The investigation of iron and mineral deficiency associated with the practice of geophagia

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Table of contents

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

APPENDICES

DECLARATION OF INDEPENDENT WORK

I, MARI VAN WYK, do hereby declare that this research project submitted for the degree MAGISTER TECHNOLOGIAE: BIOMEDICAL TECHNOLOGY in the SCHOOL OF HEALTH TECHNOLOGY at the CENTRAL UNIVERSITY OF

TECHNOLOGY, FREE STATE, is my own independent work that has not been submitted before, to any institution by me or anyone else as part of any qualification.

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Signature of student Date

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Iron and mineral deficiency associated with the practice of geophagia

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Abstract

Introduction: Geophagia, a subcategory of pica, is the practice of persistently and deliberately eating earthy or soil like substances. A definite cause for the practice of geophagia is yet to be established, but some theories claim that the soil holds nutritional value to the geophagist.
Method: Geophagic woman in the QwaQwa area between the ages of 18 and 45 years were identified by means of a questionnaire. A test group, consisting of 48 women in the habit of consuming soil, and a control group, consisting of 35 non geophagous women, were identified. Subjects in the control group were chosen from the same household or in the same area as the test subjects. On each subject, of both the test group and the control group, the following tests were done: total serum iron, transferrin, ferritin, calcium, magnesium, phosphate and albumin. The results obtained were statistically analysed and compared. Biochemical results were compared with haematology results obtained by another researcher, using the same test group and control group subjects.
Results: In the test group, 75% of the individuals had results indicative of iron deficiency, compared to only 26% in the control group. The haematology results also indicate anaemia in the test group, most probably brought on by iron deficiency. There was no significant difference in mineral results between the test- and control group. Thus no association could be established between soil consumption and mineral status.
Conclusion: In relation to non-geophagous women, people who consume soil have a tendency toward iron deficiency. It is impossible to ascertain whether the iron deficiency caused the craving for soil, or whether the consumption of soil caused the iron deficiency. No definite association could be made between soil consumption and mineral status.

Keywords: Geophagia, iron deficiency, minerals, pica, soil consumption, bio-available nutrients, soil, anaemia, pica

SUMMARY

Geophagia, a subcategory of pica, is the habit of deliberately eating earthy or soil like substances. Geophagia has been practiced since ancient times. Habits and conditions

suggestive of geophagia have been described by Greek and Roman textbooks, as well as by philosophers and travellers since the 18th century.

Although geophagia is a worldwide occurrence, there is a certain demographic in which the practice occurs more frequently. The practice of geophagia is seen more commonly among pregnant women and children. Geophagia is also more commonly seen in poverty stricken communities. The practice of geophagia has also been seen among people with learning disability, especially in the institutional environment, and those with a family history of pica.

Soil can be eaten directly from the ground, or it can be prepared for consumption. Soil can be prepared for consumption in the form of lozenges or tablets. It can be mixed with herbs or other foodstuffs, or it can be baked over a fire or in the sun. Some people make a paste with the soil and drink it or pour it over food.

Some people believe geophagia is a cultural or religious activity. Some people consider geophagia psychological disorder. Soil is consumed during pregnancy, for all the supposed benefits it holds for both the mother and the developing foetus. Soil is believed to have healing capabilities, and as such is considered for its medicinal value. Some researchers believe soil is consumed out of hunger as a replacement for food. Soil contains nutrients, and some researchers believe these nutrients may benefit the consumer. The question of whether the soil removes of supplements nutrients in the consumer still needs to be answered. The aim of this study was to determine whether there is an association between the consumption of soil and iron and mineral deficiency.

The study population was chosen from the QwaQwa area. Individuals were identified by means of a questionnaire. Individuals who complied with the inclusion and exclusion criteria were identified as the test group, individuals consuming soil, and the control group, individuals not consuming soil. The test group included 48 individuals, and the control group included 35 individuals. Blood was collected from each individual and tests done to asses iron and mineral status. The results of the test group and control group were compared.

In the test group 71% of the subjects had low ferritin results, compared to only 34% of subjects in the control group. Ferritin is considered a sensitive marker for iron deficiency, and therefore iron deficiency in most subjects of the test group was a strong possibility. In the test group 71% of the subjects had low iron levels and only 25% of the subjects in the control group had low iron levels. The mean transferrin of both the test group and the control group was within the normal range (2.0 – 3.6 g/L), however, the mean of the transferrin in the test group was higher, which indicates decreased iron status. The transferrin saturation of 85% of the subjects in the test group was decreased, and only 37% of the subjects in the control group had transferrin saturation levels below the normal range (15 – 50%). The p-values ($p<0.001$) indicate that the differences of parameters related to iron status between the test group and the control group were statistically significant.

The biochemical results showed that, in comparison to non-geophagous individuals, people who consume soil have a tendency towards iron deficiency, as 75% of the subjects in the test group had iron deficiency, compared to only 26% of subjects in the control group. The occurrence and severity of the iron deficiency did not seem to be related to the amount of soil consumed.

The haematology results revealed possible anaemia in the test group, as the mean Hb was below the normal range. The low mean values of the MCV, MCH and MCHC in the test group indicated that there was a tendency towards a hypochromic microcytic anaemia, which is typical in anaemia brought on by iron deficiency. All the results support the theory that geophagous individuals, in comparison to non-geophagous individuals, suffer from iron deficiency anaemia.

The difference in mineral results between the test group and the control group had some statistical significance, but the difference in the results held no clinical significance whatsoever.

In conclusion: when compared to non-geophagous individuals, people who consume soil have iron deficiency. No definite association could be established between mineral status and geophagia.

LIST OF FIGURES **Page**

LIST OF TABLES

ABBREVIATIONS

AD	Anno Domini
Alb	Albumin
ATP	Adenosine triphosphate
BC	Before Christ
BhCG	Beta-human chorionic gonadotropin
BMI	Body Mass Index

Ca	Calcium
C.Ca	Corrected Calcium
CRP	C-Reactive Protein
cm	Centimetre
DNA	Deoxyribonucleic Acid
EDTA	Ethylenediaminetetraacetic acid
e.g.	*exempli gratia* (for example)
ESR	Erythrocyte Sedimentation Rate
et al	*et alii* (and others)
FBC	Full Blood Count
Fe	Iron
Fe^{2+}	Ferrous iron
Fe^{3+}	Ferric iron
Ferr	Ferritin
g	Gram
Hb	Haemoglobin
hCG	Human Chorionic Gonadotropin
HCT	Haematocrit
i.e.	*id est* (that is)
ISE	Ion selective electrode
Kg	Kilogram
m	meter
Max	Maximum

MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Corpuscular Haemoglobin Concentration
MCV	Mean Corpuscular Volume
Mg	Magnesium
Min	Minimum
n	Number
NHLS	National Health Laboratory Service
nm	Nanometer
PBET	Physiologically based extraction test
PCT	Procalcitonin
PO_4	Phosphate
RBC	Red Blood Count
RNA	Ribonucleic Acid
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
SD	Standard Deviation
TIBC	Total Iron Binding Capacity
Tfn	Transferrin
Tfn sat	Transferrin saturation
USA	United States of America
WCC	White cell count

CHAPTER 1

INTRODUCTION

Geophagia is the practice of eating earthy or soil-like substances. Whether it holds nutritional benefits is still under debate. Some scientists believe that it is harmful, whereas others are of the opinion that since it is practiced by both humans and animals alike, there may be some nutritional benefits (Brown 2002; Hunter 2003; Hooda, Henry, Seyoum, Armstrong & Fowler 2004; Tayie 2004; Stiegler 2005; Gonyea 2007; Rosenberg 2009; Starks & Slabach 2012). The practice of geophagia in humans is most often seen in rural societies among all sexes, races and ages, but it is more prominent among children and pregnant woman (Abrahams 2002; Hooda *et al*. 2004; Gonyea 2007). Some people assume that the mineral contents in the soil might be available for absorption, regardless of the evidence that the absorption of minerals such as iron, zinc and copper may actually be reduced by the practice of geophagia (Hooda *et al*. 2004). It is due to this belief that minerals are available for absorption, that geophagia is not discouraged in under-privileged communities (Hooda *et al*. 2004).

Various theories exist as to the exact cause of geophagia and, although research has been conducted to prove or disprove the different theories, it seems that the precise answer still evades the researchers. Some literature alleges that geophagia results from nutrient deficiency (Young, Wilson, Miller & Hiller 2008), whereas others are of the opinion that it is merely a force of habit that has been passed on from generation to generation (Gonyea 2007). Another theory argues that geophagia is practiced as a result of poverty; people are eating soil out of hunger (Woywodt & Kiss 2002). Some people eat soil merely because they enjoy the taste (Yount 2005).

Although soil-eating may commence for its nutritional benefits, the health risk it imposes must also be considered. Soil is filled with parasite eggs from animal faeces that may or may not be transferred to humans. The compact texture of soil may cause intestinal obstruction and the coarseness of the soil may damage tooth enamel (Tayie 2004; Yount 2005; Ghorbani 2008). Other reasons to consume soil, given by geophagous women, include that it helps to counter symptoms of diarrhoea and heartburn, thus it can be concluded that they consume soil for the medicinal value ascribed to it (Tayie 2004; Gonyea 2007; Ghorbani 2008).

Geophagia has been linked to various mineral deficiencies, especially iron deficiency. The difficulty lies in determining whether the deficiency causes the practice or is a consequence of geophagia (Woywodt & Kiss 2002; Nchito, Geissler, Mubila, Friis & Olsen 2004). Stiegler (2005) describes the question of geophagia causing anaemia or anaemia causing geophagia as the "chicken or egg dilemma". He presents the uncertainty that exists regarding whether anaemia leads to a craving for soil or whether the consumption interferes with mineral metabolism, leading to the deficiency.

1.1 Problem statement

Ingested soil can affect the balance of nutrients in the individual (Abrahams, 2002). Hooda *et al*. (2004) concluded that soil removes calcium and magnesium, instead of supplementing it, and causes deficiency, especially in iron. Dreyer, Chausev & Gledhill (2004) also reported that soil consumption can cause iron deficiency by absorbing bio-available iron, but in contrast, they reported that soil actually liberates calcium and magnesium. Various other studies are related to soil ingestion and the effect it has on iron metabolism; whether ingested soil absorbs or liberates iron. Very little information is available on the effect of soil on phosphate in the human body(Tayie 2004; Yount 2005; Ghorbani 2008). A definite relation between the practice of geophagia and iron and mineral deficiency needs to be established, to help answer the question of whether there might be a nutritional advantage to the practice of geophagia, or whether it is just an adaptive behaviour.

1.2 Aim

The aim of this study is to determine the association between iron and mineral deficiency and the practice of geophagia.

1.3 Structure of dissertation

- The literature study will shed light on the background of geophagia, soil and soil consumers' views and opinions. Previous studies on the subject and outcomes of these studies will be discussed and compared
- The methodology will follow, with a detailed description of the methods and steps followed to obtain the results
- The results obtained will be included as well as a discussion of the results and how they compare with similar studies
- The dissertation will end with a concise conclusion of the results and whether they meet the goal set by the aim of the study

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Geophagia is a complex term. To fully comprehend what geophagia is, it is important to not only know the simple definition of geophagia, but also to be introduced to the history of geophagia. Although geophagia is not as isolated as people might assume, there are still certain people who are more prone to the practice of geophagia.

Various reasons are cited for why people consume soil, and how they consume soil. Minerals known to be present in soil need to be mentioned, seeing as a popular reason for consuming soil is that it contains minerals. The association between these minerals in the soil and the minerals of significance in the human body is outlined. Not all researchers are convinced that soil consumption is advantageous to the consumer. There are certain disadvantages that various researchers agree on.

Since geophagists use colour to describe soil, background on how this method is standardised and interpreted is needed and thus included as an afterthought.

2.2 Definition of geophagia

Geophagia is regarded as a subcategory of pica. Pica is defined as the persistent, deliberate, consumption of non-nutritive materials that are potentially harmful to development (Reilly & Henry 2000; Bartas & Ekman 2001; Woywodt & Kiss 2002; Wilson 2003; Yount 2005; Abrahams, Follensbee, Hunt, Smith & Wragg 2006; Gonyea 2007; Starks & Slabach 2012). Stiegler (2005) defines pica in a similar way, using guidelines set by the American Psychiatric Association. Various forms of pica exist: eating ice is termed pagophagia, amylophagia is the consumption of laundry starch and eating clay is also termed geophagia (Brown 2002: 10; Tayie 2004; Trivedi, Daga & Yeolekar 2005). Geophagia is the habit, or uncontrollable urge, to eat clay or earth (Abrahams *et al.* 2006; Ghorbani 2008). Geophagia is not a custom that is culturally approved of and requires intervention (Woywodt & Kiss 2002; Yount 2005).

2.3 Epidemiology

2.3.1 History of geophagia

Soil consumption dates back to as far as 40 BC and 1000 AD (Ghorbani 2008). Geophagia dates back as far as ancient times, as Greek and Roman textbooks describe conditions and habits suggestive of geophagia (Woywodt & Kiss 2002). The practice of geophagia has been mentioned by various philosophers and written about by travellers since the 18th and early 20th century (Tayie 2004; Ghorbani 2008).

2.3.2 Geophagia demographic

Abrahams (2002) states that geophagia is a worldwide occurrence. Geophagia is found in all age groups, races, social standings and both sexes, though it is found to be more common among children and pregnant woman (Abrahams, 2002; Hooda *et al.* 2004; Gonyea 2007). Soil consumption commonly occurs in poverty-stricken populations, particularly among children under three years and pregnant women (Ghorbani 2008). In a global study, conducted in 1958, researchers claimed that, in some areas in Africa, adolescent girls start consuming soil at the onset of puberty (Bartas & Ekman 2001). People with mental disability, as well as those with a family history of pica, are at risk of pica (Gonyea 2007). Geophagia has been observed in people with learning disabilities, especially in the institutional environment (Woywodt & Kiss 2002).

2.3.3 Preparation of soil before consumption

Soil can be eaten directly from the ground, or in some situations from more unique sources, such as termite nests or in traditional herbal-soil mixtures (Ghorbani 2008). In parts of Mexico, Belize and other Central American states, clay is consumed by rural inhabitants in the form of specially prepared tablets (Reilly & Henry 2000). Soil can be prepared for human consumption in the form of small lozenges or rolls, which are sold in local markets in Ghana, Uganda, Tanzania and Zambia (Reilly & Henry 2000). Soil can be mixed with herbs and other plant material or with flour or other foodstuffs before consumption. Soil can be baked over a fire or in the sun after it has been shaped into small cakes. Another method of preparing soil is to make a paste using water and then drinking it or pouring it over food (Reilly & Henry, 2000). Some people claim that the soil tastes better cold, thus it is kept in the fridge (Brown 2002: 10).

2.4 Reasons for consuming soil

2.4.1 Culture/Religion

Geophagia is a traditional cultural activity practiced at religious ceremonies (Ghorbani 2008; Rosenberg 2009). One of the earlier reasons for consuming soil was the belief in its religious and magical powers (Abrahams & Parsons 1996; Reilly & Henry 2000). Geophagia is considered a spiritual, ceremonial and traditional cultural activity (Tayie 2004). Geophagia is a cultural activity, possibly passed down from generation to generation (Gonyea 2007). In the study of the evolution of geophagia, it is seen as an adaptive behaviour (Starks & Slabach 2012).

2.4.2 Psychological

Geophagia is considered a psycho-behavioural disorder (Hunter 2003). Psychological upset can motivate the practice of geophagia (Tayie 2004; Gonyea 2007).

2.4.3 Pregnancy

Geophagia is commonly practiced during pregnancy (Yount 2005; Rosenberg 2009). The consumption of soil is believed to have the ability to satisfy cravings of pregnant and lactating women (Reilly & Henry, 2000). In Malawi, consuming soil is believed to confirm pregnancy and not consuming soil during pregnancy is considered strange (Ghorbani 2008). Some societies, such as the Tiv tribe of Nigeria, believe a craving for dirt is a sign of pregnancy (Starks & Slabach 2012). Pregnant women apparently consume soil to ensure a painless birth and dark skin for the child (Bartas & Ekman 2001). Geophagia is considered to counteract pregnancy-related nausea (Wilson 2003; Luoba, Geissler, Estombale, Ouma, Magnusson, Alusala, Ayah, Mwaniki & Friis 2004; Tayie 2004; Ghorbani 2008). Women eat soil before, during and after pregnancy because of their belief in the soil's fertility, and their children are encouraged to eat soil to ensure future fertility (Abrahams & Parsons 1996). In the southern parts of the USA pregnant women consume soil, because they believe it can cure swollen legs, help babies thrive and even ensure beautiful children (Tayie 2004; Ghorbani 2008).

Physiologic changes during pregnancy can lead to the practice of geophagia (Tayie 2004). Soil is consumed by pregnant women as a tonic and as a remedy for indigestion (Abrahams *et al*. 2006). During pregnancy oestrogen and progesterone levels increase; these hormones help modify the immune system to better tolerate the foetal cells that also express paternal antigens (Zen, Ghirardello, Iaccarino, Tonan, Compana, Arienti, Rampudda, Canova & Doria 2010). Geophagia is believed to be an adaptive behaviour that enhances foetal immunity, as well as boosts maternal immunity when pregnancy hormones may suppress the natural immunologic desire of the mother to destroy the foetus (Hunter 2003). Ingestion of soil can have many benefits to the consumer during pregnancy. It has been suggested that, during the first trimester, the soil will absorb some of the dietary toxins that are potentially harmful to the embryo, while simultaneously suppressing common symptoms of pregnancy sickness. In the second trimester the soil functions as a source of mineral nutrients and calcium supplementation which aid in the formation of the foetal skeleton and helps reduce the risk of developing pregnancy hypertension (Selenius, Alloway, Centeno, Finkelman, Fuge, Lindh & Smedley 2005: 452).

2.4.4 Medicinal/Health

Geophagia is associated with medicinal treatment (Tayie 2004; Gonyea 2007; Ghorbani 2008). It is practiced as a remedy for certain diseases (Ghorbani 2008; Rosenberg 2009). The Mesopotamians and ancient Egyptians used clay medicinally as a plaster and a cure for wounds (Starks & Slabach 2012). Bartas & Ekman (2001) described a global study entitled *Geophagic Customs* presented by Anell and Lagerkrants, in which they claimed that geophagia had a variety of functions in Africa, including being a cure to syphilis and diarrhhoea. One of the three major theories to explain the reasons for consuming soil is protection from toxins and pathogens (Young *et al*. 2008; Starks & Slabach 2012). The negatively charged clay molecules can easily bind to positively charged toxins in the stomach and gut, preventing the toxins from being absorbed into the bloodstream (Starks & Slabach 2012). In addition to immunologic benefits, soil consumption may eliminate gastric upsets and detoxify some plant and animal toxins (Brown 2002: 11; Hunter 2003; Wilson 2003; Starks & Slabach 2012). Some of the reasons cited for the practice of geophagia are detoxification of disagreeable compounds present in the diet, alleviation of symptoms of diarrhoea, and lessening of excess acid in the digestive tract (Wilson 2003; Kikouama, Kanon, Katty, Bonnet, Baldé & Yagoubi 2008). In modern medicine, pharmaceutical companies have taken advantage of the binding properties of kaolin to produce Kaopectate, a drug used for the treatment of diarrhoea and other digestive ailments (Starks & Slabach 2012).

2.4.5 Hunger and poverty

A major theory to explain the reason for practicing geophagia, is hunger (Bartas & Ekman 2001, Tayie 2004; Young *et al*. 2008). Although many tangible reasons are given for consuming soil, as mentioned above and below, there are scientists who add hunger to their list of reasons to consume soil. Where poverty or hunger is implicated, soil is consumed to suppress appetite or as a "filler", where it acts as a substitute for food (Reilly & Henry 2000; Woywodt & Kiss 2002; Wilson 2003; Tayie 2004). Poverty, starvation and famine are reasons for consuming soil (Wilson 2003; Ghorbani 2008).

2.4.6 Nutrition

Geophagia is practiced due to a general physiologic need for nutrients (Hunter 2003; Hooda *et al*. 2004; Gonyea 2007; Rosenberg 2009; Starks & Slabach 2012). Although the exact etiology for geophagia is not known, deficiency in iron and zinc has been implicated as causes for pica. Iron deficiency is specifically associated with geophagia (Abrahams 2002; Stiegler 2005; Abrahams *et al*. 2006; Gonyea 2007). Soil consumption may cause iron deficiency by making the element less bio-available, but it is also possible that the anaemia or iron deficiency might cause the craving for soil (Wilson 2003; Nchito *et al*. 2004). Low levels of calcium and iron may cause a craving for chalky substances (Yount 2005). Another one of the three major theories to explain the reasons for consuming soil is micronutrient deficiency. The hypothesis is that people consume soil to increase micronutrient intake, to try and supplement deficiency in iron, zinc, calcium and other micronutrients (Young *et al*. 2008). Another idea is that the deficiency causes alteration in taste sensitivity, resulting in non-food substances to become appealing. In this instance, geophagia is a consequence of micronutrient deficiency and not an attempt to correct the deficiency (Young *et al*. 2008). Soil consumption is considered for its nutritional benefits, especially relating to iron (Luoba *et al*. 2004). Soil is believed to have the ability to increase calcium levels (Hunter 2003; Wilson 2003). Hunter (2004) explains geophagia as a reflection of mineral deficiency, and the body's instinctive attempt at correcting the deficit is a craving for soil (Abrahams 2002; Hunter 2004). Soil can be consumed as a mineral nutrient supplement (Wilson 2003; Abrahams *et al*. 2006). In areas of north-eastern Brazil, it was found that the prevalence of anaemia was reduced by the consumption of clay (Hunter 2003).

2.5 Nutrients contained in soil

Clay commonly consumed in Africa contains nutrients such as: phosphorous, potassium, magnesium, calcium, copper, zinc, manganese and iron in amounts of nutritional significance (Johns & Duqutte 1991; Abrahams 2002; Hunter 2003; Ghorbani 2008; Rosenberg 2009). Soil with a high clay content, depending on the type of clay, generally has a high magnesium content, whereas soil from termite mounds has a higher sodium and potassium content, but lower iron and aluminium content than other soils (Reilly & Henry 2000). Wilson (2003) was of the opinion that soil from termite nests was often high in calcium. Red clay is rich in iron and aluminium oxide (Yount 2005).

2.6 Importance and function of iron, minerals and proteins in the human body and its relation to geophagia

The mineral and biological properties of soil can make soil ingestion either advantageous or disadvantageous for human health (Abrahams 2002). Ingested soil can affect the balance of nutrients in the individual (Abrahams 2002).

It is difficult to establish a link between soil ingestion and human health, since there are so many factors that influence experimentation and observation of humans. Some of these factors include: subclinical manifestations of disease, diversity of the human diet, mobility of people, and the many causes that exist for each condition or disease. Although some correlation exists, it is important to remember that correlation does not necessarily mean causation (Abrahams 2002).

2.6.1 Iron

For the purpose of this discussion, iron is the collective term used for all elements related to iron status, including ferritin, total serum iron, transferrin and transferrin saturation.

2.6.1.1 Association of iron with geophagia

The practice of geophagia is associated with iron deficiency (Brown 2002: 11). Kaolin, a substance found in soil, contains kaolinite which has a negatively charged surface. This characteristic enables kaolinite to absorb Fe^{2+} and Fe^{3+} in the duodenum where iron absorption occurs, which in turn may lead to iron deficiency anaemia, as less iron is available for absorption (Von Garnier, Stunitz, Decker, Battegay & Zeller 2008). Geophagia has been associated with a number of problems concerning health and development, amongst which is iron deficiency anaemia (Hooda *et al*., 2004).

Iron deficiency is the most common form of nutritional deficiency, which can lead to morbidity and mortality, and has been proposed as a possible cause for geophagia. The argument still continues regarding whether the iron deficiency causes geophagia or whether the geophagia leads to iron deficiency (Woywodt & Kiss 2002). A survey conducted in 2002 showed that 31% of children in an urban community, suffering from iron deficiency anaemia ingested soil (Trivedi *et al*. 2005). The following case studies will illustrate the relationship between iron deficiency anaemia and geophagia:

A study was conducted to investigate the bio-availability of minerals that are important in human nutrition, including iron, in soil, using an *in vitro* simulation test (Hooda *et al*. 2004). Conditions similar to those in the gastrointestinal tract were created. Mineral content in the soil was determined by digestion in concentrated hydrochloric acid. The test was aimed at determining the absorption and desorption characteristics of soil regarding already available nutrients, by using different concentrations of mineral solutions (including iron) to account for all social groups with different daily dietary intake. Simulations were carried out at two pH environments to represent the stomach and the intestine, respectively. It was found that for iron, a significant decrease of 41 – 75% occurred at low pH, and at higher pH, the soil further retained up to 90% of already available iron. Thus, it can be concluded that, contrary to popular belief, soil possibly removes, instead of supplements, bio-available iron, causing iron deficiency. The study lacks information; however, in the sense that it does not take into account the effect that enzymes might have on absorption and desorption of minerals in the gastrointestinal tract (Hooda *et al*. 2004). Hunter (2004) agrees that soil consumption can cause, rather than alleviate certain deficiencies, especially iron deficiency anaemia.

A biochemical investigation done on an African woman admitted to hospital, revealed low potassium levels and iron deficiency anaemia. Patient questioning revealed a ten-year history of geophagia. The woman consumed "black earth" from her garden and bought "red earth" from a market. Upon investigation it was found that the "black earth" absorbed sodium, potassium and iron. The "red earth" was revealed to liberate iron at pH 2 and absorb iron at pH 6. The absorbent properties of the "black earth" for potassium and iron could account for the hypokalemia and iron deficiency (Dreyer *et al*. 2004).

In a similar case study, a 21-year-old female was admitted post partum with low potassium levels and iron deficiency. The patient's history revealed that she had been consuming soil since her third month of pregnancy. The iron was rectified intravenously and orally and one month after discharge, a follow-up examination showed normal iron levels. It was also found that the patient had stopped eating clay (Trivedi *et al*. 2005).

Two samples, purchased from ethnic shops, were subjected to a 2 part acid-alkaline *in vitro* physiologically based extraction test (PBET) procedure, representing the stomach and small intestine of the human digestive tract. The study was conducted to determine the bioavailability of the elements in the soil. One sample produced 42 – 54% of the iron required by a 15–18-year-old female, while the other sample produced 90 – 119% of the iron required. The system used in this study only estimates the bio-availability of the elements, and it is still not known whether this available fraction will be absorbed by the geophagist (Abrahams *et al*. 2006).

In a case study of a 22-year-old female presenting with iron deficiency anaemia, no cause could be found and iron replacement therapy failed to normalise the haemoglobin levels. The same patient presented with severe iron deficiency anaemia 12 years later. Upon questioning the patient regarding eating habits it was revealed that the patient had been consuming "friable stone" on a daily basis for the past ten years. This stone was found to contain kaolinite, which is believed to inhibit iron absorption in the duodenum. Within a month of abstaining from consuming the soil, the anaemia was corrected, with the aid of iron replacement therapy administered intravenously. Even after three months, the blood count and iron studies remained normal (Von Garnier *et al*. 2008).

In a study conducted on schoolchildren in Zambia, a baseline iron and haemoglobin test was done, during which the children were given iron replacement, on the assumption that it would reduce the prevalence or amount of earth eaten by the children. A follow-up iron and haemoglobin test was done a few months later to test this theory. It was found that the supplementation neither stopped, nor reduced the amount of earth eaten by the children. Thus, the hypothesis that geophagia is a result of iron deficiency is not supported. The study supports the possibility that geophagia may lead to low iron status, most probably by interfering with the absorption of iron (Nchito *et al*. 2004).

To summarise, it is possible that soil may remove iron that is already bio-available, causing iron deficiency, or at the very least, interfering with the absorption of iron. One study revealed that iron is liberated from ingested soil, but it could not be established whether that liberated iron was actually available for absorption. In most case studies involving women with iron deficiency and a history of geophagia, they received iron supplementation, and the iron levels of the women remained normal in the cases where the women stopped eating soil. From the literature it is clear that there is some association between iron deficiency and geophagia, the only uncertainty being whether the iron deficiency causes geophagia, or whether iron deficiency is the consequence of geophagia.

2.6.1.2 Importance and function of iron in the human body

Two-thirds of the iron in the human body is incorporated into the haem of haemoglobin and, as such, plays an important role in the transport of oxygen. Iron is also present in haem containing enzymes such as catalase and iron sulphur proteins. A significant amount of iron is stored as ferritin and haemosiderin, primarily in the bone marrow, spleen and liver (Bishop, Duben-Engelkirk & Fody 2000: 322). Measurement of serum iron alone is not sufficient to assess iron status, because serum iron is subject to diurnal variation, and can thus fluctuate. Serum iron should be considered in conjunction with transferrin to fully assess and diagnose iron deficiency (Kaplan & Pesce 2010: 761).

Ferritin is a compound composed of iron molecules bound to apoferritin, a protein shell. Iron stores represent approximately 25% of total iron in the body, and most of this iron is stored as ferritin. Serum ferritin concentration is a good indication of available iron stores and is a very sensitive and early detector of iron deficiency. Ferritin levels are decreased with iron deficiency (Alan 2006: 393). Ferritin levels decrease before total serum iron decreases, and as such are one of the first indicators of iron deficiency (Bishop *et al.* 2000: 326; Alan 2006: 393). Serum ferritin is an acute phase reactant and therefore levels may increase during inflammatory and neoplastic conditions, confounding the evaluation of iron deficiency to a certain extent (Bishop *et al.* 2000:

326; Alan 2006: 393). The other elements measured to asses iron status is transferrin and transferrin saturation.

Transferrin is the major iron transporter in the circulation. Transferrin transports iron to the liver, spleen and haemopoetic tissue of the bone marrow (Alan 2006: 1063). Synthesis of transferrin in the liver is influenced by the iron status of the body, i.e. iron deficiency will cause an increase in transferrin synthesis (Bishop *et al*. 2000: 326).

Transferrin saturation is the ratio of serum iron and transferrin concentration, expressed as a percentage. If functional iron is low, transferrin synthesis increases in order to increase plasma iron turnover, in turn leading to decreased transferrin saturation. Decreased transferrin saturation is therefore a marker for iron deficiency (Thomas 1998: 275-276).

2.6.1.3 <u>Diagnosis of iron deficiency anaemia</u>

Diagnosis of iron deficiency anaemia in the laboratory is based on the following findings (Price & Wilson 2003: 203):

- Decreased serum ferritin
- Increased transferrin
- Decreased transferrin saturation
- Decreased serum iron
- Hypochromic, microcytic anaemia

2.6.2 Minerals

Nutrients can be defined as substances in food that are used by the body to promote normal health and function. Nutrients are divided into major nutrients, as in carbohydrates, proteins and lipids, and the nutrients, such as minerals, that are required in minute amounts only, even though they are just as crucial in maintaining health (Marieb 2001: 949).

Minerals, including calcium, magnesium and phosphate, make up about 4% of body weight, of which calcium and phosphate make up about three quarters. These minerals are not directly used as fuel, but instead, work in coordination with other nutrients to ensure health and proper functioning of the body, and incorporation of these minerals into existing structures adds support and strength (Marieb 2001: 954).

Minerals included in this discussion include the minerals only pertaining to this study, i.e. calcium, magnesium and phosphate.

2.6.2.1 Association of minerals with geophagia

From a geophagia standpoint, the presence of calcium and magnesium is of particular importance, as geophagia is observed among young children when these elements are vital to nutrition (Hooda *et al.* 2004). The question is whether these nutrients are soluble in gastrointestinal conditions and therefore available for absorption from the soil. It might be possible that the soil might remove nutrients that were already bio-available, depending on the type of soil (Hooda *et al.* 2004). Geophagia has been associated with phosphate intoxication (Tayie 2004; Yount 2005; Ghorbani 2008). Among certain populations in Africa, those who have access to calcium do not practice geophagia as often as those deprived of calcium, thus it can be assumed that the deficiency of calcium may cause a craving for soil (Starks & Slabach 2012).

In the study conducted by Hooda *et al.* (2004) to investigate the bio-availability of minerals in soil important in human nutrition using an *in vitro* simulation test, calcium and magnesium were included among the minerals tested. In the conditions created, similar to those in the gastrointestinal tract, it was found that calcium and magnesium were released from soil in an acidic environment, i.e. the stomach. At higher pH, i.e. the intestine, concentrations of calcium and magnesium decreased. Thus, it can be concluded that soil possibly removes, instead of supplements, bio-available nutrients causing nutrient deficiency. The only disadvantage the study had was that it did not take into account the effect that enzymes might have on the absorption and desorption of minerals in the gastrointestinal tract (Hooda *et al.* 2004). In contrast, Hunter (2004) was of the opinion that clay promotes calcium absorption, as it slows down gastrointestinal mobility, thus increasing the time for calcium to be absorbed from food.

An African woman was admitted to hospital with low potassium and iron deficiency, and questioning revealed that the woman had a ten-year history of geophagia. The woman consumed "black earth" from her garden and bought "red earth" from a market. Upon biochemical investigation it was found that the "black earth" liberated calcium and magnesium. When compared with dietary intake, it could be concluded that calcium liberated by the "black earth" may have supplemented the diet, as the woman was taking in less than sufficient amounts of calcium through her diet (Dreyer *et al.* 2004).

In a similar case study, a 21-year-old female was admitted post partum with low magnesium levels. The patient had been consuming soil since her third month of pregnancy. The magnesium was rectified intravenously and orally, and one month after discharge a follow-up examination revealed normal levels of magnesium and the patient had stopped eating clay (Trivedi *et al.* 2005).

In the two samples purchased from ethnic shops, subjected to a 2 part acid-alkaline *in vitro* physiologically based extraction test (PBET) procedure, it was found that significant amounts of calcium were produced by both samples. However, the system was used to estimate the bio-availability of elements in soil, and not the fraction that will be absorbed (Abrahams *et al.* 2006).

In summary, some studies in the literature revealed that soil might remove, instead of supplement, nutrients such as calcium and magnesium. On the other hand, other studies found that clay promotes calcium absorption, and that calcium is actually liberated by certain types of soil. In a case study of a woman with low magnesium levels, the magnesium was corrected intravenously and remained normal after a month, when the patient stopped practicing geophagia. The possibility that soil may supplement minerals in the body is of particular importance from a geophagia standpoint, as the practice is seen in children where these minerals are vital to development and growth. But even if these minerals are liberated by soil, it is not clear whether the liberated minerals are available for absorption.

2.6.2.2 Importance and function of minerals in the human body

Calcium is essential for myocardial contraction (Bishop e*t al.* 2000: 310). Functions of calcium in the body include: to maintain hardness of bone and teeth; it is essential for normal membrane permeability, transmission of nerve impulses, muscle contraction and blood clotting; it helps prevent hypertension; and it activates certain enzymes (Marieb 2001: 958). Symptoms of hypocalcaemia include neuromuscular irritability and cardiac irregularities (Bishop *et al.,* 2000: 310). Calcium deficit can lead to muscle tetany, osteomalacia, osteoporosis, retarded growth and rickets in children (Marieb, 2001: 958).

Magnesium has a very wide function. It is an essential component of certain enzymes, including those necessary for glycolysis, transcellular ion transport, neuromuscular transmission, as well as the synthesis of carbohydrates, proteins, lipids and nucleic acid (Bishop *et al.* 2000: 306). A deficiency of magnesium can cause neuromuscular problems, tremors, muscle weakness, irregular heartbeat and hypertension (Marieb 2001: 960).

Phosphate compounds are an essential part of all living cells and participate in some of the most important biochemical processes, such as the formation of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Phosphate concentrations have circadian variation and are greatly influenced by environmental factors such as diet. Many physiological factors also influence phosphate levels, such as fluctuations in growth hormone, insulin and renal function (Alan 2006: 853). Deficiency of phosphate can cause rickets and growth retardation (Marieb 2001: 960).

2.6.2.3 Diagnosis of mineral deficiency or excess

Diagnosis of mineral deficiency or excess is made when measured levels are above or below the reference range (Reference ranges: Chapter 4: Results and Discussion)

2.6.3 Proteins and β-hCG (β-human Chorionic Gonadotropin)

Proteins measured included albumin and C-Reactive protein (CRP), and were measured not because of their direct involvement with geophagia, but because of the supplementary part they play in the measurement and interpretation of the other elements measured. A β-hCG was done on each individual to rule out pregnancy, as pregnancy has a significant effect on minerals and the iron status in the human body.

2.6.3.1 Importance and function of proteins and β-hCG in the human body

Albumin is synthesised in the liver and is the most abundant protein in blood. Albumin plays a dual role. Albumin maintains the colloid osmotic pressure in the intravascular compartment, and it acts as the major binding protein in blood. Albumin binds to, amongst others, calcium and magnesium and also to some drugs. Malnutrition causes a decrease in albumin concentration (Bishop *et al.* 2000: 164). Up to 40% of calcium isbound to proteins, of which albumin makes up 55 – 60%. A change in albumin can lead to a change in the calcium concentration (Alan 2006: 203). It is therefore necessary for clinical purposes to correct the calcium for changes in albumin.

CRP is an acute phase protein. Rapid increases are seen in inflammatory conditions, infection, trauma, tissue necrosis, malignancies and autoimmune diseases. Hepatic production of CRP is stimulated by inflammatory cytokines and is therefore used as an inflammatory marker (Alan 2006: 191). An acute phase reaction, evident by an increased CRP, may lead to increased levels of serum ferritin (Alan 2006: 393).

Human Chorionic Gonadotropin (hCG) is composed of two subunits, α and β (Alan 2006: 253). The β subunit of hCG (β-hCG) has unique biochemical and immunological properties. The test used for measurement uses antibodies specific for this β-subunit. hCG is synthesised by the cells of the placenta and is detected as early as one week after conception. During pregnancy β-hCG levels increase for 8 – 10 weeks after the last menstrual cycle (Siemens 2010). Pregnant women tend to have increased calcium levels throughout pregnancy, as bone desorption increases, to ensure the foetus will have sufficient calcium to mineralise its bones (Marieb 2001: 1140). Ferritin tends to decrease from week 12 – 25 of pregnancy due to increased demands of the foetus (Allen 2000).

2.7 Disadvantages of consuming soil

Soil is presumed a source of parasite infection (Reilly & Henry 2000; Brown 2002: 11; Woywodt & Kiss 2002; Luoba *et al.* 2004; Nchito *et al.* 2004; Stiegler 2005; Abrahams *et al.* 2006; Young *et al.* 2008). Nutritionists and physicians do not favour the practice of geophagia due to the presence of earthworms and snail shells in the soils (Yount 2005). Ingesting soil can be poisonous, as dirt often contains bacteria, viruses, parasitic worms, and dangerous amounts of lead or arsenic (Starks & Slabach 2012).

Some of the health risks associated with geophagia include malnutrition, oral and dental health problems due to grinding sharp objects in the soil, and intestinal obstruction and perforation (Brown 2002: 11; Tayie 2004; Stiegler 2005). Electrolyte disturbances and intestinal obstruction are a common complication of geophagia, and even though intestinal perforation is rare, it is associated with a high mortality rate (Woywodt & Kiss 2002). Soil consumption rarely adds significant amounts of minerals to the diet and, in many cases, interferes with the absorption of digested food from the gut into the bloodstream, causing nutrient deficiency (Starks & Slabach 2012).

Geophagia has been associated with lead poisoning, abdominal distension, hyper- or hypokalemia, and dental injury (Tayie 2004; Yount 2005; Ghorbani 2008). Soil can contain lead concentrations that can be harmful, especially to the unborn child if consumed by a pregnant woman (Abrahams *et al.* 2006). Hypokalemia and lead poisoning are both associated with geophagia and it is believed that excessive soil intake can eventually possibly lead to death (Abrahams 2002).

Complications related to geophagia, however rare, can be linked to the amount of material ingested (Woywodt & Kiss 2002). Geophagia can be related to a high rate of complication, morbidity, and maybe even mortality (Woywodt & Kiss 2002).

Ghorbani (2008) lists several case studies, in which the abnormality present could be linked to geophagia:

1. A 21-year-old male presenting with dwarfism, hypogonadism, hepatosplenomegaly, rough and dry skin, mental lethargy, and iron deficiency anaemia, had a dietary clay intake of 0.5 kg daily. Ten more patients with similar symptoms were seen in the same hospital in the following months.
2. In 13 patients with symptoms of dwarfism, hypogonadism, hepatosplenomegaly, and iron deficiency anaemia, it was found that in those individuals who were able to follow a good diet, the symptoms either disappeared or significantly improved. In those who were not able to maintain a good diet, the symptoms remained.
3. In a school, a study done on 156 children revealed that iron deficiency anaemia was a lot more common in geophagous children than in non-geophagous children.

2.8 Identification/Classification of soil

The colour of soil is generally used for describing and identifying soil. One of the factors that determine the colour of soil is said to be the nature and abundance of iron oxides in the soil profile. The method most commonly used for determining soil colour is the Munsell colour system (Hutchinson 2010). This system uses three descriptors of elements of colour: hue, value and chroma. The hue refers to the shade of the colour and is usually denoted with an alphanumeric code, e.g. the range of hues from red to yellow would be represented by the codes 10R, 2.5YR, 5YR, 7.5YR and 10YR. The value refers to the tone or lightness of the colour and is scored 1–9 from black to white. The chroma is the colour purity, or degree of the colour saturation, where 0 represents no saturation and 9 represents intense saturation. The Munsell system also gives a descriptive name for each code, e.g. 10YR 6/6 is brownish-yellow soil (Hutchinson 2010).

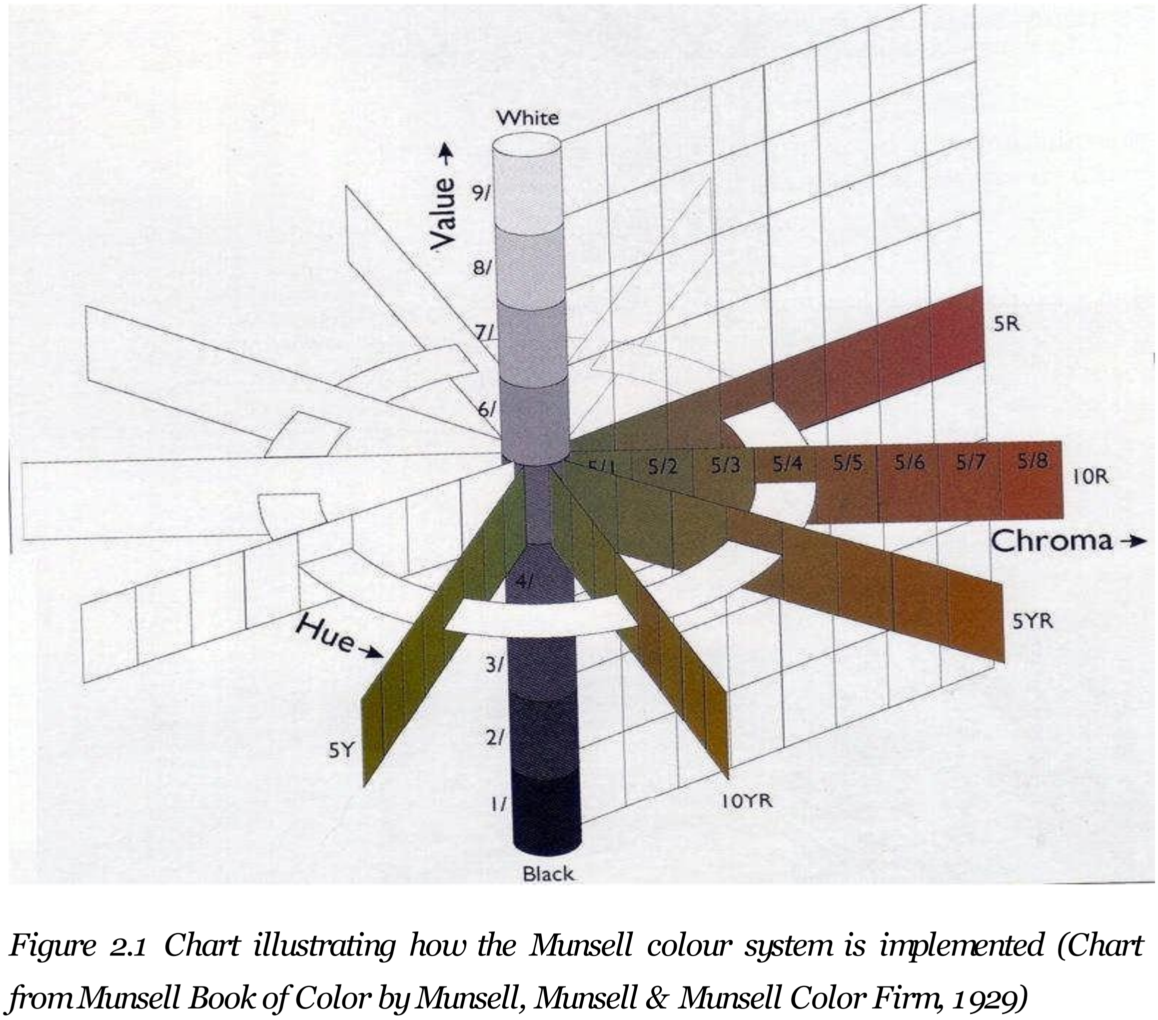

Figure 2.1 Chart illustrating how the Munsell colour system is implemented (Chart from Munsell Book of Color by Munsell, Munsell & Munsell Color Firm, 1929)

2.9 Information on the soil commonly consumed in the QwaQwa area

Except for a few geophagic women in the test group, most collected their soil of preference from one of the several mines in and around the area they lived in, or bought it from one of the many vendors at the market. Soil for consumption is commonly referred to as Mobu, and women used colour, among other things, to describe their soil of preference (Questionnaire: Appendix A, Information form questionnaire: Appendix B). Soil samples were taken from well-known and commonly used mines, as well as from vendors at the Setsing Market where soil is generally bought. Information was collected on the state of the mines and the price of the soil at the vendors, and a soil colour analysis was done by another researcher on the team (Smit 2012).

Table 2.1 Summary of information on 17 well-known mining sites in and around the QwaQwa area (Information used with permission from Smit, 2012)

Mine no.	Location	Depth of the mine	Description of the area	Soil colour analysis	Soil colour
1	Phuthaditjhaba	28 cm	Stop-valve on top of mine	2.5 YR 7/2	Pale red
2	Phuthaditjhaba	37 cm	Open mine with natural grasses surrounding it	2.5 YR 7/1	Light reddish
3	Qhelaphe area in Phuthaditjhaba	110 cm	Natural grasses surround the mine	7.5 YR 8/2	Pinkish white
4	Qhelaphe area in Phuthaditjhaba	49 cm	Surrounding area fairly neat without rubbish	10 YR 8/2	Very pale brown
5	Namahali area in Phuthaditjhaba	15 cm	Very dirty mine with glass, stone and rubbish	10 YR 8/1	White
6	Namahali area in Phuthaditjhaba	15 cm	Some glass pieces found near the mine	5 YR 7/1	Light grey
7	Namahali area in Phuthaditjhaba	5 cm	Mine is close to daily foot and vehicle traffic	5 YR 7/2	Pinkish grey

8	Namahali area in Phuthaditjhaba	5 cm	Mine is close to daily foot and vehicle traffic	2 YR 6/5B	Greenish grey
9	Phahameng area in Phuthaditjhaba	5 cm	Next to road near houses	7.5 YR 4/6	Strong brown
10	Phahameng area in Phuthaditjhaba	10 cm	Next to road near houses	7.5 YR 4/6	Strong brown
11	Kgubetswana area near Clarens	20 cm	Situated against a steep hill	5 YR 6/1	Grey
12	Kgubetswana area near Clarens	40 cm	Situated against a steep hill	2.5 YR 7/1	Light reddish grey
13	Kgubetswana area near Clarens	69 cm	Situated halfway up a steep hill	5 YR 7/2	Pinkish grey
14	Mangaung area in Phuthaditjhaba	30 cm	Situated 500 m from nearest houses	5 YR 6/4	Reddish brown
15	Mangaung area in Phuthaditjhaba	47 cm	Near a valley where cattle graze	7.5 YR 6/4	Light brown
16	Madikwe area in Phuthaditjhaba	65 cm	Near a valley where cattle graze	10 YR 7/1	Light grey
17	Madikwe area in Phuthaditjhaba	64 cm	Situated ±700 m from nearest houses	10 YR 5/4	Yellowish brown

Table 2.2 Summary of information on 13 vendors selling geophagic soil at the Setsing Market; packaged in non-sterile plastic bags (Information used with permission from Smit, 2012)

Vendor no.	**Method of mining**	**Processing method**	**Soil colour analysis**	**Soil colour**	**Price**
1	Mine self with utensils	Break into smaller pieces with scissors	10 YR 8/1	White	R2.00
2	Mine self with utensils and bare	Dry in a charcoal oven for 10 – 15	10 YR 8/2	Very pale brown	R1.50

	hands	min			
3	Mine self with utensils and hands	Dry in the sun	10 YR 7/2	Light grey	R2.00
4	Mine self with utensils and hands	Dry in a coal stove	10 YR 7/4	Very pale brown	R2.00
5	Imported form Johannesburg	No information on processing	10 YR 7/2	Light grey	R3.00
6	Mine self with utensils and bare hands	Dry in the sun or in coal stove	10YR 7/2	Very pale brown	R2.00
7	Mine self with utensils and hands	Dry in the sun or in coal stove	1YR 8/1	Light greenish grey	R2.00
8	Mine self with utensils	Dry in the sun or in coal stove	1 YR 8/2	Pale green	R2.00
9	Mine self with utensils and bare hands	Dry in the sun or in coal stove	10 YR 7/1	Light grey	R2.00
10	Mine self with utensils and bare hands	Dry in the sun or in coal stove	10 YR 6/2	Pale red	R2.00
11	Mine self with utensils and bare hands	Dry in the sun or in coal stove	10 YR 8/1	Light white	R2.00
12	Mine self with utensils and bare hands	No processing prior to selling	7.5 YR 8/1	White	R2.00
13	Mine self with utensils and bare hands	Dry in the sun	7.5 YR 6/1	Grey	R2.00

2.10 Summary of literature review

Geophagia, a subcategory of pica, is the uncontrollable practice of eating soil, and has been described since ancient times. Geophagia is a worldwide occurrence seen across all age groups, races and sexes, but it is more common among pregnant women and children. Although the habit can occur in all social ranks, it is more common in underprivileged communities.

Most geophagists eat soil directly from the ground as is, but there are those who prefer to add flavouring to the soil in the form of flour or herbs. Soil can also be prepared as tablets or rolls for consumptions or, as some prefer, be baked in the sun.

Various reasons are given for why people consume soil. These reasons include that it is a cultural or religious activity, or a psychological habit, in response to upset or distress. Pregnancy is a common motivation, as women believe that the soil has the ability to help them and the baby in various ways during pregnancy. Some consumers believe soil can cure certain ailments, but some researchers claim that soil is eaten simply because of hunger and poverty.

Another reason to consume soil, investigated extensively by researchers, is that soil holds nutritional benefit for the consumer. Soil commonly consumed has been found to contain nutrients such as phosphorus, potassium, magnesium, calcium, copper, zinc and iron. Previous research on the subject revealed that soil can cause deficiency in iron, calcium and magnesium, as it absorbs these nutrients. In contrast to this finding, there are researchers who concluded that soil can liberate these elements and as a result supplement the diet. One possibility is that soil does not only supplement the diet in terms of phosphate, but may actually cause phosphate intoxication.

Some other disadvantages associated with geophagia include parasite infection and intestinal obstruction. The texture of the soil may result in damage to tooth enamel and the oral cavity. Soil consumption can lead to lead poisoning, electrolyte disturbances and possibly even death.

As soil is identified by means of its colour, amongst others, it is necessary to understand how to scientifically distinguish between different types of soil based on colour. The method most commonly used for colour classification is the Munsell Colour System.

The belief is that geophagia is practiced as a result of nutritional deficiency. Iron deficiency, in particular, has been linked to the practice of geophagia. No definite link could be established between the practice of geophagia and mineral status, including calcium, magnesium and phosphate. The aim of this study was to determine whether there is an association between iron and mineral deficiency and the practice of geophagia. In the following chapter a detailed description of the methods applied to achieve this goal will be given.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Different approaches to investigate geophagia associated with micronutrient deficiency have been suggested. Any of the following methodologies could be applied: oral interview, sample collection, physical analysis, mineralogical analysis, chemical analysis and biological analysis (Young *et al.* 2008). Although the methods mentioned by Young *et al.* 2008 were applied to the collection and analysis of soil, some of the same principles were used in the collection of blood and data pertaining to this study.

The geophagia research team, representing South Africa, Botswana and Swaziland, attended several workshops. During these workshops numerous questionnaires were designed, including one for the identification of geophagic women. This questionnaire (Appendix A) was the tool used in selecting the subjects for participation in the research project.

3.2 Study population

A field worker, familiar with the QwaQwa area was appointed to assist in identifying participants complying with the selection criteria. The target group was women between the ages of 18 and 45 years, as they fall within the childbearing age range. Geophagia is seen more commonly in women of childbearing age than in any other age group (Bartas & Ekman 2001; Abrahams 2002; Hooda *et al*. 2004; Ghorbani 2008).

Geophagic individuals were identified and information regarding their current health status, medical history and the type of soil they preferred, were obtained. Other information obtained from the questionnaire included the frequency of soil consumption, the quantity of soil intake per day and the method of preparation, where applicable.

A control group was also identified. This group comprised women in the same age group, with a similar demographic background as the test group. The only difference being that these women did not consume soil.

3.3 Inclusion and exclusion criteria

Women consuming soil were classified as the test group, and women not consuming soil were classified as the control group.

3.3.1 General criteria with which both the test and control group subjects complied

- At least 30 subjects had to be included in each group
- The women had to be between the ages of 18 and 45 years
- No pregnant women were included. Pregnant individuals were identified and ruled out with the β-hCG test. Pregnant women needed to be excluded from the study for the influence the pregnancy may have on iron and mineral status in the body.

3.3.2 Criteria with which the test group complied

- The women were all in the habit of consuming soil, the duration of which ranged from 1 year to 20 years, and in frequency from once a month to more than once a day (Appendix B)

3.3.3 Criteria with which the control group complied

- The women were, if possible, from the same household or, at least, in the near vicinity of the test subjects
- Individuals abstained from consuming soil for a period of at least six months

3.3.4 Specimen prerequisites

- The additive free samples (7 mL yellow-top tubes) were collected first to avoid contamination with preservatives/anticoagulants from other tubes; if there was a possibility of contamination, the specimen was discarded. If the purple-top tube was collected first, it was possible that the next tube collected could be contaminated by the Ethylenediaminetetraacetic acid (EDTA) used as anticoagulant. Contamination with the EDTA from a purple-top tube could influence/interfere with the analysis of other tests. EDTA can markedly decrease calcium and magnesium levels (Cornes, Ford & Goma 2008)
- Samples were centrifuged and serum separated from cells within 2 hours after collection of the blood
- Haemolysed samples were discarded to avoid inaccurate results due to the effect of haemolysis

- Two serum aliquots were made for each specimen and frozen at -20°C in two separate freezers. The second aliquot was made, and stored separately, as a precaution in case of a freezer malfunction. If there was a problem with the freezer before analysis could be performed, and specimens were thawed, they would have been rendered unsuitable for testing and discarded, as specimens can be thawed only once to ensure accurate results

3.4 Ethical consideration

- The project formed part of a bigger project with ethical approval from the University of the Free State: ETOVS number 104/08

3.5 Materials

3.5.1 Instruments, controls and calibrators

Instruments used were the Synchron Systems LX20 from Beckman Coulter, the BN ProSpec from Dade Behring, and the Advia Centaur Immunoassay system from Siemens (*Table 3.1*). The instruments are used in the Chemical Pathology Department at NHLS (SANAS accredited), Universitas Academic Hospital, Bloemfontein, for routine analysis of biochemical profiles, proteins, iron studies, hormones and tumour markers.

Table 3.1 Analysers, reagents, controls and standards used for the analysis

		Total serum iron (Fe)	Transferrin	Ferritin	Calcium (Ca)	Magnesium (Mg)	Phosphate (PO_4)	Albumin (Alb)	CRP	BhCG
INSTRUMENTS	Synchron Clinical Systems LX20 Beckman Coulter	■			■	■	■	■	■	
	BN ProSpec Dade Behring		■							
	Advia Centaur Immunoassay System Siemens			■						■
STANDARDS	Synchron Systems Aqua Cal 1,2,3 *(Cal1: 471288, Cal2: 471291, Cal3: 471294)				■					
	Synchron Systems Multicalibrator *(442600)					■	■			
	Synchron Systems Protein Calibrator Level 1,2 *(450202)							■		
	Synchron Systems Fe/IBCT Calibrator *(442772)	■								
	N Protein standard SL *(10446073)		■							
	Advia Centaur Systems Cal C *(10311575)			■						
	Advia Centaur Systems Cal B *(10313851)									■
	Cal 5 Plus *(469965)								■	
CONTROLS	Synchron Comprehensive Chemistry Controls Levels 1,2,3 *(657365)	■			■	■	■	■		
	N/T Protein Control SL High, Medium, Low *(H: 10446086, M: 10446082, L: 10446076)		■							
	Advia Centaur Ligand Plus Level 1,2,3 *(986000)			■						■

	Vigil Serology Control Levels 2,3 *(L2: 450163, L3: 450164)									
REAGENTS	ISE Electrolyte Reference LX/DxC *(A28937)									
	ISE Electrolyte Buffer LX/DxC *(A28945)									
	Magnesium *(445360)									
	Phosphorous reagent (with Molybdate solution) *(467868)									
	Albumin *(467858)									
	Ferrous Iron *(467910)									
	Human Transferrin *(10446309)									
	Ferritin *(10309968)									
	C-RP *(465131)									
	HCG *(10313827)									

*(Catalogue numbers)

3.6 Methods

3.6.1 Collection of data

A field worker, familiar with the QwaQwa area, interviewed and identified subjects by means of a questionnaire (Appendix A) prior to the trips taken for the collection of the blood. When blood was collected, it was found that some of the identified subjects had moved or no longer complied with the criteria, and so it was necessary to again interview and identify subjects suitable for the study on those trips.

Clotted blood was collected from 50 soil-eating and 37 non-soil-eating subjects in the QwaQwa area. Non-soil-eating individuals were reluctant to participate in the study and in the end we could find only 37 willing to participate. Blood was collected by qualified medical laboratory technologists, familiar with phlebotomy, and all subjects signed a consent form prior to the blood collection. Two trips to QwaQwa were needed for the blood collection. Permission was obtained from guest house owners to set up a temporary laboratory for the pre-analytic preparation of samples. Preparation included centrifugation, separation and labelling of processed samples. Samples were labelled and identified with numbers, instead of names to ensure anonymity. Two serum aliquots were frozen and containers prepared for transportation of the samples from the location to the laboratory where tests were performed. Medical and sharp waste was disposed of according to South African National Accreditation System (SANAS) and South African Bureau of Standards (SABS) approved guidelines.

Analysis was done in two batches, i.e. one batch after each trip taken for collection. Reagents were calibrated, if needed, and controls were run with each batch being analysed. Controls were run before the batch was analysed and on the LX20, controls were also run after the analysis. After aliquots were thawed, the serum was split into three tubes for the three separate apparatus (*Table 3.1*). Serum was loaded on the respective instruments and all the tests relevant to that instrument were done on that one aliquot.

3.6.2 Principles of tests

3.6.2.1 Calcium

Calcium forms a complex dye with ArzenoIII reagent and the colour produced was measured spectrophotometrically at 578 nm. The absorbance reading is directly proportional to the Ca concentration (Beckman Coulter SA 2011).

3.6.2.2 Magnesium

At pH 11.5 magnesium forms a coloured complex with Calmagite and the colour produced was read spectrophotometrically at 520 nm. The absorbance read is directly proportional to the Mg concentration (Beckman Coulter SA 2011).

3.6.2.3 Phosphate

Serum or plasma proteins were precipitated and inorganic phosphate was liberated by trichloroacetic acid. The protein-free filtrate reacts with ammonium molybdate to form ammonium phosphomolybdate. A reducing agent was then added to convert the hexavalent molybdenum-phosphate complex to a pentavalent blue coloured complex. The intensity of the colour was measured spectrophotometrically at 700 nm. The absorbance is directly proportional to the phosphate concentration (Beckman Coulter SA 2011).

3.6.2.4 Iron

A timed end-point colorimetric method was used. Iron is released from transferrin by acetic acid and reduced to the ferrous state by hydroxylamine and thioglycolate. The ferrous iron is immediately complexed with ferrozine, a highly coloured reagent. Absorbance was read spectrophotometrically at 560nm and is directly proportional to the iron concentration (Beckman Coulter SA, 2011).

3.6.2.5 Transferrin

Transferrin was measured by nephelometry. The complexes formed between transferrin and reagent antibodies scatter a beam of light passing through the sample. The intensity of the scattered light at an angle of 90° to the incident laser beam is directly proportional to the transferrin concentration in the sample (Dade Behring 2007/8).

3.6.2.6 Transferrin saturation

Saturation is calculated using the following equation (Thomas 1998: 275):

$$\text{Transferrin saturation} = \frac{100 \text{ x serum iron}}{2 \text{ x serum transferrin}}$$

Transferrin is measured in g/L. This should be divided by the molar mass of transferrin (79570 g/mol (Da)) converting it to µmol/L. The factor 2 by which the transferrin concentration is multiplied is because each molecule of transferrin can bind two Fe^{3+} ions.

3.6.2.7 Ferritin

The Advia Centaur assay is a two-site sandwich immunoassay using direct chemiluminometric technology, which uses constant amounts of two anti-ferritin antibodies. The first antibody is a polyclonal goat anti-ferritin labelled with acridinium ester. The second solid phase antibody is a monoclonal mouse anti-ferritin antibody, which is covalently coupled to paramagnetic particles. The solid phase antibody is immobile and captures the antigen, in this case ferritin. After being washed to remove unreacted molecules, the labelled antibody is added, binds to the captured antigen, and is detected. The bound labelled antibody signal is proportional to the antigen captured, i.e. ferritin (Siemens 2010).

3.6.2.8 C-Reactive Protein

CRP was measured by turbidimetry. CRP forms a complex with reagent anti-CRP antibodies. The decrease in light intensity due to the antigen-antibody complexes is measured. The decrease in absorbance is directly proportional to the concentration of CRP in the sample (Beckman Coulter SA, 2011).

3.6.2.9 β-human Chorionic Gonadotropin

β-hCG was measured by a two-site sandwich immunoassay using direct chemiluminetric technology, which uses constant amounts of two anti-hCG antibodies. The first antibody is a polyclonal goat anti-hCG labelled with acridinium ester. The second solid phase antibody is a monoclonal mouse anti-hCG antibody, which is covalently coupled to paramagnetic particles. The solid phase antibody is immobile and captures the antigen, in this case β-hCG. After being washed to remove unreacted molecules, the labelled antibody is added, binds to the captured antigen, and is detected. The bound labelled antibody signal is proportional to the antigen captured, i.e. β-hCG (Siemens 2010).

The results of the above mentioned variables were captured on a data form. Iron studies relating to iron deficiency anaemia and infection status was compared to data obtained by Raphuthing, Mogongoa, Brand & Ekosse (2011), using White Cell Count (WCC), Red Blood Count (RBC), Haemoglobin (Hb), Haematocrit (HCT), Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC) and Procalcitonin (PCT).

3.7 Statistical analysis

Descriptive statistics, i.e. mean, standard deviation, median, 25^{th} percentile and 75^{th} percentile of the biochemical and haematological results of each group were calculated using Excel®. The biochemical and haematological results of the subjects in each group were non-parametrically distributed. Because of this, the Mann-Whitney test was applied to test the primary hypotheses of no difference between the two groups, with respect to the biochemical and haematological findings (Daniel 2005: 701-708). Linear regression, using Excel®, was used to investigate for significant linear association between the different biochemical parameters in the two groups.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

A β-hCG was done on each subject for both the test group and the control group to determine pregnancy. Blood with a positive β-hCG was discarded and subjects excluded from the study. A β-hCG greater than 5 U/L is considered a positive result (Alan 2006:258). Of the 50 individuals in the test group, two had positive β-hCG results, and two of the 37 in the control group had positive β-hCG results. These four subjects were excluded as they were no longer in compliance with the inclusion criteria, and ultimately the test group included 48 individuals and the control group included 35 individuals. Routine laboratory tests were done to assess iron and mineral status. A laboratory tracking number was given to each subject to identify the subjects, as no names were used. Laboratory results obtained for both the test group and the control group were tabulated (Appendix C).

For each test subject, a control subject was chosen in the same household, if possible, or at least in the same area. This way it could be assumed that the subjects in the test group and the control group were exposed to the same foods and any difference in nutritional status were as a result of factors other than their food intake.

4.2 Chapter structure

The discussion starts off with a look at the demographic data obtained from the questionnaire. The purpose of its inclusion is to demonstrate that the ages of both the test group and the control group were similarly distributed and any differences in the results were not due to age differences between the groups or differences in estimated nutritional status.

Biochemical results and haematological results related to iron status will be discussed individually and different parameters compared and discussed.

Results related to mineral status will also be discussed and compared. The chapter will end with a concise summary of all the results.

4.3 Demographic data

A questionnaire, completed by means of interviews with all the subjects by a field worker, revealed the age, mass and height of individuals in both the test group and the control group. Questionnaires, and thus demographic data, for one subject in the control group and two in the test group were not available.

Table 4.1 Table comparing the demographic data of the test group and the control group

	Age (Years)	**Mass (Kg)**	**Height (m)**	**BMI**	**Duration of practicing geophagia (Years)**
Control Group					
Mean	25.90	60.90	1.57	24.60	N/A
SD	7.21	10.58	0.06	3.79	N/A
Median	23.50	59.50	1.57	23.00	N/A
Min	18	40.00	1.44	17.30	N/A

Max	44	87.00	1.74	34.50	N/A
75th Percentile	30.75	65.00	1.59	26.70	N/A
25th Percentile	20.00	55.00	1.55	22.70	N/A
N	34	34	34	34	N/A
Test Group					
Mean	26.00	62.00	1.57	25.2	6.60
SD	7.64	11.98	0.04	4.81	5.28
Median	23.00	59.50	1.56	24.20	5.00
Min	18	45.00	1.46	18.70	1
Max	44	96.00	1.66	40.00	20
75th Percentile	30.00	71.25	1.60	28.40	7.50
25th Percentile	20.00	53.00	1.54	21.90	3.00
N	46	46	46	46	40
Significance	**NS**	**NS**	**NS**	**NS**	

**NS: Difference in results between the test group and the control group was not enough to be of any significance*

Body mass index (BMI) is a statistical measurement calculated from an individual's height and weight, and is considered a useful tool in estimating healthy body weight. Calculation for BMI is weight in kilograms divided by height in m^2.

$$\text{BMI} = \frac{\text{Mass (kg)}}{[\text{Height (m)}]^2}$$

A BMI of less than 18.5 is considered underweight, whereas a BMI of between 18.5 and 24.9 is normal, and BMI between 25.0 and 29.9 is defined as overweight. If a BMI is greater than 30.0, the individual is considered obese (Hammond 2008: 400; Whitney & Rolfes 2011: 252-253).

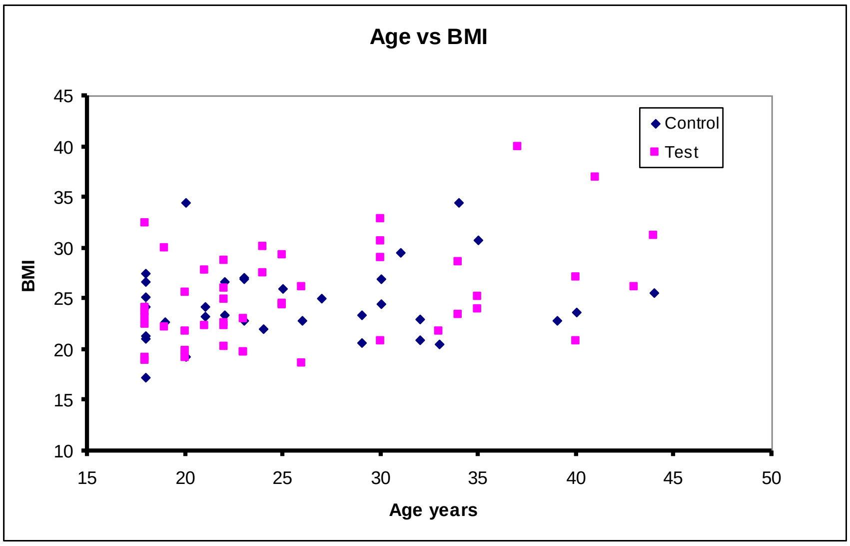

Figure 4.1 Scattergram showing the distribution of age in relation to BMI of the test- and control group

From the scattergram it could be concluded that BMI was not necessarily related to age, as the BMI was widely distributed over all age groups. It is also evident from the scattergram that subjects from the test group and the control group were equally distributed over the age group range, and any nutritional difference between the groups was thus not as a result of difference in age between the groups. The mean BMI of the test group and the control group compares relatively well with no significant difference between the groups. The mean BMI of the control group (24.60) fell within the range considered normal or healthy, whereas the mean BMI of the test group (25.20) only just fell within the range where individuals are considered overweight. Although the BMI does not reflect nutritional intake, it may be assumed that, using the mean BMI of the test group and the control group, individuals were not necessarily underfed, and any possible nutritional deficit could be as a result of malnutrition rather than starvation.

4.4 Biochemical results related to iron status

Tests routinely done in the biochemistry laboratory to assess iron status include ferritin, total serum iron (Fe), transferrin and transferrin saturation. These tests were done on all the individuals of both the test group and the control group and the results of the two groups were compared.

Table 4.2 Comparison of iron status of the test group and the control group

	Ferritin (ug/L)	**Iron (µmol/L)**	**Transferrin (g/L)**	**Transferrin saturation (%)**
Reference range	15 - 150	10 - 30	2.0 – 3.6	15 - 50
Control group				
Mean	42.80	14.00	2.71	19.20
SD	38.46	6.71	0.50	11.23
Median	32.80	12.90	2.65	17.90
Min	3.60	3.40	1.90	4.10
Max	175.50	37.50	4.29	64.30
75th Percentile	61.60	17.40	3.06	24.00
25th Percentile	11.80	9.80	2.36	11.40

N	35	35	35	35
Test Group				
Mean	13.10	7.18	3.21	8.23
SD	11.45	5.38	0.43	6.45
Median	9.10	5.55	3.22	5.50
Min	1.20	1.70	2.36	1.55
Max	57.40	27.80	4.45	29.60
75^{th} Percentile	17.95	8.70	3.49	10.09
25^{th} Percentile	5.57	3.80	2.85	4.23
N	48	48	48	48
Significance	**$p<0.001$**	**$p<0.001$**	**$p<0.001$**	**$p<0.001$**

Reference ranges used at NHLS, Universitas Academic hospital, Bloemfontein. Available from: http://www.nhls.ac.za.ChemicalPathology.pdf

The mean values of the control group were within the normal ranges for all parameters, whereas the mean of ferritin, iron and transferrin saturation for the test group was below the normal range. The difference in the results between the test group and the control group was considerably significant, both statistically and clinically. Low p-values indicate that the difference between the control group and test group was statistically significant, and therefore unlikely to have been caused by chance (Swanepoel, Swanepoel, Van Graan, Allison, Weideman & Santana 2008: 280). Difference of clinical significance imply that the difference in the results were of such a nature that the diagnosis would be different. When considering the mean values only, it could be assumed that individuals in the test group suffered from iron deficiency, as they complied with the diagnostic criteria used for iron deficiency anaemia (Price & Wilson 2003: 203).

4.4.1 Ferritin

From the histogram (*Fig 4.2*) it is clear that the majority of subjects in the test group had results below the normal range of 15 µg/L, whereas the results of subjects in the control group were more widely distributed within the normal range. Of the 48 individuals in the test group, 34 had low ferritin values and in the control group 12 of the 35 individuals had ferritin values below the normal range. That is 71% of test subjects, compared to 34% of control subjects with ferritin levels below normal.

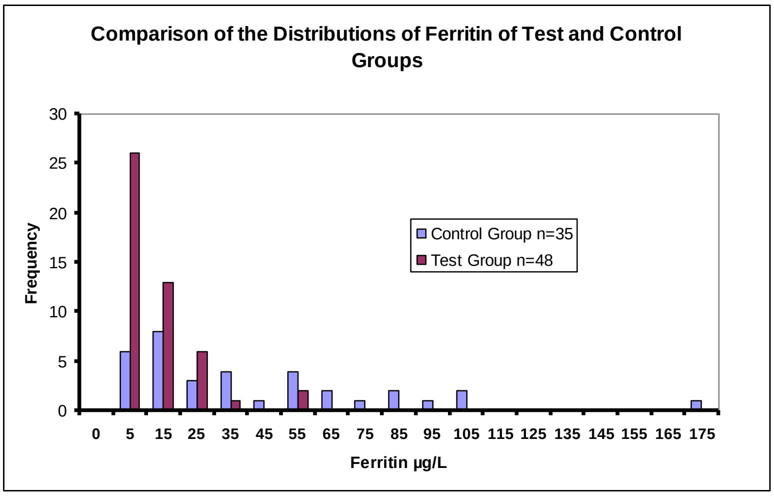

Figure 4.2 Comparison of the distribution of ferritin of the test group and the control group

Ferritin gives an indication of iron stores in the body, as most of the iron in the body is stored as ferritin, therefore ferritin is considered a sensitive marker for iron deficiency (Alan, 2006:393). The above information was an indication that iron deficiency in the test group was a strong possibility.

4.4.2 Iron

Of the 48 subjects in the test group, 38 had iron levels below the normal range of 10 µmol/L, and 9 of the 35 subjects in the control group had iron levels below normal (*Fig 4.3*). That is 79% compared to the only 25% of the control group.

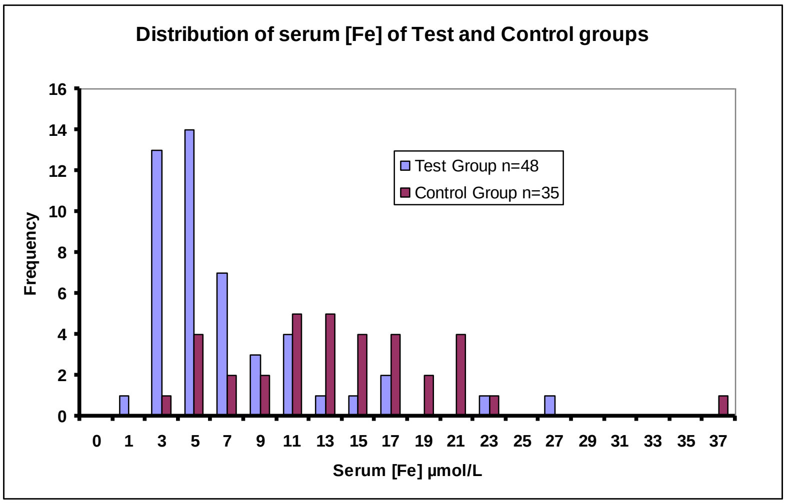

Figure 4.3 Distribution or serum iron concentration of the test group and the control group

4.4.3 Transferrin

The mean values for the transferrin of both the test group and the control group were within the normal range; however, the transferrin of the test group was higher, as is to be expected with iron deficiency. In iron deficiency anaemia, the amount of unbound transferrin increases as the saturation decreases, as a result of the decreased amount of iron bound to transferrin (Bishop *et al*. 2000: 326; Thomas 1998: 375-276).

4.4.4 Transferrin saturation

With iron deficiency, transferrin saturation is expected to be low (Price & Wilson 2003:203). In the test group 41 of the 48 subjects, i.e. 85%, had transferrin saturation below the normal range of 15%, as opposed to the 13 out of 35 of subjects in the control group, i.e. 37% with below normal transferrin saturation levels (*Fig 4.4*). This finding further contributes to the hypothesis that geophagous individuals suffer from iron deficiency. Although the mean of the transferrin saturation of the control group (19.2%) was low, it was still within the normal range. The mean value of the test group (8.23%) was far below what is considered normal.

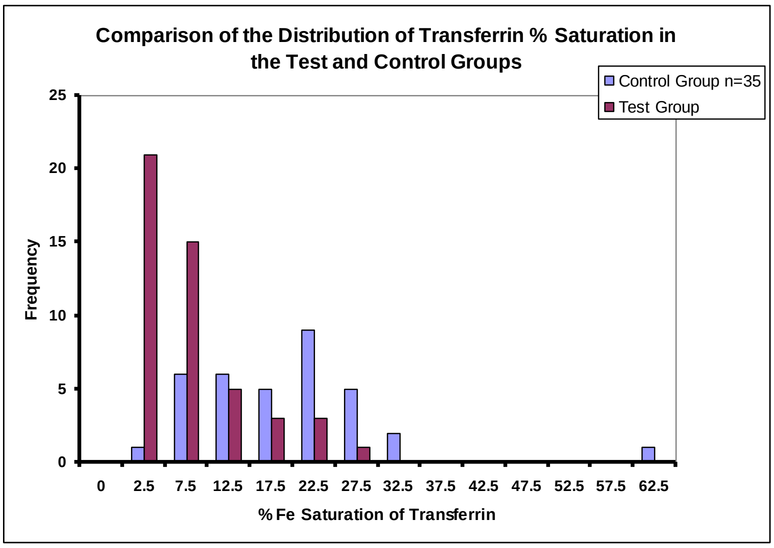

Figure 4.4 Histogram comparing the transferrin saturation of the test group and the control group

4.4.5 Ferritin vs iron

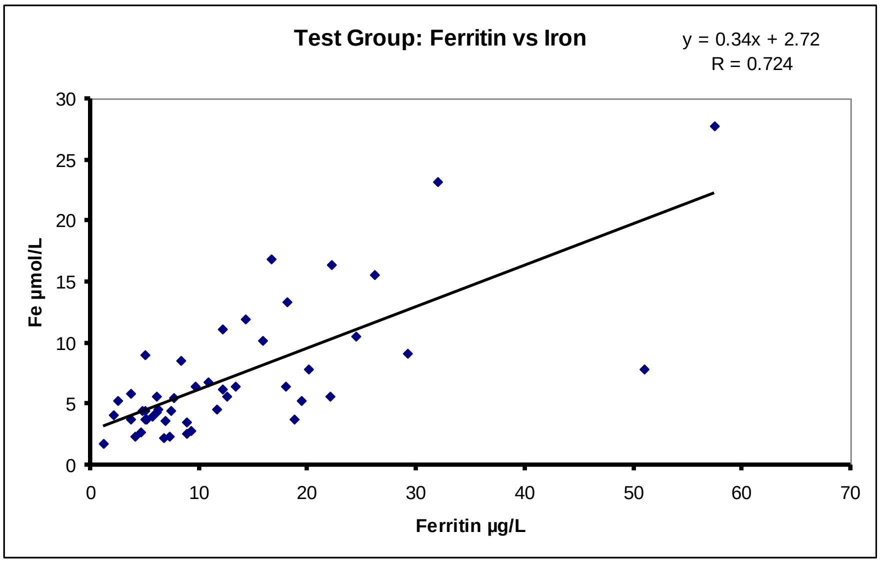

Figure 4.5 Correlation between ferritin and iron in the test group

The graph shows a positive linear relationship between the two variables, i.e. the one variable would decrease with a decrease in the other variable. This fits in with the diagnostic criteria for iron deficiency, as it is expected that the ferritin will decrease as the iron decreases (Price & Wilson 2003: 203). This adds to the theory that geophagous individuals are iron deficient (Stiegler 2005; Abrahams 2002; Young *et al*. 2008).

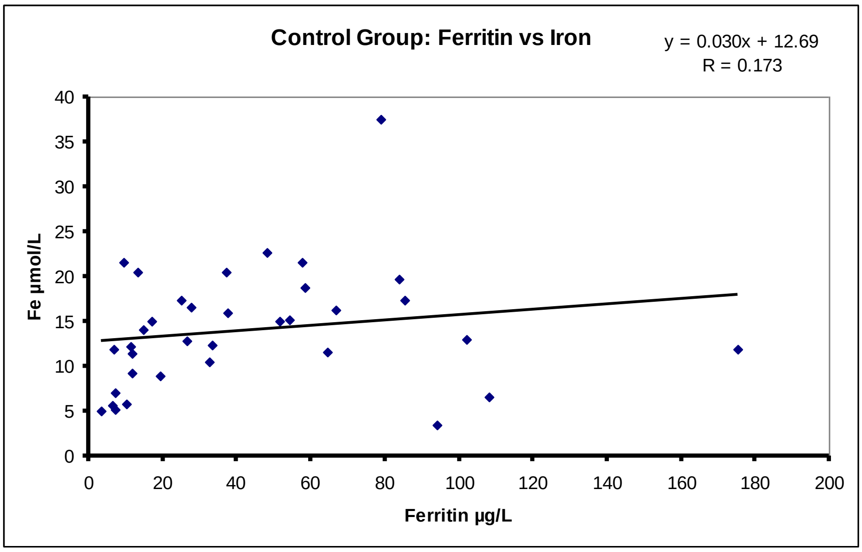

Figure 4.6 Correlation between ferritin and iron in the control group

In the control group, only 23% suffered from iron deficiency and the iron deficiency was not as prominent as in the test group. In the control group, 29% of the subjects had elevated CRP levels (> 5 mg/L), which could influence the ferritin result. Increased CRP can be an indication of an acute phase reaction, which can result in increased serum ferritin levels (Alan 2006: 393). The resulting influence of the CRP on the ferritin could have an effect on the correlation between the ferritin and iron and therefore the linear relationship is not as distinct.

4.4.6 Ferritin vs transferrin and transferrin saturation

A negative correlation exists between ferritin and transferrin, as transferrin will increase in response to a decrease in ferritin (Bishop *et al.* 2000: 326). The results of the test group were in accordance with the above statement (*Fig 4.7*). A negative correlation between the ferritin and transferrin was evident, i.e. the tranferrin increased with a decrease in the ferritin.

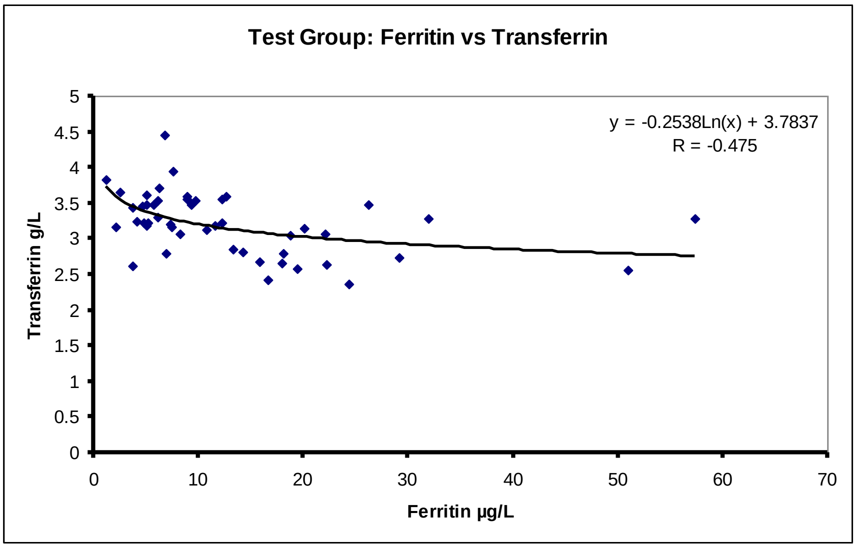

Figure 4.7 Correlation between ferritin and transferrin in the test group

A perceptible negative correlation between the ferritin and tranferrin in the control group was also observed as seen in *Fig 4.8*.

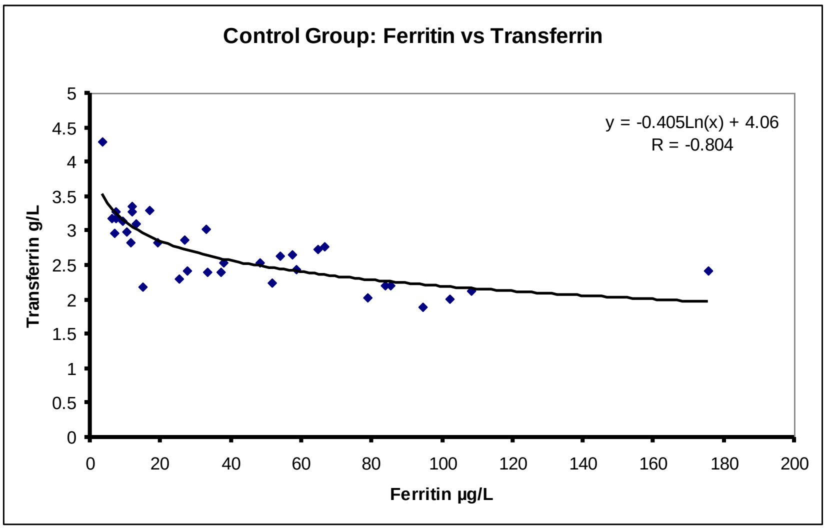

Figure 4.8 Correlation between ferritin and transferrin in the control group

Both the ferritin and transferrin saturation decreases with iron deficiency, creating a positive correlation (Alan 2006: 393; Price & Wilson 2003: 203). A positive correlation between the ferritin and transferrin saturation in the test group was clearly identifiable (*Fig 4.9*).

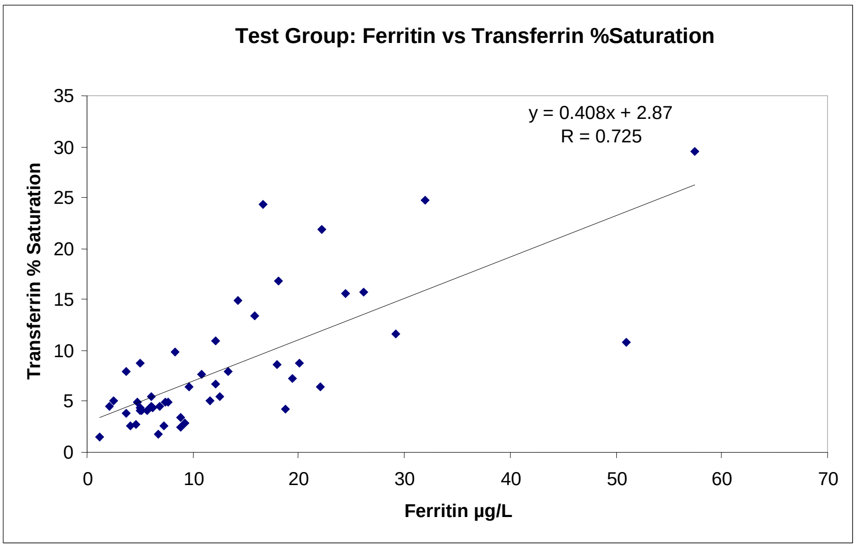

Figure 4.9 Correlation between ferritin and transferrin saturation in the test group

The correlation between the ferritin and transferrin saturation was demonstrated in the control group (*Fig 4.10*), although it was not as prominent is in the test group (*Fig 4.9*).

This could be as a result of the iron deficiency being more prevalent and perceptible in the test group and as such, was less sensitive to factors influencing the individual parameters.

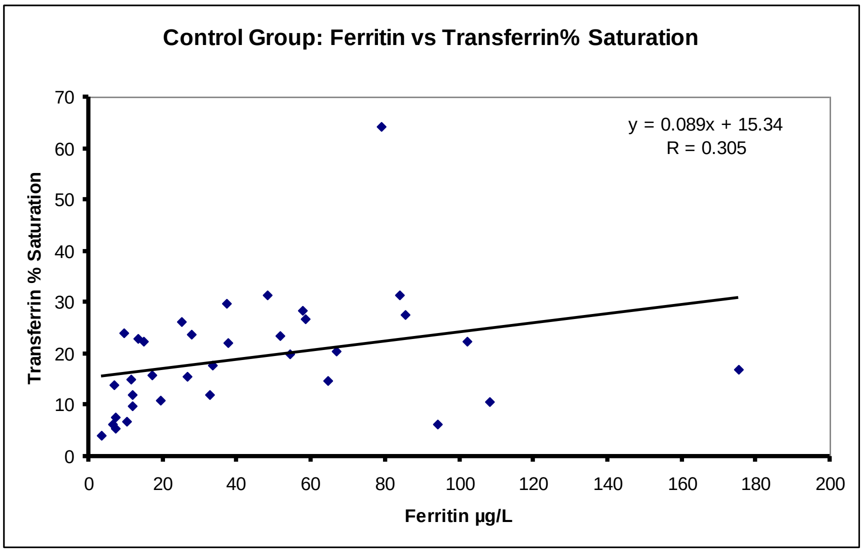

Figure 4.10 Correlation between ferritin and transferrin saturation in the control group

4.4.7 Discussion of biochemical results related to iron status

The above results reveal that, in comparison to non-geophagous individuals, people who consume soil have a tendency towards iron deficiency. In the test group, 34 of the 48 individuals had results consistent with iron deficiency. Ferritin is an acute phase protein and may increase during an acute phase response, masking a diagnostically low ferritin result (Bishop, *et al.* 2000: 326; Alan 2006: 393). CRP is an indicator of an acute phase response and two more individuals in the test group could be considered iron deficient if a possible acute phase response masked a low ferritin level, increasing the number of individuals in the test group with iron deficiency to 36 out of 48, making up 75% of individuals in the test group. In comparison, only 8 of the 35 individuals in the control group had results typical of iron deficiency. If the two subjects with possible iron deficiency, masked by acute phase response, are added, the subjects with iron deficiency in the control group amounted to 26%. The occurrence and severity of iron deficiency in geophagous individuals does not seem to be related to the amount of soil consumed, as the intake of soil in seven subjects with severe iron deficiency ranged from once a day for 1 year, to more than once a day for 15 years.

Stiegler (2005) and Abrahams (2002) were both of the opinion that iron deficiency is associated with geophagia. Young *et al.* (2008) suggested that people consume soil to try and correct deficiencies in nutrients such as iron, or that the deficiency causes alteration in taste sensitivity and as a result the individual finds non-food substances such as soil appealing. The results concur with these statements; however, it is almost impossible to establish whether the deficiency caused the craving for soil, or if the soil consumption is the cause of the deficiency. Young *et al.* (2008) also suspected that there was a possibility that geophagia might be the cause of nutrient deficiency, especially iron deficiency anaemia.

Von Garnier *et al.* (2008) stated that the kaolinite in soil has the ability to absorb iron in the duodenum, where iron absorption occurs, and as a result iron deficiency anaemia ensues. Hooda *et al.* (2004) conducted a study to investigate the bio-availability of minerals in soil, and they also found that, instead of releasing iron and minerals, the soil removes already available nutrients, particularly iron, from the individual.

The ability of soil to remove, rather than supplement, nutrients would better explain the iron deficiency in geophagous woman, as the iron deficiency does not seem to improve, even after soil consumption. If soil had the ability to release bio-available iron in the digestive tract, it would be safe to assume that the released iron would be absorbed and rectify the iron deficiency. This notion is supported by the fact that in a case study of a geophagous woman, iron deficiency was normalised after the deficient nutrients and iron were supplemented intravenously and the woman stopped consuming soil (Trivedi *et al.* 2005).

4.5 Haematological results related to iron status

A full blood count (FBC) is done routinely in a haematology laboratory to assess quantity and quality of red blood cells in the peripheral blood. The haemoglobin content and size of the red blood cells can be measured on most routine analysers. The haematological tests were done by another researcher in the research team (Raphuthing *et al.* 2011). The following parameters, included in a routine FBC, relate to assessment and diagnosis of anaemia:

Haemoglobin (Hb) is contained within red blood cells and its function is to carry oxygen. Each Hb molecule is composed of four polypeptide globin chains and a haem molecule containing iron (Mehta & Hoffbrand 2000: 12). Low quantities of iron hinder the formation of the haem molecule, resulting in a low Hb, which in turn causes anaemia (Bishop *et al.* 2000: 322). Mean Corpuscular Volume (MCV) is a measure of the average red blood cell volume. A low MCV means red blood cells are microcytic, which is most commonly caused by iron deficiency. Mean Corpuscular Haemoglobin (MCH) refers to the average mass of haemoglobin per red blood cell in a sample of blood. A low MCH makes the red blood cell hypochromic. Mean Corpuscular Haemoglobin Concentration (MCHC) is a measure of the haemoglobin concentration in a given volume of red blood cell. A low MCHC renders cells hypochromic, which is a feature of microcytic anaemias and common in iron deficiency anaemia (Mehta & Hoffbrand 2000: 26 & 33). Haematocrit (HCT) is the percentage of red blood cells per volume of blood (Marieb 2001: 651) and will be low in people with anaemia (Alan 2006: 515).

Table 4.3 Comparison between the test group and the control group of haematology results related to iron status

	RBC ($x10^6$ µL)	**Hb (g/dL)**	**HCT (%)**	**MCV (fl)**	**MCH (pg/cell)**	**MCHC (g/dL)**
Reference range	3.8 – 5.5	12.0 – 15.2	37 - 46	78 - 101	27 - 31	31 – 35
Control Group						

Mean	4.37	13.30	39.20	90.10	30.30	34.00
SD	0.38	1.06	2.73	7.93	3.32	0.74
Median	4.34	13.40	39.20	91.00	30.70	34.10
Min	3.35	11.00	34.00	67.00	21.30	31.80
Max	5.21	15.90	46.90	120.00	41.30	35.40
75^{th} Percentile	4.61	13.85	40.25	92.50	31.80	34.45
25^{th} Percentile	4.23	12.80	37.55	87.50	29.55	33.80
N	35	35	35	35	35	35
			Test Group			
Mean	4.16	11.30	33.80	79.70	26.90	33.00
SD	0.41	2.02	5.28	11.99	3.98	1.79
Median	4.17	11.45	34.05	81.50	27.50	33.30
Min	2.43	6.00	19.50	34.00	16.50	23.30
Max	4.93	15.4	44.70	97.00	32.90	34.80
75^{th} Percentile	4.38	12.8	37.45	90.00	30.20	33.85
25^{th} Percentile	3.99	9.98	30.58	73.50	24.70	32.60
N	48	48	48	48	48	48
Significance	**$p<0.01$**	**$p<0.001$**	**$p<0.001$**	**$p<0.001$**	**$p<0.001$**	**$p<0.001$**

Reference ranges used at NHLS, Universitas Academic hospital, Bloemfontein. Available from: http://www.nhls.ac.za.Haematology.pdf

All the parameters of the control group were within the normal range, i.e. no anaemia was evident from the haematology results. In the geophagia group, the mean value for Hb (11.30 g/dL) was below normal, revealing the presence of anaemia. The anaemia in the test group, when compared to the control group, was even more evident when looking at the minimum and maximum values obtained for Hb. The minimum Hb in the control group was 11.0 g/dL, whereas the minimum Hb in the test group was only 6.0 g/dL. In 1989, the National Research Council also stated that geophagous women tended to be more anaemic than non-geophagous women (Wilson 2003). The presence of anaemia in the test group was confirmed by the low HCT mean (33.80%). The HCT mean in the control group (39.20%) was normal. The MCV of the test group (79.70 fl) was within the normal range; however, it could be considered a low normal, and the difference in the MCV between the control and test group was significant. The mean MCH of the test group (26.90%) was low, making it a hypochromic anaemia. The mean values of the Hb, MCV, MCH and MCHC in the test group indicate that there was a tendency toward a hypochromic microcytic anaemia. Iron deficiency is known to result in a hypochromic microcytic anaemia, i.e. low Hb, MCV and MCHC (Mehta & Hoffbrand 2000: 33).

4.6 Comparison between biochemical and haematological results

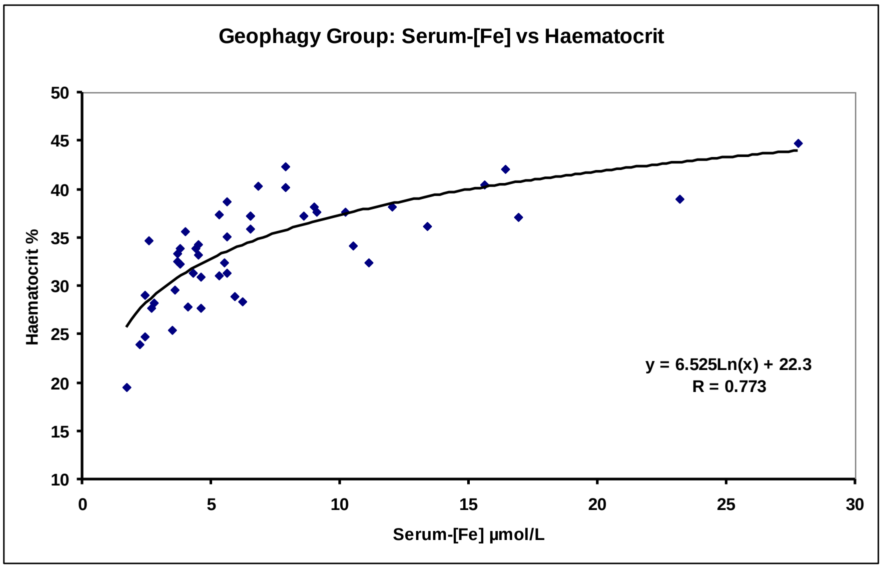

Figure 4.11 Correlation between serum iron and haematocrit in the test group

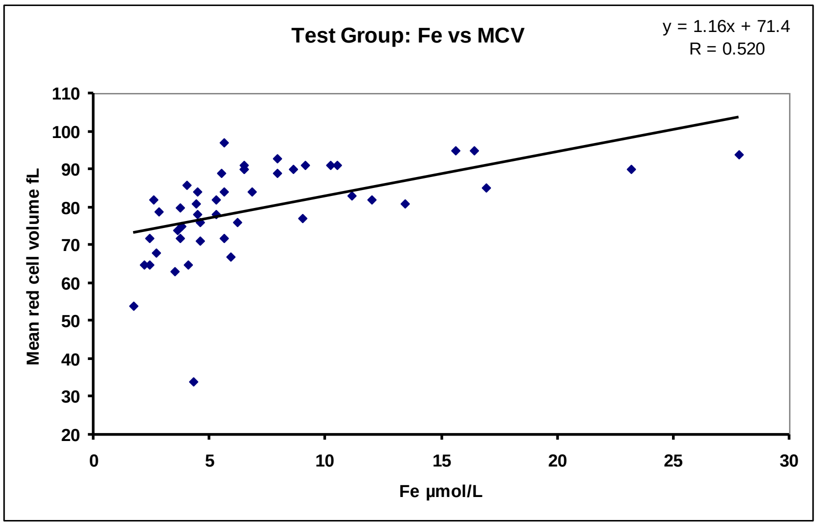

Figure 4.12 Graph showing the correlation between the MCV and serum iron in the test group

The positive correlation between the serum iron and haematocrit is in accordance with the hypothesis that geophagous individuals suffer from anaemia, most probably brought on by iron deficiency. The positive correlation between the serum iron and MCV in the test group was another display that the microcytic tendency of the red blood cells was possibly related to the iron deficiency.

Of the 34 test group subjects with iron deficiency, 18 had a hypochromic microcytic anaemia, which is typical of iron deficiency. A hypochromic normocytic anaemia was seen in two of the individuals with iron deficiency, and 5 of the 34 only had a low Hb. There were no apparent haematological features of anaemia in 9 of the 34 subjects with iron deficiency.

In the control group, three subjects had a below normal Hb. One of them had features of hypochromic anaemia, and biochemical results revealed that the subject had iron deficiency. Another of the three subjects with a low Hb who had a severe iron deficiency, had a microcytic, hypochromic anaemia. The other subject with a low Hb, had no haematological features of anaemia other than the low Hb.

From the biochemistry and haematology results it can be deducted that, in comparison to the control group, the individuals in the test group suffered from iron deficiency anaemia. This finding of iron deficiency anaemia corresponds with the case study of a 22-year-old woman with persistent iron deficiency anaemia, who had a 10-year history of consuming soil. Iron replacement therapy failed to remedy the iron deficiency anaemia, and only after abstaining from soil for as little as a month, the anaemia was corrected by intravenous replacement therapy. In this case the blood count and iron studies remained normal even during follow-up after three months (Von Garnier *et al.* 2008). Ghorbani (2008) stated that iron deficiency anaemia is a lot more common in geophagous children than in non-geophagous children.

4.7 Results related to mineral status

Calcium, magnesium and phosphate analysis was done on all the subjects of both the test group and the control group.

Table 4.4 Calcium, magnesium and phosphate results of the control group compared to those of the test group

	Ca (mmol/L)	Alb (g/L)	Corrected Ca (mmol/L)	Mg (mmol/L)	PO4 (mmol/L)
Reference range	2.05 – 2.56	35 - 52	2.05 – 2.56	0.65 – 1.10	0.80 – 1.40
Control Group					
Mean	2.37	40.80	2.36	0.88	1.12
SD	0.11	3.57	0.07	0.07	0.21
Median	2.38	41.00	2.35	0.87	1.14
Min	2.14	33.60	2.23	0.75	0.71
Max	2.63	47.70	2.50	1.06	1.51
75th Percentile	2.44	43.60	2.39	0.93	1.27

25th Percentile	2.29	38.50	2.31	0.82	1.02
N	35	35	35	35	35
Test Group					
Mean	2.32	39.30	2.34	0.84	1.12
SD	0.11	4.32	0.07	0.08	0.22
Median	2.32	40.20	2.34	0.84	1.13
Min	2.06	29.20	2.19	0.69	0.65
Max	2.53	48.90	2.49	1.12	1.80
75th Percentile	2.40	42.20	2.38	0.88	1.23
25th Percentile	2.26	36.60	2.28	0.80	0.99
N	48	48	48	48	48
Significance	**p<0.05**	**p<0.05**	**NS**	**p<0.05**	**NS**

**NS: Difference in results between the test group and the control group was not enough to be of any significance*

Reference ranges used at NHLS, Universitas Academic hospital, Bloemfontein. Available from: http://www.nhls.ac.za.ChemicalPathology.pdf

Up to 40% of calcium is bound to protein and is therefore altered by changes in protein. Albumin makes up 55 – 60% of protein in the serum. Albumin plays an important role in binding and transporting endogenous substances in the plasma (Alan 2006: 67). A change of 10 g/L in albumin can lead to a change in the calcium concentration of ≤0.2 mmol/l (Alan 2006: 203). It is for this reason that corrected calcium is used for clinical purposes, as it corrects calcium for changes in albumin.

$$\text{Corrected Ca} = [(40 - \text{albumin}) \times 0.025] + \text{Calcium}$$

(Marshall & Bangert 1995: 93)

The difference in the results of phosphate was of no significance either statistically or clinically. The difference in the calcium, albumin and magnesium was big enough to have some statistical significance, but not big enough to be of clinical significance. The mean of the results for all the parameters of both groups were within the normal range and thus, no excess or deficit was established in either group.

Hunter (2003) was of the opinion that soil has the ability to increase calcium levels. His theory was that clay slows down gastrointestinal mobility and, as a result, the absorption time of calcium from food was increased (Hunter 2004). There is not much information available on the effects of soil on magnesium and phosphate, other than that it is believed to contain these nutrients and as a result must supplement these minerals in the human body when consumed (Johns & Duqutte 1991; Abrahams 2002; Hunter 2003; Ghorbani 2008; Rosenberg 2009).

No definite association could be established between soil consumption and mineral status. Only 2 of the 48 subjects in the test group (0.04%) had below normal phosphate levels, and 3 of the 48 (0.06%) had elevated phosphate levels. In the control group 3 of the 35 subjects (0.08%) had elevated phosphate levels and 3 of the 35 (0.08%) had decreased levels. All the results for calcium and magnesium for both the test group and the control group were within the normal ranges. It is therefore difficult to prove or disprove the assertion that soil consumption might somehow influence the balance of these nutrients. It could be true that the soil has no significant effect on calcium, magnesium or phosphate, but it could also be possible that the individuals consuming soil may have had a deficiency of these elements and the consumption of soil has rectified the deficiency. In the study by Dreyer, Chausev & Gledhill (2004), a soil-consuming woman, taking in less than the daily requirement of calcium through her diet, had normal calcium levels, which might lead us to believe that the soil may have supplemented her calcium intake. The fact that there was no significant difference between the test group and the control group regarding levels of calcium, magnesium or phosphate, is, however, in contradiction to this theory that soil can supplement calcium in the diet.

4.8 Summary of results

The test group included 48 individuals and the control group 35, all of which were given a laboratory tracking number for identification. Subjects in the control group were chosen from the same household, if possible, or from the same area as control group subjects, in an attempt to make sure subjects were exposed to the same foods and elements.

There was no significant difference in the BMI of the test group and the control group and results were relatively within the normal range. Thus it can be assumed that any possible nutritional deficit was probably more a result of malnutrition rather than starvation.

In the test group 71% of the subjects had low ferritin results, compared to only 34% of subjects in the control group. Ferritin is considered a sensitive marker for iron deficiency, and therefore iron deficiency in most subjects of the test group was a strong possibility. In the test group 71% of the subjects had low iron levels and only 25% of the subjects in the control group had low iron levels. The mean transferrin of both the test group and the control group was within the normal range, however, the mean of the transferrin in the test group was higher, which indicates decreased iron status. The transferrin saturation of 85% of the subjects in the test group was decreased, and only 37% of the subjects in the control group had transferrin saturation levels below the normal range. The p-values ($p<0.001$) indicate that the differences of parameters related to iron status between the test group and the control group were statistically significant.

A diagnosis of iron deficiency anaemia is made if the ferritin, serum iron and transferrin saturation is decreased and transferrin increased, and a hypochromic microcytic anaemia exists (Price & Wilson 2003: 203). When comparing the biochemical and haematology results, it can be assumed that the anaemia is related to the iron deficiency.

The biochemical results showed that, in comparison to non-geophagous individuals, people who consume soil have a tendency towards iron deficiency, as 75% of the subjects in the test group had iron deficiency, compared to only 26% of subjects in the control group. The occurrence and severity of the iron deficiency did not seem to be related to the amount of soil consumed.

The haematology results revealed possible anaemia in the test group, as the mean Hb was below the normal range. The low mean values of the MCV, MCH and MCHC in the test group indicated that there was a tendency towards a hypochromic microcytic anaemia, which is typical in anaemia brought on by iron deficiency. All the results support the theory that geophagous individuals, in comparison to non-geophagous individuals, suffer from iron deficiency anaemia.

The difference in mineral results between the test group and the control group had some statistical significance, but the difference in the results held no clinical significance however.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

A debate on the possible benefits that soil can have for the consumer has been going on for a while now. The only thing researchers agree on is that soil, when ingested, affects the balance of nutrients in the geophagist. The aim of this study was to determine whether there was an association between soil consumption and iron and mineral deficiency.

It was clear from the results that the individuals in the test group when compared to the control group, suffers from iron deficiency anaemia. Although it has been established in this study that there is an association between iron deficiency anaemia and geophagia, it was not possible to say whether it is the geophagia that caused the deficiency, or the deficiency that caused the craving for soil. The argument leads to the iron deficiency causing the craving for soil. No definite association could be established between mineral status and geophagia.

5.2 Recommendations

5.2.1 Application of results

The results can be used as a backdrop to assist in educating the citizens on the advantages and possible disadvantages of consuming soil

Support should be given to those women with iron deficiency to try and rectify the deficit, whether in the form of medication or education on daily intake through diet.

5.2.2 Future research

A study involving the same parameters and approach as this one could be performed on subjects outside the QwaQwa area, being more representative of the geophagia population as a whole.

If it is at all possible, a study could be performed to solve the "chicken or egg dilemma". The question needs to be answered on whether the geophagia causes the iron deficiency, or whether the iron deficiency causes the craving for soil. If the latter proves to be true, then steps can be taken to rectify the iron deficiency, and in this way prevent people from craving soil, as soil holds other disadvantages.

The role that chelation could have played in lowering iron levels of the group practicing geophagia can be investigated. Chelation in soil increases nutrient availability to plants. It could be that the chelating agents in soil can lead to iron deficiency because it removed iron from the women consuming soil.

As very little literature exists on the association between geophagia and minerals, especially phosphate, the field is wide open for research to be conducted in this area. Minerals, other than calcium, magnesium and phosphate can be included in the study.

Although geophagia is seen more commonly in woman of childbearing age, it may be necessary to investigate the occurrence and effects of geophagia of individuals in other age groups. Although rare, the practice of geophagia can also occur in men and, as such, they can also be included in the study population.

5.3 Drawbacks of this study

Limitations on cost, time and accessibility prevented a larger sample size from being used. A bigger study population would have been more representative of the QwaQwa population. Another factor contributing to the small sample size is unwillingness of individuals to give blood and participate in the study.

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APPENDIX A - Questionnaire

NATIONAL RESEARCH FOUNDATION

In partnership with

University of Limpopo
Central University of Technology
University of Botswana
University of Swaziland

SOUTH AFRICAN REGIONAL COOPERATION FUND FOR SCIENTIFIC RESEARCH AND TECHNOLOGICAL DEVELOPMENT

NRF Grant UID 63583
Research Project
Human and Enzootic Geophagia in South Africa, Botswana and Swaziland

QUESTIONAIRE RELATED TO HUMAN GEOPHAGIA: ADULT
2009

QUESTIONNAIRE RELATED TO HUMAN GEOPHAGIA: ADULT

INTRODUCTION

The University of Limpopo in the Limpopo Province and the Central University of Technology, Free State in Bloemfontein, South Africa - in collaboration with the Universities of Swaziland and Botswana - are conducting a study to characterise habits related to human and enzootic geophagia in South Africa, Botswana and Swaziland. It is also designed to characterise, in physico-chemical, microbiological, mineralogical and ecological terms, the soils that are preferred by geophagic individuals and animals in these three countries. This exercise is mainly for academic purposes; however, the information gathered may be used generally to improve methods of harvesting geophagic soils that will guarantee the health of geophagic individuals. Strict confidentiality of the information provided is guaranteed at all times, and respondents are therefore urged to cooperate fully with the interviewers in order to facilitate this study.

For office use only

Number [ ] 1-7

Date of interview: ________________ (dd/mm/yy) [ ] 8-13

Name of interviewee (optional): ________________ [ ] 14-16

Country: [ ] 17

RSA	Botswana	Swaziland

Region: [ ] 18

Free State		
Limpopo		
North West		
Gauteng		

District: ________________ [ ] 19-20

A. DEMOGRAPHIC INFORMATION

1. Geographic Information

1. Location: [ ] 21

Rural	Suburban	Urban

2. Specify town or area: ________________ [ ] 22-23

2. Personal and Demographic Information

3. Gender [ ] 24

Male	Female

4. Age: ________________ (years) [ ] 25-26

5. Ethnic Group: [ ] 27

- [ ] Afrikaans
- [ ] English
- [ ] Sesotho
- [ ] Setswana
- [ ] siSwati
- [ ] isiXhosa
- [ ] isiZulu
- [ ] Other, please specify: ________________ [ ] 28-29

6. Number of children: ________________ [ ] 30-31

	6.1 Age of Child	6.2 Gender of child		
1			32-33	34
2			35-36	37
3			38-39	40
4			41-42	43
5			44-45	46
6			47-48	49
7			50-51	52
8			53-54	55

1

7. Marital status: | Married | Divorced | Single | Widowed | Engaged | Cohabiting | 56

8. Income source: [ ] Wage employment 57
[ ] Non-wage employment
[ ] Other, please specify:________________ 58-59

9. Occupation: ________________________________ 60-61

10. Monthly income: R/Pula________________ 62-67

11. Highest educational level attained: [ ] No schooling 68
[ ] Primary
[ ] Secondary
[ ] Tertiary

12. Highest grade/standard completed successfully:
________________(if GRADE is applicable) 69-70
________________(if STANDARD is applicable) 71-72

13. Number of years in formal education: ____________ years 73-74

B. SOCIO-ECONOMIC AND CULTURAL ASPECTS

1. Geophagic Habits

14. Are you presently in the habit of eating soil? | Yes | No | 75

14.1 If **YES**, how often do you eat soil? [ ] Once a month 76
[ ] Once a week
[ ] Once a day
[ ] More than once a day

14.2 If **YES**, for how long have you been eating soil? ______________(years) 77-78

15. What is/are your reason(s) for eating soil?
[ ] Standard practice (cultural, traditional, spiritual) 1
[ ] Craving 2
[ ] Medicinal value 3
[ ] Supplement diet 4
[ ] Ritualistic 5
[ ] When hungry 6
[ ] When pregnant 7
[ ] Don't know 8
[ ] Other, please specify: ____________________ 9 10-11

16. Do you ever crave soil? | Yes | No | 12

16.1 If **YES**, how often? [ ] Regularly - Monthly 13
[ ] Regularly - Weekly
[ ] Regularly - Daily
[ ] Only when pregnant

17. When do you crave soil?

☐ Pregnant	☐ Nauseous, but not pregnant	14	15	
☐ Lactating	☐ Constipated	16	17	
☐ Both pregnant and lactating	☐ Feeling weak	18	19	
☐ Having trouble sleeping	☐ Other, please specify: ______________	20	21	22-23

18. When **pregnant**, how often do you eat soil? — 24

- ☐ Once a month
- ☐ Once a week
- ☐ Once a day
- ☐ Other, please specify: ______________________ — 25-26

19. Do you eat any other non-food substance? Yes | No — 27

19.1 If **YES**, name the substance: ______________________________________ — 28-29

20. How often do you eat this substance? — 30

- ☐ Daily
- ☐ More than once a day
- ☐ Weekly
- ☐ Monthly

21. How much of the soil do you eat?

Daily	1	2	3	4	5	31
More than once a day	1	2	3	4	5	32
Weekly	1	2	3	4	5	33
Monthly	1	2	3	4	5	34

22. Do other people know that you eat clay? Yes | No | Don't know — 35

22.1 If **YES**, who knows about it?

- ☐ Family members — 36
- ☐ Extended family members — 37
- ☐ Friends — 38
- ☐ Other, please specify: ____________________ — 39 — 40-41

23. How do people perceive this habit of eating non-food substances?

- ☐ Positive — 42
- ☐ Negative — 43
- ☐ Indifferent — 44
- ☐ Don't know — 45

24. Is this practice of eating soil more common among certain members of the community?
Yes | No | Don't know — 46

24.1 If **YES**, specify: ____ — 47-48

C. INDIGENOUS KNOWLEDGE

25. Which substances are eaten?

- ☐ Soil — 49
- ☐ Clay — 50
- ☐ Soil from termite mounds — 51
- ☐ Other, please specify: _______________ — 52 — 53-54

26. How are the substances eaten?

- ☐ Wet — 55
- ☐ Dry — 56
- ☐ With other food — 57
- ☐ Other, please specify: _______________ — 58 — 59-60

3

27. What are the traditional names of the substances consumed? 61-62 63-64

____

____

28. Where do you obtain your preferred substance?

- [ ] From nature 65
- [ ] Buy it 66
- [ ] Am given it 67
- [ ] Other, please specify: ____________ 68 69-70

28.1 If you **BUY** it, give the brand name: ____________________ 71-72

28.2 If you **BUY** it, indicate the price per handful: R/Pula ____________ 73-76

29. What is the colour of your preferred substance?

- [ ] Reddish 1
- [ ] Yellowish 2
- [ ] Whitish 3
- [ ] Khaki 4
- [ ] Blackish 5
- [ ] Other, please specify: ____________ 6 7-8

30. Why do you prefer to eat a substance of that specific colour?

- [ ] Taste 9
- [ ] Tradition / belief 10
- [ ] Easily accessible 11
- [ ] Other, please specify: ____________ 12 13-14

31. Where do you store the substance? 15-16

____

32. For how long do you usually store the substance?__________(days) 17-19

D. PHYSICO-CHEMICAL, MINERALOGICAL, GEOLOGICAL AND CHEMICAL ASPECTS

33. Where can your preferred substance be found?

- [ ] Hill / mountain 20
- [ ] Riverbed 21
- [ ] Termitaria / termite mound 22
- [ ] Valley 23
- [ ] Pit / excavation 24
- [ ] Other, please specify: ____________ 25 26-27

33.1 If a **termitaria/ termite mound**, from where specifically is the substance collected?

- [ ] From the outer surface of the mound 28
- [ ] Inside the mound above the surface of the soil 29
- [ ] Inside the mound below the surface of the soil 30
- [ ] Does not matter 31
- [ ] Not sure 32

34. Is your preferred substance found close to rocks? | Yes | No | Not sure | 33

34.1 If **YES**, what type of rock?

- [ ] Very hard 34
- [ ] Hard 35
- [ ] Soft 36
- [ ] Very soft 37

35. Substance-collection method

- [ ] Digging — 38
- [ ] Scooping handfuls — 39
- [ ] Scraping — 40
- [ ] Selective hand-picking — 41
- [ ] Other, please specify: ________________ — 42, 43-44

35.1 If **digging**, how deep?______________cm — 45-47

36. How does the substance feel? — 48

- [ ] Gritty
- [ ] Silky
- [ ] Powdery
- [ ] Does not matter
- [ ] Don't know

37. In what condition is the substance collected? | Wet | Dry | Both | — 49

37.1 If **collected wet**, how does the substance feel? — 50

- [ ] Very sticky
- [ ] Sticky
- [ ] Very soapy
- [ ] Soapy
- [ ] None of the above

38. Is the substance processed before being eaten? | Yes | No | Sometimes | — 51

38.1 If **YES**, how is it processed?

- [ ] Grinding — 52
- [ ] Pounding — 53
- [ ] Sieving — 54
- [ ] Slurrying — 55
- [ ] Other, please specify: ________________ — 56, 57-58

39. Is there any heat treatment of the substance before it is eaten? | Yes | No | Sometimes | — 59

39.1 If **YES**, specify the type of heat treatment:

- [ ] Baking — 60
- [ ] Boiling — 61
- [ ] Burning — 62
- [ ] Combination, please specify: ________________ — 63, 64-65
- [ ] Other, please specify: ________________ — 66, 67-68

E. ECOLOGICAL ASPECTS

40. If applicable, please specify the type of termitaria from which you prefer to collect substances?

- [ ] Mound — 69
- [ ] Tree — 70

40.1 If the substance is collected from a **termite mound** (Section C), describe the preferred height of the mound. — 71

- [ ] < 0.5 m
- [ ] 0.5 – 1 m
- [ ] 1 – 2 m
- [ ] > 2 m

40.2 What is the preferred shape of the mound?

- [ ] Conical — 72
- [ ] Flat topped — 73
- [ ] Dome shaped — 74
- [ ] Other, please specify — 75

40.3 Do you prefer to eat the substance when
- [ ] Newly formed
- [ ] Old
- [ ] Does not matter
- [ ] Not sure

76

40.4 In what type of terrain do you normally find these mounds?
- [ ] Flat — 1
- [ ] Hilly — 2
- [ ] Undulating — 3
- [ ] Valley — 4
- [ ] Other, please specify: ________________ — 5 — 6-7

40.5 Do you collect the substance from
- [ ] Mound — 8
- [ ] Base of the mound
- [ ] Some distance from the mound
- [ ] Other, please specify: ________________

41. If substance is collected from a **tree**, do you prefer it to be a particular type of tree? — 9

Yes	No	Not sure	oes not matt

41.1 If **YES**, name the preferred type of tree: ____________________________ — 10-11

F. HUMAN HEALTH ASSOCIATED WITH GEOPHAGIA

42. What is your height?__________(cm) — 12-14

43. What is your weight?__________(kg) — 15-17

44. Do you think that the substance could be harmful? Yes | No — 18

44.1 If **YES**, in what way?
- [ ] Constipation — 19
- [ ] Abdominal pains — 20
- [ ] Poisoning the body — 21
- [ ] Causing tooth decay — 22
- [ ] Other, please specify: ________________ — 23 — 24-25

45. Have you ever undergone surgery for a stomach ailment? Yes | No — 26

45.1 If **YES**,
How many times? ______________ — 27-28
For what reason? ____________________________________ — 29-30
____

46. Do you think there are harmful elements / parasites present in the substance?
Yes | No — 31

47. Do you know the components of the substance? Yes | No — 32

47.1 If **YES**, name these components:
- [ ] Vitamins — 33
- [ ] Calcium — 34
- [ ] Iron — 35
- [ ] Salt — 36
- [ ] Other, please specify: ________________ — 37 — 38-39

48. Why do you eat the substance(s) you do?

- [ ] To clean your body — 40
- [ ] For additional nutritional value — 41
- [ ] To protect against infections — 42
- [ ] Don't know — 43
- [ ] Other, please specify: ______________ — 44 [ ][ ] 45-46

49. Are you often ill (infections like colds, flu, etc.)? [Yes | No] — 47

49.1 If **YES**, how often? — 48

- [ ] More than once a month
- [ ] Once a month
- [ ] Once every three months
- [ ] Twice a year
- [ ] Once a year

50. Do you eat these substances when ill? [Yes | No | Sometimes] — 49

51. Any medical condition diagnosed/experienced [Yes | No] — 50

51.1 If **YES**, which of these?

- [ ] Constant headaches — 51
- [ ] Dizziness — 52
- [ ] Blood in stool — 53
- [ ] Fatigue — 54
- [ ] Chest pains — 55
- [ ] Coughs — 56
- [ ] Muscle pains — 57
- [ ] Tremors — 58
- [ ] Blood in urine — 59
- [ ] Nosebleeds — 60
- [ ] Iron deficiency — 61
- [ ] High Blood pressure — 62
- [ ] Constipation — 63
- [ ] Other, please specify — 64

52. Number of stillborn children (full time)? ________ — 65

53. Number of miscarriages? ________ — 66

54. Number of children born with abnormalities? ________ — 67

55. Name the abnormalities. ______________ — 68-69
______________ — 70-71
______________ — 72-73

Information document

Study title:

Human and Enzootic Geophagia in South Africa, Botswana and Swaziland

Dear participant,
We, the geophagia team (researchers from the University of Limpopo and Central University of Technology, Free State, University of Swaziland and Botswana) are doing research on geophagia (the purposeful ingestion of soils and clays by humans and animals) in Southern Africa. We are asking you to participate in this research project

The study aims to identify and characterize selected soils and clays in Botswana, South Africa and Swaziland that are being ingested by local communities as well as calves, lambs and kids. The study will be directed at identifying soils and clays in target areas, carry out appropriate mineralogical, chemical, microbiological, ecological and environmental health analyses geared towards the documentation of geophagic practices that have been going on for several centuries in these countries. We want to conduct structured questionnaires-response studies which will address aspects related to environmental health and indigenous knowledge (IK) associated with geophagia in these countries. In South Africa the team will conduct structured interviews with 330 adults, 132 children, 110 students and 66 farmers to determine the attitudes and beliefs, standard practice of geophagea, as well as general health status of the respondents. The study will also be conducted in Swaziland and Botswana. In each of Botswana and Swaziland 110 adults, 66 children, 44 students and twenty farmers will be interviewed.

There are no risk being involved in the study, the field worker will ask you a number of questions relating to the practice of geophagia to enable the research team to gain more insight into this practice.

There will be no direct benefits of being involved in the study. However, the study ultimately aims to advance more suitable harvesting techniques of geophagic soils and clays which will aid in reducing down side effects.

You, as participant in the study will be given information on the results of the study once it is completed.

Please note that participation to the study is voluntary and that refusal to participate will involve no penalty. You may discontinue your participation at any time during the study without any penalty.

Efforts will be made to keep personal information confidential. Personal information may be disclosed if required by law. If results are published, this may lead to cohort identification.

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CONSENT TO PARTICIPATE IN RESEARCH

You have been asked to participate in a research study.

You have been informed about the study by………………………………………………

You may contact Prof L de Jager at the Central University of Technology, Dr G Ekosse at the University of Limpopo, Dr M Ditlhogo, University of Limpopo or Dr NO Simelane, University of Swaziland any time if you have questions about the research or if you are injured as a result of the research.

You may contact the Secretariat of the Ethics Committee of the Faculty of Health Science, UFS, Bloemfontein, South Africa at telephone number (051) 405 2812 if you have questions about your right as a research subject.

Your participation in this research is voluntary, and you will not be penalized or lose benefits if you refuse to participate or decide to terminate participation.

If you agree to participate, you will be given a signed copy of this document as well as the participant information sheet, which is a written summary of the research.

The research study, including the above information has been verbally described to me.

I understand what my involvement in the study means and I voluntarily agree to participate.

______________________ Signature of Participant	______________________ Date
______________________ Signature of Witness (if available)	______________________ Date
______________________ Signature of Interviewer	______________________ Date

Pampitshana ya Molaetsa

Sehloho sa Thuto:
Batho le Enzootic Geophagia Afrika e Borwa, Botswana le Swaziland

Dumela Monka-karolo
Re le sehlopha sa diphuputso(Baphupotsi hotswa Yunivesithi ya Limpopo, Yunivesithi e bohareng ya thekenoloji, Foreistata, Yuniovesithi ya Swaziland le Botswana) re etsa dipatlisiso ka ho JA mobu le letsopa ke batho le diphoofolo ho la Afrika e Borwa le di naha tse mabapi. Re kopa hore o nke karolo phupotsong/patlisisong ena.

Thuto e ikemiseditse ho temoho le ho hlopolla mefuta ya mebu le letsopa ho la Botswana, Afrika Borwa le Swaziland e Jewang ke Batho metseng le diphoofolo mmoho le bana. Thuto e tla lebiswa ho temoho ya mobu le letsopa di bakeng tse kgethilweng ho ntshetsa hantle mineralogical, dikhemikale, microbiology, ecological le patlisisa ka tsa bophelo ho I setsa ho ngolweng ha ntle ha tlhaello ena ya ho ja mobu e e sa le e etswa ka dilemo lemo naheng tsena. Re rata ho ntshetsa pele dipotso ka tsela ya thuto e tla buwa ka mabaka a amanang le tsa bophelo di bakeng tsa rona le tshebo ya lehae e amanang le ho ja mobu dinaheng tsena. Afrka borwa sehlopha se tlo etsa dipotso le Batho ba baholo ba kabang 330, Bana ba 132, Bithuti ba 110 le bo ramapolasi ba 66 ho fumana hatle tlhaello le mokgwa, le tumelo mmoho le bophello ka kakaretso ho ba nkakarolo. Thuto ena e boetse e tla etsa dipotso tsena Swaziland le Botswana. Ho se seng le se seng sa sebaka 110 Batho ba baholo, 110 Bana, baithuti 44 bo rapolasi ba 22.

Ha ona kotsi ho nkeng karolo ha hao thutong ena, mosebetsi o tla o botsa dipotso tse mmalwa mabapi le tlwaello ya ho ja mobu ho etsa hore patlisiso e fumane le sedi le itseng ka ho ja mobu.

Ha ho naba le moputso/ kgolo (benefits) e itse ho tla ho wena ka nepo thutong ena. Empa thuto e ekemiseditse ho ntlafatsa mekga e nepahetseng ya ho kga mobu le letsopa e tla fokotsa di tla moraho tse itseng.

Wena tjhe ka monka-karolo otla fumana lesedi hang ha thuto e fedile.

Re kopa o ele hloko ho re ho nka-karolo ha hao ho thuto ea ke ka bo ithaopo hape le ho hana ha hao ho se nke karolo ha ho letlo leo re ka o etsang lona (No penalty). Oka e misa kapa wa tlohela nako engwe le engwe ka thuto ntle le kotlo e itseng.

Maikitlaetso a tla etswa ho o sireletsa ditaba tsa hao ele le kunotu ka hohle hohle. Dibata tsa hao ditla fumaneha fela ka tsela ya molao. E bang tse fumangweng thutong di phatlalatswa sena se ka isa ho phatlallatso e itseng empa esa totoballa. (cohort identification)

TUMALLANO HO NKA KAROLO HO PATLISISO

O kupuwe ho nka karolo thutong ea ya patlisiso

O se o fumane lesedi ka thuto ena?
Ka.......................................

Oka ikopanya le Moporofesa L de Jager Yunivesithing e bohareng ya Foreistata, Ngaka G Ekosse Yunivesithing ya Limpopo, Ngaka M Ditlhogo Yunivesithing ya Limpopo, Ngaka Simelane Yunivesithing ya Swaziland ka nako tsohle ha ona le dipotso ka thuto kapa tse fumangeng patlisisong ena.

Oka boela wa ikopanya le Mokgodi wa komiti ya mekgwa ya bophelo bo bottle le science, UFS, Bloemfontein Afrika Borwa ka mohala nomorong ena (051) 405 2812 ha ona le dipotso ka ditokelo tsa hao tjhe ka monka-karolo.

Ho nka-karolo ha hao ke boithaopo, hape ha ona fumantshwa kotlo kapa wa latlehelwa ke omonyetla oitseng ka ho hana ho nka-karolo kapa ha oka nka qeto ya ho tlohela ebang o ne o se o qadile.

Ha o dumela ho nka-karolo , o tla fumana pampiri ya ho saena le pampitshana ya ditaba mabapi le thuto, e ngotswe ditabana tsa patlilsioso.

Patlisiso , ho kenyeletswa le ditaba tse ngotsweng ka hodimo dibuilwe ho nna. Ke othisisa ho nakakarolo ha ka thutong ho bolellang hape ke e thaopile ho nkakarolo.

______________________ Saene ya Monka-karolo	______________________ Letsatsi
______________________ Saene ya Paki (Ha ho tlokahala)	______________________ Letsatsi
______________________ Saene ya Motsamaisi/mobutsi	______________________ Letsatsi

APPENDIX B – Questionnaire information

TEST GROUP

Lab ID	: ADCI7001
Questionnaire number	: SAQA65
Age	: 19

Soil Consumption:

How long	: Not sure
How often	: Once a day
Why	: Not disclosed
How much	: ½packet a day
Type of soil	: Not disclosed
Why that type	: Not disclosed
How do you prefer soil	: Not disclosed
From where	: Not disclosed
Colour	: White
Is soil processed; How	: Not disclosed
Collection	: Not disclosed
Storage	: Not disclosed
Any other substance	: No

Health:

Height	: 155 cm
Weight	: 72.1 kg
Illness (colds, flu, etc)	: Constipation

Summary of results:

Iron deficiency with a hypochromic, microcytic anaemia. The mineral results are within normal ranges. Infection markers indicate possible infection or acute phase response with elevated CRP and slightly elevated PCT.

Lab ID	:	ADCI7004
Questionnaire number	:	SAQA68
Age	:	44

Soil Consumption:

How long	:	Not disclosed
How often	:	Not disclosed
Why	:	Not disclosed
How much	:	Not disclosed
Type of soil	:	Not disclosed
Why that type	:	Not disclosed
How do you prefer soil	:	Not disclosed
From where	:	Not disclosed
Colour	:	Not disclosed
Is soil processed; How	:	Not disclosed
Collection	:	Not disclosed
Storage	:	Not disclosed
Any other substance	:	Ice, 3 times a week

Health:

Height	:	160 cm
Weight	:	79.5 kg
Illness (colds, flu, etc)	:	No

Summary of results:

Iron deficiency with a hypochromic, normocytic anaemia. Mineral results are within the normal ranges, and infection markers are normal.

Lab ID	:	ADCI7008
Questionnaire number	:	SAQA95
Age	:	25

Soil Consumption:

How long : 5 years

How often : More than once a day

Why : Craving(Pregnant, after eating), Medicinal value, additional nutritional value

How much : 5 packs a day

Type of soil : Soil, Clay (Mobu)

Substance silky

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (Hill/mountain, Pit/excavation) close to hard rocks, Buy it

Colour : Whitish, Yellowish

Is soil processed; How : No

Collection : Digging (±200 cm), Wet and dry

Storage : In plastic containers (7 days)

Any other substance : Chews on Plastic (weekly)

Health:

Height : 155 cm

Weight : 59 kg

Illness (colds, flu, etc) : Once a year, Constant Headaches

Summary of results:

No apparent iron deficiency or anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7009

Questionnaire number : SAQA94

Age : 20

Soil Consumption:

How long : 7 years

How often : More than once a day

Why : Craving (pregnant, before eating), for additional nutritional value

How much : 5 packs a day

Type of soil : Soil, Clay (Mobu)

Substance silky

Why that type : Taste

How do you prefer soil : Wet or Dry

From where : Nature(Hill/mountain, Pit/excavation) close to hard rocks, Buy it

Colour : Whitish

Is soil processed; How : No

Collection : Digging (± 200 cm), Wet and dry

Storage : In plastic containers (7 days)

Any other substance : No

Health:

Height : 152.5 cm

Weight : 45 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

No apparent iron deficiency or anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7010

Questionnaire number : SAQA93

Age : 22

Soil Consumption:

How long : 5 years

How often : Daily

Why : Craving (when pregnant, after eating), Appetite, Taste, for additional nutritional value

How much : 4 packs daily

Type of soil : Soil, Clay (Mobu)

Substance silky

Why that type : Taste

How do you prefer soil : Wet or Dry

From where : Nature (Hill/mountain, Pit/excavation) close t hard rocks, Buy it

Colour : Whitish, Yellowish

Is soil processed; How : Sun exposure

Collection : Digging (±200cm), Wet and Dry

Storage : In plastic containers (7 days)

Any other substance : No

Health:

Height : 157 cm

Weight : 49.5 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

Iron deficiency with a hypochromic, microcytic anaemia. Mineral results are within normal ranges and infections markers are normal.

Lab ID : ADCI7011

Questionnaire number : SAQA71

Age : 30

Soil Consumption:

How long : Not disclosed

How often : More than once a day

Why : Not disclosed

How much : Approxiamately 50 g

Type of soil : Not disclosed

Why that type : Not disclosed

How do you prefer soil : Not disclosed

From where : Not disclosed

Colour : Yellowish

Is soil processed; How : Not disclosed

Collection : Not disclosed

Storage : Not disclosed

Any other substance : Ice, Approximately 12 blocks a day

Health:

Height : 152 cm

Weight : 47.8 kg

Illness (colds, flu, etc) : Not disclosed

Summary of results:

Iron deficiency with a hypochromic, microcytic anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7014

Questionnaire number : SAQA74

Age : 40

Soil Consumption:

How long : Not disclosed

How often : More than once a day

Why : Not disclosed

How much : 50 g

Type of soil : Soil

Why that type : Not disclosed

How do you prefer soil : Not disclosed

From where : Not disclosed

Colour : White

Is soil processed; How : Not disclosed

Collection : Not disclosed

Storage : Not disclosed

Any other substance : No

<u>Health:</u>

Height : 155 cm

Weight : 65.2 kg

Illness (colds, flu, etc) : Not disclosed

<u>Summary of results:</u>

Iron deficiency with a hypochromic, microcytic anaemia. Mineral results show a low phosphate result. Infection markers indicate some inflammatory or acute phase response, as CRP is elevated. Bacterial infection seems unlikely, since PCT is normal.

Lab ID : ADCI7017

Questionnaire number : SAQA96

Age : 34

<u>Soil Consumption:</u>

How long : 20 years

How often : More than once a day

Why : Craving (When pregnant, When see soil)

How much : 5 packets a day

Type of soil : Soil (Mobu), substance silky

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (Pit/excavation) close to hard rocks, Buy it

Colour : Whitish

Is soil processed; How : Pounding, Baking, Sun exposure

Collection : Digging (±200 cm), Wet (Sticky when wet)

Storage : In plastic bags (5 days)

Any other substance : Ice cubes

<u>Health:</u>

Height : 159 cm

Weight : 59.1 kg

Illness (colds, flu, etc) : Twice a year, HIV

Summary of results:

Serum iron and transferrin saturation is low but ferritin is normal. No anaemia present. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7018

Questionnaire number : SAQA97

Age : 20

Soil Consumption:

How long : 5 years

How often : More than once a day

Why : Craving (When see soil), Pregnancy, Taste

How much : 4 packets a day

Type of soil : Soil (Mobu), Substance silky

Why that type : Taste (sour taste)

How do you prefer soil : Dry

From where : Nature (Pit/excavation) close to hard rocks, Buy it

Colour : Whitish

Is soil processed; How : Pounding, Baking, Sun exposure

Collection : Digging (±200 cm)

Storage : On top of roof (5 days)

Any other substance : Ice cubes

Health:

Height : 156 cm

Weight : 53 kg

Illness (colds, flu, etc) : Twice a year

Summary of results:

Iron and Transferrin saturation low, ferritin normal, No anaemia present, Mineral results fall within normalranges. Infection markers indicate the presence of some infection, as all markers are elevated. Since ferritin is an acute phase protein it may increase in response to the infection and thus the ferritin might actually be low, but as a result of the infection, appear normal. This would mean that the individual actually suffers from iron deficiency.

Lab ID : ADCI7022

Questionnaire number : SAQA79

Age : 25

Soil Consumption:

How long : Not disclosed

How often : Once a day

Why : Not disclosed

How much : Not disclosed

Type of soil : Not disclosed

Why that type : Not disclosed

How do you prefer soil : Not disclosed

From where : Not disclosed

Colour : White or Grey

Is soil processed; How : Not disclosed

Collection : Not disclosed

Storage : Not disclosed

Any other substance : No

Health:

Height : 158 cm

Weight : 72.6 kg

Illness (colds, flu, etc) : Not disclosed

Summary of results:

Iron deficiency present, but no anaemia. Mineral results are within normal ranges. Infection markers indicate an inflammatory or acute phase response with the elevated CRP. Bacterial infection is unlikely with the normal PCT result.

Lab ID : ADCI7023

Questionnaire number : SAQA80

Age : 34

<u>Soil Consumption:</u>

How long : Not disclosed

How often : More than once a day

Why : Not disclosed

How much : 200 g

Type of soil : Not disclosed

Why that type : Not disclosed

How do you prefer soil : Not disclosed

From where : Not disclosed

Colour : Gray

Is soil processed; How : Not disclosed

Collection : Not disclosed

Storage : Not disclosed

Any other substance : No

<u>Health:</u>

Height : 161 cm

Weight : 73.7 kg

Illness (colds, flu, etc) : Not disclosed

<u>Summary of results:</u>

Iron deficiency present but no anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7025

Questionnaire number : SAQA87

Age : 20

<u>Soil Consumption:</u>

How long : 3 years

How often : More than once a day

Why : Craving (After rain), Pregnancy, To replace sweets

How much : 3 packets a day

Type of soil : Soil (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : From nature (Pit/Excavation), Buy it

Colour : Red or White

Is soil processed; How : Baking

Collection : Digging (60cm)

Storage : In a plastic bag (14 days)

Any other substance : Chalk (Weekly)

Health:

Height : 153 cm

Weight : 56.6 kg

Illness (colds, flu, etc) : Once every three months, Asthma

Summary of results:

Iron and Transferrin saturation low but ferritin result is normal. No anaemia present. Mineral results reveal a slightly elevated phosphate.. Infection markers are normal.

Lab ID : ADCI7026

Questionnaire number : SAQA89

Age : 19

Soil Consumption:

How long : 2 years

How often : Once a week

Why : Craving, Common practice

How much : 2 packets weekly

Type of soil : Soil (Mobu, Dijo tru Rana), Feels silky

Why that type : Easily accessible

How do you prefer soil : Dry

From where : Nature (Pit/Excavation), Buy it

Colour : White or Brown

Is soil processed; How : Mix with vinegar, Baking

Collection : Digging (60 cm)

Storage : Inside the house in container (2 days)

Any other substance : No

<u>Health:</u>

Height : 156 cm

Weight : 54.1 kg

Illness (colds, flu, etc) : Constant headaches

<u>Summary of results:</u>

Iron deficiency present but no anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7028

Questionnaire number : SAQA98

Age : 21

<u>Soil Consumption:</u>

How long : 5 years

How often : More than once a day

Why : Craving (after eating)

How much : 4 packets a day

Type of soil : Soil (Mobu), Substance silky

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (Pit/excavation) close to hard rocks, Buy it

Colour : Whitish

Is soil processed; How : Baking

Collection : Digging (±10 cm), Dry

Storage : In plastic bag (2 days)

Any other substance : No

Health:

Height : 151 cm

Weight : 50.9 kg

Illness (colds, flu, etc) : Once every three months, Constant headaches

Summary of results:

Iron deficiency present with no anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7029

Questionnaire number : SAQA100

Age : 18

Soil Consumption:

How long : 4 years

How often : More than once a day

Why : Craving (After eating)

How much : 3 packets a day

Type of soil : Soil, Clay (Mobu), Substance gritty or silky

Why that type : Taste, Easily accesible

How do you prefer soil : Dry

From where : Nature (Pit/excavation) close to hard rocks, Buy

Colour : Reddish, Whitish, Khaki

Is soil processed; How : Baking

Collection : Digging (±10 cm), Dry

Storage : In plastic bags (1 day)

Any other substance : No

<u>Health:</u>

Height : 154 cm

Weight : 54.8 kg

Illness (colds, flu, etc) : Twice a year, Constant headaches

<u>Summary of results:</u>

Iron deficiency with hypochromic, microcytic anaemia Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7031

Questionnaire number : SAQA99

Age : 18

<u>Soil Consumption:</u>

How long : 3 years

How often : Once a month

Why : Taste, for fun

How much : 1 packet a month

Type of soil : Clay (Mobu), Substance Gritty

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (Pit/excavation) close to hard rocks, Buy

Colour : Whitish

Is soil processed; How : No

Collection : Digging (±10 cm), Dry

Storage : In a plastic bag (30 days)

Any other substance : No

<u>Health:</u>

Height : 156 cm

Weight : 45.8 kg

Illness (colds, flu, etc) : Twice a year

<u>Summary of results:</u>

A slight iron deficiency present with no anaemia. Mineral results are within normal ranges, except for slightly elevated phosphate, and infection markers normal.

Lab ID	: ADCI7032
Questionnaire number	: SAQA101
Age	: 30
<u>Soil Consumption:</u>	
How long	: 7 years
How often	: More than once a day
Why	: Standard practice, Craving (Any time), Pregnancy, Additional nutritional value
How much	: 5 packets a day
Type of soil	: Soil (Mobu), Substance silky
Why that type	: Easily accessible
How do you prefer soil	: Dry
From where	: Nature (Hill/mountain, Pit/excavation) close to soft rocks, Buy it
Colour	: Whitish
Is soil processed; How	: Baking, Sun exposure
Collection	: Digging (±200 cm), Wet(soapy when wet) and dry
Storage	: In a steel container (30 days)
Any other substance	: No
<u>Health:</u>	
Height	: 162 cm
Weight	: 76 kg
Illness (colds, flu, etc)	: Twice a year, Constant headaches

<u>Summary of results:</u>

Subject suffers from a severe iron deficiency with a hypochromic, microcytic anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7037

Questionnaire number : SAQA104

Age : 35

<u>Soil Consumption:</u>

How long : 10 years

How often : More than once a day

Why : Craving (After eating), Pregnancy

How much : 5 packets a day

Type of soil : Soil (Mobu), Substance gritty

Why that type : Taste, Easily accessible

How do you prefer soil : Dry

From where : Nature (Pit/excavation), close to soft or hard rocks

Colour : Whitish, Khaki

Is soil processed; How : Pounding, Baking

Collection : Digging (±10 cm), Wet and Dry (soapy when wet)

Storage : In a steel container (2 days)

Any other substance : No

<u>Health:</u>

Height : 146 cm

Weight : 50.8 kg

Illness (colds, flu, etc) : No, Diagnosed with high blood pressure

<u>Summary of results:</u>

Iron deficiency with a hypochromic, microcytic anaemia. Mineral results are wihtin normal ranges and infection markers normal.

Lab ID : ADCI7039

Questionnaire number : SAQA105

Age : 35

Soil Consumption:

How long : 2 years

How often : More than once a day

Why : Craving (When smell it), Pregnancy

How much : 5 packets a day

Type of soil : Soil (Mobu), Substance silky

Why that type : Taste, easily accessible

How do you prefer soil : Dry

From where : Nature (Pit/excavation), close to hard rocks

Colour : Whitish

Is soil processed; How : Sometimes - Pounding

Collection : Digging (10 cm), Dry

Storage : No

Any other substance : No

Health:

Height : 158 cm

Weight : 63.4 kg

Illness (colds, flu, etc) : Once every three months

Summary of results:

Iron deficiency with a hypochromic, microcytic anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7040

Questionnaire number : SAQA102

Age : 18

Soil Consumption:

How long : 3 years

How often : More than once a day

Why : Craving (daily, anytime), Just because

How much : 2 packets a day

Type of soil : Soil (Mobu), substance silky

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (Pit/excavation), close to hard rocks

Colour : Whitish

Is soil processed; How : Pounding, Sun exposure

Collection : Digging (±60 cm)

Storage : In the house in a plastic bag (5 days)

Any other substance : No

Health:

Height : 156 cm

Weight : 79 kg

Illness (colds, flu, etc) : Twice a year

Summary of results:

Subject suffers from a severe iron deficiency with a hypochromic, microcytic anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7042

Questionnaire number : SAQA103

Age : 37

Soil Consumption:

How long : 1 year

How often : Once a month

Why : Craving (After rain), Additional nutritional value

How much : 1 packet a month

Type of soil : Clay (Mobu), Substance silky

Why that type : Taste

How do you prefer soil : Dry

From where : Buy it

Colour : Whitish

Is soil processed; How : Baking

Collection : N/A

Storage : In a plastic bag in the house (14 days)

Any other substance : No

Health:

Height : 155 cm

Weight : 96 kg

Illness (colds, flu, etc) : Twice a year

Summary of results:

Subject suffers from a severe iron deficiency with a hypochromic, microcytic anaemia. Mineral results reveal Calcium and Phosphate levels slightly below normal. Infection markers indicate the presence of an inflammatory or acute phase response with the elevated CRP. Bacterial infection seems unlikely with normal PCT and WCC.

Lab ID : ADCI7047

Questionnaire number : SAQA106

Age : 18 years

Soil Consumption:

How long : 4 years

How often : More than once a day

Why : Craving (After eating), Sour taste

How much : 3 packets a day

Type of soil : Soil (Mobu), substance gritty

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (Pit/excavation), close to soft rocks, Buy

Colour : Whitish

Is soil processed; How : Grinding, Pounding, Baking

Collection : Digging (±10 cm), Wet (Soapy when wet)

Storage : In the house in a steel container (3 days)

Any other substance : No

<u>Health:</u>

Height : 159 cm

Weight : 60 kg

Illness (colds, flu, etc) : Once a year

<u>Summary of results:</u>

Iron deficiency present with anaemia revealed by low Hb. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADST1901

Questionnaire number : SAQA112

Age : 33

<u>Soil Consumption:</u>

How long : 9 years

How often : Once a day

Why :Craving (smell), Common practice, for additional nutritional value

How much : 4 packets a day

Type of soil : Clay (Mobu), substance silky

Why that type : Taste, Easily accessible

How do you prefer soil : Dry

From where : Nature (hill/mountain), close to soft rocks, Buy it

Colour : Whitish

Is soil processed; How : Pounding, Baking

Collection : Digging (±100 cm), wet and dry (soapy when wet)

Storage : In a steel container (2 days)

Any other substance : No

<u>Health:</u>

Height : 166 cm

Weight : 60 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

Iron deficiency present with no anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADST1902

Questionnaire number : SAQA111

Age : 26

Soil Consumption:

How long : 13 years

How often : Once a day

Why : Craving (When pregnant, after rain), Common practice, Additional nutritional value

How much : 4 packets a day

Type of soil : Clay (Mobu)

Why that type : Taste, Easily accessible

How do you prefer soil : Dry

From where : Nature (Hill/mountain), close to soft rocks, Buy it

Colour : Whitish

Is soil processed; How : Pounding, Baking

Collection : Digging (±100 cm), Dry and wet (soapy when wet)

Storage : In a steel container (2 days)

Any other substance : No

Health:

Height : 154 cm

Weight : 62 kg

Illness (colds, flu, etc) : Twice a year

Summary of results:

All results within normal ranges, except for a slightly elevated phosphate level.

Lab ID : ADST1906

Questionnaire number : SAQA109

Age : 18 years

Soil Consumption:

How long : 1 year

How often : Once a day

Why : Craving (After eating), Taste

How much : 1 packet a day

Type of soil : Soil (Mobu), substance silky

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (Pit/excavation), close to hard rocks, Buy

Colour : Whitish

Is soil processed; How : Pounding, Sun exposure

Collection : Digging (±10 cm), Wet and Dry

Storage : In a plastic bag in the house (5 days)

Any other substance : No

Health:

Height : 160 cm

Weight : 49.2 kg

Illness (colds, flu, etc) : Twice a year

Summary of results:

Iron and transferrin saturation levels are low, however the ferritin level fall within the normal range. Subject has a hypochromic, normocytic anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADCI7046

Questionnaire number : SAQA107

Age : 18 years

Soil Consumption:

How long : 3 years

How often : More than once a day

Why : Craving (When need sour taste), Pregnancy

How much : 2 packets a day

Type of soil : Soil (Mobu), substance gritty

Why that type : Easily accessible, Taste

How do you prefer soil : Dry

From where : Buy it, Nature (Pit/excavation), close to hard rocks

Colour : Whitish

Is soil processed; How : Baking

Collection : Digging (±10 cm), Dry

Storage : In a plastic bag (7 days)

Any other substance : No

Health:

Height : 154 cm

Weight : 57 kg

Illness (colds, flu, etc) : Twice a year, Constant headaches

Summary of results:

Iron and transferrin saturation levels are low however the ferritin level is within normal range. No anaemia present and mineral result and infection markers are within normal ranges.

Lab ID : ADST1907

Questionnaire number : SAQA108

Age : 22 years

Soil Consumption:

How long : 7 years

How often : Once a week

Why : Craving (Daily, after eating)

How much : 1 packet a week

Type of soil : Soil (Mobu), substance silky

Why that type : Taste

How do you prefer soil : Dry

From where : Buy it

Colour : Whitish

Is soil processed; How : No

Collection : N/A

Storage : In plastic bags in the house (30 days)

Any other substance : No

Health:

Height : 152 cm

Weight : 59.9 kg

Illness (colds, flu, etc) : Once a year, Constant headaches

Summary of results:

All results are within normal ranges.

Lab ID : ADST1900

Questionnaire number : SAQA110

Age : 40

Soil Consumption:

How long : 4 years

How often : More than once a day

Why : Craving (when bored), Taste, Additional nutritional value

How much : 5 packets a day

Type of soil : Clay (Mobu), substance silky

Why that type : Taste, Easily accessible

How do you prefer soil : Dry

From where : Nature (close to soft rocks), Buy it

Colour : Whitish

Is soil processed; How : Pounding, Baking

Collection : Digging (± 100 cm), wet and dry (soapy when wet)

Storage : In a bottle container (2 days)

Any other substance : No

Health:

Height : 164 cm

Weight : 56 kg

Illness (colds, flu, etc) : Twice a year, Muscle pains

Summary of results:

All results within normal ranges.

Lab ID : ADST1909

Questionnaire number : SAQA114

Age : 26

Soil Consumption:

How long : 12 years

How often : Once a month

Why : Craving, on a weekly basis, when it's raining

How much : ½packet

Type of soil : Soil, Clay (Mobu)

Why that type : Taste (sour)

How do you prefer soil : Dry

From where : From nature (Hill, mountain, sometimes outside house), Buy it,

Colour : Yellow

Is soil processed; How : No

Collection : Digging (10cm)

Storage : Hide it in dry place (3 days)

Any other substance : Ice, weekly

<u>Health:</u>

Height : 157 cm

Weight : 46 kg

Illness (colds, flu, etc) : Once a month

<u>Summary of results:</u>

Iron deficiency present with a hypochromic, microcytic anaemia. Mineral results are within normal ranges. Infection markers indicate the possibility of an inflammatory or acute phase response with a slightly elevated CRP. Bacterial infection seems unlikely with normal PCT.

Lab ID : ADST1911

Questionnaire number : SAQA116

Age : 23

<u>Soil Consumption:</u>

How long : 7 years

How often : Once a month

Why : Craving, Weekly, Smell after rain

How much : 3 packets

Type of soil : Soil (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : Buy it, Digging (Found close to hard rock)

Colour : Greyish

Is soil processed; How : No

Collection : Digging (50cm), feels gritty or silky

Storage : In schoolbag (5 days)

Any other substance : No

<u>Health:</u>

Height : 164 cm

Weight : 53 kg

Illness (colds, flu, etc) : 2x per year

<u>Summary of results:</u>

Subject suffers from a severe iron deficiency with a hypochromic, microcytic anaemia. Mineral results are within normal ranges andiInfection markers are normal.

Lab ID : ADST1913

Questionnaire number : SAQA117

Age : 21

<u>Soil Consumption:</u>

How long : ± 1 year

How often : More than once a day (when pregnant, 2x per week)

Why : Craving (Daily), Taste (sour)

How much : 4 packets

Type of soil : Clay (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : Buy it (from hill or mountain), Digging

Colour : Yellow

Is soil processed; How : Yes, baking in oven

Collection : Digging (dig until hit rock, still wet)

Storage : In the sun (3 days)

Any other substance : No

<u>Health:</u>

Height : 161 cm

Weight : 72 kg

Illness (colds, flu, etc) : Sinus, more than once a month

Summary of results:

Iron deficiency with a slight anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADST1921

Questionnaire number : SAQA118

Age : 30

Soil Consumption:

How long : 20 years

How often : More than once a day, when pregnant more than once a day

Why : Craving daily, after rain and after eating

How much : 2 packs per day

Type of soil : Clay (Mobu)

Why that type : Taste, tradition, belief, easily accessible

How do you prefer soil : Wet or Dry

From where : Nature (Pit/excavation), close to soft rock

Colour : Reddish, Yellow

Is soil processed; How : Baking in oven

Collection : Digging with knife/hand (very deep), wet, sticky

Storage : No

Any other substance : No

Health:

Height : 150 cm

Weight : 69 kg

Illness (colds, flu, etc) : No

Summary of results:

Subject suffers from a slight iron deficiency and anaemia. Mineral results and infectionn markers are within normal ranges.

Lab ID : ADST1922

Questionnaire number : SAQA119

Age	: 22

Soil Consumption:

How long	: 16 years
How often	: More than once a day
Why	: Craving (daily), after rainfall, after consumption
How much	: 2 packs per day
Type of soil	: Clay (Mobu)
Why that type	: Taste (sour)
How do you prefer soil	: Wet or Dry
From where	: Nature (Pit/excavation)
Colour	: Reddish/Whitish
Is soil processed; How	: Baking in oven
Collection	: Digging with knife or fork (very deep), Wet/Sticky
Storage	: No
Any other substance	: Chalk (Monthly)

Health:

Height	: 155 cm
Weight	: 69 kg
Illness (colds, flu, etc)	: Headache, twice a week

Summary of results:

Iron deficiency with a hypochromic, microcytic anaemia. Mineral results are within normal ranges. Infection markers indicate the presence of inflammatory or acute phase response with high CRP and WCC, normal PCT reduces the possibility of the cause being bacterial.

Lab ID	: ADST1923
Questionnaire number	: SAQA120
Age	: 23

Soil Consumption:

How long	: 1 year

How often : Once a month

Why : Taste, Medicinal value, Craving (When someone else eats it)

How much : 4 packs

Type of soil : Clay (Mobu), Gritty/Silky

Why that type : Taste

How do you prefer soil : Dry

From where : Given it

Colour : Whitish, Khaki

Is soil processed; How : No

Collection : Given

Storage : On open plastic (2 days)

Any other substance : No

Health:

Height : 156 cm

Weight : 48 kg

Illness (colds, flu, etc) : 2x per year, eye problems

Summary of results:

All results within normal ranges.

Lab ID : ADST1924

Questionnaire number : SAQA121

Age : 22

Soil Consumption:

How long : 1 year

How often : Once a day

Why : Craving (Daily)

How much : 1 packet a day

Type of soil : Clay (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : From nature (Pit/excavation)

Colour : Whitish (Silky)

Is soil processed; How : Pounding, Baking in oven or exposure to sun

Collection : Digging (30 cm), Wet and Dry (if wet, soapy)

Storage : In a closed container (14 days)

Any other substance : No

Health:

Height : 153 cm

Weight : 53 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

Subject suffers from a severe iron deficiency with a hypochromic, microcytic anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADST1925

Questionnaire number : SAQA122

Age : 30

Soil Consumption:

How long : 3 years

How often : Once a week

Why : Taste, Craving

How much : 1 packet

Type of soil : Any (Mobu)

Why that type : Easily accessible

How do you prefer soil : Wet or Dry

From where : Nature

Colour : Reddish

Is soil processed; How : Sundried in the window

Collection : Digging (Pen length), Wet

Storage : Sundry in the window (1 day)

Any other substance : No

<u>Health:</u>

Height : 152 cm

Weight : 76 kg

Illness (colds, flu, etc) : Flu, once a year in summer

<u>Summary of results:</u>

All results are within normal ranges.

Lab ID : ADST1926

Questionnaire number : SAQA123

Age : 24

<u>Soil Consumption:</u>

How long : ± 1 year

How often : More than once a day

Why : Craving (Daily, Early morning and evening)

How much : 2 packets daily

Type of soil : Soil

Why that type : Taste

How do you prefer soil : Dry

From where : From nature (Pit/excavation), Close to soft rock

Colour : Reddish

Is soil processed; How : No

Collection : Digging (10 cm)

Storage : Window sill (2 days)

Any other substance : No

<u>Health:</u>

Height : 162 cm

Weight : 72 kg

Illness (colds, flu, etc) : Headaches twice a month

Summary of results:

Iron deficiency with no anaemia present, although cells are hypochromic, microcytic. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADST1928

Questionnaire number : SAQA124

Age : 24

Soil Consumption:

How long : 15 years

How often : More than once a day

Why : Common Practice, Craving (especially after rain), nutritional value

How much : 3 packets daily

Type of soil : Soil, Clay (Mobu)

Why that type : Taste (sour)

How do you prefer soil : Dry, mixed with vinegar

From where : From nature (Hill/mountain), close to hard rock, Buy it

Colour : Khaki

Is soil processed; How : Baking in oven, exposure to sun

Collection : Digging (500 cm), Wet and dry

Storage : Hidden inside the house (1 day)

Any other substance : No

Health:

Height : 161 cm

Weight : 78 kg

Illness (colds, flu, etc) : 2x per year

Summary of results:

Subject suffers from a severe iron deficiency and anaemia tending toward being hypochromic, microcytic with MCV and MCH on the lower limit of normal. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADST1930

Questionnaire number : SAQA125

Age : 20

Soil Consumption:

How long : 6 years

How often : More than once a day

Why : Medicinal value (heartburn), Taste, Craving (Daily, after rainfall)

How much : 1 packet daily

Type of soil : Soil (Mobu)

Why that type : Taste (sour)

How do you prefer soil : Dry, mixed with vinegar

From where : From nature (Pit/excavation), close to hard rock, Buy it

Colour : Reddish, Khaki

Is soil processed; How : Baking in oven, sun exposure

Collection : Digging (500 cm) (Gritty/Silky), Wet and dry

Storage : In a plastic bag (2 days)

Any other substance : Chalk (Once in a while)

Health:

Height : 157 cm

Weight : 49 kg

Illness (colds, flu, etc) : 2x per year, Pulse (? Blood pressure)

Summary of results:

All results within normal ranges.

Lab ID : ADST1932

Questionnaire number : SAQA126

Age : 43

Soil Consumption:

How long : 5 years

How often : More than once a day

Why : Craving (Daily), when pregnant

How much : 3 packets daily

Type of soil : Soil (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : From nature (Riverbed, Pit/excavation), Close to hard rock

Colour : Whitish

Is soil processed; How : Baking in oven, sun exposure

Collection : Digging (60 cm), Wet and Dry (Soapy when wet), Silky, Gritty

Storage : On top of cupboard (1 day)

Any other substance : Ashes (Monthly)

Health:

Height : 160 cm

Weight : 67 kg

Illness (colds, flu, etc) : Once a year, Coldness in feet

Summary of results:

Iron deficiency present with a microcytic anaemia, with extremely low MCV. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADST1933

Questionnaire number : SAQA127

Age : 18

Soil Consumption:

How long : 13 years

How often : More than once a day

Why : Craving (Daily, after eating)

How much : 1 packet a day

Type of soil : Clay (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : From nature (Newly formed mound in valley)

Colour : Whitish

Is soil processed; How : No

Collection : Digging, Scraping with knife (½m), Wet or Dry

Storage : Window (1 day)

Any other substance : No

Health:

Height : 155 cm

Weight : 54 kg

Illness (colds, flu, etc) : Headache twice a week

Summary of results:

Subject suffers from a severe iron deficiency with an extreme hypochromic, microcytic anaemia. Mineral results are within normal ranges and infection markers are normal.

Lab ID : ADST1938

Questionnaire number : SAQA128

Age : 41

Soil Consumption:

How long : 17 years

How often : More than once a day

Why : Craving (Daily, morning and before sleeping), Taste

How much : 4 packs per day

Type of soil : Clay (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (cave, newly formed mounds)

Colour : Whitish

Is soil processed; How : Baking

Collection : Digging with knife (30 cm) in cave, sticky, very sticky if wet

Storage : In oven (1 day)

Any other substance : No

Health:

Height : 156 cm

Weight : 90 kg

Illness (colds, flu, etc) : colds, flu, headache more then once a month

Summary of results:

Low iron and transferrin saturation however ferritin level is normal. No anaemia present. Mineral results are within normal ranges. Infection markers indicate an inflammatory or acute phase response, but with normal PCT, origin is unlikely to be bacterial. Ferritin is also an acute phase protein and high CRP indicate possibility of ferritin being high as a result of acute phase response, masking a possible low ferritin and thus iron deficiency.

Lab ID : ADST1940

Questionnaire number : SAQA130

Age : 23

Soil Consumption:

How long : 6 years

How often : More than once a day

Why : Taste, Craving (Daily

How much : 1 packet daily

Type of soil : Soil (Mobu)

Why that type : Taste (sour)

How do you prefer soil : Dry

From where : Nature(Pit/excavation), Close to hard rock, Buy

Colour : Khaki

Is soil processed; How : Baking in oven, exposure to sun

Collection : Digging (60 cm), Gritty, Wet and dry, soapy when wet

Storage : In a container (7 days)

Any other substance : Plastic (Once in a while)

Health:

Height : 160 cm

Weight : 59 kg

Illness (colds, flu, etc) : 2x per year, Constant headaches

Summary of results:

Iron deficiency with a hypochromic, microcytic anaemia. Mineral results and infection markers are within normal ranges.

Lab ID : ADST1941

Questionnaire number : SAQA131

Age : 20

Soil Consumption:

How long : 6 years

How often : More then once a day

Why : Taste, Craving (Daily, after eating)

How much : 2 packets daily

Type of soil : Soil (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : Nature (Pit/excavation), Close to hard rock, Buy

Colour : Khaki

Is soil processed; How : Exposure to sun

Collection : Digging (60 cm), Silky, Wet and dry, soapy when wet

Storage : In a plastic bag (2 days)

Any other substance : No

Health:

Height : 163 cm

Weight : 68 kg

Illness (colds, flu, etc) : Constant headaches

Summary of results:

Iron deficiency with no anaemia present. Mineral and infection marker results are within normal ranges.

Lab ID : ADST1943

Questionnaire number : SAQA129

Age : 22

Soil Consumption:

How long : 6 years

How often : once a day

Why : Taste, Pregnancy, Craving (after rain)

How much : 1 packet daily

Type of soil : Soil (Mobu)

Why that type : Taste

How do you prefer soil : Dry

From where : Buy it

Colour : Whitish, silky

Is soil processed; How : Baking, exposure to sun

Collection : Not sure – buy it

Storage : In a cup or container (2 days)

Any other substance : No

<u>Health:</u>

Height : 157 cm

Weight : 55 kg

Illness (colds, flu, etc) : 2x per year

<u>Summary of results:</u>

All results within normal ranges.

Lab ID : ADST7038

Questionnaire number : SAQA 113

Age : 22

<u>Soil Consumption:</u>

How long : 5 years

How often : Once a week

Why : Standard practice, Craving

How much : ¼of standard packet

Type of soil : Soil (White soil), substance silky

Why that type : Sour taste

How do you prefer soil : After food, Condition collected in – dry)

From where : Buy it (can be found by riverbed), close to rocks

Colour : Whitish

Is soil processed; How : No

Collection : Not sure – buy it

Storage : Bag (2 days)

Any other substance : No

<u>Health:</u>

Height : 162,5cm

Weight : 65,6kg

Illness (colds, flu, etc) : Piles

Summary of results:

Iron deficiency with only a slight anaemia present. Mineral and infection marker results are within normal ranges.

Lab ID : ADCI7034 (Questionnaire not available)

Summary of results:

Iron deficiency with a hypochromic, microcytic anaemia. Mineral and infection marker results are within normal ranges.

Lab ID : ADCI7036 (Questionnaire not available)

Summary of results:

Iron deficiency with no anaemia present. Mineral and infection marker results within normal ranges.

CONTROL GROUP

Lab ID : ADCI7000

Questionnaire number : SAQAC64

Age : 32

Health:

Height : 156 cm

Weight : 56.4 kg

Illness (colds, flu, etc) : More than once a month, HIV

Summary of results:

Normal iron studies, with high serum iron and no anaemia, but high MCV and MCH indicate cells are hyperchromic, macrocytic. Mineral and infection marker results are within normal ranges.

Lab ID : ADCI7002

Questionnaire number : SAQAC65

Age : 29

Health:

Height : 151 cm

Weight : 46.5 kg

Illness (colds, flu, etc) : Once a year, Constant headaches

Summary of results:

Iron deficiency with no anaemia present. Mineral results are within normal ranges. Slightly elevated CRP indicates possible acute phase reaction.

Lab ID : ADCI7003

Questionnaire number : SAQAC13

Age : 21

Health:

Height : 158 cm

Weight : 58 kg

Illness (colds, flu, etc) : Twice a year

Summary of results:

Iron deficiency with no anaemia present. Mineral results reveal slightly elevated phosphate level and infection markers are normal.

Lab ID : ADCI7005

Questionnaire number : SAQAC68

Age : 20

Health:

Height : 157 cm

Weight : 85.4 kg

Illness (colds, flu, etc) : Once a year, High blood pressure

Summary of results:

All results are within normal ranges.

Lab ID : ADCI7006

Questionnaire number : Not available

Name : Mantoa Mokotedi

Age	:	29

Health:

Height	:	156 cm
Weight	:	57 kg
Illness (colds, flu, etc)	:	Once a year

Summary of results:

All results are within normal ranges.

Lab ID	:	ADCI7007
Questionnaire number	:	SAQAC93
Age	:	23

Health:

Height	:	155 cm
Weight	:	55 kg
Illness (colds, flu, etc)	:	Once a year

Summary of results:

Iron and trasnferrin saturation levels low however the ferritin level is normal. No anaemia present. Mineral results are within normal ranges. Infection markers indicate inflammatory or acute phase response with very high CRP. Normal PCT indicates the possibility of bacterial infection unlikely. Presence of an acute phase reaction might be the cause of an increased ferritin, masking the possibility of low ferritin and thus typical iron deficiency in this case.

Lab ID	:	ADCI7015
Questionnaire number	:	SAQAC72
Age	:	21

Health:

Height	:	160 cm
Weight	:	62.4 kg
Illness (colds, flu, etc)	:	Once a year, Constant headaches

Summary of results:

Iron deficiency with no anaemia present. Mineral and infection marker results are within normal ranges.

Lab ID : ADCI7016

Questionnaire number : SAQAC74

Age : 24

Health:

Height : 158 cm

Weight : 54.8 kg

Illness (colds, flu, etc) : Once a year, Constant headaches

Summary of results:

All results are within normal ranges.

Lab ID : ADCI7020

Questionnaire number : SAQAC10

Age : 19

Health:

Height : 144 cm

Weight : 47 kg

Illness (colds, flu, etc) : Twice a year

Summary of results:

All results are within normal ranges.

Lab ID : ADCI7021

Questionnaire number : SAQAC50

Age : 18

Health:

Height : 163.5 kg

Weight : 64.5 kg

Illness (colds, flu, etc) : Once a year, Painful hands

Summary of results:

All results are within normal ranges.

Lab ID : ADCI7024

Questionnaire number : SAQAC79

Age : 32

Health:

Height : 162 cm

Weight : 55.1 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

Low ferritin and transferrin saturation indicates possible iron deficiency. No anaemia present. Mineral and infection marker results within normal ranges.

Lab ID : ADCI7027

Questionnaire number : SAQAC00

Age : 18

Health:

Height : 153 cm

Weight : 49.9 kg

Illness (colds, flu, etc) : Once a year, Toothaches

Summary of results:

Results reveal a slightly low iron and transferrin saturation however ferritin level is normal. No anaemia present. Mineral and infection marker results are within normal ragnes.

Lab ID : ADCI7030

Questionnaire number : SAQAC04

Age : 18

Health:

Height : 155 cm

Weight : 64.3 kg

Illness (colds, flu, etc) : Once a year, Chronic Fatigue

Summary of results:

Subject suffers from a light iron deficiency with no anaemia present. Mineral and infection marker results are within normal ranges.

Lab ID : ADCI7041

Questionnaire number : SAQAC02

Age : 18

<u>Health:</u>

Height : 150 cm

Weight : 62 kg

Illness (colds, flu, etc) : Once every three months, Constant headaches

<u>Summary of results:</u>

Only abnormal result is a slightly elevated phosphate level.

Lab ID : ADCI7043

Questionnaire number : SAQAC03

Age : 39

<u>Health:</u>

Height : 162 cm

Weight : 60 kg

Illness (colds, flu, etc) : Twice a year

<u>Summary of results:</u>

Ferritin and transferrin saturation levels below normal. No anaemia present. Mineral and infection marker results within normal ranges.

Lab ID : ADST1903

Questionnaire number : SAQAC11

Age : 22

<u>Health:</u>

Height : 159 cm

Weight : 59 kg

Illness (colds, flu, etc) : Once every three months, Constant headaches

<u>Summary of results:</u>

Iron and transferrin saturation levels are low and ferritin level is high, but still within normal range. Subject suffers from a slight anaemia. Mineral results are within normal ranges. Infection markers indicate inflammatory or acute phase response with very high

CRP. Normal PCT indicates the possibility of bacterial infection unlikely. Presence of an acute phase reaction might be the cause of an increased ferritin, masking the possibility of low ferritin and thus typical iron deficiency in this case.

Lab ID	: ADST1904
Questionnaire number	: SAQAC09
Age	: 26

Health:

Height	: 155 cm
Weight	: 55 kg
Illness (colds, flu, etc)	: Once every three months, Constant headaches

Summary of results:

All results are within normal ranges.

Lab ID	: ADST1905
Questionnaire number	: SAQAC08
Age	: 30

Health:

Height	: 159 cm
Weight	: 62 kg
Illness (colds, flu, etc)	: Once a year, Constant headaches

Summary of results:

The parameters for iron studies are normal except for slightly low ferritin and a slight hypochromic, microcytic anaemia. Mineral results are within normal ranges. Infection markers indicate inflammatory or acute phase response with elevated CRP. Bacterial infection seems unlikely with a normal PCT.

Lab ID	: ADST1908
Questionnaire number	: SAQAC15
Age	: 33

Health:

Height	: 159 cm
Weight	: 52 kg

Illness (colds, flu, etc) : 2x per year, TB

Summary of results:

All results are within normal ranges.

Lab ID : ADST1912

Questionnaire number : SAQAC21

Age : 44

Health:

Height : 148 cm

Weight : 56 kg

Illness (colds, flu, etc) : Once a year, Constant headaches

Summary of results:

All results are within normal ranges.

Lab ID : ADST1914

Questionnaire number : SAQAC16

Age : 35

Health:

Height : 155 cm

Weight : 74 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

Normal iron studies and no anaemia present. Mineral results are within normal ranges. Infection markers indicate inflammatory or acute phase response with elevated CRP. Bacterial infection seems unlikely with a normal PCT.

Lab ID : ADST1915

Questionnaire number : SAQAC20

Age : 18

Health:

Height : 148 cm

Weight : 55 kg

Illness (colds, flu, etc) : 2x per year

<u>Summary of results:</u>

Parameters for iron status are normal except for slightly low ferritin. No anaemia present. Mineral results reveal decreased phosphate level. Infection markers are normal.

Lab ID : ADST1916

Questionnaire number : SAQAC17

Age : 18

<u>Health:</u>

Height : 152 cm

Weight : 40 kg

Illness (colds, flu, etc) : 2x per year

<u>Summary of results:</u>

Iron deficiency with a hypochromic, microcytic anaemia. Mineral and infection marker results are within normal ranges.

Lab ID : ADST1917

Questionnaire number : SAQAC23

Age : 34

<u>Health:</u>

Height : 159 cm

Weight : 87 kg

Illness (colds, flu, etc) : Colds and headaches over weekends

<u>Summary of results:</u>

All results are within normal ranges.

Lab ID : ADST1918

Questionnaire number : SAQAC22

Age : 27

<u>Health:</u>

Height : 174 cm

Weight : 76 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

Results are within normal ranges except for a slightly elevated CRP.

Lab ID : ADST1919

Questionnaire number : SAQAC19

Age : 22

Health:

Height : 156 cm

Weight : 65 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

Iron studies normal and no anaemia present. Mineral results are within normal ranges. Infection markers indicate an inflammatory or acute phase response with elevated CRP. Bacterial infection seems unlikely with normal PCT.

Lab ID : ADST1920

Questionnaire number : SAQAC18

Age : 20

Health:

Height : 151 cm

Weight : 44 kg

Illness (colds, flu, etc) : 2x per year

Summary of results:

All results are within normal ranges.

Lab ID : ADST1927

Questionnaire number : SAQAC24

Age : 31

Health:

Height : 157 cm

Weight : 73 kg

Illness (colds, flu, etc) : Colds weekly, Vomiting when warm

Summary of results:

Iron studies normal and no anaemia present. Mineral results reveal a slightly decreased phosphate. Infection markers indicate and inflammatory or acute phase response present with high CRP. Bacterial infection seems unlikely with normal PCT.

Lab ID : ADST1929

Questionnaire number : SAQAC25

Age : 23

Health:

Height : 164 cm

Weight : 73 kg

Illness (colds, flu, etc) : Once every three months

Summary of results:

The parameters for iron status are normal, except for a slightly decreased ferritin. No anaemia present. Mineral and infection marker results are within normal ranges.

Lab ID : ADST1934

Questionnaire number : SAQAC27

Age : 30

Health:

Height : 159 cm

Weight : 68 kg

Illness (colds, flu, etc) : Once a year, Eye problems

Summary of results:

Only abnormal result is a slightly elevated phosphate.

Lab ID : ADST1935

Questionnaire number : SAQAC26

Age : 25

Health:

Height : 157 cm

Weight : 64 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

All results are within normal ranges.

Lab ID : ADST1937

Questionnaire number : Not available

Age : 40

Health:

Height : 163 cm

Weight : 63 kg

Illness (colds, flu, etc) : Once a year

Summary of results:

All results are within normal ranges.

Lab ID : ADST1939

Questionnaire number : SAQAC30

Age : 23

Health:

Height : 160 cm

Weight : 69 kg

Illness (colds, flu, etc) : 2x per year, Muscle pains

Summary of results:

Iron deficiency with no anaemia present. Mineral results are within normal ranges. CRP only slightly elevated.

Lab ID : ADST1942

Questionnaire number : Not available

Age : 18

Health:

Height : 156 cm

Weight : 58 kg

Illness (colds, flu, etc) : Headache once a month

<u>Summary of results:</u>

Iron studies normal and no anaemia present. Mineral results are within normal ranges. Infection markers indicate inflammatory or acute phase response with elevated CRP. Bacterial infection seems unlikely with normal PCT.

APPENDIX C – Results: Test group

Nr	Track nr	Age	Ferr	Iron	Tfn	Tfn sat	Ca
1	ADCI7001	19	12.6	5.6	3.59	5.46	2.34
2	ADCI7004	44	9.3	2.8	3.48	2.82	2.29
3	ADCI7008	25	24.4	10.5	2.36	15.57	2.13

4	ADCI7009	20	19.4	5.3	2.58	7.19	2.20
5	ADCI7010	22	11.6	4.6	3.18	5.06	2.40
6	ADCI7011	30	8.9	3.5	3.56	3.44	2.18
7	ADCI7014	40	6.8	2.2	4.45	1.73	2.09
8	ADCI7017	34	22.1	5.6	3.06	6.41	2.33
9	ADCI7018	20	51.0	7.9	2.55	10.84	2.44
10	ADCI7022	25	10.8	6.8	3.13	7.60	2.26
11	ADCI7023	34	5.0	4.4	3.48	4.43	2.24
12	ADCI7025	25	20.1	7.9	3.15	8.78	2.41
13	ADCI7026	19	5.7	4.0	3.47	4.03	2.43
14	ADCI7028	21	6.1	5.6	3.54	5.54	2.39
15	ADCI7029	18	3.7	3.7	3.43	3.78	2.43
16	ADCI7031	18	14.2	12.0	2.81	14.95	2.48
17	ADCI7032	30	5.0	3.8	3.19	4.17	2.35
18	ADCI7034		6.2	4.6	3.71	4.34	2.35
19	ADCI7036		13.3	6.5	2.86	7.95	2.28
20	ADCI7037	35	7.4	4.5	3.17	4.97	2.32
21	ADCI7039	35	12.2	6.2	3.22	6.74	2.17
22	ADCI7040	18	4.6	2.7	3.45	2.74	2.42
23	ADCI7042	37	3.7	5.9	2.61	7.91	2.06
24	ADCI7047	18	7.6	5.5	3.94	4.89	2.47
25	ADST1901	33	9.7	6.5	3.53	6.44	2.43
26	ADST1902	26	31.9	23.2	3.28	24.76	2.31
27	ADST1906	18	18.7	3.7	3.05	4.25	2.3
28	ADCI7046	18	29.2	9.1	2.74	11.62	2.34
29	ADST1907	22	15.9	10.2	2.67	13.37	2.41
30	ADST1900	40	18.1	13.4	2.79	16.81	2.26
31	ADST1909	26	6.9	3.6	2.8	4.50	2.2
32	ADST1911	23	2.1	4.1	3.16	4.54	2.28
33	ADST1913	21	8.9	2.6	3.6	2.53	2.39
34	ADST1921	30	12.2	11.1	3.56	10.91	2.34
35	ADST1922	22	5.2	3.8	3.23	4.12	2.3
36	ADST1923	23	26.2	15.6	3.48	15.69	2.53
37	ADST1924	22	4.1	2.4	3.24	2.59	2.32
38	ADST1925	30	16.6	16.9	2.43	24.34	2.29
39	ADST1926	24	5.0	9.0	3.62	8.70	2.5
40	ADST1928	24	2.5	5.3	3.66	5.07	2.29
41	ADST1930	20	57.4	27.8	3.29	29.57	2.51
Nr	**Track nr**	**Age**	**Ferr**	**Iron**	**Tfn**	**Tfn sat**	**Ca**
42	ADST1932	43	6.1	4.3	3.3	4.56	2.24
43	ADST1933	18	1.2	1.7	3.83	1.55	2.24
44	ADST1938	41	17.9	6.5	2.65	8.58	2.37
45	ADST1940	23	7.3	2.4	3.21	2.62	2.28

46	ADST1941	20	8.3	8.6	3.06	9.84	2.36
47	ADST1943	22	22.2	16.4	2.63	21.83	2.23
48	ADCI7038	22	4.8	4.5	3.22	4.89	2.29

Nr	Track nr	Alb	C.Ca	Mg	PO_4	CRP	WCC
1	ADCI7001	37.76	2.38	0.86	1.196	12.2	5.5
2	ADCI7004	40.51	2.28	0.81	0.999	3.9	4.8
3	ADCI7008	29.23	2.35	0.86	0.649	2.9	3.7
4	ADCI7009	36.04	2.28	0.91	0.995	3.9	4.4

5	ADCI7010	35.30	2.49	0.80	1.224	1.5	3.6
6	ADCI7011	29.38	2.39	0.82	1.164	4.0	7.7
7	ADCI7014	30.47	2.28	0.80	0.659	11.4	2.8
8	ADCI7017	36.48	2.40	0.80	1.331	<1.0	4.5
9	ADCI7018	43.58	2.37	0.90	1.797	6.7	9.1
10	ADCI7022	37.32	2.31	0.86	1.201	11.6	4.8
11	ADCI7023	35.50	2.33	0.78	1.042	3.5	6.4
12	ADCI7025	42.68	2.36	0.88	1.413	1.8	5.3
13	ADCI7026	42.44	2.38	0.82	1.335	<1.0	6.6
14	ADCI7028	42.40	2.32	0.85	1.126	<1.0	4.4
15	ADCI7029	41.45	2.40	0.84	1.059	2.8	7.7
16	ADCI7031	42.30	2.43	0.93	1.422	1.4	6.5
17	ADCI7032	40.07	2.35	0.74	0.995	1.3	5.2
18	ADCI7034	37.85	2.39	0.79	0.804	<1.0	5.0
19	ADCI7036	42.93	2.22	0.85	1.231	<1.0	8.3
20	ADCI7037	39.22	2.34	0.79	1.194	<1.0	3.7
21	ADCI7039	33.85	2.29	0.73	0.839	1.8	2.3
22	ADCI7040	42.20	2.38	0.82	1.197	1.1	6.7
23	ADCI7042	31.33	2.23	0.85	0.797	19.9	6.7
24	ADCI7047	42.90	2.41	0.87	1.305	<1.0	7.4
25	ADST1901	41.57	2.4	0.85	0.959	1.1	4.9
26	ADST1902	46.18	2.19	0.83	1.495	1.2	5.2
27	ADST1906	36.66	2.37	1.01	0.892	<1.0	4.1
28	ADCI7046	41.07	2.32	0.90	1.173	<1.0	4.3
29	ADST1907	41.44	2.38	0.75	1.193	1.5	4.4
30	ADST1900	32.50	2.41	0.69	0.974	<1.0	6.0
31	ADST1909	37.92	2.24	1.02	1.184	6.0	5.0
32	ADST1911	40.38	2.27	0.77	0.964	<1.0	2.9
33	ADST1913	43.13	2.33	0.81	1.103	2.2	4.5
34	ADST1921	40.90	2.32	0.96	1.059	1.5	9.7
35	ADST1922	37.94	2.34	0.81	1.039	21.0	9.0
36	ADST1923	43.65	2.46	0.89	1.060	1.4	12.8
37	ADST1924	36.09	2.40	0.71	1.331	<1.0	7.3
38	ADST1925	39.33	2.30	0.94	1.166	<1.0	7.6
39	ADST1926	46.70	2.37	0.83	1.095	<1.0	7.4
40	ADST1928	40.25	2.28	0.92	0.846	<1.0	6.4
41	ADST1930	48.92	2.33	0.76	1.384	<1.0	6.4
42	ADST1932	40.69	2.23	1.12	1.053	<1.0	4.6
43	ADST1933	39.89	2.24	0.80	0.982	<1.0	5.6
Nr	**Track nr**	**Alb**	**C.Ca**	**Mg**	**PO_4**	**CRP**	**WCC**
44	ADST1938	35.94	2.45	0.75	1.234	14.0	2.9
45	ADST1940	36.80	2.34	0.84	0.851	<1.0	4.2
46	ADST1941	41.19	2.34	0.88	1.248	<1.0	4.0
47	ADST1943	39.70	2.24	0.86	1.128	<1.0	4.4

48	ADCI7038	41.27	2.26	0.85	1.356	<1.0	5.0

Nr	Track nr	RBC	Hb	HCT	MCV	MCH	MCHC	PCT
1	ADCI7001	4.35	10.0	31.3	72	23.0	31.9	0.306
2	ADCI7004	3.56	9.2	28.2	79	26.0	32.8	0.338
3	ADCI7008	3.74	11.6	34.2	91	31.1	34.0	0.185
4	ADCI7009	4.59	12.5	37.4	82	27.2	33.3	0.173

5	ADCI7010	3.63	9.1	27.7	76	25.1	32.9	0.253
6	ADCI7011	4.01	8.0	25.4	63	20.1	31.7	0.288
7	ADCI7014	3.68	7.2	23.9	65	19.7	30.3	0.069
8	ADCI7017	3.97	13.0	38.7	97	32.7	33.5	0.217
9	ADCI7018	4.53	13.5	40.2	89	29.8	33.5	0.302
10	ADCI7022	4.80	13.8	40.3	84	28.7	34.1	0.216
11	ADCI7023	4.17	11.0	33.9	81	26.3	32.4	0.234
12	ADCI7025	4.55	14.3	42.3	93	31.4	33.8	0.284
13	ADCI7026	4.17	11.9	35.7	86	28.6	33.4	0.321
14	ADCI7028	4.15	11.8	35.1	84	28.4	33.7	0.248
15	ADCI7029	4.50	10.7	32.6	72	23.8	32.9	0.330
16	ADCI7031	4.66	12.8	38.2	82	27.6	33.6	0.262
17	ADCI7032	4.54	11.3	33.9	75	24.9	33.3	0.162
18	ADCI7034	4.36	10.1	30.9	71	23.1	32.6	0.312
19	ADCI7036	4.17	12.8	37.3	90	30.6	34.2	0.230
20	ADCI7037	4.27	11.0	33.2	78	25.7	33.1	0.274
21	ADCI7039	3.72	9.2	28.4	76	24.7	32.3	0.234
22	ADCI7040	4.05	8.5	27.7	68	21.1	30.8	0.448
23	ADCI7042	4.33	9.4	28.9	67	21.7	32.4	0.301
24	ADCI7047	3.65	10.8	32.4	89	29.7	33.5	0.256
25	ADST1901	3.96	11.9	35.9	91	30.1	33.2	0.255
26	ADST1902	4.31	12.8	39.0	90	29.7	32.8	0.255
27	ADST1906	4.19	11.0	33.4	80	26.2	33.0	0.387
28	ADCI7046	4.14	12.9	37.6	91	31.2	34.4	0.181
29	ADST1907	4.12	12.6	37.7	91	30.5	33.3	0.317
30	ADST1900	4.45	12.2	36.2	81	27.3	33.6	0.189
31	ADST1909	4.03	9.9	29.6	74	24.6	33.5	0.225
32	ADST1911	4.26	8.9	27.9	65	20.5	31.4	0.301
33	ADST1913	4.25	11.7	34.7	82	27.6	33.8	0.241
34	ADST1921	3.91	11.2	32.4	83	28.6	34.5	0.201
35	ADST1922	4.31	10.8	32.3	75	25.0	33.3	0.152
36	ADST1923	4.26	14.0	40.5	95	32.9	34.6	0.259
37	ADST1924	2.43	7.6	24.7	72	22.2	30.8	0.366
38	ADST1925	4.36	12.8	37.1	85	29.4	34.6	0.229
39	ADST1926	4.93	12.6	38.2	77	25.7	33.1	0.290
40	ADST1928	4.00	10.5	31.1	78	26.2	33.8	0.335
41	ADST1930	4.76	15.4	44.7	94	32.3	34.4	0.165
42	ADST1932	3.74	10.5	31.4	34	28.0	23.3	0.269
43	ADST1933	3.63	6.0	19.5	54	16.5	30.6	0.315
Nr	**Track nr**	**RBC**	**Hb**	**HCT**	**MCV**	**MCH**	**MCHC**	**PCT**
44	ADST1938	4.14	12.7	37.2	90	30.6	34.0	0.238
45	ADST1940	4.46	9.5	29.0	65	21.2	32.6	0.258
46	ADST1941	4.13	13.0	37.3	90	31.5	34.8	0.127
47	ADST1943	4.45	14.4	42.1	95	32.4	34.1	0.198

48	ADCI7038	4.07	11.6	34.3	84	30.6	34.2	0.230

APPENDIX D – Results: Control group

Nr	Track nr	Age	Ferr	Iron	Tfn	Tfn sat	Ca
1	ADCI7000	32	78.9	37.5	2.04	64.34	2.27
2	ADCI7002	29	7.4	5.1	3.28	5.44	2.38

3	ADCI7003	21	7.2	7.0	3.18	7.70	2.31
4	ADCI7005	20	66.7	16.3	2.77	20.60	2.41
5	ADCI7006	29	48.3	22.7	2.53	31.40	2.54
6	ADCI7007	23	94.3	3.4	1.90	6.26	2.39
7	ADCI7015	21	10.2	5.8	2.98	6.81	2.36
8	ADCI7016	24	37.7	16.0	2.54	22.05	2.29
9	ADCI7020	19	57.5	21.6	2.65	28.53	2.44
10	ADCI7021	18	37.1	20.5	2.41	29.77	2.41
11	ADCI7024	32	6.7	11.9	2.97	14.02	2.30
12	ADCI7027	18	19.2	8.9	2.84	10.97	2.34
13	ADCI7030	18	11.7	9.2	3.28	9.82	2.48
14	ADCI7035		175.5	11.8	2.42	17.07	2.47
15	ADCI7041	18	26.7	12.8	2.87	15.61	2.48
16	ADCI7043	39	11.9	11.4	3.35	11.91	2.21
17	ADST1903	22	108.1	6.5	2.12	10.73	2.15
18	ADST1904	26	83.9	19.7	2.20	31.34	2.25
19	ADST1905	30	11.3	12.2	2.84	15.03	2.25
20	ADST1905	33	102.1	12.9	2.01	22.46	2.28
21	ADST1912	44	54.1	15.1	2.63	20.10	2.38
22	ADST1914	35	27.7	16.6	2.43	23.91	2.40
23	ADST1915	18	9.3	21.6	3.15	24.00	2.43
24	ADST1916	18	3.6	5.0	4.29	4.08	2.63
25	ADST1917	34	33.4	12.3	2.41	17.86	2.37
26	ADST1918	27	85.3	17.4	2.21	27.56	2.32
27	ADST1919	22	17.0	15.0	3.31	15.86	2.42
28	ADST1920	20	58.6	18.8	2.45	26.86	2.46
29	ADST1927	31	14.8	14.0	2.19	22.37	2.14
30	ADST1929	23	13.1	20.4	3.10	23.03	2.39
31	ADST1934	30	64.6	11.6	2.73	14.87	2.42
32	ADST1935	25	51.5	15.0	2.24	23.44	2.46
33	ADST1937	40	25.1	17.4	2.31	26.36	2.28
34	ADST1939	23	6.3	5.6	3.18	6.16	2.26
35	ADST1942	18	32.8	10.4	3.02	12.05	2.60

Nr	**Track nr**	**Alb**	**C.Ca**	**Mg**	**PO_4**	**CRP**	**WCC**
1	ADCI7000	41.38	2.24	0.79	0.713	2.1	6.5
2	ADCI7002	41.33	2.35	0.79	1.310	5.5	9.1
3	ADCI7003	40.09	2.31	0.85	1.419	1.0	8.5

4	ADCI7005	41.90	2.37	0.90	1.211	3.7	3.9
5	ADCI7006	43.56	2.47	0.81	1.143	2.4	7.4
6	ADCI7007	38.42	2.42	0.93	0.856	28.6	6.3
7	ADCI7015	40.97	2.34	0.94	1.086	1.1	4.4
8	ADCI7016	38.10	2.33	1.06	1.331	<1.0	4.4
9	ADCI7020	44.39	2.35	0.96	1.105	1.4	10.2
10	ADCI7021	43.66	3.34	0.84	0.969	1.1	6.0
11	ADCI7024	36.26	2.37	0.82	1.095	1.3	4.3
12	ADCI7027	44.00	2.26	0.94	0.994	<1.0	4.5
13	ADCI7030	46.82	2.34	0.91	1.354	<1.0	5.8
14	ADCI7035	44.89	2.37	0.77	1.083	3.2	3.4
15	ADCI7041	39.06	2.50	0.86	1.506	1.2	5.9
16	ADCI7043	38.59	2.24	0.97	1.135	1.5	3.5
17	ADST1903	34.00	2.27	0.88	1.165	23.4	3.6
18	ADST1904	37.33	2.30	0.80	1.050	<1.0	8.4
19	ADST1905	33.55	2.38	0.75	0.858	11.3	4.2
20	ADST1905	38.25	2.32	0.80	1.377	4.6	4.6
21	ADST1912	39.79	2.38	0.86	1.044	2.7	8.0
22	ADST1914	40.57	2.39	0.87	1.302	6.1	6.3
23	ADST1915	44.47	2.34	0.87	0.715	<1.0	7.1
24	ADST1916	47.64	2.48	0.95	1.161	<1.0	5.5
25	ADST1917	38.55	2.40	0.95	1.396	2.5	4.0
26	ADST1918	41.22	2.30	0.86	1.187	5.7	4.2
27	ADST1919	41.60	2.39	0.92	0.859	6.3	8.6
28	ADST1920	42.68	2.41	0.88	0.836	<1.0	5.0
29	ADST1927	35.60	2.23	0.81	0.740	24.0	5.0
30	ADST1929	43.79	2.31	0.90	1.197	<1.0	6.1
31	ADST1934	42.49	2.37	0.89	1.470	2.5	8.5
32	ADST1935	38.74	2.49	0.80	1.183	4.5	10.7
33	ADST1937	39.40	2.29	0.96	1.040	1.6	3.6
34	ADST1939	36.59	2.33	0.86	1.244	5.5	5.8
35	ADST1942	47.67	2.45	0.89	1.107	<1.0	6.4

Nr	**Track nr**	**RBC**	**Hb**	**HCT**	**MCV**	**MCH**	**MCHC**	**PCT**
1	ADCI7000	3.35	13.8	40.1	120	41.2	34.3	0.226
2	ADCI7002	4.71	13.0	39.1	83	27.5	33.2	0.288

3	ADCI7003	4.05	12.7	37.3	92	31.3	33.9	0.214
4	ADCI7005	4.48	13.4	39.4	88	29.9	34.0	0.203
5	ADCI7006	4.64	15.3	44.9	97	33.0	34.1	0.200
6	ADCI7007	4.64	13.9	40.4	87	30.0	34.5	0.198
7	ADCI7015	4.59	13.2	38.6	84	28.8	34.2	0.214
8	ADCI7016	4.63	14.1	41.9	91	30.6	33.8	0.193
9	ADCI7020	4.93	15.9	46.9	95	32.3	34.1	0.343
10	ADCI7021	4.32	13.4	39.6	92	31.0	33.8	0.198
11	ADCI7024	4.28	12.4	36.6	86	29.0	33.9	0.221
12	ADCI7027	4.43	13.1	37.8	85	29.5	34.6	0.229
13	ADCI7030	4.20	13.0	38.2	91	30.9	34.0	0.327
14	ADCI7035	5.01	13.9	41.0	82	27.9	34.0	0.188
15	ADCI7041	4.05	13.3	38.4	95	32.9	34.6	0.304
16	ADCI7043	4.12	12.7	36.9	89	30.7	34.3	0.199
17	ADST1903	3.74	11.2	34.0	91	29.8	32.8	0.191
18	ADST1904	4.26	13.6	40.1	94	31.8	33.8	0.331
19	ADST1905	4.45	11.0	34.6	78	24.8	31.8	0.170
20	ADST1905	4.09	12.7	36.7	90	31.0	34.6	0.182
21	ADST1912	4.10	13.3	39.4	96	32.5	33.8	0.244
22	ADST1914	4.25	13.1	39.2	92	30.8	33.5	0.256
23	ADST1915	4.34	12.9	38.6	89	29.6	33.3	0.187
24	ADST1916	5.21	11.1	34.9	67	21.3	31.8	0.349
25	ADST1917	4.25	13.7	39.4	93	32.2	34.7	0.248
26	ADST1918	4.44	13.6	39.6	89	30.6	34.3	0.168
27	ADST1919	4.75	14.6	42.4	89	30.7	34.4	0.175
28	ADST1920	4.44	14.4	40.7	92	22.4	35.4	0.179
29	ADST1927	3.59	12.4	35.9	100	34.4	34.4	0.290
30	ADST1929	4.31	13.4	38.8	90	31.0	34.5	0.258
31	ADST1934	4.31	13.5	39.0	91	31.3	34.6	0.228
32	ADST1935	4.58	14.6	42.4	93	31.9	34.4	0.241
33	ADST1937	4.30	13.7	39.7	92	31.8	34.5	0.333
34	ADST1939	4.43	12.2	36.1	82	27.5	33.7	0.279
35	ADST1942	4.84	14.6	42.4	88	30.1	34.4	0.267