GEOSCIENTIFIC DETERMINATION OF CONTAMINATION POTENTIAL AROUND MPAPE DUMPSITE, MPAPE, ABUJA, CENTRAL NIGERIA

BY

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MTech/SPS/2018/8409

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FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA.
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN GEOLOGY (ENVIRONMENTAL GEOLOGY)

AUGUST, 2023

DECLARATION

I hereby declare that this thesis titled “**Geoscientific Determination of Contamination Potential around Mpape Dumpsite, Mpape, Abuja, Central Nigeria**” is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (Published or unpublished) has been dully acknowledged.

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CERTIFICATION

The Thesis **“Geoscientific Determination of Contamination Potential Around Mpape Dumpsite, Mpape, Abuja, Central Nigeria”** by OKEDIJI, Olasunkanmi Babatunde (MTech/SPS/2018/8409) meets the regulations governing the award of the degree of Master of Technology of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

Leachate originating from open dumpsite system can be delineated through an integration of qualitative and quantitative methods. This study was designed to assess extent of leachate contamination from Mpape dumpsite, Mpape, Abuja, Central Nigeria. Qualitative assessment was determined using two dimensional (2-D) Electrical Resistivity Tomography (ERT) geophysical method. Both geophysical andgeochemical methods were used to investigate how the refuse dumpsite in Mpape affects the subsurface soil within the study area. Wenner array configuration of electrical resistivitywas used to image the subsurface resistivity within the area using ABEM SAS 300 Terrameter. A total number of three profiles were probed within and around the dump site and the measured data across the profiles were processed using the RES2DINV and Geographic Information System (Arc GIS 10.4) computer interactive software. The resulting inverse resistivity model isolated three resistivity zones (anomanously low, intermediate and high resistivity). Qualitative assessment was achieved by analysis of geochemical substances in the soil and leachate samples taken from within and outside the dumpsite zone. The results of the parameters analysed in the leachate samples indicate the concentration of cations to be in the order of $Ca^{2+}>Mg^{2+}>P$, while that of the anions is in the order of $Cl>NH_3>SO_4>NO_3>F$. The heavy metals concentration vary as follows: Fe>Cr. The 2-D geographical investigation results also show the presence of contaminated plumes (denoted by low resistivity values of the overburden soil layer) within the dump site. Modern sanitary landfills should replace the practice of open dumping.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The menace of environmental contamination has been haunting the world since early times and is still growing due to excessive growth in developing countries. It is observed widely that over the last half a century; developing countries of the world have and are still experiencing rapid urban growth. This trend, accompanied by a corresponding rise in population, industrialization and change in consumption styles results in the generation of high solid waste volumes of diverse compositional characteristics (Nhamo, 2009; Jha, 2011).

The issue of solid waste management in developing countries faces so many challenges which include inadequate collection coverage, improper method of transportation, poor practice of final disposal such as open dumping, weak institutional and regulating provision and lack of adequate funding (Henry *et al*, 2006; Imam, 2008). Environmental contamination by solid wastes has been a serious issue in most developing countries owing to the waste disposal management. The effect of solid waste and its management on the quality of the environment and public health are widely recognized (Christensen, 2001).

Municipal solid waste (MSW) dumpsite constitutes a major anthropogenic point source of leachate contamination to the ambient environment (Nabegu, 2010). Pollution of soil by leachate from surrounding municipal waste dumps has been recognized for a long time (Amadi, 2011). Most solid waste disposal facilitates in Nigeria are poorly conceptualized particularly with respect to site selection, design and maintenance (Olayinka and Olayiwola, 2001). As submitted by Agunwamba, 2003; there is no simple sanitary landfill or disposal site in Nigeria that meets the basic requirements of protecting groundwater pollution.

Soil is usually the most polluted part of the ecosystem around dumpsite because the seepage of water through the waste dump leaches out undesirable components that pollute it as the main medium of transporting and distributing chemical elements (Magaji, 2012). Soils that have proximity to dumpsites are likely to have high concentration of contaminants which can be easily introduced into groundwater of that area through infiltration (Yadav and Fulekar 2018). seepage contamination from waste dump is a major source of soil pollution and it must be collected and treated before allowing it to flow on the ground surface. (Badmus *et al*, 2014).

The closed dumpsite in Mpape was originally a quarry site before it was converted to an un-engineered dumpsite which was operated between 1989 and 2005. On commissioning in 1989, the dumpsite was remote to settlement. But due to high pace of urban expansion in Abuja over the year; Mpape dumpsite is currently at the center bordering numerous residential, commercial and industrial facilities. Typical of substandard dumpsite that usually lack bottom liner, it is expected that the ambient environment including soil and groundwater around the dumpsite have been heavily contaminated over the years following percolation of leachate emanating from the decomposed wastes.

This study entitled “Geoscientific Determination of Contamination Potential around Mpape Dumpsite, Mpape, Abuja, Central Nigeria” was carried to investigate the subsurface conditions of the site.

1.2 Statement of the Research Problem

Various research works have been carried out around Mpape Dumpsite, Mpape, Abuja; Magaji (2012) worked on effects of waste dump on the quality of plants cultivated around Mpape Dumpsite and reported that the concentration of heavy metals in all the samples collected around the dumpsite were higher than those from control site and they are also above the FEPA limits. Alkali (2022) also worked on environmental impacts of Mpape Dumpsite on soil quality and submitted that there is significant variation in the concentrations in the values of the analysed metals in the dumpsite and the control site. He concluded that it is evident that the dumpsite has impacted on the soil and plants. Hence, published work has been tailored towards evaluating the impacts of the dumpsite on soil, which this research work will be all about.

1.3 Aim and Objectives

The aim of this study is to assess the potential soil contamination arising from percolation of the leachate generated around Mpape dumpsite, Mpape, Abuja, Central Nigeria. The specific objectives were to:

i. Produce the geological map of the study area on the scale of 1:12,500.
ii. Characterize waste dumped at the dumpsite.
iii. Collect soil and leachate samples around the vicinity of the dumpsite.
iv. Carry out grain size analysis of the soil in order to determine infiltration rate of leachate.
v. Establish the correlation between levels of pollutants in soil with distance from the dumping site, using geochemical and geophysical survey approaches.

1.4 Justification for the Study

Over the years, poor management and indiscriminate disposal of wastes have remained one of the recurring decimals, among the myriads of environmental issues confronting developing countries (Ajadike, 2001). Due to the unavailability of standard dumpsites and coupled with a substandard waste management system in these countries; wastes were dumped indiscriminately at the un-engineered dumpsites (Abgede and Ajabpe, 2004).

Leachates are complex and highly concentrated effluent that are generated when liquid, particularly rain water percolates through sustained dumpsites. They flow due to gravity and may pollute the ambient subsurface environment and subsurface. Olafisoye (2012) employed VLF-EM and hydro-physiochemical methods in the investigation of groundwater contamination at Aarada waste disposal site, Ogbomoso, southwestern Nigeria. The results obtained from the proceed VLT-EM data revealed that the surface of the study area was heavily contaminated by leachate. The water quality report showed hazardously high values of heavy metals, which confirmed the findings of the VLF-EM survey. Popoola and Adenuga (2019) used integrated geophysical method to delineate leachate in Ogun State, southwestern Nigeria. The study concluded that the area was underlain by laterite and sand which both lacked the capacity to curtail infiltration of pollutants into the aquifer.

From the results obtained in these prior studies among others, it is certain that the output of this research will help stakeholders to successfully plan and implement waste management projects and other environment within the vicinity of the dumpsite.

1.5 Description of the Study Area

1.5.1 Location, extent and accessibility

The study area is located at the North Eastern edge of the Gwaga plain the known expressway near the tipper garage of Mpape, within the water shed of the River Usuma basin. The Federal Capital Territory (FCT) Abuja is located between latitudes 8^0 25^1 and 9^1 25^1 North of the equator and longitude 6^0 45^1 and 7^0 45^1 East of Greenwich Meridian (Figure 1).

It occupies an area approximately 8,000 km^2 and occupies about 0.87 percentage of Nigeria. The territory is situated within the region generally referred to as the middle Belt (Mabogunje, 1977) and is boarded on all sides by four states namely Kogi, Niger, Kaduna and Nasarawa.

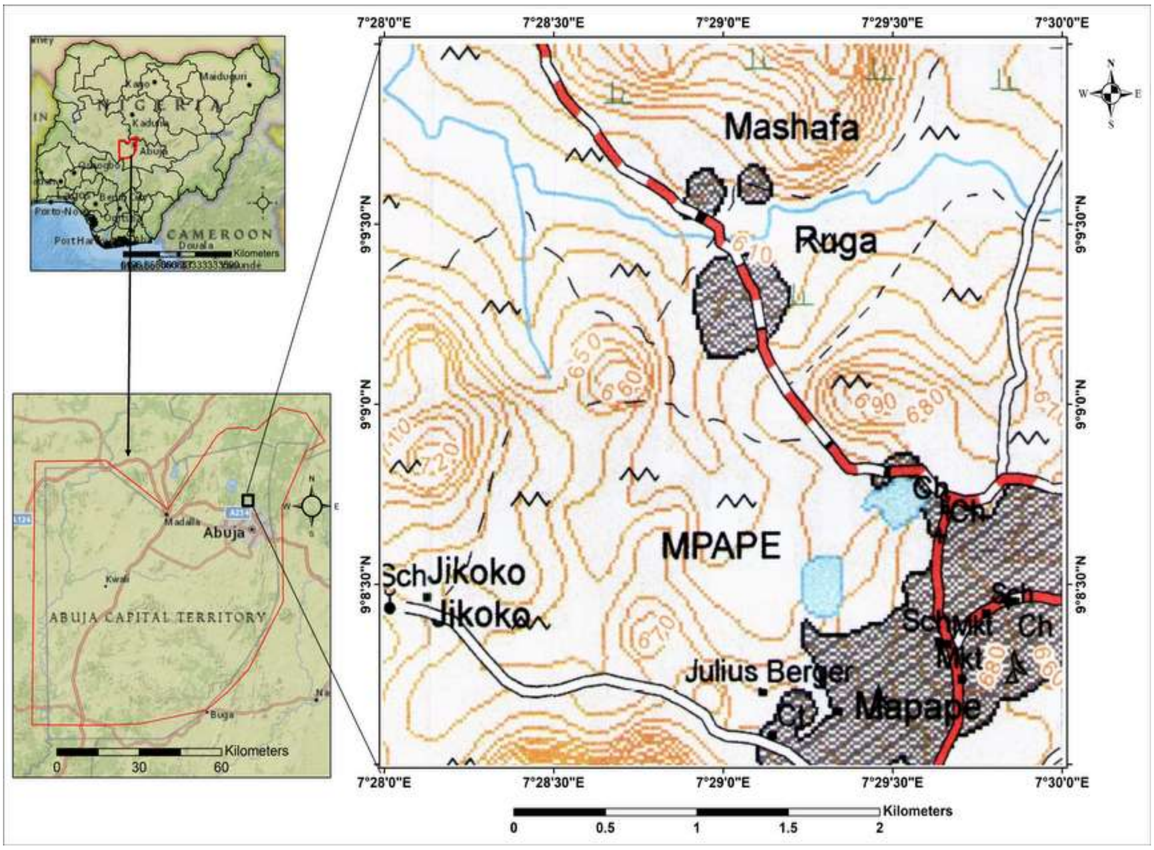


Figure 1.1: Location Map of the Study Area

1.5.2 Relief and drainage

The lowest elevation in the FCT is found in the extreme southwest where the flood plain of the river Guraje is at an elevation of about 10m above sea level from there; the land rises irregularly eastward, northward and northwestward. The highest part of the territory is in the northeast where there are many peaks over 760m above sea level. Hills occur either as clusters or from long ranges. The most prominent of these include Gawa range in the northeast, the Guartata range south-west of Suleija, the Idon-kasa range North-West of Kuje and the Wuna range north of Gwagwalada. Elsewhere in the territory, there are many rather roundish isolated hills usually called ISELBERGS in between the major hills are extensive plains; the most important of which are the Gwagwa plains and the Rubochi plain.

1.5.3 Climate and vegetation

The FCT has two main seasons, rainy (April-October) and dry (November-March) seasons. During the dry season, the typical month being March; the temperature varies between 30^0C in the northeast to about 37^0C in the southwest. This period is characterised by high diurnal ranges when drops as low as 17^0c may be recorded between the highest and lowest temperature in the dry season.

During the rainy season, temperature drops considerably due to dense cloud cover. The annual range also drops to around 7^0C, especially between July and August. The FCT records a relative humidity in the dry season of some 20% in the afternoon at higher elevations and at more northern locations but also 30% in the extreme south.

The FCT falls within the Guinea savanna vegetation zone of Nigeria. However, patches of rain forest, constituting about 7.4% of the total mass of the vegetation occurs in the Gwagwa plains. The dominant vegetation of the territory is classified into three (3) namely: Park or grassy savanna (about 53%), Savanna woodland about (12.85%) and Shrub savanna (about 12.9%). The soils of the FCT are generally shallow and sandy in November, especially on the major plains such as Iku-Gurara, Roboes and Ruboch. The high sand content makes the soils to be highly erodible. Those on the famous Gwagwa plains are however deep and clayey; perhaps reflecting the influence of parent materials gabbro and fine to medium textured biotite granite.

1.5.4 Regional geology

The area of study forms part of the basement complex of north-central Nigeria. Lithologic units fall under three main categories, which include:

1. Undifferentiated Mignatite complex of Proterozoic to Archean origin
2. Metavolcano-sedimentary rocks of late Proterozoic age
3. Older granite complex of late Precambrian-lower Paleozoic age also known as Pan-African granites (Oyawoye, 1972; Rahman, 1988)

1.6 Study Expectations

It is hope that this study will provide a guide for policy stakeholders in the Federal Capital Territory, Abuja and the whole of Nigeria to make informed decision in relation to solid waste management (SWM) as to achieve the desired goal of sustainable development. It would also help in updating existing policies and interventions aimed at protecting the environment and improving the quality of life in local communities.

1.7 Scope and Limitations

Although the subjects covered in the overall research programme are wide in context, this particular study was undertaken with the following scope and limitations:

i. While outcomes of the study might be applicable to other areas especially in the developing countries; the discussion presented are based mainly on the case study conducted around Mpape dumpsite.

ii. Political statements were avoided as much as possible.

iii. Although the importance of microbial contaminants to the evaluations of soil quality is greatly appreciated, this investigation's assessments of leachate and soil quality were limited to only physic-chemical parameters mentioned in Chapter four.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Waste Management Challenges in Less Developed Countries

The issue of solid waste management in less developed countries like Nigeria faces with many challenges which include collection coverage; improper methods of transportation, poor practice of final disposal such as open dumping without due regard to protection of environmental pollution, weak institutional and regulatory provisions and lack of adequate funding (Henry *et al*. 2006; Imam, 2008). These challenges hinder the development of effective and sustainable waste management systems.

2.1.1 Magnitude and diversity of solid waste

It is recognized widely by many authors such as Medina (2003), Bueurostro and Bocco (2003), Lau (2004), Henry *et al.* (2006), Nhamo (2009), and Jha (2011) that over the last half a century, less developing countries have been and still experiencing rapid urban growth. This trend, accompanied by a corresponding rise in population, industrialization and change in consumption styles, results in the generation of high solid waste volumes of diverse compositional characteristics. The volume generated varies greatly between different communities, season, culture and economic prosperity, which are peculiar to each community. Figure 2.1 presents the amount of solid waste generated per capital for selected countries while Table 2.1 presents the solid waste composition of selected cities.

Figure 2.1: Solid Waste Generation in Selected Countries (Raw data from: Lau, 2004; WHO, 2006, Pippati,2006).

Although the amount of solid waste generated per capita in urban area of developing countries is comparably lower than that generated in more developed countries, the effective magnitude is significantly high as a result of greater population density. These urban areas also vary considerably in terms of compositional characteristics of waste.

Table 2.1: Solid waste composition in selected cities

Solid waste material (%)	Abuja, Nigeria	Dar es Salaam, Tanzania	Lucknow, India	Jakarta, Indonesia	Brooklyn, USA	London, Uk
Paper	17	9	2	8	35	37
Glass / Ceramics	2	1	6	1	9	8
Metals	5	3	3	1	13	8
Plastics	4	2	4	4	10	2
Textiles	7	1	3	2	4	2
Wood / bones	0	0	1	4	4	0
Total organic	43	60	80	80	22	28
Inert	22	24	2	0	4	15
Total inorganic	35	16	18	15	74	58
Total	100	100	100	100	100	100
Ratio	1.23	3.75	4.44	5.33	0.30	0.49

(Raw data from WHO, 2006; Ogwueleka, 2009; Pippati, 2006)
*Ratio of the amount organic to inorganic materials in the waste mass

Generally, more developed urban areas generate less organic waste than less developed urban areas. The higher contents of moisture, organic and decomposable materials, including human and animal waste in the solid waste generated in less developed urban areas added to the prevailing poor conditions of disposal sites, resulting in a greater risk of leachate generation and migration to the environment (Ogwueleka, 2019; Nabegu, 2010). These processes pose a significant risk of environmental degradation around the disposal sites, especially the contamination of soil and groundwater resources.

The ratio of organic to inorganic waste materials (as shown in Table 3.1) indicates much lower volume (L 0.5) for the more developed urban areas, compared with the less developed ones (ratio >1). Interestingly, the ratio value for Abuja, Nigeria.

(Ratio = 1.23) is significantly lower than other less developed cities (Dar es Salaam, Tanzania; Ratio = 3.75, Lucknow, India; Ratio = 4.44 and Jakarta, Indonesia; Ratio = 5.33). The low ratios values in Abuja suggests that its waste materials contain high inorganic constituents, as reflected in the higher paper content. This is typical of urban area in the more developed regions and more industrialised cities of less developed regions.

2.1.2 Management of solid waste

Problem of solid waste management are recognized as the most visible environmental challenge facing most urban areas in less developed countries (Lau, 2004; Henry *et al*. 2006; Ogwueleka, 2009). This is as a result of their inability to regulate and manage properly the huge amount of solid waste generated, which in turn, poses a significant threat not only to the quality of environment and public health, but also to economic prosperity.

According to many sources of literature (such as Medina, 2003), these urban areas in the less developed countries, share many common characteristics relating to solid waste management practices. Unfortunately, these are negative and include lack of appropriate government policy and legislation; lack of political will and public commitment; inadequate technical expertise; insufficient financial resources or inappropriate allocation of available resources; poor participation and lack of proper planning. These are major obstacles to sound environmental management and the achievement of sustainable development.

In contrast to the communities, in more developed countries, such as the United Kingdom where SWM is more organized and is addressed in an effective manner; most urban areas in less developed countries lack structured and coherent waste management systems and are faced with inefficient and corrupt public sanitation. Thus, SWM in these urban areas often focuses only on waste collection, with little or total lack of emphasis on treatment and sustainable sanitary disposal. While collection helps to remove waste from its generations, collected waste in these areas is often disposed of in open dumps and uncontrolled landfills without any consideration for the environment and public health.

For instance, in Nigeria, many authors, such as Iwegbue (2006), have reported that solid waste heaps are often distributed randomly in urban areas, blocking motorways and hindering passage along alleys and pavements. It is also common practice in these urban areas in Nigeria for various non-biodegradable household petro-chemical products such as polythene bags, plastic containers, tyres and used crankcase oil from mechanical workshop; industries and power stations to be discharged indiscriminately into drains and ground surface. This is highly unsustainable and poses significant threat to the environment and public health.

2.1.3 Solid waste disposals

It is of great concern that open dumping is the predominant method of final disposals of solid waste in most parts of the less developed countries (Tatsi and Zouboulis, 2002; Agunwamba, 2003; Medina, 2003; Buenrostro and Bocco, 2003, Vidanaarachchi *et al*. 2006). Moreover, these disposal sites are not usually soil covered and their selection process is based largely on proximity to the collection areas and available space rather than any protection of environmental quality and public health.

The norm in most parts of the less developed countries is for little or no consideration to be given to environmental sustainability and public health in the process of selecting disposal sites. Often, solid waste is collected from its generations and disposed of indiscriminately at riverbanks, motor ways or abandoned quarry (Henry *et al*.2002).

In Nigeria, for instance, Agunwamba (2003) confirmed that there is no single sanitary law fill or disposal site that meets the basic requirements of protecting ground water pollution. Moreover, people use most abandoned waste disposal sites in many towns and villages as fertile ground for cultivating a variety of crops and vegetables. The soils are also used as compose by many farmers without any consideration to the possible health hazard that this may pose (Binns *et al*. 2003; Iwegbue, 2006).

Buenrostro and Bocco (2003) confirmed that much of the solid waste generated in Mexican urban centers, especially hazardous materials are usually deposited in sites located in small municipalities that do not have the economic and technical capacity to supervise the sites or carry out any proper environmentally-sustainable disposal. Similar incidences have been confirmed in Nigeria (Amusan *et al*. 2005) and India (Gupta, 1998).

These practices are highly unsustainable and must be addressed if the goal of sustainable development is to be achieved.

2.1.4 Environmental impacts of solid waste management

The effects of solid waste and its management activities on the quality of the environment are widely recognized (Henry *et al*. 2002; Christensen, 2001; Tatsi and Zouboulis, 2002; Kjelden, 2002; Agunwamba, 2003; Binns *et al*. 2003; Wilson *et al*. 2006; Vidanaarachchi *et al*. 2008), although not fully understood.

In view of the SWM practices in most parts of less developed countries, added to their prevailing financial and institutional constraints, the quantum of these effects can creates even more hazardous situations, than those in the more developed countries, and pose a significant threat not only to the environment and public health, but also to economic prosperity.

Of particular concern is the resultant leachate produced in the disposal sites, which can potentially contaminate the ambient environment especially the underlying ground water aquiter as well as the surrounding soil and surface water resources. Such contamination could have significant health implications, especially as many communities rely on untreated well water for drinking and other domestic purpose. In addition to the potentials of land and water contamination as a result of improper SWM in the less-developed countries, the widely practiced open burning also results I significant air pollution.

Although nature has the capacity to dilute disperse, degrade, absorb or otherwise reduce the impact of unwanted residues in the atmosphere, in waterways and on land within its carrying capacity, ecological imbalance can occur when the natural assimilative capacity is exceeded. Thus, a more coordinated effort is needed to protect, prevent and control environmental pollution, and to promote the concept of sustainable SWM practice. This is particularly relevant to the less developed countries, which appear to be lagging far behind.

2.2 Leachate Formation

Land fill leachate is recognized widely as one of the most significant sources of groundwater pollution. It is produced as a result of the biochemical decomposition of organic substances within the deposited waste materials, and the subsequent washing out of soluble minerals and organic constituents by precipitation and water run offs (Christensen, 2001; Tatsi and Zouboulis, 2002; Yoshida, 2002; Kjelden, 2002; Henry *et al.* 2006). Some of the key processes of leachate formation are presented in figure 2.2. Immediately after solid waste materials are deposited in disposal sites, the process of stabilization begins. This process which forms the leachate within the site, occurs mainly through four key physical, chemical and biological processes. These processes include hydrolysis of solid waste, biological degradation of organic waste, solubilization of soluble salts contained within the waste mass and the transportation of waste as colloids or particular matter (Kjeldsen, 2002).

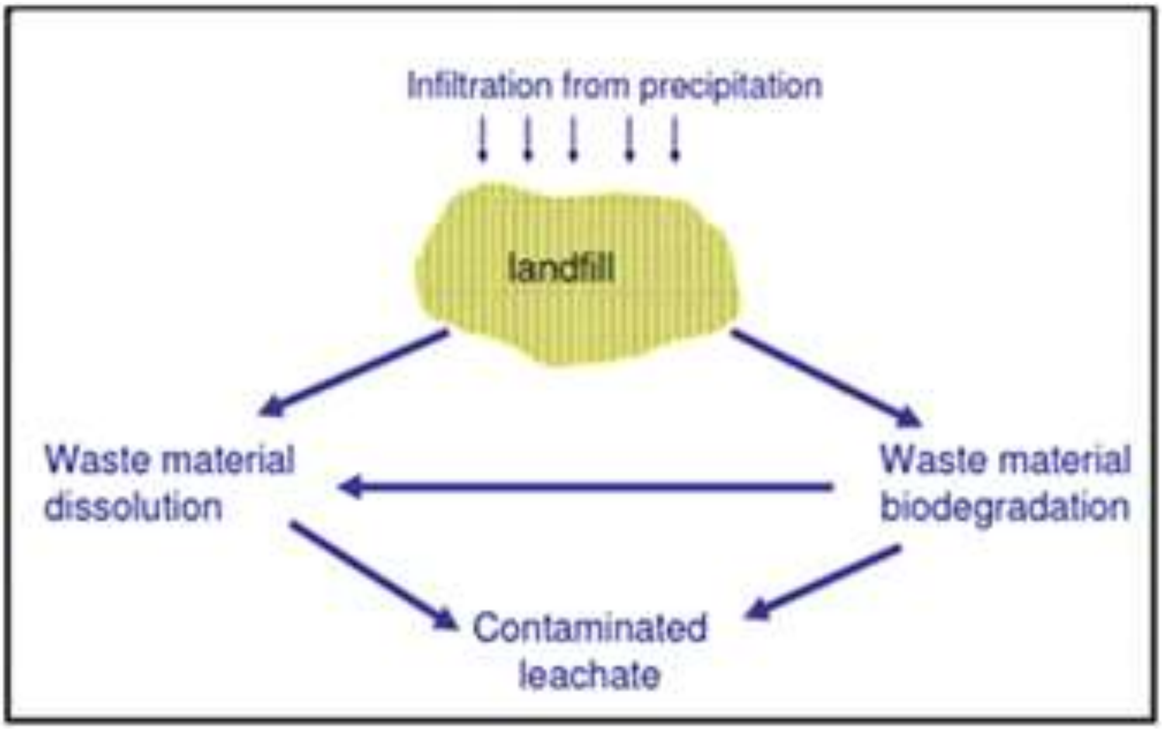


Figure 2.2: Process of leachate formation (Singh and Mittal, 2009)

The quality and physic-chemical characteristics of the leachate formed depends on many factors; the volume characteristics of the solid waste materials deposited; their degree of compaction and prevailing moisture content; total inflow of water to the disposals site; climatic conditions; and age of the waste materials in the disposals site (WHO, 2006). Researchers such as Kjelden (2002), have studied the processes of waste stabilization in landfills over several years and identified many distinct but interrelated phases of waste decomposition. These phases can be characterized by the composition of leachate and land fill gas generated in the process.

While these phases vary greatly, they are all dependent primarily on the age of the landfill. Moreover, they can be categorized as a primary aerobic phase followed by a number of anaerobic phases, with the potential for a return to a terminal aerobic phase.

2.3 Leachate Composition

As a highly contaminated solution, landfill leachate comprises both organic and inorganic components that originate directly from deposited solid waste materials. It is known generally to contain significantly more contaminant loads than raw sewage or many industrial wastes. The relative quality of leachate varies widely depending on a series of complex but interrelated factors. However, there are certain constituents that are common to nearly all landfills, though at diverse concentrations (Yoshida, 2002; Tatsi and Zouboulis, 2002; Jorstad, 2006).

Leachate often moves out of landfill areas and percolates to the groundwater aquiter or overflows to the vicinity of the disposal sites in many parts of the world (Tatsi and Zouboulis, 2002). This poses a significance threat to the quality and sustainability of the surrounding soil and water resources. The following sections present short review of the major constituents typically present in leachates.

2.3.1 Ions

While a large number of ions are reported present in landfill leachates, the major ones often reported by many authors which include Christensen, 2001; Kjeldsen, 2002; Youshida, 2002; Tatsi and Zouboulis, 2002; Acworth and Jorstad, 2006; Jorstad, 2006; Talalaj and Dzienis, 2007 consist of the actions; Ca^{zt} Mg^{2t}, Na^{t}, K^{t}, Fe^{zt}, Mn^{zt} and NH_4 and anions; HCO_3 , CC and SO_4^{z-}.

Also, the amount and distribution of each ion within the leachate vary greatly depending one many factors such as waste composition, degree of waste stabilization and the quantity of the infiltrating water after the leachate is released into the environment, the amount and distribution of each major ion therein will be influenced significantly by the interactions of the leachate with the receiving water and aquifer minerals.

2.3.2 Trace elements

The addition to major ions, a significant amount of other organic and inorganic elements also exists at trace concentrations in leachates. They are mainly derived from the contents of the waste materials deposited in the SWD site, although a small amount could also be sourced from the aquifer solid in the reducing environment of leachate plume. Examples of some typically reported trace elements include heavy metals such as Cd, Cr, Cu,Ni, Pb and Zn. Some of which are regulated by strict water quality standard because of their level of toxicity (Jorstad, 2006).

2.3.3 Heavy metals

Many studies have confirmed that the concentrations of heavy metals in leachate are usually very low. However, they may constitute a significant environmental threat, even when very low concentrations (Ug/L) are leached into surface water, ground water resources or soil (Ehring, 1983; Cecen and Gursay, 2000. Kjelden and Christensen, 2001). Although their relative abundance in leachate also differs between different landfills, the typically reported heavy metals in leachate include: Cd, Pb, Zn, Ni, Cr, and Cu.

More so, even when a significant quantity of metal waste may be present in the landfills, it is estimated that only small fraction is leached even after so many years. The solubility in leachate is influenced by many factors such as PH, redox potential and ion exchange capacity in the waste mass (Christensen, 2001; Jorstad, 2006).

2.3.4 Dissolved organic matter

According to Kjeldsen (2002), dissolved organic matter in landfill leachates is a bulk parameter covering a variety of organic degradation products varying from small volatile acids to refractory fulvic and humic-like compounds that form the bulk of the products of immediate degradation of organic waste material is solid waste disposal (SWD) sites. Their concentrations are best described using the bulk parameters; Total Organic Carbon (TOC), Chemical Oxygen (BOD). Dissolved organic matter can have a crucial influence on the mobilization and attenuation of various contaminants. They act as susbrate for microbially-mediated redox reactions, and may increase the mobility of heavy metals in solution through complexation with organic legends and sorption outo organic colloids (Christensen, 2001; Kjeldsen, 2002; Jorstad, 2006).

2.4 Leachate Soil Contamination

The soil is an important component of dumpsite where various polluted materials are deposited. Biological, chemical and physical processes within the landfill promote the degradation of waste and result in the production of leachate. The movement of water first through the waste dumps and then through soil results in soil pollution. Leachates are known to cause pollution within and around landfill soil.

Leachate may contain various hazardous substances like chemicals, heavy metals, batteries, pharmaceutical e.t.c. The migration or flow of leachate into the soil has contributed to the soil being a sink of contamination. Contamination with heavy metals such as Pb, Cu, Zn, Fe, Nn, Cr, Cd may lead to

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Geological Mapping

Geological mapping of the study was carried out to identify the different rock types and their geological structures. Systematic geological mapping was conducted using Global Positioning System (GPS) to obtain coordinates and elevation readings of the outcrops and also to locate position on the base map. Rock sampling was also undertaken to hand specimen to study their mineralogy.

Field notebook and pen were used to record all observation and measurements taken in the field. Photographs were also taken to determine some observations. Ten (10) soil samples were collected from various locations.

The sampling map shows the sample collection locations within the study area (Figure 3.1).

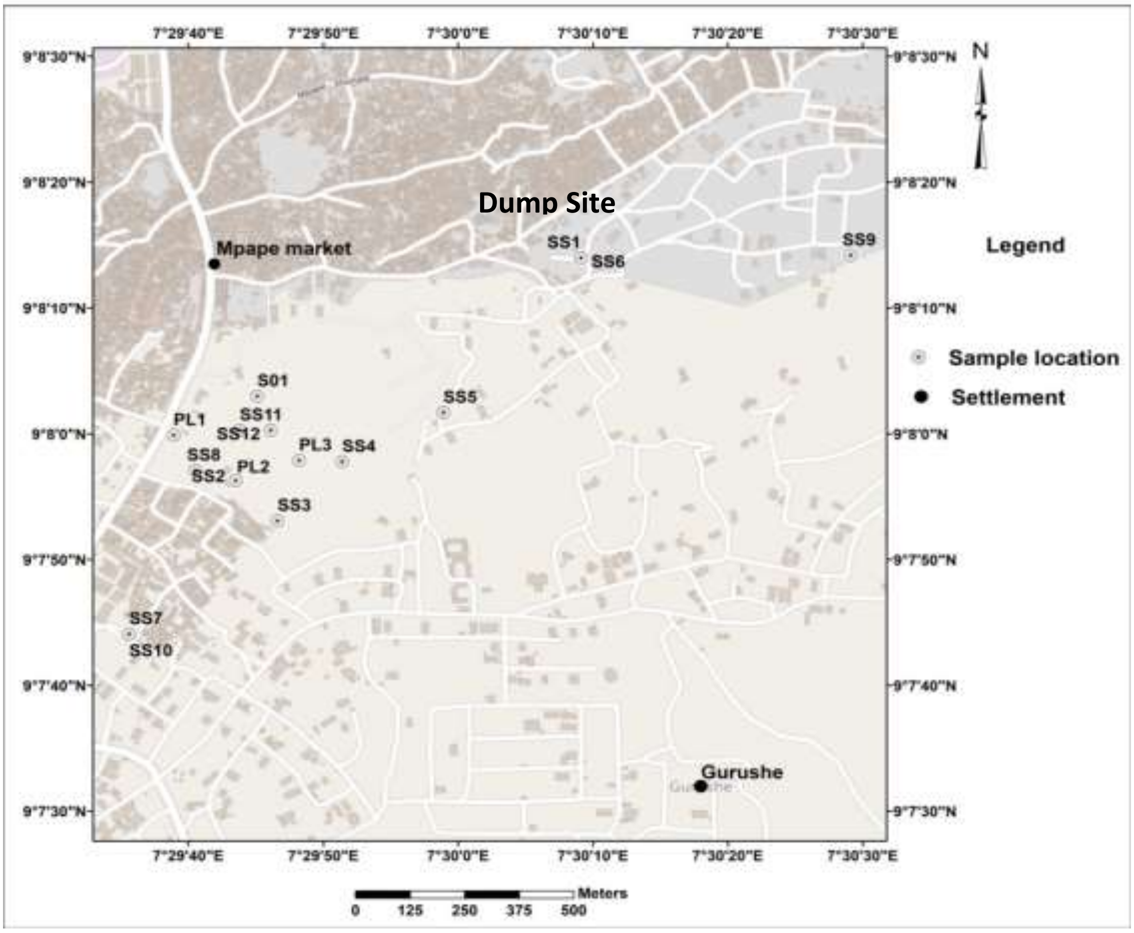


Figure 3.1 Samples Location Map

3.2 Waste Charaterisation

The wastes deposited in the dump site were characterized to know the nature and the diversity of the dumps at the vicinity of the dump site.

Plate I: Waste observed at dumpsite during field work

3.3 Geophysical Survey Investigation

The geological investigation involved two dimensional (2-D) Electrical imaging using Wenner array utilizing resistivity meter, ABEM SAS 300 Terrameter.

In the 2-D resistivity imaging, four horizontal profile stations were occupied, utilizing a multi-electrode system with equal minimum spacing “a” between successive electrodes.

Plate II: Geophysical Survey Investigation

The multi core cable was laid on the ground in a straight line along the traverse with interval spacing ranges at 5m to 30m at each sounding station. The electrodes were connected to a contract switching system (Terrameter) and currents were injected into the ground via the current electrodes (C1 and C2) located at the exterior of the potential electrodes (P1 and P2). The potential differences between to potential electrodes were measured and the resistance of the ground was calculated automatically by the meter. After taking the first reading at station 1, the cable and electrode were moved in a leap frog manner to be next position for the second reading. This process contained until all measurements points along the traverse were covered.

Data points were acquired and subsequently processed using the RES 2 DINV and Geographic Information System (Arc GIS 10.4) software.

3.4 Sampling of Soil and Leachate

Based on the focus of this study, ten (10) soil samples collected MSS 001 – MSS 010 were collected from within the waste disposal zone and outside waste disposal zone (Figure 3.2). Four (4) soil samples labeled B1-B4 were taken for grain size analysis to determine infiltration rate of leachate.

Two (2) leachate samples labelled MLS1 and MLS2 were collected from the dump site zone for analysis.

Plate III: Soil Sample Collection

Soil samples MSS 001 – MSS 010 were taken to the laboratory of central instrumentation centre for dry land agriculture, Bayero University, Kano for X-R-F analysis. Soil samples B1-B4 were taken to the laboratory of the Department of Geology, Federal University of Technology, Minna for grain size analysis while leachate samples labeled MLS 1 and MLS 2 were taken to the laboratory of the Federal Ministry of Water resources, Minna for physic-chemical and micro biological analysis.

3.5 Data Interpretation

The measured and calculated apparent resistivities were presented as pseudo sections. The results of soil samples analysis came as oxides after which they were converted to elements using their conversion factors. Result of leachate sample analysis for chemical parameters are in mg/L while those for microbiological parameters are in CFU/100ml

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Field Observations

Geological field investigation revealed that the area is underlain by porphyritic biotite granite, composing of biotite mica, plagioclase feldspar and quartz. Accessory minerals include apatite, microcline and zircon. The porphyritic granites were observed to have xenoliths on granodiorite occurring as patches in many of the outcrops.

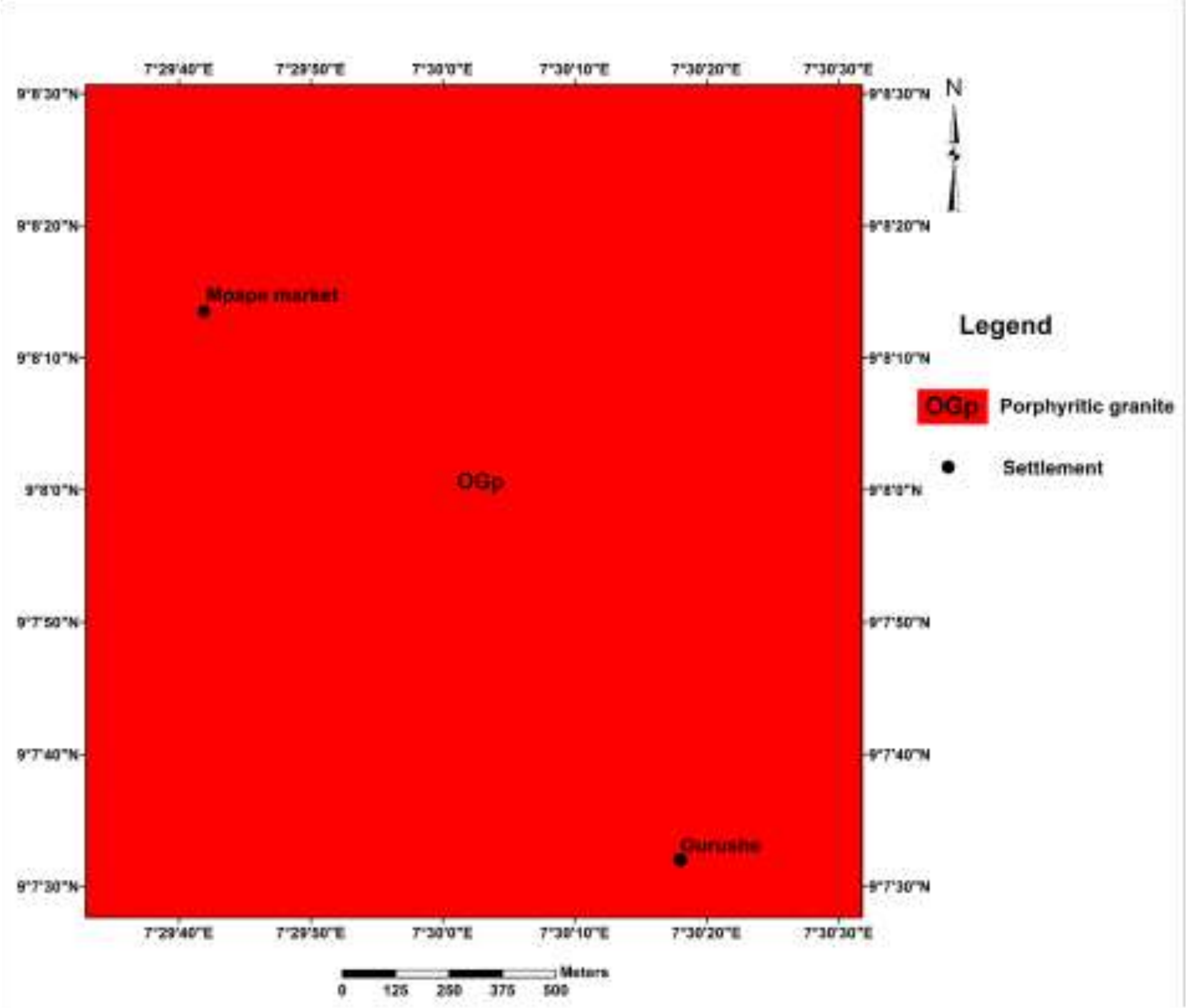


Figure 4.1: The geological map on with the scale of 1:12,500

Plate IV: Quartz veinlet (1.5cm thick) striking N27° on porphyritic granite outcrop with xenolith of granodiorite (N09° 08´ 01.1´´, E07° 29´ 43.3´´; 696m ASL)

Plate V: Porphyritic granite boulder with xenolith of granodiorite (N09° 07´ 57.8´´, E07° 29´ 45.7´´; 689m ASL)

4.2 Characterisation of Waste in the Dumpsite

The waste deposited in the dumpsite predominantly contain domestic, agricultural, industrial and medical wastes. The components of the wastes include foods, papers, nylon, plastics, animal feed, cotton wool, bandages and metals (Plate 4.3).

Plate VI: Waste disposed at the dumpsite

There is no any prior segregation except for scavengers who partially pick-up metals, glass, plastics for reuse and recycling purposes (Plate 4.4).

Plate VII: Scavengers at the Site

4.3 Geophysical Survey Investigation

The measured and calculated apparent resistivity pseudo sections as well as corresponding inverse model resistivity sections of profiles 1-3 are presented in Figure 4.2 to 4.4.

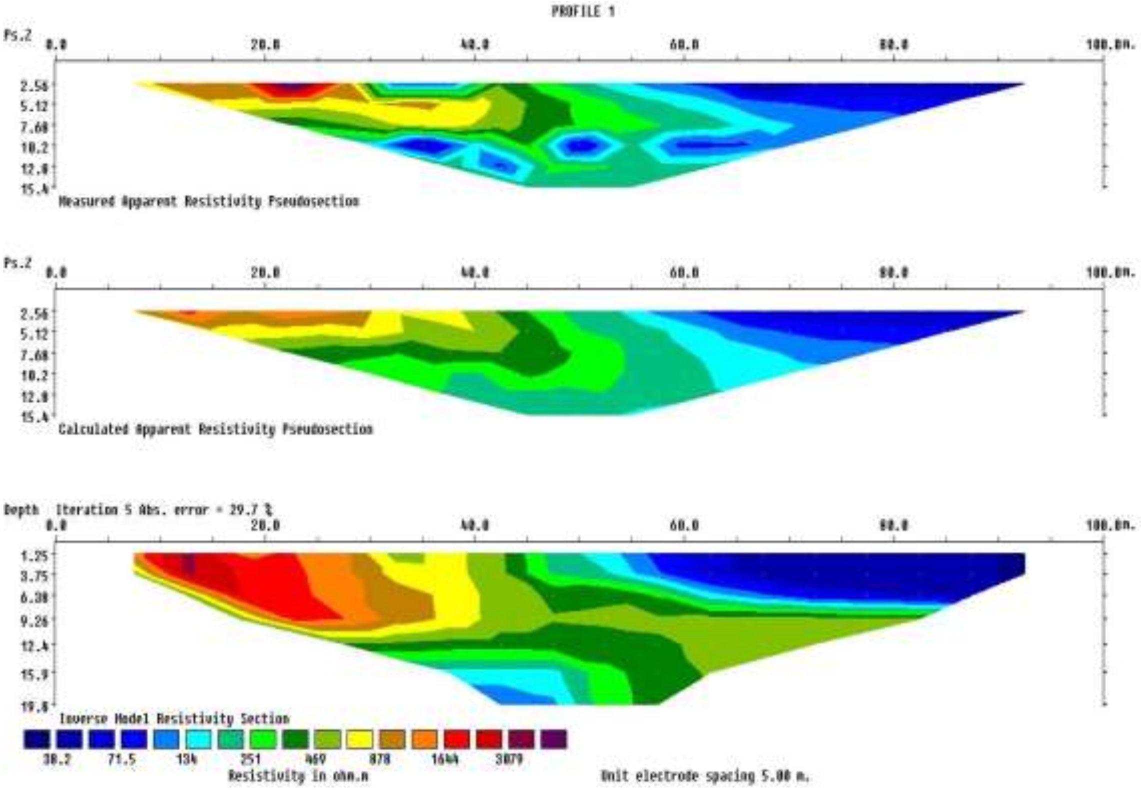


Figure 4.2: 2D Electric resistivity Pseudo section of Profile 1

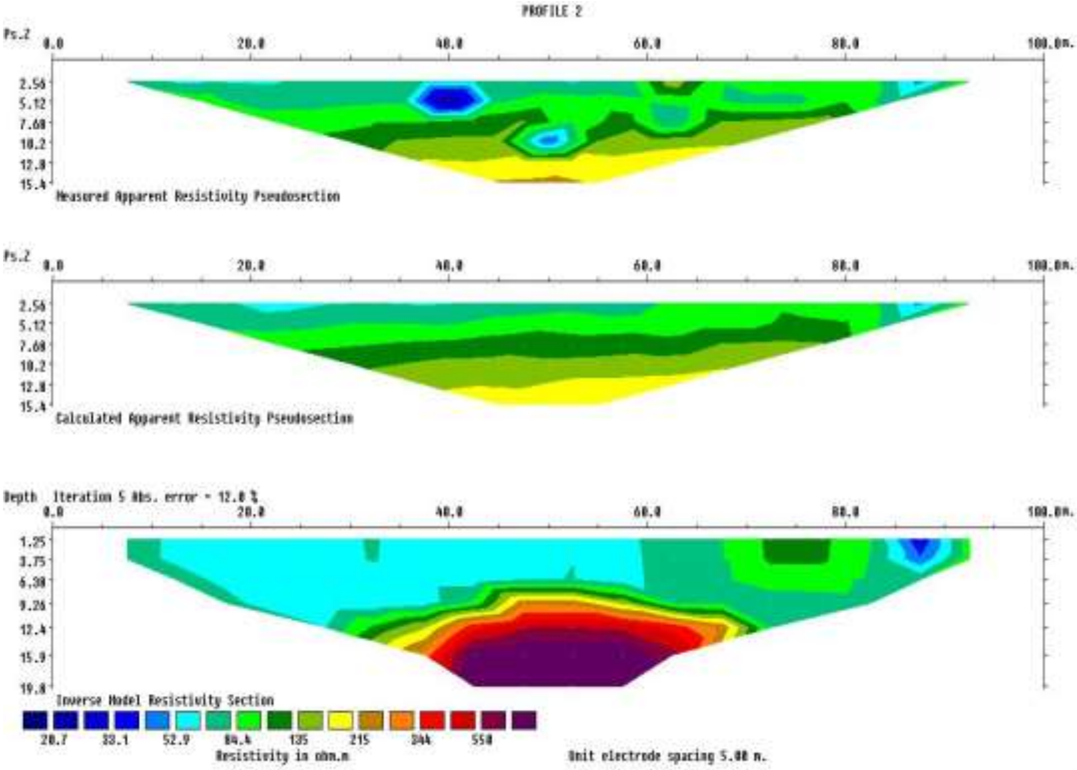


Figure 4.3: 2D Electric resistivity Pseudo section of Profile 2

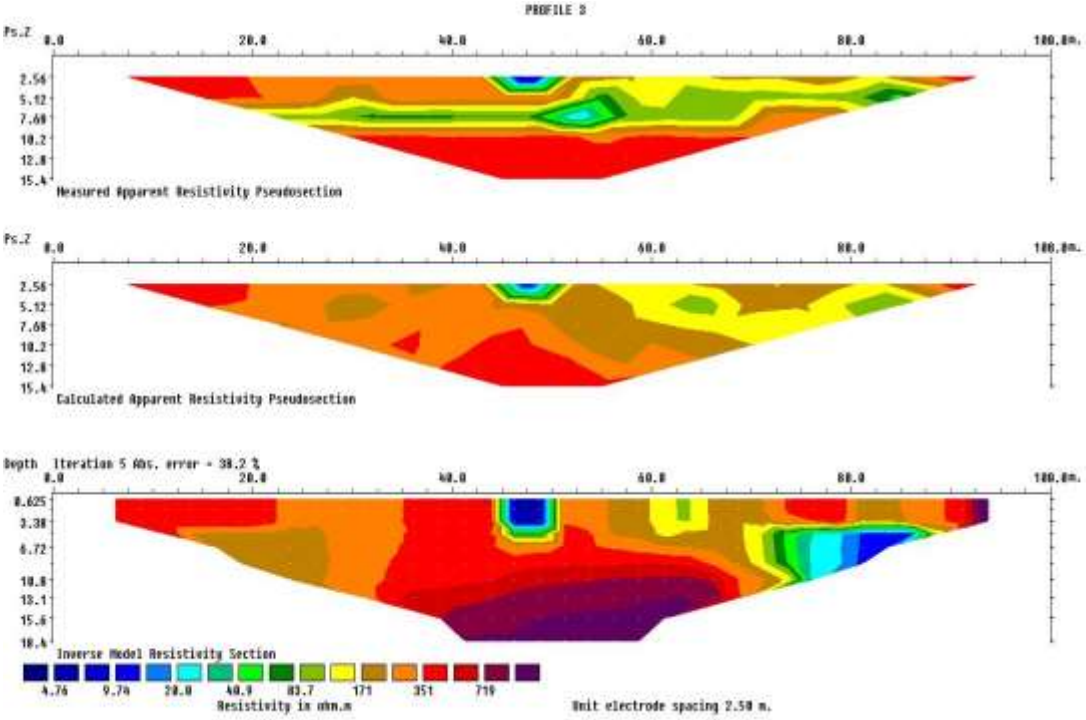


Figure 4.4: 2D Electrical Resistivity Pseudo section ofProfile 3

2-D resistivity imaging is a method used to map subsurface electrical resistivity. It involves measuring the resistance to the flow of electrical current through the ground. The resulting data is used to create a 2-dimensional image of the subsurface, with different colors or shades indicating variations in resistivity. In this case, the study was used to identify areas of anomalously low resistivity, which were interpreted as being caused by leachate contaminant plumes.

The 2-D resistivity imaging mapped three (3) distinctive zones of anomalously low resistivity (deep to light blue) in the profiles were interpreted as high conductive leachate contaminant plumes (as a result of decomposing landfill waste) containing organic and inorganic substances, pathogens and dissolved solid. The leachate contaminant plume is observed; seepage is enhanced by the nature of permeable sandy layer characteristics of the area.Low resistivity generally indicates a high conductivity or ease of electrical current flow. In this case, the low resistivity is interpreted as being caused by high conductive leachate contaminant plumes which are formed by decomposing waste in a landfill. The color coding (deep to light blue) is used to indicate the level of low resistivity, with deep blue representing areas of very low resistivity and light blue representing areas of less low resistivity.

The zone of increasing resistivity (light green to yellow) was also identified as porous and permeable sandy layers of varying grain sizes and moisture content. Increasing resistivity means that the ease of electrical current flow through the ground is decreasing. This can indicate that the subsurface material is less conductive, such as a layer of clay or rock. In this case, the increasing resistivity is typically mapped using different colors or shades, with light green indicating the lowest resistivity and yellow indicating the highest resistivity. Typically, it could be an indication of different subsurface materials or less contaminated area.

The zones of anomalously high resistivity (pink to purple) were interpreted as uncontaminated water filled sand. Anomalously high resistivity means that the subsurface material is more resistive to the flow of electrical current than would be expected based on the surrounding area. This can indicate that the subsurface material is less conductive, such as a layer of rock or a very dry soil. In this case, the high resistivity is typically mapped using different colors or shades, with pink indicating the lowest resistivity and purple indicating the highest resistivity. Typically, it could be an indication of different subsurface materials or less contaminated area.

The results showed that the modeled subsurface is more resistive (uncontaminated) as we move away from the dumpsite as seen in profile 3 which was taken about 2000m away from the site.

Table 4.1: Soil samples concentration (%) in the Study Area

Sample Code	Si	Al	Fe	Ca	K	Ti	Mg	Mn	Zr	P	Ce	Ba	Nd	Sr	Cl	S
MLS 001	22.82	10.44	11.28	2.30	4.96	1.41	0.8	0.17	0.29	0.21	ND	0.17	0.06	0.06	0.28	0.21
MLS 002	18.70	9.74	21.46	0.58	3.53	1.63	0.50	0.18	0.32	0.15	0.06	0.09	0.09	ND	0.26	0.17
MLS 003	17.85	9.24	23,69	0.55	3.37	1.60	0.48	0.17	0.29	0.15	0.05	ND	ND	ND	0.26	0.17
MLS 004	22.93	9.87	11.18	2.59	5.15	1.32	1.00	0.18	0.17	0.41	0.05	0.22	ND	0.06	0.29	0.18
MLS 005	22.14	10.46	12.50	2.38	4.35	1.44	0.90	0.21	0.19	0.29	ND	0.13	ND	ND	0.25	0.23
MLS 006	23.13	8.15	11.55	4.00	5.15	1.47	1.03	0.22	0.21	0.32	ND	0.13	ND	ND	0.29	0.21
MLS 007	24.00	9.64	9.85	2.91	5.36	1.17	0.66	0.16	0.16	0.33	ND	0.15	ND	ND	0.3	0.29
MLS 008	33.23	6.06	4.13	1.72	4.07	0.55	ND	0.13	0.15	0.29	ND	ND	ND	ND	0.3	ND
MLS 009	25.88	11.11	5.83	1.04	4.42	1.68	0.54	0.17	0.45	0.06	ND	ND	ND	ND	0.26	0.23
MLS 010	25.77	10.84	8.00	2.52	3.43	1.23	0.66	0.13	0.66	0.13	0.36	0.16	ND	0.05	0.24	0.28
Min Value	17.85	6.06	4.13	0.55	3.37	0.55	0.48	0.13	0.15	0.06	0.05	0.05	0.06	0.05	0.24	0.17
Max Value	33.23	11.11	23.69	2.91	5.36	1.68	1.03	0.22	0.45	0.41	0.36	0.22	0.09	0.06	0.3	0.29
Mean	23.55	9.56	11.95	2.06	4.38	1.35	0.73	0.17	0.26	0.24	0.16	0.13	0.08	0,06	0.27	0.22

***** ND – Means not detected***

Table 4.2: Measured Physical Parameters of Leachate Samples of Study Area.

Sample Code / Location	Temp (°C)	PH	Cond (N5/cm)	TDS	Turbidity (NTU)	Suspended Solid (Mg/l)
MLS 001	31.5	6.24	667	428	4,975	4,675
MLS 002	30.8	7.02	206	134	75	200
Min Value	30.8	6.04	206	134	7.5	200
Max Value	31.5	7.02	667	428	4,975	4,675
Mean	31.15	6.63	436.50	281	2,525	2,437.50

Table 4.3: Result of Chemical Parameters of Leachate in the Study Area.

Sample Code	Location	Cr^{2+}	Ca^{2+}	Mg^{2+}	TH	TA	CL	DO	BOD	NO_3	NO_2	SO_4	P_2O_3	NH_3	Fe	COD	F
MLS 001		BDL	43.20	35.40	253	94.0	62	1.0	135	14.4	BDL	12.0	5.25	23.0	3.05	229	BDL
MLS 002		BDL	33.60	8.78	120	46.0	34	2.0	126	0.60	0.07	9.0	3.04	4.00	0.29	198	BDL
Min Value		BDL	33.60	8.78	120	46.0	34	2.0	126	0.60	0.07	9.0	3.04	4.00	0.29	198	BDL
Max Value		BDL	43.20	35.40	253	94	62	2.0	135	14.40	0.07	12.0	5.25	23	3.25	229	BDL
Mean		BDL	38.40	22.09	186.50	70	48	1.50	130.50	7.50	0.035	10.50	4.15	13.5	1.67	213.50	BDL

Table 4.4: Microbiological Parameters of Leachate in the Study Area

Sample Code / Location	**Total Conc**	**E.Cole**
MLS 001	2060	920
MLS 002	780	260
Min Value	780	260
Max Value	2060	920
Mean	1420	590

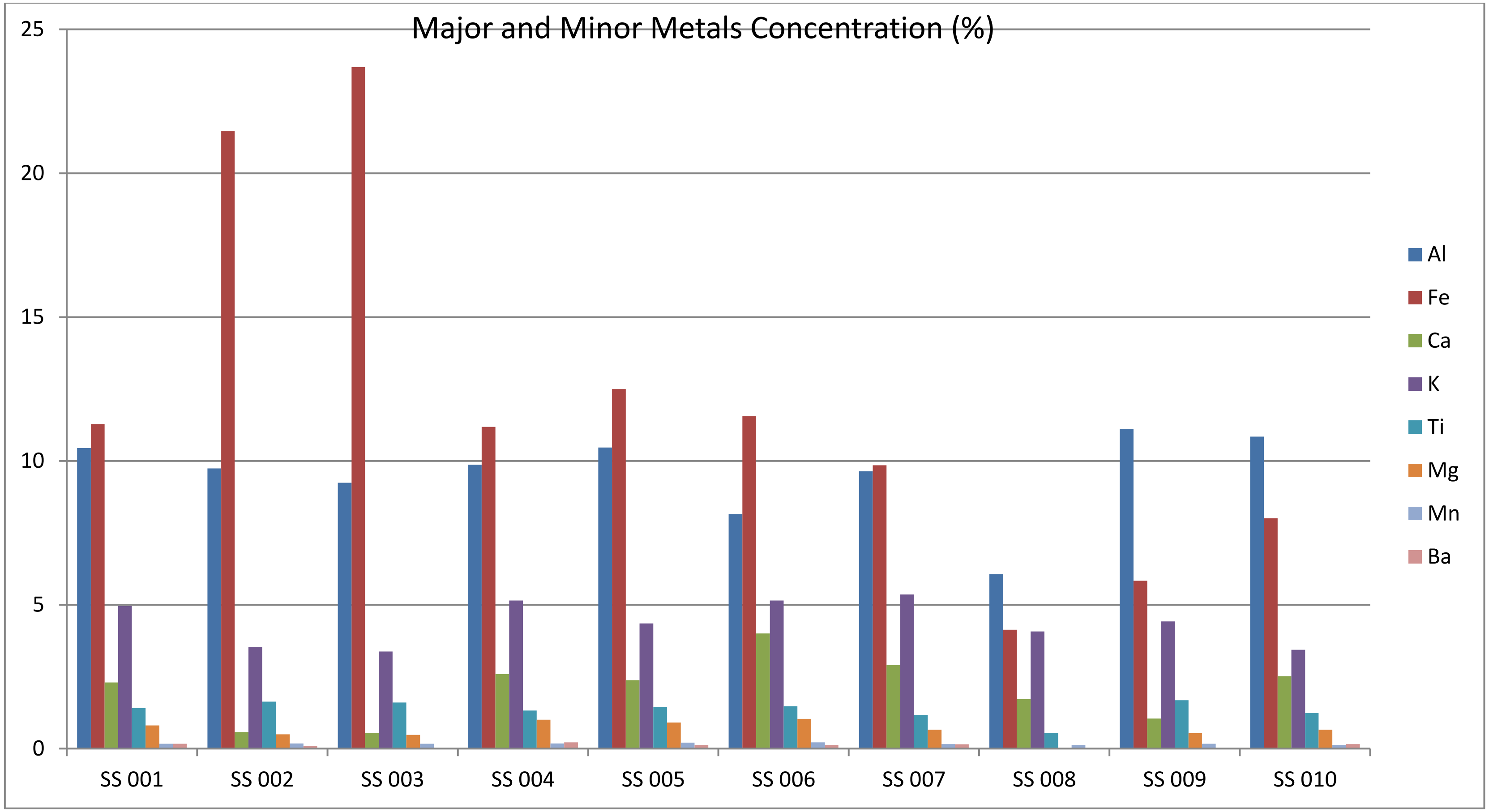


Figure 4.5: Metal Concentration Chart

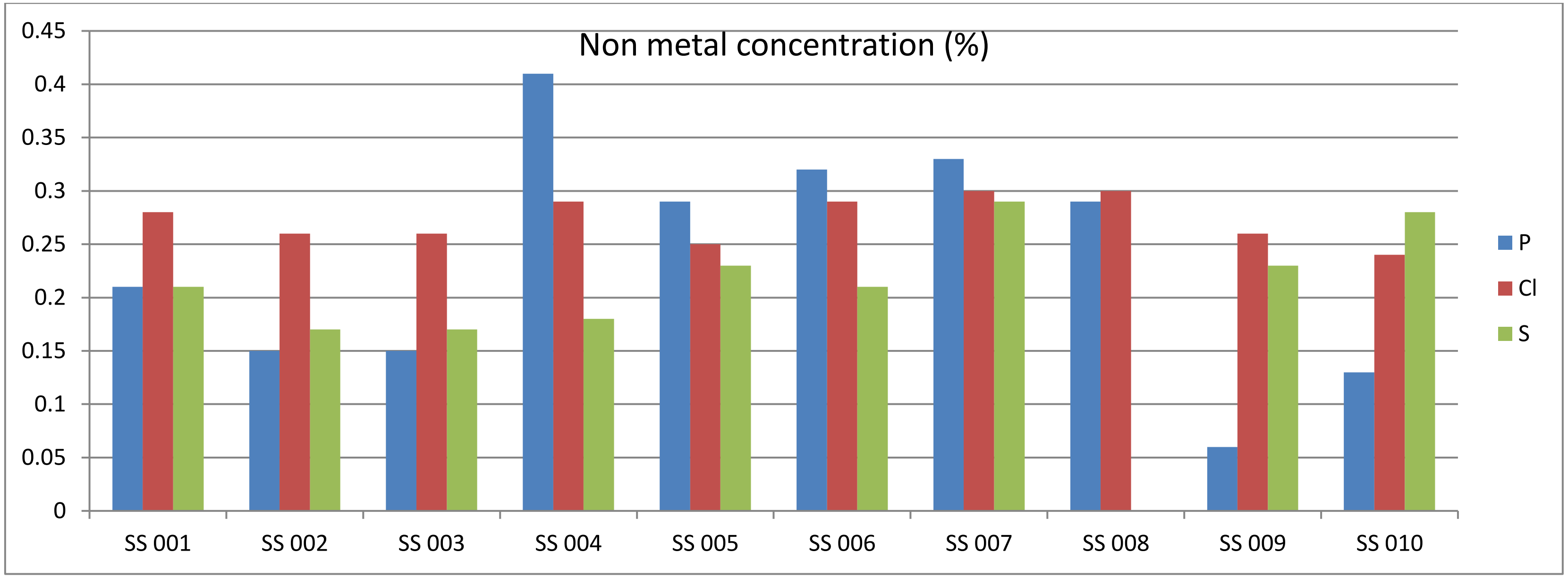


Figure 4.6: Non-Metal Concentration Chart

Table 4.5: Sample B1

Initial Dry Mass.... 201.37

Total Final Mass ... 200.17

Mass Lost........... 1.2 (0.6%)

Screen Name	Screen Size (mm)	Mass Retained	% Retained	% Retained	Cumulative% Finer
#4	4.75	0.00	0.00	0.00	100.0
#6	3.35	0.00	0.00	0.00	100.0
#8	2.36	0.00	0.00	0.00	100.0
#10	2.00	76.11	37.80	37.80	62.2
#20	0.85	30.33	15.10	52.90	47.1
#40	0.42	26.00	12.90	65.80	34.2
#60	0.25	17.99	8.90	74.70	25.3
#80	0.18	11.88	5.90	80.60	19.4
#100	0.15	8.98	4.50	85.10	14.9

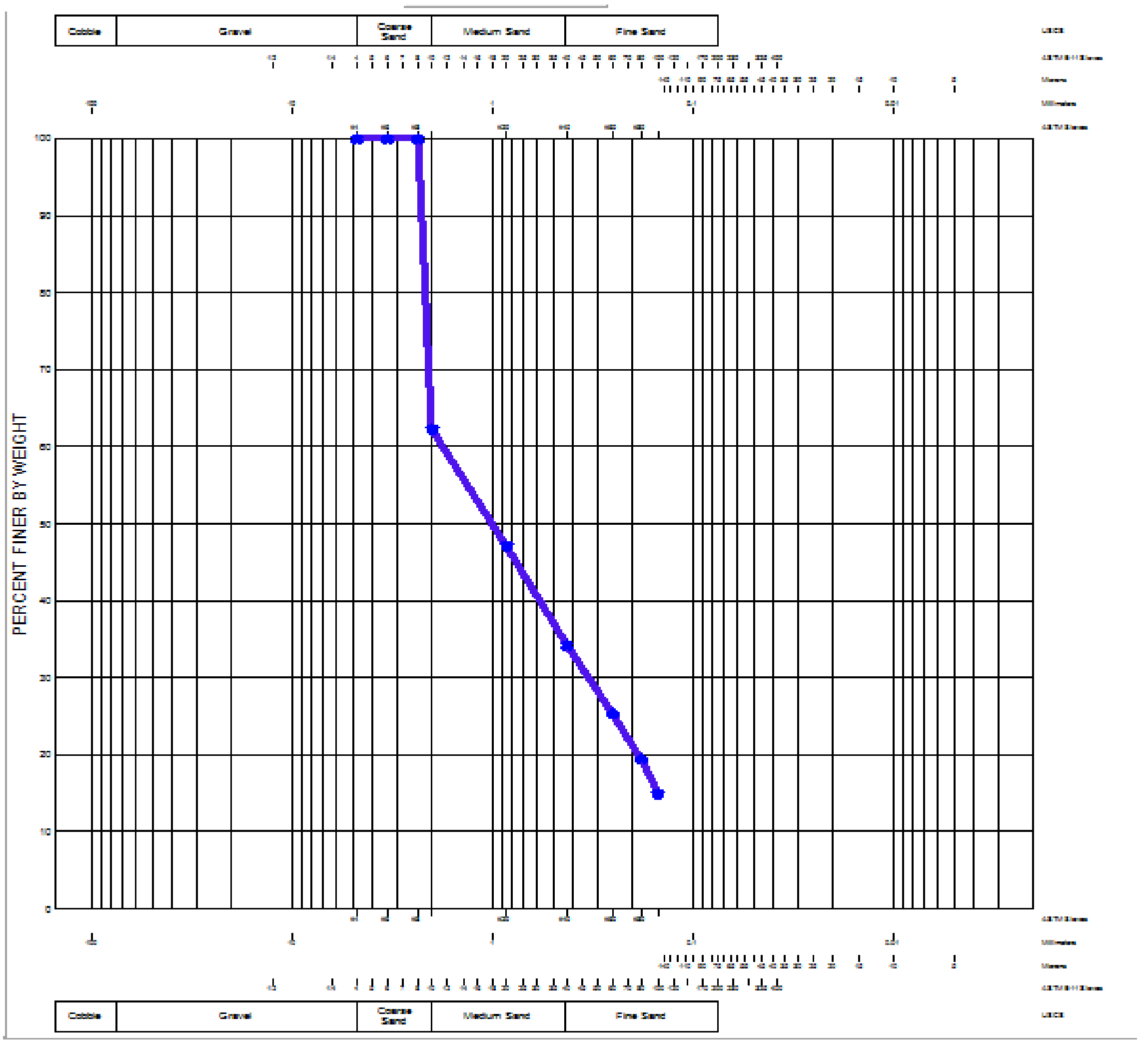


Figure 4.7: Plot of Sieve Analysis Result of Soil Sample B1

Table 4.6: Sample B2

Initial Dry Mass.... 241.32

Total Final Mass ... 237.56

Mass Lost........... 3.76 (1.6%)

Screen Name	Screen Size (mm)	Mass Retained	% Retained	% Retained	Cumulative % Finer
#4	4.75	0.00	0.00	0.00	100.0
#6	3.35	0.00	0.00	0.00	100.0
#8	2.36	0.00	0.00	0.00	100.0
#10	2.00	59.32	24.60	24.60	75.4
#20	0.85	53.69	22.20	46.80	53.2
#40	0.42	35.67	14.80	61.60	38.4
#60	0.25	24.48	10.10	71.80	28.2
#80	0.18	15.72	6.50	78.30	21.7
#100	0.15	13.15	5.40	83.70	16.3

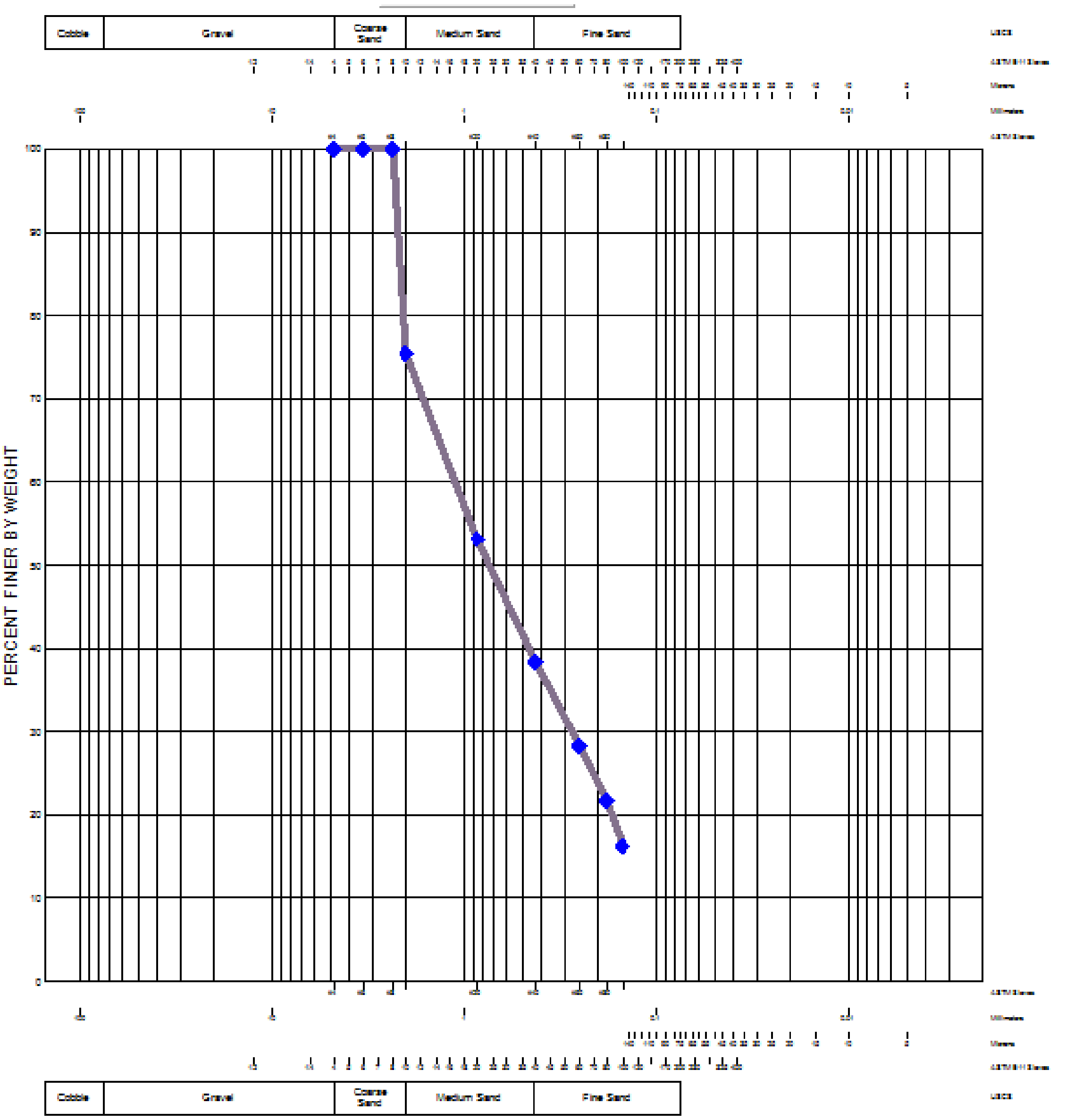


Figure 4.8: Plot of Sieve Analysis Result of Soil Sample B2

Table 4.7: Sample B3

Initial Dry Mass.... 202.39

Total Final Mass ... 202.0

Mass Lost........... 0.39 (0.2%)

Screen Name	Screen Size (mm)	Mass Retained	% Retained	% Retained	Cumulative % Finer
#4	4.75	0.00	0.00	0.00	100.0
#6	3.35	0.00	0.00	0.00	100.0
#8	2.36	0.00	0.00	0.00	100.0
#10	2.00	14.86	7.30	7.30	92.7
#20	0.85	46.79	23.10	30.50	69.5
#40	0.42	52.68	26.00	56.50	43.5
#60	0.25	25.90	12.80	69.30	30.7
#80	0.18	18.16	9.00	78.30	21.7
#100	0.15	17.18	8.50	86.70	13.3

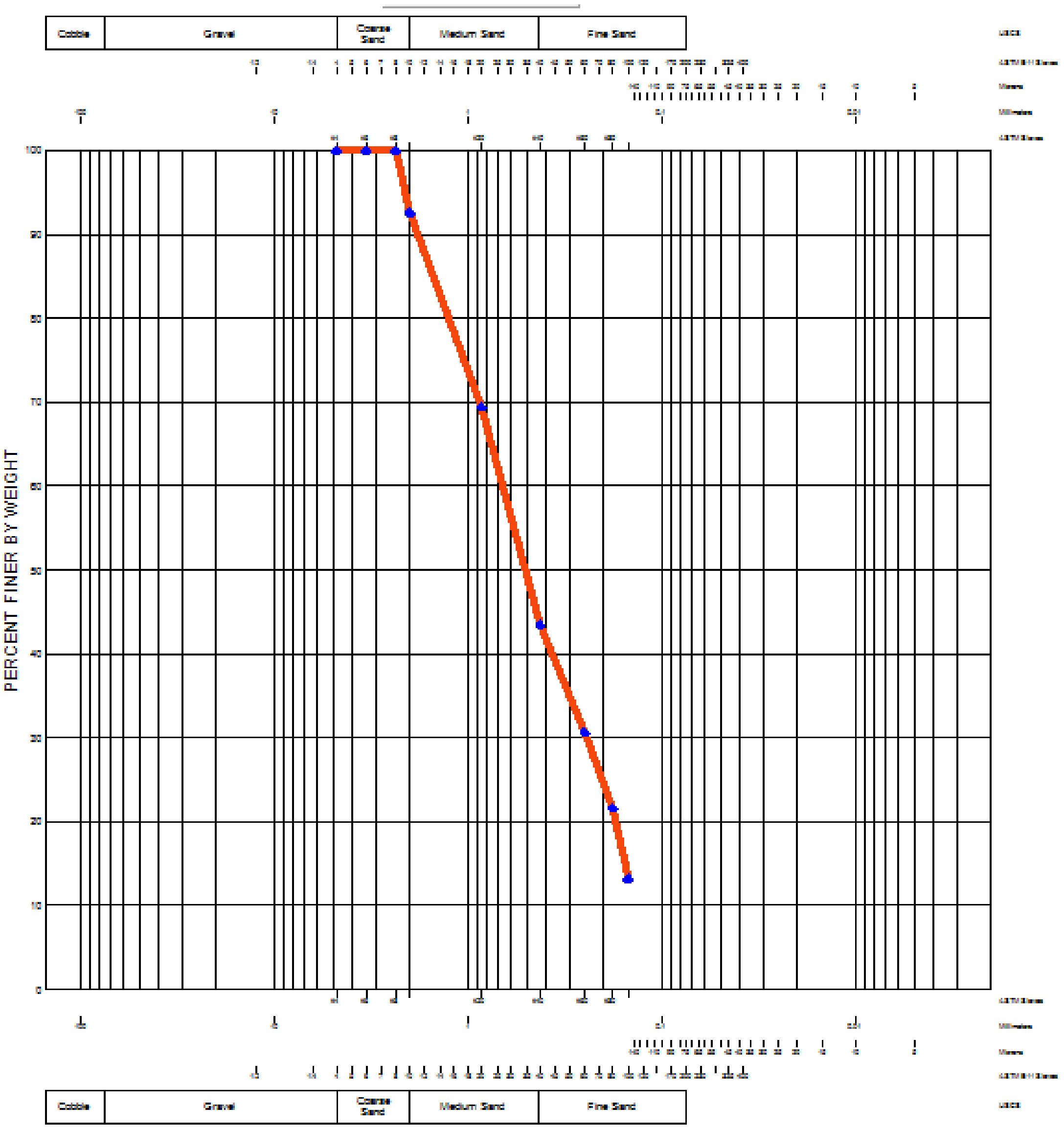


Figure 4.9: Plot of Sieve Analysis Result of Soil Sample B3

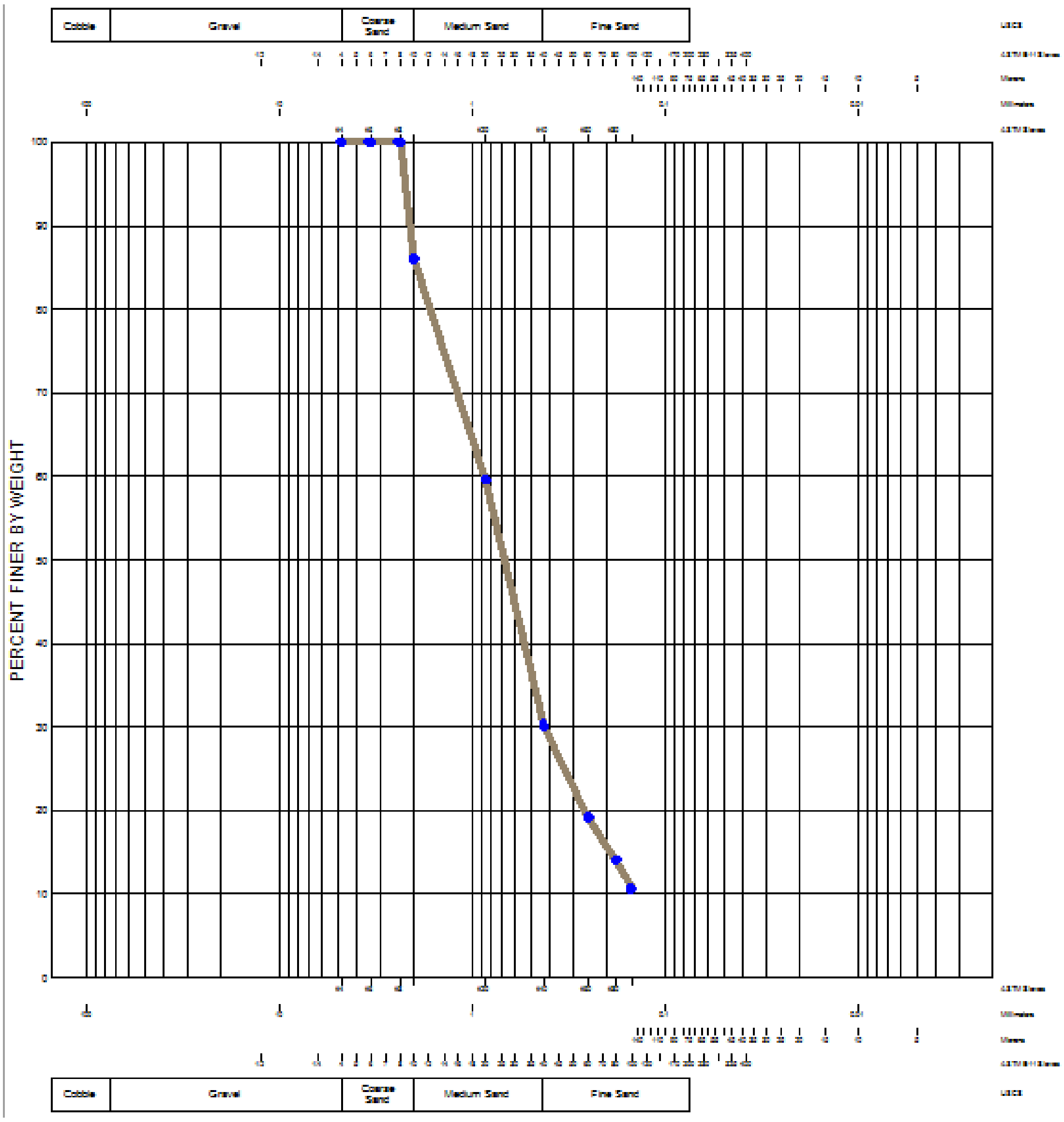
Table 4.8 Sample B4

Initial Dry Mass.... 183.01

Total Final Mass ... 182.25

Mass Lost........... 0.76 (0.4%)

Screen Name	Screen Size (mm)	Mass Retained	% Retained	% Retained	Cumulative % Finer
#4	4.75	0.00	0.00	0.00	100.0
#6	3.35	0.00	0.00	0.00	100.0
#8	2.36	0.00	0.00	0.00	100.0
#10	2.00	25.47	13.90	13.90	86.1
#20	0.85	48.41	26.50	40.40	59.6
#40	0.42	54.07	29.50	69.90	30.1
#60	0.25	20.05	11.00	80.90	19.1
#80	0.18	9.28	5.10	85.90	14.1
#100	0.15	6.22	3.40	89.30	10.7



This is the combination of the 4 samples

Figure 4.10: Plot of Sieve Analysis Result of Soil Sample B4

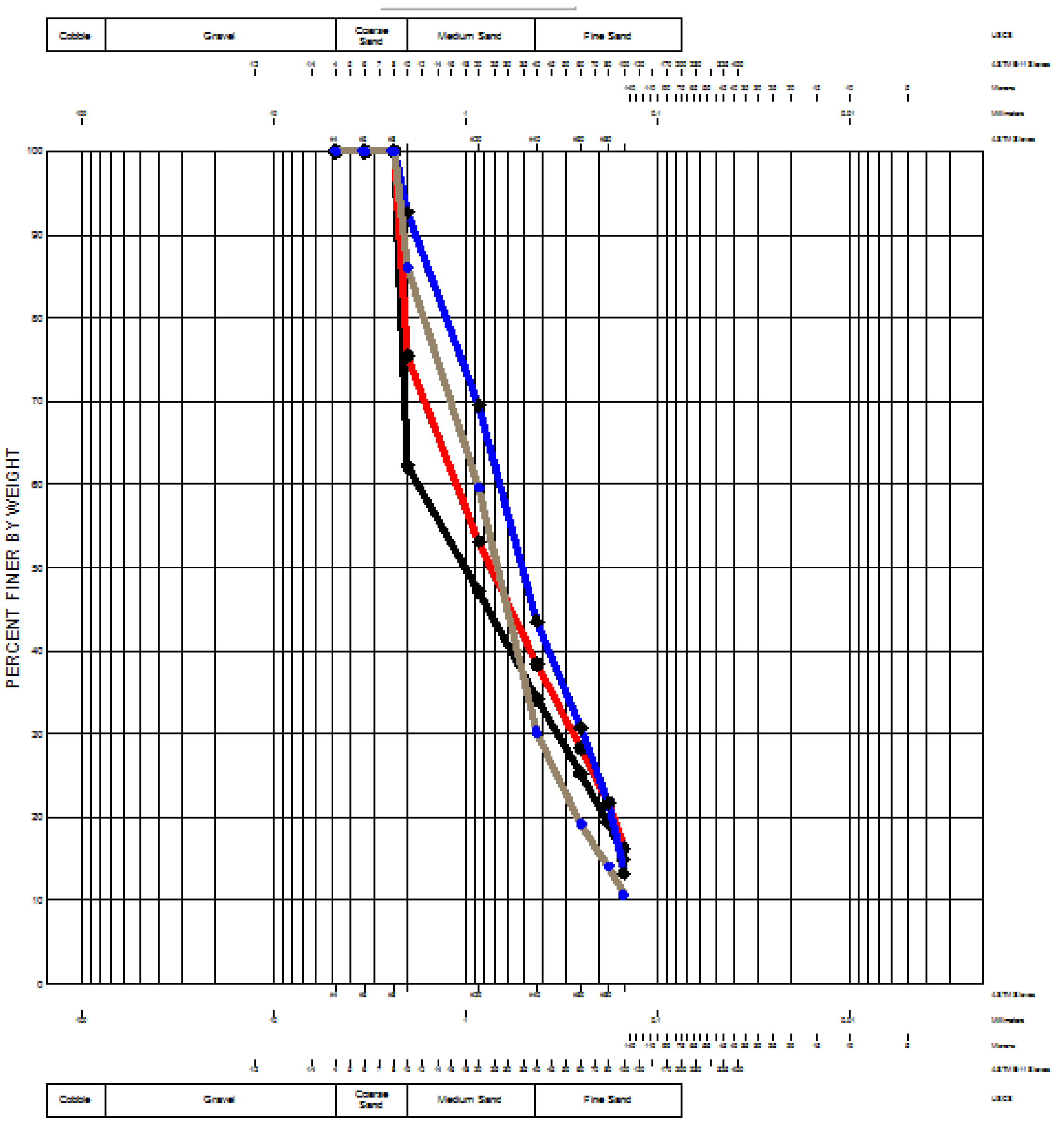


Figure 4.11: Plot of Sieve Analysis Result of Combination of Soil B1-B4

4.4 Major Element Concentration

The major element concentration (%) of the soil samples are presented in Table 4.2. The soils are characterized with high concentration of Si which ranges between 17.85 and 33.23 wt % with mean value of 23.55 wt % (table 4.2). From Figure 4.12 shows the 2-D contour map of Si concentration, it shows that the highest values of Si, is at SS008, while the lowest concentration are within SS001, 002 and 003.

The concentration of Fe ranges between 4.13 wt % and 23.69 wt % with average of 11.95 wt %. A 2-D contour map of the spread of Fe concentration is shown in Figure 4.13. SS003 has the highest concentration of Fe and it decreases towards the northern part of the study area.

Al concentration ranges between 6.06 wt % and 11.11 wt % and has mean value of 9.56 wt %. From Figure 4.14 shows the 2-D contour map of Al concentration, it shows that the lowest concentration are within SS001, 002 and 008. Al concentrations are higher within the southern, and north eastern parts of the study area.

Ca concentration ranges from 0.55 wt % and 2.91 wt % with average concentration of 1.06 wt %. From Figure 4.15, the 2-D contour map of Ca concentration it shows that the northern parts of the study area have higher concentration of Ca, while the southern part of the study area has lower concentrations.

K concentration is between 3.37 wt % and 5.36 wt % and has mean value of 4.38 wt %. From Figure 4.16, the 2-D contour map of K concentration it shows that the northern parts of the study area around SS001, SS004, SS006 and SS007 have higher concentration of K, while the southern part of the study area has lower concentrations.

Ti has concentration ranges between 0.55 wt % and 1.68 wt % with average concentration of 1.35 wt %. A 2-D contour map of the spread of Ti concentration is shown in Figure 4.17. The eastern part of the study area has the highest concentration of Ti.

Mg concentration varies from 0.48 wt % and 1.03 wt %. A 2-D contour map of the spread of Mg concentration is shown in Figure 4.18. Around SS004 and SS006 has the highest Mg concentration within the northern part of the study area.

Mn concentration is between 0.13 wt % and 0.22 wt % with average concentration of 0.17 wt %. A 2-D contour map of the spread of Mn concentration is shown in Figure 4.19. Around SS009 has the highest Mn concentration within the extremely north eastern part of the study area.

Zr concentration is between 0.15 wt % and 0.145 wt % with mean concentration of 0.26 wt %. A 2-D contour map of the spread of Zr concentration is shown in Figure 4.20. Zr concentration increases from the northern part of the study area to the southern part of the study.

P concentration is between0.15 and 0.45 wt % with mean concentration of 0.24 wt %. A 2-D contour map of the spread of P concentration is shown in Figure 4.21. P concentration decreases from the northern part of the study area to the southern part of the study. SS004 has the highest P concentration.

The concentration of Cl is between 0.24 wt % and 0.3 wt % and mean concentration of 0.27 wt %.A 2-D contour map of the spread of Cl concentration is shown in Figure 4.22. Cl concentration highest concentration is within SS006, SS007 and SS008 around the north-western part of the study area.

S concentration is between 0.17 wt % and 0.29 wt % with average of 0.22 wt %. A 2-D contour map of the spread of S concentration is shown in Figure 4.23. S concentration highest concentration at, SS007 around the north-western part of the study area.

Ba concentration ranges between 0.05 wt % and 0.22 wt % with average of 0.13 wt %.A 2-D contour map of the spread of Ba concentration is shown in Figure 4.24. Ba concentration highest concentration at, SS004 in the study area.

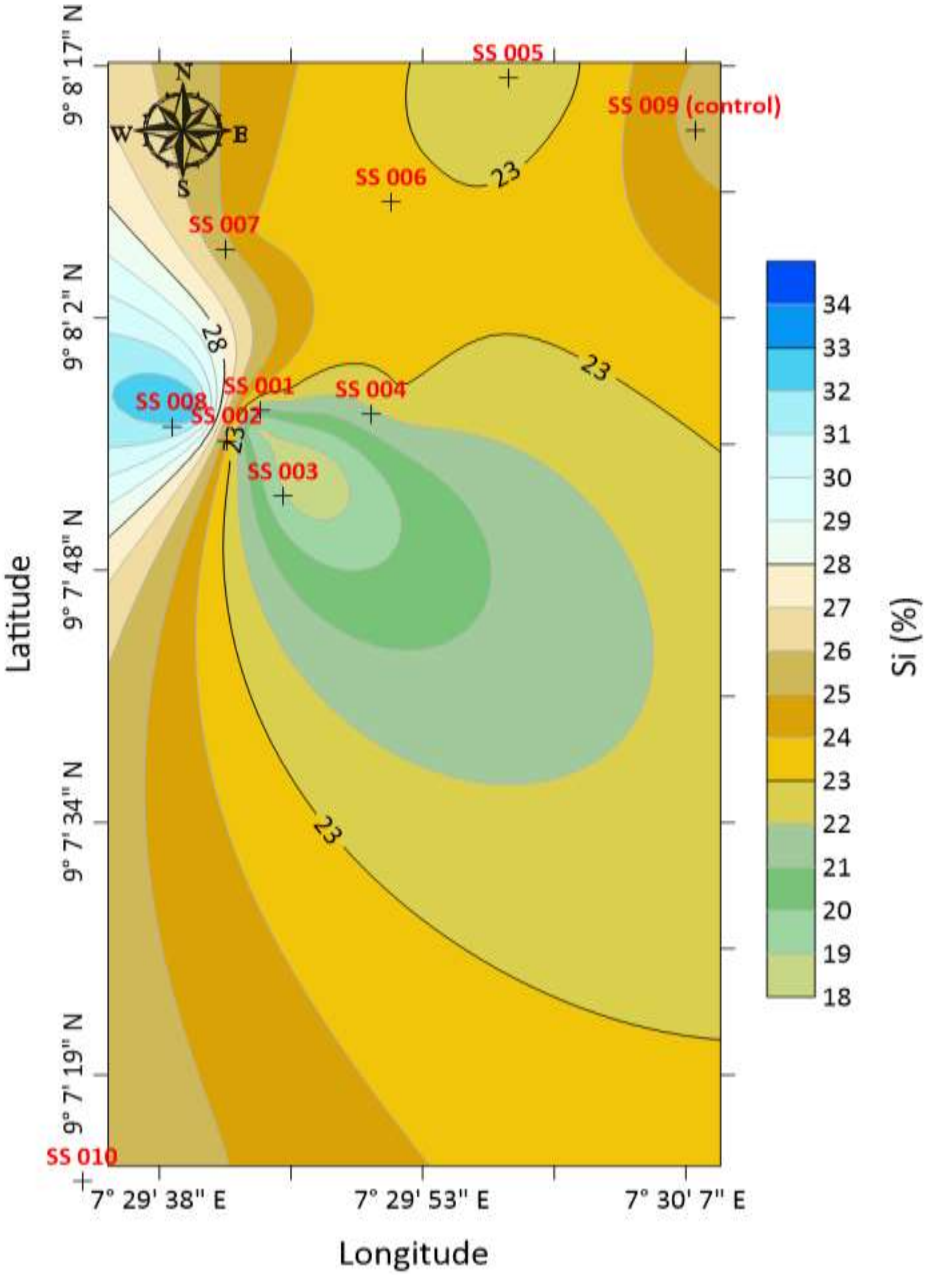


Figure 4.12: 2-D Contour map of Si (%) for soil sample in the study area

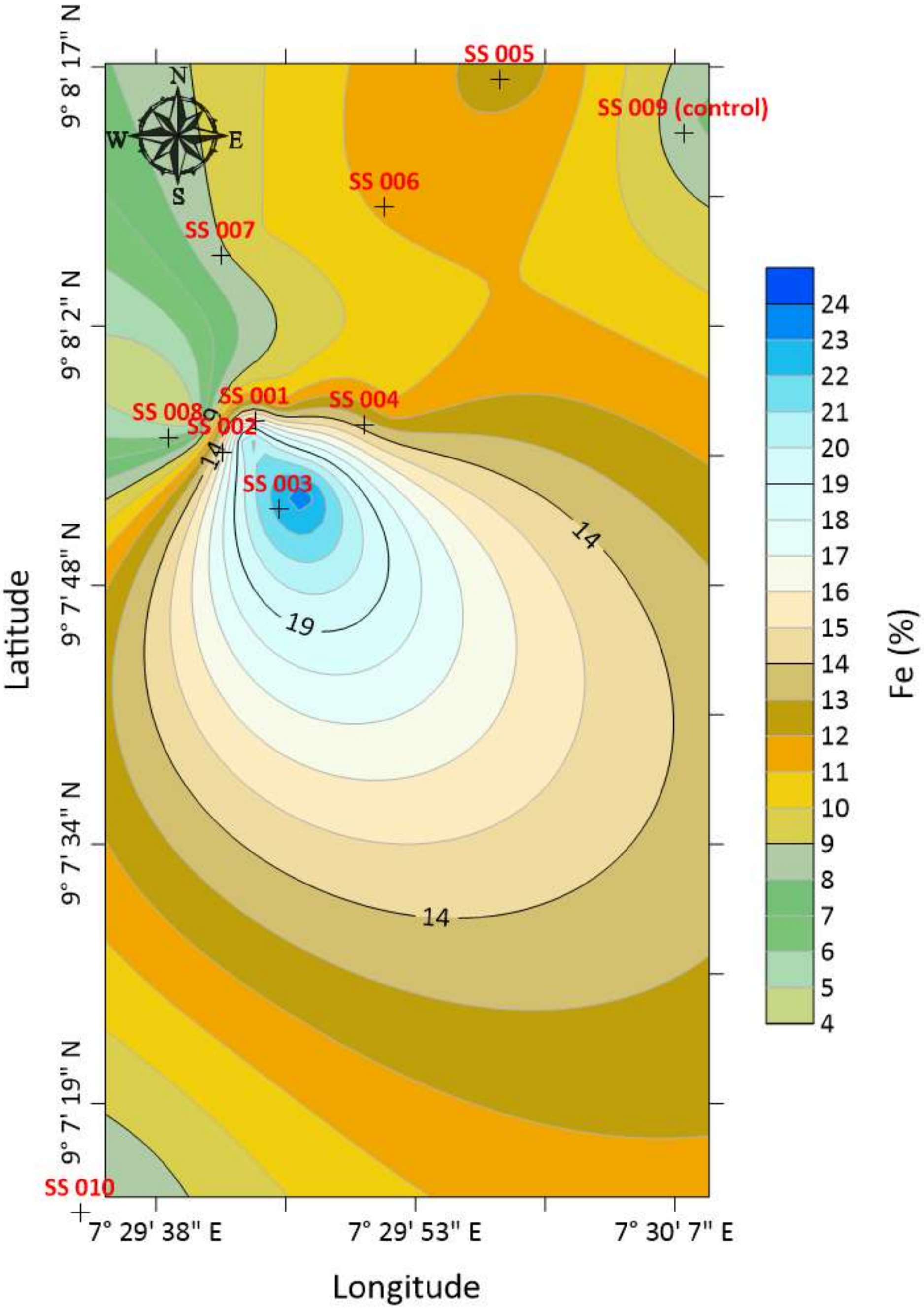


Figure 4.13: 2-D Contour map of Fe (%) for soil sample in the study area

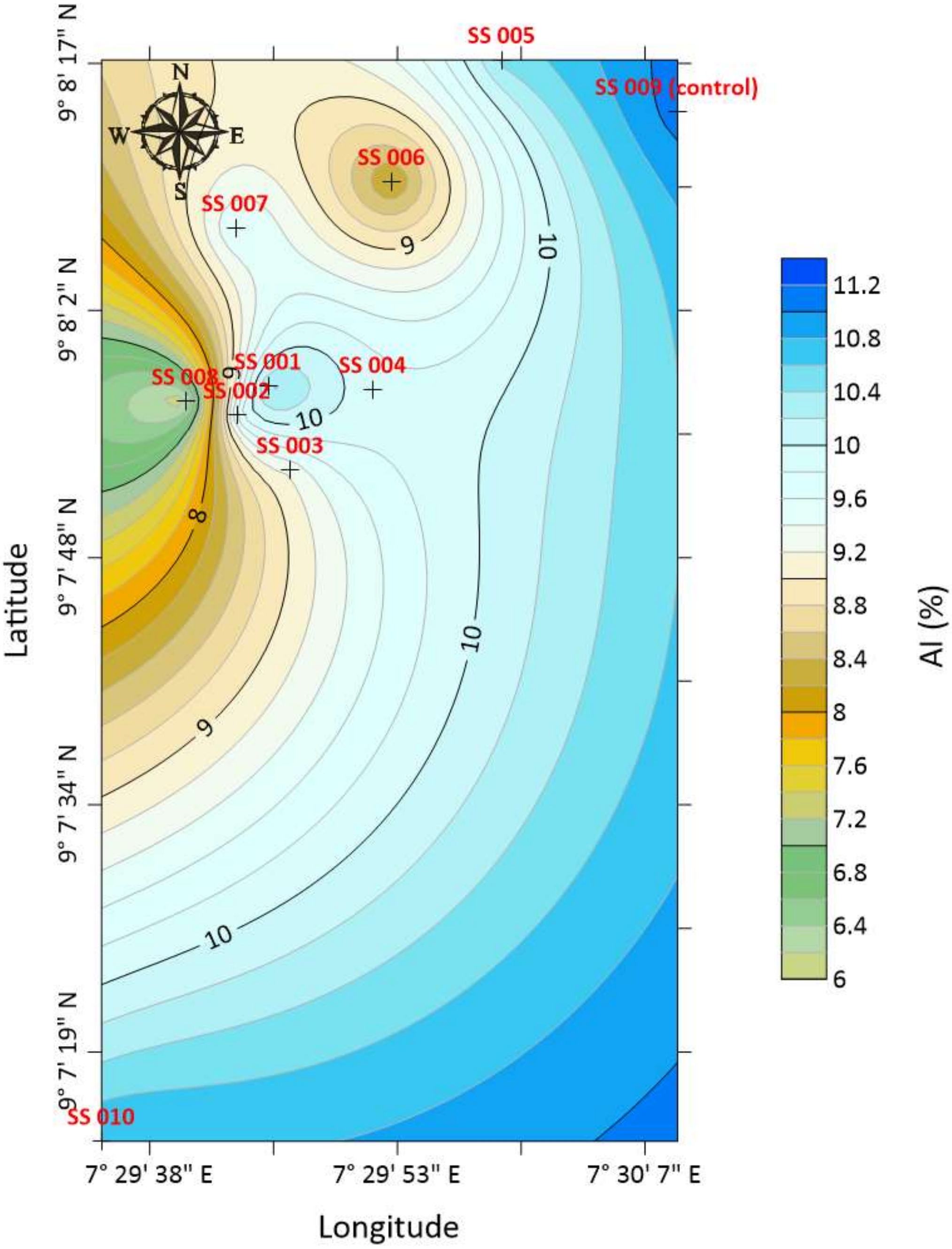


Figure 4.14: 2-D Contour map of Al (%) for soil sample in the study area

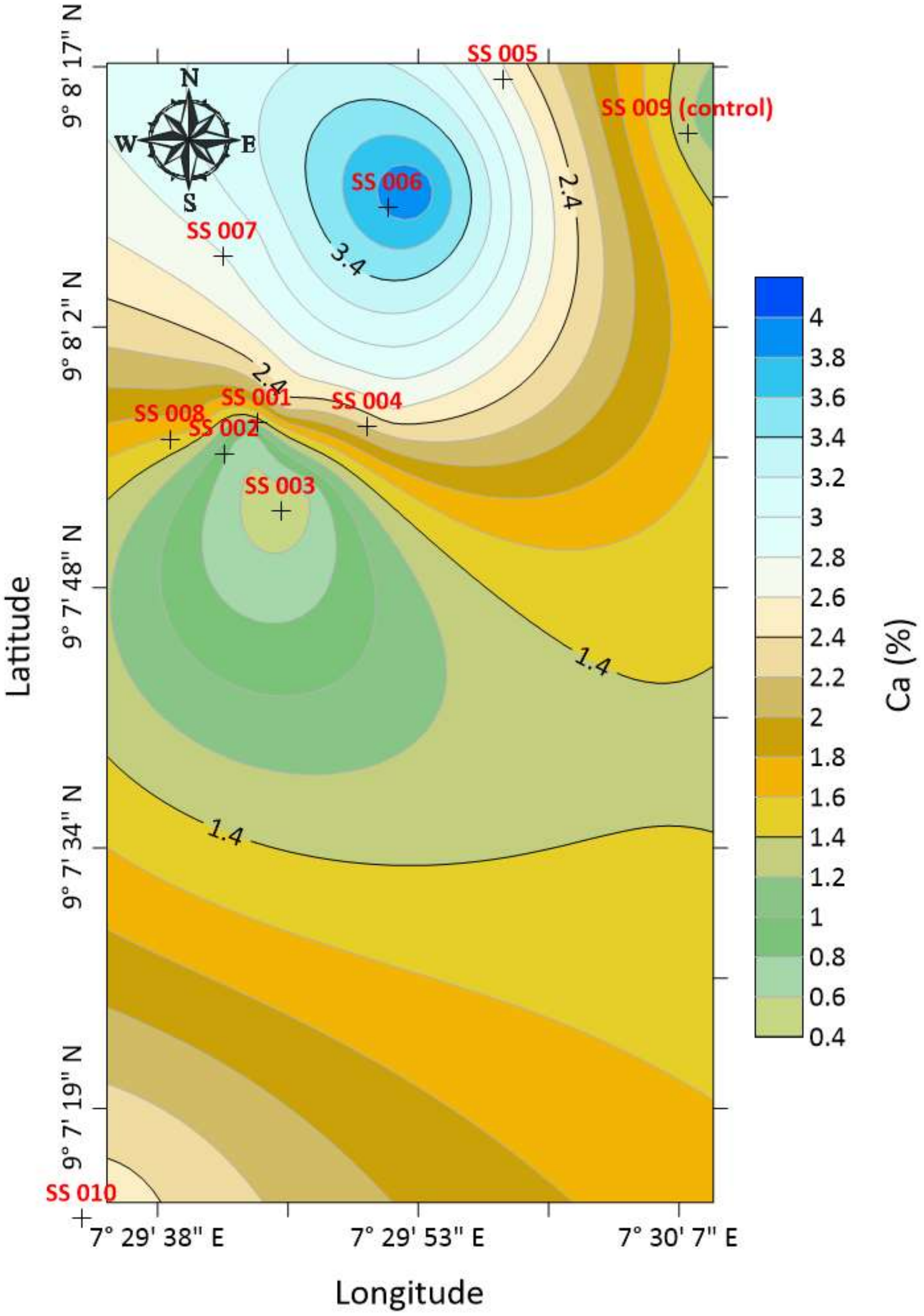


Figure 4.15: 2-D Contour map of Ca (%) for soil sample in the study area

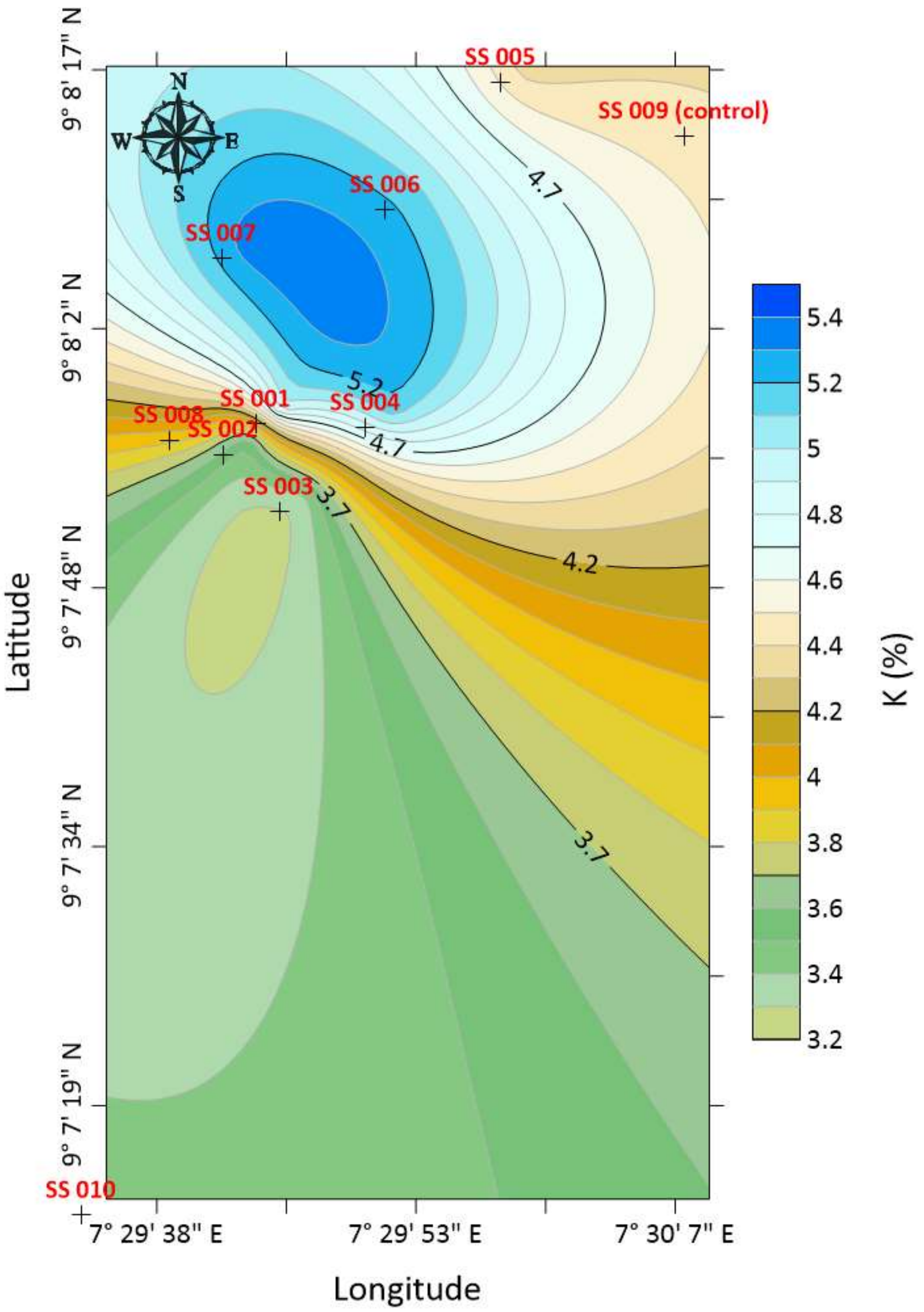


Figure 4.16: 2-D Contour map of K (%) for soil sample in the study area

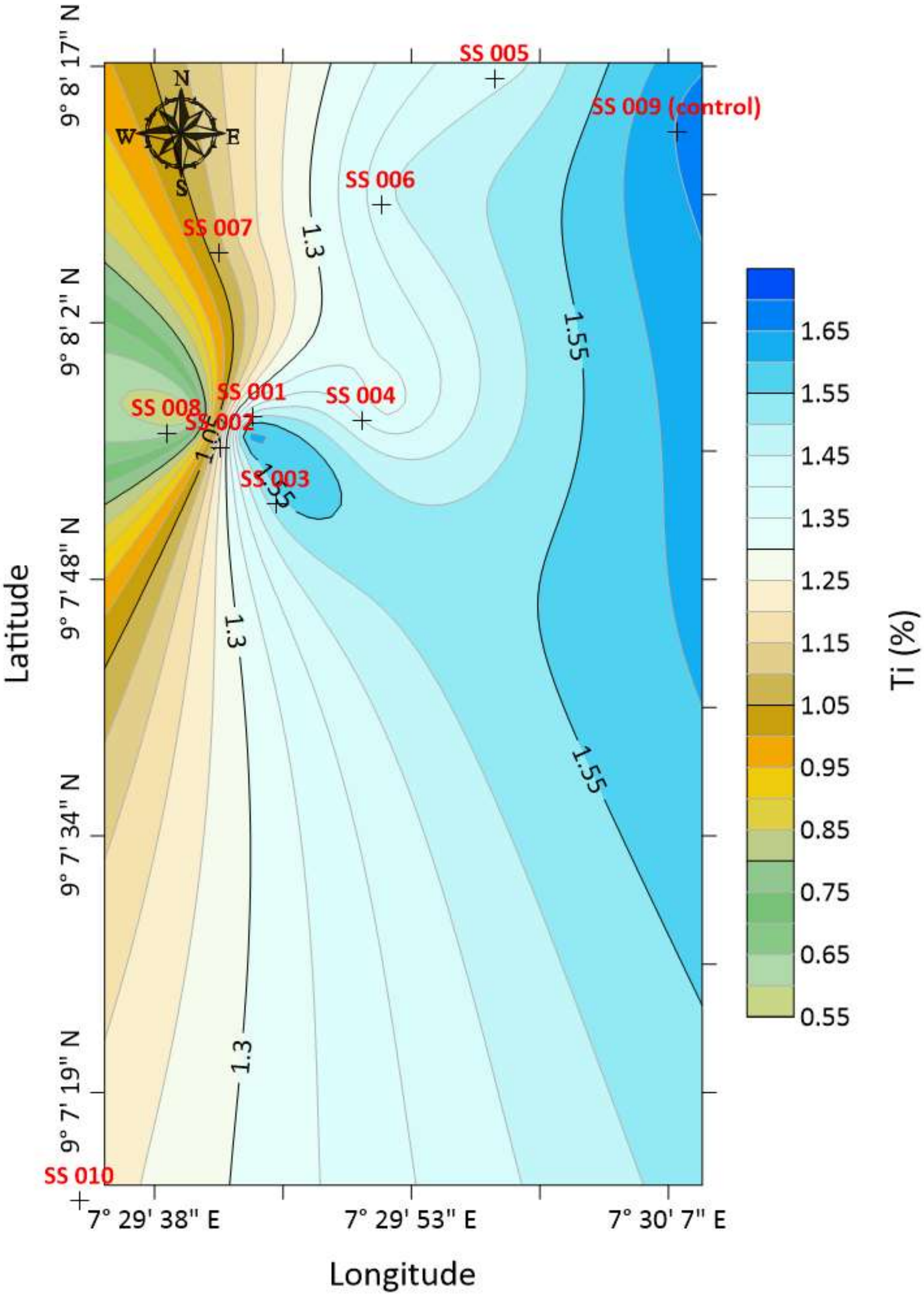


Figure 4.17: 2-D Contour map of Ti (%) for soil sample in the study area

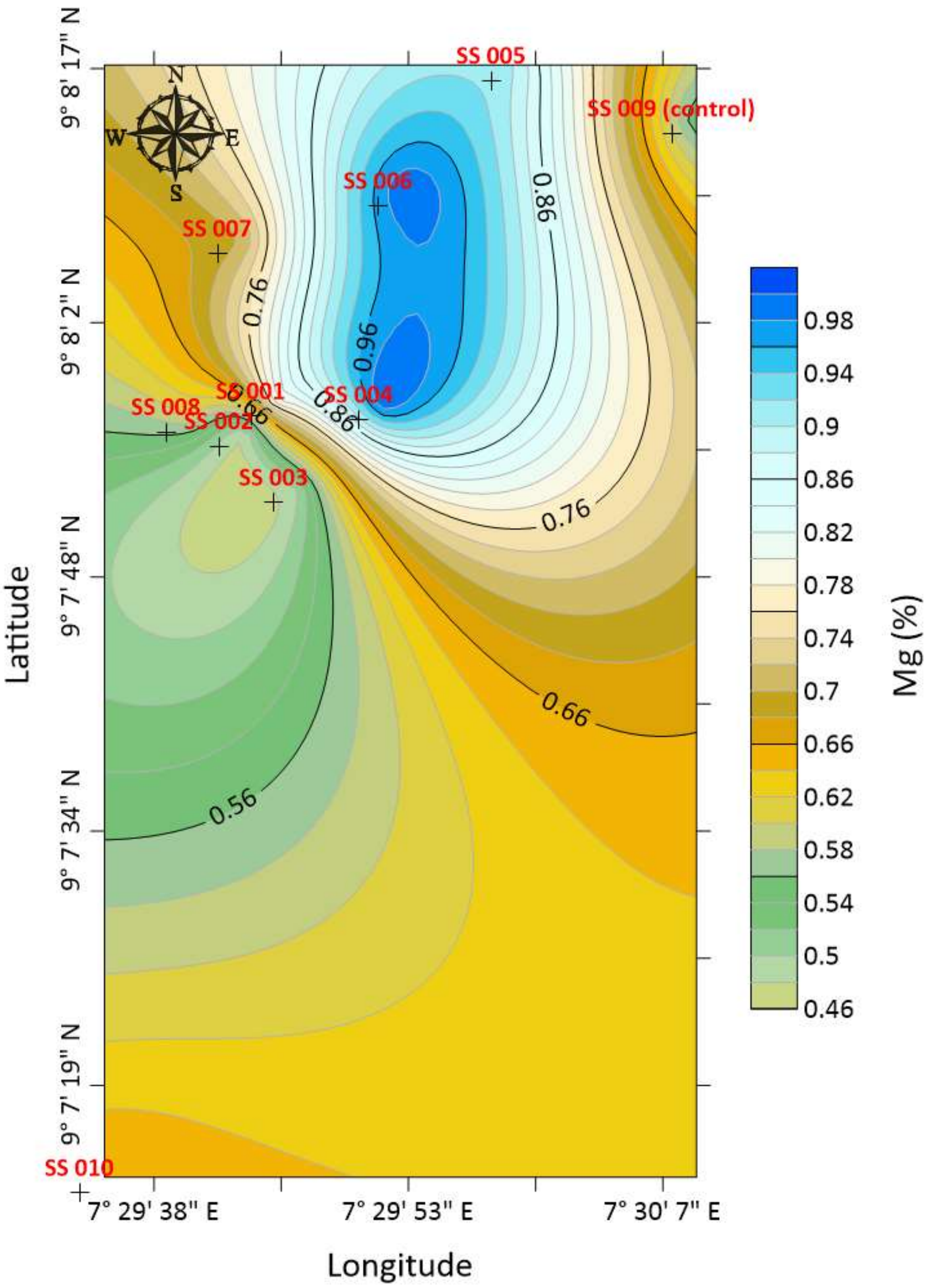


Figure 4.18: 2-D Contour map of Mg (%) for soil sample in the study area

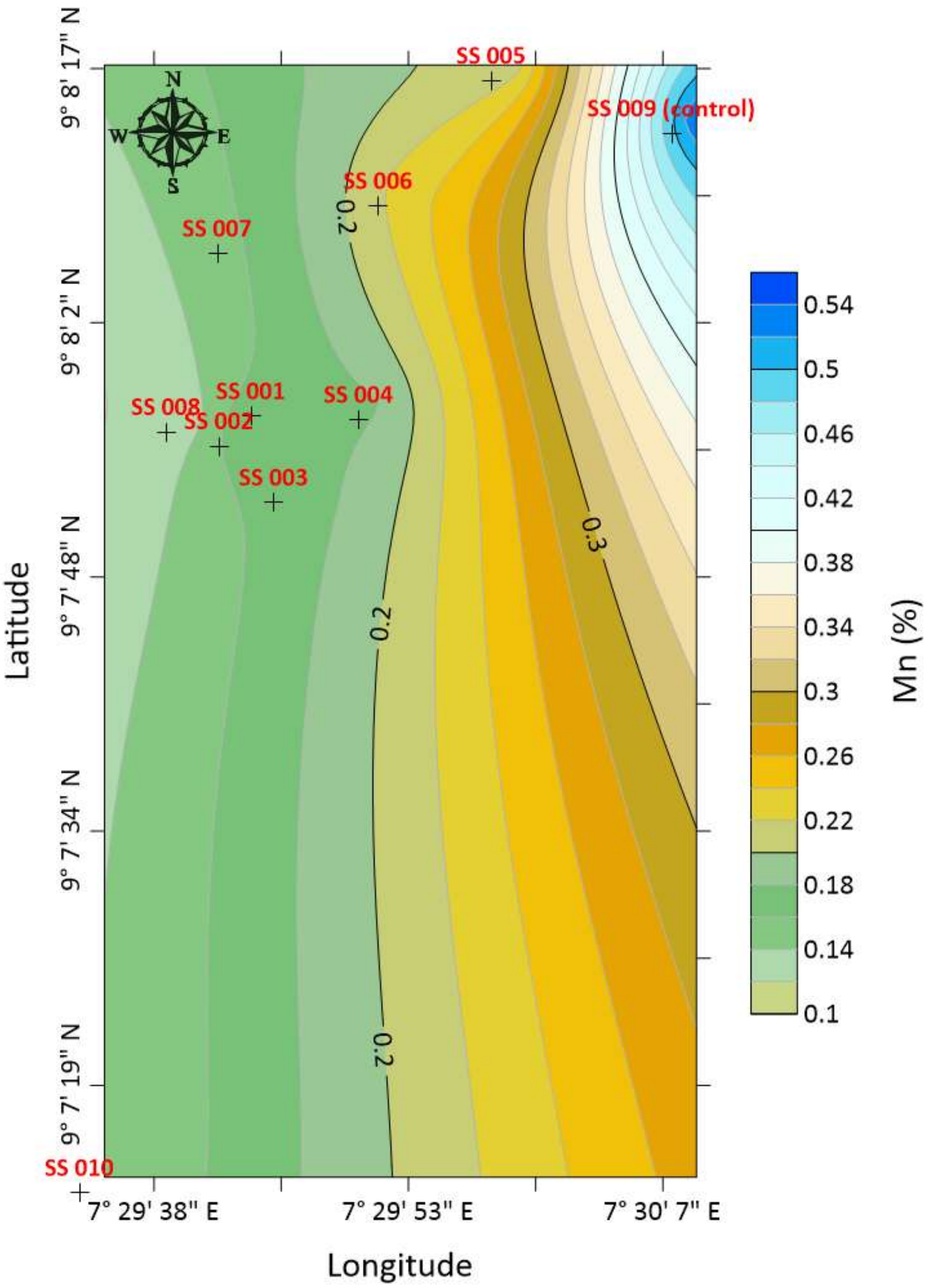


Figure 4.19: 2-D Contour map of Mn (%) for soil sample in the study area

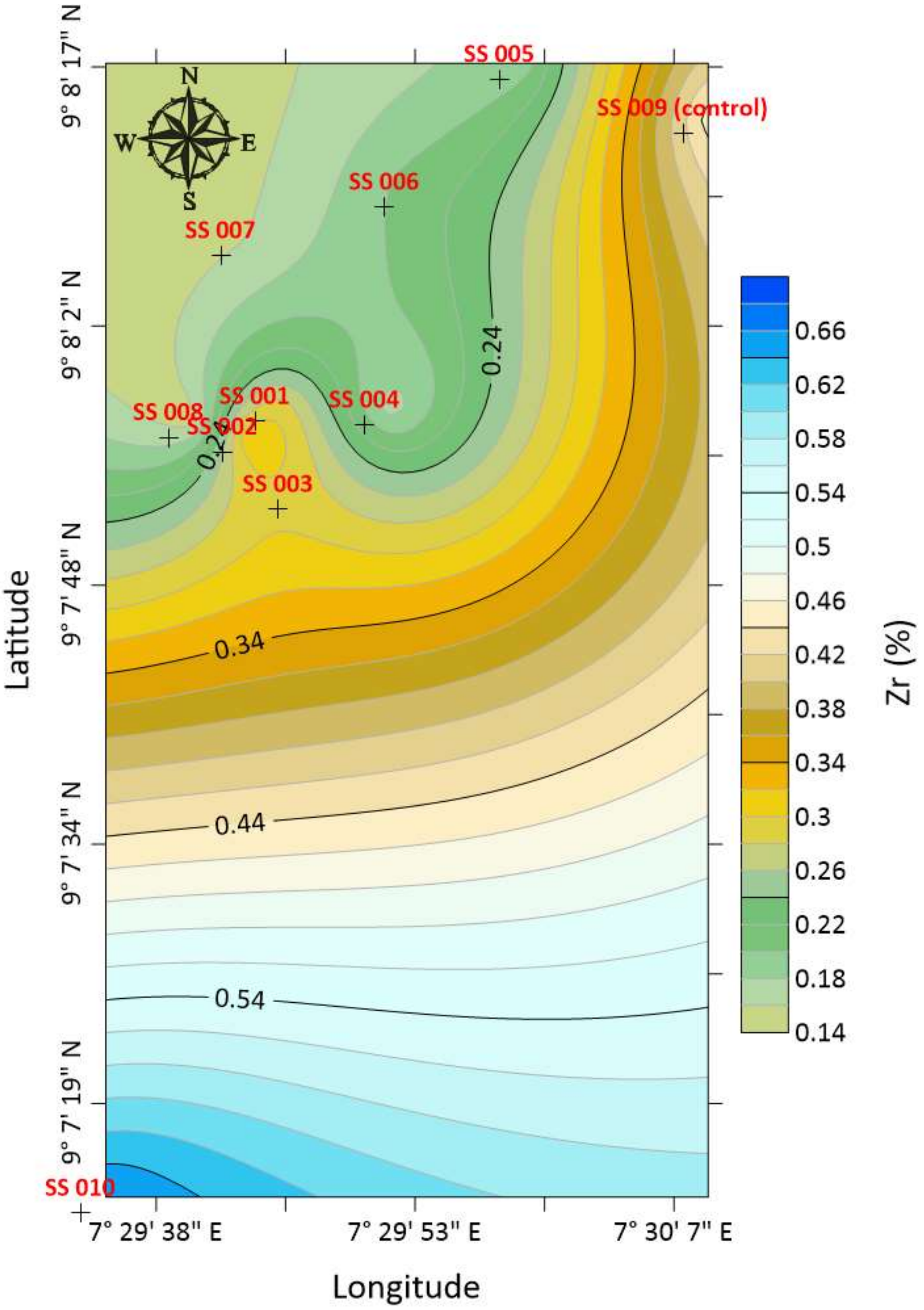


Figure 4.20: 2-D Contour map of Zr (%) for soil sample in the study area

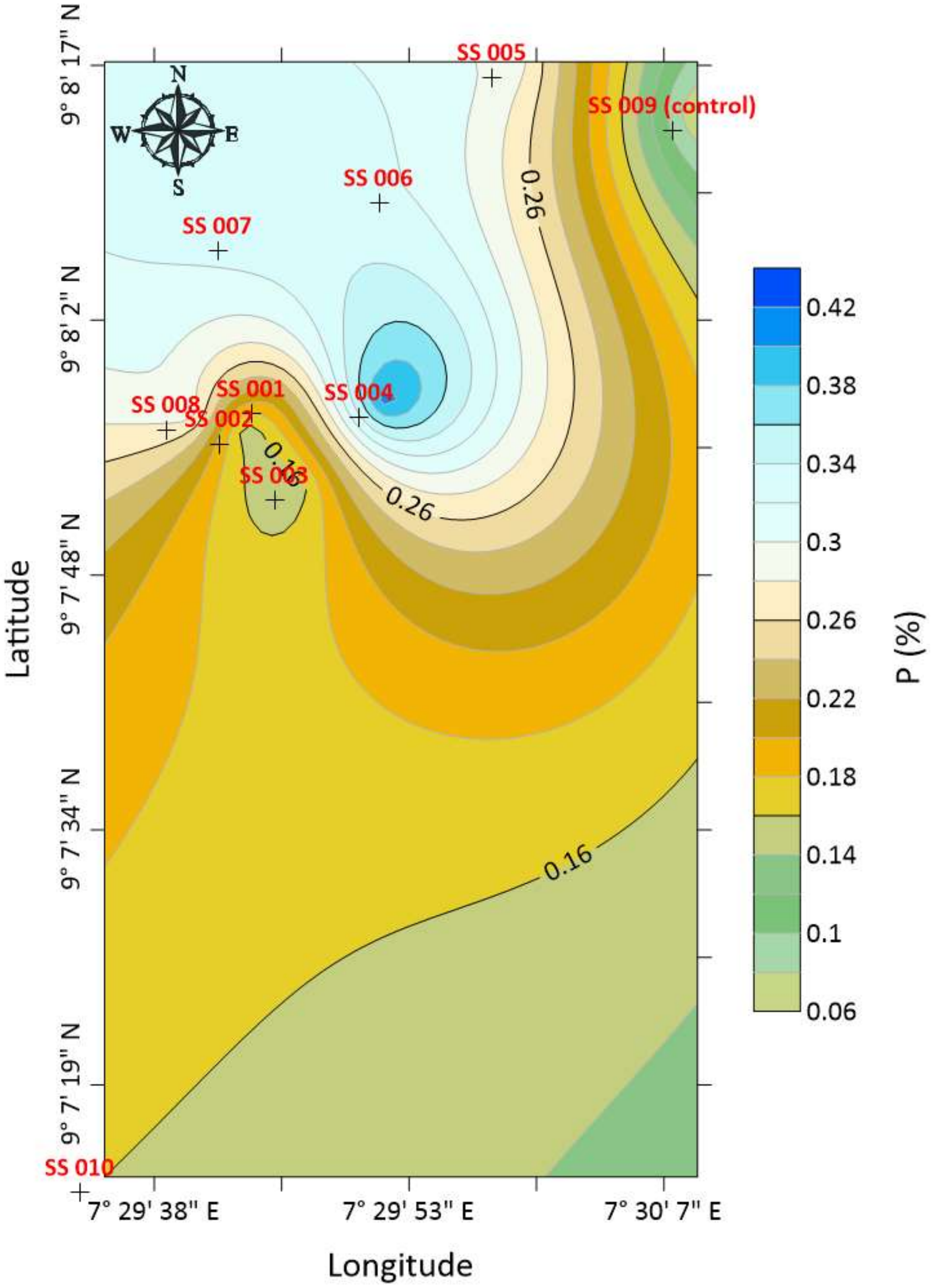


Figure 4.21: 2-D Contour map of P (%) for soil sample in the study area

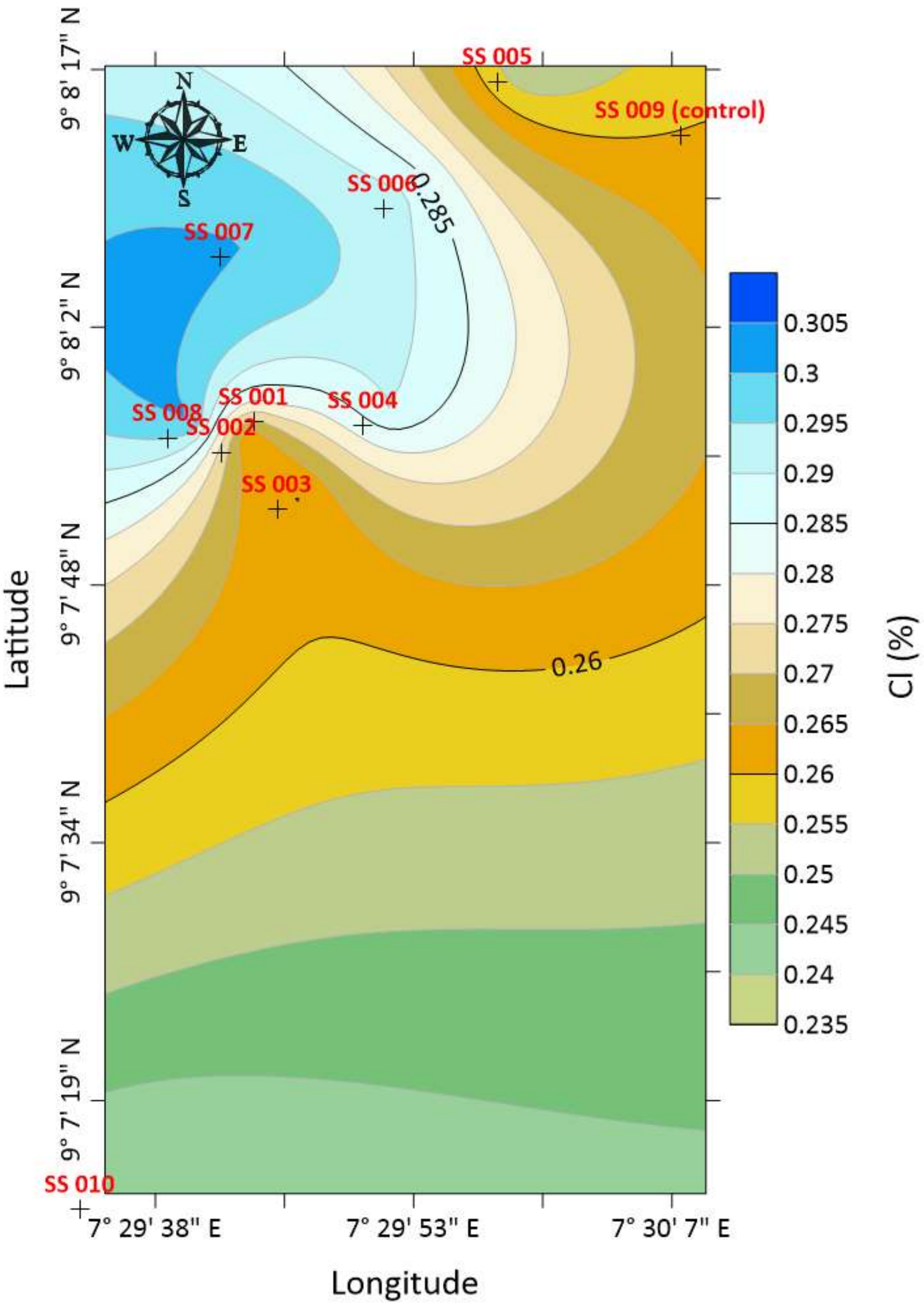


Figure 4.22: 2-D Contour map of Cl (%) for soil sample in the study area

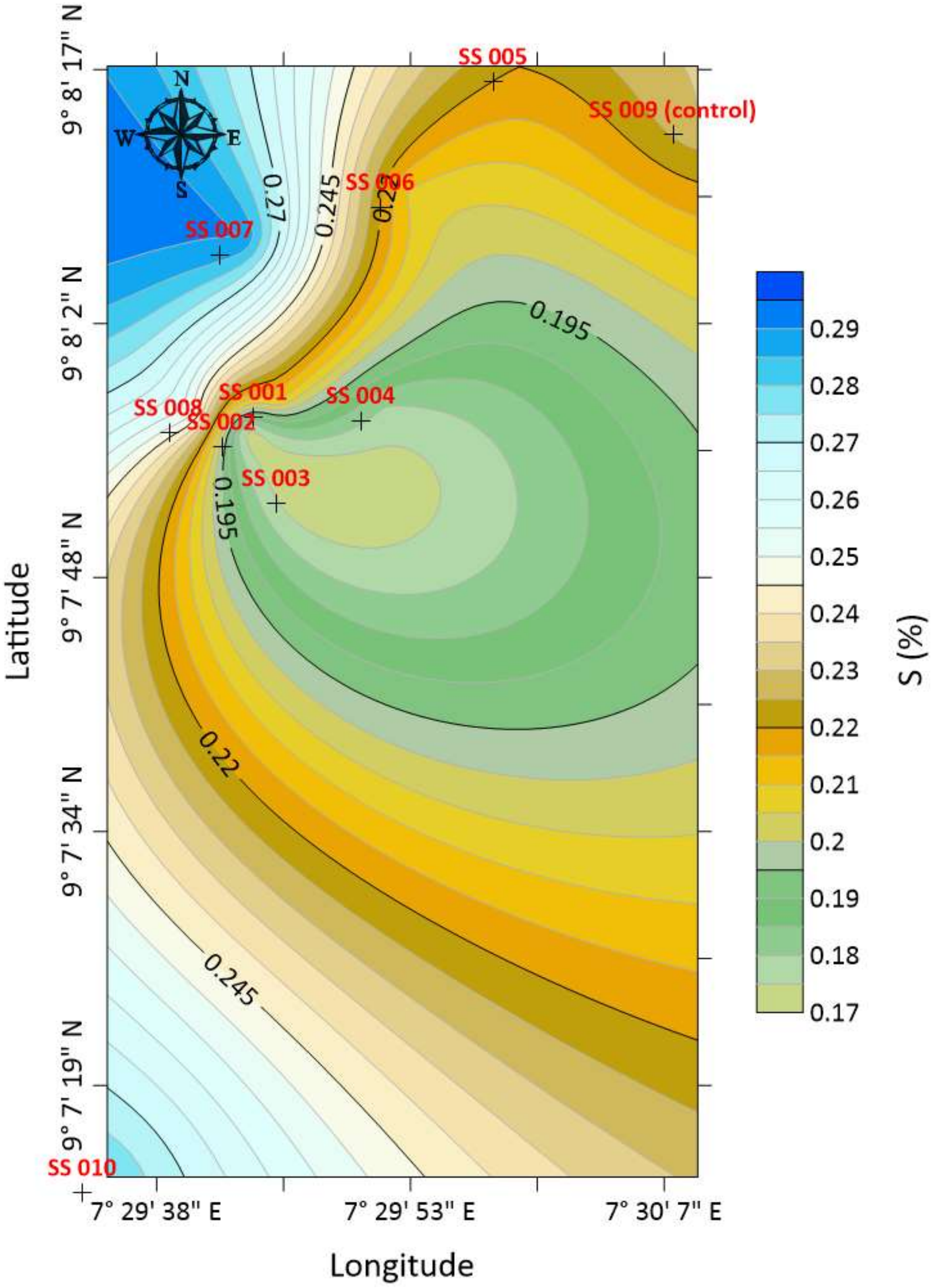


Figure 4.23: 2-D Contour map of S (%) for soil sample in the study area

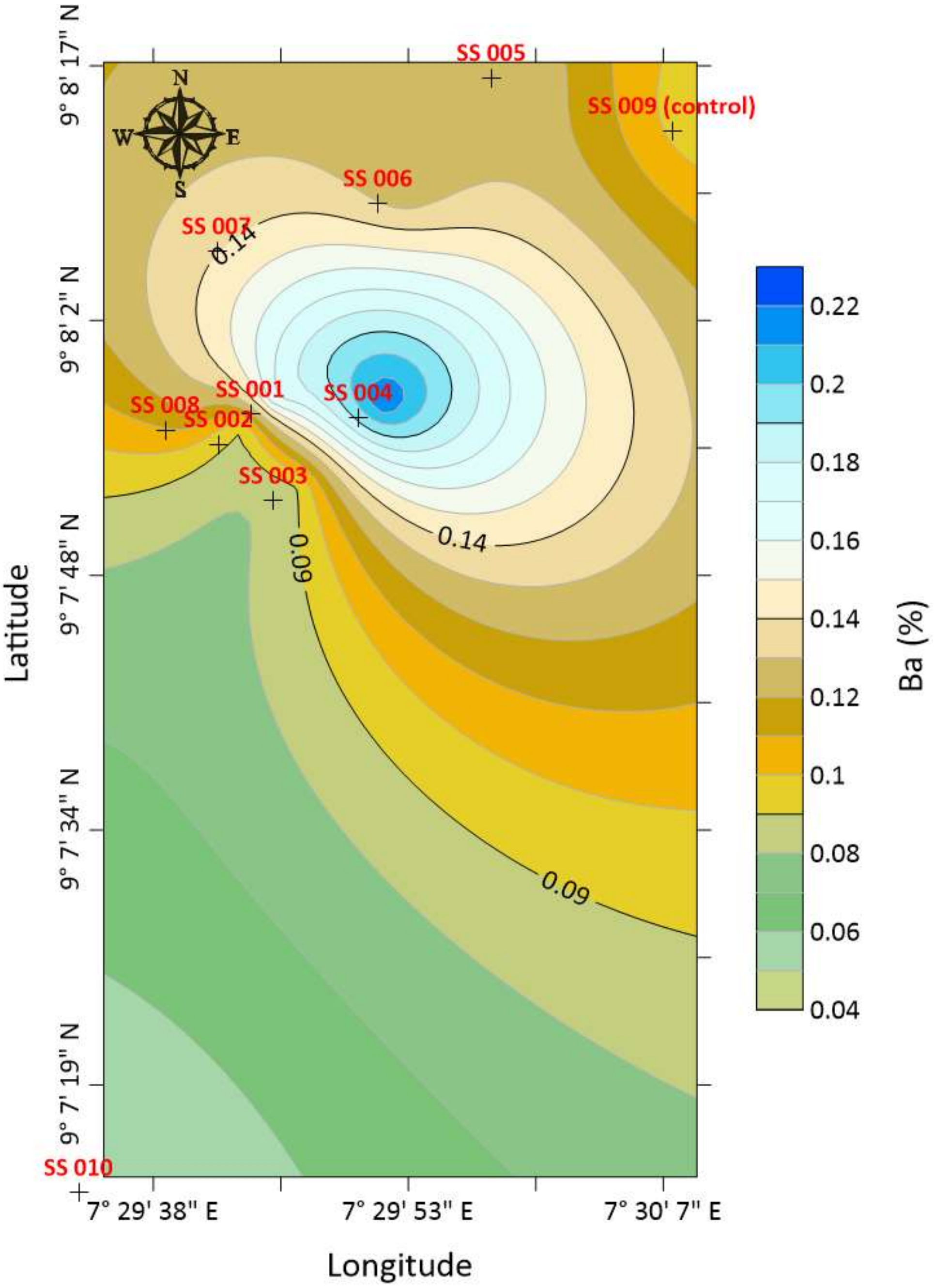


Figure 4.24: 2-D Contour map of Ba (%) for soil sample in the study area

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The effect of Mpape dumpsite on soil quality is minimal. The results of the 2-D resistivity Survey indicating the presence of leachate. The extent is within the topsoil, an indication that the underlying layer has a greater risk of contamination by leachate and decomposed solid materials. However, the geochemical results also shown possible contamination with time. The combined techniques gave a better understanding of the study area than using a single investigative method.

5.2 Recommendations

It is hereby recommended that a periodic study of the dumping site be done annually as the age of dumpsite affects significantly the quantity of leachate formed. It is also recommended to know the effect of depth on leachate contamination and chemical constituents of soil samples to ascertain the nature of pollutants. It is recommended that a well-coordinated clean-up operation should be carried out at the dumpsite to curtail the spread of leachate to the ambient environment. Also, modern sanitary landfills should replace the practices of open dumping.

5.3 Contribution to Knowledge

i. Based on the focus of this study, ten (10) soil samples were collected from within the waste disposal zone and outside waste disposal zone. Four (4) soil samples were taken for grain size analysis to determine infiltration rate of leachate. Two (2) leachate samples were collected from the dump site zone for analysis.

ii. The soils are characterized with high concentration of **Si** which ranges between (17.85 and 33.23 wt %), **Fe** (4.13 wt % and 23.69 wt %), **Al** (6.06 wt % and 11.11 wt %), **Ca** (0.55 wt % and 2.91 wt %), **K** (3.37 wt % and 5.36 wt %), **Ti** (0.55 wt % and 1.68 wt %), **Mg** (0.48 wt % and 1.03 wt %), **Mn** (0.13 wt % and 0.22 wt %), **Zr** (0.15 wt % and 0.145 wt %), **P** (0.15 and 0.45 wt %) and **Cl** is between (0.24 wt % and 0.3 wt %).

iii. The geological investigation involved two dimensional (2-D) Electrical imaging using Wenner array utilizing resistivity meter, ABEM SAS 300 Terrameter. The 2-D resistivity imaging mapped three (3) distinctive zones of anomalously low resistivity (deep to light blue) in the profiles were interpreted as high conductive leachate contaminant plumes (as a result of decomposing landfill waste) containing organic and inorganic substances, pathogens and dissolved solid.

iv. The zone of increasing resistivity (light green to yellow) was also identified as porous and permeable sandy layers of varying grain sizes and moisture content. With light green indicating the lowest resistivity and yellow indicating the highest resistivity. Typically, it could be an indication of different subsurface materials or less contaminated area.

v. The zones of anomalously high resistivity (pink to purple) were interpreted as uncontaminated water filled sand. Anomalously high resistivity means that the subsurface material is more resistive to the flow of electrical current than would be expected based on the surrounding area. The pink indicate the lowest resistivity and purple indicate the highest resistivity.

vi. The results showed that the modeled subsurface is more resistive (uncontaminated) as we move away from the dumpsite as seen in profile 3 which was taken about 2000m away from the site.

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