.2531	3.593	18	.002
Pair 228	Y vs Gd	3.1821	3.85147	.88359	1.3258	5.0385	3.601	18	.002
Pair 229	Y vs Er	3.7398	4.50987	1.03464	1.5661	5.9135	3.615	18	.002
Pair 230	Y vs Yb	3.8017	4.62760	1.06164	1.5713	6.0321	3.581	18	.002
Pair 231	Y vs Tl	4.0492	4.87624	1.11869	1.6989	6.3995	3.620	18	.002
Pair 232	Zr vs Nb	45.0532	63.36166	14.53616	14.5138	75.5925	3.099	18	.006
Pair 233	Zr vs Mo	47.3174	62.80614	14.40872	17.0458	77.5890	3.284	18	.004
Pair 234	Zr vs Ba	-8.6947	77.47908	17.77492	-46.0385	28.6490	-.489	18	.631
Pair 235	Zr vs Nd	43.3874	59.48900	13.64771	14.7146	72.0602	3.179	18	.005
Pair 236	Zr vs Sm	47.3775	62.44331	14.32548	17.2808	77.4742	3.307	18	.004
Pair 237	Zr vs Gd	47.2447	62.31024	14.29495	17.2122	77.2773	3.305	18	.004
Pair 238	Zr vs Er	47.8024	62.76632	14.39958	17.5500	78.0548	3.320	18	.004
Pair 239	Zr vs Yb	47.8643	62.83678	14.41575	17.5780	78.1507	3.320	18	.004
Pair 240	Zr vs Tl	48.1118	63.03711	14.46170	17.7289	78.4948	3.327	18	.004
Pair 241	Nb vs Mo	2.2642	3.10091	.71140	.7696	3.7588	3.183	18	.005
Pair 242	Nb vs Ba	-53.7479	33.20157	7.61696	-69.7505	-37.7453	-7.056	18	.000
Pair 243	Nb vs Nd	-1.6658	5.57027	1.27791	-4.3506	1.0190	-1.304	18	.209
Pair 244	Nb vs Sm	2.3244	3.15424	.72363	.8041	3.8447	3.212	18	.005
Pair 245	Nb vs Gd	2.1916	3.22249	.73929	.6384	3.7448	2.964	18	.008
Pair 246	Nb vs Er	2.7493	3.17944	.72941	1.2168	4.2817	3.769	18	.001
Pair 247	Nb vs Yb	2.8112	3.17912	.72934	1.2789	4.3434	3.854	18	.001
Pair 248	Nb vs Tl	3.0587	3.24000	.74331	1.4971	4.6203	4.115	18	.001
Pair 249	Mo vs Ba	-56.0121	32.32001	7.41472	-71.5899	-40.4344	-7.554	18	.000
Pair 250	Mo vs Nd	-3.9300	5.46885	1.25464	-6.5659	-1.2941	-3.132	18	.006
Pair 251	Mo vs Sm	.0602	1.30826	.30014	-.5704	.6907	.200	18	.843
Pair 252	Mo vs Gd	-.0726	1.42599	.32715	-.7599	.6147	-.222	18	.827
Pair 253	Mo vs Er	.4851	1.04041	.23869	-.0164	.9865	2.032	18	.057
Pair 254	Mo vs Yb	.5469	.98448	.22586	.0724	1.0215	2.422	18	.026
Pair 255	Mo vs Tl	.7945	.98031	.22490	.3220	1.2670	3.533	18	.002
Pair 256	Ba vs Nd	52.0821	34.45279	7.90401	35.4764	68.6878	6.589	18	.000
Pair 257	Ba vs Sm	56.0723	32.82699	7.53103	40.2502	71.8944	7.445	18	.000
Pair 258	Ba vs Gd	55.9395	32.86371	7.53945	40.0997	71.7793	7.420	18	.000
Pair 259	Ba vs Er	56.4972	32.68022	7.49736	40.7458	72.2485	7.536	18	.000
Pair 260	Ba vs Yb	56.5591	32.65143	7.49075	40.8216	72.2965	7.551	18	.000
Pair 261	Cu vs Mo	56.8066	32.56317	7.47050	41.1116	72.5015	7.604	18	.000
Pair 262	Cu vs Ba	3.9902	4.52576	1.03828	1.8088	6.1715	3.843	18	.001
Pair 263	Ba vs Tl	3.8574	4.36123	1.00053	1.7553	5.9594	3.855	18	.001
Pair 264	Nd vs Sm	4.4151	5.01906	1.15145	1.9959	6.8342	3.834	18	.001

Pair 265	Nd vs Gd	4.4769	5.13584	1.17824	2.0015	6.9523	3.800	18	.001
Pair 266	Nd vs Er	4.7245	5.38291	1.23492	2.1300	7.3190	3.826	18	.001
Pair 267	Nd vs Yb	-.1328	.18231	.04182	-.2207	-.0449	-3.175	18	.005
Pair 268	Nd vs Tl	.4249	.49445	.11343	.1866	.6632	3.746	18	.001
Pair 269	Sm vs Gd	.4868	.61267	.14056	.1915	.7821	3.463	18	.003
Pair 270	Sm vs Er	.7343	.85916	.19710	.3202	1.1484	3.726	18	.002
Pair 271	Sm vs Yb	.5577	.66216	.15191	.2385	.8768	3.671	18	.002
Pair 272	Sm vs Tl	.6196	.78075	.17912	.2433	.9959	3.459	18	.003
Pair 273	Gd vs Er	.8671	1.02740	.23570	.3719	1.3623	3.679	18	.002
Pair 274	Gd vs Yb	.0619	.12284	.02818	.0027	.1211	2.196	18	.041
Pair 275	Gd vs Tl	.3094	.36939	.08474	.1314	.4875	3.651	18	.002
Pair 276	Yb Vs Tl	.2475	.26130	.05995	.1216	.3735	4.129	18	.001

Paired Samples Test Fe with other trace elements in Nyamira Sub County

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Fe – B	1515.19105	1639.57048	376.14326	724.94338	2305.43873	4.028	18	.001
Pair 2	Fe - Ti	1456.26316	1548.55028	355.26180	709.88581	2202.64050	4.099	18	.001
Pair 3	Fe - V	1542.84211	1638.53912	375.90666	753.09153	2332.59268	4.104	18	.001
Pair 4	Fe - Cr	1543.22600	1638.97083	376.00570	753.26735	2333.18465	4.104	18	.001
Pair 5	Fe - Mn	1215.39474	1634.96393	375.08645	427.36735	2003.42213	3.240	18	.005
Pair 6	Fe - Co	1543.56895	1639.33237	376.08864	753.43604	2333.70186	4.104	18	.001
Pair 7	Fe - Ni	1542.71000	1639.18622	376.05511	752.64753	2332.77247	4.102	18	.001
Pair 8	Fe - Cu	1534.71421	1637.90297	375.76071	745.27025	2324.15817	4.084	18	.001
Pair 9	Fe - Zn	1507.48947	1626.31986	373.10336	723.62839	2291.35055	4.040	18	.001
Pair 10	Fe - Ga	1542.75474	1638.46440	375.88951	753.04018	2332.46930	4.104	18	.001
Pair 11	Fe - Se	1542.40316	1639.35796	376.09451	752.25791	2332.54840	4.101	18	.001
Pair 12	Fe - Rb	1497.00000	1630.84848	374.14230	710.95619	2283.04381	4.001	18	.001
Pair 13	Fe - Sr	1436.13158	1655.83344	379.87424	638.04541	2234.21775	3.781	18	.001
Pair 14	Fe - Y	1539.78368	1638.53707	375.90619	750.03409	2329.53327	4.096	18	.001
Pair 15	Fe - Zr	1495.72105	1642.27587	376.76392	704.16942	2287.27268	3.970	18	.001

Pair 16	Fe - Nb	1540.77421	1636.41358	375.41902	752.04811	2329.50031	4.104	18	.001
Pair 17	Fe - Mo	1543.03842	1639.27390	376.07522	752.93369	2333.14315	4.103	18	.001
Pair 18	Fe - Ba	1487.02632	1644.85123	377.35475	694.23340	2279.81923	3.941	18	.001
Pair 19	Fe - Nd	1539.10842	1638.13066	375.81295	749.55472	2328.66213	4.095	18	.001
Pair 20	Fe - Sm	1543.09858	1639.38468	376.10064	752.94046	2333.25670	4.103	18	.001
Pair 21	Fe - Gd	1542.96579	1639.39603	376.10324	752.80220	2333.12938	4.103	18	.001
Pair 22	Fe - Er	1543.52347	1639.51878	376.13140	753.30072	2333.74623	4.104	18	.001
Pair 23	Fe - Yb	1543.58537	1639.53137	376.13429	753.35654	2333.81419	4.104	18	.001
Pair 24	Fe - Tl	1543.83289	1639.61436	376.15333	753.56407	2334.10172	4.104	18	.001

T-crtical = 4.210 $P < 0.05$

APPENDIX XIII

Paired Samples Test for Trace elements in Borabu Subcounty

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	B vs Ti	-48.2579	70.70964	16.22190	-82.3389	-14.1769	-2.975	18	.008
Pair 2	B vs V	25.6963	14.32401	3.28615	18.7924	32.6003	7.820	18	.000
Pair 3	B vs Cr	25.6763	14.31017	3.28298	18.7790	32.5736	7.821	18	.000
Pair 4	B vs Mn	-345.7737	373.08505	85.59158	-525.5949	-165.9524	-4.040	18	.001
Pair 5	B vs Co	26.3376	14.38432	3.29999	19.4046	33.2706	7.981	18	.000
Pair 6	B vs Cu	25.6126	14.27356	3.27458	18.7330	32.4923	7.822	18	.000
Pair 7		18.7026	13.45526	3.08685	12.2174	25.1879	6.059	18	.000
Pair 8	B- Ni	-14.3789	23.73211	5.44452	-25.8175	-2.9404	-2.641	18	.017
Pair 9	B vs Zn	25.4658	14.37804	3.29855	18.5358	32.3958	7.720	18	.000
Pair 10	B vs Ga	24.7737	14.59463	3.34824	17.7393	31.8081	7.399	18	.000
Pair 11	B vs Se	-11.4053	29.38037	6.74032	-25.5661	2.7556	-1.692	18	.108
Pair 12	B vs Rb	-84.2053	73.30463	16.81723	-119.5370	-48.8736	-5.007	18	.000
Pair 13	B vs Sr	20.7121	18.42053	4.22596	11.8337	29.5905	4.901	18	.000
Pair 14	B vs Y	-67.0368	118.39634	27.16198	-124.1020	-9.9716	-2.468	18	.024
Pair 15	B vs Zr	23.7705	14.53076	3.33359	16.7669	30.7741	7.131	18	.000
Pair 16	B vs Nb	25.8774	14.49365	3.32507	18.8917	32.8631	7.783	18	.000
Pair 17	B vs Mo	-28.5947	26.32874	6.04023	-41.2848	-15.9047	-4.734	18	.000
Pair 18	B vs Ba	20.3805	18.21561	4.17895	11.6009	29.1602	4.877	18	.000
Pair 19	B vs Nd	25.5676	14.52790	3.33293	18.5654	32.5699	7.671	18	.000

Pair 20	B vs Sm	25.4063	14.56216	3.34079	18.3876	32.4251	7.605	18	.000
Pair 21	B vs Gd	26.1283	14.43234	3.31101	19.1721	33.0844	7.891	18	.000
Pair 22	B vs Er	26.2129	14.41137	3.30620	19.2668	33.1590	7.928	18	.000
Pair 23	B vs Yb	26.5901	14.45260	3.31565	19.6241	33.5560	8.020	18	.000
Pair 24	B vs Tl	73.9542	69.65231	15.97934	40.3829	107.5255	4.628	18	.000
Pair 25	Ti vs V	73.9342	70.05009	16.07059	40.1712	107.6973	4.601	18	.000
Pair 26	Ti vs Cr	-297.5158	376.71663	86.42472	-479.0874	-115.9442	-3.442	18	.003
Pair 27	Ti vs Mn	74.5955	70.23607	16.11326	40.7428	108.4482	4.629	18	.000
Pair 28	Ti vs Co	73.8705	69.83758	16.02184	40.2099	107.5312	4.611	18	.000
Pair 29	Ti vs Ni	66.9605	69.65771	15.98057	33.3866	100.5345	4.190	18	.001
Pair 30	Ti vs Cu	33.8789	60.30635	13.83523	4.8122	62.9457	2.449	18	.025
Pair 31	Ti vs Zn	73.7237	69.56632	15.95961	40.1938	107.2536	4.619	18	.000
Pair 32	Ti vs Ga	73.0316	70.49775	16.17329	39.0527	107.0104	4.516	18	.000
Pair 33	Ti vs Se	36.8526	63.32254	14.52719	6.3321	67.3731	2.537	18	.021
Pair 34	Ti vs Rb	-35.9474	90.50136	20.76244	-79.5676	7.6729	-1.731	18	.100
Pair 35	Ti vs Sr	68.9700	71.86017	16.48585	34.3345	103.6055	4.184	18	.001
Pair 36	Ti vs Y	-18.7789	152.51048	34.98830	-92.2866	54.7287	-.537	18	.598
Pair 37	Ti vs Zr	72.0284	67.63348	15.51618	39.4301	104.6267	4.642	18	.000
Pair 38	Ti vs Nb	74.1353	70.41903	16.15523	40.1944	108.0762	4.589	18	.000
Pair 39	Ti vs Mo	19.6632	76.87403	17.63611	-17.3889	56.7153	1.115	18	.280
Pair	Ti vs Ba	68.6384	71.23120	16.34156	34.3061	102.9708	4.200	18	.001

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Pair 41	Ti vs Nd	73.8255	70.46947	16.16681	39.8603	107.7907	4.566	18	.000
Pair 42	Ti vs Sm	73.6642	70.52902	16.18047	39.6703	107.6581	4.553	18	.000
Pair 43	Ti vs Gd	74.3862	70.45904	16.16441	40.4260	108.3463	4.602	18	.000
Pair 44	Ti vs Er	74.4708	70.43139	16.15807	40.5239	108.4176	4.609	18	.000
Pair 45	Ti vs Yb	74.8479	70.47145	16.16726	40.8818	108.8141	4.630	18	.000
Pair 46	Ti vs Tl	-.0200	.91325	.20951	-.4602	.4202	-.095	18	.925
Pair 47	V vs Cr	-371.4700	377.55976	86.61815	-553.4480	-189.4920	-4.289	18	.000
Pair 48	V vs Mn	.6413	.59477	.13645	.3546	.9279	4.700	18	.000
Pair 49	V vs Co	-.0837	.52212	.11978	-.3353	.1680	-.699	18	.494
Pair 50	V vs Ni	-6.9937	3.09977	.71114	-8.4877	-5.4996	-9.835	18	.000
Pair 51	V vs Cu	-40.0753	26.96581	6.18638	-53.0724	-27.0782	-6.478	18	.000
Pair 52	V vs Zn	-.2305	.50727	.11638	-.4750	.0140	-1.981	18	.063
Pair 53	V vs Ga	-.9226	2.65866	.60994	-2.2041	.3588	-1.513	18	.148
Pair 54	V vs Se	-37.1016	27.85338	6.39000	-50.5265	-23.6767	-5.806	18	.000
Pair 55	V vs Rb	-109.9016	71.86655	16.48732	-144.5401	-75.2630	-6.666	18	.000
Pair 56	V vs Sr	-4.9842	12.14424	2.78608	-10.8375	.8691	-1.789	18	.090
Pair 57	V vs Y	-92.7332	122.05962	28.00240	-151.5640	-33.9023	-3.312	18	.004
Pair 58	V vs Zr	-1.9258	2.13542	.48990	-2.9550	-.8966	-3.931	18	.001
Pair 59	V vs Nb	.1811	1.10543	.25360	-.3517	.7139	.714	18	.484
Pair 60	V vs Mo	-54.2911	31.23925	7.16678	-69.3479	-39.2342	-7.575	18	.000

Pair 61	V vs Ba	-5.3158	11.63849	2.67005	-10.9254	.2938	-1.991	18	.062
Pair 62	V vs Nd	-.1287	2.12166	.48674	-1.1513	.8939	-.264	18	.794
Pair 63	V vs Sm	-.2900	2.48340	.56973	-1.4870	.9070	-.509	18	.617
Pair 64	V vs Gd	.4319	1.19202	.27347	-.1426	1.0065	1.580	18	.132
Pair 65	V vs Er	.5166	.97317	.22326	.0475	.9856	2.314	18	.033
Pair 66	V vs Yb	.8937	.84450	.19374	.4867	1.3008	4.613	18	.000
Pair 67	V vs Tl	-371.4500	377.65886	86.64088	-553.4757	-189.4243	-4.287	18	.000
Pair 68	Cr vs Mn	.6613	.88096	.20211	.2367	1.0859	3.272	18	.004
Pair 69	Cr vs Co	-.0637	1.03783	.23809	-.5639	.4365	-.267	18	.792
Pair 70	Cr vs Ni	-6.9737	3.31313	.76008	-8.5706	-5.3768	-9.175	18	.000
Pair 71	Cr vs Cu	-40.0553	26.93657	6.17967	-53.0383	-27.0723	-6.482	18	.000
Pair 72	Cr vs Zn	-.2105	1.16149	.26646	-.7703	.3493	-.790	18	.440
Pair 73	Cr vs Ga	-.9026	2.78312	.63849	-2.2441	.4388	-1.414	18	.175
Pair 74	Cr vs Se	-37.0816	28.14693	6.45735	-50.6480	-23.5152	-5.743	18	.000
Pair 75	Cr vs Rb	-109.8816	71.96313	16.50947	-144.5667	-75.1965	-6.656	18	.000
Pair 76	Cr vs Sr	-4.9642	12.25459	2.81140	-10.8707	.9423	-1.766	18	.094
Pair 77	Cr vs Y	-92.7132	122.16044	28.02553	-151.5926	-33.8337	-3.308	18	.004
Pair 78	Cr vs Zr	-1.9058	2.67098	.61276	-3.1932	-.6184	-3.110	18	.006
Pair 79	Cr vs Nb	.2011	1.24440	.28549	-.3987	.8008	.704	18	.490
Pair 80	Cr vs Mo	-54.2711	31.31406	7.18394	-69.3639	-39.1782	-7.554	18	.000
Pair	Cr vs Ba	-5.2958	11.77163	2.70060	-10.9695	.3780	-1.961	18	.066

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Pair 82	Cr vs Nd	-.1087	2.29293	.52603	-1.2138	.9965	-.207	18	.839
Pair 83	Cr vs Sm	-.2700	2.64024	.60571	-1.5426	1.0026	-.446	18	.661
Pair 84	Cr vs Gd	.4519	1.38331	.31735	-.2148	1.1187	1.424	18	.172
Pair 85	Cr vs Er	.5366	1.18428	.27169	-.0342	1.1074	1.975	18	.064
Pair 86	Cr vs Yb	.9137	1.00091	.22963	.4313	1.3962	3.979	18	.001
Pair 87	Cr vs Tl	372.1113	377.66422	86.64211	190.0829	554.1396	4.295	18	.000
Pair 88	Mn vs Co	371.3863	377.30451	86.55959	189.5314	553.2413	4.291	18	.000
Pair 89	Mn vs Ni	364.4763	376.47535	86.36937	183.0210	545.9316	4.220	18	.001
Pair 90	Mn vs Cu	331.3947	375.23100	86.08390	150.5392	512.2503	3.850	18	.001
Pair 91	Mn vs Zn	371.2395	377.60642	86.62885	189.2390	553.2399	4.285	18	.000
Pair 92	Mn vs Ga	370.5474	377.84242	86.68300	188.4332	552.6616	4.275	18	.000
Pair 93	Mn vs Se	334.3684	371.43546	85.21314	155.3423	513.3946	3.924	18	.001
Pair 94	Mn vs Rb	261.5684	394.34641	90.46927	71.4995	451.6373	2.891	18	.010
Pair 95	Mn vs Sr	366.4858	378.54983	86.84529	184.0306	548.9410	4.220	18	.001
Pair 96	Mn vs Y	278.7368	389.66607	89.39553	90.9238	466.5499	3.118	18	.006
Pair 97	Mn vs Zr	369.5442	377.37238	86.57516	187.6565	551.4319	4.268	18	.000
Pair 98	Mn vs Nb	371.6511	377.74722	86.66116	189.5827	553.7194	4.289	18	.000
Pair 99	Mn vs Mo	317.1789	382.01491	87.64023	133.0537	501.3042	3.619	18	.002
Pair 100	Mn vs Ba	366.1542	378.35431	86.80043	183.7933	548.5152	4.218	18	.001
Pair 101	Mn vs Nd	371.3413	377.80700	86.67487	189.2442	553.4385	4.284	18	.000

Pair 102	Mn vs Sm	371.1800	377.83030	86.68022	189.0716	553.2884	4.282	18	.000
Pair 103	Mn vs Gd	371.9019	377.74134	86.65981	189.8364	553.9674	4.292	18	.000
Pair 104	Mn vs Er	371.9866	377.71270	86.65324	189.9349	554.0383	4.293	18	.000
Pair 105	Mn vs Yb	372.3637	377.70809	86.65218	190.3143	554.4132	4.297	18	.000
Pair 106	Mn vs Tl	-.7249	.63053	.14465	-1.0289	-.4210	-5.012	18	.000
Pair 107	Co vs Ni	-7.6349	3.17208	.72773	-9.1638	-6.1061	-10.492	18	.000
Pair 108	Co vs Cu	-40.7165	27.32752	6.26936	-53.8880	-27.5451	-6.495	18	.000
Pair 109	Co vs Zn	-.8718	.80521	.18473	-1.2599	-.4837	-4.719	18	.000
Pair 110	Co vs Ga	-1.5639	2.51049	.57595	-2.7739	-.3539	-2.715	18	.014
Pair 111	Co vs Se	-37.7428	28.10375	6.44744	-51.2884	-24.1973	-5.854	18	.000
Pair 112	Co vs Rb	-110.5428	71.97063	16.51119	-145.2316	-75.8541	-6.695	18	.000
Pair 113	Co vs Sr	-5.6255	12.07004	2.76906	-11.4430	.1921	-2.032	18	.057
Pair 114	Co vs Y	-93.3744	121.91829	27.96997	-152.1372	-34.6117	-3.338	18	.004
Pair 115	Co vs Zr	-2.5671	2.67708	.61417	-3.8574	-1.2767	-4.180	18	.001
Pair 116	Co vs Nb	-.4602	.80447	.18456	-.8480	-.0725	-2.494	18	.023
Pair 117	Co vs Mo	-54.9323	31.22650	7.16385	-69.9830	-39.8816	-7.668	18	.000
Pair 118	Co vs Ba	-5.9571	11.59050	2.65904	-11.5435	-.3706	-2.240	18	.038
Pair 119	Co vs Nd	-.7699	1.94261	.44566	-1.7063	.1664	-1.728	18	.101
Pair 120	Co vs Sm	-.9313	2.31543	.53120	-2.0473	.1847	-1.753	18	.097
Pair 121	Co vs Gd	-.2093	.86431	.19829	-.6259	.2073	-1.056	18	.305
Pair	Co vs Er	-.1247	.56652	.12997	-.3977	.1484	-.959	18	.350

122									
Pair 123	Co vs Yb	.2525	.26360	.06047	.1254	.3795	4.175	18	.001
Pair 124	Co vs Tl	-6.9100	2.80631	.64381	-8.2626	-5.5574	-10.733	18	.000
Pair 125	Ni vs Cu	-39.9916	27.10758	6.21890	-53.0570	-26.9261	-6.431	18	.000
Pair 126	Ni vs Zn	-.1468	.71718	.16453	-.4925	.1988	-.892	18	.384
Pair 127	Ni vs Ga	-.8389	2.60599	.59785	-2.0950	.4171	-1.403	18	.178
Pair 128	Ni vs Se	-37.0179	27.65252	6.34392	-50.3460	-23.6898	-5.835	18	.000
Pair 129	Ni vs Rb	-109.8179	72.06569	16.53300	-144.5524	-75.0833	-6.642	18	.000
Pair 130	Ni vs Sr	-4.9005	12.08994	2.77362	-10.7277	.9266	-1.767	18	.094
Pair 131	Ni vs Y	-92.6495	121.83087	27.94992	-151.3701	-33.9289	-3.315	18	.004
Pair 132	Ni vs Zr	-1.8421	2.33647	.53602	-2.9682	-.7160	-3.437	18	.003
Pair 133	Ni vs Nb	.2647	1.06742	.24488	-.2497	.7792	1.081	18	.294
Pair 134	Ni vs Mo	-54.2074	31.21961	7.16227	-69.2547	-39.1600	-7.568	18	.000
Pair 135	Ni vs Ba	-5.2321	11.59134	2.65924	-10.8190	.3547	-1.968	18	.065
Pair 136	Ni vs Nd	-.0450	2.07499	.47604	-1.0451	.9551	-.095	18	.926
Pair 137	Ni vs Sm	-.2063	2.43391	.55838	-1.3794	.9668	-.369	18	.716
Pair 138	Ni vs Gd	.5156	1.14703	.26315	-.0372	1.0685	1.959	18	.066
Pair 139	Ni vs Er	.6003	.92910	.21315	.1525	1.0481	2.816	18	.011
Pair 140	Ni vs Yb	.9774	.83203	.19088	.5764	1.3784	5.121	18	.000
Pair 141	Ni vs Tl	-33.0816	26.01235	5.96764	-45.6191	-20.5440	-5.543	18	.000
Pair 142	Cu vs Zn	6.7632	3.16770	.72672	5.2364	8.2899	9.306	18	.000

Pair 143	Cu vs Ga	6.0711	4.07429	.93471	4.1073	8.0348	6.495	18	.000
Pair 144	Cu vs Se	-30.1079	26.26804	6.02630	-42.7687	-17.4471	-4.996	18	.000
Pair 145	Cu vs Rb	-102.9079	73.91494	16.95725	-138.5338	-67.2820	-6.069	18	.000
Pair 146	Cu vs Sr	2.0095	12.47853	2.86277	-4.0050	8.0239	.702	18	.492
Pair 147	Cu vs Y	-85.7395	120.47174	27.63811	-143.8050	-27.6740	-3.102	18	.006
Pair 148	Cu vs Zr	5.0679	3.71903	.85320	3.2754	6.8604	5.940	18	.000
Pair 149	Cu vs Nb	7.1747	3.13555	.71934	5.6634	8.6860	9.974	18	.000
Pair 150	Cu vs Mo	-47.2974	31.24278	7.16759	-62.3559	-32.2388	-6.599	18	.000
Pair 151	Cu vs Ba	1.6779	12.01764	2.75704	-4.1144	7.4702	.609	18	.550
Pair 152	Cu vs Nd	6.8650	3.77363	.86573	5.0462	8.6838	7.930	18	.000
Pair 153	Cu vs Sm	6.7037	3.98773	.91485	4.7817	8.6257	7.328	18	.000
Pair 154	Cu vs Gd	7.4256	3.32623	.76309	5.8224	9.0288	9.731	18	.000
Pair 155	Cu vs Er	7.5103	3.22621	.74014	5.9553	9.0652	10.147	18	.000
Pair 156	Cu vs Yb	7.8874	3.25426	.74658	6.3189	9.4559	10.565	18	.000
Pair 157	Cu vs Tl	39.8447	27.02182	6.19923	26.8206	52.8688	6.427	18	.000
Pair 158	Zn vs Ga	39.1526	27.50150	6.30928	25.8973	52.4079	6.206	18	.000
Pair 159	Zn vs Se	2.9737	33.11934	7.59810	-12.9893	18.9367	.391	18	.700
Pair 160	Zn vs Rb	-69.8263	78.17907	17.93551	-107.5074	-32.1452	-3.893	18	.001
Pair 161	Zn vs S r	35.0911	29.81628	6.84032	20.7201	49.4620	5.130	18	.000
Pair 162	Zn vs Y	-52.6579	121.18792	27.80242	-111.0686	5.7528	-1.894	18	.074
Pair	Zn vs Zr	38.1495	26.32486	6.03934	25.4613	50.8377	6.317	18	.000

163									
Pair 164	Zn vs Nb	40.2563	27.31367	6.26619	27.0915	53.4211	6.424	18	.000
Pair 165	Zn vs Mo	-14.2158	36.44066	8.36006	-31.7796	3.3480	-1.700	18	.106
Pair 166	Zn vs Ba	34.7595	29.49329	6.76622	20.5442	48.9748	5.137	18	.000
Pair 167	Zn vs Nd	39.9466	27.49588	6.30799	26.6940	53.1992	6.333	18	.000
Pair 168	Zn vs Sm	39.7853	27.53693	6.31740	26.5129	53.0576	6.298	18	.000
Pair 169	Zn vs Gd	40.5072	27.45319	6.29819	27.2752	53.7392	6.432	18	.000
Pair 170	Zn vs Er	40.5918	27.42235	6.29112	27.3747	53.8090	6.452	18	.000
Pair 171	Zn vs Yb	40.9690	27.49090	6.30685	27.7188	54.2192	6.496	18	.000
Pair 172	Zn vs Tl	-.6921	2.25400	.51710	-1.7785	.3943	-1.338	18	.197
Pair 173	Ga vs Se	-36.8711	27.77693	6.37247	-50.2591	-23.4830	-5.786	18	.000
Pair 174	Ga vs Rb	-109.6711	71.88347	16.49120	-144.3178	-75.0243	-6.650	18	.000
Pair 175	Ga vs Sr	-4.7537	11.69323	2.68261	-10.3896	.8823	-1.772	18	.093
Pair 176	Ga vs Y	-92.5026	121.74551	27.93033	-151.1821	-33.8232	-3.312	18	.004
Pair 177	Ga vs Zr	-1.6953	2.08252	.47776	-2.6990	-.6915	-3.548	18	.002
Pair 178	Ga vs Nb	.4116	1.23486	.28330	-.1836	1.0068	1.453	18	.163
Pair 179	Ga vs Mo	-54.0605	31.17437	7.15189	-69.0861	-39.0350	-7.559	18	.000
Pair 180	Ga vs Ba	-5.0853	11.18076	2.56504	-10.4742	.3037	-1.983	18	.063
Pair 181	Ga vs Nd	.1018	1.73702	.39850	-.7354	.9391	.256	18	.801
Pair 182	Ga vs Sm	-.0595	2.08587	.47853	-1.0648	.9459	-.124	18	.902
Pair 183	Ga vs Gd	.6625	.98004	.22484	.1901	1.1348	2.946	18	.009

Pair 184	Ga vs Er	.7471	.87953	.20178	.3232	1.1710	3.703	18	.002
Pair 185	Ga vs Yb	1.1243	1.01816	.23358	.6335	1.6150	4.813	18	.000
Pair 186	Ga vs Tl	-36.1789	27.88254	6.39669	-49.6179	-22.7400	-5.656	18	.000
Pair 187	Se vs Rb	-108.9789	72.43177	16.61699	-143.8899	-74.0680	-6.558	18	.000
Pair 188	Se vs Sr	-4.0616	9.57018	2.19555	-8.6743	.5511	-1.850	18	.081
Pair 189	Se vs Y	-91.8105	119.97335	27.52377	-149.6358	-33.9852	-3.336	18	.004
Pair 190	Se vs Zr	-1.0032	3.86565	.88684	-2.8663	.8600	-1.131	18	.273
Pair 191	Se vs Nb	1.1037	2.60857	.59845	-.1536	2.3610	1.844	18	.082
Pair 192	Se vs Mo	-53.3684	30.93624	7.09726	-68.2792	-38.4576	-7.520	18	.000
Pair 193	Se vs Ba	-4.3932	9.10110	2.08793	-8.7797	-.0066	-2.104	18	.050
Pair 194	Se vs Nd	.7939	.60026	.13771	.5046	1.0833	5.765	18	.000
Pair 195	Se vs Sm	.6326	.28593	.06560	.4948	.7704	9.644	18	.000
Pair 196	Se vs Gd	1.3546	1.67733	.38480	.5461	2.1630	3.520	18	.002
Pair 197	Se vs Er	1.4392	1.98925	.45637	.4804	2.3980	3.154	18	.005
Pair 198	Se vs Yb	1.8164	2.52288	.57879	.6004	3.0324	3.138	18	.006
Pair 199	Se vs Tl	-72.8000	81.30508	18.65267	-111.9878	-33.6122	-3.903	18	.001
Pair 200	Rb vs Sr	32.1174	28.80836	6.60909	18.2322	46.0026	4.860	18	.000
Pair 201	Rb vs Y	-55.6316	113.00153	25.92433	-110.0966	-1.1666	-2.146	18	.046
Pair 202	Rb vs Zr	35.1758	27.03494	6.20224	22.1454	48.2062	5.671	18	.000
Pair 203	Rb vs Nb	37.2826	28.04272	6.43344	23.7665	50.7988	5.795	18	.000
Pair	Rb vs Mo	-17.1895	36.78038	8.43800	-34.9171	.5381	-2.037	18	.057

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Pair 205	Rb vs Ba	31.7858	28.39592	6.51447	18.0994	45.4722	4.879	18	.000
Pair 206	Rb vs Nd	36.9729	27.95452	6.41321	23.4992	50.4465	5.765	18	.000
Pair 207	Rb vs Sm	36.8116	27.94115	6.41014	23.3444	50.2788	5.743	18	.000
Pair 208	Rb vs Gd	37.5335	28.10210	6.44706	23.9887	51.0783	5.822	18	.000
Pair 209	Rb vs Er	37.6182	28.11760	6.45062	24.0659	51.1704	5.832	18	.000
Pair 210	Rb vs Yb	37.9953	28.25846	6.48294	24.3752	51.6155	5.861	18	.000
Pair 211	Rb vs Tl	104.9174	74.66171	17.12857	68.9316	140.9032	6.125	18	.000
Pair 212	Sr vs Y	17.1684	165.39999	37.94536	-62.5518	96.8887	.452	18	.656
Pair 213	Sr vs Zr	107.9758	71.45811	16.39361	73.5341	142.4175	6.586	18	.000
Pair 214	Sr vs Nb	110.0826	71.98906	16.51542	75.3850	144.7802	6.665	18	.000
Pair 215	Sr vs Mo	55.6105	61.30523	14.06438	26.0624	85.1587	3.954	18	.001
Pair 216	Sr vs Ba	104.5858	74.25929	17.03625	68.7940	140.3776	6.139	18	.000
Pair 217	Sr vs Nd	109.7729	72.27057	16.58001	74.9396	144.6062	6.621	18	.000
Pair 218	Sr vs Sm	109.6116	72.32114	16.59161	74.7539	144.4693	6.606	18	.000
Pair 219	Sr vs Gd	110.3335	72.13774	16.54953	75.5642	145.1028	6.667	18	.000
Pair 220	Sr vs Er	110.4182	72.10753	16.54260	75.6634	145.1729	6.675	18	.000
Pair 221	Sr vs Yb	110.7953	72.00084	16.51813	76.0920	145.4986	6.707	18	.000
Pair 222	Sr vs Tl	-87.7489	112.63887	25.84113	-142.0391	-33.4587	-3.396	18	.003
Pair 223	Y vs Zr	3.0584	12.55224	2.87968	-2.9916	9.1084	1.062	18	.302
Pair 224	Y vs Nb	5.1653	12.08856	2.77331	-.6612	10.9918	1.862	18	.079

Pair 225	Y vs Mo	-49.3068	31.19270	7.15610	-64.3412	-34.2724	-6.890	18	.000
Pair 226	Y vs Ba	-.3316	.80878	.18555	-.7214	.0582	-1.787	18	.091
Pair 227	Y vs Nd	4.8555	10.13575	2.32530	-.0297	9.7408	2.088	18	.051
Pair 228	Y vs Sm	4.6942	9.76369	2.23994	-.0117	9.4002	2.096	18	.051
Pair 229	Y vs Gd	5.4162	11.23358	2.57716	.0017	10.8306	2.102	18	.050
Pair 230	Y vs Er	5.5008	11.54604	2.64884	-.0642	11.0658	2.077	18	.052
Pair 231	Y vs Yb	5.8779	12.08102	2.77158	.0551	11.7008	2.121	18	.048
Pair 232	Y vs Tl	90.8074	122.52918	28.11012	31.7502	149.8645	3.230	18	.005
Pair 233	Zr vs Nb	92.9142	121.75361	27.93219	34.2308	151.5976	3.326	18	.004
Pair 234	Zr vs Mo	38.4421	115.12722	26.41200	-17.0474	93.9316	1.455	18	.163
Pair 235	Zr vs Ba	87.4174	113.17873	25.96498	32.8670	141.9678	3.367	18	.003
Pair 236	Zr vs Nd	92.6045	120.41137	27.62426	34.5681	150.6409	3.352	18	.004
Pair 237	Zr vs Sm	92.4432	120.11748	27.55684	34.5484	150.3379	3.355	18	.004
Pair 238	Zr vs Gd	93.1651	121.23970	27.81429	34.7294	151.6008	3.350	18	.004
Pair 239	Zr vs Er	93.2497	121.46180	27.86525	34.7070	151.7925	3.346	18	.004
Pair 240	Zr vs Yb	93.6269	121.90741	27.96748	34.8694	152.3844	3.348	18	.004
Pair 241	Zr vs Tl	2.1068	3.00334	.68901	.6593	3.5544	3.058	18	.007
Pair 242	Nb vs Mo	-52.3653	31.37776	7.19855	-67.4889	-37.2417	-7.274	18	.000
Pair 243	Nb vs Ba	-3.3900	11.96421	2.74478	-9.1566	2.3766	-1.235	18	.233
Pair 244	Nb vs Nd	1.7971	3.49474	.80175	.1127	3.4815	2.241	18	.038
Pair	Nb vs Sm	1.6358	3.75376	.86117	-.1735	3.4450	1.899	18	.074

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Pair 246	Nb vs Gd	2.3577	3.01656	.69205	.9038	3.8117	3.407	18	.003
Pair 247	Nb vs Er	2.4424	2.91640	.66907	1.0367	3.8480	3.650	18	.002
Pair 248	Nb vs Yb	2.8195	2.89706	.66463	1.4232	4.2159	4.242	18	.000
Pair 249	Nb vs Tl	-54.4721	31.03412	7.11972	-69.4301	-39.5141	-7.651	18	.000
Pair 250	Mo vs Ba	-5.4968	11.61362	2.66435	-11.0944	.1007	-2.063	18	.054
Pair 251	Mo vs Nd	-.3097	2.08818	.47906	-1.3162	.6967	-.647	18	.526
Pair 252	Mo vs Sm	-.4711	2.43042	.55758	-1.6425	.7004	-.845	18	.409
Pair 253	Mo vs Gd	.2509	1.15273	.26445	-.3047	.8065	.949	18	.355
Pair 254	Mo vs Er	.3355	.94426	.21663	-.1196	.7906	1.549	18	.139
Pair 255	Mo vs Yb	.7127	.80036	.18362	.3269	1.0984	3.881	18	.001
Pair 256	Mo vs Tl	48.9753	31.06608	7.12705	34.0019	63.9486	6.872	18	.000
Pair 257	Ba vs Nd	54.1624	30.94104	7.09836	39.2493	69.0755	7.630	18	.000
Pair 258	Ba vs Sm	54.0011	30.87594	7.08343	39.1193	68.8828	7.624	18	.000
Pair 259	Ba vs Gd	54.7230	31.11143	7.13745	39.7278	69.7182	7.667	18	.000
Pair 260	Ba vs Er	54.8076	31.15496	7.14744	39.7914	69.8238	7.668	18	.000
Pair 261	Ba vs Yb	55.1848	31.25471	7.17032	40.1205	70.2491	7.696	18	.000
Pair 262	Cu vs Mo	5.1871	9.66420	2.21712	.5291	9.8451	2.340	18	.031
Pair 263	Cu vs Ba	5.0258	9.29441	2.13228	.5460	9.5056	2.357	18	.030
Pair 264	Ba vs Tl	5.7477	10.76449	2.46954	.5594	10.9361	2.327	18	.032
Pair 265	Nd vs Sm	5.8324	11.07619	2.54105	.4938	11.1709	2.295	18	.034

Pair 266	Nd vs Gd	6.2095	11.61204	2.66399	.6127	11.8064	2.331	18	.032
Pair 267	Nd vs Er	-.1613	.37595	.08625	-.3425	.0199	-1.870	18	.078
Pair 268	Nd vs Yb	.5606	1.10117	.25262	.0299	1.0914	2.219	18	.040
Pair 269	Nd vs Tl	.6453	1.41442	.32449	-.0365	1.3270	1.989	18	.062
Pair 270	Sm vs Gd	1.0224	1.94879	.44708	.0831	1.9617	2.287	18	.035
Pair 271	Sm vs Er	.7219	1.47215	.33774	.0124	1.4315	2.138	18	.047
Pair 272	Sm vs Yb	.8066	1.78583	.40970	-.0542	1.6673	1.969	18	.065
Pair 273	Sm vs Tl	1.1837	2.31889	.53199	.0661	2.3014	2.225	18	.039
Pair 274	Gd vs Er	.0846	.31602	.07250	-.0677	.2369	1.167	18	.258
Pair 275	Gd vs Yb	.4618	.85012	.19503	.0520	.8715	2.368	18	.029
Pair 276	Gd vs Tl Yb vs Tl	.3772	.54465	.12495	.1146	.6397	3.018	18	.007

Paired Samples Test for iron with other trace elements in Borabu

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Fe – B	1394.93158	1373.58881	315.12288	732.88297	2056.98019	4.427	18	.000
Pair 2	Fe - Ti	1346.67368	1305.24246	299.44316	717.56696	1975.78041	4.497	18	.000
Pair 3	Fe - V	1420.62789	1374.18320	315.25925	758.29279	2082.96300	4.506	18	.000
Pair 4	Fe - Cr	1420.60789	1374.52405	315.33744	758.10851	2083.10728	4.505	18	.000
Pair 5	Fe - Mn	1049.15789	1387.66832	318.35295	380.32317	1717.99261	3.296	18	.004
Pair 6	Fe - Co	1421.26916	1374.77223	315.39438	758.65015	2083.88816	4.506	18	.000

Pair 7	Fe - Ni	1420.54421	1374.38570	315.30570	758.11151	2082.97691	4.505	18	.000
Pair 8	Fe - Cu	1413.63421	1374.14851	315.25129	751.31583	2075.95259	4.484	18	.000
Pair 9	Fe – Zn	1380.55263	1358.91667	311.75687	725.57576	2035.52950	4.428	18	.000
Pair 10	Fe - Ga	1420.39737	1374.11146	315.24279	758.09684	2082.69789	4.506	18	.000
Pair 11	Fe - Se	1419.70526	1374.98639	315.44351	756.98304	2082.42749	4.501	18	.000
Pair 12	Fe – Rb	1383.52632	1362.73316	312.63243	726.70996	2040.34268	4.425	18	.000
Pair 13	Fe - Sr	1310.72632	1363.59632	312.83045	653.49393	1967.95870	4.190	18	.001
Pair 14	Fe – Y	1415.64368	1375.41597	315.54206	752.71441	2078.57296	4.486	18	.000
Pair 15	Fe - Zr	1327.89474	1404.49018	322.21214	650.95214	2004.83733	4.121	18	.001
Pair 16	Fe - Nb	1418.70211	1372.24597	314.81482	757.30072	2080.10349	4.506	18	.000
Pair 17	Fe - Mo	1420.80895	1374.93509	315.43174	758.11145	2083.50645	4.504	18	.000
Pair 18	Fe - Ba	1366.33684	1375.35079	315.52711	703.43898	2029.23470	4.330	18	.000
Pair 19	Fe - Nd	1415.31211	1374.86110	315.41477	752.65027	2077.97394	4.487	18	.000
Pair 20	Fe - Sm	1420.49921	1374.98667	315.44358	757.77685	2083.22157	4.503	18	.000
Pair 21	Fe - Gd	1420.33789	1375.03533	315.45474	757.59208	2083.08371	4.503	18	.000
Pair 22	Fe - Er	1421.05984	1374.99833	315.44625	758.33186	2083.78782	4.505	18	.000
Pair 23	Fe - Yb	1421.14447	1374.97448	315.44078	758.42799	2083.86096	4.505	18	.000
Pair 24	Fe - Tl	1421.52689	1375.01278	315.44957	758.79195	2084.26184	4.506	18	.000

T- Critical =4.21 $P < 0.05$

APPENDIX XIV

Paired Samples Test for Trace elements in Ekerenyo Sub County

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	T	df	Sig. (2-tailed)
Pair 1	B vs Ti	-49.1158	69.59392	15.96594	-82.6590	-15.5726	-3.076	18	.007
Pair 2	B vs V	21.0716	13.36563	3.06629	14.6295	27.5136	6.872	18	.000
Pair 3	B vs Cr	21.0826	13.28801	3.04848	14.6780	27.4872	6.916	18	.000
Pair 4	B vs Mn	-341.7368	367.95680	84.41508	-519.0863	-164.3873	-4.048	18	.001
Pair 5	B vs Co	21.6658	13.45846	3.08758	15.1790	28.1526	7.017	18	.000
Pair 6	B vs Cu	20.9616	13.29432	3.04993	14.5539	27.3692	6.873	18	.000
Pair 7	B- Ni	14.0942	12.89339	2.95795	7.8798	20.3086	4.765	18	.000
Pair 8	B vs Zn	-17.5737	23.67307	5.43097	-28.9837	-6.1636	-3.236	18	.005
Pair 9	B vs Ga	20.7658	13.43476	3.08214	14.2904	27.2411	6.737	18	.000
Pair 10	B vs Se	20.3316	13.72188	3.14802	13.7178	26.9453	6.459	18	.000
Pair 11	B vs Rb	-16.1053	30.44320	6.98415	-30.7784	-1.4321	-2.306	18	.033
Pair 12	B vs Sr	-87.9589	72.57664	16.65022	-122.9398	-52.9781	-5.283	18	.000
Pair 13	B vs Y	16.1200	17.61827	4.04191	7.6283	24.6117	3.988	18	.001
Pair 14	B vs Zr	-72.5184	119.99313	27.52831	-130.3533	-14.6836	-2.634	18	.017
Pair 15	B vs Nb	19.0274	13.57939	3.11533	12.4823	25.5724	6.108	18	.000
Pair 16	B vs Mo	21.2522	13.54947	3.10846	14.7215	27.7828	6.837	18	.000
Pair 17	B vs Ba	-33.2184	27.27102	6.25640	-46.3626	-20.0742	-5.310	18	.000
Pair 18	B vs Nd	15.6679	17.69059	4.05850	7.1413	24.1945	3.861	18	.001
Pair 19	B vs Sm	20.8658	13.63266	3.12755	14.2951	27.4365	6.672	18	.000
Pair 20	B vs Gd	20.7279	13.66560	3.13510	14.1413	27.3145	6.612	18	.000
Pair 21	B vs Er	21.4326	13.51046	3.09951	14.9208	27.9445	6.915	18	.000
Pair 22	B vs Yb	21.5116	13.47730	3.09190	15.0157	28.0074	6.957	18	.000
Pair 23	B vs Tl	21.8842	13.50601	3.09849	15.3745	28.3939	7.063	18	.000
Pair 24	Ti vs V	70.1874	68.84554	15.79425	37.0049	103.3699	4.444	18	.000
Pair 25	Ti vs Cr	70.1984	69.17844	15.87062	36.8555	103.5414	4.423	18	.000
Pair 26	Ti vs Mn	-292.6211	374.69005	85.95979	-473.2159	-112.0262	-3.404	18	.003
Pair 27	Ti vs Co	70.7816	69.35222	15.91049	37.3549	104.2083	4.449	18	.000
Pair 28	Ti vs Ni	70.0774	68.97711	15.82443	36.8315	103.3233	4.428	18	.000
Pair 29	Ti vs Cu	63.2100	68.97485	15.82392	29.9652	96.4548	3.995	18	.001
Pair 30	Ti vs Zn	31.5421	60.10333	13.78865	2.5732	60.5110	2.288	18	.034
Pair 31	Ti vs Ga	69.8816	68.67565	15.75527	36.7810	102.9822	4.435	18	.000
Pair 32	Ti vs Se	69.4474	69.49428	15.94308	35.9522	102.9425	4.356	18	.000
Pair 33	Ti vs Rb	33.0105	62.89160	14.42832	2.6977	63.3233	2.288	18	.034
Pair 34	Ti vs Sr	-38.8432	92.60788	21.24570	-83.4787	5.7924	-1.828	18	.084
Pair 35	Ti vs Y	65.2358	70.87433	16.25969	31.0755	99.3961	4.012	18	.001
Pair 36	Ti vs Zr	-23.4026	152.71485	35.03519	-97.0088	50.2036	-.668	18	.513

Pair 37	Ti vs Nb	68.1432	66.68576	15.29876	36.0016	100.2847	4.454	18	.000
Pair 38	Ti vs Mo	70.3679	69.57894	15.96250	36.8320	103.9039	4.408	18	.000
Pair 39	Ti vs Ba	15.8974	77.48198	17.77559	-21.4478	53.2425	.894	18	.383
Pair 40	Ti vs Nd	64.7837	70.40034	16.15095	30.8518	98.7156	4.011	18	.001
Pair 41	Ti vs Sm	69.9816	69.59153	15.96539	36.4395	103.5236	4.383	18	.000
Pair 42	Ti vs Gd	69.8437	69.62602	15.97331	36.2850	103.4024	4.373	18	.000
Pair 43	Ti vs Er	70.5484	69.57423	15.96142	37.0147	104.0821	4.420	18	.000
Pair 44	Ti vs Yb	70.6274	69.54290	15.95424	37.1088	104.1460	4.427	18	.000
Pair 45	Ti vs Tl	71.0000	69.57773	15.96223	37.4646	104.5354	4.448	18	.000
Pair 46	V vs Cr	.0111	.52548	.12055	-.2422	.2643	.092	18	.928
Pair 47	V vs Mn	-362.8084	375.33136	86.10692	-543.7123	-181.9045	-4.213	18	.001
Pair 48	V vs Co	.5942	.52559	.12058	.3409	.8475	4.928	18	.000
Pair 49	V vs Ni	-.1100	.52797	.12113	-.3645	.1445	-.908	18	.376
Pair 50	V vs Cu	-6.9774	3.16523	.72615	-8.5030	-5.4518	-9.609	18	.000
Pair 51	V vs Zn	-38.6453	26.12940	5.99449	-51.2392	-26.0513	-6.447	18	.000
Pair 52	V vs Ga	-.3058	.53144	.12192	-.5619	-.0496	-2.508	18	.022
Pair 53	V vs Se	-.7400	2.40518	.55179	-1.8993	.4193	-1.341	18	.197
Pair 54	V vs Rb	-37.1768	27.87802	6.39566	-50.6136	-23.7401	-5.813	18	.000
Pair 55	V vs Sr	-109.0305	72.05199	16.52986	-143.7585	-74.3026	-6.596	18	.000
Pair 56	V vs Y	-4.9516	11.69478	2.68297	-10.5883	.6851	-1.846	18	.081
Pair 57	V vs Zr	-93.5900	122.27244	28.05122	-152.5234	-34.6566	-3.336	18	.004
Pair 58	V vs Nb	-2.0442	2.25437	.51719	-3.1308	-.9576	-3.953	18	.001
Pair 59	V vs Mo	.1806	1.03837	.23822	-.3199	.6811	.758	18	.458
Pair 60	V vs Ba	-54.2900	30.97162	7.10538	-69.2178	-39.3622	-7.641	18	.000
Pair 61	V vs Nd	-5.4037	11.67016	2.67732	-11.0285	.2212	-2.018	18	.059
Pair 62	V vs Sm	-.2058	2.10639	.48324	-1.2210	.8095	-.426	18	.675
Pair 63	V vs Gd	-.3437	2.40045	.55070	-1.5007	.8133	-.624	18	.540
Pair 64	V vs Er	.3611	1.14852	.26349	-.1925	.9146	1.370	18	.187
Pair 65	V vs Yb	.4400	.91368	.20961	-.0004	.8804	2.099	18	.050
Pair 66	V vs Tl	.8126	.76548	.17561	.4437	1.1816	4.627	18	.000
Pair 67	Cr vs Mn	-362.8195	375.36072	86.11365	-543.7375	-181.9014	-4.213	18	.001
Pair 68	Cr vs Co	.5832	.46840	.10746	.3574	.8089	5.427	18	.000
Pair 69	Cr vs Ni	-.1211	.72082	.16537	-.4685	.2264	-.732	18	.474
Pair 70	Cr vs Cu	-6.9884	3.20179	.73454	-8.5316	-5.4452	-9.514	18	.000
Pair 71	Cr vs Zn	-38.6563	26.11206	5.99052	-51.2419	-26.0707	-6.453	18	.000
Pair 72	Cr vs Ga	-.3168	.89471	.20526	-.7481	.1144	-1.544	18	.140
Pair 73	Cr vs Se	-.7511	2.47581	.56799	-1.9444	.4423	-1.322	18	.203
Pair 74	Cr vs Rb	-37.1879	28.12539	6.45241	-50.7439	-23.6319	-5.763	18	.000
Pair 75	Cr vs Sr	-109.0416	72.13970	16.54998	-143.8118	-74.2714	-6.589	18	.000
Pair 76	Cr vs Y	-4.9626	11.76792	2.69975	-10.6346	.7093	-1.838	18	.083
Pair 77	Cr vs Zr	-93.6011	122.25822	28.04796	-152.5276	-34.6745	-3.337	18	.004
Pair 78	Cr vs Nb	-2.0553	2.64707	.60728	-3.3311	-.7794	-3.384	18	.003
Pair 79	Cr vs Mo	.1695	1.03514	.23748	-.3294	.6684	.714	18	.484
Pair 80	Cr vs Ba	-54.3011	31.00301	7.11258	-69.2440	-39.3581	-7.635	18	.000

Pair 81	Cr vs Nd	-5.4147	11.76350	2.69873	-11.0846	.2551	-2.006	18	.060
Pair 82	Cr vs Sm	-.2168	2.15376	.49411	-1.2549	.8212	-.439	18	.666
Pair 83	Cr vs Gd	-.3547	2.45453	.56311	-1.5378	.8283	-.630	18	.537
Pair 84	Cr vs Er	.3500	1.13549	.26050	-.1973	.8973	1.344	18	.196
Pair 85	Cr vs Yb	.4289	.87513	.20077	.0071	.8507	2.137	18	.047
Pair 86	Cr vs Tl	.8016	.63522	.14573	.4954	1.1077	5.500	18	.000
Pair 87	Mn vs Co	363.4026	375.40856	86.12463	182.4615	544.3438	4.219	18	.001
Pair 88	Mn vs Ni	362.6984	375.03256	86.03837	181.9385	543.4583	4.216	18	.001
Pair 89	Mn vs Cu	355.8311	374.09908	85.82422	175.5211	536.1410	4.146	18	.001
Pair 90	Mn vs Zn	324.1632	371.90426	85.32069	144.9110	503.4153	3.799	18	.001
Pair 91	Mn vs Ga	362.5026	375.36467	86.11456	181.5827	543.4226	4.210	18	.001
Pair 92	Mn vs Se	362.0684	375.55342	86.15786	181.0575	543.0794	4.202	18	.001
Pair 93	Mn vs Rb	325.6316	369.81051	84.84035	147.3886	503.8745	3.838	18	.001
Pair 94	Mn vs Sr	253.7779	392.94293	90.14729	64.3855	443.1703	2.815	18	.011
Pair 95	Mn vs Y	357.8568	376.27215	86.32275	176.4995	539.2142	4.146	18	.001
Pair 96	Mn vs Zr	269.2184	386.93118	88.76810	82.7236	455.7133	3.033	18	.007
Pair 97	Mn vs Nb	360.7642	375.12635	86.05989	179.9591	541.5693	4.192	18	.001
Pair 98	Mn vs Mo	362.9890	375.50177	86.14601	182.0029	543.9751	4.214	18	.001
Pair 99	Mn vs Ba	308.5184	379.96793	87.17062	125.3797	491.6571	3.539	18	.002
Pair 100	Mn vs Nd	357.4047	376.20272	86.30682	176.0808	538.7286	4.141	18	.001
Pair 101	Mn vs Sm	362.6026	375.56391	86.16027	181.5866	543.6186	4.208	18	.001
Pair 102	Mn vs Gd	362.4647	375.57592	86.16302	181.4429	543.4865	4.207	18	.001
Pair 103	Mn vs Er	363.1695	375.48650	86.14251	182.1908	544.1482	4.216	18	.001
Pair 104	Mn vs Yb	363.2484	375.44816	86.13372	182.2882	544.2086	4.217	18	.001
Pair 105	Mn vs Tl	363.6211	375.44502	86.13300	182.6623	544.5798	4.222	18	.001
Pair 106	Co vs Ni	-.7042	.62941	.14440	-1.0076	-.4008	-4.877	18	.000
Pair 107	Co vs Cu	-7.5716	3.20764	.73588	-9.1176	-6.0255	-10.289	18	.000
Pair 108	Co vs Zn	-39.2395	26.42087	6.06136	-51.9739	-26.5050	-6.474	18	.000
Pair 109	Co vs Ga	-.9000	.81746	.18754	-1.2940	-.5060	-4.799	18	.000
Pair 110	Co vs Se	-1.3342	2.28960	.52527	-2.4378	-.2307	-2.540	18	.021
Pair 111	Co vs Rb	-37.7711	28.11816	6.45075	-51.3236	-24.2185	-5.855	18	.000
Pair 112	Co vs Sr	-109.6247	72.13888	16.54979	-144.3946	-74.8549	-6.624	18	.000
Pair 113	Co vs Y	-5.5458	11.62953	2.66800	-11.1510	.0595	-2.079	18	.052
Pair 114	Co vs Zr	-94.1842	122.16097	28.02565	-153.0639	-35.3045	-3.361	18	.003
Pair 115	Co vs Nb	-2.6384	2.73924	.62842	-3.9587	-1.3182	-4.198	18	.001
Pair 116	Co vs Mo	-.4136	.77111	.17690	-.7853	-.0420	-2.338	18	.031
Pair 117	Co vs Ba	-54.8842	30.99991	7.11187	-69.8257	-39.9427	-7.717	18	.000
Pair 118	Co vs Nd	-5.9979	11.62573	2.66713	-11.6013	-.3945	-2.249	18	.037
Pair 119	Co vs Sm	-.8000	1.95493	.44849	-1.7422	.1422	-1.784	18	.091
Pair 120	Co vs Gd	-.9379	2.25899	.51825	-2.0267	.1509	-1.810	18	.087
Pair 121	Co vs Er	-.2332	.87291	.20026	-.6539	.1876	-1.164	18	.260
Pair 122	Co vs Yb	-.1542	.57356	.13158	-.4307	.1222	-1.172	18	.256
Pair 123	Co vs Tl	.2184	.25936	.05950	.0934	.3434	3.671	18	.002
Pair 124	Ni vs Cu	-6.8674	2.85888	.65587	-8.2453	-5.4894	-10.471	18	.000
Pair 125	Ni vs Zn	-38.5353	26.17936	6.00596	-51.1533	-25.9172	-6.416	18	.000
Pair 126	Ni vs Ga	-.1958	.76416	.17531	-.5641	.1725	-1.117	18	.279

Pair 127	Ni vs Se	-.6300	2.39376	.54917	-1.7838	.5238	-1.147	18	.266
Pair 128	Ni vs Rb	-37.0668	27.67975	6.35017	-50.4081	-23.7256	-5.837	18	.000
Pair 129	Ni vs Sr	-108.9205	72.23384	16.57158	-143.7361	-74.1049	-6.573	18	.000
Pair 130	Ni vs Y	-4.8416	11.67016	2.67732	-10.4664	.7833	-1.808	18	.087
Pair 131	Ni vs Zr	-93.4800	122.08584	28.00841	-152.3235	-34.6365	-3.338	18	.004
Pair 132	Ni vs Nb	-1.9342	2.41864	.55487	-3.1000	-.7685	-3.486	18	.003
Pair 133	Ni vs Mo	.2906	1.04701	.24020	-.2141	.7952	1.210	18	.242
Pair 134	Ni vs Ba	-54.1800	30.99715	7.11123	-69.1201	-39.2399	-7.619	18	.000
Pair 135	Ni vs Nd	-5.2937	11.65125	2.67298	-10.9094	.3220	-1.980	18	.063
Pair 136	Ni vs Sm	-.0958	2.10713	.48341	-1.1114	.9198	-.198	18	.845
Pair 137	Ni vs Gd	-.2337	2.39445	.54932	-1.3878	.9204	-.425	18	.676
Pair 138	Ni vs Er	.4711	1.16247	.26669	-.0892	1.0313	1.766	18	.094
Pair 139	Ni vs Yb	.5500	.93239	.21390	.1006	.9994	2.571	18	.019
Pair 140	Ni vs Tl	.9226	.81561	.18711	.5295	1.3157	4.931	18	.000
Pair 141	Cu vs Zn	-31.6679	25.27145	5.79767	-43.8483	-19.4874	-5.462	18	.000
Pair 142	Cu vs Ga	6.6716	3.25120	.74588	5.1046	8.2386	8.945	18	.000
Pair 143	Cu vs Se	6.2374	3.93816	.90348	4.3392	8.1355	6.904	18	.000
Pair 144	Cu vs Rb	-30.1995	26.47349	6.07344	-42.9593	-17.4397	-4.972	18	.000
Pair 145	Cu vs Sr	-102.0532	74.30403	17.04651	-137.8666	-66.2398	-5.987	18	.000
Pair 146	Cu vs Y	2.0258	12.04525	2.76337	-3.7798	7.8314	.733	18	.473
Pair 147	Cu vs Zr	-86.6126	120.64665	27.67824	-144.7625	-28.4628	-3.129	18	.006
Pair 148	Cu vs Nb	4.9332	3.93798	.90344	3.0351	6.8312	5.460	18	.000
Pair 149	Cu vs Mo	7.1579	3.16157	.72531	5.6341	8.6818	9.869	18	.000
Pair 150	Cu vs Ba	-47.3126	31.30357	7.18153	-62.4005	-32.2248	-6.588	18	.000
Pair 151	Cu vs Nd	1.5737	12.06937	2.76890	-4.2436	7.3909	.568	18	.577
Pair 152	Cu vs Sm	6.7716	3.79016	.86952	4.9448	8.5984	7.788	18	.000
Pair 153	Cu vs Gd	6.6337	3.95733	.90787	4.7263	8.5411	7.307	18	.000
Pair 154	Cu vs Er	7.3384	3.32694	.76325	5.7349	8.9420	9.615	18	.000
Pair 155	Cu vs Yb	7.4174	3.22174	.73912	5.8645	8.9702	10.035	18	.000
Pair 156	Cu vs Tl	7.7900	3.25377	.74647	6.2217	9.3583	10.436	18	.000
Pair 157	Zn vs Ga	38.3395	26.09575	5.98677	25.7617	50.9172	6.404	18	.000
Pair 158	Zn vs Se	37.9053	26.49053	6.07734	25.1372	50.6733	6.237	18	.000
Pair 159	Zn vs Rb	1.4684	32.87274	7.54152	-14.3757	17.3126	.195	18	.848
Pair 160	Zn vs S r	-70.3853	78.30638	17.96472	-108.1277	-32.6428	-3.918	18	.001
Pair 161	Zn vs Y	33.6937	28.59414	6.55995	19.9117	47.4756	5.136	18	.000
Pair 162	Zn vs Zr	-54.9447	121.25324	27.81740	-113.3869	3.4975	-1.975	18	.064
Pair 163	Zn vs Nb	36.6011	25.38263	5.82318	24.3670	48.8351	6.285	18	.000
Pair 164	Zn vs Mo	38.8258	26.45145	6.06838	26.0766	51.5750	6.398	18	.000
Pair 165	Zn vs Ba	-15.6447	36.45630	8.36365	-33.2161	1.9266	-1.871	18	.078
Pair 166	Zn vs Nd	33.2416	28.50389	6.53924	19.5031	46.9800	5.083	18	.000
Pair 167	Zn vs Sm	38.4395	26.54915	6.09079	25.6432	51.2358	6.311	18	.000
Pair 168	Zn vs Gd	38.3016	26.58593	6.09923	25.4876	51.1156	6.280	18	.000
Pair 169	Zn vs Er	39.0063	26.51978	6.08406	26.2242	51.7884	6.411	18	.000
Pair 170	Zn vs Yb	39.0853	26.48940	6.07709	26.3178	51.8527	6.432	18	.000

Pair 171	Zn vs Tl	39.4579	26.56515	6.09446	26.6539	52.2619	6.474	18	.000
Pair 172	Ga vs Se	-.4342	2.00397	.45974	-1.4001	.5317	-.944	18	.357
Pair 173	Ga vs Rb	-36.8711	27.77693	6.37247	-50.2591	-23.4830	-5.786	18	.000
Pair 174	Ga vs Sr	-108.7247	72.04796	16.52894	-143.4507	-73.9987	-6.578	18	.000
Pair 175	Ga vs Y	-4.6458	11.24034	2.57871	-10.0635	.7719	-1.802	18	.088
Pair 176	Ga vs Zr	-93.2842	121.98216	27.98463	-152.0777	-34.4907	-3.333	18	.004
Pair 177	Ga vs Nb	-1.7384	2.13171	.48905	-2.7659	-.7110	-3.555	18	.002
Pair 178	Ga vs Mo	.4864	1.23571	.28349	-.1092	1.0820	1.716	18	.103
Pair 179	Ga vs Ba	-53.9842	30.93151	7.09617	-68.8927	-39.0757	-7.608	18	.000
Pair 180	Ga vs Nd	-5.0979	11.20488	2.57057	-10.4985	.3027	-1.983	18	.063
Pair 181	Ga vs Sm	.1000	1.74238	.39973	-.7398	.9398	.250	18	.805
Pair 182	Ga vs Gd	-.0379	2.01987	.46339	-1.0114	.9357	-.082	18	.936
Pair 183	Ga vs Er	.6668	.98674	.22637	.1912	1.1424	2.946	18	.009
Pair 184	Ga vs Yb	.7458	.88338	.20266	.3200	1.1716	3.680	18	.002
Pair 185	Ga vs Tl	1.1184	1.02104	.23424	.6263	1.6105	4.775	18	.000
Pair 186	Se vs Rb	-36.4368	27.87538	6.39505	-49.8723	-23.0013	-5.698	18	.000
Pair 187	Se vs Sr	-108.2905	72.49228	16.63087	-143.2307	-73.3504	-6.511	18	.000
Pair 188	Se vs Y	-4.2116	9.35723	2.14670	-8.7216	.2985	-1.962	18	.065
Pair 189	Se vs Zr	-92.8500	120.43224	27.62905	-150.8965	-34.8035	-3.361	18	.003
Pair 190	Se vs Nb	-1.3042	3.67122	.84224	-3.0737	.4653	-1.549	18	.139
Pair 191	Se vs Mo	.9206	2.37324	.54446	-.2233	2.0644	1.691	18	.108
Pair 192	Se vs Ba	-53.5500	30.73655	7.05145	-68.3645	-38.7355	-7.594	18	.000
Pair 193	Se vs Nd	-4.6637	9.35581	2.14637	-9.1730	-.1543	-2.173	18	.043
Pair 194	Se vs Sm	.5342	.41770	.09583	.3329	.7355	5.575	18	.000
Pair 195	Se vs Gd	.3963	.26519	.06084	.2685	.5241	6.514	18	.000
Pair 196	Se vs Er	1.1011	1.45925	.33477	.3977	1.8044	3.289	18	.004
Pair 197	Se vs Yb	1.1800	1.76804	.40562	.3278	2.0322	2.909	18	.009
Pair 198	Se vs Tl	1.5526	2.30275	.52829	.4427	2.6625	2.939	18	.009
Pair 199	Rb vs Sr	-71.8537	81.42193	18.67947	-111.0978	-32.6096	-3.847	18	.001
Pair 200	Rb vs Y	32.2253	28.64484	6.57158	18.4189	46.0316	4.904	18	.000
Pair 201	Rb vs Zr	-56.4132	113.20682	25.97142	-110.9771	-1.8492	-2.172	18	.043
Pair 202	Rb vs Nb	35.1326	27.00685	6.19580	22.1157	48.1495	5.670	18	.000
Pair 203	Rb vs Mo	37.3574	28.07166	6.44008	23.8273	50.8875	5.801	18	.000
Pair 204	Rb vs Ba	-17.1132	36.85001	8.45397	-34.8743	.6480	-2.024	18	.058
Pair 205	Rb vs Nd	31.7732	28.39118	6.51338	18.0890	45.4573	4.878	18	.000
Pair 206	Rb vs Sm	36.9711	27.95976	6.41441	23.4949	50.4472	5.764	18	.000
Pair 207	Rb vs Gd	36.8332	27.93685	6.40915	23.3680	50.2983	5.747	18	.000
Pair 208	Rb vs Er	37.5379	28.10850	6.44853	23.9900	51.0858	5.821	18	.000
Pair 209	Rb vs Yb	37.6168	28.11633	6.45033	24.0652	51.1685	5.832	18	.000
Pair 210	Rb vs Tl	37.9895	28.26190	6.48372	24.3677	51.6113	5.859	18	.000
Pair 211	Sr vs Y	104.0789	74.72939	17.14410	68.0605	140.0974	6.071	18	.000
Pair 212	Sr vs Zr	15.4405	165.92955	38.06685	-64.5350	95.4160	.406	18	.690
Pair 213	Sr vs Nb	106.9863	71.63587	16.43440	72.4589	141.5137	6.510	18	.000
Pair 214	Sr vs Mo	109.2111	72.21884	16.56814	74.4027	144.0195	6.592	18	.000

Pair 215	Sr vs Ba	54.7405	61.39345	14.08462	25.1498	84.3312	3.887	18	.001
Pair 216	Sr vs Nd	103.6268	74.45760	17.08175	67.7394	139.5143	6.067	18	.000
Pair 217	Sr vs Sm	108.8247	72.43696	16.61818	73.9112	143.7382	6.549	18	.000
Pair 218	Sr vs Gd	108.6868	72.47591	16.62711	73.7546	143.6191	6.537	18	.000
Pair 219	Sr vs Er	109.3916	72.31395	16.58996	74.5374	144.2458	6.594	18	.000
Pair 220	Sr vs Yb	109.4705	72.27911	16.58197	74.6331	144.3079	6.602	18	.000
Pair 221	Sr vs Tl	109.8432	72.16473	16.55572	75.0609	144.6254	6.635	18	.000
Pair 222	Y vs Zr	-88.6384	113.24725	25.98070	-143.2218	-34.0550	-3.412	18	.003
Pair 223	Y vs Nb	2.9074	12.11050	2.77834	-2.9297	8.7444	1.046	18	.309
Pair 224	Y vs Mo	5.1322	11.63802	2.66994	-.4772	10.7415	1.922	18	.071
Pair 225	Y vs Ba	-49.3384	30.87776	7.08384	-64.2210	-34.4558	-6.965	18	.000
Pair 226	Y vs Nd	-.4521	.61655	.14145	-.7493	-.1549	-3.196	18	.005
Pair 227	Y vs Sm	4.7458	9.68361	2.22157	.0784	9.4131	2.136	18	.047
Pair 228	Y vs Gd	4.6079	9.38044	2.15202	.0867	9.1291	2.141	18	.046
Pair 229	Y vs Er	5.3126	10.78501	2.47425	.1144	10.5108	2.147	18	.046
Pair 230	Y vs Yb	5.3916	11.09775	2.54600	.0426	10.7405	2.118	18	.048
Pair 231	Y vs Tl	5.7642	11.63450	2.66914	.1566	11.3719	2.160	18	.045
Pair 232	Zr vs Nb	91.5458	122.77259	28.16596	32.3713	150.7203	3.250	18	.004
Pair 233	Zr vs Mo	93.7706	121.99338	27.98720	34.9717	152.5695	3.350	18	.004
Pair 234	Zr vs Ba	39.3000	115.33937	26.46067	-16.2918	94.8918	1.485	18	.155
Pair 235	Zr vs Nd	88.1863	113.44368	26.02576	33.5082	142.8644	3.388	18	.003
Pair 236	Zr vs Sm	93.3842	120.64927	27.67884	35.2331	151.5353	3.374	18	.003
Pair 237	Zr vs Gd	93.2463	120.41359	27.62477	35.2088	151.2838	3.375	18	.003
Pair 238	Zr vs Er	93.9511	121.47408	27.86807	35.4024	152.4997	3.371	18	.003
Pair 239	Zr vs Yb	94.0300	121.69377	27.91847	35.3755	152.6845	3.368	18	.003
Pair 240	Zr vs Tl	94.4026	122.14178	28.02125	35.5322	153.2731	3.369	18	.003
Pair 241	Nb vs Mo	2.2248	3.07694	.70590	.7418	3.7078	3.152	18	.006
Pair 242	Nb vs Ba	-52.2458	31.16946	7.15076	-67.2690	-37.2226	-7.306	18	.000
Pair 243	Nb vs Nd	-3.3595	11.99397	2.75161	-9.1404	2.4214	-1.221	18	.238
Pair 244	Nb vs Sm	1.8384	3.54372	.81298	.1304	3.5464	2.261	18	.036
Pair 245	Nb vs Gd	1.7005	3.73574	.85704	-.1000	3.5011	1.984	18	.063
Pair 246	Nb vs Er	2.4053	3.07314	.70503	.9241	3.8865	3.412	18	.003
Pair 247	Nb vs Yb	2.4842	2.97091	.68157	1.0523	3.9161	3.645	18	.002
Pair 248	Nb vs Tl	2.8568	2.95146	.67711	1.4343	4.2794	4.219	18	.001
Pair 249	Mo vs Ba	-54.4706	30.86017	7.07981	-69.3447	-39.5965	-7.694	18	.000
Pair 250	Mo vs Nd	-5.5843	11.63809	2.66996	-11.1936	.0251	-2.092	18	.051
Pair 251	Mo vs Sm	-.3864	2.07299	.47558	-1.3855	.6128	-.812	18	.427
Pair 252	Mo vs Gd	-.5243	2.35420	.54009	-1.6589	.6104	-.971	18	.345
Pair 253	Mo vs Er	.1805	1.12080	.25713	-.3597	.7207	.702	18	.492
Pair 254	Mo vs Yb	.2594	.90594	.20784	-.1772	.6961	1.248	18	.228
Pair 255	Mo vs Tl	.6321	.74951	.17195	.2708	.9933	3.676	18	.002
Pair 256	Ba vs Nd	48.8863	30.83826	7.07478	34.0227	63.7499	6.910	18	.000
Pair 257	Ba vs Sm	54.0842	30.69073	7.04094	39.2918	68.8767	7.681	18	.000
Pair 258	Ba vs Gd	53.9463	30.63824	7.02890	39.1792	68.7135	7.675	18	.000
Pair 259	Ba vs Er	54.6511	30.87262	7.08266	39.7709	69.5312	7.716	18	.000
Pair 260	Ba vs Yb	54.7300	30.90940	7.09110	39.8321	69.6279	7.718	18	.000

Pair 261	Cu vs Mo	55.1026	31.01115	7.11445	40.1557	70.0495	7.745	18	.000
Pair 262	Cu vs Ba	5.1979	9.68698	2.22235	.5289	9.8669	2.339	18	.031
Pair 263	Ba vs Tl	5.0600	9.38438	2.15292	.5369	9.5831	2.350	18	.030
Pair 264	Nd vs Sm	5.7647	10.79106	2.47564	.5636	10.9659	2.329	18	.032
Pair 265	Nd vs Gd	5.8437	11.10294	2.54719	.4922	11.1951	2.294	18	.034
Pair 266	Nd vs Er	6.2163	11.63959	2.67031	.6062	11.8264	2.328	18	.032
Pair 267	Nd vs Yb	-.1379	.30866	.07081	-.2867	.0109	-1.947	18	.067
Pair 268	Nd vs Tl	.5668	1.10524	.25356	.0341	1.0995	2.236	18	.038
Pair 269	Sm vs Gd	.6458	1.41885	.32551	-.0381	1.3297	1.984	18	.063
Pair 270	Sm vs Er	1.0184	1.95365	.44820	.0768	1.9601	2.272	18	.036
Pair 271	Sm vs Yb	.7047	1.40857	.32315	.0258	1.3836	2.181	18	.043
Pair 272	Sm vs Tl	.7837	1.72235	.39514	-.0465	1.6138	1.983	18	.063
Pair 273	Gd vs Er	1.1563	2.25626	.51762	.0688	2.2438	2.234	18	.038
Pair 274	Gd vs Yb	.0789	.31754	.07285	-.0741	.2320	1.084	18	.293
Pair 275	Gd vs Tl	.4516	.85158	.19536	.0411	.8620	2.311	18	.033
Pair 276	Yb Vs Tl	.3726	.54581	.12522	.1096	.6357	2.976	18	.008

Paired Samples t-Test for iron with other trace elements in Ekerenyo

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 Fe – B	1394.93158	1373.58881	315.12288	732.88297	2056.98019	4.427	18	.000
Pair 2 Fe - Ti	1346.67368	1305.24246	299.44316	717.56696	1975.78041	4.497	18	.000
Pair 3 Fe - V	1420.62789	1374.18320	315.25925	758.29279	2082.96300	4.506	18	.000
Pair 4 Fe - Cr	1420.60789	1374.52405	315.33744	758.10851	2083.10728	4.505	18	.000
Pair 5 Fe - Mn	1049.15789	1387.66832	318.35295	380.32317	1717.99261	3.296	18	.004
Pair 6 Fe - Co	1421.26916	1374.77223	315.39438	758.65015	2083.88816	4.506	18	.000
Pair 7 Fe - Ni	1420.54421	1374.38570	315.30570	758.11151	2082.97691	4.505	18	.000
Pair 8 Fe - Cu	1413.63421	1374.14851	315.25129	751.31583	2075.95259	4.484	18	.000
Pair 9 Fe – Zn	1380.55263	1358.91667	311.75687	725.57576	2035.52950	4.428	18	.000

Pair 10	Fe - Ga	1420.39737	1374.11146	315.24279	758.09684	2082.69789	4.506	18	.000
Pair 11	Fe - Se	1419.70526	1374.98639	315.44351	756.98304	2082.42749	4.501	18	.000
Pair 12	Fe – Rb	1383.52632	1362.73316	312.63243	726.70996	2040.34268	4.425	18	.000
Pair 13	Fe - Sr	1310.72632	1363.59632	312.83045	653.49393	1967.95870	4.190	18	.001
Pair 14	Fe – Y	1415.64368	1375.41597	315.54206	752.71441	2078.57296	4.486	18	.000
Pair 15	Fe - Zr	1327.89474	1404.49018	322.21214	650.95214	2004.83733	4.121	18	.001
Pair 16	Fe - Nb	1418.70211	1372.24597	314.81482	757.30072	2080.10349	4.506	18	.000
Pair 17	Fe - Mo	1420.80895	1374.93509	315.43174	758.11145	2083.50645	4.504	18	.000
Pair 18	Fe - Ba	1366.33684	1375.35079	315.52711	703.43898	2029.23470	4.330	18	.000
Pair 19	Fe - Nd	1415.31211	1374.86110	315.41477	752.65027	2077.97394	4.487	18	.000
Pair 20	Fe - Sm	1420.49921	1374.98667	315.44358	757.77685	2083.22157	4.503	18	.000
Pair 21	Fe - Gd	1420.33789	1375.03533	315.45474	757.59208	2083.08371	4.503	18	.000
Pair 22	Fe - Er	1421.05984	1374.99833	315.44625	758.33186	2083.78782	4.505	18	.000
Pair 23	Fe - Yb	1421.14447	1374.97448	315.44078	758.42799	2083.86096	4.505	18	.000
Pair 24	Fe - Tl	1421.52689	1375.01278	315.44957	758.79195	2084.26184	4.506	18	.000

T-Crtical = 4.210 $P < 0.05$

APPENDIX XV

Paired Samples Test for Trace Elements in Manga Sub County

		Paired Differences					T	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	B vs Ti	-39.2053	58.17358	13.34593	-67.2440	-11.1665	-2.938	18	.009
Pair 2	B vs V	31.7663	16.57545	3.80267	23.7772	39.7554	8.354	18	.000
Pair 3	B vs Cr	32.0058	16.87676	3.87180	23.8714	40.1401	8.266	18	.000
Pair 4	B vs Mn	-372.9105	642.63503	147.43059	-682.6507	-63.1704	-2.529	18	.021
Pair 5	B vs Co	32.5728	16.99924	3.89989	24.3795	40.7662	8.352	18	.000
Pair 6	B vs Cu	31.3095	16.28925	3.73701	23.4583	39.1606	8.378	18	.000
Pair 7	B- Ni	23.2111	15.34464	3.52030	15.8152	30.6069	6.593	18	.000
Pair 8	B vs Zn	-9.5684	25.88861	5.93925	-22.0463	2.9095	-1.611	18	.125
Pair 9	B vs Ga	31.8942	16.97596	3.89455	23.7121	40.0764	8.189	18	.000
Pair 10	B vs Se	31.4474	17.07049	3.91624	23.2197	39.6751	8.030	18	.000
Pair 11	B vs Rb	-14.7263	33.71969	7.73583	-30.9787	1.5261	-1.904	18	.073
Pair 12	B vs Sr	-75.7526	72.75300	16.69068	-110.8185	-40.6868	-4.539	18	.000
Pair 13	B vs Y	29.2505	15.75970	3.61552	21.6546	36.8465	8.090	18	.000
Pair 14	B vs Zr	-54.7789	104.53396	23.98174	-105.1627	-4.3952	-2.284	18	.035
Pair 15	B vs Nb	30.0111	16.93367	3.88485	21.8493	38.1728	7.725	18	.000
Pair 16	B vs Mo	32.1379	17.26189	3.96015	23.8179	40.4579	8.115	18	.000
Pair 17	B vs Ba	-37.6579	45.62496	10.46708	-59.6484	-15.6674	-3.598	18	.002
Pair 18	B vs Nd	28.7379	15.85108	3.63649	21.0979	36.3779	7.903	18	.000
Pair 19	B vs Sm	32.3002	17.01212	3.90285	24.1006	40.4998	8.276	18	.000
Pair 20	B vs Gd	32.1758	16.94931	3.88844	24.0065	40.3451	8.275	18	.000
Pair 21	B vs Er	32.6578	17.14838	3.93411	24.3925	40.9230	8.301	18	.000
Pair 22	B vs Yb	32.7114	17.18442	3.94238	24.4287	40.9940	8.297	18	.000
Pair 23	B vs Tl	32.9443	17.30361	3.96972	24.6042	41.2844	8.299	18	.000
Pair 24	Ti vs V	70.9716	59.93259	13.74948	42.0850	99.8582	5.162	18	.000
Pair 25	Ti vs Cr	71.2111	60.48701	13.87667	42.0572	100.3649	5.132	18	.000
Pair 26	Ti vs Mn	-333.7053	655.98258	150.49272	-649.8787	-17.5318	-2.217	18	.040
Pair 27	Ti vs Co	71.7781	60.74496	13.93585	42.5000	101.0562	5.151	18	.000
Pair 28	Ti vs Ni	70.5147	60.63848	13.91142	41.2879	99.7415	5.069	18	.000
Pair 29	Ti vs Cu	62.4163	58.82527	13.49544	34.0634	90.7692	4.625	18	.000
Pair 30	Ti vs Zn	29.6368	45.08631	10.34351	7.9059	51.3678	2.865	18	.010
Pair 31	Ti vs Ga	71.0995	60.29867	13.83346	42.0364	100.1625	5.140	18	.000
Pair 32	Ti vs Se	70.6526	60.87861	13.96651	41.3101	99.9952	5.059	18	.000
Pair 33	Ti vs Rb	24.4789	65.97785	15.13636	-7.3214	56.2793	1.617	18	.123
Pair 34	Ti vs Sr	-36.5474	83.18305	19.08350	-76.6403	3.5456	-1.915	18	.072
Pair 35	Ti vs Y	68.4558	60.55406	13.89205	39.2697	97.6419	4.928	18	.000
Pair 36	Ti vs Zr	-15.5737	128.56865	29.49567	-77.5418	46.3944	-.528	18	.604

Pair 37	Ti vs Nb	69.2163	58.78447	13.48608	40.8831	97.5495	5.132	18	.000
Pair 38	Ti vs Mo	71.3432	60.71761	13.92958	42.0782	100.6081	5.122	18	.000
Pair 39	Ti vs Ba	1.5474	65.12333	14.94032	-29.8411	32.9358	.104	18	.919
Pair 40	Ti vs Nd	67.9432	60.34706	13.84456	38.8568	97.0295	4.908	18	.000
Pair 41	Ti vs Sm	71.5055	60.99080	13.99225	42.1088	100.9021	5.110	18	.000
Pair 42	Ti vs Gd	71.3811	60.97962	13.98968	41.9898	100.7723	5.102	18	.000
Pair 43	Ti vs Er	71.8631	61.05870	14.00783	42.4337	101.2924	5.130	18	.000
Pair 44	Ti vs Yb	71.9166	61.06442	14.00914	42.4845	101.3487	5.134	18	.000
Pair 45	Ti vs Tl	72.1496	61.13587	14.02553	42.6830	101.6161	5.144	18	.000
Pair 46	V vs Cr	.2395	.80315	.18426	-.1476	.6266	1.300	18	.210
Pair 47	V vs Mn	-404.6768	648.10520	148.68553	-717.0535	-92.3001	-2.722	18	.014
Pair 48	V vs Co	.8065	.98837	.22675	.3301	1.2829	3.557	18	.002
Pair 49	V vs Ni	-.4568	1.67422	.38409	-1.2638	.3501	-1.189	18	.250
Pair 50	V vs Cu	-8.5553	6.50201	1.49166	-11.6891	-5.4214	-5.735	18	.000
Pair 51	V vs Zn	-41.3347	28.01272	6.42656	-54.8364	-27.8330	-6.432	18	.000
Pair 52	V vs Ga	.1279	.96716	.22188	-.3383	.5941	.576	18	.571
Pair 53	V vs Se	-.3189	1.49357	.34265	-1.0388	.4009	-.931	18	.364
Pair 54	V vs Rb	-46.4926	36.53480	8.38166	-64.1018	-28.8834	-5.547	18	.000
Pair 55	V vs Sr	-107.5189	72.12220	16.54597	-142.2807	-72.7572	-6.498	18	.000
Pair 56	V vs Y	-2.5158	3.43777	.78868	-4.1727	-.8588	-3.190	18	.005
Pair 57	V vs Zr	-86.5453	107.70628	24.70952	-138.4580	-34.6325	-3.503	18	.003
Pair 58	V vs Nb	-1.7553	1.81446	.41627	-2.6298	-.8807	-4.217	18	.001
Pair 59	V vs Mo	.3716	1.67928	.38525	-.4378	1.1810	.965	18	.348
Pair 60	V vs Ba	-69.4242	51.33528	11.77712	-94.1670	-44.6814	-5.895	18	.000
Pair 61	V vs Nd	-3.0284	3.90446	.89575	-4.9103	-1.1465	-3.381	18	.003
Pair 62	V vs Sm	.5339	1.48230	.34006	-.1806	1.2483	1.570	18	.134
Pair 63	V vs Gd	.4095	1.49981	.34408	-.3134	1.1324	1.190	18	.249
Pair 64	V vs Er	.8915	1.43247	.32863	.2010	1.5819	2.713	18	.014
Pair 65	V vs Yb	.9451	1.42719	.32742	.2572	1.6329	2.886	18	.010
Pair 66	V vs Tl	1.1780	1.49229	.34235	.4587	1.8973	3.441	18	.003
Pair 67	Cr vs Mn	-404.9163	647.99163	148.65948	-717.2383	-92.5943	-2.724	18	.014
Pair 68	Cr vs Co	.5671	.34996	.08029	.3984	.7357	7.063	18	.000
Pair 69	Cr vs Ni	-.6963	1.56370	.35874	-1.4500	.0574	-1.941	18	.068
Pair 70	Cr vs Cu	-8.7947	6.75361	1.54938	-12.0499	-5.5396	-5.676	18	.000
Pair 71	Cr vs Zn	-41.5742	28.36307	6.50693	-55.2448	-27.9037	-6.389	18	.000
Pair 72	Cr vs Ga	-.1116	.51728	.11867	-.3609	.1377	-.940	18	.360
Pair 73	Cr vs Se	-.5584	.91065	.20892	-.9973	-.1195	-2.673	18	.016
Pair 74	Cr vs Rb	-46.7321	36.65300	8.40878	-64.3983	-29.0659	-5.558	18	.000
Pair 75	Cr vs Sr	-107.7584	72.33088	16.59384	-142.6208	-72.8961	-6.494	18	.000
Pair 76	Cr vs Y	-2.7553	3.33634	.76541	-4.3633	-1.1472	-3.600	18	.002
Pair 77	Cr vs Zr	-86.7847	107.55789	24.67547	-138.6260	-34.9435	-3.517	18	.002
Pair 78	Cr vs Nb	-1.9947	1.97242	.45250	-2.9454	-1.0441	-4.408	18	.000
Pair 79	Cr vs Mo	.1321	1.10605	.25375	-.4010	.6652	.521	18	.609
Pair 80	Cr vs Ba	-69.6637	51.77405	11.87778	-94.6180	-44.7094	-5.865	18	.000

Pair 81	Cr vs Nd	-3.2679	3.85589	.88460	-5.1264	-1.4094	-3.694	18	.002
Pair 82	Cr vs Sm	.2944	.89622	.20561	-.1375	.7264	1.432	18	.169
Pair 83	Cr vs Gd	.1700	.95207	.21842	-.2889	.6289	.778	18	.446
Pair 84	Cr vs Er	.6520	.74559	.17105	.2926	1.0114	3.812	18	.001
Pair 85	Cr vs Yb	.7056	.72391	.16608	.3567	1.0545	4.249	18	.000
Pair 86	Cr vs Tl	.9385	.78649	.18043	.5595	1.3176	5.202	18	.000
Pair 87	Mn vs Co	405.4834	647.99283	148.65975	93.1608	717.8059	2.728	18	.014
Pair 88	Mn vs Ni	404.2200	647.14361	148.46493	92.3068	716.1332	2.723	18	.014
Pair 89	Mn vs Cu	396.1216	646.80003	148.38610	84.3739	707.8692	2.670	18	.016
Pair 90	Mn vs Zn	363.3421	650.93494	149.33472	49.6015	677.0827	2.433	18	.026
Pair 91	Mn vs Ga	404.8047	648.00414	148.66234	92.4767	717.1327	2.723	18	.014
Pair 92	Mn vs Se	404.3579	647.72790	148.59897	92.1630	716.5527	2.721	18	.014
Pair 93	Mn vs Rb	358.1842	629.22810	144.35483	54.9060	661.4624	2.481	18	.023
Pair 94	Mn vs Sr	297.1579	669.28783	153.54516	-25.4285	619.7443	1.935	18	.069
Pair 95	Mn vs Y	402.1611	646.35793	148.28468	90.6265	713.6956	2.712	18	.014
Pair 96	Mn vs Zr	318.1316	647.74287	148.60241	5.9295	630.3336	2.141	18	.046
Pair 97	Mn vs Nb	402.9216	648.22543	148.71311	90.4869	715.3562	2.709	18	.014
Pair 98	Mn vs Mo	405.0484	648.16754	148.69983	92.6417	717.4552	2.724	18	.014
Pair 99	Mn vs Ba	335.2526	651.01590	149.35329	21.4730	649.0323	2.245	18	.038
Pair 100	Mn vs Nd	401.6484	646.58364	148.33646	90.0051	713.2918	2.708	18	.014
Pair 101	Mn vs Sm	405.2107	647.81293	148.61848	92.9749	717.4466	2.727	18	.014
Pair 102	Mn vs Gd	405.0863	647.75514	148.60522	92.8783	717.2943	2.726	18	.014
Pair 103	Mn vs Er	405.5683	647.91495	148.64188	93.2833	717.8533	2.728	18	.014
Pair 104	Mn vs Yb	405.6219	647.96229	148.65274	93.3141	717.9297	2.729	18	.014
Pair 105	Mn vs Tl	405.8548	648.04169	148.67096	93.5087	718.2009	2.730	18	.014
Pair 106	Co vs Ni	-1.2634	1.57223	.36069	-2.0212	-.5056	-3.503	18	.003
Pair 107	Co vs Cu	-9.3618	6.87481	1.57719	-12.6753	-6.0482	-5.936	18	.000
Pair 108	Co vs Zn	-42.1413	28.61222	6.56409	-55.9319	-28.3506	-6.420	18	.000
Pair 109	Co vs Ga	-.6786	.57459	.13182	-.9556	-.4017	-5.148	18	.000
Pair 110	Co vs Se	-1.1255	.77570	.17796	-1.4993	-.7516	-6.324	18	.000
Pair 111	Co vs Rb	-47.2992	36.68453	8.41601	-64.9805	-29.6178	-5.620	18	.000
Pair 112	Co vs Sr	-108.3255	72.41265	16.61260	-143.2273	-73.4237	-6.521	18	.000
Pair 113	Co vs Y	-3.3223	3.31239	.75992	-4.9188	-1.7258	-4.372	18	.000
Pair 114	Co vs Zr	-87.3518	107.59448	24.68387	-139.2107	-35.4929	-3.539	18	.002
Pair 115	Co vs Nb	-2.5618	2.15720	.49490	-3.6015	-1.5221	-5.176	18	.000
Pair 116	Co vs Mo	-.4349	1.04566	.23989	-.9389	.0690	-1.813	18	.087
Pair 117	Co vs Ba	-70.2307	51.96975	11.92268	-95.2794	-45.1821	-5.891	18	.000
Pair 118	Co vs Nd	-3.8349	3.84119	.88123	-5.6863	-1.9836	-4.352	18	.000
Pair 119	Co vs Sm	-.2726	.70182	.16101	-.6109	.0656	-1.693	18	.108
Pair 120	Co vs Gd	-.3971	.77570	.17796	-.7709	-.0232	-2.231	18	.039
Pair 121	Co vs Er	.0849	.48620	.11154	-.1494	.3193	.762	18	.456
Pair 122	Co vs Yb	.1385	.46183	.10595	-.0841	.3611	1.307	18	.208
Pair 123	Co vs Tl	.3715	.51555	.11827	.1230	.6200	3.141	18	.006
Pair 124	Ni vs Cu	-8.0984	5.72487	1.31337	-10.8577	-5.3391	-6.166	18	.000
Pair 125	Ni vs Zn	-40.8779	28.54793	6.54934	-54.6376	-27.1182	-6.242	18	.000
Pair 126	Ni vs Ga	.5847	1.71949	.39448	-.2440	1.4135	1.482	18	.156

Pair 127	Ni vs Se	.1379	1.71781	.39409	-.6901	.9659	.350	18	.730
Pair 128	Ni vs Rb	-46.0358	35.40358	8.12214	-63.0998	-28.9718	-5.668	18	.000
Pair 129	Ni vs Sr	-107.0621	72.89171	16.72251	-142.1948	-71.9294	-6.402	18	.000
Pair 130	Ni vs Y	-2.0589	3.26882	.74992	-3.6345	-.4834	-2.746	18	.013
Pair 131	Ni vs Zr	-86.0884	107.12195	24.57546	-137.7195	-34.4573	-3.503	18	.003
Pair 132	Ni vs Nb	-1.2984	2.70075	.61959	-2.6001	.0033	-2.096	18	.051
Pair 133	Ni vs Mo	.8284	2.05438	.47131	-.1618	1.8186	1.758	18	.096
Pair 134	Ni vs Ba	-68.9674	51.82051	11.88844	-93.9441	-43.9907	-5.801	18	.000
Pair 135	Ni vs Nd	-2.5716	3.93065	.90175	-4.4661	-.6771	-2.852	18	.011
Pair 136	Ni vs Sm	.9907	1.79033	.41073	.1278	1.8536	2.412	18	.027
Pair 137	Ni vs Gd	.8663	1.78969	.41058	.0037	1.7289	2.110	18	.049
Pair 138	Ni vs Er	1.3483	1.74553	.40045	.5070	2.1896	3.367	18	.003
Pair 139	Ni vs Yb	1.4019	1.74790	.40100	.5594	2.2444	3.496	18	.003
Pair 140	Ni vs Tl	1.6348	1.82704	.41915	.7542	2.5154	3.900	18	.001
Pair 141	Cu vs Zn	-32.7795	26.76730	6.14084	-45.6809	-19.8780	-5.338	18	.000
Pair 142	Cu vs Ga	8.6832	6.87855	1.57805	5.3678	11.9985	5.502	18	.000
Pair 143	Cu vs Se	8.2363	7.04386	1.61597	4.8413	11.6313	5.097	18	.000
Pair 144	Cu vs Rb	-37.9374	31.26945	7.17370	-53.0088	-22.8660	-5.288	18	.000
Pair 145	Cu vs Sr	-98.9637	75.65187	17.35573	-135.4267	-62.5007	-5.702	18	.000
Pair 146	Cu vs Y	6.0395	7.52709	1.72683	2.4115	9.6674	3.497	18	.003
Pair 147	Cu vs Zr	-77.9900	104.40023	23.95106	-128.3093	-27.6707	-3.256	18	.004
Pair 148	Cu vs Nb	6.8000	6.79663	1.55925	3.5241	10.0759	4.361	18	.000
Pair 149	Cu vs Mo	8.9268	7.16211	1.64310	5.4748	12.3789	5.433	18	.000
Pair 150	Cu vs Ba	-60.8689	51.42789	11.79837	-85.6564	-36.0815	-5.159	18	.000
Pair 151	Cu vs Nd	5.5268	7.98800	1.83257	1.6767	9.3769	3.016	18	.007
Pair 152	Cu vs Sm	9.0892	7.15162	1.64069	5.6422	12.5361	5.540	18	.000
Pair 153	Cu vs Gd	8.9647	7.15209	1.64080	5.5175	12.4119	5.464	18	.000
Pair 154	Cu vs Er	9.4467	7.11192	1.63159	6.0189	12.8746	5.790	18	.000
Pair 155	Cu vs Yb	9.5003	7.08615	1.62567	6.0849	12.9157	5.844	18	.000
Pair 156	Cu vs Tl	9.7333	7.16463	1.64368	6.2800	13.1865	5.922	18	.000
Pair 157	Zn vs Ga	41.4626	28.31394	6.49566	27.8157	55.1095	6.383	18	.000
Pair 158	Zn vs Se	41.0158	28.76007	6.59801	27.1539	54.8777	6.216	18	.000
Pair 159	Zn vs Rb	-5.1579	41.51847	9.52499	-25.1692	14.8534	-.542	18	.595
Pair 160	Zn vs S r	-66.1842	77.17796	17.70584	-103.3828	-28.9856	-3.738	18	.002
Pair 161	Zn vs Y	38.8189	28.65660	6.57428	25.0069	52.6310	5.905	18	.000
Pair 162	Zn vs Zr	-45.2105	107.76992	24.72412	-97.1540	6.7329	-1.829	18	.084
Pair 163	Zn vs Nb	39.5795	27.40356	6.28681	26.3714	52.7876	6.296	18	.000
Pair 164	Zn vs Mo	41.7063	28.55143	6.55015	27.9450	55.4677	6.367	18	.000
Pair 165	Zn vs Ba	-28.0895	48.20228	11.05836	-51.3222	-4.8567	-2.540	18	.021
Pair 166	Zn vs Nd	38.3063	28.60164	6.56167	24.5208	52.0919	5.838	18	.000
Pair 167	Zn vs Sm	41.8686	28.83543	6.61530	27.9704	55.7669	6.329	18	.000
Pair 168	Zn vs Gd	41.7442	28.82886	6.61379	27.8491	55.6393	6.312	18	.000
Pair 169	Zn vs Er	42.2262	28.86010	6.62096	28.3161	56.1363	6.378	18	.000
Pair 170	Zn vs Yb	42.2798	28.85181	6.61906	28.3737	56.1859	6.388	18	.000

Pair 171	Zn vs Tl	42.5127	28.91175	6.63281	28.5777	56.4478	6.409	18	.000
Pair 172	Ga vs Se	-.4468	.80145	.18387	-.8331	-.0606	-2.430	18	.026
Pair 173	Ga vs Rb	-46.6205	36.65900	8.41015	-64.2896	-28.9515	-5.543	18	.000
Pair 174	Ga vs Sr	-107.6468	72.38955	16.60730	-142.5375	-72.7562	-6.482	18	.000
Pair 175	Ga vs Y	-2.6437	3.16598	.72633	-4.1696	-1.1177	-3.640	18	.002
Pair 176	Ga vs Zr	-86.6732	107.59692	24.68443	-138.5332	-34.8131	-3.511	18	.002
Pair 177	Ga vs Nb	-1.8832	1.64759	.37798	-2.6773	-1.0890	-4.982	18	.000
Pair 178	Ga vs Mo	.2437	.97005	.22254	-.2239	.7112	1.095	18	.288
Pair 179	Ga vs Ba	-69.5521	52.04554	11.94006	-94.6373	-44.4670	-5.825	18	.000
Pair 180	Ga vs Nd	-3.1563	3.65685	.83894	-4.9189	-1.3938	-3.762	18	.001
Pair 181	Ga vs Sm	.4060	.82271	.18874	.0095	.8025	2.151	18	.045
Pair 182	Ga vs Gd	.2816	.87825	.20148	-.1417	.7049	1.398	18	.179
Pair 183	Ga vs Er	.7636	.76765	.17611	.3936	1.1336	4.336	18	.000
Pair 184	Ga vs Yb	.8172	.77335	.17742	.4444	1.1899	4.606	18	.000
Pair 185	Ga vs Tl	1.0501	.85893	.19705	.6361	1.4641	5.329	18	.000
Pair 186	Se vs Rb	-46.1737	36.59314	8.39504	-63.8110	-28.5364	-5.500	18	.000
Pair 187	Se vs Sr	-107.2000	72.64615	16.66617	-142.2143	-72.1857	-6.432	18	.000
Pair 188	Se vs Y	-2.1968	2.87070	.65858	-3.5805	-.8132	-3.336	18	.004
Pair 189	Se vs Zr	-86.2263	107.28113	24.61198	-137.9342	-34.5185	-3.503	18	.003
Pair 190	Se vs Nb	-1.4363	2.30455	.52870	-2.5471	-.3256	-2.717	18	.014
Pair 191	Se vs Mo	.6905	1.11282	.25530	.1542	1.2269	2.705	18	.015
Pair 192	Se vs Ba	-69.1053	52.33331	12.00608	-94.3291	-43.8814	-5.756	18	.000
Pair 193	Se vs Nd	-2.7095	3.40575	.78133	-4.3510	-1.0680	-3.468	18	.003
Pair 194	Se vs Sm	.8528	.47944	.10999	.6218	1.0839	7.754	18	.000
Pair 195	Se vs Gd	.7284	.51923	.11912	.4782	.9787	6.115	18	.000
Pair 196	Se vs Er	1.2104	.54389	.12478	.9483	1.4726	9.701	18	.000
Pair 197	Se vs Yb	1.2640	.58931	.13520	.9800	1.5480	9.349	18	.000
Pair 198	Se vs Tl	1.4969	.73943	.16964	1.1406	1.8533	8.824	18	.000
Pair 199	Rb vs Sr	-61.0263	95.27601	21.85782	-106.9479	-15.1047	-2.792	18	.012
Pair 200	Rb vs Y	43.9768	35.99678	8.25823	26.6269	61.3267	5.325	18	.000
Pair 201	Rb vs Zr	-40.0526	93.10672	21.36015	-84.9286	4.8234	-1.875	18	.077
Pair 202	Rb vs Nb	44.7374	36.56205	8.38791	27.1150	62.3597	5.334	18	.000
Pair 203	Rb vs Mo	46.8642	36.71648	8.42334	29.1674	64.5610	5.564	18	.000
Pair 204	Rb vs Ba	-22.9316	65.72343	15.07799	-54.6093	8.7461	-1.521	18	.146
Pair 205	Rb vs Nd	43.4642	36.33371	8.33552	25.9519	60.9765	5.214	18	.000
Pair 206	Rb vs Sm	47.0265	36.73897	8.42850	29.3189	64.7341	5.579	18	.000
Pair 207	Rb vs Gd	46.9021	36.72225	8.42466	29.2025	64.6017	5.567	18	.000
Pair 208	Rb vs Er	47.3841	36.76194	8.43377	29.6654	65.1028	5.618	18	.000
Pair 209	Rb vs Yb	47.4377	36.75645	8.43251	29.7216	65.1537	5.626	18	.000
Pair 210	Rb vs Tl	47.6706	36.85519	8.45516	29.9070	65.4343	5.638	18	.000
Pair 211	Sr vs Y	105.0032	73.01457	16.75069	69.8113	140.1951	6.269	18	.000
Pair 212	Sr vs Zr	20.9737	148.93168	34.16727	-50.8091	92.7565	.614	18	.547
Pair 213	Sr vs Nb	105.7637	72.22765	16.57016	70.9511	140.5763	6.383	18	.000
Pair 214	Sr vs Mo	107.8905	72.37612	16.60422	73.0064	142.7747	6.498	18	.000

Pair 215	Sr vs Ba	38.0947	57.92222	13.28827	10.1771	66.0124	2.867	18	.010
Pair 216	Sr vs Nd	104.4905	72.88991	16.72209	69.3587	139.6223	6.249	18	.000
Pair 217	Sr vs Sm	108.0528	72.57082	16.64889	73.0748	143.0309	6.490	18	.000
Pair 218	Sr vs Gd	107.9284	72.56471	16.64749	72.9534	142.9035	6.483	18	.000
Pair 219	Sr vs Er	108.4104	72.56150	16.64675	73.4369	143.3839	6.512	18	.000
Pair 220	Sr vs Yb	108.4640	72.56219	16.64691	73.4901	143.4379	6.516	18	.000
Pair 221	Sr vs Tl	108.6969	72.52852	16.63918	73.7393	143.6546	6.533	18	.000
Pair 222	Y vs Zr	-84.0295	106.35035	24.39844	-135.2887	-32.7702	-3.444	18	.003
Pair 223	Y vs Nb	.7605	3.75430	.86130	-1.0490	2.5700	.883	18	.389
Pair 224	Y vs Mo	2.8874	3.49106	.80090	1.2047	4.5700	3.605	18	.002
Pair 225	Y vs Ba	-66.9084	52.03052	11.93662	-91.9863	-41.8305	-5.605	18	.000
Pair 226	Y vs Nd	-.5126	.79429	.18222	-.8955	-.1298	-2.813	18	.012
Pair 227	Y vs Sm	3.0497	2.79197	.64052	1.7040	4.3954	4.761	18	.000
Pair 228	Y vs Gd	2.9253	2.68048	.61495	1.6333	4.2172	4.757	18	.000
Pair 229	Y vs Er	3.4073	3.14358	.72119	1.8921	4.9224	4.725	18	.000
Pair 230	Y vs Yb	3.4608	3.23374	.74187	1.9022	5.0195	4.665	18	.000
Pair 231	Y vs Tl	3.6938	3.40586	.78136	2.0522	5.3354	4.727	18	.000
Pair 232	Zr vs Nb	84.7900	107.86568	24.74608	32.8004	136.7796	3.426	18	.003
Pair 233	Zr vs Mo	86.9168	107.40307	24.63995	35.1502	138.6835	3.527	18	.002
Pair 234	Zr vs Ba	17.1211	120.70544	27.69173	-41.0571	75.2992	.618	18	.544
Pair 235	Zr vs Nd	83.5168	106.25574	24.37674	32.3032	134.7305	3.426	18	.003
Pair 236	Zr vs Sm	87.0792	107.34614	24.62689	35.3400	138.8183	3.536	18	.002
Pair 237	Zr vs Gd	86.9547	107.31479	24.61970	35.2307	138.6788	3.532	18	.002
Pair 238	Zr vs Er	87.4367	107.46222	24.65352	35.6416	139.2319	3.547	18	.002
Pair 239	Zr vs Yb	87.4903	107.45476	24.65181	35.6988	139.2819	3.549	18	.002
Pair 240	Zr vs Tl	87.7233	107.57826	24.68014	35.8722	139.5743	3.554	18	.002
Pair 241	Nb vs Mo	2.1268	2.10934	.48392	1.1102	3.1435	4.395	18	.000
Pair 242	Nb vs Ba	-67.6689	51.90085	11.90687	-92.6844	-42.6535	-5.683	18	.000
Pair 243	Nb vs Nd	-1.2732	4.09603	.93969	-3.2474	.7011	-1.355	18	.192
Pair 244	Nb vs Sm	2.2892	2.37087	.54392	1.1464	3.4319	4.209	18	.001
Pair 245	Nb vs Gd	2.1647	2.39267	.54892	1.0115	3.3180	3.944	18	.001
Pair 246	Nb vs Er	2.6467	2.37902	.54579	1.5001	3.7934	4.849	18	.000
Pair 247	Nb vs Yb	2.7003	2.38178	.54642	1.5523	3.8483	4.942	18	.000
Pair 248	Nb vs Tl	2.9333	2.43625	.55891	1.7590	4.1075	5.248	18	.000
Pair 249	Mo vs Ba	-69.7958	52.36637	12.01367	-95.0356	-44.5560	-5.810	18	.000
Pair 250	Mo vs Nd	-3.4000	3.97907	.91286	-5.3179	-1.4821	-3.725	18	.002
Pair 251	Mo vs Sm	.1623	1.09863	.25204	-.3672	.6918	.644	18	.528
Pair 252	Mo vs Gd	.0379	1.18412	.27166	-.5328	.6086	.139	18	.891
Pair 253	Mo vs Er	.5199	.96141	.22056	.0565	.9833	2.357	18	.030
Pair 254	Mo vs Yb	.5735	.93262	.21396	.1240	1.0230	2.680	18	.015
Pair 255	Mo vs Tl	.8064	.94926	.21777	.3489	1.2639	3.703	18	.002
Pair 256	Ba vs Nd	66.3958	51.96619	11.92186	41.3489	91.4427	5.569	18	.000
Pair 257	Ba vs Sm	69.9581	52.23756	11.98412	44.7804	95.1358	5.838	18	.000
Pair 258	Ba vs Gd	69.8337	52.18868	11.97290	44.6795	94.9878	5.833	18	.000
Pair 259	Ba vs Er	70.3157	52.27024	11.99162	45.1222	95.5091	5.864	18	.000
Pair 260	Ba vs Yb	70.3693	52.27418	11.99252	45.1739	95.5646	5.868	18	.000

Pair 261	Cu vs Mo	70.6022	52.30385	11.99933	45.3926	95.8119	5.884	18	.000
Pair 262	Cu vs Ba	3.5623	3.30778	.75886	1.9680	5.1566	4.694	18	.000
Pair 263	Ba vs Tl	3.4379	3.19750	.73356	1.8967	4.9790	4.687	18	.000
Pair 264	Nd vs Sm	3.9199	3.67410	.84290	2.1490	5.6908	4.651	18	.000
Pair 265	Nd vs Gd	3.9735	3.76432	.86359	2.1591	5.7878	4.601	18	.000
Pair 266	Nd vs Er	4.2064	3.93275	.90224	2.3109	6.1019	4.662	18	.000
Pair 267	Nd vs Yb	-.1244	.12788	.02934	-.1861	-.0628	-4.241	18	.000
Pair 268	Nd vs Tl	.3576	.37115	.08515	.1787	.5365	4.200	18	.001
Pair 269	Sm vs Gd	.4112	.46347	.10633	.1878	.6345	3.867	18	.001
Pair 270	Sm vs Er	.6441	.63055	.14466	.3402	.9480	4.453	18	.000
Pair 271	Sm vs Yb	.4820	.48183	.11054	.2498	.7142	4.360	18	.000
Pair 272	Sm vs Tl	.5356	.57485	.13188	.2585	.8126	4.061	18	.001
Pair 273	Gd vs Er	.7685	.73935	.16962	.4122	1.1249	4.531	18	.000
Pair 274	Gd vs Yb	.0536	.10219	.02344	.0043	.1028	2.285	18	.035
Pair 275	Gd vs Tl	.2865	.27132	.06225	.1558	.4173	4.603	18	.000
Pair 276	Yb Vs Tl	.2329	.20029	.04595	.1364	.3295	5.070	18	.000

Paired Samples t-Test for iron with other trace elements in Manga

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Fe – B	1394.93158	1373.58881	315.12288	732.88297	2056.98019	4.427	18	.000
Pair 2	Fe - Ti	1346.67368	1305.24246	299.44316	717.56696	1975.78041	4.497	18	.000
Pair 3	Fe - V	1420.62789	1374.18320	315.25925	758.29279	2082.96300	4.506	18	.000
Pair 4	Fe - Cr	1420.60789	1374.52405	315.33744	758.10851	2083.10728	4.505	18	.000
Pair 5	Fe - Mn	1049.15789	1387.66832	318.35295	380.32317	1717.99261	3.296	18	.004
Pair 6	Fe - Co	1421.26916	1374.77223	315.39438	758.65015	2083.88816	4.506	18	.000
Pair 7	Fe - Ni	1420.54421	1374.38570	315.30570	758.11151	2082.97691	4.505	18	.000
Pair 8	Fe - Cu	1413.63421	1374.14851	315.25129	751.31583	2075.95259	4.484	18	.000
Pair 9	Fe - Zn	1380.55263	1358.91667	311.75687	725.57576	2035.52950	4.428	18	.000
Pair 10	Fe - Ga	1420.39737	1374.11146	315.24279	758.09684	2082.69789	4.506	18	.000
Pair 11	Fe - Se	1419.70526	1374.98639	315.44351	756.98304	2082.42749	4.501	18	.000
Pair 12	Fe - Rb	1383.52632	1362.73316	312.63243	726.70996	2040.34268	4.425	18	.000
Pair 13	Fe - Sr	1310.72632	1363.59632	312.83045	653.49393	1967.95870	4.190	18	.001
Pair 14	Fe - Y	1415.64368	1375.41597	315.54206	752.71441	2078.57296	4.486	18	.000
Pair 15	Fe - Zr	1327.89474	1404.49018	322.21214	650.95214	2004.83733	4.121	18	.001
Pair 16	Fe - Nb	1418.70211	1372.24597	314.81482	757.30072	2080.10349	4.506	18	.000
Pair 17	Fe - Mo	1420.80895	1374.93509	315.43174	758.11145	2083.50645	4.504	18	.000
Pair 18	Fe - Ba	1366.33684	1375.35079	315.52711	703.43898	2029.23470	4.330	18	.000
Pair 19	Fe - Nd	1415.31211	1374.86110	315.41477	752.65027	2077.97394	4.487	18	.000
Pair 20	Fe - Sm	1420.49921	1374.98667	315.44358	757.77685	2083.22157	4.503	18	.000

Pair 21	Fe - Gd	1420.33789	1375.03533	315.45474	757.59208	2083.08371	4.503	18	.000
Pair 22	Fe - Er	1421.05984	1374.99833	315.44625	758.33186	2083.78782	4.505	18	.000
Pair 23	Fe - Yb	1421.14447	1374.97448	315.44078	758.42799	2083.86096	4.505	18	.000
Pair 24	Fe - Tl	1421.52689	1375.01278	315.44957	758.79195	2084.26184	4.506	18	.000

T-Crtical = 4.210 $P < 0.05$

APPENDIX XVI

Paired Samples t-Test for Macro elements in Borabu

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Mg- Al	1079.2105	1693.15742	388.43695	263.1348	1895.2863	2.778	18	.012
Pair 2	Mg - Si	1357.8947	1566.47722	359.37452	602.8769	2112.9126	3.778	18	.001
Pair 3	Mg - P	536.6842	1471.24513	337.52678	-172.4332	1245.8017	1.590	18	.129
Pair 4	Mg - S	66.8421	1445.52587	331.62638	-629.8791	763.5633	.202	18	.843
Pair 5	Mg - K	-16673.6842	12810.86614	2939.01426	-22848.3240	-10499.0444	-5.673	18	.000
Pair 6	Mg – Ca	-13544.2105	8684.92712	1992.45893	-17730.2114	-9358.2096	-6.798	18	.000
Pair 7	Al - Si	278.6842	1267.96153	290.89033	-332.4537	889.8221	.958	18	.351
Pair 8	Al – P	-542.5263	1772.87990	406.72654	-1397.0271	311.9744	-1.334	18	.199
Pair 9	Al - S	-1012.3684	1159.51768	266.01160	-1571.2381	-453.4988	-3.806	18	.001
Pair 10	Al - K	-17752.8947	13312.22352	3054.03353	-24169.1811	-11336.6084	-5.813	18	.000
Pair 11	Al - Ca	-14623.4211	9354.37167	2146.04004	-19132.0839	-10114.7582	-6.814	18	.000
Pair 12	Si - P	-821.2105	1572.19099	360.68535	-1578.9823	-63.4387	-2.277	18	.035
Pair 13	Si - S	-1291.0526	862.43128	197.85531	-1706.7312	-875.3741	-6.525	18	.000
Pair 14	Si - K	-18031.5789	13689.75662	3140.64556	-24629.8304	-11433.3275	-5.741	18	.000
Pair 15	Si - Ca	-14902.1053	9513.85048	2182.62699	-19487.6344	-10316.5761	-6.828	18	.000
Pair 16	P – S	-469.8421	1371.65044	314.67819	-1130.9565	191.2722	-1.493	18	.153
Pair 17	P - K	-17210.3684	12799.56854	2936.42241	-23379.5630	-11041.1739	-5.861	18	.000
Pair 18	P - Ca	-14080.8947	9577.85088	2197.30969	-18697.2711	-9464.5184	-6.408	18	.000
Pair 19	S - K	-16740.5263	13335.16174	3059.29592	-23167.8685	-10313.1841	-5.472	18	.000
Pair 20	S - Ca	-13611.0526	9364.40121	2148.34097	-18124.5495	-9097.5557	-6.336	18	.000
Pair 21	K - Ca	3129.4737	13968.81665	3204.66632	-3603.2804	9862.2278	.977	18	.342

T-crtical = 4.210 $P < 0.05$

APPENDIX XVII

Paired Samples t-Test for Macro elements in Nyamira

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Mg- Al	940.3158	2368.18651	543.29925	-201.1136	2081.7451	1.731	18	.101
Pair 2	Mg - Si	1443.0526	1540.22071	353.35086	700.6900	2185.4152	4.084	18	.001
Pair 3	Mg - P	283.5789	1384.82311	317.70021	-383.8844	951.0423	.893	18	.384
Pair 4	Mg - S	184.3684	1438.22975	329.95253	-508.8361	877.5730	.559	18	.583
Pair 5	Mg - K	-16785.8947	14367.17531	3296.05607	-23710.6516	-9861.1379	-5.093	18	.000
Pair 6	Mg – Ca	-13066.6842	8208.88184	1883.24665	-17023.2386	-9110.1298	-6.938	18	.000
Pair 7	Al - Si	502.7368	1704.57567	391.05648	-318.8423	1324.3160	1.286	18	.215
Pair 8	Al – P	-656.7368	1965.48393	450.91294	-1604.0698	290.5961	-1.456	18	.162
Pair 9	Al - S	-755.9474	1563.87327	358.77713	-1509.7102	-2.1846	-2.107	18	.049
Pair 10	Al - K	-17726.2105	15089.46354	3461.76035	-24999.0991	-10453.3219	-5.121	18	.000
Pair 11	Al - Ca	-14007.0000	9445.76635	2167.00742	-18559.7136	-9454.2864	-6.464	18	.000
Pair 12	Si - P	-1159.4737	1506.94125	345.71603	-1885.7961	-433.1513	-3.354	18	.004
Pair 13	Si - S	-1258.6842	753.76065	172.92455	-1621.9852	-895.3832	-7.279	18	.000
Pair 14	Si - K	-18228.9474	15406.79861	3534.56201	-25654.7866	-10803.1081	-5.157	18	.000
Pair 15	Si - Ca	-14509.7368	8960.55623	2055.69258	-18828.5867	-10190.8870	-7.058	18	.000
Pair 16	P – S	-99.2105	1113.10160	255.36302	-635.7083	437.2873	-.389	18	.702
Pair 17	P - K	-17069.4737	14508.69528	3328.52297	-24062.4410	-10076.5064	-5.128	18	.000
Pair 18	P - Ca	-13350.2632	9102.18510	2088.18447	-17737.3759	-8963.1504	-6.393	18	.000
Pair 19	S - K	-16970.2632	15057.43970	3454.41358	-24227.7168	-9712.8095	-4.913	18	.000
Pair 20	S - Ca	-13251.0526	8802.51031	2019.43436	-17493.7268	-9008.3785	-6.562	18	.000
Pair 21	K - Ca	3719.2105	15056.08665	3454.10317	-3537.5909	10976.0120	1.077	18	.296

T-crtical = 4.210 $P < 0.05$

APPENDIX XVIII

Paired Samples t-Test for Macro elements in Ekerenyo

		Paired Differences					T	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Mg- Al	1.0732	1.67448	.38415	.2661	1.8802	2.794	18	.012
Pair 2	Mg - Si	1.3316	1.56023	.35794	.5796	2.0836	3.720	18	.002
Pair 3	Mg - P	.5142	1.49390	.34272	-.2058	1.2342	1.500	18	.151
Pair 4	Mg - S	.0116	1.44511	.33153	-.6849	.7081	.035	18	.973
Pair 5	Mg - K	-16.8153	13.04822	2.99347	-23.1043	-10.5262	-5.617	18	.000
Pair 6	Mg – Ca	-14.0558	9.03101	2.07186	-18.4086	-9.7030	-6.784	18	.000
Pair 7	Al - Si	.2584	1.28621	.29508	-.3615	.8784	.876	18	.393
Pair 8	Al – P	-.5589	1.77585	.40741	-1.4149	.2970	-1.372	18	.187
Pair 9	Al - S	-1.0616	1.14904	.26361	-1.6154	-.5078	-4.027	18	.001
Pair 10	Al - K	-17.8884	13.52290	3.10237	-24.4062	-11.3706	-5.766	18	.000
Pair 11	Al - Ca	-15.1289	9.75681	2.23837	-19.8316	-10.4263	-6.759	18	.000
Pair 12	Si - P	-.8174	1.58972	.36471	-1.5836	-.0511	-2.241	18	.038
Pair 13	Si - S	-1.3200	.87215	.20008	-1.7404	-.8996	-6.597	18	.000
Pair 14	Si - K	-18.1468	13.89896	3.18864	-24.8459	-11.4478	-5.691	18	.000
Pair 15	Si - Ca	-15.3874	9.93212	2.27859	-20.1745	-10.6002	-6.753	18	.000
Pair 16	P – S	-.5026	1.41505	.32464	-1.1847	.1794	-1.548	18	.139
Pair 17	P - K	-17.3295	13.02169	2.98738	-23.6057	-11.0532	-5.801	18	.000
Pair 18	P - Ca	-14.5700	10.02395	2.29965	-19.4014	-9.7386	-6.336	18	.000
Pair 19	S - K	-16.8268	13.56541	3.11212	-23.3652	-10.2885	-5.407	18	.000
Pair 20	S - Ca	-14.0674	9.79041	2.24608	-18.7862	-9.3485	-6.263	18	.000
Pair 21	K - Ca	2.7595	13.87051	3.18211	-3.9259	9.4448	.867	18	.397

T-crtical = 4.210 $P < 0.05$

APPENDIX XIX

Paired Samples t-Test for Macro elements in manga

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Mg- Al	983.5263	1718.41821	394.23218	155.2752	1811.7774	2.495	18	.023
Pair 2	Mg - Si	1188.1053	1463.62844	335.77939	482.6589	1893.5516	3.538	18	.002
Pair 3	Mg - P	64.2105	1416.55025	324.97892	-618.5448	746.9659	.198	18	.846
Pair 4	Mg - S	-693.1579	1468.23421	336.83603	-1400.8241	14.5083	-2.058	18	.054
Pair 5	Mg - K	-20123.6842	14795.53206	3394.32785	-27254.9024	-12992.4660	-5.929	18	.000
Pair 6	Mg – Ca	-12725.7895	8632.38818	1980.40567	-16886.4674	-8565.1116	-6.426	18	.000
Pair 7	Al - Si	204.5789	1071.64356	245.85189	-311.9367	721.0946	.832	18	.416
Pair 8	Al – P	-919.3158	1811.99841	415.70094	-1792.6711	-45.9605	-2.211	18	.040
Pair 9	Al - S	-1676.6842	1301.30635	298.54015	-2303.8938	-1049.4746	-5.616	18	.000
Pair 10	Al - K	-21107.2105	15496.77477	3555.20396	-28576.4169	-13638.0042	-5.937	18	.000
Pair 11	Al - Ca	-13709.3158	9027.53593	2071.05878	-18060.4488	-9358.1828	-6.619	18	.000
Pair 12	Si - P	-1123.8947	1635.28570	375.16027	-1912.0772	-335.7123	-2.996	18	.008
Pair 13	Si - S	-1881.2632	918.48141	210.71409	-2323.9570	-1438.5693	-8.928	18	.000
Pair 14	Si - K	-21311.7895	15683.62376	3598.07005	-28871.0542	-13752.5248	-5.923	18	.000
Pair 15	Si - Ca	-13913.8947	9266.72646	2125.93285	-18380.3139	-9447.4756	-6.545	18	.000
Pair 16	P – S	-757.3684	1313.77252	301.40009	-1390.5865	-124.1503	-2.513	18	.022
Pair 17	P - K	-20187.8947	14915.42251	3421.83260	-27376.8983	-12998.8912	-5.900	18	.000
Pair 18	P - Ca	-12790.0000	9638.62196	2211.25153	-17435.6671	-8144.3329	-5.784	18	.000
Pair 19	S - K	-19430.5263	15576.20460	3573.42641	-26938.0166	-11923.0360	-5.438	18	.000
Pair 20	S - Ca	-12032.6316	9403.70426	2157.35771	-16565.0719	-7500.1912	-5.577	18	.000
Pair 21	K - Ca	7397.8947	16095.24691	3692.50288	-359.7660	15155.5554	2.003	18	.060

T-crtical = 4.210 $P < 0.05$

APPENDIX XX

Paired t-test for macro elements in Nyamira County

a) Paired Samples t-Test for Magnesium in Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP – NMP	-23.6842	691.50569	158.64228	-356.9793	309.6109	-.149	18	.883	2.451	0.05
Pair 2	BMP-MMP	28.9474	731.98281	167.92837	-323.8571	381.7518	.172	18	.865	2.451	0.05
Pair 3	BMP – EMP	14.7368	74.63753	17.12302	-21.2373	50.7110	.861	18	.401	2.451	0.05
Pair 4	NMP – MMP	52.6316	595.99443	136.73050	-234.6285	339.8917	.385	18	.705	2.451	0.05
Pair 5	NMP – EMP	38.4211	700.28774	160.65703	-299.1068	375.9489	.239	18	.814	2.451	0.05
Pair 6	MMP-EMP	-14.2105	729.11907	167.27139	-365.6347	337.2136	-.085	18	.933	2.451	0.05

b) Paired Samples t-Test for Aluminium in Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-173.4118	1979.20104	480.02676	-1191.0230	844.1995	-.361	16	.723	2.342	0.05
Pair 2	BMP-MMP	-66.7368	1313.05140	301.23465	-699.6074	566.1337	-.222	18	.827	2.451	0.05
Pair 3	BMP - EMP	8.6842	53.16437	12.19674	-16.9402	34.3086	.712	18	.486	2.451	0.05
Pair 4	NMP - MMP	111.1765	1382.74578	335.36511	-599.7658	822.1188	.332	16	.745	2.342	0.05
Pair 5	NMP - EMP	179.0000	1983.23019	481.00397	-840.6829	1198.6829	.372	16	.715	2.342	0.05
Pair 6	MMP-EMP	75.4211	1311.36991	300.84889	-556.6390	707.4811	.251	18	.805	2.451	0.05

c) Paired Samples t-Test for Silicon in Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	84.7059	218.29217	52.94363	-27.5296	196.9414	1.600	16	.129	2.342	0.05
Pair 2	BMP-MMP	-140.8421	346.45206	79.48155	-307.8267	26.1424	-1.772	18	.093	2.451	0.05
Pair 3	BMP - EMP	-11.5789	34.19928	7.84585	-28.0625	4.9046	-1.476	18	.157	2.451	0.05
Pair 4	NMP - MMP	-220.9412	352.87046	85.58366	-402.3704	-39.5119	-2.582	16	.020	2.342	0.05
Pair 5	NMP - EMP	-97.6471	217.21330	52.68196	-209.3278	14.0337	-1.854	16	.082	2.342	0.05
Pair 6	MMP-EMP	129.2632	338.21966	77.59291	-33.7535	292.2798	1.666	18	.113	2.451	0.05

d) Paired Samples t-Test for Phosphorus in medicinal plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-220.3684	670.00607	153.70993	-543.3010	102.5642	-1.434	18	.169	2.451	0.05
Pair 2	BMP-MMP	-390.8947	745.80359	171.09908	-750.3606	-31.4289	-2.285	18	.035	2.451	0.05
Pair 3	BMP - EMP	-3.5263	47.93093	10.99611	-26.6283	19.5757	-.321	18	.752	2.451	0.05
Pair 4	NMP - MMP	-170.5263	564.88419	129.59332	-442.7918	101.7392	-1.316	18	.205	2.451	0.05
Pair 5	NMP - EMP	216.8421	683.10608	156.71528	-112.4045	546.0887	1.384	18	.183	2.451	0.05
Pair 6	MMP-EMP	387.3684	752.18823	172.56381	24.8253	749.9115	2.245	18	.038	2.451	0.05

e) Paired Samples t-Test for Sulphur in medicinal plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	44.7368	862.31193	197.82793	-370.8842	460.3579	.226	18	.824	2.451	0.05
Pair 2	BMP-MMP	-731.0526	842.31754	193.24090	-1137.0367	-325.0686	-3.783	18	.001	2.451	0.05
Pair 3	BMP - EMP	-40.5263	93.95470	21.55469	-85.8110	4.7584	-1.880	18	.076	2.451	0.05
Pair 4	NMP - MMP	-775.7895	731.19625	167.74792	-1128.2148	-423.3642	-4.625	18	.000	2.451	0.05
Pair 5	NMP - EMP	-85.2632	894.62822	205.24179	-516.4602	345.9338	-.415	18	.683	2.451	0.05
Pair 6	MMP-EMP	690.5263	858.72304	197.00458	276.6351	1104.4176	3.505	18	.003	2.451	0.05

f) Paired Samples t-Test for potassium Medicinal plants in Nyamira County

		Paired Differences					t	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	400.0000	6514.94010	1494.62976	-2740.1006	3540.1006	.268	18	.792	2.451	0.05
Pair 2	BMP-MMP	-2894.7368	6451.48335	1480.07179	-6004.2523	214.7786	-1.956	18	.066	2.451	0.05
Pair 3	BMP - EMP	-101.0526	1126.11868	258.34934	-643.8245	441.7192	-.391	18	.700	2.451	0.05
Pair 4	NMP - MMP	-3294.7368	4552.10253	1044.32394	-5488.7800	-1100.6937	-3.155	18	.005	2.451	0.05
Pair 5	NMP - EMP	-501.0526	5975.70349	1370.92040	-3381.2495	2379.1443	-.365	18	.719	2.451	0.05
Pair 6	MMP-EMP	2793.6842	5739.68564	1316.77419	27.2443	5560.1241	2.122	18	.048	2.451	0.05

g) Paired Samples t-Test for calcium in medicinal plants in Nyamira County

		Paired Differences					t	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	1578.9474	8525.13271	1955.79958	-2530.0351	5687.9298	.807	18	.430	2.451	0.05
Pair 2	BMP-MMP	847.3684	7109.08092	1630.93502	-2579.0989	4273.8357	.520	18	.610	2.451	0.05
Pair 3	BMP - EMP	-643.1579	2373.42709	544.50152	-1787.1131	500.7973	-1.181	18	.253	2.451	0.05
Pair 4	NMP - MMP	-731.5789	6370.99091	1461.60555	-3802.2983	2339.1404	-.501	18	.623	2.451	0.05
Pair 5	NMP - EMP	-2222.1053	7418.07146	1701.82231	-5797.5013	1353.2907	-1.306	18	.208	2.451	0.05
Pair 6	MMP-EMP	-1490.5263	6766.65885	1552.37800	-4751.9515	1770.8988	-.960	18	.350	2.451	0.05

APPENDIX XXI

The t-test for the trace elements in the medicinal plants in Nyamira County

a) Paired Samples t-Test for Boron in the medicinal plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-2.1947	9.03687	2.07320	-6.5504	2.1609	-1.059	18	.304	2.451	0.05
Pair 2	BMP-MMP	-6.3632	13.75824	3.15636	-12.9944	.2681	-2.016	18	.059	2.451	0.05
Pair 3	BMP - EMP	4.7000	4.99210	1.14527	2.2939	7.1061	4.104	18	.001	2.451	0.05
Pair 4	NMP - MMP	-4.1684	8.08318	1.85441	-8.0644	-.2725	-2.248	18	.037	2.451	0.05
Pair 5	NMP - EMP	6.8947	10.12091	2.32190	2.0166	11.7729	2.969	18	.008	2.451	0.05
Pair 6	MMP-EMP	11.0632	13.59727	3.11943	4.5095	17.6168	3.547	18	.002	2.451	0.05

b) Paired Samples t-Test for Titanium in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-7.1474	88.17764	20.22934	-49.6476	35.3529	-.353	18	.728	2.451	0.05
Pair 2	BMP-MMP	.0579	63.88729	14.65675	-30.7348	30.8506	.004	18	.997	2.451	0.05
Pair 3	BMP - EMP	-8.1895	44.18176	10.13599	-29.4844	13.1055	-.808	18	.430	2.451	0.05
Pair 4	NMP - MMP	7.2053	60.61729	13.90656	-22.0113	36.4219	.518	18	.611	2.451	0.05
Pair 5	NMP - EMP	-1.0421	55.16315	12.65529	-27.6299	25.5457	-.082	18	.935	2.451	0.05
Pair 6	MMP-EMP	-8.2474	57.40891	13.17051	-35.9176	19.4228	-.626	18	.539	2.451	0.05

c) Paired Samples t-Test for Vanadium in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-.0447	1.03821	.23818	-.5451	.4557	-.188	18	.853	2.451	0.05
Pair 2	BMP-MMP	-.0089	.36143	.08292	-.1832	.1653	-.108	18	.915	2.451	0.05
Pair 3	BMP - EMP	.0489	.14776	.03390	-.0223	.1202	1.444	18	.166	2.451	0.05
Pair 4	NMP - MMP	.0358	.86758	.19904	-.3824	.4539	.180	18	.859	2.451	0.05
Pair 5	NMP - EMP	.0937	1.13292	.25991	-.4524	.6397	.360	18	.723	2.451	0.05
Pair 6	MMP-EMP	.0579	.44902	.10301	-.1585	.2743	.562	18	.581	2.451	0.05

d) Paired Samples t-Test for Chromium in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	.2571	1.00585	.23076	-.2278	.7419	1.114	18	.280	2.451	0.05
Pair 2	BMP-MMP	-.0337	.35154	.08065	-.2031	.1358	-.418	18	.681	2.451	0.05
Pair 3	BMP - EMP	.1574	.72803	.16702	-.1935	.5083	.942	18	.359	2.451	0.05
Pair 4	NMP - MMP	-.2907	.78018	.17899	-.6668	.0853	-1.624	18	.122	2.451	0.05
Pair 5	NMP - EMP	-.0997	.51789	.11881	-.3493	.1499	-.839	18	.412	2.451	0.05
Pair 6	MMP-EMP	.1911	.56493	.12960	-.0812	.4633	1.474	18	.158	2.451	0.05

e) Paired Samples t-Test for Manganese in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	37.0684	144.91131	33.24494	-32.7766	106.9134	1.115	18	.280	2.451	0.05
Pair 2	BMP-MMP	-33.5000	326.53582	74.91245	-190.8852	123.8852	-.447	18	.660	2.451	0.05
Pair 3	BMP - EMP	8.7368	19.60681	4.49811	-.7133	18.1870	1.942	18	.068	2.451	0.05
Pair 4	NMP - MMP	-70.5684	372.09133	85.36361	-249.9107	108.7739	-.827	18	.419	2.451	0.05
Pair 5	NMP - EMP	-28.3316	139.18293	31.93075	-95.4156	38.7524	-.887	18	.387	2.451	0.05
Pair 6	MMP-EMP	42.2368	331.28564	76.00214	-117.4377	201.9114	.556	18	.585	2.451	0.05

f) Paired Samples t-Test for Cobalt in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-.0039	.32647	.07490	-.1612	.1535	-.052	18	.959	2.451	0.05
Pair 2	BMP-MMP	-.1279	.41561	.09535	-.3282	.0724	-1.341	18	.196	2.451	0.05
Pair 3	BMP - EMP	.0282	.04364	.01001	.0072	.0492	2.818	18	.011	2.451	0.05
Pair 4	NMP - MMP	-.1240	.50904	.11678	-.3694	.1214	-1.062	18	.302	2.451	0.05
Pair 5	NMP - EMP	.0321	.33149	.07605	-.1277	.1919	.422	18	.678	2.451	0.05
Pair 6	MMP-EMP	.1561	.42221	.09686	-.0474	.3596	1.612	18	.124	2.451	0.05

g) Paired Samples t-Test for Nickel in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	.0826	.84691	.19429	-.3256	.4908	.425	18	.676	2.451	0.05
Pair 2	BMP-MMP	-.6663	1.07180	.24589	-1.1829	-.1497	-2.710	18	.014	2.451	0.05
Pair 3	BMP - EMP	.0489	.07738	.01775	.0117	.0862	2.757	18	.013	2.451	0.05
Pair 4	NMP - MMP	-.7489	1.67839	.38505	-1.5579	.0600	-1.945	18	.068	2.451	0.05
Pair 5	NMP - EMP	-.0337	.79676	.18279	-.4177	.3503	-.184	18	.856	2.451	0.05
Pair 6	MMP-EMP	.7153	1.07902	.24754	.1952	1.2353	2.889	18	.010	2.451	0.05

h) Paired Samples t-Test for Copper in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	.1632	2.14065	.49110	-.8686	1.1949	.332	18	.744	2.451	0.05
Pair 2	BMP-MMP	-1.8547	5.23056	1.19997	-4.3758	.6663	-1.546	18	.140	2.451	0.05
Pair 3	BMP - EMP	-6.6821	29.55450	6.78027	-20.9269	7.5627	-.986	18	.337	2.451	0.05
Pair 4	NMP - MMP	-2.0179	4.18495	.96009	-4.0350	-.0008	-2.102	18	.050	2.451	0.05
Pair 5	NMP - EMP	-6.8453	29.55575	6.78056	-21.0907	7.4002	-1.010	18	.326	2.451	0.05
Pair 6	MMP-EMP	-4.8274	29.10111	6.67625	-18.8537	9.1989	-.723	18	.479	2.451	0.05

i) **Paired Samples t-Test for Zinc in the Medicinal Plants in Nyamira County**

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	.4632	12.30254	2.82240	-5.4665	6.3928	.164	18	.871	2.451	0.05
Pair 2	BMP-MMP	-1.5316	15.13157	3.47142	-8.8248	5.7616	-.441	18	.664	2.451	0.05
Pair 3	BMP - EMP	1.5000	2.25783	.51798	.4118	2.5882	2.896	18	.010	2.451	0.05
Pair 4	NMP - MMP	-1.9947	18.45467	4.23379	-10.8896	6.9001	-.471	18	.643	2.451	0.05
Pair 5	NMP - EMP	1.0368	12.93798	2.96818	-5.1991	7.2727	.349	18	.731	2.451	0.05
Pair 6	MMP-EMP	3.0316	14.60655	3.35097	-4.0086	10.0717	.905	18	.378	2.451	0.05

j) **Paired Samples t-Test for Gallium in the Medicinal Plants in Nyamira County**

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-.0242	1.32969	.30505	-.6651	.6167	-.079	18	.938	2.451	0.05
Pair 2	BMP-MMP	.0416	.93659	.21487	-.4098	.4930	.194	18	.849	2.451	0.05
Pair 4	BMP - EMP	.0658	.84785	.19451	-.3429	.4744	.338	18	.739	2.451	0.05
Pair 5	NMP - MMP	.0242	1.32969	.30505	-.6167	.6651	.079	18	.938	2.451	0.05
Pair 6	NMP - EMP	-.0416	.93659	.21487	-.4930	.4098	-.194	18	.849	2.451	0.05

k) Paired Samples t-Test for Selenium in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	.4058	1.69773	.38949	-.4125	1.2241	1.042	18	.311	2.451	0.05
Pair 2	BMP-MMP	.3105	2.16946	.49771	-.7351	1.3562	.624	18	.541	2.451	0.05
Pair 3	BMP - EMP	.2368	.34191	.07844	.0720	.4016	3.019	18	.007	2.451	0.05
Pair 4	NMP - MMP	-.0953	.68547	.15726	-.4256	.2351	-.606	18	.552	2.451	0.05
Pair 5	NMP - EMP	-.1689	1.46348	.33574	-.8743	.5364	-.503	18	.621	2.451	0.05
Pair 6	MMP-EMP	-.0737	1.92234	.44101	-1.0002	.8529	-.167	18	.869	2.451	0.05

l) Paired Samples t-Test for Rubidium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-9.2053	16.27170	3.73298	-17.0480	-1.3626	-2.466	18	.024	2.451	0.05
Pair 2	BMP-MMP	-9.6842	27.09685	6.21644	-22.7445	3.3761	-1.558	18	.137	2.451	0.05
Pair 3	BMP - EMP	-2.2895	10.10131	2.31740	-7.1582	2.5792	-.988	18	.336	2.451	0.05
Pair 4	NMP – MMP	-.4789	26.28279	6.02969	-13.1468	12.1890	-.079	18	.938	2.451	0.05
Pair 5	NMP - EMP	6.9158	12.74133	2.92306	.7747	13.0569	2.366	18	.029	2.451	0.05
Pair 6	MMP-EMP	7.3947	26.11863	5.99202	-5.1940	19.9835	1.234	18	.233	2.451	0.05

m) Paired Samples t-Test for Strontium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-2.1421	41.91643	9.61629	-22.3452	18.0610	-.223	18	.826	2.451	0.05
Pair 2	BMP-MMP	2.0895	46.36245	10.63627	-20.2565	24.4355	.196	18	.846	2.451	0.05
Pair 3	BMP - EMP	1.0895	2.61765	.60053	-.1722	2.3511	1.814	18	.086	2.451	0.05
Pair 4	NMP - MMP	4.2316	42.69750	9.79548	-16.3480	24.8111	.432	18	.671	2.451	0.05
Pair 5	NMP - EMP	3.2316	42.39446	9.72596	-17.2019	23.6651	.332	18	.744	2.451	0.05
Pair 6	MMP-EMP	-1.0000	45.57888	10.45651	-22.9683	20.9683	-.096	18	.925	2.451	0.05

n) Paired Samples t-Test for Yttrium in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	1.6926	7.91808	1.81653	-2.1238	5.5090	.932	18	.364	2.451	0.05
Pair 2	BMP-MMP	2.1753	9.62881	2.20900	-2.4657	6.8162	.985	18	.338	2.451	0.05
Pair 3	BMP - EMP	.1079	.46125	.10582	-.1144	.3302	1.020	18	.321	2.451	0.05
Pair 4	NMP – MMP	.4826	2.69361	.61796	-.8156	1.7809	.781	18	.445	2.451	0.05
Pair 5	NMP - EMP	-1.5847	7.47821	1.71562	-5.1891	2.0196	-.924	18	.368	2.451	0.05
Pair 6	MMP-EMP	-2.0674	9.18402	2.10696	-6.4939	2.3592	-.981	18	.339	2.451	0.05

o) Paired Samples t-Test for Zirconium in the Medicinal Plants in Nyamira County

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	44.5263	72.35973	16.60046	9.6500	79.4026	2.682	18	.015	2.451	0.05
Pair 2	BMP-MMP	5.8947	86.02964	19.73655	-35.5702	47.3597	.299	18	.769	2.451	0.05
Pair 3	BMP - EMP	.0137	30.45146	6.98604	-14.6635	14.6908	.002	18	.998	2.451	0.05
Pair 4	NMP - MMP	-38.6316	62.54439	14.34867	-68.7770	-8.4861	-2.692	18	.015	2.451	0.05
Pair 5	NMP - EMP	-44.5126	69.11587	15.85627	-77.8254	-11.1998	-2.807	18	.012	2.451	0.05
Pair 6	MMP-EMP	-5.8811	83.72870	19.20868	-46.2370	34.4749	-.306	18	.763	2.451	0.05

p) Paired Samples t-Test for Niobium in the Medicinal Plants in Nyamira Count

		Paired Differences					T	Df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-.3616	3.40734	.78170	-2.0039	1.2807	-.463	18	.649	2.451	0.05
Pair 2	BMP-MMP	-.1226	2.88321	.66145	-1.5123	1.2670	-.185	18	.855	2.451	0.05
Pair 3	BMP - EMP	-.0432	.07718	.01771	-.0804	-.0060	-2.438	18	.025	2.451	0.05
Pair 4	NMP - MMP	.2389	2.08787	.47899	-.7674	1.2453	.499	18	.624	2.451	0.05
Pair 5	NMP - EMP	.3184	3.43287	.78756	-1.3362	1.9730	.404	18	.691	2.451	0.05
Pair 6	MMP-EMP	.0795	2.92666	.67142	-1.3311	1.4901	.118	18	.907	2.451	0.05

q) Paired Samples t-Test for Molybdenum in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-.1053	.53520	.12278	-.3632	.1527	-.857	18	.403	2.451	0.05
Pair 2	BMP-MMP	-.1026	1.07558	.24675	-.6210	.4158	-.416	18	.682	2.451	0.05
Pair 3	BMP - EMP	.0642	.09686	.02222	.0175	.1109	2.890	18	.010	2.451	0.05
Pair 4	NMP - MMP	.0026	.94791	.21747	-.4542	.4595	.012	18	.990	2.451	0.05
Pair 5	NMP - EMP	.1695	.56379	.12934	-.1023	.4412	1.310	18	.207	2.451	0.05
Pair 6	MMP-EMP	.1668	1.04722	.24025	-.3379	.6716	.694	18	.496	2.451	0.05

r) Paired Samples t-Test for Barium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	-1.4684	22.42818	5.14538	-12.2785	9.3416	-.285	18	.779	2.451	0.05
Pair 2	BMP-MMP	-15.4263	49.62829	11.38551	-39.3464	8.4938	-1.355	18	.192	2.451	0.05
Pair 3	BMP - EMP	.1037	.74969	.17199	-.2577	.4650	.603	18	.554	2.451	0.05
Pair 4	NMP - MMP	-13.9579	42.80900	9.82106	-34.5912	6.6754	-1.421	18	.172	2.451	0.05
Pair 5	NMP - EMP	1.5721	22.22785	5.09942	-9.1414	12.2856	.308	18	.761	2.451	0.05
Pair 6	MMP-EMP	15.5300	49.71767	11.40601	-8.4331	39.4931	1.362	18	.190	2.451	0.05

s) Paired Samples t-Test for Neodymium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower						
Pair 1	BMP - NMP	1.3142	7.42606	1.70365	2.451	0.05	.771	18	.450	2.451	0.05
Pair 2	BMP-MMP	1.9942	8.57506	1.96725	2.451	0.05	1.014	18	.324	2.451	0.05
Pair 3	BMP - EMP	-.0121	.04626	.01061	2.451	0.05	-1.141	18	.269	2.451	0.05
Pair 4	NMP - MMP	.6800	2.61556	.60005	2.451	0.05	1.133	18	.272	2.451	0.05
Pair 5	NMP - EMP	-1.3263	7.45035	1.70923	2.451	0.05	-.776	18	.448	2.451	0.05
Pair 6	MMP-EMP	-2.0063	8.59875	1.97269	-6.1508	2.1381	-1.017	18	.323	2.451	0.05

t) Paired Samples t-Test for Samarium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	.2573	1.28196	.29410	-.3606	.8751	.875	18	.393	2.451	0.05
Pair 2	BMP-MMP	.3694	1.46387	.33583	-.3361	1.0750	1.100	18	.286	2.451	0.05
Pair 3	BMP - EMP	.0024	.01818	.00417	-.0064	.0111	.568	18	.577	2.451	0.05
Pair 4	NMP - MMP	.1122	.44627	.10238	-.1029	.3273	1.095	18	.288	2.451	0.05
Pair 5	NMP - EMP	-.2549	1.28163	.29403	-.8726	.3628	-.867	18	.397	2.451	0.05
Pair 6	MMP-EMP	-.3671	1.46238	.33549	-1.0719	.3378	-1.094	18	.288	2.451	0.05

u) Paired Samples t-Test for Gadolinium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	.2674	1.48127	.33983	-.4466	.9813	.787	18	.442	2.451	0.05
Pair 2	BMP-MMP	.4063	1.75778	.40326	-.4409	1.2535	1.008	18	.327	2.451	0.05
Pair 3	BMP - EMP	.0216	.07581	.01739	-.0150	.0581	1.241	18	.231	2.451	0.05
Pair 4	NMP - MMP	.1389	.55135	.12649	-.1268	.4047	1.098	18	.286	2.451	0.05
Pair 5	NMP - EMP	-.2458	1.42818	.32765	-.9342	.4426	-.750	18	.463	2.451	0.05
Pair 6	MMP-EMP	-.3847	1.69580	.38904	-1.2021	.4326	-.989	18	.336	2.451	0.05

v) Paired Samples t-Test for Erbium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP - NMP	.1389	.56007	.12849	-.1310	.4088	1.081	18	.294	2.451	0.05
Pair 2	BMP-MMP	.1664	.67196	.15416	-.1575	.4902	1.079	18	.295	2.451	0.05
Pair 3	BMP - EMP	-.0272	.20898	.04794	-.1279	.0735	-.568	18	.577	2.451	0.05
Pair 4	NMP - MMP	.0275	.23057	.05290	-.0837	.1386	.519	18	.610	2.451	0.05
Pair 5	NMP - EMP	-.1661	.56058	.12861	-.4363	.1041	-1.292	18	.213	2.451	0.05
Pair 6	MMP-EMP	-.1936	.68167	.15639	-.5221	.1350	-1.238	18	.232	2.451	0.05

w) Paired Samples t-Test for Ytterbium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP – NMP	.1046	.36401	.08351	-.0709	.2800	1.252	18	.226	2.451	0.05
Pair 2	BMP- MMP	.1353	.43694	.10024	-.0753	.3459	1.350	18	.194	2.451	0.05
Pair 3	BMP – EMP	-.0013	.01350	.00310	-.0078	.0052	-.425	18	.676	2.451	0.05
Pair 4	NMP – MMP	.0307	.19750	.04531	-.0645	.1259	.678	18	.506	2.451	0.05
Pair 5	NMP – EMP	-.1059	.36480	.08369	-.2817	.0699	-1.265	18	.222	2.451	0.05
Pair 6	BMP – NMP	-.1366	.43595	.10001	-.3468	.0735	-1.366	18	.189	2.451	0.05

x) Paired Samples t-Test for Thallium in the Medicinal Plants in Nyamira County

		Paired Differences					T	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference						
					Lower	Upper					
Pair 1	BMP – NMP	-.0040	.04586	.01052	-.0261	.0181	-.380	18	.708	2.451	0.05
Pair 2	BMP- MMP	-.0094	.03803	.00872	-.0278	.0089	-1.080	18	.294	2.451	0.05
Pair 3	BMP – EMP	-.0027	.01141	.00262	-.0082	.0028	-1.026	18	.319	2.451	0.05
Pair 4	NMP – MMP	-.0054	.03578	.00821	-.0227	.0118	-.660	18	.517	2.451	0.05
Pair 5	NMP - EMP	.0013	.04526	.01038	-.0205	.0231	.127	18	.901	2.451	0.05
Pair 6	BMP - NMP	.0067	.03592	.00824	-.0106	.0240	.818	18	.424	2.451	0.05

y) **Samples t-Test for iron in medicinal plants in Nyamira County**

		Paired Differences					t	df	Sig. (2-tailed)	t-critical	P<
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper					
Pair 1	BMP - NMP	-164.8947	1658.20291	380.41784	-964.1230	634.3335	-.433	18	.670	2.451	0.05
Pair 2	BMP-MMP	-32.8421	1199.54622	275.19478	-611.0049	545.3207	-.119	18	.906	2.451	0.05
Pair 3	BMP - EMP	-146.3158	446.29239	102.38650	-361.4218	68.7903	-1.429	18	.170	2.451	0.05
Pair 4	NMP - MMP	132.0526	1136.55994	260.74473	-415.7517	679.8570	.506	18	.619	2.451	0.05
Pair 5	NMP - EMP	18.5789	1386.10591	317.99450	-649.5027	686.6606	.058	18	.954	2.451	0.05
Pair 6	MMP-EMP	-113.4737	883.56597	202.70393	-539.3388	312.3915	-.560	18	.583	2.451	0.05