Assessment of Water Quality, Minerals and Phytate Content in Some Legume Seeds in Elseleim Agricultural Scheme

By

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DEDICATION

Dedicated to the few... ... ...

My lovely Family... ...

My Parents... ...

&

My beloved Sister...

Sincerely yours,

Mervat
ACKNOWLEDGEMENTS

First, I am grateful to Allah for giving me assistance, health and patience to complete this work.

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Assessment of Water Quality, Minerals and Phytate Content in Some Legume Seeds in Elseleim Agricultural Scheme

M. Sc. in Nutritional Science
Mervat Ahmed Ibrahim Elhaj

ABSTRACT
This study aimed to evaluate the quality of water; some minerals and phytic acid content in some legume seeds. All samples obtained from Elseleim Agricultural Scheme, north Sudan state. Sixteen water samples from wells, tanks, hand pumps and the river Nile were collected in sterilized plastic bottles and subjected to laboratory analysis to estimate their physical and chemical properties, these sources used for drinking for human and animal as well as irrigation in the field site. On the other hand, minerals and phytic acid were estimated in the seeds of cowpea (Vigna unguiculata), chickpea (Cicer arietinum), pigeon pea (Cajanus cajan), faba bean (Vicia faba), white bean (Phaseolus vulgaris), lablab bean (Lablab purpureus), field pea (Pisum sativum) and chickling (Lathyrus sativus) that irrigated from the same water sources. The results showed that pH, odor, taste, electric conductivity, ammonia, nitrate, nitrite, sulfate, alkalinity, cations, anions and heavy metals in water samples were within the safe limit according to World Health Organization, 1993 and Sudanese Standards and Metrology Organization, 2002. However, significantly (P<0.05) high levels of arsenic (0.1 mg/l); Fe (0.3 mg/l) and total dissolved solids (156 mg/l) were detected in the River Nile water sample. All the estimated values of the total hardness of the water samples collected from hand pumps, tanks and wells were higher than the recommended limit (200 mg/l).
Moreover, water turbidity of the samples from the well (5.15 mg/l) was significantly ($P<0.05$) higher than the recommended level. All the tested legume seeds were rich in K (0.97-2.1g/100g), P (0.083- 0.65 g/100g) and Ca (0.1 – 0.18 g/100g), while they contained low amounts of Co (0.005 -0.06 mg/100g). Seeds of faba bean followed by white bean were significantly ($P<0.05$) higher in Zn than the seeds of other legumes, Chickpea seeds contained significantly ($P<0.05$) the highest amount of Mn. Faba bean, pigeon pea and chickpea were significantly ($P<0.05$) the richest in Fe. Selenium was found to be deficient in both water samples and legume seeds. Furthermore, the level of phytic acid was significantly ($P<0.05$) the lowest in chickpea (0.017 g/100g), while lablab bean had the highest concentration (0.14 g/100g), this perhaps increase the chelate effect on minerals availability particularly phosphorus.
تقييم نوعية المياه و محتوى المعادن ومادة الفايتنات في بعض البقاليات من مشروع السليم الزراعي
درجة ماجستير علوم التغذية
مشرف: أحمد إبراهيم الحاج

المستخلص

هدفت هذه الدراسة إلى تقييم نوعية المياه بالإضافة إلى قياس محتوى المعادن و حمض الفايتناك في بعض بذور البقاليات المنتجة في مشروع السليم الزراعي في بالولاية الشمالية.

جعت ست عشرة عينة من مياه (إبار، صهاريج، مضخات مياه و نهر النيل) في قناني بلاستيكية. وتم تحليلها عملياً للتقدير خواصها الفيزيائية والكيميائية، وتستخدم هذه المصادر للشرب بالنسبة للإنسان والحيوان بالإضافة إلى البرى في الحقل. وعلى صعيد آخر تم تقدير محتوى المعادن و حمض الفايتناك في بذور البقاليات اللوباء حلو و الحمص و اللوباء عدس، الفول المصري و الفاصوليا و اللوباء عفن و البسلة بالإضافة إلى البسيطة الخلوية أو الأوريق التي تم ريها من نفس مصادر المياه.

أوضح النتائج أن الإس الهيدروجيني و الرائحة و الطعم و التوصيل الكهربائي و الملوحة و المواد الصلبة العالية و الأمونيا و السليت و السليت-ك و السلافات والكربونات والكليات و المعادن الثقيلة في جميع عينات المياه مطابقة للحد المسموح به بناءً على منظمة الصحة العالمية (1993) و الهيئة السودانية للمواصفات و المعايير (2002). أما معدلات الزرنيخ (0.1 ملغم/التر) و الحديد (0.3 ملغم/التر) و المواد الصلبة الذائبة (156 ملغم/التر) فقط.

كانت عالية معنويًا (0.05 ≤ P) في العينة التي أخذت من نهر النيل. كانت جميع قيم درجة العصر الكلية في عينات المجمعة من مياه الرايعات و الصهاريج و الآبار أعلى من الحد الموصى به (200 ملغم/التر). كانت درجة الكحارة في عينات المجمعة من مياه (0.05 ≤ P≤ 1.5) الآبار (200 ملغم/التر) عالية معنويًا من الحد الموصى به. وقد كانت جميع عينات البلازبات غنية بالبوتاسيوم (0.97 - 2.1 جرام/100 جرام) و الكالسيوم (0.1 - 0.18 جرام/100 جرام) و الفسفور (0.083 - 0.65 جرام/100 جرام). بينما كانت تحتوي على كمية قليلة من الكوبالات (0.005 - 0.06 ملجم/100 جرام). وكانت بذور الفول المصري و الفاصوليا الأعلى معنويًا (0.05 ≤ P) بعنصر الزئبق مقابلة جميع عينات البقاليات الأخرى. و عينة الحمص الأعلى معنويًا (0.05 ≤ P) في عنصر المنجنيز. و عينات الفول المصري و اللوباء عدسی و
الحمص الاغني معنوي (P<0.05) بعنصر الحديد. ولقد وجد ان جميع عينات المياه و بذور البقوليات فقيرة في السيلينيوم. و كانت عينة الحمص (0.017 جرام/100 جرام) تحتوى على نسبة ضئيلة من حمض الفايتيك، بينما احتوت عينة اللويا حلو (0.14 جرام/100 جرام) على اعلى نسبة من المادة وهذا قد يؤدي الى زيادة تأثيرها المثبط على المعادن و خاصة الفسفور.
INTRODUCTION

People need good health to enjoy their lives; hence, the food that supplies their bodies with energy and nourishment to keep them in a good health, so good nutrition is the way to accomplish that. Knowledge of the chemical composition of the diet and the recommended amounts help to understand how to meet our bodies' requirements. Basically, water is an essential nutrient, which is vital for life and required in greater quantity than any other orally ingested substance.

Water has many functions in the body: At first, it is considered as a mean of protection from environmental stress. Beside that, it plays an important role in digestion, absorption and metabolism. Also, transport nutrients through the body and excrete the waste products in addition to that it is vital to electrolyte balance (Chalupka, 2005).

Although minerals in water are found in small amounts, they are better absorbed than those found in food (Bragg and Bragg, 1986).

Anyway, highly saline water may contain: calcium, magnesium, sodium, bicarbonate, chloride and sulfate ions to exert toxic effect and may increase the risk of heart disease and certain cancers. However, consuming enough water daily may help to reduce the cancer risk of the colon, kidney and bladder (Altieri et al., 2003).

Chlorine and lead are the most common contaminants; chlorine is a strong oxidizing agent and may lead to cancer as well as lead.

More commonly, contaminated water can be a source of mineral toxicity. Therefore, salinity, alkalinity, nitrate, sulfate, bacterial contamination and other factors are affecting the quality of water (Guyer, 1996).
Legumes are characterized by low fat content, good source of fiber, rich in antioxidants, contain minerals: iron, zinc, calcium, selenium beside vitamins; moreover they help to minimize chances for many chronic diseases like diabetes mellitus, heart disease, obesity and cancer (Messina, 1999).

In general, legume seeds contain anti-nutritive factors, especially phytic acid which binds with the available minerals and phosphorous in particular to become unavailable to monogastrics. Actually ruminants have no problem due to the production of phytase by rumen microbes while monogastrics are usually sensitive (Cheeke, 1998).

Elseleim Agricultural Scheme represents one of the greatest agricultural projects in the country. It is the biggest agricultural project in the northern region and represents 50% of the total income of Dongola city. Since no research has been reported concerning water and legumes in that area the objectives of this study are:

1. To evaluate the quality of drinking water in Elseleim area.

2. To determine the mineral content for different types of legume Seeds obtained from Elseleim agricultural scheme, Vicia faba, Phaseolus vulgaris, Cicer arietinum, Pisum sativum, Lathyrus sativus, Cajanus cajan, Lablab purpureus and Vigna unguiculata.

3. To estimate phytic acid (phytate) content in these legume samples.
Chapter One
LITERATURE REVIEW

1.1 Water

Generally, water found in the earth is distribute in the oceans, lakes and as snow fields but only 0.5% is included in hydrologic cycle (Teare and Peet, 1983). Water is an important element for survival and from a nutritional point of view, some scientists considered water as a liquid diet (Kowtaluk and Beyer, 1980).

The newborn human baby contains 74% of water, while in the embryo it is about 80%. In animals the amount of water varies according to age, in other words it falls with age, comparing the water content in new born animal with mature fat one is 750 g/kg and 500 g/kg respectively. In plants water range from as little as 60 g/kg in concentrates to over 900 g/kg in some crop roots (McDonald et al., 2002).

The body gets water from different sources: either from drinking water, water occurring in feedstuff or even arising from nutrient metabolism (metabolic water) that represents the major source of water for some desert animals (Schmidt, 1964).

There is always a risk from chemicals including heavy metals, chemical disinfectants and other carcinogen substances affect human and animal health as well as bacterial contamination. So, hard efforts have been made to ensure that drinking water is health hazardous free (World Health Organization, 1993).

1.1.1 Chemical constituents

1.1.1.1 Ammonia
Ammonia has different origins, either from metabolic, agricultural and industrial processes beside disinfection with chloramines. It could be found as ionized (NH$_4^+$) or non-ionized (NH$_3$) forms.

The natural level in ground and surface water is below 0.2 mg/l, but in anaerobic ground water reach up to 3 mg/l.

Intensive livestock rearing excess the concentration of ammonia and lead to contamination in the surface water. Moreover, contamination also resulted from cement mortar pipe linings.

However, high level of ammonia in drinking water is considered as an indicator to pollution which resulted from bacterial, animal waste or sewage.

Ammonia has toxic impact when it is level rises to 200 mg/kg body weight (World Health Organization, 1993).

1.1.1.2 Nitrate and Nitrite

Nitrite and nitrate are naturally occurring ions that are parts of the nitrogen cycle, based on some studies, they have no direct risk on animal health but there are more chances for human's cancer (World Health Organization, 1993).

Nitrate is a substance free of color, taste and even odor. It can be detected only by chemical analysis (Self and Waskom, 1998). Nitrate concentration in ground and surface water is low, but it can be highly deposited in ground water found in areas with intensification of farming activities. Water is considered as a major source of nitrate, when its level reaches up to 50 mg/l (World Health Organization, 1993). For animal consumption the level of nitrate could reach 100 mg/l and water still save. Otherwise, water should be monitored especially when the
animal fed high amounts of nitrate in his diet particularly in drought season (Self and Waskom, 1998). However, more than 300 mg/l nitrate in drinking water is harmful (Guyer, 1977).

1.1.1.3 Chlorine

Natural sources, sewages and industrial effluents are the common sources of chlorine in water (World Health Organization, 1993). Despite of the use of chlorine was very popular as drinking water disinfectant (Price, 1969), it sabotage the immune system because it destroys the beneficial bacteria (Page et al., 1976).

The danger of excess chlorine in the distribution system comes from increasing the rate of metal corrosion in the supply system (World Health Organization, 1993).

Any way, chlorine is one of the most common water pollutant and considered as oxidizing agent and may increase the rise of heart disease (Schwatzr, 2001) and cause cancer particularly bladder cancer (Villanueva et al., 2004). Therefore, chlorine concentration in drinking water should not exceed 250 mg/l (World Health Organization, 1993).

1.1.1.4 Fluoride

Regarding to type of water, fluoride concentration in ground water is very high compared to raw water; it is about 10 to 1.5 ppm respectively (Urban Watershed Project, 1999).

Although, fluoride is categorized as an agent that does not cause carcinogenicity to human (International Agency for Research on Cancer, 1987). Other studies showed the reverse. The intake of more than 1.5 ppm fluoride in drinking water causes dental fluorosis and skeletal fluorosis (World Health Organization, 1993).
It is very necessary to consider climatic conditions, volume of water intake and other sources of intake such as food; air etc for a set the permissible limits (World Health Organization, 1993).

1.1.1.5 Hardness

Hardness refers to cations dissolved in water and its degree affects the taste acceptability. Hardness is usually expressed as an equivalent quantity of calcium carbonate (Harris et al., 1992).

The increase of cations in water means more hard water and the reverse means more soft water. Calcium is the most common cation in water, compared to magnesium, manganese and iron (Harris et al., 1992).

The allowed limit of World Health Organization (1993) is 200 mg/l. Some studies reported that, increasing water softness has negative influence on minerals balance in the body (World Health Organization, 1993) and harder water prevents the formation of kidney stones for human (Guyer, 1977), while in animals hard water is more beneficial than soft water (Epestein and Zavon, 1974).

1.1.1.6 Alkalinity

In common, alkalinity estimates the proportion of bicarbonate in water (Herschdoerfer, 1986). Alkalinity is also represented as CaCO$_3$ ppm (Rodenburg, 1985). It is also defined as the capacity of water neutralize acid. All cations elements, bases or hydroxides are expressed in empirical term as water alkalinity. 1000 mg/l alkalinity of water is considered as sufficient to all livestock species (Guyer, 1977). In case water alkalinity reaches up to 1000 mg/l and the nature of alkalinity based on bicarbonate and pH ranged between 7 to 8, the water is not
harmful. Nevertheless, if the alkalinity exceeds 1000 mg/l and the pH range between 8 to 9 and nature of alkalinity based on presence of carbonate, the water classified as harmful (Rodenburg, 1985).

1.1.1.7 Sodium

The major daily intake sources of sodium are common salt (NaCl) (Cheeke, 2005) followed by water then by air (which represent least one). There are other good sources such as marine food and vegetables (McDonald et al., 2002). Sodium is necessary in transmission of nerve impulse, absorption of sugars and amino acids (McDonald et al., 2002). Thus, ingestion of large amounts of sodium resulted hypertension (Cheeke, 2005), while low amounts cause low osmotic pressure, dehydration, poor growth and adverse impact on digestion of energy and protein beside egg production. In extreme situation it leads to death (McDonald et al., 2002). Due to its ability to change tastes of drinking water, World Health Organization (1993) decided that, the level of sodium must be 20 mg/l. However, the amount of sodium is related to water hardness (World Health Organization, 1993).

1.1.1.8 Potassium

Potassium is one of the common dissolved solids in water. It is necessary for plant growth and has no harm effect on humans' health (Robertson et al, 1979). Potassium, sodium and chorine are inorganic cations inter-related in their metabolism. When sodium depleted in ruminants, potassium act as substitute (Cheeke, 2005). Potassium contributes mainly in acid-base balance, osmotic regulation, nerve and muscle excitability also carbohydrates metabolism. According to Food Standards Agency (2000), taking 3770 mg or less of K supplements a day is unlikely to cause harm. Actually excess potassium draining from
the body through urine, but very high level may effect absorption and metabolism of magnesium and lead to aetiology hypomagnesaemic tetany defacing (McDonald et al., 2002). Sudanese Standards and Metrology Organization (2002) announced that, the maximum allowed level of potassium in drinking water is 20 mg/l.

1.1.1.9 Manganese

Limited studies showed the toxic effect of manganese on human health through drinking. Manganese has variation in absorption rate; it is very high in infants and young animals. The daily intake can reach 20 mg/l with no adverse effect on health. Generally, 0.5 mg/l should be protecting consumers' health (World Health Organization, 1993; Food Standards Agency, 2000). 5.5 mg per day should be ingested by a kid (Indian Council of Medical Research, 1992).

In poultry 1 g/kg has no toxic effect, but in young pigs 0.5 g/kg reduces the appetite as well as growth (McDonald et al., 2002). In cattle about 1 to 4% of manganese in the diet is absorbed (Hurley and Keen, 1987).

1.1.1.10 Sulfate

Sulfates occur in many minerals like Ca, Mg and Na. They are found in drinking water because of industrial waste and the highest levels of sulfates are found in ground water.

In spite the fact that, sulfate is one of the least toxic anions it hurts the gastrointestinal tract. Based on that sulfate concentration in drinking water is 500 mg/l as maximum (World Health Organization, 1993).

1.1.1.11 Nickel
The amount of nickel released from industrial process can be higher than 1 mg/l, but usually the normal level in drinking water is 0.02 mg/l or less. Some studies approved that nickel is carcinogenic (World Health Organization, 1993).

### 1.1.1.12 Selenium

Selenium shows its common importance with vitamin E as antioxidants (Cheeke, 2005). As a component of deodinase, selenium has the ability to convert thyroxin to tri-iodothyronine (Burk and Hill, 1993). Moreover, selenium forms a substance called selenoprotein which is found in blood and muscle, but its function still unknown (Yeh et al., 1997). Selenium and vitamin E have a protective role against heavy metal toxicity (McDonald et al., 2002). Furthermore, they support the immune system (Knight and Tyzink, 1990).

Selenium level in water should not exceed 0.01 mg/l. Sudanese Standards and Metrology Organization (2002) reported that 0.007 mg/l as daily intake. Food Standards Agency (2000) suggested that, 0.075 mg/day for men and 0.06 mg/day for women is considered to be sufficient, On the other hand, 5 mg/kg DM and 500 μg/kg liquid milk or water is potentially harmful; Selenium is toxic and harms the liver in human. In rats also sign of growth retardation with liver problem were seen clearly (World Health Organization, 1993).

### 1.1.1.13 Zinc

Zinc concentration in surface and ground water is about 0.01 and 0.05 mg/l respectively, whereas in tap water is more concentrated due to the dissolution of elements from the pipes. Zinc has the ability to change
water taste; accordingly, more than 5 mg/l lead to undesirable taste (World Health Organization, 1993).

Food Standards Agency (2000) advices against taking more than 25 mg of Zn supplements a day. Also Indian Council of Medical Research (1992) recommended, 15 mg for Zn per day is sufficient for a child needs.

1.1.1.14 Arsenic

Arsenic is found in water from industrial effluents, atmospheric deposition and corrosion (World Health Organization, 1993).

Arsenic has strong toxic nature; it causes nausea, vomiting, diarrhea and severe abdominal pain (Mc Donland et al., 2002).

Also it is classified as human carcinogenic (International Agency for Research on Cancer, 1987). According to United States of Environmental Protection Agency (1990), arsenic concentration in drinking water should be at maximum 10 ppb.

In addition, the maximum permissible limit 0.007 mg\l set by Sudanese Standards and Metrology Organization (2002) as well as World Health Organization (1993).

1.1.1.15 Lead

There are many factors affecting the amount of lead in plumping system which include pH, temperature, hardness and standing time of water (World Health Organization, 1993).

Lead is classified by International Agency for Research on Cancer (1987) as possible carcinogenic element. Also other studies showed that, lead actually causes cancer and heart disease as well as chlorine (Schwatzr, 2001; Villanueva et al., 2004).
Joint Food and Agriculture Organization/World Health Organization Expert committee on food additives (1983) established a provisional tolerable weekly intake for infant and children as 25 \(\mu g/k\) body weight. The maximum permissible limit of World Health Organization (1993) and Sudanese Standards and Metrology Organization (2002) are 0.01 and 0.007 mg/l respectively.

1.11.16 Iron

Iron is a dietary essential element especially during pregnancy, lactation and other specific requirements, but to avoid its accumulation in the body. Women need about 14.8 mg daily (Food Standards Agency, 2000). The maximum daily intake of iron should be 0.8 mg/kg (Joint Food and Agriculture Organization/World Health Organization Expert committee on food additives, 1983). The International Council for Medical Research (1992) recommended 19 mg /day for children. Green leafy plants are rich in iron as well as leguminous plants and seed coats. Moreover blood meal and fishmeal are good sources reverse to milk.

Usually in drinking water iron ranges between 0.5 and 50 mg/l and its existence is due to iron coagulants or the corrosion of steel and cast iron pipes during distribution of water.

Iron also has the ability to affect the taste and appearance of drinking water (World Health Organization, 1993).

1.11.17 Cobalt

Cobalt (Co) is important in human and animal diet, but in small amounts. Usually, Co is found in higher levels in industrial areas. In fresh water is <5\(\mu g/l\). Anyway, Co concentration in fresh water should not exceed 5\(\mu g/l\), due its toxic effect on human, animal and aquatic
plants (Nagbal, 1981). Cobalt can be toxic if it exceeds the safety level; 1 mg/kg and 3.5 mg/kg body weight are toxic levels for cattle and sheep respectively (McDonald et al., 2002). Anyway, adults need approximately 0.0015 mg of cobalt (Food Standards Agency, 2000).

1.1.1.18 Calcium

Calcium, magnesium and phosphate are considered as essential elements, they have structural role in body (Bender, 1997). Calcium is crucial for the transmission of nerve impulses as well as muscles contraction; nerve impulses and it play an important role in blood coagulation (McDonald et al., 2002).

1.1.1.19 Phosphorus

Phosphorus (P) is considered as one of the key elements in animals and plants life. It participate in the building of the structure in addition it has a general role as growth element (International Minerals and Chemical Corporation, 1966), also it has a role in metabolism of the body (McDonald et al., 2002). In the plants, phosphorous condense in seeds or fruits. Milk, fishmeal, bones and eggs are representing rich sources of phosphorous (International Minerals and Chemical Corporation, 1966; McDonald et al., 2002).

Phytate has drastic effect on the availability of phosphorous. Anyway, the defacing or unavailability leads to lack of appetite, depletion of production, reduction in the conception rate (International Minerals and Chemical Corporation, 1966).

1.1.1.20 Copper

Normally the average intake of copper should range between 1 and 3 mg/day (Food Standards Agency, 2000), if it increases more than
3 mg/l for mature person, acute gastric irritation may appear. Infants are more susceptible to liver cirrhosis (World Health Organization, 1993) as well as kidney damage (United States Environmental Protection Agency, 1990). 2.2 mg per day is suggested by International Council for Medical Research (1992) for kids. In farm animals, deficiency symptoms of copper are characterized by anemia, poor growth, skeletal deformity and depigmentation (McDonald et al., 2002; Cheeke, 2005). In grazing cattle the mal-absorption syndrome may lead to severe diarrhea (Fell et al., 1975).

**1.1.1.21 Magnesium**

Magnesium is needed in the body for neuromuscular activity beside it act as cofactor of many enzyme, necessary in metabolism of energy, lipids and carbohydrate (Cheeke, 2005). Moreover, magnesium plays an important role in cellular reactions including cellular respiration.

Colostrum is rich in magnesium unlike milk, wheat bran, dressed yeast and most vegetable, protein concentrates are classified as good source too (McDonald et al., 2002), 300 mg daily intake for men and 270 mg daily intake for women is safe (Food Standards Agency, 2000). In case of magnesium depletion in farm animals, supplement (MgO) should be added to the feed either in the form of salt or oral bullets (Stuedemann et al, 1984). Taking high doses of Mg for short time cause diarrhea (Food Standards Agency, 2000).

The change of colour in drinking water is an indicator to presence of coloured organic matter, soil, metals in addition to industrial
effluents, when colour is less than 15 TCU (True Colour Units) water considered to be acceptable (World Health Organization, 1993).

1.1.2.2 Taste and odour

Chemical contaminants; or by products from waste treatment affect the taste and odour of the water. In case of taste and odour changes, immediate check should be done and this includes the whole stages of water treatments beside distribution system (World Health Organization, 1993).

1.1.2.3 Temperature

Generally, consumer prefers cool water. Anyway increasing temperature allows many problems to appear like the microbial growth, arise metal corrosion plus effect taste and odour (World Health Organization, 1993).

1.1.2.4 pH

Although, some disorders connected with pH such as irritation and exacerbation of skin, it does not affect humans' health directly. However, pH values above 11 considered hazardous (World Health Organization, 1993).

1.1.2.5 Electric conductivity

Is the salts or minerals concentration in liquid and measured as micro-siemens/centimeter at 20°C which is recommended as the standard temperature particularly in UK. In USA, 25°C is the standard temperature (Herschodoerfer, 1986).

1.1.2.6 Total Dissolved Solids (TDSs)
Total Dissolved Solids in water are the inorganic salts (mainly include Ca, Mg, K, Na, bicarbonate, chloride and sulfates) and little levels of dissolved organic matter (World Health Organization, 1993).

Total Dissolved Solids in drinking water could result of drainage from sewage, urban run-off, industrial waste, natural sources and even salts that are used for road de-icing.

Total dissolved solids are differing according to geological region. However, 1000 mg/l TDSs in drinking water the taste will be acceptable (World Health Organization, 1993).

Animals can stands up to 1000 ppm with slight problems that differs between species as well as TDS concentration, eventually more than 10000 ppm TDS water considered as not acceptable (Peterson, 1999).

1.1.2.7 Total Suspended Solids (TSSs)

Total Dissolved Solids include many organic substances like silt, sewage, decaying plants and animal matter. The excess of total suspended solids increase the concentration of bacteria, metals, pesticides etc.

There are many factors affecting TSSs such as: high flow rate, soil erosion, urban run-off, wastewater and septic system. No standard provided for TSSs concentration in drinking water, but high TSSs may scour or even block pipes and machinery used for industry (Murphy, 2007).

1.2 Legumes
Legumes beside cereals and oilseeds constitute about 90% of total harvested areas in the world. They are used for human and animal food and provide complementation to cereals in the amino acids, so to reduce the problem of mal-nutrition in the developing countries they have been introduced specially in the weaning food system (Bahal, 1990).

The total pulses production in 2002 was 73,000 metric ton in Sudan (Food and Agriculture Organization, 2002). More grain legumes are produced specially for human consumption, whereas animals are fed cull and sometimes the forage.

Moreover, legumes are rich in thiamine, riboflavin, nicotinic acid, ascorbic acid (Gupta, 1988), as well as minerals which are better in forage than grasses (Robert et al., 1995).

Actually due to anti-nutritional factors, legumes are lower in protein digestibility than vegetable than animal protein. Anyway, different types of treatments such as heat and cooking improve the digestibility (Bahal, 1990). But heat treatment should not be high to avoid the reduction of the nutritive value of protein (Bahal, 1990). Legumes play an important role most of them fix nitrogen, a leguminous crop can add up to 500 kg/ha/year nitrogen to the soil (National Academy of Science, 1977).

1.2.1 *Phaseolus vulgaris* (Fasulia)

Common beans are the second most important legume crop in term of area cultivated (Harderson et al, 1993) and widely found in temperate and semi-tropical regions (Duke, 1983). They are grown for their mature dry seeds, immature green/yellow pods beside leaves (Cobley and Steele, 1976). After harvest, plants residues can be fed to
farm animals green, hay or silage (after pod removal) (Duke, 1983). *Phaseolus vulgaris* has high nutritive value, thereof high in protein content which is considered relatively low cost. Moreover they are low in fat content also contain the vitamins thiamine, riboflavin, nicotinic acid and ascorbic acid.

Among different varieties of whole seeds of common beans, some studies showed that, they are considered as good sources of the minerals P, Ca, Mg and N, while relatively lower in Fe Zn, Cu, Na as well as Cl (Duke, 1983).

Although seeds are used in blood cancer treatment plus urinary tract disorders (Launert, 1981), they contain trypsin and chymotrypsin inhibitors beside the toxic substance lections (Cobley and Steele, 1976). In China common beans are used more as therapeutic agent as in heal dropsy, diarrhea and as tonic to viscera (Li, 1973).

A study done by Bahl (1990) approved that a mixture of common beans and maize as 50: 50 protein content, the protein efficiency rate (Protein Efficiency Ratio) has been increased to 122.2%.

### 1.2.2 *Cicer arietinum* (Hummus)

Chickpea is thought to have originated in western Asia. Now the world's cultivation is centered in Indian and Pakistan and spread in Africa, South America and as feed in Turkey, Syria, Pakistan (Capper, 1990).

The crop is grown for its mature seeds either whole seed or ground to flour, in addition to immature pods and young leaves (Cobley and Steele, 1976). Hummus is considered as good source of highly digestible protein (Bahl, 1990); carbohydrates, fibre, vitamins (Hulse,
1991) and minerals (Ibrikci et al., 2002). It has also protease inhibitors, which can be treated by heat (Cheeke, 1998). High lysine and limited in methionine (Cheeke, 1998).

Although Cicer arietinum grown for human consumption, it can be also fed to dairy cattle as replacement for soybean (Newman et al., 1987).

In an experimental diet, which had been provided to a group of children represent a mixture of chickpea to wheat as 20: 80 respectively, their nutritional status was significantly improved (Daniel et al., 1969).

Generally, among food legumes chickpea is the most hypcholesteronic agent (Geervani, 1991).

1.2.3 Vicia faba (Ful masri)

Also called broad beans or faba beans, are cultivated in Europe and middle East for human consumption, but used to feed livestock in North America (Cheeke, 2005), beside that, they are found in Morocco and Nile Valley (Capper, 1990). Broad beans are often grown for their green manure (Duke, 1981). In Egypt and Sudan Vicia faba is one of the cash crops (Bond et al., 1985).

Broad beans contain about 88.6%, oil as unsaturated form, crude protein is range between 24 and 30% (Duke, 1981). The amino acids are balanced except methionine (Bond et al., 1985). The dried seeds contain larger amount of the minerals K, P, Ca compared with Fe and Na (Duke, 1981).

Ful masri causes favism to human, which occur in individuals with a genetic deficiency of glucose-6-phosphate dehydrate (Mc Donlad et al., 2002).
The toxic substance lectin found in the crop can be destroyed by heat (Hussein and Saleh, 1985). Furthermore, other objectionable factors are found such as tannin, phytate, cyanogens, favogens and trypsin inhibitors (Williams et al., 1998).

1.2.4 Pisum sativum (Bisella)

*Pisum sativum* or garden peas are used either as human food or as forage (Cheeke, 2005). The most productive areas are USA and European countries (Duke, 1983). They had been grown for their very palatable and edible immature seeds, seedpods and mature seeds (Cobley and Steele, 1976). Usually, the white flower peas had higher nutritive value than dark flower one. Peas are generally low in protein content in general and methionine in specific (Cheeke, 2005). When they are cultivated in low selenium soil, selenium supplementation must be used in the diet (Cheeke, 2005).

*Pisum sativum* have considerable amounts of trypsin inhibitors (John, 1987) and non-starch polysaccharides (Igbasan et al., 1997).

1.2.5 Cajanus cajan (Luba adasi)

Also known as pigeon pea, the crop cultivated in the Nile valley, India and Pakistan (Cobley and Steele, 1976). Nowadays more than 25 tropical and subtropical countries cultivate pigeon peas. Although *Cajanus cajan* has high level protein, sulfur, amino acids and tryptophan are lacked (Cheeke, 2005). Seeds contain protease inhibitors used in liver and kidney ailments (Duke, 1981).

1.2.6 Lablab purpureus (Lubia afin)

Lablab beans or hyacinth bean is an Asian crop probably domesticated in India whereas it occur wild or cultivated grain legumes
(Cobley and Steele, 1976). In addition, it is widely utilized in South Africa, Egypt and Sudan (Evans, 2002). Lablab beans have a dual purpose, they are grown as a pulse crop for human consumption and the flowers beside immature pods used as vegetable, also function as cover crop.

The grains are rich in A, B, and C vitamins, good source of protein. In spite of this, their palatability ranges from low to moderate (Pengally and Mass, 2001).

In study carried out in India on lablab beans found that, the amount of Ca and Fe was high more than the recommended daily allowance (400g), while the rest of micro elements Zn, Cu and Mn were lower (Arinathan et al., 2003). As animal feed, lablab hay increases milk yield and improves growth rate (Murungweni et al., 2004).

1.2.7 Vigna unguiculata (Luba helo)

Vigna unguiculata has many common names like cowpea, black eye bean, black eye pea and southern pea (Duke, 1981). It is an annual legume which is native in Africa. Seeds used fresh/dried as human food, the leaves used as vegetable. A study showed that seeds can be stored for many years (Duke, 1981), where other proved the reverse (Mc Leod, 1982). Usually N content in cowpea range between 1.4 and 1.5%, it also considered as good supply of minerals K, P, Ca, Cu, Fe and Zn (Igbal et al., 2004) as well as essential amino acids (Igbal et al., 2004). Black eye beans are higher in protein content than sorghum and this was approved by an experiment on weaning food showed that, the amount crude protein even much better in these mentioned amino acids than milk (Oyus et al., 1985).
1.2.8 *Lathyrus sativus* (Grass Pea)

*Lathyrus sativus* or Grass pea have also different local names include; Chickling pea, Indian vetch (UK and N. America), Almorta (Spain), khesari or Batura (India), Alverjas (Venezuela), Guaya (Ethiopia), Matri (Pakistan), Gesette (France), Pisello bretonne (Italy). It is one of the most important food legumes in some of the developing countries in Asia and Africa such as Bangladesh, India and Ethiopia.

This plant belongs to family *Leguminosae*, it used in the developing countries as contain 18.2-34.6% protein, 0.6% fat, 58.2% carbohydrate and 3.6% phytin, it contain vitamins especially folic acid, biotin and pyridoxine. Grass pea oil has therapeutic nature also the seeds are used locally in homeopathic medicine (Duke, 1981). Consuming much grass pea in the diet (30%-50%) for more than three months will cause some diseases for both human and animals including "Lathyrism" and "Neurolathyrism"(Williams et al., 1994; Smartt et al., 1994), fortunately soaking the seeds in water for 24 hours before cooking will expunge the toxic effect (Duke, 1981).

1.3 Phytic acid

Phytic acid or phytate is chemically known as insitol hexakisphosphate (IP6), other forms of phytate are also found including insitol *penta*, *tetra* and *tri*-phosphate. It is found in plant tissues especially in legume seeds, oilseeds and cereal (Reddy *et al.*, 1981; Oberleas, 1983). Tuber, nuts and roots also contain phytic acid (Marfo *et al.*, 1990).

Despite of the fact that phytate function as store the positive charge or cations which are necessary for seed germination (Reddy *et
al., 1989), it has a powerful effect on those dietary important minerals (P, Ca, Cu, Ma, Fe, Zn) and lead to serious deficiency symptoms particularly for people living in developing countries. This is comes from the formation of unabsorbable phytate-mineral complexes especially with phosphorous through the intestinal tract (Davies, 1982). In infants, the effect of phytate on Zn absorption seems to be more important than adults according to the fact that it is most important in recovering infections (Hurrell, 2003). Another form of phytate-protein complexes also found and impaired the protein solubility (De Rham and Jost, 1979).

Ruminants have the enzyme phytase which is produced by anaerobic fungi and bacteria, has the ability to breakdown this bond in the rumen (Richardson et al., 1985).

Unfortunately, monogastrics lack this enzyme and excrete the excess P as manure and it may lead to environmental problem (Mallin and Cahoon, 2003).

Phytic acid also acts as an acid, chelating the niacin and lead to pellagra (Anderson, 2005). Moreover, it has the same effect on the enzymes trypsin, pepsin, a-amylase and ß-galactosidase by reducing their function (Deshpande and Mc Cheryan, 1984; Singh and Kriksrian, 1982; Inagawa et al., 1987). Cooking, germination, fermentation, soaking and auolysis are reducing the chelating influence of phytate (urban et al., 2000).

Insitol hexa-kisphosphate has many health benefits, it acts as antioxidant (Graf et al., 1987) and prevents the damage that associated with cancer of heart disease, it may reduce danger of the colonic carcinoma (Dvorakova, 1998) and this can be accomplished by its anti-
prolificative activity of the cells. It also improves the effectiveness of the chemotherapy (Vucenik and Shamsuddin, 2003). Onomi et al. (2004) found that 0.035% phytic acid ingestion may protect from fatty liver which occurs from elevated hepatilipogenesis and that for the anti-nutritive effect of phytae on absorption of P. However, more studies should be done to determine the optimal safe and effective dosage of phytate to be ingested.
Chapter Two
MATERIALS AND METHODS

2.1 Study area

All water and legumes samples were obtained from Elseleim Agricultural Scheme which is found in Elseleim area which is located in the Northern region of Sudan. It lies in the eastern side of the river Nile extending from Elkawa by the southern part to Elburgeig in the northern part. The total cultivated area is 55410 Feddan.

2.2 Water and sampling techniques

Sixteen samples of water were collected from different four sources to evaluate the physical and chemical characteristics and to assess the contaminants levels, the sources included: Hand pump, the River Nile, tanks and wells with 2, 2, 4 and 8 replicates respectively.

Water samples were collected in sterile plastic bottles, tightly closed then transferred to the laboratory.

2.3 Physical characteristics

2.3.1 Temperature

At the time the sample was collected, temperature was measured immediately by glass mercury thermometer (0.1°C graduation), the thermometer was immersed for one minute in the beaker which contained the water sample, and after the thermometer’s liquid column stopped moving readings were documented (Lenore et al., 1998).

2.3.2 Odour
It was detected by direct smelling.

2.3.3 Turbidity

The turbidity was estimated according to Lenore et al. (1998) by the nephelometric method, where the turbidity meter/ HACH 2000 was used, following the devise temperature was adjusted to 20 ± 1°C and the samples were estimated, then results were expressed as Nephelometric Turbidity Unit (NTU).

2.3.4 pH

The pH was estimated by using the digital pH meter/superfit. As described by Lenore et al. (1998), the device’s electrode as well the beaker were cleaned with distilled water, followed by small amount of the sample.

The beaker was filled with adequate amount of the sample and the electrode’s tip was immersed in (2 cm height and 1 cm away from bottoms and sides). After the temperature was checked to insure that not be high the device was turned on and the readings were measured.

2.3.5 Electric conductivity

According to Lenore et al. (1998) the electric conductivity was measured by EC meter (4510 Conductivity Meter).

After the temperature of small amount of the sample was adjusted to 20 °C ± 1°C the electrodes of the conductivity cell was rinsed with the sample three times, then immersed in a clean beaker filled with suitable amount of the sample (the vent holes was covered by the sample where there was no air bubbles noticed).
The sample’s temperature was monitored and recorded to the nearest 0.1°C.

After that the EC meter was turned on (20 °C ± 1°C) and the results were obtained as milliseimens per meter ((1mS/m) is equal 10 μs/cm = 10 μmhos)).

2.3.6 Total dissolved solids

Hundred ml of the water sample was filtered through filter paper (whatman No.42) and the filtrate collected in a flask then transferred to pre-weighed ceramic dish. Then the weight of the container and filtrate was recorded before transferred to the dry oven 105 °C for 24 hrs.

The filtrate was evaporated in the dry oven then the sample was placed in desiccators for 3 hrs.

The sample and the container were reweighed several times until the readings were constant.

The initial weight (in grams) of the empty container and the weight of the container with the dried residue were subtracted to obtain the increase in weight which represented total dissolved solids/TDS.

The calculations

A- Weight of clean dried container (0.0000 grams)
B- Weight of container and residue (0.0000 grams)
C- Volume of Sample (not included rinse water) (100 ml)

\[
\text{Concentration (mg/L)} = \frac{(B - A)}{C} * (1000 \text{ mg/g}) * (1000 \text{ ml/L})
\]
(Lenore et al., 1998).

2.3.7 **Total suspended solids**

First the filter disc was oriented in the filter holder and the filter holder was assembled in suction flask apparatus and vacuumed by vacuum source.

The standard filter paper (whatman. No 42) was put on the filter holder, attached to suction flask apparatus and vacuum source then washed by distilled water and vacuumed for 2 minutes. When the water passed all the way through the filter; the filtrate was discarded. After that the filter paper was removed and placed in dry oven (105°C for 1 hr).

The Procedure was continued until the weight loss between two successive series of operation was less than 0.5 mg, then weighed in sensitive balance and kept in desiccators as \( W_1 \).

The filter was located in the filter holder and it assembled in suction flask and vacuum was applied.

After that 100 ml of the sample was taken and immersed into funnel, filtered through the filter paper followed by distilled water.

The filter paper was removed, dried in the dry oven (105°C for 1 hr), weighed in sensitive balance and kept in desiccators as \( W_2 \).

The difference between the two weights represented the total suspended solids TSSs (Lenore et al., 1998).

\[
\text{TSSs} = W_2 - W_1
\]

2.4 **Chemical parameters**
2.4.1 Ammonia

A clean vial (24 mm diameter and 10 ml volume) was washed with distilled water, filled with ten ml of water sample and placed in the sample chamber of the spectrophotometer /Aquanova, and then the calibration key was pressed. After that the vial containing the sample was removed from the device’s chamber and one ammonia tablet was added straight from the foil to the sample and mixed by cleaned stirring rod (washed by distilled water) another ammonia tablet was also added.

The vial was return back to the spectrophotometer and after the device turned on the sample left for 10 minutes - 676 nm wavelength then the result was displayed out as ppm.

2.4.2 Nitrite

Clean vial (24 mm diameter and 10 ml volume) washed by distilled water and then water sample was immersed in it and placed inside the spectrophotometer- Aquanova chamber and then the device was calibrated, after that the sample was removed.

One nitrite LR tablet was added straight from the foil to the water sample inside the vial then mixed by clean stirring rod until vanished.

The sample was return to the spectrophotometer chamber (for 10 minutes - 545 nm wavelength) then results were recorded as ppm.

2.4.3 Nitrate

Ten ml of the water sample was put in vial (24 mm diameter) after cleaned by distilled water, then placed in spectrophotometer- Aquanova then the device calibrated and the vial was removed.
One tablet of nitrate was added straight from the foil and dissolved by stirring rod (cleaned by distilled water before used). The sample was oriented in the spectrophotometer Aquanova and measured at 567 nm for 10 minutes. Then the result was shown in ppm.

2.4.4 Hardness

A vial (24 mm diameter and 10 ml volume) was washed with distilled water and filled by 10 ml of the water sample, then it was located in the sample chamber of spectrophotometer -Aquanova, after that calibration key was pressed. Then after the sample was removed one hard check P tablet was added to it and mixed by stirring rod and returned to the device. After the device was turned on and the sample left for 5 minutes - 571 nm wavelength then results were shown as ppm.

2.4.5 Sulfate

Ten ml of the water sample was immersed in a clean vial and located in spectrophotometer- Aquanova, after the device calibrated the sample was removed then sulfate tablet dissolved inside the vial contained the sample using stirring rod and then returned to the spectrophotometer- Aquanova. The device was turned on and water sample kept for 5 minutes - 450 nm, after that the results recorded in ppm.

2.4.6 Alkalinity

Ten ml volume of the sample was poured in cleaned vial (24 mm diameter) and placed inside spectrophotometer- Aquanova then the device was calibrated.
The sample was removed and one tablet ALA-M-photometer was dissolved inside the vial which contained the sample where clean stirring rod used to mix up.

The sample was oriented in the device’s chamber and left for 10 minutes- 615 nm to be estimated then results were obtained in ppm.

2.4.7 Potassium
Avail (24 mm diameter) was washed with distilled water, then 10 ml of water sample was poured in it.
The sample was oriented in the spectrophotometer- Aquanova and the device calibrated.
After the sample was removed, one tablet of K was added straight from the foil and mixed to dissolve using clean stirring rod and then returned to the device’s sample chamber for 2 minutes - 730, and then the result was shown in ppm.

2.4.8 Chloride
Ten ml of the water sample was immersed in a cleaned vial and put inside the spectrophotometer- Aquanova, fallowing the device calibration the sample was removed.

The vial was emptied from the sample except one ml then one tablet DPD No. 1 and other one DPD No. 3 were dissolved in it.
The volume was completed to 10 ml and the vial was located in spectrophotometer- Aquanova.
The device then turned on for 2 minutes – 510 nm, after that result was obtained as ppm.
2.4.9 Fluoride

Before take 10 ml of the water sample the vial was cleaned first with distilled water. The vial contained the sample was oriented in spectrophotometer- Aquanova chamber and then device calibrated.

After the device calibrated the vial was removed, and then one tablet of F was dissolved in the sample and returned back to the spectrophotometer- Aquanova. The device was adjusted at 580 nm for 2 minutes, and then result was recorded as ppm.

2.4.10 Sodium

Ten ml of the water sample was poured inside a beaker which was washed by distilled water before used, specific lens was placed in the flame photometer (abs 6 ml/min) then the candle was switched on.

When the flame photometer was turned on and the device electrode was immersed inside the beaker contained the water sample (2 cm height and 1 cm away from bottoms and sides), then readings were shown as ppm.

(Lenore et al., 1998).

2.4.11 Other minerals

The rest of the commons dissolved heavy metals were estimated by atomic absorption spectrophotometer (AA-6800).

According to Lenore et al. (1998), each mineral was detected as fallow:
The atomic absorption spectrophotometer cells were washed by distilled water carefully then dried.

After that, cell filled in water sample and placed in the device sample chamber, then the electrode immersed inside the sample.

The corresponding wavelength was selected from the menu and the start key was pressed, the results shown in ppm.

Each mineral was read at specific lamp wavelength.

<table>
<thead>
<tr>
<th>Element</th>
<th>Wavelength (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg</td>
<td>285</td>
</tr>
<tr>
<td>Ca</td>
<td>422</td>
</tr>
<tr>
<td>Zn</td>
<td>213</td>
</tr>
<tr>
<td>Mn</td>
<td>279</td>
</tr>
<tr>
<td>Cu</td>
<td>324</td>
</tr>
<tr>
<td>Fe</td>
<td>248</td>
</tr>
<tr>
<td>P6</td>
<td>282</td>
</tr>
<tr>
<td>Co</td>
<td>240</td>
</tr>
<tr>
<td>Se</td>
<td>196</td>
</tr>
<tr>
<td>As</td>
<td>193</td>
</tr>
<tr>
<td>Ni</td>
<td>232</td>
</tr>
</tbody>
</table>

2.5 Legumes and sampling technique

The examined legumes? samples were represented the whole mature seeds of the different types collected from the field in plastic bags at the harvesting season (March, 2008) to assess the minerals and the phytic acid content. All cultivated legumes were grown in the southern part of the scheme.

The dried seeds were cleaned from the dust, powdered to flour and kept in the desiccators inside labeled paper bags.
2.5.1 Dry ashing

According to Ryan et al (1977), two grams of the sample were weighed in a crucible then placed in muffle furnace at 550°C for 2 hours.

Then ten ml of HCl - 5 normality were added to the sample, and then the crucible was located in sand path for 2 minute to accelerate the dissolution.

The solution was filtered through filter paper (Whatman No.42) and the solution diluted with distilled water to 100 ml volume.

Dry ashing (stock) was used to estimate the following elements:

2.5.1.1 Phosphorous

One hundred ml volumetric flask was washed by distilled water. Then five ml was taken from the stock solution and transferred to the flask fallowed by 5 ml of the indicator ammonium molybalate vantate. Then the volume was completed to 100 ml by distilled water and left for 1 hour.

Blank sample was prepared by taking 5 ml of the indicator ammonium molybalate vantate and completed to 100 ml by distilled water in a clean volumetric flask.

Phosphorus values were estimated by spectrophotometer (6505 UV/vis and 470 nm).

Where ten ml of the sample was immersed in a clean cell (which was washed first by distilled water) and then located in the device chamber right after the device calibrated.
The wave length was selected and the power button was pressed, each sample had three replicates. Then readings were representing the absorption of the element, calculations

\[
\text{Phosphorus mg/l} = 5.5772 \times X^2 + 45.68X - 0.429
\]

Where

\[
X = \text{absorption}
\]

\[
\text{Phosphorus mg/100g} = \frac{\text{mg/l x 100 x 5 x 100}}{1000 x 1000 x 2}
\]

(Ryan et al, 1977).

2.5.1.2 Calcium and magnesium (titration)

According to Ryan et al (1977)

Volumetric flask was washed by distilled water then five ml from the stock was poured in it. Then the volume was completed to 50 ml by distilled water.

Then 2 ml from the previously mentioned solution (5/50 ml) was diluted again to 25 ml by distilled water in another clean volumetric flask.

After that 10 drops from the buffer solution (ammonia chloride and ammonium solution) followed by 3 drop of EBT (Eriochrome Black) were added to the sample and formed purple solution.

As the color changed by the absorbent solution, titration was done with EDTA Ethylene eliamine tetra acetic (0.01 conc.) The distillation was continued until one drop of the standard solution changed the color to blue.
The blank was used as reference for the colour comparison.

After the readings were recorded, Ca, Mg concentration was calculated by the following formula:

\[
\text{Meq/l} = \frac{\text{The readings} \times 1000 \times 0.01}{2}
\]  

(1)

To estimate the amount of Calcium, 2 ml from the solution (5/50 ml) was added to 25 ml volumetric flask followed by 5 drops from NaOH and 50 mg of ammonium purpurate nurroxide and completed to 25 by distilled water.

The pink solution was titrated by EDTA (0.01 conc.) and the colour turned to purple.

The readings were calculated by the following formula:

\[
\text{Meq/l} = \frac{\text{The readings} \times 1000 \times 0.01}{2}
\]  

(2)

To estimate the concentration of the Calcium the results from formula (1) were calculated in the following formula:

\[
\text{Ca (mg/100g)} = \frac{\text{Meq/l} \times 100 \times 20 \times 100}{1000 \times 1000 \times \text{sample weight}}
\]

To estimate the concentration of the magnesium the results from formula (2) were calculated in the following formula:

\[
\text{Mg (mg/100g)} = \frac{\text{Meq/l} \times 100 \times 12 \times 100}{1000 \times 1000 \times \text{sample weight}}
\]

2.5.1.3 Sodium and Potassium

Sodium and Potassium were estimated using the same method. Sufficient amount from the stock was put inside a beaker washed very well by distilled water before used.
Then flame photometer (abs 6 ml/min) was turned on after the candle was lighted and the lens was oriented (each mineral measured by specific lens).

The electrode was immersed in the sample within the beaker (2 cm height and 1 cm away from bottoms and sides), and then the measurements were recorded as ppm then values were transferred to mg/100g (Ryan et al., 1977).

2.5.1.4 Zn, Mn, Fe and Cu determination

These minerals were estimated by atomic absorption spectrophotometer (AA-6800) (Ryan et al., 1977).

The cell was washed by distilled water carefully then dried.

After that it was filled with the water sample and placed in the device sample chamber.

After that the corresponding wavelength was selected from the menu and start key was pressed, the results shown in ppm and then transferred to mg/100g.

2.5.2 Wet digestion (Cobalt and Selenium)

This method was used according to Ryan et al. (1977) to estimate the minerals cobalt and selenium beside iodine and chlorine.

Two grams of the sample was weighed in 100 ml beaker. Then Twenty ml from the chemical mixture [750 ml nitric acid + 150 sulfuric acid (conc.) + 300 per choleric acid 60%] were added.

The beaker was put under hood and exposed to low heat gently in hot plate until sulfuric acid brown gases released.
The solution was filtered by filter paper (Whatman No. 42).
The filtrate was completed to 50 ml volume by the acid mixture.
Then Cobalt and Selenium amounts in the samples were estimated by atomic absorption spectrophotometer (AA-6800) (Ryan et al, 1977).

2.5.3 Phytic acid:
Phytic acid was determined according to the procedure described by Wheeler and Ferrel (1971). Where there were two replicates for each sample.

Statistical Analysis
Mean values in physical properties and chemical contaminants and micro elements contaminants of water samples with the macro and micro nutrients plus phytate in pulses seeds were subjected to one way ANOVA. Differences in mean values were compared using the student's t-test at the 5% level.
Chapter Three
RESULTS

3.1 Water
The results of the physical contaminants or properties shown in table 3.1 include pH, turbidity, electric conductivity, total suspended solids, total dissolved solids and the physical appearance, odour, taste and colour. The pH of water samples fluctuated from 7.5 to 7.9. The highest value was the one which was collected from the river Nile and the lowest value was collected from well.
The turbidity of the collected water samples ranged between 5.1 to 4.6 NTU. The turbidity value of the sample collected from well was noticed to be the highest while the sample collected from hand pump was found to be the lowest value. However, all turbidity values estimated from water samples had no significant (P=0.05) pair wise differences among their means.
The content of EC in water samples graded from (59.6 micro ohms/cm) as minimum value found in the hand pump sample to (209.9 micro ohms /cm) found in the river Nile sample. Nevertheless among all collected samples, there were no significant (P<0.05) differences found.
The total suspended solids (TSSs) varied from 9.88 to 0.0 mg/l. The total suspended solids content in all samples obtained from hand pump, tank and the river Nile was not detected. Anyhow well sample represent the highest value and the only reading that detected 9.88 mg/l. Despite of that, all TSS values were not significantly (P<0.05) different from each others.
The results of total dissolved solids (TDSs) ranged between 33.85 mg/l to 155.6 mg/l, the sample obtained from the river Nile represented the
highest value while the sample obtained from tank represented the lowest value. In addition to that, the TDS values of samples collected from hand pump (29.6 mg/l) and tank (33.85 mg/l) were not significantly (P>0.05) different from each other but slightly different from well sample (75.4 mg/l), (table 3.1).
### TABLE (3.1): Physical properties of water samples collected from Elselim agricultural scheme.

<table>
<thead>
<tr>
<th>Source of Sample</th>
<th>Parameters means value ± standard err</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PH</td>
</tr>
<tr>
<td>Hand pump</td>
<td>7.8 ± 1.0&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Nile</td>
<td>7.9 ± 0.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Tank</td>
<td>7.6 ± 0.08&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Well</td>
<td>7.5 ± 0.05&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values with different subscripts a,b,c,d,e,f,g & h in the same raw are significantly different (P= 0.05).

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC</td>
<td>Electric conductivity</td>
</tr>
<tr>
<td>TDS</td>
<td>Total dissolved solids</td>
</tr>
<tr>
<td>TSS</td>
<td>Total suspended solids</td>
</tr>
</tbody>
</table>
As explained in table 3.2 the results of the chemical contaminants include ammonia, nitrate, nitrite, hardness, sulphate, chloride, potassium, sodium, magnesium and calcium.

Ammonia content in the collected water samples was ranged from 0.02 to 0.09 mg/l. The highest value was that of well and tank samples while the lowest value was that of hand pump and the river Nile samples.

The amount of nitrate in the collected samples was graded from 7.02 to 1.24 mg/l. the sample collected from the river Nile represented the highest value and the sample obtained from the tank was the lowest one.

The value of NO₃ recorded from sample collected from the river Nile (7.02 mg/l) was significantly (P<0.05) the highest while the value of the sample collected from the tank (1.24 mg/l) was the lowest.

Nitrite (NO₂) values ranged from 0.8 to 0.0 mg/l. The sample obtained from hand pump was significantly (P<0.05) the highest, on the other hand the values of the samples obtained from well (0.1 mg/l), river Nile (0.1 mg/l) and tank (0.0 mg/l) were not significantly (P≥0.05) different from each other.

As shown in table 3.2 the hardness of the collected samples fluctuated between 100 and 800 mg/l. the sample obtained from well recorded the highest value and the sample obtained from the Nile recorded the lowest value. Nevertheless among all sample there were no significant (P=0.05) difference.

Also the amount of sulphate (SO₄) was graded from 3.5 mg/l that had been observed in tank sample until 68.75 mg/l that had been observed in well sample, no significant (P≥0.05) difference among the values was found.

Potassium (K) concentration in the collected water samples ranged between 7.70 mg/l recorded in the river Nile sample to 3.70 mg/l found
in the tank sample. Regarding to the all estimated values, there were no significant (P=0.05) differences between the samples.

Chloride fell under the rate of 4.00 and 28.00 mg/l. the lowest value was recorded from well and the highest value was recorded from hand pump. The sample of hand pump was considered as significantly (P<0.05) the highest, (table 3.2).

The amount of sodium measured in the collected samples ranged from 0.1 to 0.0 mg/l. the sample obtained from the river Nile (0.11 mg/l) was significantly (P<0.05) the highest.

The recorded values of Magnesium ranged from 19.02 to 9.02 mg/l. The sample obtained from the well had the highest value and the sample obtained from hand pump was the lowest. All the recorded results were not significantly (P=0.05) different from each other.

The amount of Calcium found in water samples fluctuated between 49.27 to 8.78 mg/l. The highest value was found in the sample collected from well whereas the lowest value was found in the sample collected from the river Nile. All the estimated means were not significantly (P=0.05) different from each other.
## TABLE (3.2): The chemical contaminants (common dissolved solids) of water samples collected from Elselim agricultural scheme.

<table>
<thead>
<tr>
<th>Source of sample</th>
<th>Ammonia mean ± standard err</th>
<th>NO3 ± 1.01</th>
<th>NO2 ± 0.2</th>
<th>HA ± 44.29</th>
<th>SO4 ± 3.56</th>
<th>Cl ± 1.59</th>
<th>K ± 0.006</th>
<th>Na ± 0.004</th>
<th>Mg ± 6.77</th>
<th>Ca ± 20.91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand pump</td>
<td>0.02 ±0.02</td>
<td>3.0</td>
<td>0.8</td>
<td>300</td>
<td>17</td>
<td>28</td>
<td>6.4</td>
<td>9.02</td>
<td>29.50</td>
<td></td>
</tr>
<tr>
<td>Nile</td>
<td>0.04 ± 0.02</td>
<td>7.02</td>
<td>0.1</td>
<td>100</td>
<td>30.50</td>
<td>10</td>
<td>7.70</td>
<td>9.35</td>
<td>8.78</td>
<td></td>
</tr>
<tr>
<td>Tank</td>
<td>0.09±0.02</td>
<td>1.24</td>
<td>0.0</td>
<td>550</td>
<td>3.50</td>
<td>8</td>
<td>3.70</td>
<td>12.26</td>
<td>21.27</td>
<td></td>
</tr>
<tr>
<td>Well</td>
<td>0.09±0.018*</td>
<td>3.64</td>
<td>0.1</td>
<td>800</td>
<td>68.75</td>
<td>4</td>
<td>4.25</td>
<td>19.02</td>
<td>49.27</td>
<td></td>
</tr>
</tbody>
</table>

Values with different subscripts a,b,c,d,e,f,g & h in the same row are significantly different (P= 0.05).

\[ \text{NO}_3 = \text{Nitrate} \quad \text{K} = \text{Potassium} \]
\[ \text{NO}_2 = \text{Nitrite} \quad \text{Na} = \text{Sodium} \]
\[ \text{HA} = \text{Hardness} \quad \text{Mg} = \text{Magnesium} \]
\[ \text{SO}_4 = \text{Sulfate} \quad \text{Ca} = \text{Calcium} \]
\[ \text{Cl} = \text{Chlorine} \]
TABLE (3.3): The chemical contaminants: microelements - metals of water samples collected from Elselim agricultural scheme (mg\L).

<table>
<thead>
<tr>
<th>Source of sample</th>
<th>Zn</th>
<th>Cu</th>
<th>Mn</th>
<th>Fe</th>
<th>Pb</th>
<th>Co</th>
<th>Se</th>
<th>As</th>
<th>Ni</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand pump</td>
<td>0.003(^b) ± 0.0003</td>
<td>0.0a ± 0.001</td>
<td>0.0002(^a) ± 0.08</td>
<td>0.001(^b) ± 0.08</td>
<td>00008(^a) ± 0.0001</td>
<td>0.0 a ± 0.0001</td>
<td>0.0006(^ab) ± 0.0003</td>
<td>0.01(^a) ± 0.002</td>
<td>0.001(^ab) ± 0.0007</td>
<td>0.01(^a) ± 0.21</td>
</tr>
<tr>
<td>Nile</td>
<td>0.01(^a) ± 0.0003</td>
<td>0.0005(^a) ± 0.0001</td>
<td>0.001(^a) ± 0.08</td>
<td>0.3(^a) ± 0.08</td>
<td>0.0001(^a) ± 0.0001</td>
<td>0.0 a± 0.0001</td>
<td>0.0008(^ab) ± 0.0003</td>
<td>0.1(^a) ± 0.02</td>
<td>0.003(^a) ± 0.0007</td>
<td>0.2(^a) ± 0.21</td>
</tr>
<tr>
<td>Tank</td>
<td>0.0006(^c) ± 0.0002</td>
<td>0.0001(^a) ± 0.0001</td>
<td>0.2(^a) ± 0.05</td>
<td>0.02(^ab) ± 0.06</td>
<td>0.0001(^a) ± 0.0001</td>
<td>0.003(^a) ± 0.00001</td>
<td>0.0003(^a) ± 0.0002</td>
<td>0.0 (\text{l})a± 0.001</td>
<td>0.00005 (\text{b}) ± 0.0005</td>
<td>0.4(^a) ± 0.5</td>
</tr>
<tr>
<td>Well</td>
<td>0.0003(^c) ± 0.0001</td>
<td>0.0001(^a) ± 0.00009</td>
<td>0.2(^a) ± 0.4</td>
<td>0.08(^b) ± 0.04</td>
<td>0.003(^a) ± 0.00009</td>
<td>0.00004(^a) ± 0.00009</td>
<td>0.0004(^b) ± 0.0001</td>
<td>0.008(^a) ± 0.001</td>
<td>0.001(^a) ± 0.0003</td>
<td>0.31(^a) ± 0.11</td>
</tr>
</tbody>
</table>

Values with different subscripts \(\text{a,b,c,d,e,f,g & h}\) in the same row are significantly different \((P = 0.05)\).

\(\text{Zn} = \) Zinc \hspace{1cm} \(\text{Co} = \) Cobalt
\(\text{Cu} = \) Copper \hspace{1cm} \(\text{Se} = \) Selenium
\(\text{Mn} = \) Manganese \hspace{1cm} \(\text{As} = \) Arsenic
\(\text{Fe} = \) Iron \hspace{1cm} \(\text{Ni} = \) Nickel
\(\text{Pb} = \) Lead
\(\text{F} = \) Floride
As expressed in table 3.3 Zinc (Zn) content ranged from 0.01 to 0.0003 mg/l. the highest value of Zn was found in the sample obtained from the river Nile and the lowest value found in the sample collected from well. Besides that, the Zn value of the river Nile was significantly (P≤0.05) the highest.

Copper content in the collected samples was ranged from 0.0 to 0.0005 mg/l. the highest value was that of the river Nile and the lowest value was that of hand pump. Among the different means there were no significant (P≤0.05) differences.

Manganese (Mn) content in the evaluated samples in table 3.3 fluctuated between 0.2 and 0.0002 mg/l. The highest amount of Mn was found in the sample that was collected from well, the lowest value was found in the sample collected from hand pump. No significant (P=0.05) difference was found among all value.

The Iron concentration in water samples ranged from 0.3 to 0.001 mg/l. the highest value was that of river Nile, where the lowest value was that of hand pump. The sample obtained from the Nile was significantly (P≤0.05) the highest.

The maximum value of lead (Pb) in the collected samples 0.003 mg/l was found in well and the minimum value 0.00008 mg/l was found in hand pump. All the values were not significantly (P≥0.05) different.

As presented in table 3.3, the maximum limit of lead (Pb) in the collected samples 0.003 mg/l was found in the sample collected from well and the minimum value 0.00008 mg/l was found in the sample collected from hand pump. All the values were not significantly (P=0.05) different.

Cobalt (Co) ranged from 0.0003 to 0.0000 mg/l, the amount of Co that found in tank sample was 0.0003 mg/l and 0.00004 mg/l was found in
Well sample, on the other hand the values of Co estimated in the river Nile was 0.0000 mg/l. Although among the means there was no significant (P=0.05) difference.

The concentration of Selenium (table 3.3) in the collected water samples fell under the rate 0.001 as the highest value of tank and 0.0004 mg/l as the lowest value of well. Whereas the value of the sample obtained from the tank sample was significantly (P \leq 0.05) the highest and well sample was significantly (P \leq 0.05) the lowest. The values of Se measured in Hand pump 0.0006 and river Nile 0.0008 were not significantly (P>0.05) different from each other.

Arsenic values ranged from 0.1 mg/l found in the sample obtained from river Nile and 0.0 mg/l found in the sample obtained from tank. The values 0.01 mg/l and 0.008 mg/l were recorded from Hand pump and well respectively. All means were not significantly (P=0.05) different.

Nickel values fluctuated between 0.003 mg/l in the river Nile sample and 0.00005 mg/l in the tank sample. The sample of the river Nile was significantly (P \leq 0.05) the highest, while the ample from tank was significantly the lowest.

All estimated values of fluoride in the water samples ranged between 0.40 to 0.01 mg/l. the highest value was recorded for tank while the lowest value was recorded for hand pump. There were no significant (P=0.05) differences among the values, table 3.3.

3.2 Legumes

All legumes seeds: *Vicia faba, Cajanus cajan, Vigna unguiculata, Pisum sativum, Lathyrus sativus, Lablab purpureus, Cicer arietinum* and *Phaseolus vulgaris* their results shown in table 3.4 and 3.5. The results revealed that the mineral Selenium was not detected (Table 3.5). On the other hands Potassium constitute was the highest amount compared to
other minerals where the values ranged from 2100 mg/100g found in *Phaseolus vulgaris* to 971.6 mg/100g found in *Pisum stivum. Phaseolus vulgaris* was found to be significantly (*P*≤0.05) the highest in Potassium content (Table 3.4).

As illustrated in table 3.5 the concentration of Copper (Cu) in the samples ranged between 1.69 mg/100g in *Lablab purpureus* or lablab beans to 0.60 mg/100g in *Vicia faba. Lablab purpureus* and *Vigna unguiculata* 1.47 mg/100g were significant (P≤0.05) the highest in Cu. *Vicia faba* 5.84 mg/100g was found to be containing the highest value of zinc unlike *Lathyrus sativus* 1.00 mg/100g which has the lowest value. All values were significantly (P≤0.05) different from each other except *Cajanus cajan* 2.90 mg/100g and *Cicer arietinum* 2.78 mg/100g, table 3.5.

(Table 3.5) despite the evaluated sample were not rich in Manganese, *Cicer arietinum* 2.61 mg/100g recorded maximum value while *Pisum sativum* 0.71 mg/100g recorded the minimum value. All values of Mn content in the entire samples were significantly (P≤0.05) different from each other.

As presented in table 3.5 another essential nutrient Iron fluctuated between 25.68 mg/100g in *Vicia faba* or Faba beans to 6.18 mg/100g in *Lathyrus sativus* or Grasspea. Faba beans was significantly (P≤0.05) the highest value.

As shown in table 3.4, *Vigna unguiculata* 155.02 mg/100g reflected the highest value of Sodium content and *Cajanus cajan* 23.46 mg/100g was the lowest value. *Vigna unguiculata* was also significantly (P≤0.05) the highest.

All pulses rich in the nutrient phosphorus, it ranged from 650.38 mg/100g in *Phaseolus vulgaris* to 63.24 mg/100g in *Cajanus cajan*.
Phaseolus vulgaris was significantly (P≤0.05) the highest value. Cicer arietinum 580.92 mg/100g, Vicia faba 573.10 mg/100g and Vigna unguiculata 552.41 mg/100g were not significantly (P≤0.05) different from each other but noticeably higher than Pisum sativum 83.44 mg/100g, Lathyrus sativus 290.92 mg/100g and Cajanus cajan 63.24 mg/100g.

The values of Calcium (Ca) in table 3.4 were ranged from 188.32 mg/100g as maximum value found in Lathyrus sativus and 100.88 mg/100g found in Cajans cajan as minimum value. All legumes samples were significantly (P≤0.05) different from one to another. Ca was found to be significantly (P≤0.05) the highest in Lathyrus sativus. On the other hand Cajanus cajan was significantly (P≤0.05) the lowest value.

Magnesium content varied from 82.90 to 3.47 mg100g with a minimum value obtained for Lathyrus sativus and maximum one for Cajanus cajan. Cajanus cajan was significantly (P≤0.05) the highest, Lablab purpureus or lablab beans 50.84 mg/100g had slight significant (P≤0.05) different from Pisum sativum 53.00 mg/100g and Vigna unguiculata 47.74 mg/100g (table, 3.4).
TABLE (3.4) Minerals content- Macro nutrients and phytate in pulses seeds (mg/100 g).

<table>
<thead>
<tr>
<th>Pulses Minerals</th>
<th>Vicia faba (Ful masri)</th>
<th>Vigna Unguiculata (Luba helo)</th>
<th>Pisum Sativum (Bisella)</th>
<th>Lathyrus sativus (Orieg)</th>
<th>Lablab Purpureus (Luba afin)</th>
<th>Cicer Areitinum (Humus)</th>
<th>Phaseolus Vulgairs (Fasulia)</th>
<th>Cajanus Cajan (Luba adasi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>108.51 ± 1.28^g</td>
<td>131.63 ± 1.28^c</td>
<td>146.63 ± 1.28^d</td>
<td>188.32 ± 1.28^a</td>
<td>120.73 ± 1.28^f</td>
<td>170.94 ± 1.28^b</td>
<td>157.59 ± 1.28^c</td>
<td>100.88 ± 1.28^h</td>
</tr>
<tr>
<td>Mg</td>
<td>73.76 ± 0.99^b</td>
<td>47.74 ± 0.99^d</td>
<td>53 ± 0.99^e</td>
<td>3.47 ± 0.99^g</td>
<td>50.84 ± 0.99^cd</td>
<td>9.19 ± 0.99^f</td>
<td>23.29 ± 0.99^e</td>
<td>82.90 ± 0.99^h</td>
</tr>
<tr>
<td>Na</td>
<td>35.26 ± 3.73^c</td>
<td>155.02 ± 3.73^a</td>
<td>95.67 ± 3.73^d</td>
<td>97.19 ± 3.73^c</td>
<td>84.13 ± 3.73^d</td>
<td>118.38 ± 3.73^b</td>
<td>104.3 ± 3.73^c</td>
<td>23.46 ± 3.73^i</td>
</tr>
<tr>
<td>K</td>
<td>1418.8 ± 74.42^b</td>
<td>1053 ± 74.42^d</td>
<td>971.58 ± 74.42^c</td>
<td>1092.4 ± 74.42^d</td>
<td>1092.3 ± 74.42^d</td>
<td>1645.8 ± 74.42^b</td>
<td>2100 ± 74.42^a</td>
<td>1349 ± 74.42^c</td>
</tr>
<tr>
<td>P</td>
<td>573.1 ± 16.7^i</td>
<td>552.41 ± 16.7^b</td>
<td>83.44 ± 16.7^d</td>
<td>290.92 ± 16.7^c</td>
<td>602.99 ± 16.7^ab</td>
<td>580.92 ± 16.7^b</td>
<td>650.38 ± 16.7^a</td>
<td>63.24 ± 16.7^d</td>
</tr>
<tr>
<td>Phytate</td>
<td>40.45 ± 1.79^d</td>
<td>68.12 ± 2.54^c</td>
<td>42.58 ± 1.79^d</td>
<td>68.12 ± 1.79^c</td>
<td>144.76 ± 1.79^a</td>
<td>17.03 ± 1.79^c</td>
<td>76.64 ± 1.79^b</td>
<td>63.87 ± 1.79^c</td>
</tr>
</tbody>
</table>

Values with different subscripts a,b,c,d,e,f,g & h in the same row are significantly different (P = 0.05).
<table>
<thead>
<tr>
<th>Pulses Minerals</th>
<th>Vicia faba (Ful masri)</th>
<th>Vigna unguiculata (Luba helo)</th>
<th>Pisum sativum (Bisella)</th>
<th>Lathyrus sativus (Orieg)</th>
<th>Lablab purpureus (Luba afin)</th>
<th>Cicer arietinum (Humus)</th>
<th>Phaseolus vulgaris (Fasulia)</th>
<th>Cajanus cajan (Luba adasi)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cu</strong></td>
<td>0.60±0.10</td>
<td>1.47±0.10</td>
<td>0.91±0.10</td>
<td>0.84±0.10</td>
<td>1.69±0.10</td>
<td>0.93±0.10</td>
<td>1.37±0.10</td>
<td>1.07±0.10</td>
</tr>
<tr>
<td><strong>Zn</strong></td>
<td>5.84±0.06</td>
<td>3.41±0.06</td>
<td>2.52±0.06</td>
<td>1.00±0.06</td>
<td>3.12±0.06</td>
<td>2.78±0.06</td>
<td>4.49±0.06</td>
<td>2.9±0.06</td>
</tr>
<tr>
<td><strong>Mn</strong></td>
<td>1.12±0.01</td>
<td>0.88±0.01</td>
<td>0.71±0.01</td>
<td>0.75±0.01</td>
<td>1.63±0.01</td>
<td>2.61±0.01</td>
<td>1.30±0.01</td>
<td>0.94±0.01</td>
</tr>
<tr>
<td><strong>Fe</strong></td>
<td>25.68±0.19</td>
<td>18.53±0.19</td>
<td>8.14±0.19</td>
<td>6.18±0.19</td>
<td>10.64±0.19</td>
<td>24.17±0.19</td>
<td>18.62±0.19</td>
<td>24.14±0.19</td>
</tr>
<tr>
<td><strong>Co</strong></td>
<td>0.005±0.002</td>
<td>0.005±0.002</td>
<td>0.005±0.002</td>
<td>0.006±0.002</td>
<td>0.03±0.002</td>
<td>0.04±0.002</td>
<td>0.06±0.002</td>
<td>0.03±0.002</td>
</tr>
<tr>
<td><strong>Se</strong></td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
<td>0.00±0.00</td>
</tr>
</tbody>
</table>

Values with different subscripts a,b,c,d,e,f,g & h in the same raw are significantly different (P= 0.05).
Legumes seeds recorded small amount of mineral Cobalt, it actually varied from 0.06 mg/100g as maximum in *Phaseolus vulgaris* to 0.005 mg/100g as minimum value in *Vigna unguiculata, Vicia faba & Pisum sativum*. *Phaseolus vulgaris* was significantly (*P*<0.05) the highest. *Cicer arietinum* 0.04 mg/100g, *Cajanus cajan* 0.03 mg/100g and *Lablab purpureus* 0.03 mg/100g were not significantly (*P*≤0.05) different from each other (Table 3.5).

The results of phytate or phytic acid revealed in table 3.4 showed that the phytic acid content of the legumes varied from 144.76 mg/100g in *Lablab purpureus* or Lablab beans to 17.03 mg/100g in *Cicer arietinum*. Lablab beans was significantly (*P*<0.05) the highest value. *Lathyrus sativus* 68.12 mg/100g, *Vigna unguiculata* 68.12 mg/100g and *Cajanus cajan* 63.87 mg/100g were not significantly (*P*=0.05) different from one to another. *Pisum sativum* 42.58 mg/100g and *Vicia faba* 40.45 mg/100g also were not significantly (*P*≤0.05) different.
Chapter Four

DISCUSSION

Water

The results of the water samples that had been collected from four sources including hand pump, tanks, wells and river Nile are presented in table 3.1 to 3.3. These sources have dual purposes; they are used for drinking and irrigation.

The examination of pH showed that all the pH values of the collected water samples fell within the permissible level of WHO (1993); USEPA (1999) and SSMO (2002). Moreover all the recorded results of the turbidity were accepted by WHO (1993) and SSMO (2002) (5 NTU) except the sample obtained from the well 5.15 NTU which exceeded the standards, and this may perhaps caused by geological reasons.

It was observed that the values of electric conductivity of all water samples when compared to the guidelines of drinking water 350 micro ohms/cm which set by SSMO (2002) and 250 micro ohms/cm of WHO (1993) actually were not exceeding the maximum limit.

The amount of total suspended solids in all samples was neither nil except the sample collected from well, anyway neither USEPA (1999) nor WHO (1993) provide a standard for TSS in drinking water (Table 3.1).

The amount of total dissolve solids in the sample collected from river Nile 155.6 mg/l exceeded the value 150 mg/l that permitted by SSMO (2002) and this considered reasonable because this sample came from raw source where there was no treatment, on the other hand it was found to be within the range 150-500 mg/l that agreed by WHO (1993) and USEPDA (1999), table3.1.

All the samples were within the acceptable level, whereas odour, taste and colour of all samples estimated were accepted.
The concentration of ammonia in water samples was less than the permissible limit 1.5 mg/l that set by SSMO (2002), WHO (1993) and USEPA (1999). Moreover, the amount of NO₃ in all samples was less than accepted level of SSMO (2002), WHO (1993) and USEPA (1999) 45-50 mg/l, table 3.2.

As mentioned in table 3.2 all the values of Nitrite (NO₂) that measured in the samples were within the acceptable level 10 mg/l of WHO (1993); USEPA (1999) as well as SSMO (2002).

The SSMO (2002), WHO (1993) and USEPA (1999) noted that the accepted level of total hardness in drinking water should range from 180-200 mg/l. actually when the amount of water hardness above 180 mg/l then drinking water considered to be hard water. The values of the hardness found in the samples obtained from well 800 mg/l, tank 550 mg/l and hand pump 300 mg/l were all exceeded the standard, based on that they classified as very hard water. However they are not health hazardous except causing scale, reducing the ability of soap to foam and precipitate on the distribution net parts such as pipes fixtures (Herman and Jenning, 1996). On the other hand result of the sample that obtained from the Nile 100 mg/l was less than the accepted level accordingly the type of water considered to be soft (Table 3.2).

All the Sulphate values in table 3.2 were less than the safe limit 250 mg/l of WHO (1993), USEPA (1999) and SSMO (2002). Besides that, the results of Potassium were within the safe limit 20 mg/l of WHO (1993), USEPA (1999) and SSMO (2002).

On the other hand, all the concentrations of Chloride were lower than the maximum permitted level (250 mg/l) agreed by WHO (1998), USEPA (1999) and SSMO (2002), table 3.2.
(Table 3.2) All Sodium values in the collected samples were less than the permissible limit of WHO (1993) and SSMO (2002). Furthermore compared to the national and international drinking water guidelines, Magnesium (Mg) concentration in the investigated water samples was lower than the standard 20 mg/l of WHO (1993), USEPA (1999) and SSMO (2002). In addition to that all the calcium values in water samples were lower than the range 175-200 mg/l that agreed with WHO (1993).

In table (3.3) Zinc content in all samples did not exceed the permissible level 3.5 mg/l level of WHO (1993) and 3.00 mg/l of SSMO (2002). Also Copper content in all samples was lower than the safe rate 2.00 and 1.5 mg/l of WHO (1993) and SSMO (2002).

All the estimated values of Manganese (Mn) content were less than 0.50 mg/l that was suggested by WHO (1993), USEPA (1999) and SSMO (2002).

As demonstrated in table 3.3 the values of Iron in the samples of well and hand pump were less than the maximum limit 0.2 that recorded by WHO (1993) and 0.3 mg/l of SSMO (2002), but the study showed that the amount of this mineral in the sample collected from river Nile 0.3 mg/l exceeded the standard. Usually the existence of Fe in high amounts in drinking water is due to the corrosion of steel and cast iron pipes during distribution of water or even from rainfall; however its excess in this sample may due to the amount of clay that dissolved in the water contain high amounts of Fe. In fact Iron is essential for good health, it helps in transport oxygen in the blood. But excess of iron develop reddish brown stains and may cause the growth of iron bacteria (Florida Department of Health, 2005). Anyway, 1.0 mg/l Fe excess in raw water source does not represent serious threat.
Furthermore, all the recorded concentrations of Lead (Pb) were lower than the recommended limit 0.007 mg/l of the WHO (1993) and SSMO (2002), table 3.3.

Even though the highest value of the Cobalt was 0.0003 mg/l (Table 3.3), the Ministry of Environment of the Government of British Colombia (1981) recommended that the maximum content of Co should not exceed 110 µg/l.

The concentration of Selenium in all samples (Table 3.3) was not exceeding the permissible level of 0.07 of SSMO (2002) and 0.01 mg/l of WHO (1993). Selenium is strengthen the immune system.

Most of the recorded values of Arsenic (As) were lower than the maximum limit 0.007 mg/l that was published by SSMO (2002) and WHO (1993), except the value 0.1mg/l (Table 3.3) that recorded from the sample of the river Nile. Arsenic is very harmful to human, animal and plant at the same level. It causes to human vomiting, diarrhoea, cramps and nausea (UWP, 1999) also the International Agency for Research on Cancer (1987) classified (As) as human carcinogenic.

All the values of Nickel and Flouride in the water samples were less than the maximum limit (0.014 mg/l) and (1.50 mg/l) that was recommended by WHO (1993) and SSMO (2002) respectively, table 3.3.

3.2 Legumes

The chemical examinations of legumes samples in this study showed that the absence of Selenium (Table 3.5) probably due to its deficiency in the soil. While the mineral potassium recorded the highest values compared to other estimated minerals, Siddhuraju et al. (2001) reported that ingestion of high amount of K help people who suffer from hypertension to recover the continuous loss of K due to diuretics usage. The result that found K content in *Pisum sativum* or garden pea 971.58 mg/100g was lower than that
mentioned by Duke and Ayensu (1985) in China. Furthermore, the values of K content in *Lablab purpureus* 1092.3 mg/100g and *Vigna unguiculata* 1053 mg/100g was less than that reported by Arninathan *et al.* (2003).

On the other hand, *Phaseolus vulgaris* 2100 mg/100g was higher than that recorded by Duke (1983) in USA, while *Vicia faba* 1418.8 mg/100g was lower than the result that recorded in the same study. Compared with a study done in Hudieba Agricultural Research Station, Sudan by Abd El Rahman *et al.* (2005), both *Vicia faba* cultivars (Bsabir and Hudieba-73) were lower in K amount. Even the estimated K level in *Cajanus cajan* 1349 mg/100g was higher than immature seed that showed by Duke (1981).

The levels of the elements Copper, Zinc and Manganese that illustrated in table 3.5 were less than the recommended daily allowance for children 2.2, 15 and 5.5 mg respectively which set by ICMR (1992).

Copper content which was estimated in *Lablab purpureus* 1.68 mg/100g was higher than the value showed by Arninathan *et al.* (2003) in South India, there was also a wide difference observed in *Vigna unguiculata* 1.46 mg/100g which was higher in Cu than that found in same study. In study has been made in some East Asian countries by FAO (2003) reported that Cu content in *Cajanus cajan* 1.07 mg/100g, *Phaseolus vulgaris* 1.37 mg/100g and *Pisum sativum* 0.91 mg/100g was lower, while it was higher in *Cicer arietinum* 0.93 mg/100g compared with the current study.

Regarding study carried in Ethyiopa by Urga *et al.* (2005) the amount of Cu in *Lathyrus sativus* was similar to the amount 0.83 mg/100g that found in the present study.

Comparing with the results recorded by Arninathan *et al.* (2003), the values of Zn in *Lablab purpureus* 3.12 mg/100g and *Vigna unguiculata* 3.41 mg/100g were lower than that revealed in the current study. According to FAO (2003), Zinc content in *Pisum sativum* 2.52 mg/100g was lower,
where \textit{Phaseolus vulgaris} 4.49 mg/100g was slightly higher than that found in the East Asian countries. Also, based on the same study \textit{Cicer arietinum} 2.78 mg/100g and \textit{Cajanus cajan} 2.90 mg/100g was lower. \textit{Lathyrus sativus} 1.00 g/100g was lower than Urga \textit{et al.} (2005).

Manganese content in \textit{Lablab purpureus} 1.63 mg/100g and \textit{Vigna unguiculata} 0.88 mg/100g were lower in Mn content than that recorded by Arninathan \textit{et al.} (2003). The element Mn which was estimated by FAO (2003) in \textit{Cicer arietinum} 2.61 mg/100g, \textit{Cajanus cajan} 0.94 mg/100g, \textit{Pisum sativum} 0.71 mg/100g and \textit{Phaseolus vulgaris} 1.305 mg/100g were all lower than that recorded in the present study. The values obtained by Urga \textit{et al.} (2005) were higher in Mn than 0.75 mg/100g in \textit{Lathyrus sativus}.

As mentioned in table (3.5), \textit{Vicia faba} 25.68 mg/100g, \textit{Cajanus cajan} 24.14 mg/100g and \textit{Cicer arietinum} 24.17 mg/100g were higher in Iron content than the recommended daily allowance from children approved by ICMR (1992). The level of Fe in \textit{Lablab purpureus} 10.64 mg/100g and \textit{Vigna unguiculata} 18.53 mg/100g were higher than that estimated by Arninathan \textit{et al.} (2003). \textit{Phaseolus vulgaris} 18.62 mg/100g was higher than that reported by Duke (1983), \textit{Cicer arietinum} 24.17 mg/100g was also higher than that recorded by FAO (2003). \textit{Lathyrus sativus} 6.18 mg/100g was almost resembled to the data estimated by Urga \textit{et al.} (2005). \textit{Vicia faba} 25.68 mg/100g was more than that reported by Duke (1983). \textit{Pisum sativum} 8.14 mg/100g mg/100g was higher than that estimated in fresh seed by Duke and Ayensu (1985) in China. The same thing is \textit{Cajanus cajan} 24.14 mg/100g which was more condense in Fe than that showed by Duke (1981).

Sodium content (Table 3.4) in \textit{Vigna unguiculata} 155.02 mg/100g was
noticeably higher than that revealed by Arninathan et al. (2003). *Vicia faba* 35.26 mg/100g was much higher that estimated by Duke (1981) in USA, while in other study in Sudan *Vicia faba* was higher than the cultivar Hudieba-72 and lower than cultivar Basabir that evaluated by Abdel Al Rahman et al. (2005). Referring to the same study Na concentration in three different *Phaseolus vulgaris* or white beans cultivars serage, Giza-3 and RO21 were all lower than 104.3 mg/100g that estimated with the current study. Moreover, Na content in white beans was also higher than that calculated by Duke (1983). In *Pisum sativum* 95.67 mg/100g Na was more than that recorded by Duke and Ayensu (1985). The level of Na in *Lablab purpureus* or lablab beans 84.13 mg/100g was higher than that found by Arninathan et al. (2003).

*Phaseolus vulgaris* 650.38 mg/100g was much higher in Phosphorus content than that reported by Duke (1983) in USA. Moreover, P is higher than the results obtained by Abd Al Rahman et al. (2005). P in *Cajans cajan* 63.24 mg/100g was lower than that shown by Duke (1981). Lablab beans 602.99 mg/100g and *Vigna unguiculata* 552.41 mg/100g were observed to contain high P content than that reported by Arninathan et al. (2003). *Cicer arietinum* 580.92 mg/100g content of P was beyond the range that estimated by Duke (1984). In *Vicia faba* the result of the present study was higher than that evaluated by Duke (1981), *Pisum sativum* was lower than that recorded by Duke and Ayensu (1985), while P content in *Lathyrus sativus* 290.92 mg/100g was so close to the records collected from North Wollo- Ethiopia by Urga et al. (2005), table 3.4.

The amount of Calcium showed in table 3.4 in *Pisum sativum* 146.63 mg/100g and *Lathyrus sativus* 188 mg/100g were much higher than that showed by Duke and Ayensu (1985) and Urga et al. (2005) respectively,
whereas *Cajanus cajan* 100.88 mg/100g was higher than the value that recorded by Duke (1981). The results of Ca content in *Lablab purpurus* 120.73 mg/100g and *Vigna unguiculata* 131.63 mg/100g that concluded by Arninathan *et al.* (2003) were higher compared to the present study. *Phaseolus vulgaris* 157.59 mg/100g was higher than that evaluated by Duke (1983). The value of Ca in *Cicer arietinum* 170.94 mg/100g was close to the result that obtained by Duke (1981). Based on the results of the same study Ca content in *Vicia faba* 108.51 mg/100g was higher than the contemporary study.

The value of Magnesium content in *Lablab purpureus* 50.84 mg/100g was lower than the result recorded by Arninathan *et al.* (2003) while *Vigna unguiculata* 47.74 mg/100g was higher. The recorded results of *Pisum sativum* 53.00 mg/100g was higher than that measured by Duke and Agensu (1983). On the other hand *Lathyrus sativus* 3.46 mg/100g was lower than found by Urga *et al.* (2005) Also *Cajanus cajan* 82.90 mg/100g was higher than the value shown by FAO (2003). According to the results obtained by Abd Al Rahman *et al.* (2005) *Vicia faba* 73.76 mg/100g and *Phaseolus vulgaris* 23.29 mg/100g were lower in Mg content, table 3.4.

Compared with FAO (2003), Cobalt content in *Vigna unguiculata* 0.005 mg/100g was lower while *Cicer arietinum* 0.04 mg/100g *Phaseolus vulgaris* 0.06 mg/100g, *Cajanus cajan* 0.03 mg/100g, *Lablab purpureus* 0.03 mg/100g and *Pisum sativum* 0.005 mg/100g were found to be higher in Co content than that in this study.

The values of phytate content in *Vicia faba* 40.45 mg/100g and *Phaseolus vulgaris* 76.64 mg/100g were lower than those reported by Abd Al Rahman *et al.* (2005). *Cicer arietinum* or chickpea 17.03 mg/100g and pigeon pea 63.87 mg/100g were lower than the results recorded by Chitra *et al.* (1995).
Also chickpea was lower than the range estimated by Subagio (2006). *Vigna unguiculata* or cowpea 68.12 mg/100g was also higher than the range recorded by Towo et al. (2003). *Pisum sativum* or garden pea 42.58 mg/100g was also so higher than the average shown by Idvig and Asztity (2002). *Lathyrus sativus* 68.12 mg/100g was lower than the values obtained by Urga et al. (2005).
Chapter Five
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

- Based on the results of the physical and chemical investigations, most of water samples were completely safe for human consumption where the contaminants values were low and similar to the values as recommended by SSMO (2002) and WHO (1993), with few exceptions:

a) The concentration of Arsenic 0.1 mg/l recorded from the sample of the river Nile was significantly ($P \leq 0.05$) higher than the daily allowance limit 0.007 mg/l of WHO (1993).

b) Also the turbidity recorded from the sample of the well 5.15 NTU was significantly ($P < 0.05$) higher than the maximum limit 5.00 NTU approved by SSMO (2002) and WHO (1993).

c) Total hardness of the water samples collected from hand pumps 300 mg/l, tanks 550mg/l & wells 800 mg/l exceeded the permissible limit 200 mg/l announced by SSMO (2002) and WHO (1993), in this case water considered very hard.

d) The total dissolved solids calculated in the sample of river Nile 155.6 mg/l did not match with the maximum limit 150 mg/l of WHO (1993) and SSMO (2002).

e) The concentration of Iron was significantly ($P < 0.05$) the highest in the sample of river Nile 0.3 mg/l and higher than the recommended amount 0.2 mg/l of WHO (1993) and SSMO (2002).

- The pH, odour, taste, electric conductivity, total suspended solids, nitrate, nitrite, sulfate, chlorine, potassium, sodium, magnesium,
calcium, fluoride, zinc, copper, manganese, lead, cobalt, selenium and nickel were within the admissible level of (WHO, 1993).

- All legume samples were rich in potassium and deficient in Selenium.

- Faba beans and pigeon pea were significantly (P<0.05) rich in Iron compared to the other estimated legumes.

- All legume seeds were significantly (P<0.05) rich in Zn than Mn.

- White beans and lablab beans were significantly rich in phosphorus.

- All seeds were significantly (P<0.05) rich in Zn rather than Mn.

- Moreover cow pea and chickpea were containing significantly (P<0.05) high concentration of Sodium compared to the other legumes.

- The study found that, grasspea contained significantly(P<0.05) the highest amount of Calcium and the lowest amount of Magnesium. On the other hand Pigeon pea contain the lowest amount of Calcium while and the highest amount of Magnesium.

- Lablab beans contained significantly the highest (P<0.05) amount of phytic acid and chickpea had the lowest content.

5.2 Recommendations

- Microbiological estimation should be carried out in the study area to assess the bacterial contamination.

- Further investigations supposed to be oriented in that area to explore the excess of mineral Arsenic in the river Nile.

- Selenium supplementation needed be added to the soil to recover the shortage.

- Further studies with larger samples are needed to assess the nutrients profile as well as the anti-nutritional substances of the legumes in this area.
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Appendix

*Estimation of water Turbidity:*

The nephelometric method actually based on a comparison between the intensity of light scattered by the sample in certain circumstances and the intensity of light scattered by standard reference suspension under the same circumstances.

*Estimation of Total Suspended Solids*

The total suspended solids apply to the dry weight of the material that is removed from a measured quantity of water sample by filtration through a standard filter.

*Phytic Acid determination*

Two grams of the sample were weighed in conical flask, then 50 ml of 3% TCA (trichloro acetic acid) were added to extract the sample. After shaking for 3 hours, the suspension was centrifuged (5 minutes at 2500 rpm). Ten ml of supernatant were poured in 40 ml tube. Four ml FeCl₃ solution which contained 2 mg Fe³⁺/ml 3% TCA were added. The tube was transferred to boiling water bath for 45 minutes. Two drops of the solution (3% Na₂SO₄ in 3% TCA) were added to develop precipitate. Then the tube was cooled and centrifuged for 10 – 15 min at 2500 rpm. The clear supernatant was discharged while the precipitate was washed twice with water and was dispersed in few ml of water. Then three ml of 1.5 N NaOH were added and the volume completed to 30 ml with water. The tube was moved to boiling water bath for 30 min, and then hot filtered by using filter paper Whatman No. 1. The precipitate was washed 60-70 ml hot water and the washings were poured.
The precipitate was dissolved from the filter paper with 40 ml hot 3.2 N HNO₃ into 100 ml volumetric flask and the paper was washed with water over again in the same flask and completed to volume with distilled water. Then 0.5 ml of the suspension was transferred into 10 ml volumetric flask. Two ml of 1.5 NKSCN were added and the volume completed with distilled water, and then the absorbance was measured immediately by using spectrophotometer – DR3 at 480 nm.

A standard curve of different Fe (NO₃)₃ concentrations was calculated from the ferric ion concentration assuming 4:6 iron to phosphorus molar ratio.

<table>
<thead>
<tr>
<th>MI standard</th>
<th>Fe +3 conc.ppm</th>
<th>A (optical density)</th>
<th>K = Conc/A</th>
</tr>
</thead>
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<tr>
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</tr>
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</tr>
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<td>4.0019</td>
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</tr>
<tr>
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<td>5.001</td>
<td>0.46</td>
<td>2.17</td>
</tr>
</tbody>
</table>

Mean K= 5.004

**Calculations**

Phytic Acid mg/ 100g = \( \frac{6}{4} \times A \times \text{mean} \times K \times 20 \times 10 \times 50 \times \frac{100}{1000 \times 2} \)