ASSESSMENT OF HEAVY METALS IN OPEN DUMPSITES AND SUITABILITY ANALYSIS ON NEW DUMPSITES SELECTION IN IBULE-SORO AND ILARA MOKIN.

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IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF TECHNOLOGY (B.TECH) IN REMOTE SENSING & GIS

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CERTIFICATION

I certify that this work was carried out by **OFOBUTU ABIODUN EMMANUEL**, with matriculation number RSG/17/2833 under my supervision in the Department of Remote Sensing and Geosciences Information System, School of Earth and Mineral Science, The Federal University of Technology Akure, Ondo State.

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DEDICATION

This project is dedicated to the Almighty God who saw me through this course of my undergraduate programme.

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I must express my gratitude to so many people for their advice and assistance in carrying out this research project. Without them, I could not have completed my bachelor's degree in technology. I first want to thank God Almighty for His faithfulness throughout the entire study session. I owe a debt of gratitude to my supervisor, Dr. S.O. Oladejo, for allowing me the freedom to pursue a variety of interests and for his enthusiastic oversight and direction during my study. Thanks to the head of department Dr. S.A Adegboyega and other staff of my department I also like to thank my parents, Mr and Mrs Ofobutu, for their unwavering support. I would also like to express my heartfelt gratitude to my friends for their moral supports.

ABSTRACT

Open dumpsites are uncontrolled and unengineered waste disposal sites with no measures to protect the environment or public health. Soil contamination by heavy metals poses risk to human and ecological health. In recents years, the use of satellite data integration, time series analysis and hotspot analysis have been used to assess and map the impacts of heavy metal contamination in soils. This research made used of interpolation tool: inverse distance weighting (IDW) to estimate heavy metals concentrations at unsampled locations and identify affected area using buffering and overlay analysis. GPS data, Landsat and DEM to determine coordinates of dumpsites, LULC, and slope and area extents of the study area. 12 soil samples were collected from different dumpsites locations, heavy metal concentrations for copper, cobalt, chromium, cadmium, iron, nickel, lead, and arsenic were measured. Spectral reflectance curves were acquired for soils using spectroradiometer. The concentrations of the heavy metals were below WHO limits, though isolated contamination was found for cobalt and nickel. Spectral reflectance curves (350-900 nm) showed variability indicating compositional differences between sites. Buffer analysis highlighted 9 schools, 4 health center, and infrastructures within risky proximity to dumpsites. GIS multicriteria evaluation integrated factors like slope, distance from sensitive receptors, and accessibility to generate a suitability map for new controlled dumpsites. Results indicate current dumpsites pose localized risks to soil and communities. While heavy metal accumulation is not yet widespread, the unregulated dumping practices merit intervention. Community engagement, and phytoremediation in buffer zones can help mitigate ecological and public health impacts.

Keywords: Buffer Analysis**,** GPS (Ground Positioning System), Heavy Metal, Inverse distance weighting (IDW), Spectral Reflectance Curve

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Open dumping, or the intentional abandonment of waste in unauthorized areas (Lu, 2019: Liu et al., 2021), has been extensively studied from the point of view of its various effects. Illegal dumping refers to the unlawful and unauthorized disposal of waste in open areas or vacant lots instead of proper waste disposal facilities, it is also refers to the dumping of large items of rubbish in public areas such as roadsides or illegal landfills-private land where waste is dumped without councils or Environmental Protection Authority approval. Illegal refuse dumping includes waste materials that have been dumped, tipped or otherwise deposited onto land where no license or approval exists to accept such waste. It is a major problem confronting cities and municipalities worldwide, especially in developing countries that lack adequate waste management infrastructure (Guerrero et al, 2013). Improper waste disposal, including illegal dumping, has resulted in environmental degradation, posing a significant threat to the health and well-being of individuals and communities (Chu and A.M.Y 2021).

Dumpsites, characterized by the unregulated disposal of waste, pose significant challenges to both the environment and public health. The repercussions of improper waste disposal extend far beyond the boundaries of the dumping grounds, affecting ecosystems, human populations, and overall well-being. The establishment and expansion of dumpsites contribute to environmental degradation, with repercussions on soil, water, and air quality (UNEP, 2020). As organic and inorganic waste decomposes, it releases harmful substances into the soil, altering its composition and fertility (Ayalon et al., 2021). The resulting contamination can leach into groundwater, compromising its quality and posing a threat to aquatic ecosystems (EPA, 2021).

In many developing nations, uncontrolled open landfills for the disposal of municipal solid waste present significant dangers of contaminating soil and degrading the environment. Soil can undergo major physical, chemical, and biological changes when waste materials from homes, businesses, and often dangerous sources are carelessly dumped onto it. Numerous organic and inorganic contaminants are released when waste breaks down and leachate seeps into the underlying soil layers, impairing the quality and function of the soil.

Heavy metals including lead, cadmium, and chromium as well as organic molecules such petroleum hydrocarbons and polyaromatic hydrocarbons are among the main contaminants found in open dumpsites (Egbuche et al., 2018). These have the ability to bond to soil particles, making them more harmful to plants and animals. They may also seep into groundwater aquifers. Soil fertility is further reduced by garbage dumping's excess nutrients. Dumpsites are often hotspots for open burning of waste, leading to the release of toxic pollutants into the air (Badruzzaman et al., 2019). The combustion of plastics and other materials produces hazardous substances such as dioxins and furans, contributing to air pollution. Inhalation of these pollutants poses serious respiratory health risks to nearby communities (Gadepalli et al., 2020).

The presence of dumpsites is intricately linked to public health challenges, including the spread of diseases. The decomposition of organic waste attracts disease vectors such as rodents and insects, increasing the risk of vector-borne diseases (Rehfuess et al., 2018). Moreover, the improper disposal of medical waste in dumpsites can pose severe health hazards, exposing communities to infectious agents (WHO, 2018).

Dumpsites exert social and economic burdens on communities. The unsightly appearance of dumpsites diminishes the quality of life for residents, impacting community aesthetics and pride (Lohri et al., 2018). Furthermore, the stigma associated with living near dumpsites may lead to decreased property values, affecting the economic well-being of affected areas (Bartone et al., 2020).

The expansion of dumpsites encroaches upon natural habitats, contributing to biodiversity loss and habitat destruction (Sinha et al., 2021). Dumping activities disrupt ecosystems, displacing flora and fauna. The infiltration of pollutants into surrounding water bodies further imperils aquatic life, causing long-term ecological damage (Nepstad et al., 2020). The impact of dumpsites is multi-faceted, encompassing environmental, health, social, and economic dimensions. Addressing the challenges posed by dumpsites requires comprehensive strategies that involve community engagement, regulatory measures, and the adoption of sustainable waste management practices.

Over the past decades, environmental concerns have increasingly become a global issue, with the adverse effects of poor waste management practices being a critical challenge for society worldwide (Ichinose et al, 2011; Mohammed et al, 2017). Improper waste disposal, including illegal dumping, has resulted in environmental degradation, posing a significant threat to the health and well-being of individuals and communities (Chu et al, 2018). Despite global efforts to properly manage solid waste, illegal dumping remains a significant contributor to environmental degradation, particularly in developing countries, with African nations bearing the highest burden (UNEP 2018; Ozoh et al, 2021).

Lagos State, as one of the fastest-growing urban centers in Nigeria, faces a significant challenge in effectively managing its solid waste, with illegal dumping becoming a widespread practice. This practice can lead to severe environmental and health consequences, including water, soil, and air contamination, and the spread of diseases (UNEP 2018; Niyobuhungiro et al, 2021). As a result, illegal dumping has been characterized as a “wicked act” due to its complexities, including intractable, open-ended problems and rights-based and legal issues (Niyobuhungiro et al, 2021).

Illegal dumping, a significant contributor to poor waste management, leads to many types of environmental pollution in communities, costing cities worldwide millions yearly for cleanup (Onifade et al 2014).

The impact of dumpsites on public health is a critical concern that cannot be overstated. Improper waste disposal creates breeding grounds for disease vectors, such as rodents and insects, which can transmit diseases to humans. The decomposition of organic waste at dumpsites produces noxious odors and gases, contributing to respiratory and dermatological issues among nearby residents.

1.2 PROBLEM STATEMENT

Illegal refuse dumping in the world at large has become a huge problem and a menace in the society today, illegal dumping is a significant environmental degradation issue that poses health risks to humans, animals, and the environment. Despite efforts by countries to manage solid waste properly, illegal dumping still accounts for a major portion of all waste generated globally, with the burden disproportionately affecting African countries. In Nigeria, illegal dumping presents a significant health risk to both the environment and human health (Oyebode, 2013; Kadafa, 2017; Adama, 2021). With uncollected waste being a common sight on the streets of Lagos and other parts of the country (Nnatu 2018). Poor waste disposal education, inadequate waste management practices, and the prevalence of illegal dumping sites are some of the most pressing issues facing waste management authorities in Nigeria. Another contributing factor to this problem is the negative perception of waste management among the public (Olukanni et al, 2020) and the inability of waste management authorities to collect waste timeously. This research initiative uses Ibule and Ilara as a case study to assess the impact of illegal dumping of solid waste on public health, with a particular focus on its implications for environmental degradation and health risks.

Land, abandoned buildings and gullies have been converted into refuse dumps sites by dwellers, these activities have led to environmental degradation, air pollution, land pollution and poor economic and social environment. People living close to illegal dump sites suffer as a result of these problems**.** This study seeks to answer the following specific questions that relate to dumpsites in ibule-soro and Ilara-mokin which are:

1. What is the current spatial distribution and extent of dumpsites in the study area
2. What is the pattern of land use land cover of the study area?
3. Which areas are more affected by the dumpsites?
4. What are the features that could be affected by the dumpsites
5. What type of approach can be adopted to reduce the risk dumpsites in the study area?

1.3 AIM

The aim of this study is to assess impact of dumpsites on the soil based on it spectral reflectance and heavy metals concentration etc. identify parts of the study areas that are more affected and also propose suitable solid waste dumpsites in the study area using GIS based tool.

1.4 OBJECTIVES

Specific objectives are to:

- To determine the spatial distribution and area extent of each dumpsites in the study area.
- Assessment of heavy metals concentration in the soil and its spectral reflectance.

- To identify high risk areas and infrastructures that can be affected.
- To determine potential solid waste dumpsites using multi criteria analysis.

1.5 RESEARCH QUESTIONS

- Where are the illegal dumpsites located?
- What is the area extent of the dumpsites?
- What is the level concentration of heavy metals spectral reflectance of the soil in the study area?
- Where are the potential sites for sitting dumpsites?

1.6 JUSTIFICATION OF STUDY

There is an urgent need for further research and analysis on the environmental and public health impacts of illegal dumping. Though illegal waste disposal is a widespread issue globally, the full extent of the problem and its consequences are not adequately quantified and documented in literature. Most existing studies on illegal dumpsites are small-scale and localized, focusing on specific cities or regions (Eigenraam et al., 2016). More extensive data is needed to comprehensively understand the scale and gravity of the problem across different geographies.

Quantitative assessments are required to map the proliferation of illegal dumpsites in both urban and rural areas over time. This can help identify dumping hotspots and trends, while shedding light on the driving factors behind illegal disposal practices (Lambooy, 2011). There is also a need for in-depth characterization of the composition and toxicity of illegally dumped waste through rigorous sampling and lab analyses. This is crucial to determine the exact contaminants being released into soil open dumpsites (Slavuj & Trg, 2019).

Overall, multidisciplinary research covering geospatial mapping, waste characterization, environmental sampling, and social surveys can provide tangible evidence on the environmental, health and social costs of illegal dumping. The findings would help shape stronger policy and regulatory frameworks to crack down on unlawful waste disposal. It is only through dedicated research that the true enormity of this environmental threat can be established beyond doubt. This study would be of immense benefit towards the improvement of the environment so as to maintain a healthy people which would in turn encourage migration of people to the area

1.7 SCOPE OF STUDY

The scope of this proposed study on open dumpsites will encompass the following aspects:

Geographic Scope: The study will gather data and examine dumpsites within Ibule-soro and Ilara-mokin. This will allow analysis of open dumping patterns across diverse landscapes.

Dumpsites Sampling: Soil from each dumpsite will undergo laboratory analysis to determine toxic content like heavy metals concentration.

Dumpsite Characteristics: Sampled dumpsites will be documented including size, proximity to human settlements and roads.

CHAPTER TWO

CONCEPTUAL FRAMWORK AND LITERATURE REVIEW

2.0 INTRODUCTION

This chapter provides a comprehensive overview of the relevant literature on impacts of open dumpsites, heavy metals content on the soil and site suitability analysis

Open dumpsites have been a persistent environmental challenge, with significant consequences for ecosystems, public health, and communities. This review provides insights into the historical context, key studies, and the evolving concept of assessing illegal dumpsites, incorporating relevant references and citations.

2.1 REVIEW ON HISTORICAL CONTEXT

The emergence of open dumpsites can be traced back to urbanization and industrialization processes, with accelerated growth leading to increased waste generation (Wilson et al., 2017). Rapid urban expansion often outpaces waste management infrastructure, creating opportunities for illegal dumping. The Industrial Revolution marked a turning point, introducing mass production and urbanization. As industries flourished, the improper disposal of industrial waste contributed to the growth of illegal dumpsites (Benson and Anderson, 2018).

The issue of dumpsites, characterized by unregulated waste disposal, has garnered significant attention due to its far-reaching implications on the environment, public health, and community well-being.

2.2 HEALTH IMPLICATIONS OF SOLID WASTE

A major adverse impact is its attraction of rodents and vector insects for which it provides food and shelter. Impact on environmental quality takes the form of foul odours and unsightliness. These impacts are not confined merely to the disposal site. On the contrary, they pervade the area surrounding the site and wherever the wastes are generated, spread, or accumulated. Unless an organic waste is appropriately managed, its adverse impact will continue until it has fully decomposed or otherwise stabilized. Uncontrolled or poorly managed intermediate decomposition products can contaminate air, water, and soil resources.

The impact of dumpsites on public health is a major concern, particularly in terms of disease transmission and respiratory health risks. (Rehfuess et al, 2018) stress that dumpsites serve as breeding grounds for disease vectors, increasing the risk of vector-borne diseases in nearby communities. (Badruzzaman et al, 2019) highlight the role of open burning at dumpsites in contributing to air pollution, exposing communities to respiratory health risks associated with the release of toxic pollutants.

Dumpsites exert significant socioeconomic burdens on communities, affecting both aesthetics and property values. (Lohri et al, 2018) emphasize the negative impact of dumpsites on community aesthetics, diminishing the quality of life for residents. The study by (Bartone et al, 2020) underscores the socioeconomic consequences of living near dumpsites, including decreased property values, further underscoring the importance of addressing these issues.

The expansion of dumpsites into natural habitats contributes to biodiversity loss and habitat destruction. (Sinha et al, 2021) highlight the disruption of ecosystems caused by dumping activities, leading to the displacement of flora and fauna. The study by (Nepstad et al. 2020) emphasizes the long-term ecological damage to aquatic life resulting from the infiltration of pollutants from dumpsites into surrounding water bodies.

2.3 SOIL

Dumpsites are recognized as significant contributors to environmental degradation, adversely affecting soil, water, and air quality. Ayalon et al. (2021) noted that the decomposition of organic and inorganic waste at dumpsites results in the release of harmful substances, leading to soil contamination and alterations in its fertility. The United Nations Environment Programme (UNEP, 2020) emphasizes the global scale of environmental damage caused by dumpsites, highlighting the urgent need for sustainable waste management practices.

The physical properties of soil play a crucial role in its ability to support plant growth, filter water, and provide habitat for various organisms. The physical properties of soil are

- Texture: Soil texture refers to the relative proportion of sand, silt, and clay particles in a soil. Sand particles are the largest, followed by silt particles, then clay particles. The texture of a soil affects its permeability, water holding capacity, and drainage (USDA 2023).
- Structure: Soil structure refers to the arrangement of soil particles into aggregates. Soil aggregates can be loose and crumbly, or they can be tightly packed. Soil structure affects the soil's porosity, permeability, and aeration (Brady et al 2020).
- Porosity: Soil porosity refers to the percentage of the soil volume that is not occupied by solid particles. Porosity is important for water infiltration, drainage, and aeration.
- Bulk density: Soil bulk density refers to the mass of soil per unit volume. Bulk density is affected by the soil's texture, structure, and porosity.
- Particle density: Soil particle density refers to the mass of soil particles per unit volume. Particle density is relatively constant for all soils, but it can vary slightly depending on the mineralogy of the soil (Hillel, Dan 2013).
- Color: Soil color is affected by the organic matter content, iron oxide content, and moisture content of the soil. Soil color can be used to identify different soil types and to assess soil health.
- Temperature: Soil temperature is affected by the air temperature,solar radiation, and soil moisture content. Soil temperature affects the rate of chemical reactions and biological activity in the soil (Campbell et al 2017).
- Electrical conductivity: Soil electrical conductivity refers to the ability of the soil to conduct electricity. Electrical conductivity is affected by the soil's salinity,clay content, and moisture content.
- pH: Soil pH refers to the acidity or alkalinity of the soil. Soil pH affects the availability of nutrients to plants and the activity of microorganisms in the soil.

- Cation exchange capacity (CEC): CEC refers to the ability of the soil to hold and exchange cations such as calcium, magnesium, and potassium. CEC is affected by the soil's clay content and organic matter content.

2.4 METALS

Metals are a group of chemical elements characterized by their specific properties and structure. These elements are typically found on the left and center of the periodic table of elements and share certain common traits (William 2016).

Heavy metals and trace metals are two categories of metallic elements that are defined based on their concentration and potential environmental and health impacts:

Heavy metals are metallic elements with a high atomic weight, typically characterized by a density greater than 5 g/cm^3. They include elements like lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As).

Characteristics: Heavy metals are often toxic to living organisms, including humans, even at low concentrations. They tend to accumulate in the environment and can have harmful health effects when they enter the food chain. Exposure to heavy metals can lead to various health issues, including neurological, developmental, and organ damage (WHO 2012).

Heavy metal accumulation has been documented in soil near dumpsites. Cadmium, lead, iron, chromium, nickel, and zinc were present at elevated concentrations in soils within a 5 km radius of landfills in Nagpur, India (Patil et al., 2013). Soils near an e-waste recycling site and dump in China displayed high levels of polybrominated diphenyl ethers and heavy metals. This soil contamination can result in uptake of toxic substances by crops and livestock, impacting the food supply.

2.5 MONITOR, CONTROL AND CHALLENGES OF DUMPSITES

Argote et al. (2020) conducted a notable study on the use of Geographic Information Systems (GIS) for monitoring and identifying illegal waste disposal sites. GIS technologies enable efficient spatial analysis, aiding in the identification and assessment of dumpsite locations.

Dekraai et al. (2020) explored the effectiveness of community cleanups in reducing illegal dumping. The study emphasizes the role of community involvement as a proactive strategy in dumpsite assessment and mitigation.

Research by Pardo et al. (2018) delves into the legal aspects of addressing illegal dumping. The study highlights the importance of stringent legal frameworks and enforcement measures as essential components of dumpsite assessment and control.

Addressing the challenges posed by dumpsites necessitates the implementation of comprehensive waste management strategies. The literature emphasizes the importance of community engagement, regulatory measures, and sustainable waste management practices. (Gadepalli et al, 2020) advocate for the regulation of waste disposal practices, emphasizing the role of enforcement actions in discouraging illegal dumping.

Cox and Mankin (2019) conducted a study on the use of Geographic Information Systems (GIS) for addressing illegal dumping. The research emphasizes the technological solutions available for spatial analysis and decision support in the assessment of dumpsite locations.

Thind et al. (2019) explore the role of community engagement in illegal dumpsite assessment. The study advocates for community-centric approaches, acknowledging local knowledge and involvement as integral to effective dumpsite identification and mitigation.

Challenges persist in data quality and availability for illegal dumpsite assessments. Yadav et al. (2016) highlight the need for improved data collection infrastructure and data sharing mechanisms to enhance the accuracy of assessments.

The study by Argote et al. (2020) emphasizes the ongoing advancements in remote sensing technologies for the detection and monitoring of illegal waste disposal sites. Future directions may involve the integration of emerging technologies like satellite imagery and machine learning algorithms.

2.5 SITE SELECTION OF DUMPSITES ANALYSIS

Recent studies have explored integrating remote sensing data and GIS-based multicriteria evaluation techniques for optimal siting of waste disposal facilities. Remote sensing provides land

use/land cover information for exclusion criteria while GIS facilitates weighting and overlay analysis of suitability factors (Sumathi et al., 2008). For instance, resistant substrates and areas of low habitat sensitivity or water resource value might be favorable.
Kumar et al. (2018) introduced the application of Multi-Criteria Decision Analysis in GIS-based site selection for landfill facilities. The study provides a conceptual framework for evaluating multiple criteria, including proximity to urban centers, environmental sensitivity, and accessibility.

Researchers have utilized satellite imagery to derive land use/cover maps and performed NDVI analysis to identify vegetation cover unsuitable for dumpsites (Al-Hanbali & Alsaaideh, 2013). Elevation data from DEMs and slope derivatives have also informed site suitability modeling (Şener et al., 2010). Additionally, researchers have incorporated GPS coordinates of urban areas, roads, water bodies and other exclusion areas into GIS (Demesouka et al., 2013).

Weighting criteria based on guidelines from environmental protection agencies, multi-criteria evaluation methods like AHP have been applied on factor maps before aggregating site suitability layers (Gemitzi et al., 2007). Studies have also applied fuzzy set theory to integrate subjective criteria and handle uncertainty in constraint weights and boundaries (Babalola et al., 2021).

In conclusion, there is a close connection between the development of illegal dumpsites throughout history and shifts in society and industry. Important research and theoretical frameworks offer insightful information about evaluating and reducing the effects of illicit dumpsites, emphasizing the necessity of a multifaceted strategy that incorporates technology, regulatory frameworks, and community involvement.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY AREA

The study sites were located in the towns of Ibule-Soro and Ilara-Mokin in Ifedore Local Government Area, Ondo State, Nigeria. The towns are approximately 3 km apart and 14–20 km northwest of Akure, the capital of Ondo State. The postal code of Ibule-Soro and Ilara-Mokin are 30110 and 340112 respectively.

3.1.1 Topology: The geographical coordinates of Ibule-Soro are latitude N 7° 19' 2.2836'', 5° 7' 10.0344'', and elevation of 1,237ft (377 meters) above sea level, for Ilara- Mokin are latitude 7°20'58.92''N and longitude 5°6'24.23''E, and elevation of 1,089.34ft (332.03 meters)

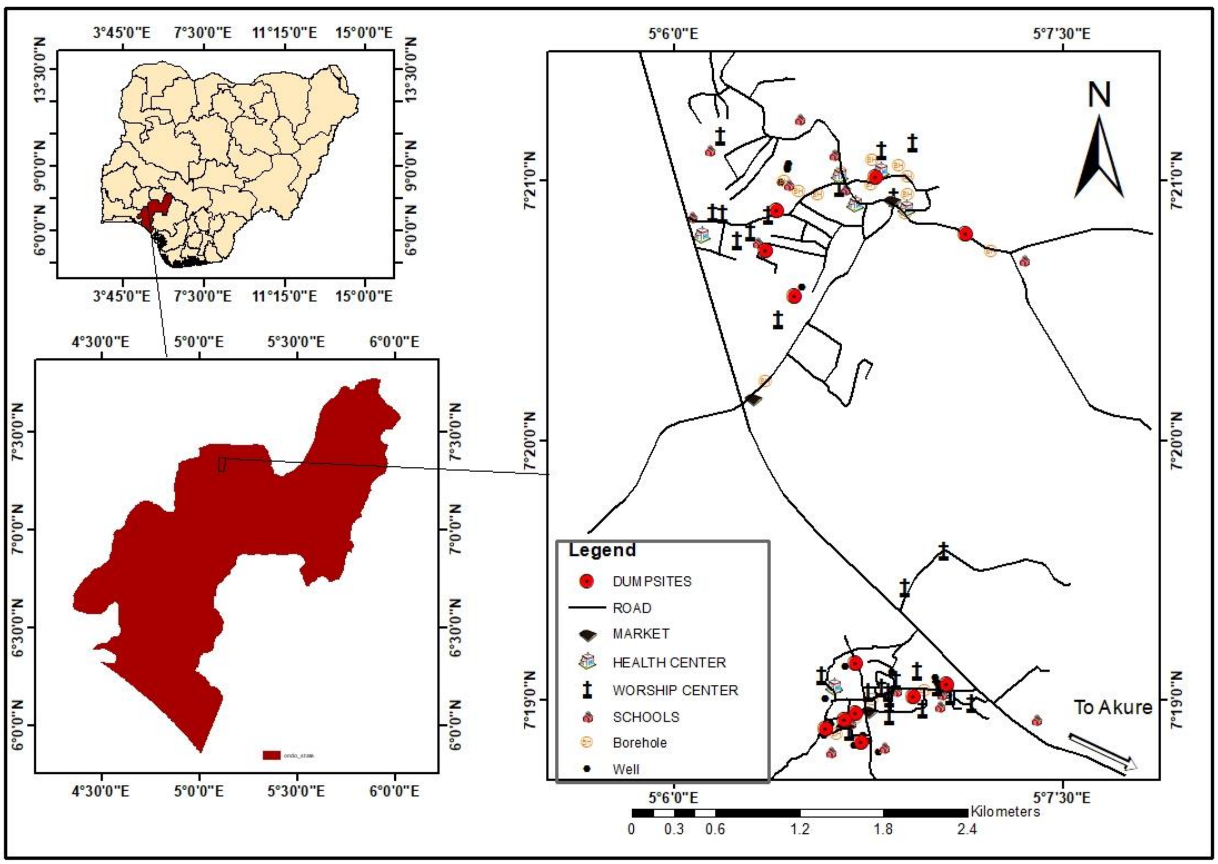

Figure 3. 1: Map of Study Area

Source: Author’s Finding, 2023

Figure 3. 2: Image of dumpsites location in Ibule soro

Source: Author’s Finding, 2023

Figure 3. 3: Image of dumpsites location in Ilara-Mokin

Source: Author’s Finding, 2023

3.2 SOFTWARE USED

I. GPS

II. Google Earth

III. Microsoft office (word, office)

IV. ArcGIS 10.8.1

In the process of achieving the aims and objectives of this project, several tools and data were used. Global Positioning System (GPS) technology plays a crucial role in mapping and addressing dumpsites. GPS was used to record the precise location (coordinates) of the open defecation sites and features that could be affected by the effect of dumpsites examples; schools, river, wells, borehole etc. ArcGIS 10.8 is the major software used for the analysis e.g. LULC analysis, interpolation, buffer analysis etc. The Microsoft excel software was used to store spatial and non-spatial data. The Google earth was used to generate boundaries, roads and also verify facilities within the study area

Table 3. 1: Data Used

DATA	SOURCE	YEAR	PURPOSE
Landsat 9	www.earthexplorer.usgs.gov	2023	To extract the Land-use types of the study area.
ADMINISTATIVE MAP	NARSDA	NIL	To extract the state where the study area is located
Satellite Imagery	Google Earth pro	2023	T extract the road network and also verify the dumpsites within the study area
DEM(Digital Elevation Model)	Data.humdata.org	NIL	To extract Slope and contours

Source: Author's Finding, 2023

3.3 DATA ACQUISITION

The first thing I did was to have a knowledge of the study area and to know the extent and the extent of human habitation using Google earth pro

3.4 DATA PREPARATION

Data preparation is the process of preparing raw data so that it is suitable for further processing and analysis acted by a GIS analyst that involves data gathering, editing and computation of all the data acquired using software like Excel and ArcGIS.

3.5 PROJECTION

Projections are a mathematical transformation that take spherical coordinates (latitude and longitude) and transform them to an XY (planar) coordinate system. This enables you to create a map that accurately shows distances, areas, or directions. With this information, you can accurately work with the data to calculate areas and distances and measure directions. As implemented in Geographic Information Systems. Projections are transformations from spherical coordinates to XY coordinates systems and transformations from one XY coordinate system to another. The data management tool was used to add the coordinate system information.

For this project, or the purpose of uniformity I chose all datasets to be projected to UTM zone 31. The projection method is the technique which the curved surface of the earth is portrayed on the surface. UTM (Universe Transverse Mercator) is the best projection for distributing data that cross state boundaries. Projections are chosen based on the needs of the map or data analysis and on the area of the world. Projections are useful for a limited set of purposes or scales. Finally, projections are based on local needs and standards.

3.6 LABORATORY ANALYSIS

3.6.1 Spectral Reflectance of the Soil

Spectral reflectance**:** The amount of light that soil reflects across the electromagnetic spectrum at various wavelengths is referred to as soil reflectance. This can reveal details about the physical and chemical characteristics of the soil.

- **Preparation:**

I. Collect soil samples from the field and air dry them. Sieve samples to <2 mm to remove rocks, debris, and break up aggregates.

II. Pack samples uniformly into containers or trays to provide a smooth, flat surface for spectral measurements. Avoid compacting too tightly.

III. Determine appropriate sampling depth based on soil type and moisture conditions. Shallow 1-2 cm depth is common.

- **Measurements:**

Use a spectroradiometer that covers the desired spectral range, typically 350-2500 nm.

I. Optimize instrument settings and configure foreoptics for the right distance and field of view over the soil sample.

II. I took the measurements outdoors under direct sunlight, ideally near solar noon. Avoid shadowing.

III. Place sample horizontally and take multiple scans rotating 120 degrees between scans to account for bidirectional reflectance effects.

IV. Include a Spectralon white reference panel in the scene to calculate reflectance from the raw signal. Take new reference scans periodically.

- **Analysis:**

I. Average the scans to produce reflectance signatures for each soil sample.

II. Preprocess data by splicing overlapping detector ranges, and applying smoothing, derivatives, or continuum removal to enhance spectral features.

III. Relate absorption features to soil properties using reference spectral libraries or statistical methods like partial least squares regression.

IV. Validate with laboratory reference measurements of soil organic matter, iron oxides, texture, moisture content, etc.

3.6.2 Heavy metals contents Analysis

Heavy metals are elements that exhibit high density and are typically toxic even at relatively low concentrations. Some common heavy metals include lead, mercury, cadmium, arsenic, chromium, and nickel. The presence of heavy metals in the environment, whether through natural processes or human activities, can have significant impacts on various ecosystems, human health, and overall environmental quality.

3.6.2.1 Extraction of Heavy Metals from Soil

Sieving: Sieving of soil samples were performed by an atomic testing sieve shaker with the following size fractions: >1000, >495,>350, >150, and >75µm.

Acid Digestion: Homogenous and grounded bulk soil samples (0.1 g) are treated with 4 ml of an oxidizing mixture (HNO_3: HCI =3:1) and 6 ml HF in a Teflon recipient put in a microwave oven (800 w, 4 min; 400 w, 4 min, 800 w, 4 min; 20 min. of ventilation). Recovered sample are then treated with 5.6 g HNO_3 to avoid silica evaporation and diluted to 100 ml by deionized water. Metal concentrations in solution were determined by atomic Absorption Spectrometer (AAS, Perkin Elmer Model 306). Step 1: 5g of soil sample was treated with 45 ml of ammonium acetate IM at pH5 with acetic acid under stirring for 24 hours at room temperature; suspension was then centrifuged at 300 rpm for 20min, diluted to 100 ml with deionised water and analysed by AAS. Step 11: The residual solid of the previous step was treated with 22.5 ml of hydroxyl ammonium acetate following by acetic acid (25%). After 24 h stirring at room temperature solid -liquid separation is performed by centrifugation as before and the metal bearing solution is diluted (to 100 ml) and analysed by AAS. Step 111: The residual solid of the previous step was treated with 12.5 ml of HCI (0.1 m) and stirred for 24 hrs at room temperature. As in previous steps, solid – liquid separation was performed and the solution diluted to 25 ml was analysed for metal concentrations. Step IV: The residual solid of the previous step was treated with 12.5 ml of NaOH (0.5 m) under stirring for 24hrs at room temperature for soil samples with large organic content; this treatment was repeated until a clear solution was obtained. All the solutions separated from the solid were then dried by an IR lamp at 60° c and then digested by using 4 ml of HNO^3 65% and 2 ml HF (40%) in a microwave oven (250 w, 1 min; o w, 2 min; 250 w, 5 min; 600 w, 5 min). The acid solution was then diluted to 25ml and analysed for metals by AAS. Step V: The residual solid of the previous step was treated with 12.5 ml of HNO_3 (8 M) and digested for 2h at 80°C. The solution was then diluted to 25 ml and analyzed by AAS for metal concentrations

3.7 GIS ANALYSIS

3.7.1 Clipping

Clipping in GIS refers to the process of extracting a portion of one spatial dataset (study area) based on the spatial extent or boundary of another dataset. This operation is commonly used to limit the geographical extent of a dataset to the boundary of another dataset. Clipping is useful in various GIS applications, such as spatial analysis, map creation, and data management

3.7.2 Land use/land cover (Supervised Classification)

Image classification is defined as the extraction of distinct classes or themes: Land use and Land cover categories from Satellite Imagery. It is the process of assigning pixels to classes.

Image analysis and pattern recognition with image classification is an integral part of Remote Sensing. For this study, supervised classification, using maximum likelihood algorithm, was employed. The choice of this method is based on findings from several studies which have highlighted this technique as a better way of land use land cover classification. Vegetation and bare surfaces were identified across the study area.

I used Landsat 9 (2023) for the supervised classification. After I downloaded the imageries from USGS, I generated false colour composite for the imageries so as to aid the supervised classification. After I did this I generated a tiff image of the imageries I performed mosaic to raster on. Then 1 performed the supervised classification (maximum likelihood method) on the ArcGIS 10.8 software, using my image Classification tool and creating signature shapefile for each of the classes.

The image classification done based on the knowledge of the study area gives a broad classification where the land use land cover was identified by a single digit.

3.7.3 Buffering

It is a spatial analysis known as proximity analysis, generating zones of a given distance around a feature theme. It form a polygon around a point, line or polygon theme by locating its boundaries at a specified distance. The dumpsites in the study area were buffered at 100m 200m and 300m respectively in order to determine infrastructures that are at risk of dumpsites infection

3.7.4 Slope

The slope is the ratio of steep ness or the degree of inclination of a feature relative to the horizontal plane. Gradient, grade, incline and pitch are used interchangeable with slope. The slope is typically denoted as a percentage, an angle, or a ratio. The average slope of a topographical texture can be measured from contour lines on a top map or by DEM. The slope is achieved by dividing the rise over run

3.7.5 Soil Data

In this study area, the soil map was generated from the soil data extracted from the dominant soils of Nigeria Map the source of this map is the FAO soil portal. It was imported into Arc

GIS. 10.8 geo-referenced, my study area was overlaid on it to identify the soil typed. I created a shape file to digitize the soil type within my study area extent. I now classified the digitized soil type and generated the soil map of my study area on ArcGIS 10.8.

3.7.6 Spatial Data Analysis

Identification of Potential Solid Waste Dumpsites Using Multi-criteria Analysis. To achieve the first objective in this research work the following data were used needed to perform the spatial analysis: land-use map, slope, road and building map. The data were selected based on the criteria that must be satisfied to determine the most suitable location for a dumpsite in the study area according to the Environment Protection Agency Landfill Manual 2006.

3.7.6.1 Weight Overlay

The weighted overly tool in spatial analyst is applied for the analysis. The three reclassified raster layers are weighted based on the weights of the pairwise comparison process and then combined based on the assigned rankings used in the reclassification. The cell values of each input raster are multiplied by the raster's weight then the resulting cell values are added to produce the final output raster. To achieve this objective in this research work the following data were selected based on the criteria that must be satisfied to determine the most suitable location for a dumpsite in the study area. The various criteria that were created as layer in the GIS environment are:

Table 3. 2: Factor Criteria Table

S/n	Criteria
1	Slope
2	Distance to school
3	Distance to health center
4	Distance to boreholes and wells
5	Distance to road
6	Distance to building

Source: Author’s finding, 2023

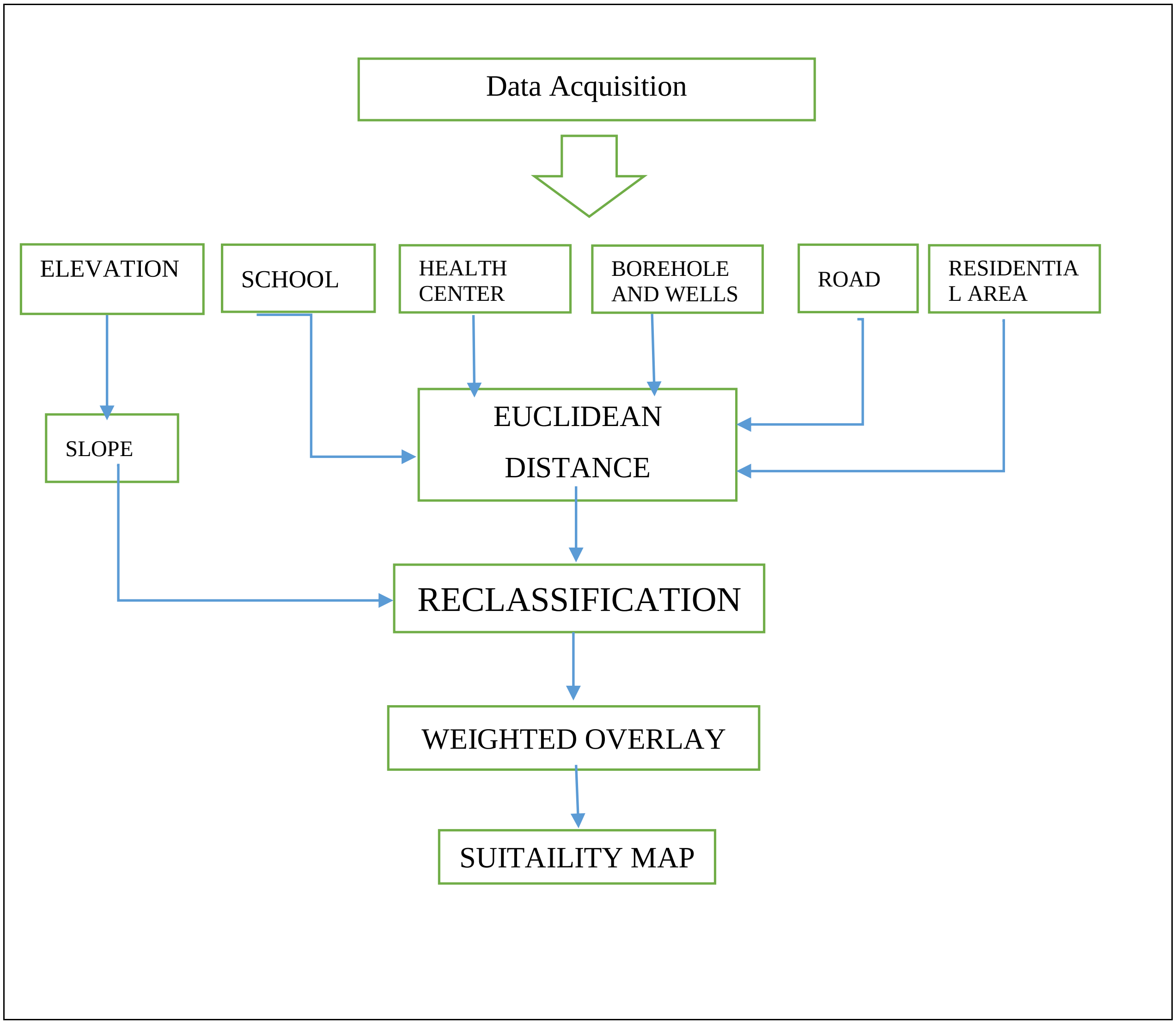

Figure 3. 4: Flowchart of Suitability Analysis

Source: Author's finding, 2023

CHAPTER 4

RESULTS

4.1 SOIL AND GEOLOGY MAP

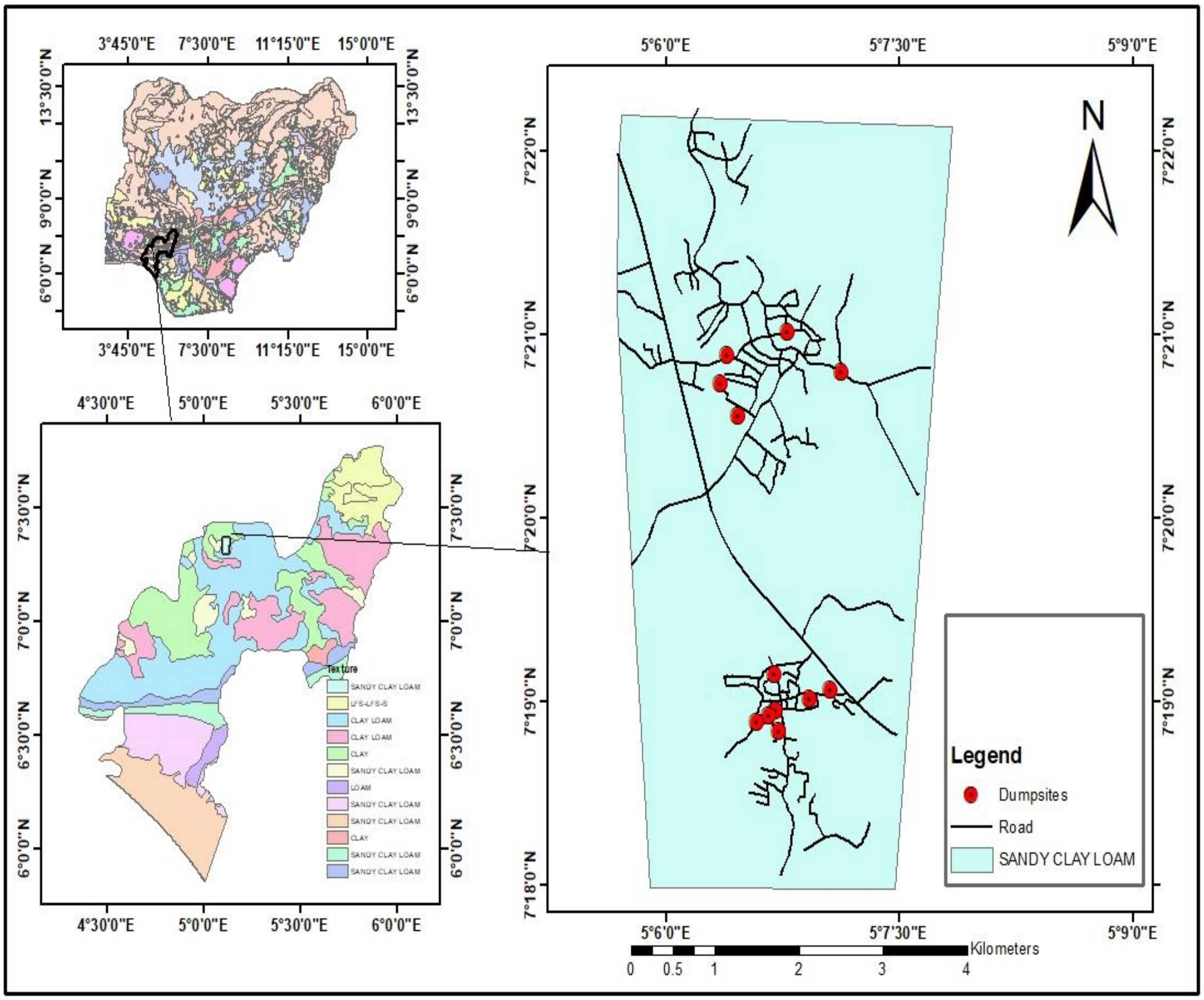

Figure 4. 1: Soil Map of the Study Area

Source: Author's Data Analysis

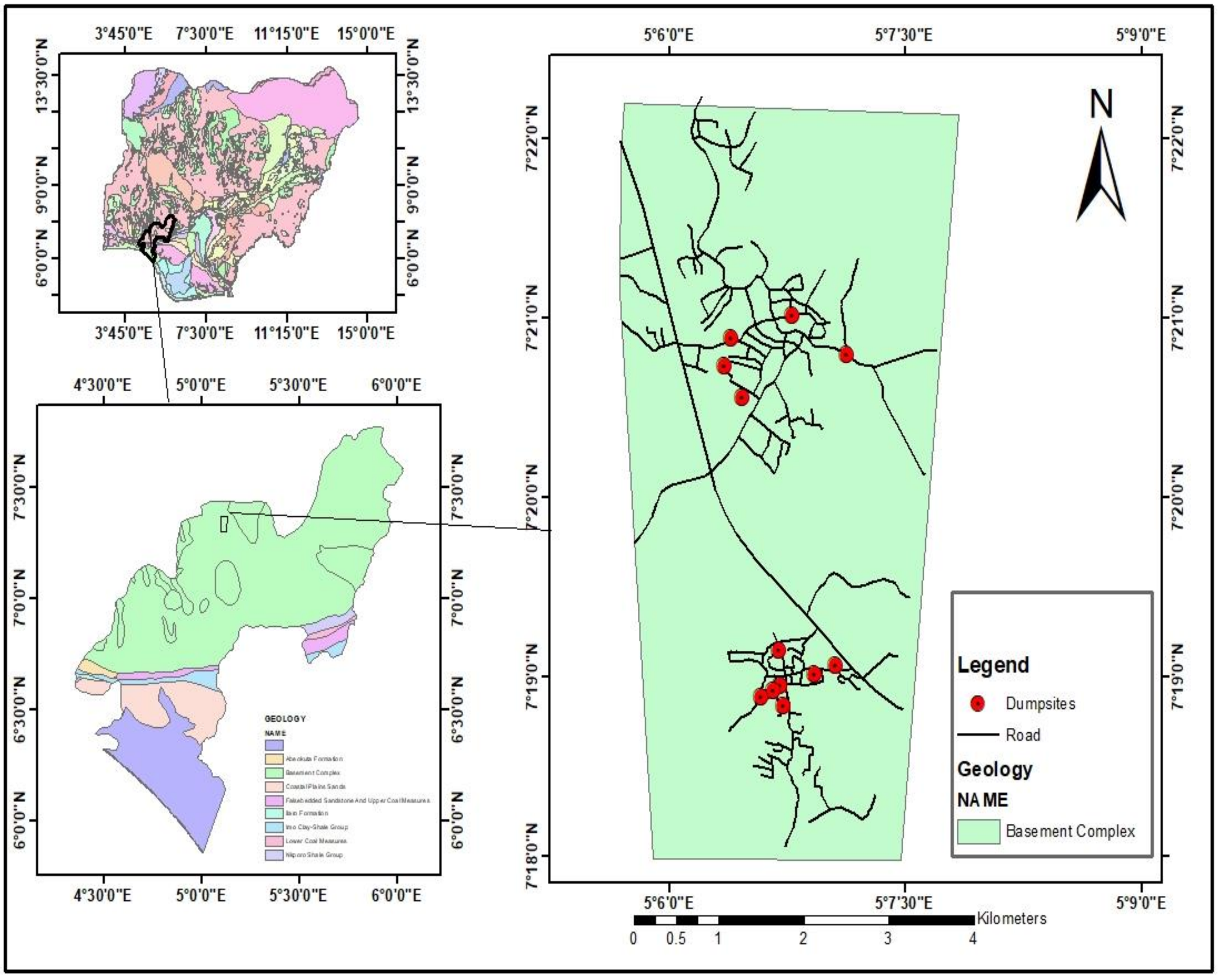

Figure 4. 2: Geology Map of the Study Area

Source: Author’s Data Analysis

4.2 SPECTRAL REFLECTANCE OF THE SOIL

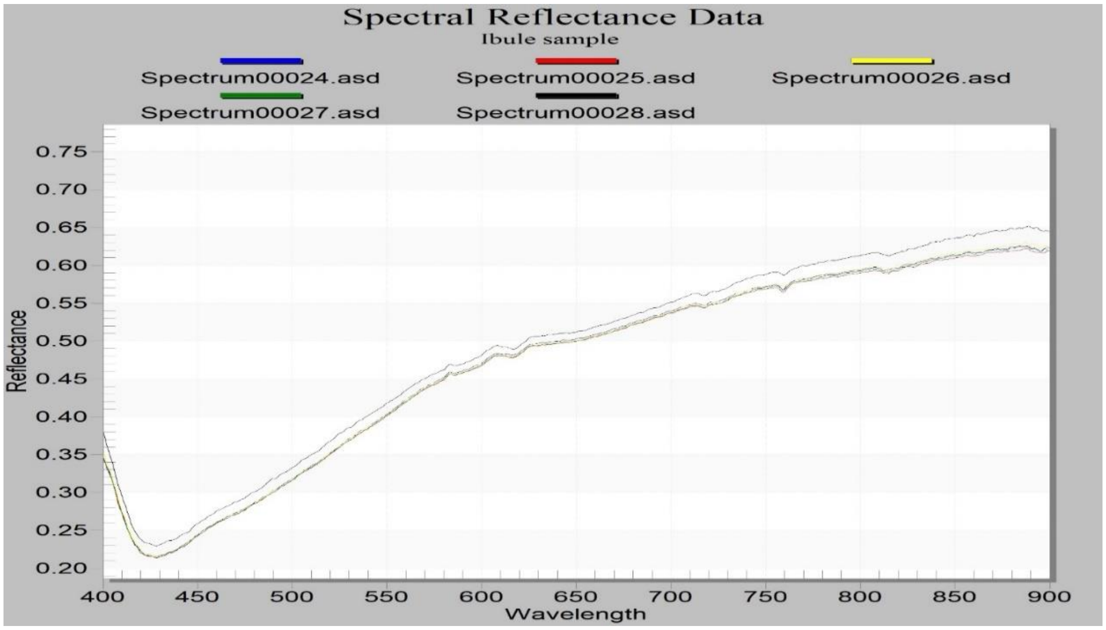

Figure 4. 3: showing spectral signature for Ibule sample A

Source: Author's Data Analysis

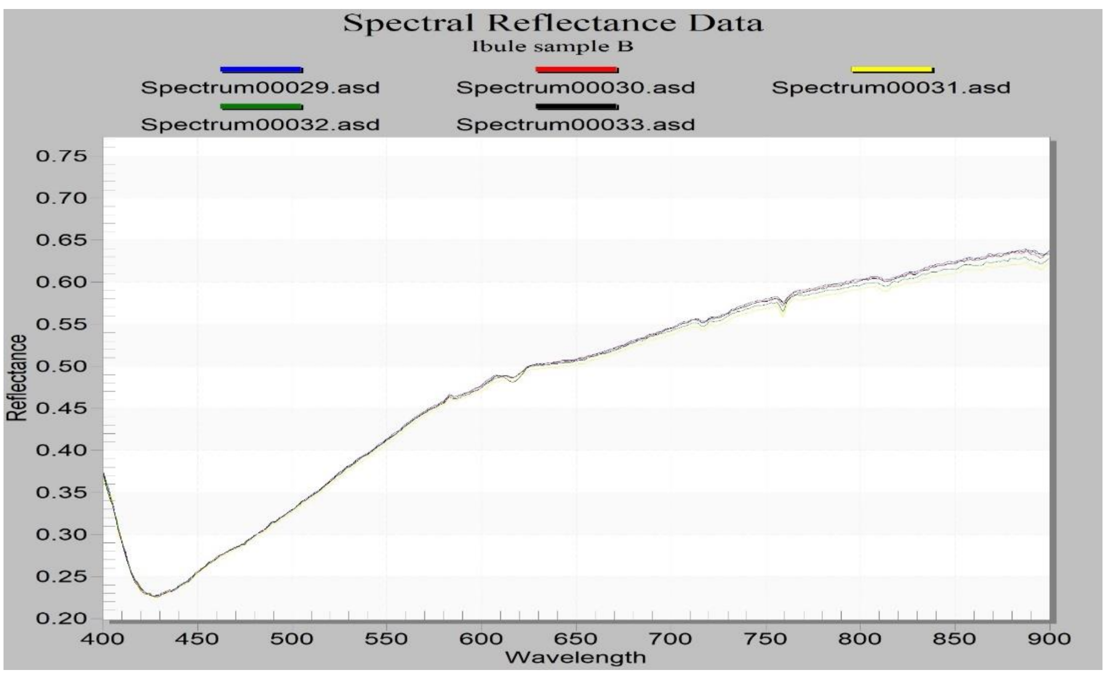

Figure 4. 4: map showing spectral signature for Ibule sample B

Source: Author's Data Analysis

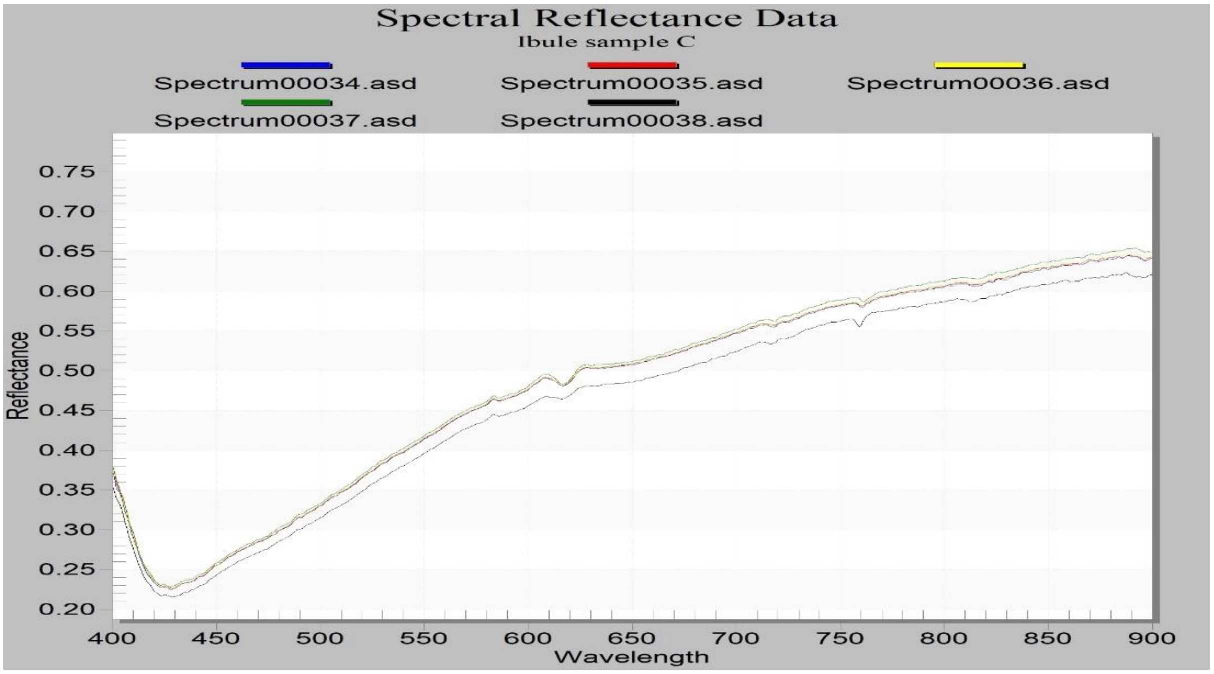

Figure 4. 5: map showing spectral signature for Ibule sample C

Source: Author's Data Analysis

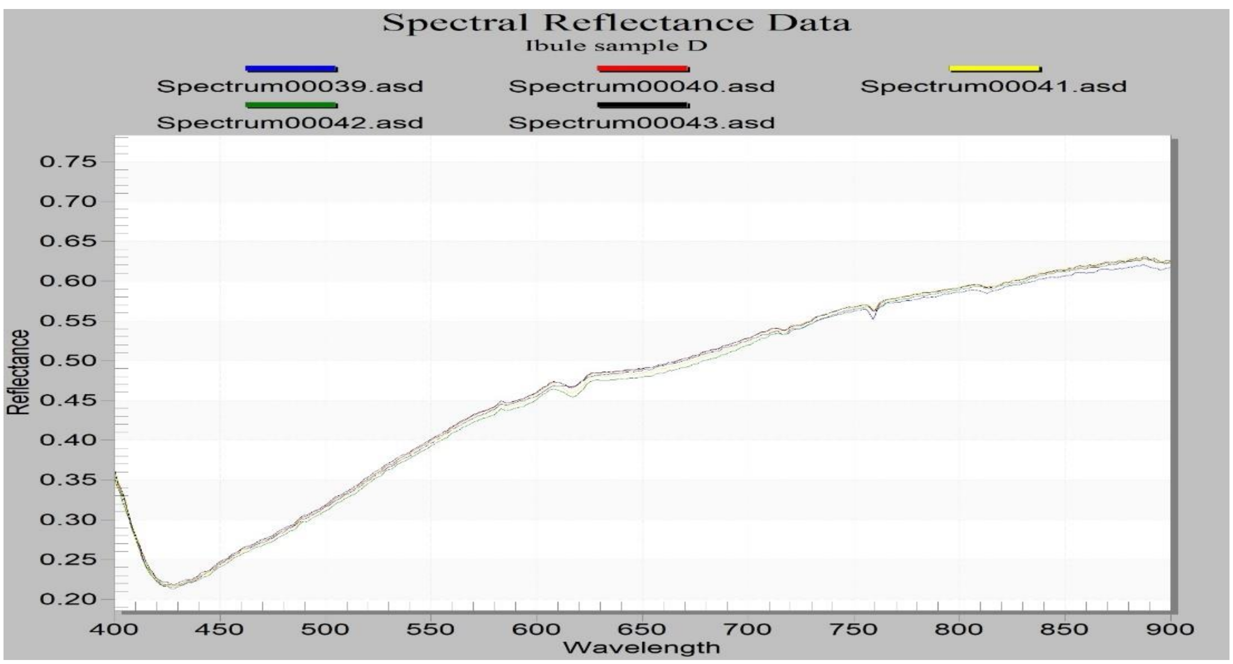

Figure 4. 6: map showing spectral signature for Ibule sample D

Source: Author's Data Analysis

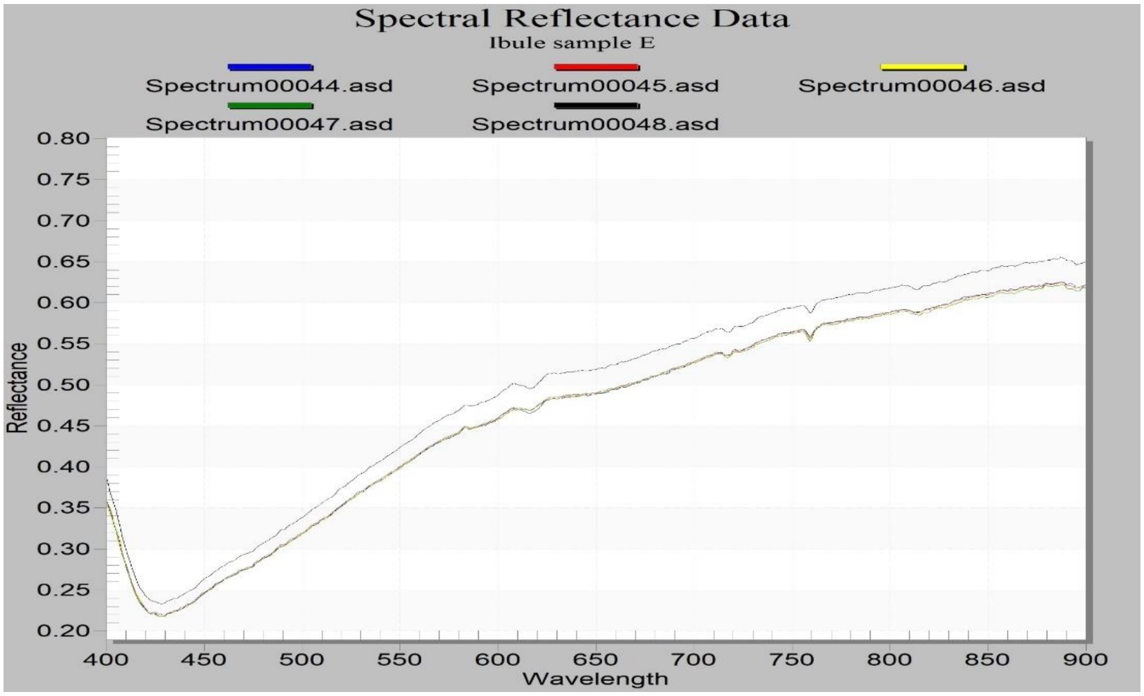

Figure 4. 7: map showing spectral signature for Ibule sample E

Source: Author’s Data Analysis

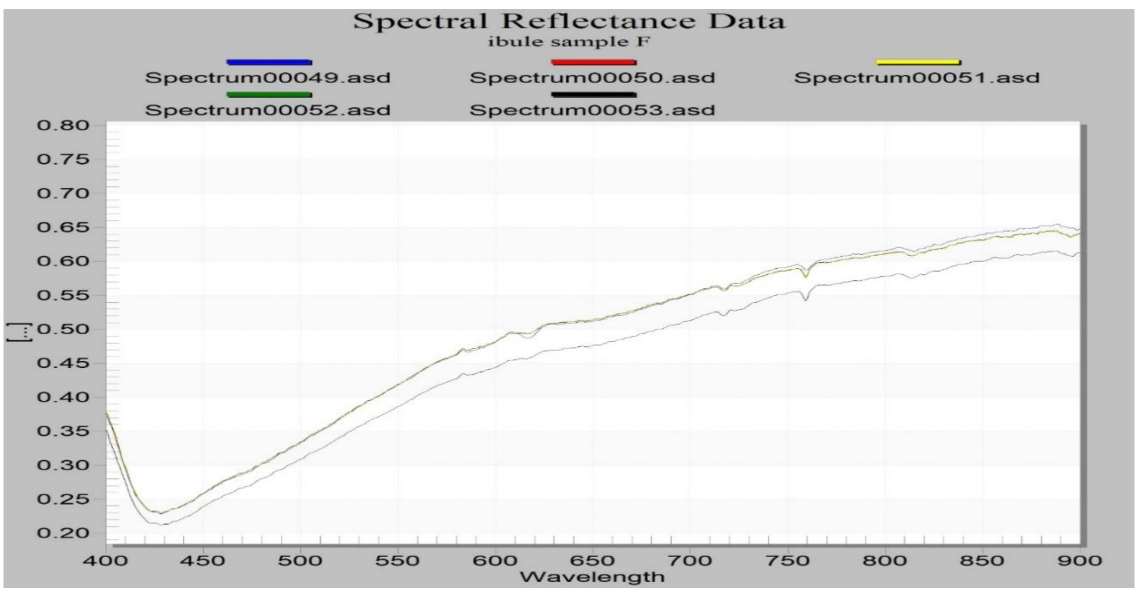

Figure 4. 8: map showing spectral signature for Ibule sample F

Source: Author’s Data Analysis

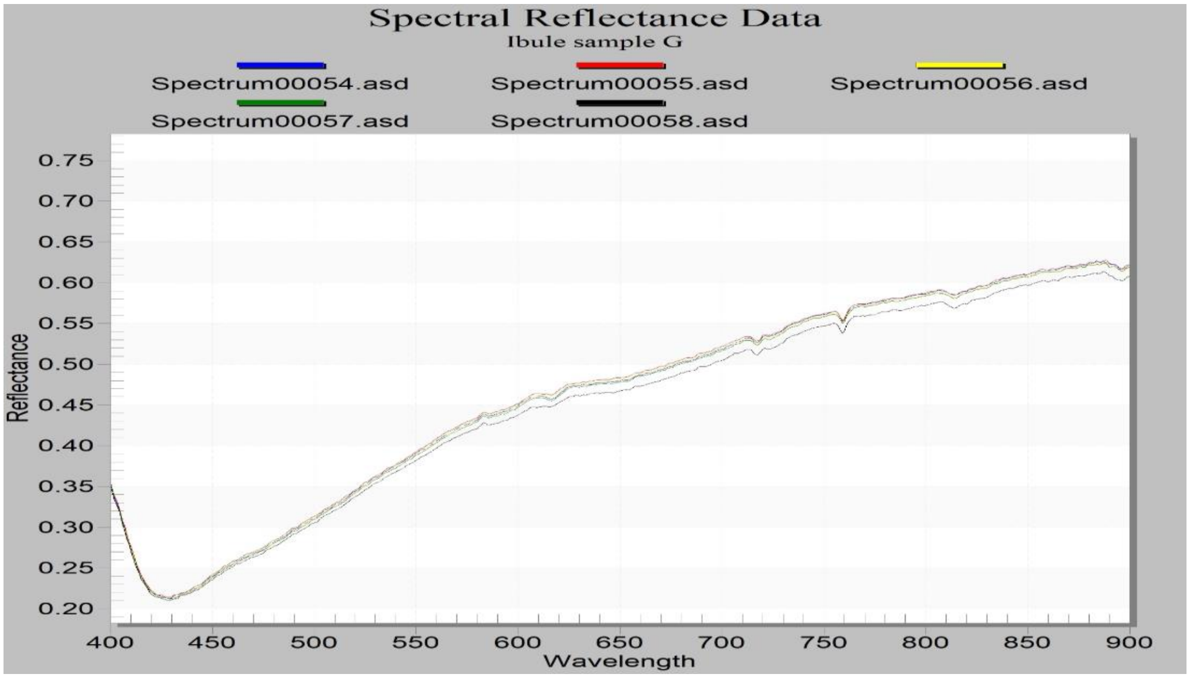

Figure 4. 9 map: showing spectral signature for Ibule sample G

Source: Author's Data Analysis

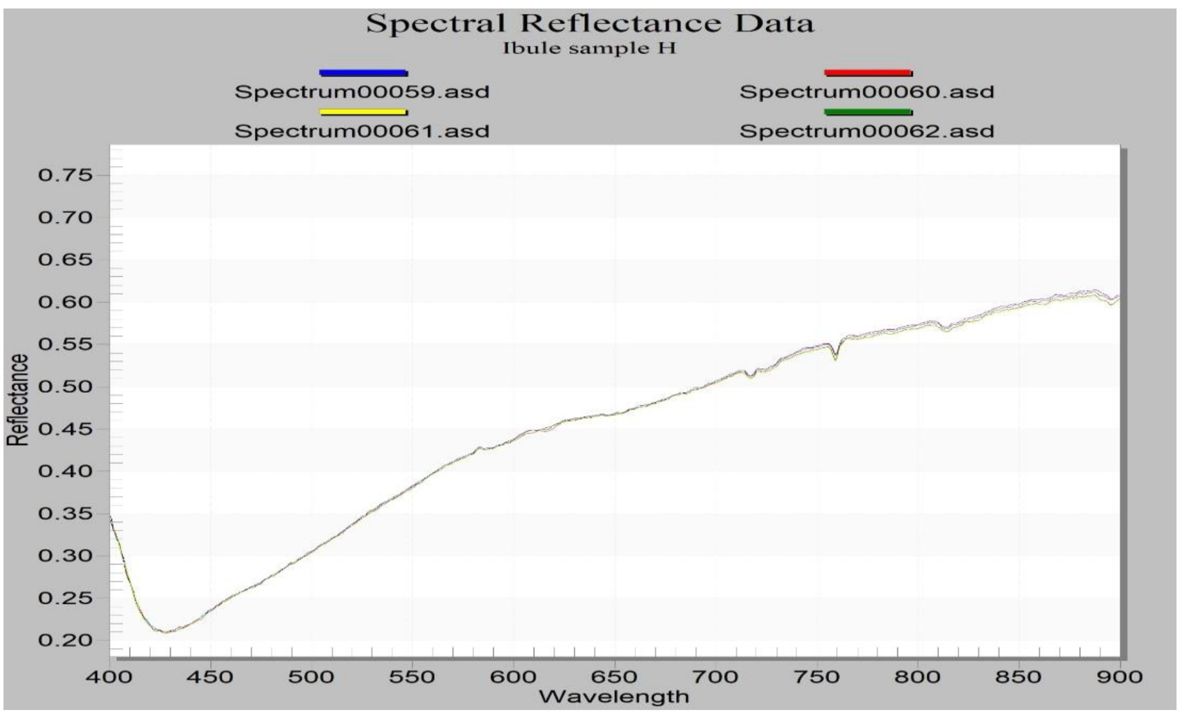

Figure 4. 10: map showing spectral signature for Ibule sample H

Source: Author's Data Analysis

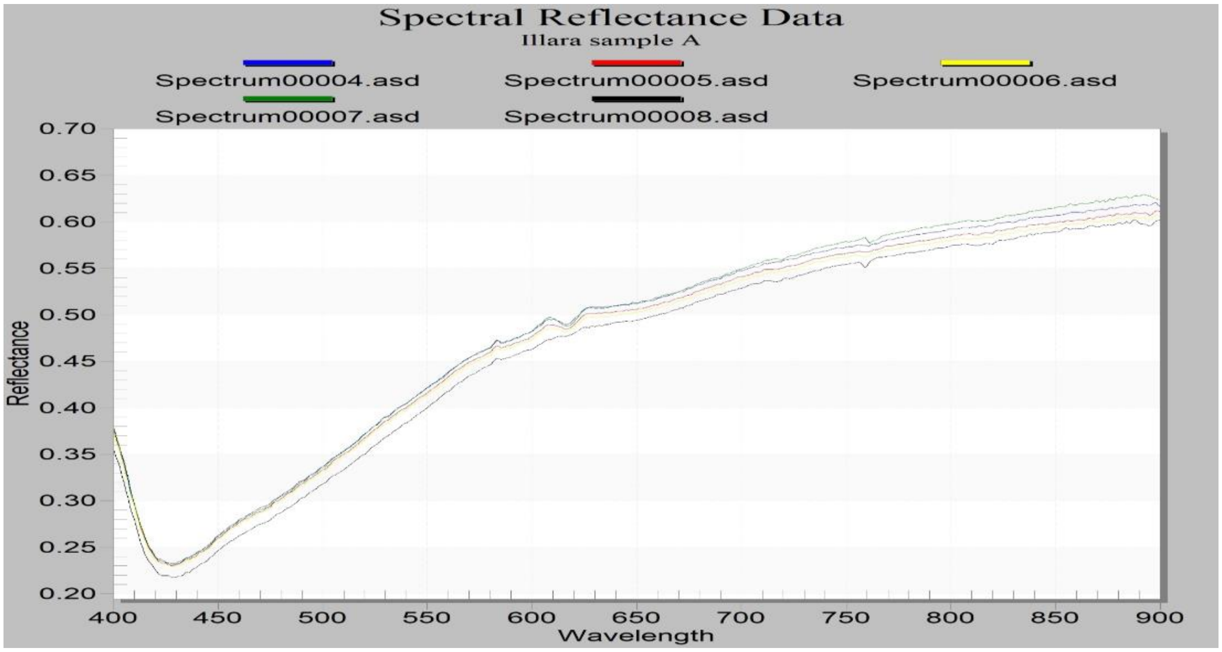

Figure 4. 11: map showing spectral signature for Ilara sample A

Source: Author's Data Analysis

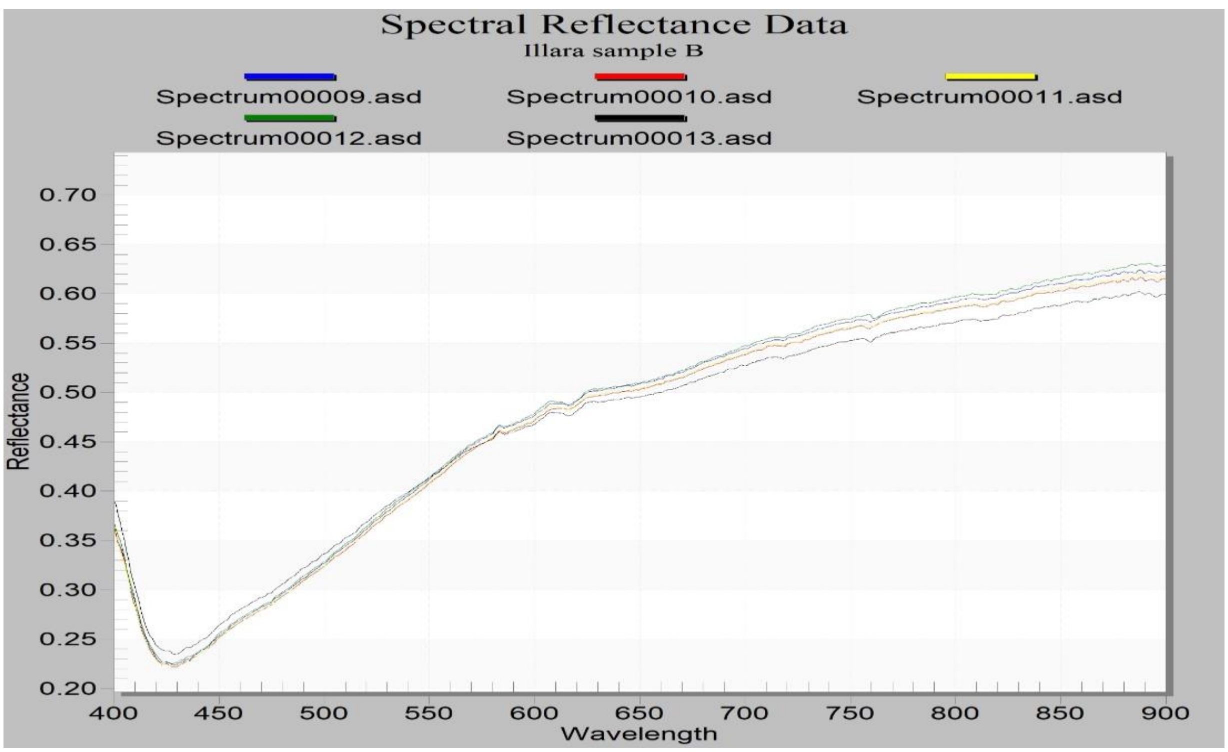

Figure 4. 12: map showing spectral signature for Ilara sample B

Source: Author's Data Analysis

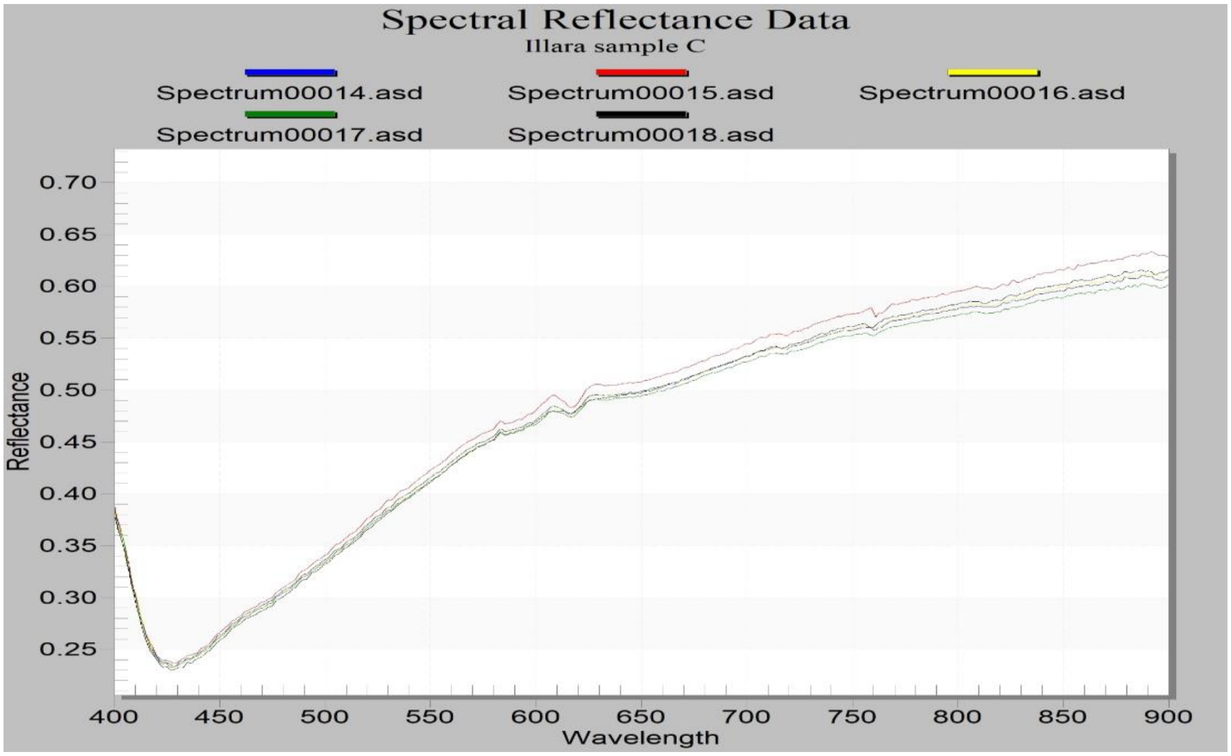

Figure 4. 13: map showing spectral signature for Ilara sample C

Source: Author’s Data Analysis

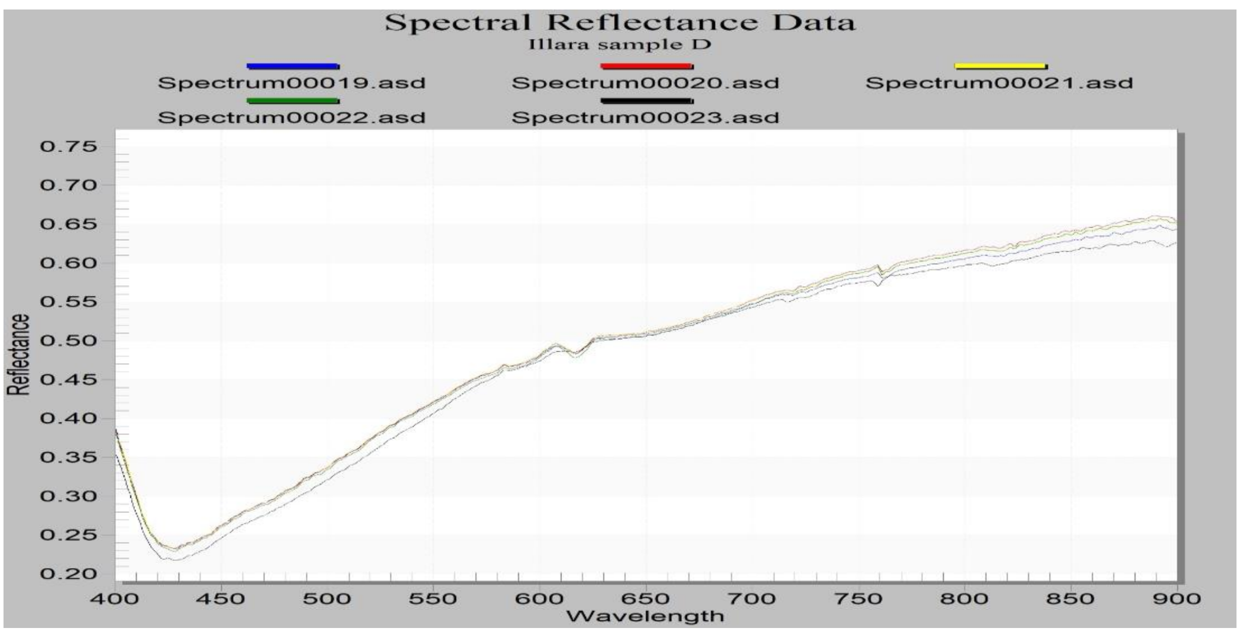

Figure 4. 14: map showing spectral signature for Ilara sample A

Source: Author’s Data Analysis

4.3 CONCENTRATION OF HEAVY METALS IN SOIL SAMPLES AND SPATIAL DISTRIBUTION.

The table 4.1 below shows the concentration of the heavy metals in the soil samples collected from selected sites. The concentrations of the heavy metals (Cu, Co, Cr, Cd, Fe, Ni, Pb, AS)

Table 4. 1: Concentration of Heavy Metals in soil samples of areas considered

OD Samples	Cu (mg/kg)	Co (mg/kg)	Cr (mg/kg)	Cd (mg/kg)	Fe (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	As (mg/kg)
Ibule A	0.115	0.030	ND	ND	0.100	0.010	ND	ND
Ibule B	0.119	0.020	0.040	0.010	0.114	0.050	ND	ND
Ibule C	0.113	ND	0.027	ND	0.086	0.020	0.020	0.010
Ibule D	0.123	0.050	ND	ND	0.099	0.060	0.030	0.013
Ibule F	0.127	0.360	0.052	0.003	0.114	0.032	0.020	ND
Ibule H	0.118	ND	0.049	0.040	0.118	0.019	ND	0.013
Ilara A	0.120	0.190	0.070	0.020	0.115	0.020	0.040	0.020
Ilara B	0.112	ND	0.036	ND	0.120	0.060	ND	ND
Ilara C	0.114	0.300	ND	ND	0.113	0.043	ND	0.010
Ilara D	0.117	ND	0.030	ND	0.100	0.030	ND	ND

N.D: NOT DETECTED

Source: Author's Finding, 2023

Table 4. 2: Maximum allowable limit of heavy metals concentrations in soil

sample	mg/kg
Cu	100
Co	50
Cr	100
Cd	3
Fe	50000
Ni	30
Pb	100
As	20

Source: W.H.O

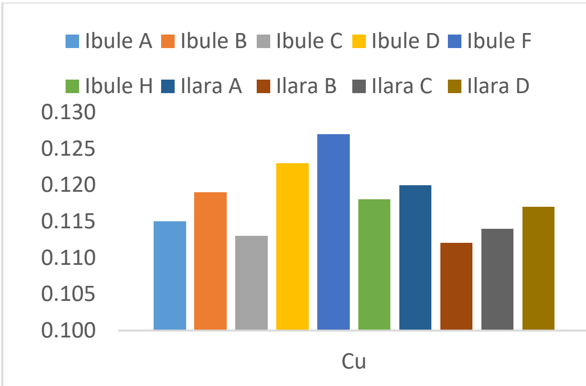

Figure 4. 15: Graphical Representation of the concentration of Copper (Cu) in the tested samples

Source: Author's Data Analysis

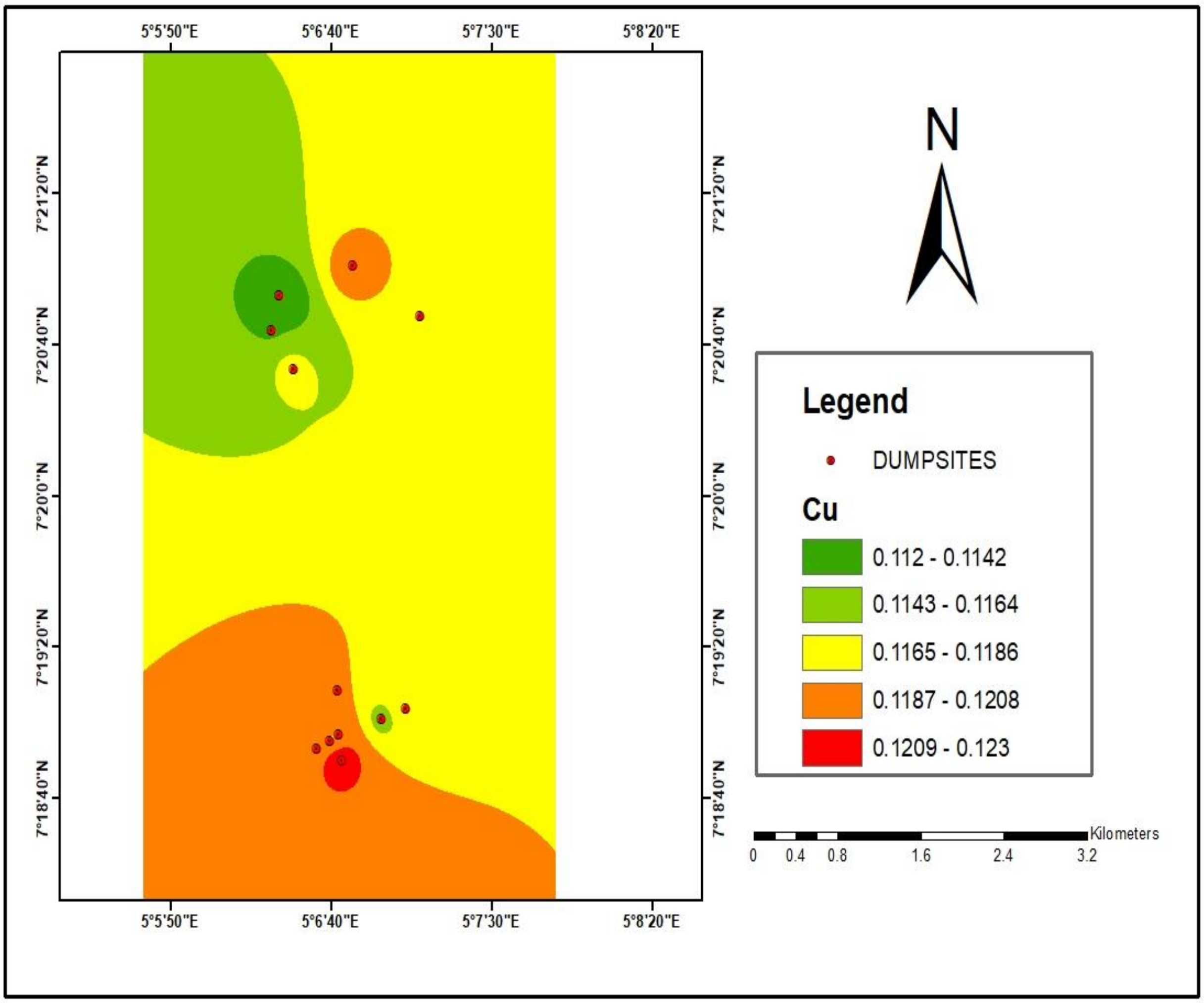

Figure 4. 16: inverse distance weighting (IDW) to forecast contamination levels in unsampled places for copper

Source: Author's Data Analysis

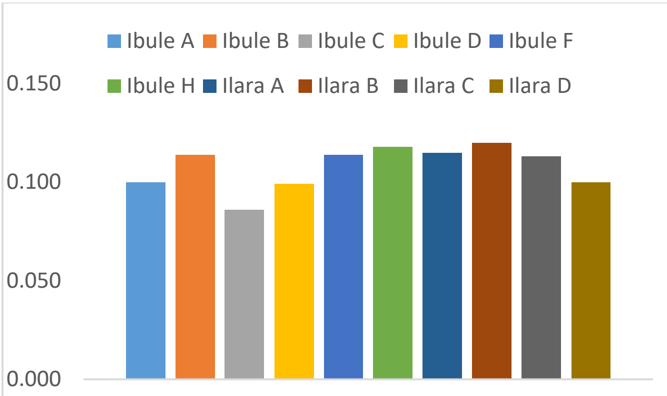

Figure 4. 17: Graphical Representation of the concentration of Iron (Fe) in the tested samples

Source: Author's Data Analysis

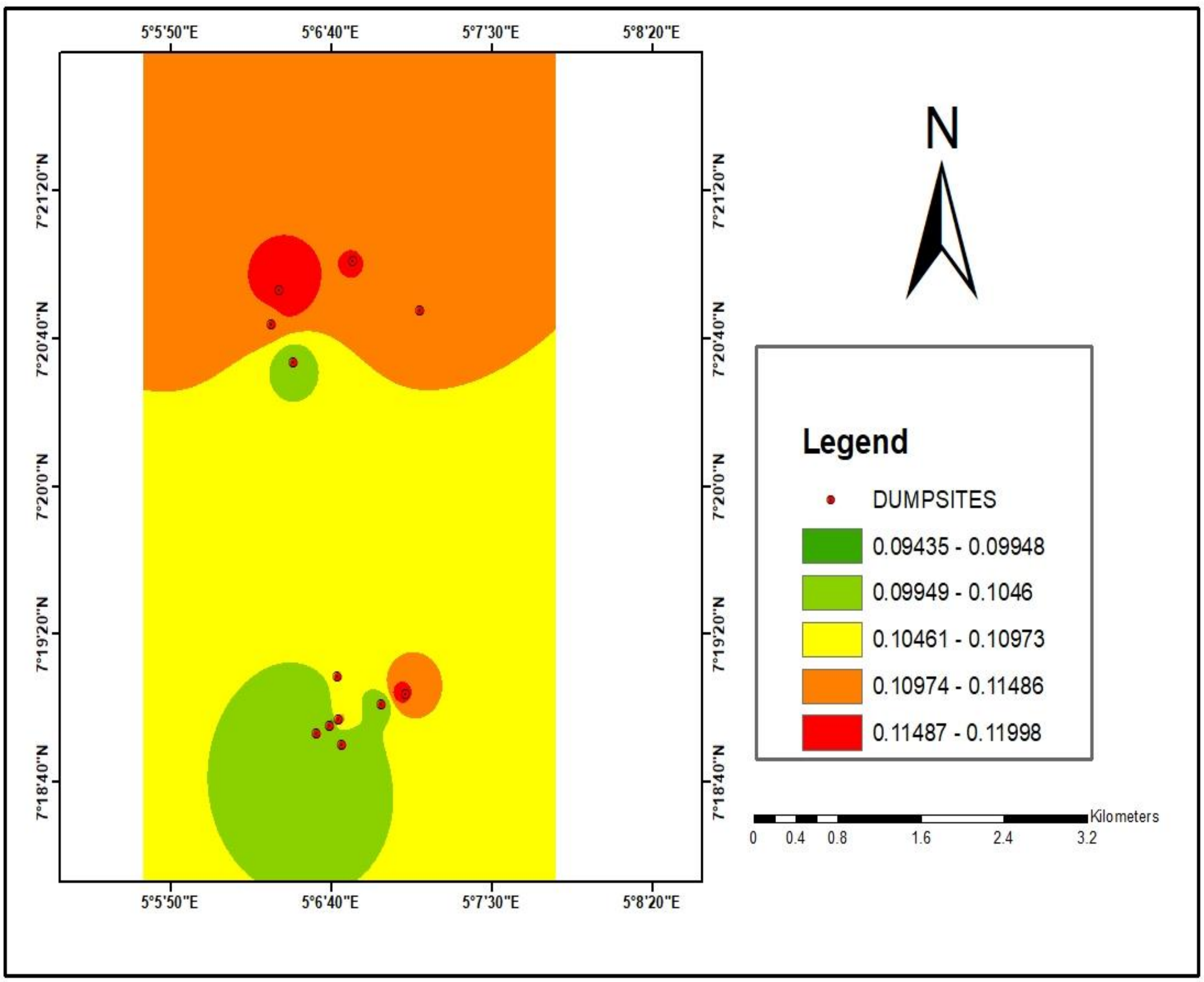

Figure 4. 18: inverse distance weighting (IDW) to forecast contamination levels in unsampled places for iron

Source: Author's Data Analysis

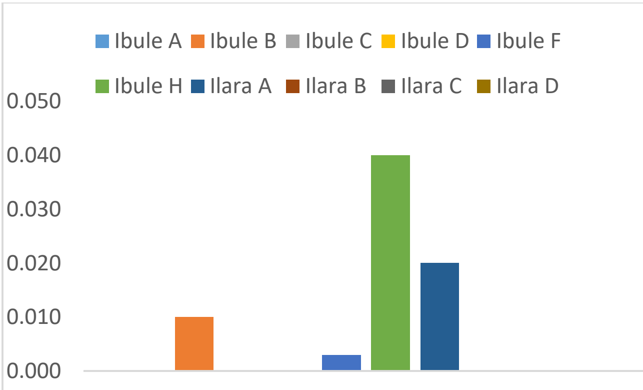

Figure 4. 19: Graphical Representation of the concentration of Cadmium (Cd) in the tested

Source: Author's Data Analysis

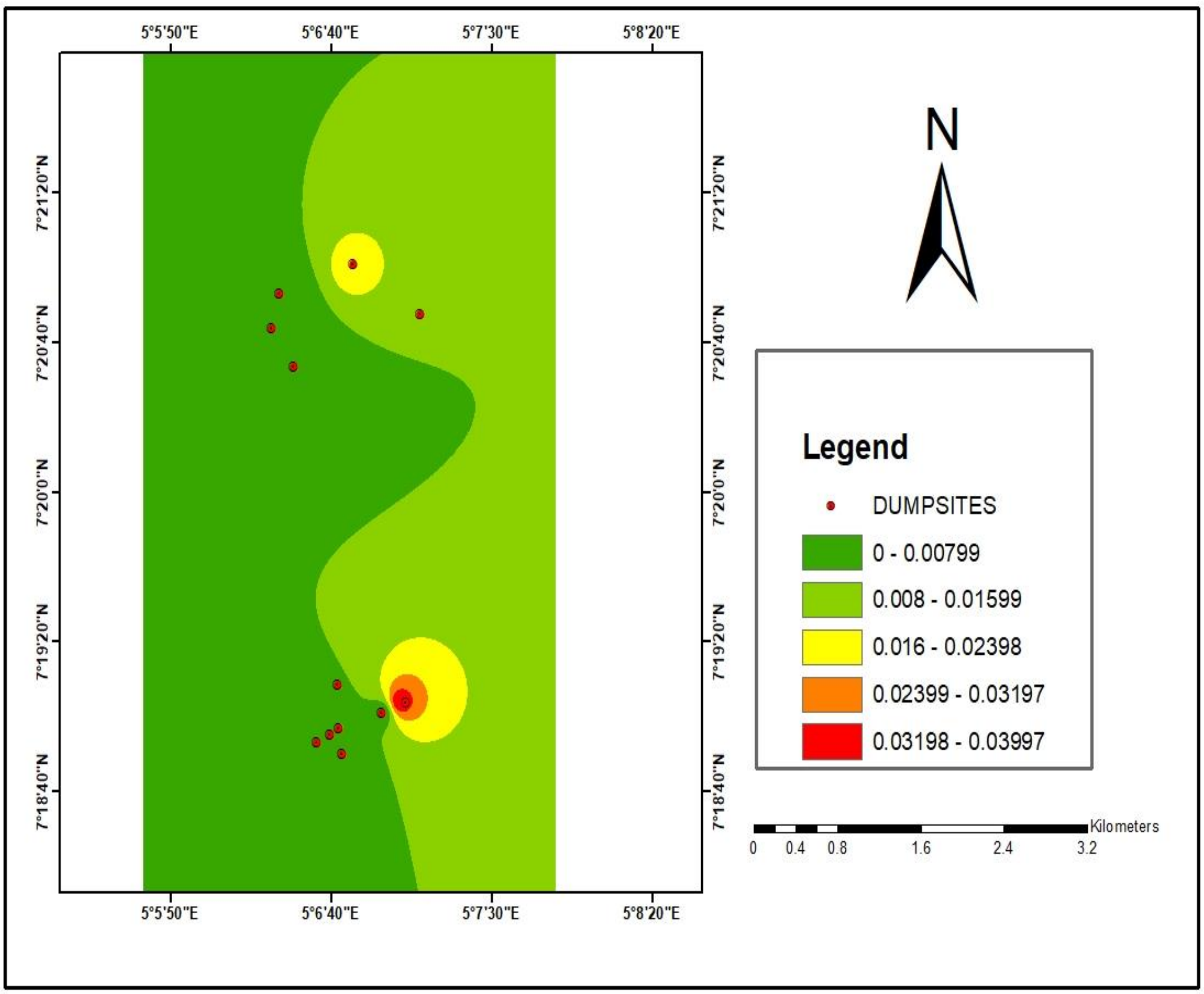

Figure 4. 20: inverse distance weighting (IDW) to forecast contamination levels in unsampled places for Cadmium

Source: Author's Data Analysis

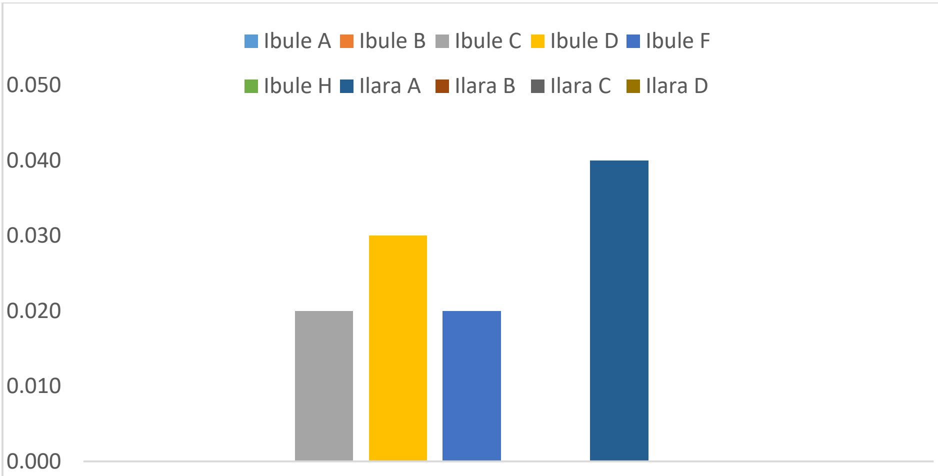

Figure 4. 21: Graphical Representation of the concentration of Lead (Pb) in the tested samples
Source: Author's Data Analysis

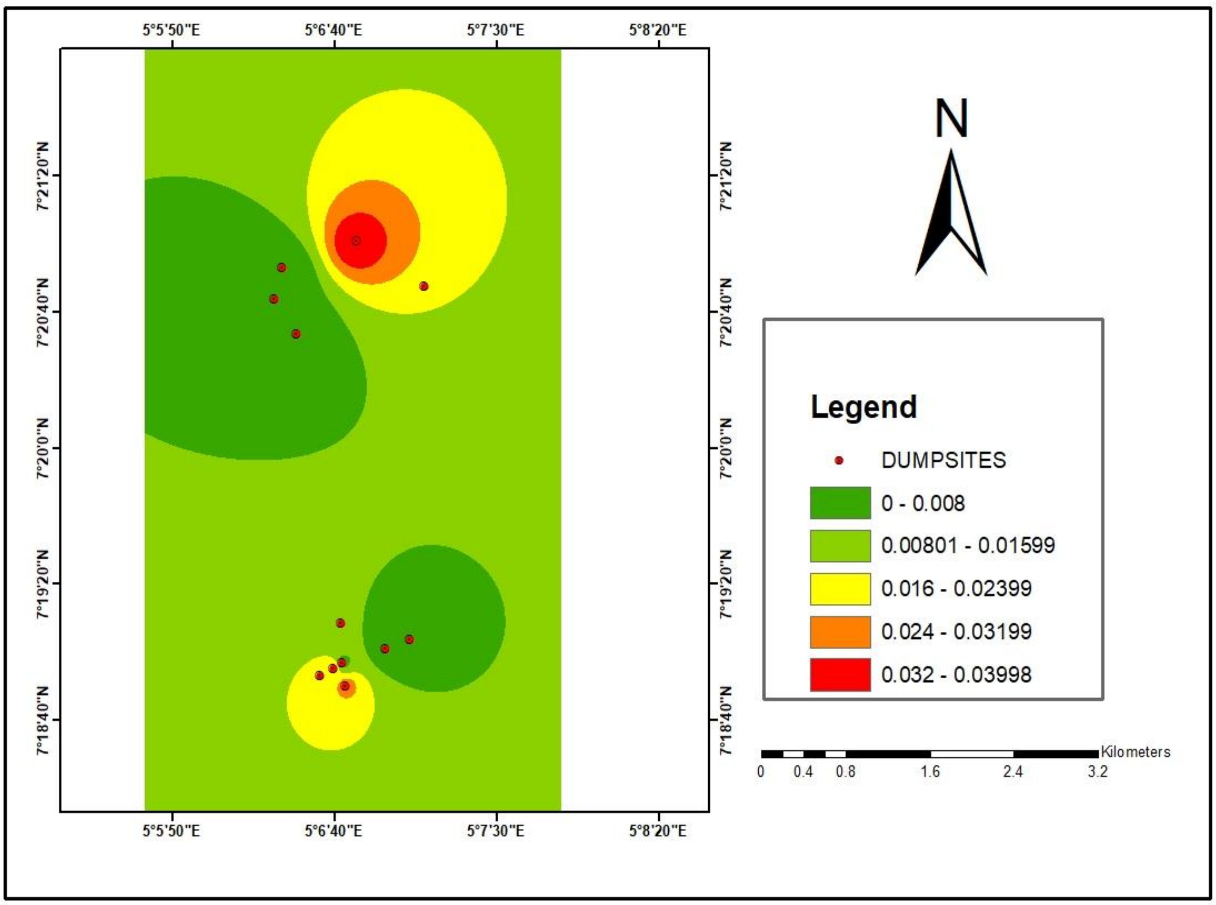

Figure 4. 22: inverse distance weighting (IDW) to forecast contamination levels in unsampled places for Lead

Source: Author's Data Analysis

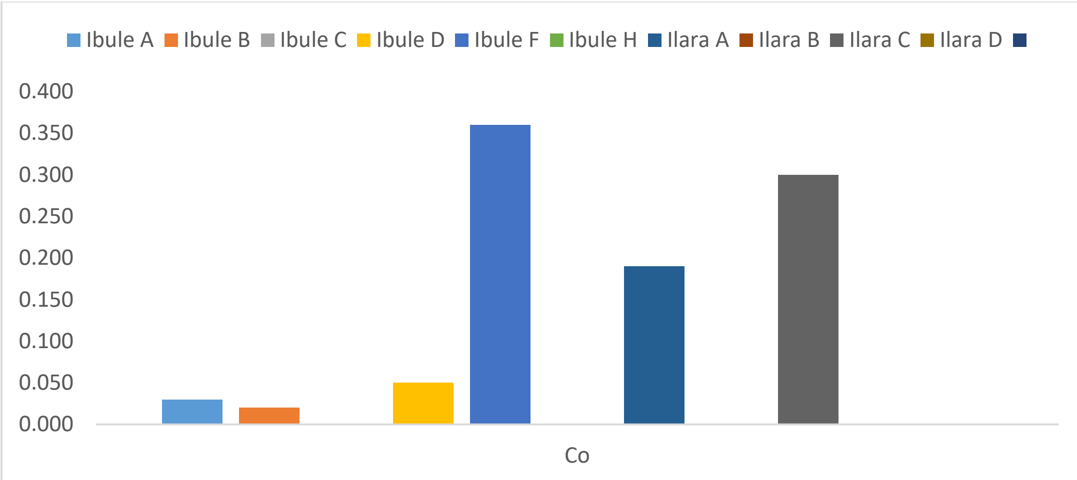

Figure 4. 23: Graphical Representation of the concentration of Cobalt (Co) in the tested samples

Source: Author’s Data Analysis

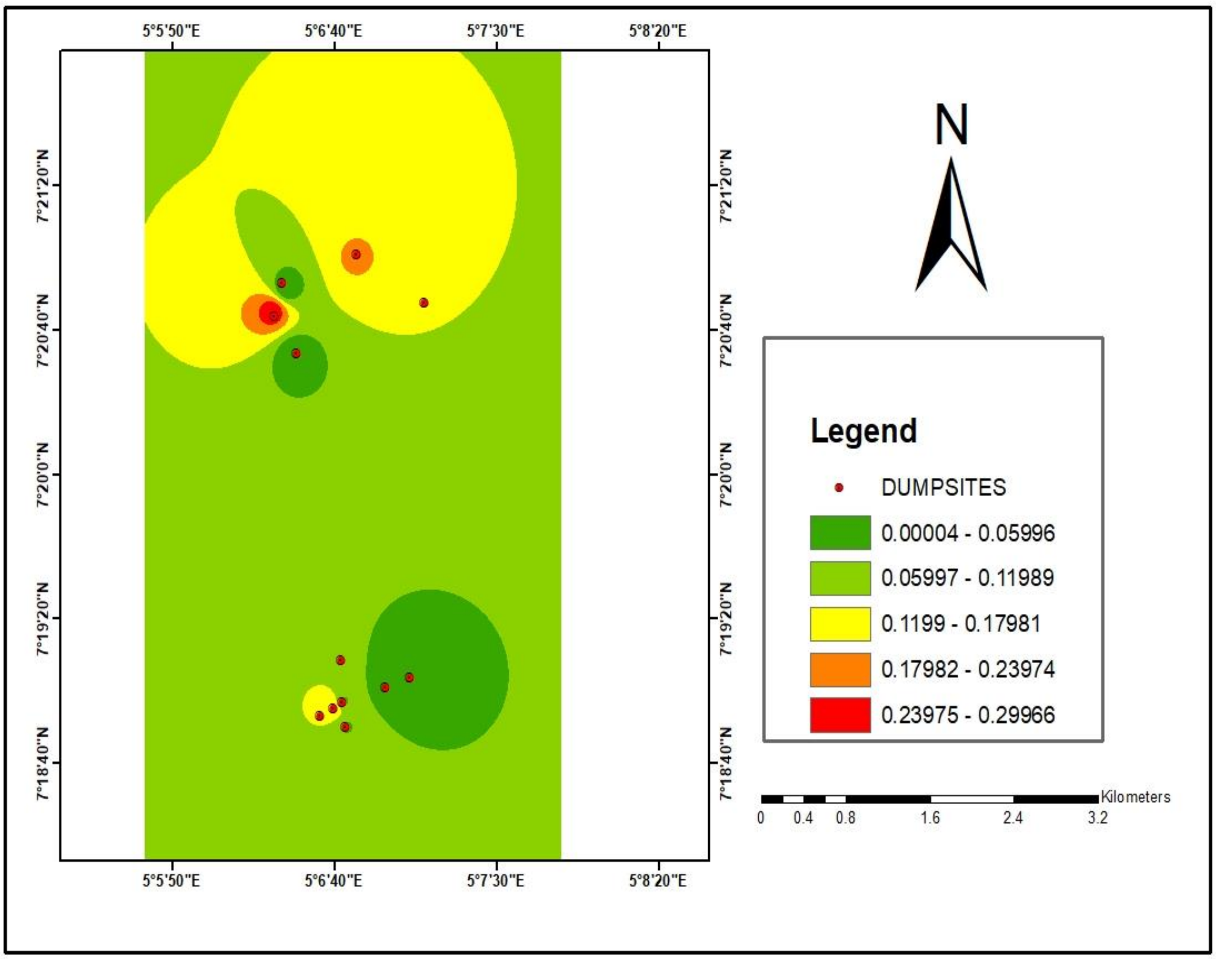

Figure 4. 24: inverse distance weighting (IDW) to forecast contamination levels in unsampled places for Cobalt

Source: Author’s Data Analysis

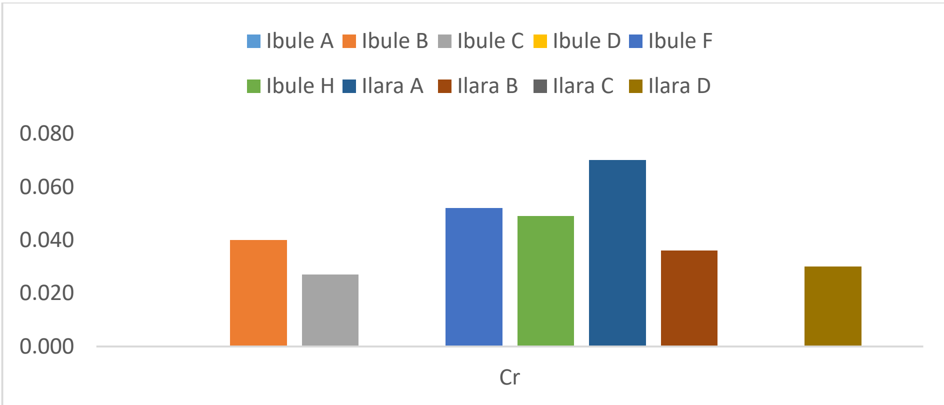

Figure 4. 25: Graphical Representation of the concentration of Chromium (Cr) in the tested samples

Source: Author's Data Analysis

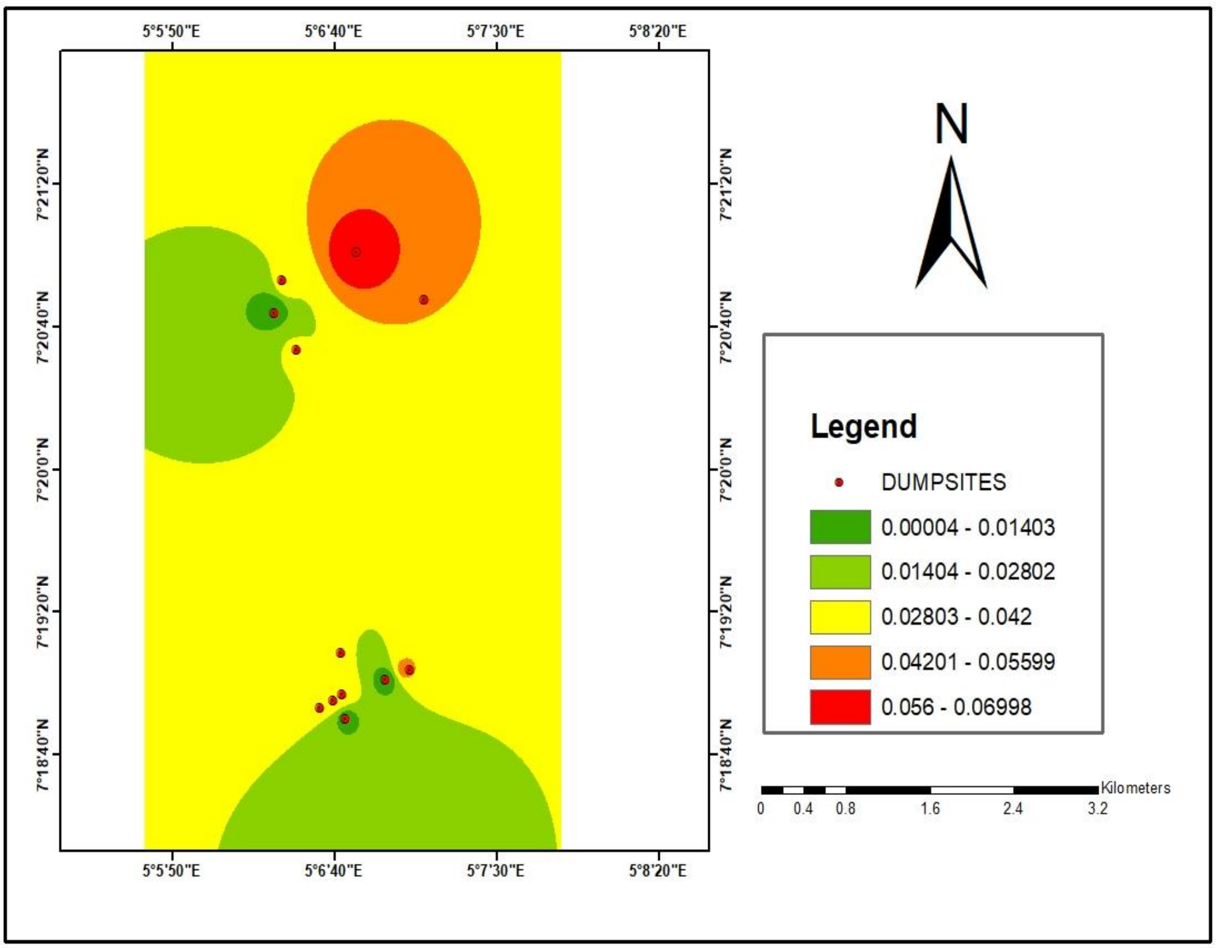

Figure 4. 26: inverse distance weighting (IDW) to forecast contamination levels in unsampled places for Chromium

Source: Author's Data Analysis

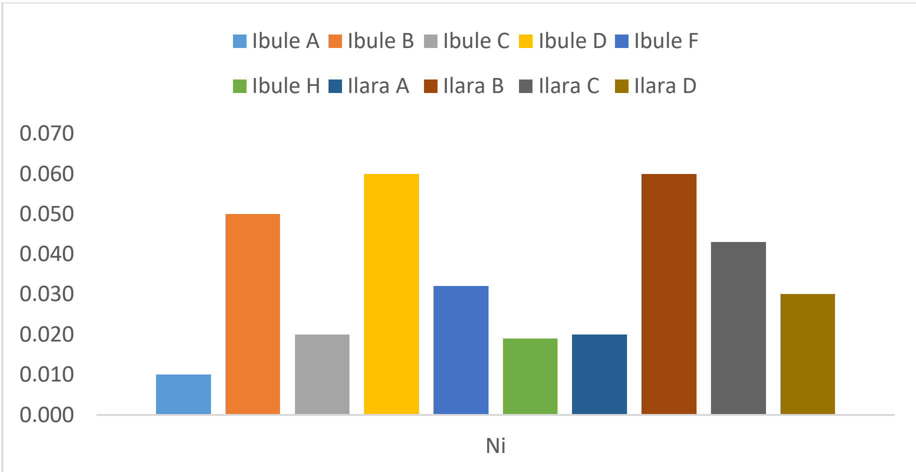

Figure 4. 27: Graphical Representation of the concentration of Iron (Fe) in the tested samples
Source: Author's Data Analysis

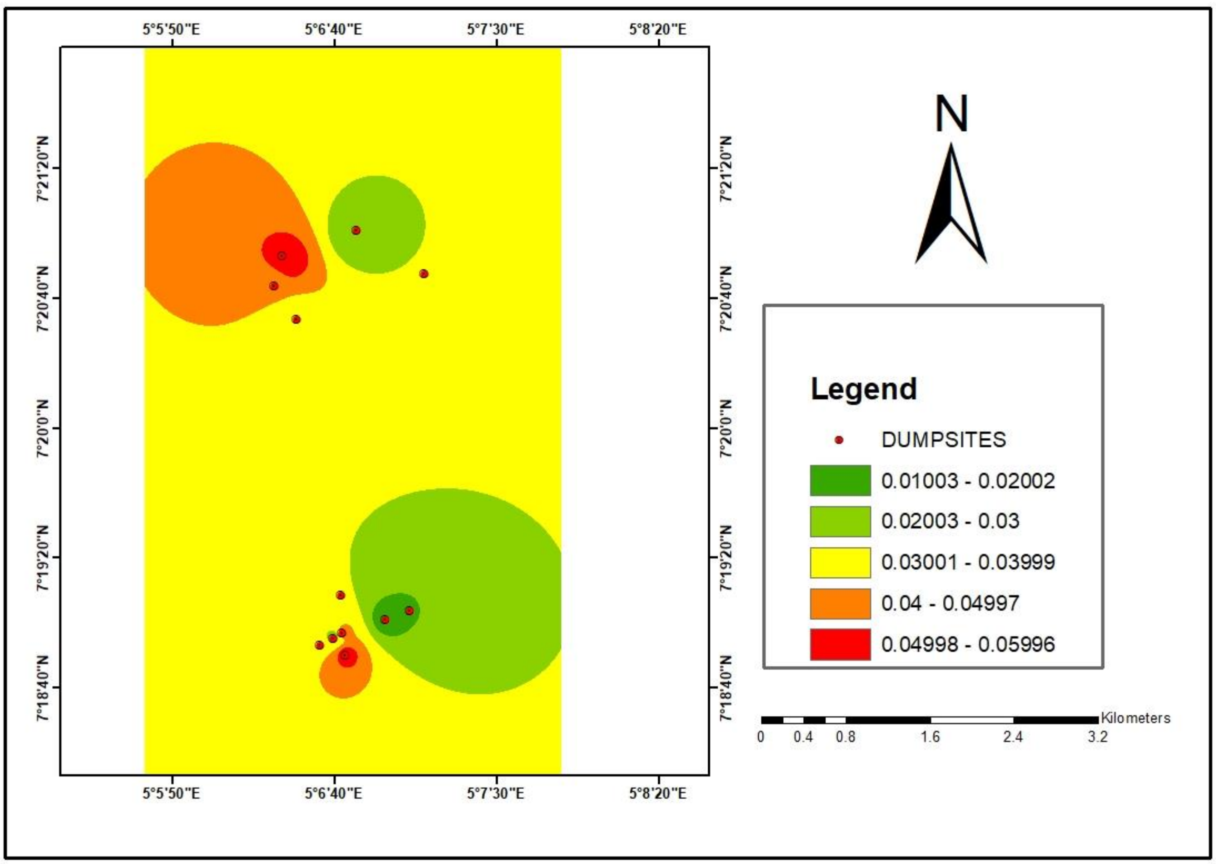

Figure 4. 28: inverse distance weighting (IDW) to forecast contamination levels in unsampled places for nickel

Source: Author's Data Analysis

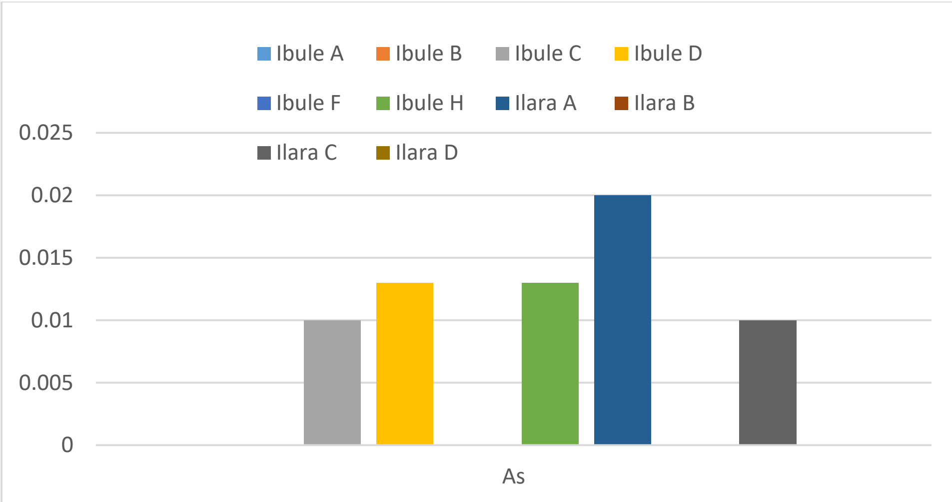

Figure 4. 29: Graphical Representation of the concentration of Iron (Fe) in the tested samples
Source: Author's Data Analysis

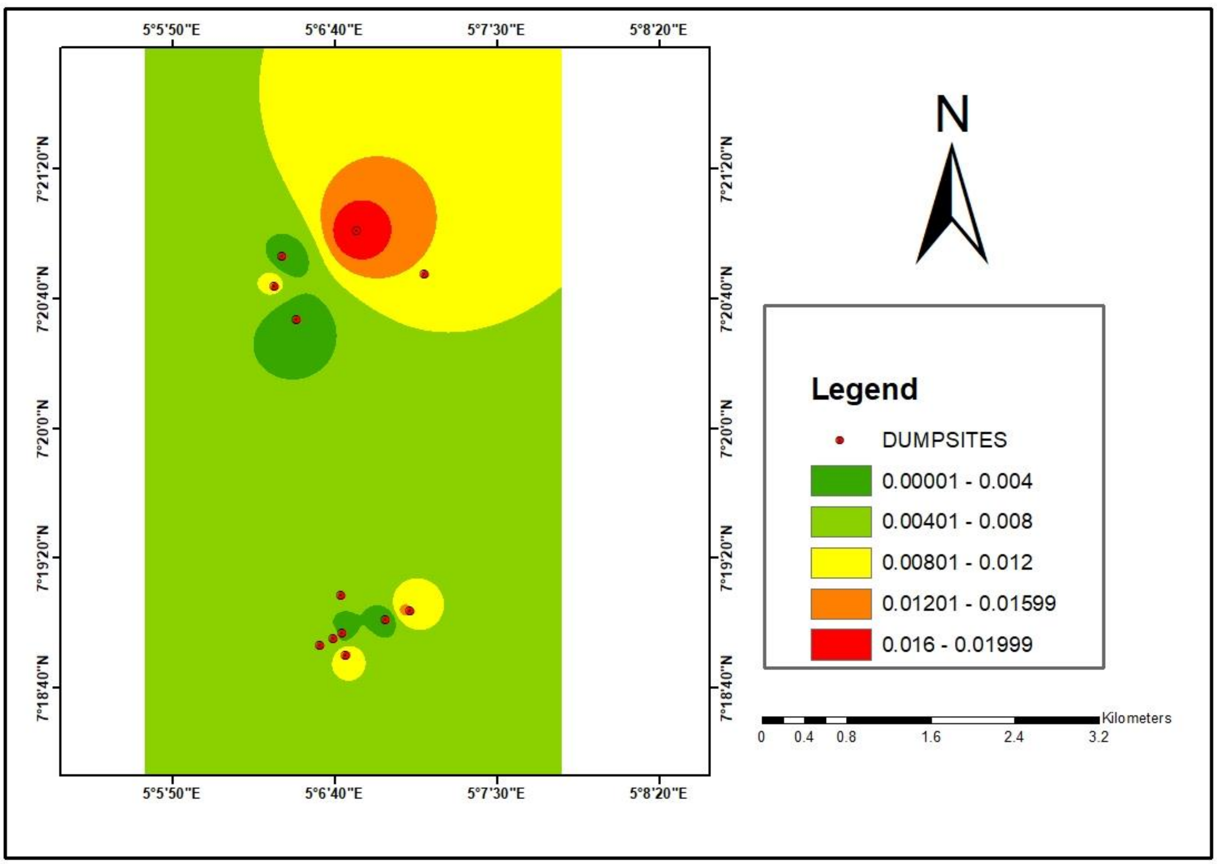

Figure 4. 30: inverse distance weighting (IDW) to forecast contamination levels in unsampled places for Arsenic

Source: Author's Data Analysis

4.4 CLASSIFICATION OF LAND USE/LAND COVER

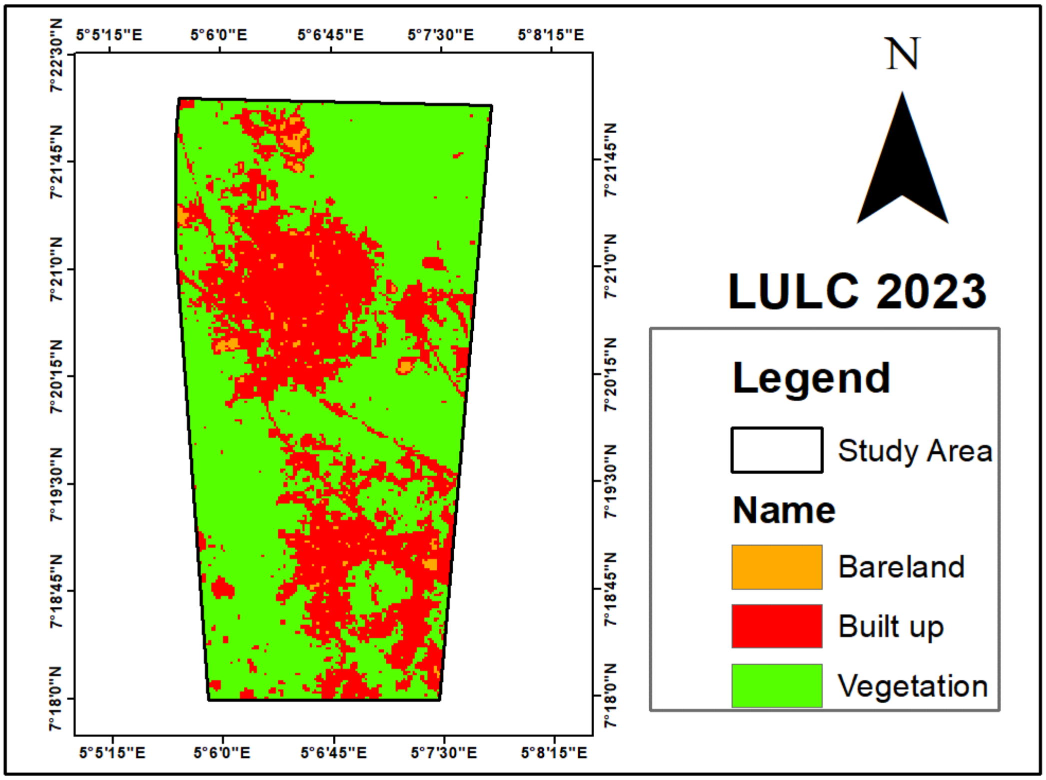

Figure 4. 31: LULC 2023 of Study Area

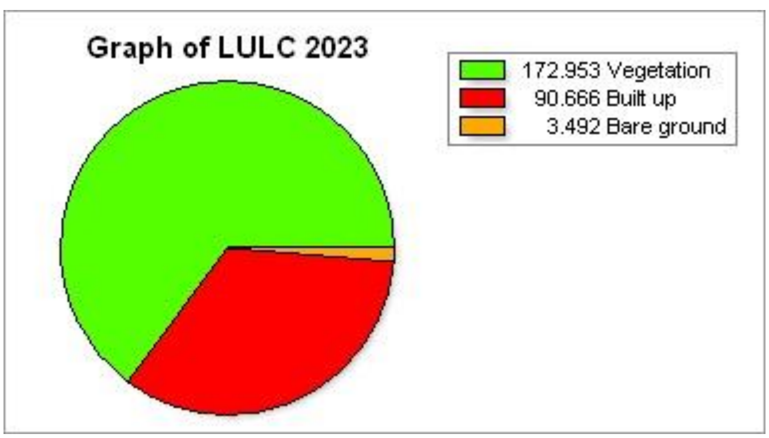

Figure 4. 32: PIE Chart of the classified features

Source: Author's Data Analysis

4.5 BUFFERING AND OVERLAY

The dumpsites in the study area were buffered at 100m 200m and 300m respectively in order to determine infrastructures that are at risk of dumpsites

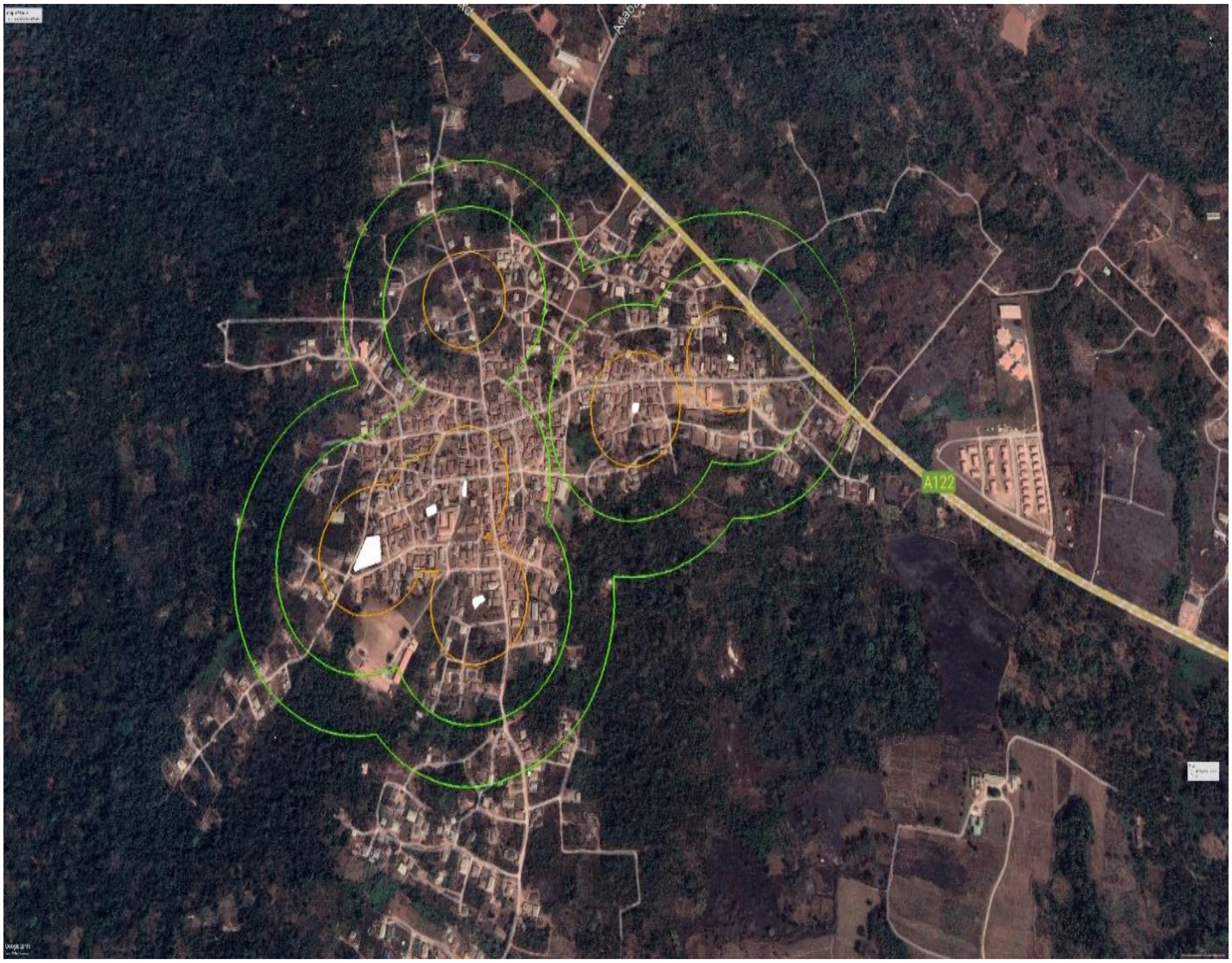

Figure 4.33: Satellite image of Ibule showing buffer around dumpsites

Source: Author’s Data Analysis

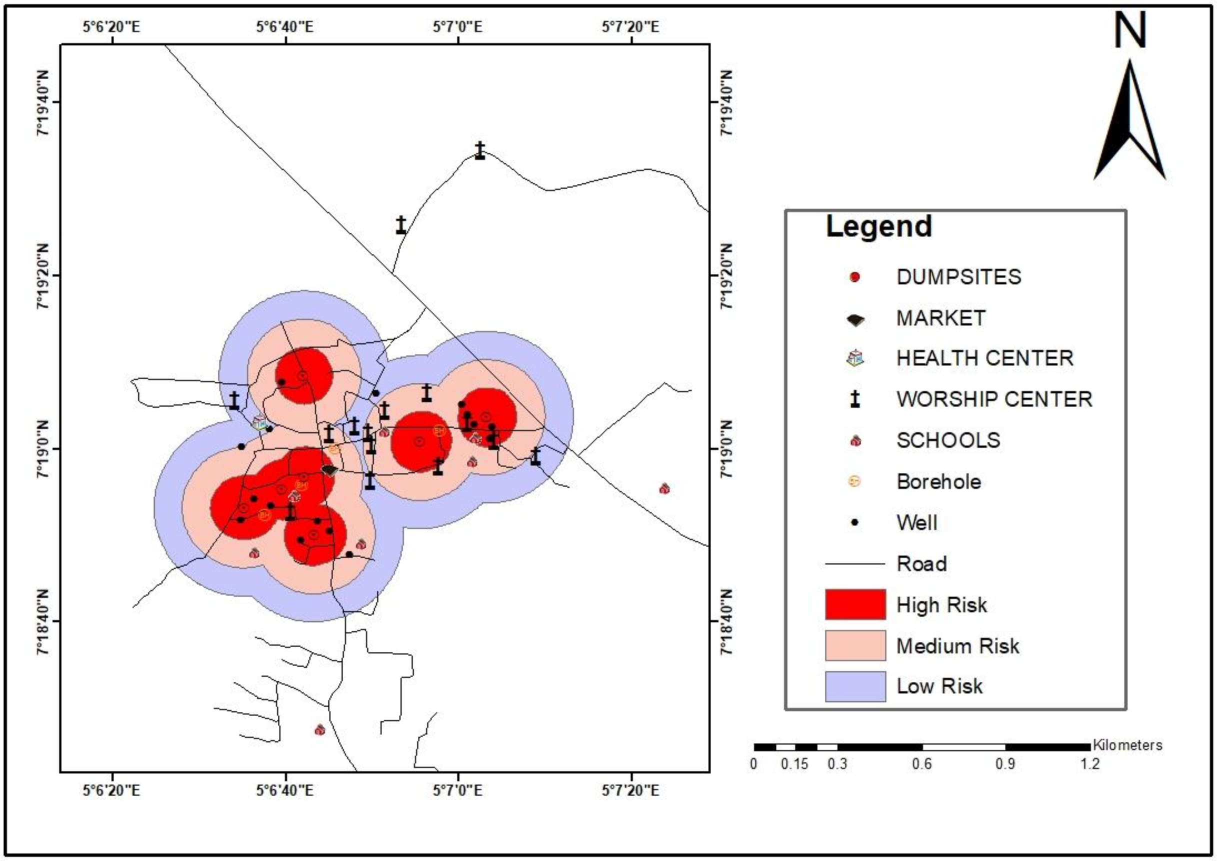

Figure 4. 33: Risk map of Ibule Dumpsites

Source: Author’s Data Analysis

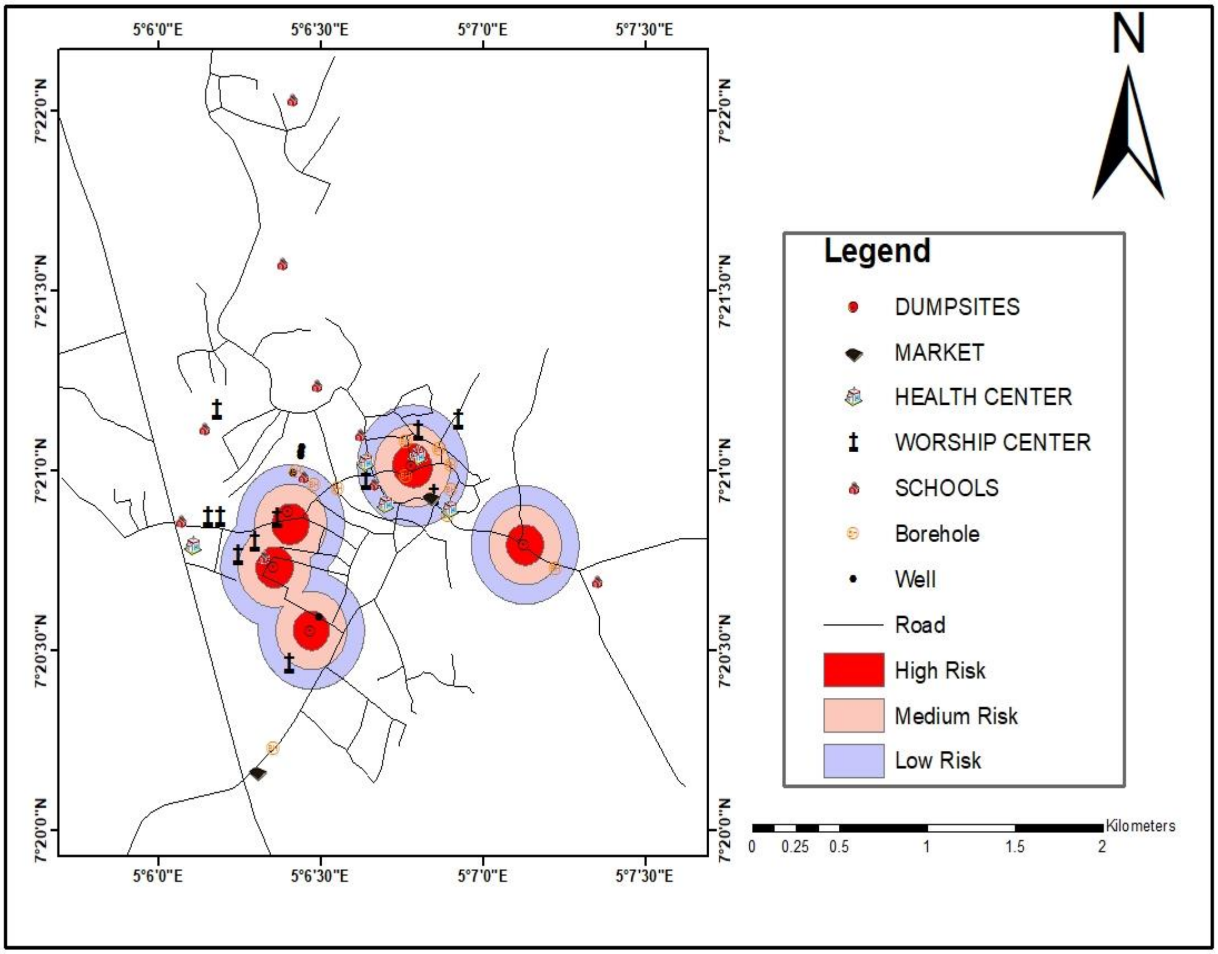

Figure 4.35: Risk map of Ilara Dumpsites

Source: Author's Data Analysis

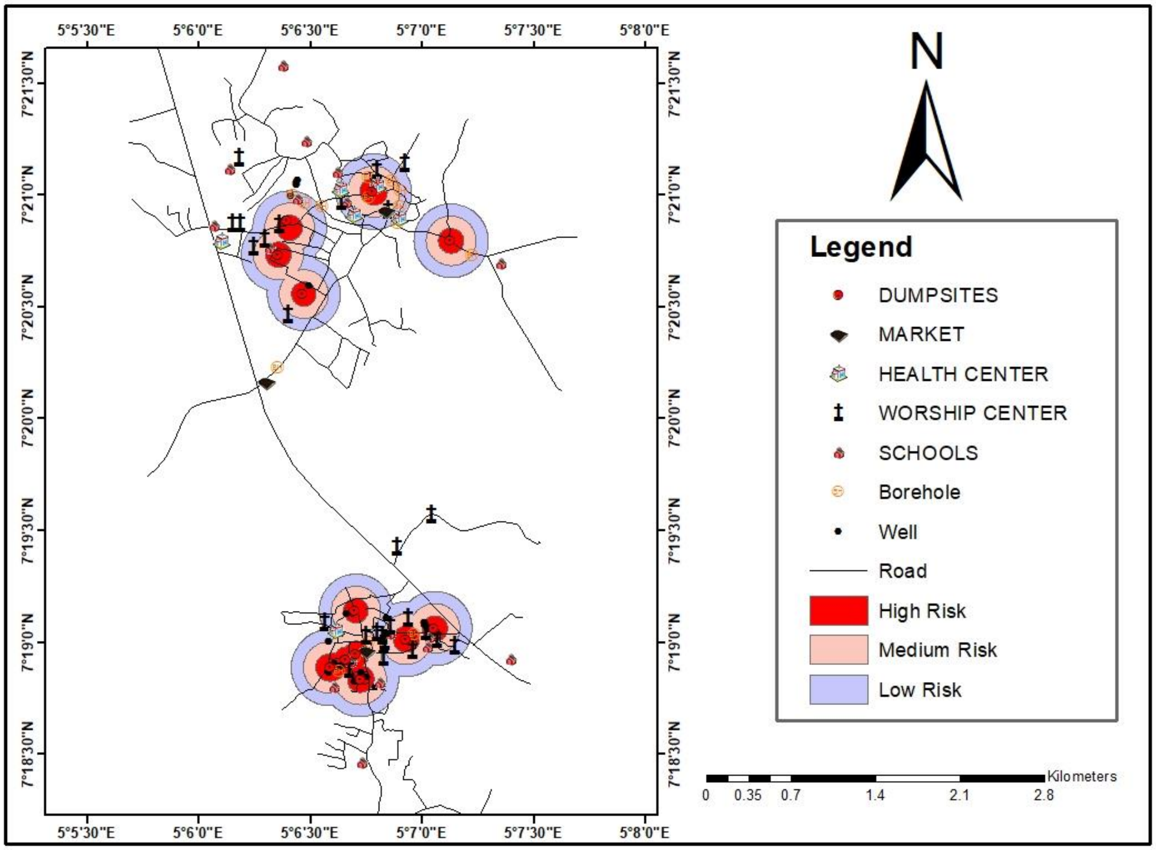

Figure 4.36: Risk Map of Study Area

Source: Author’s Data Analysis

4.6 SITE SUITABILITY ASSESSMENT OF SOLID WASTE DUMPSITES

4.6.1 The Euclidean distance

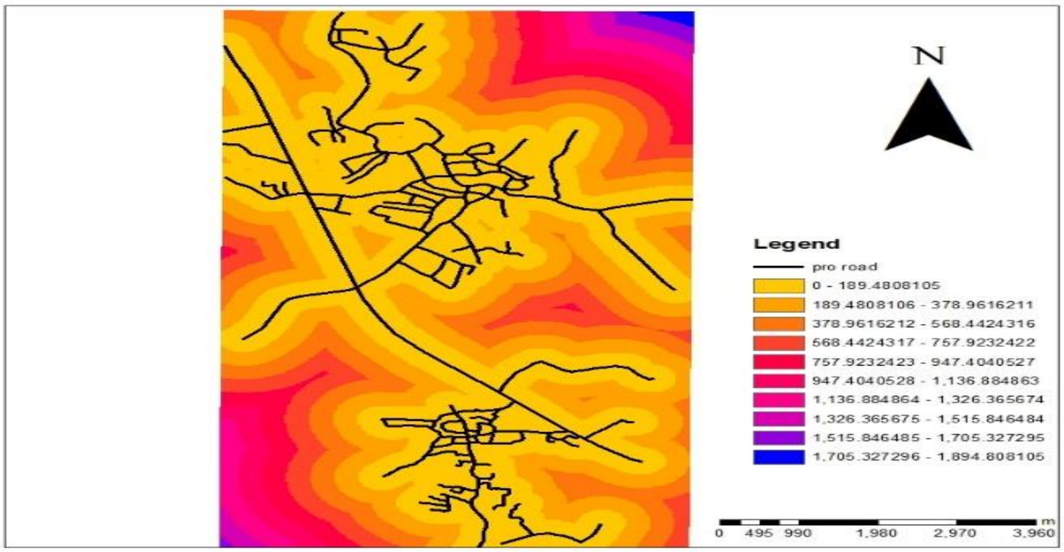

Figure 4. 34 : Euclidean Distance Analysis for Road Data Map Layer

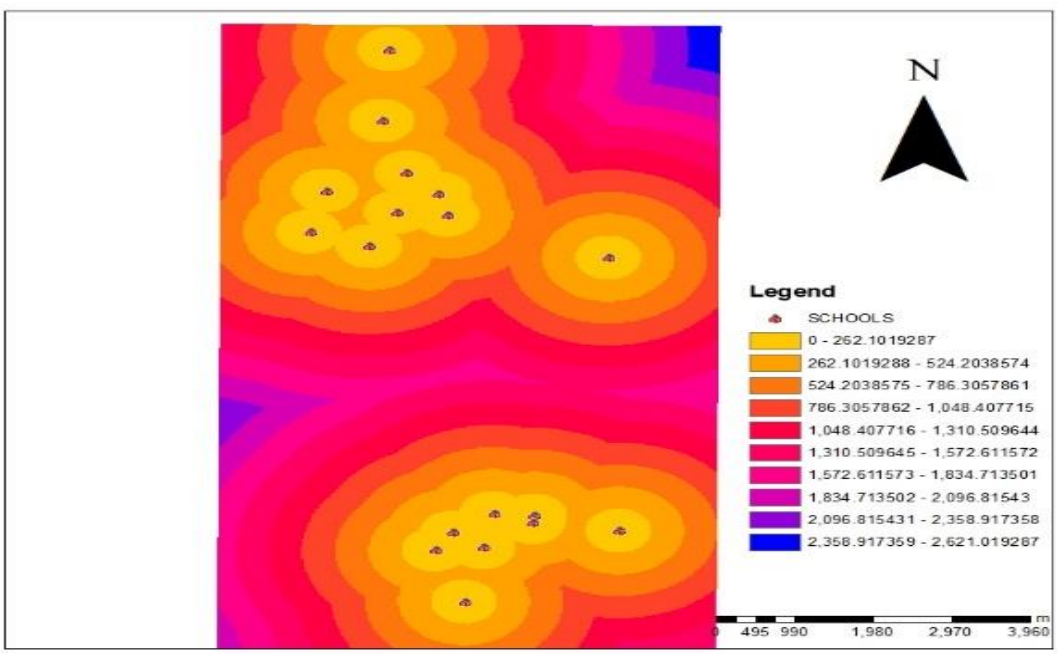

Figure 4. 35 : Euclidean Distance Analysis for Schools Data Map Layer

Source: Author’s Data Analysis

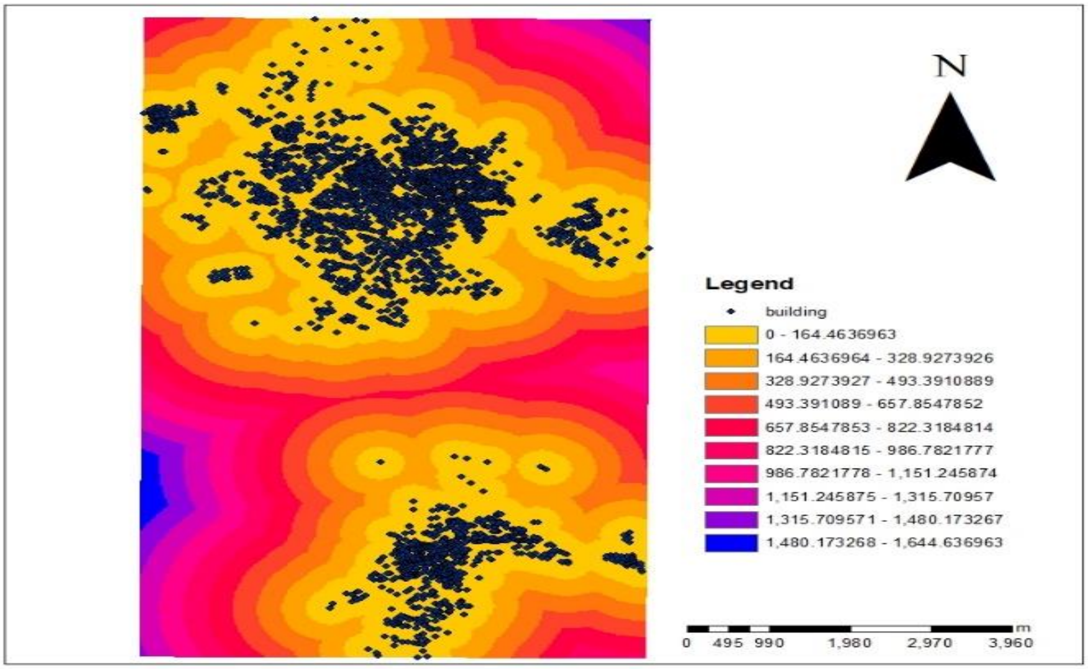

Figure 4. 36 : Euclidean Distance Analysis for buildings Data Map Layer

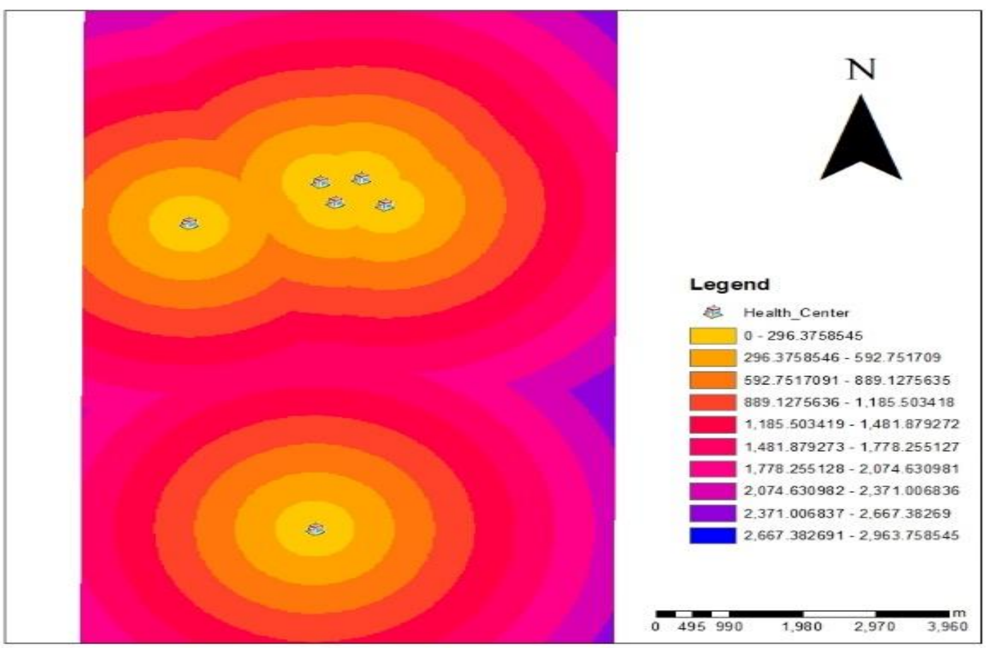

Figure 4. 37 : Euclidean Distance Analysis for Health center Data Map Layer

Source: Author’s Data Analysis

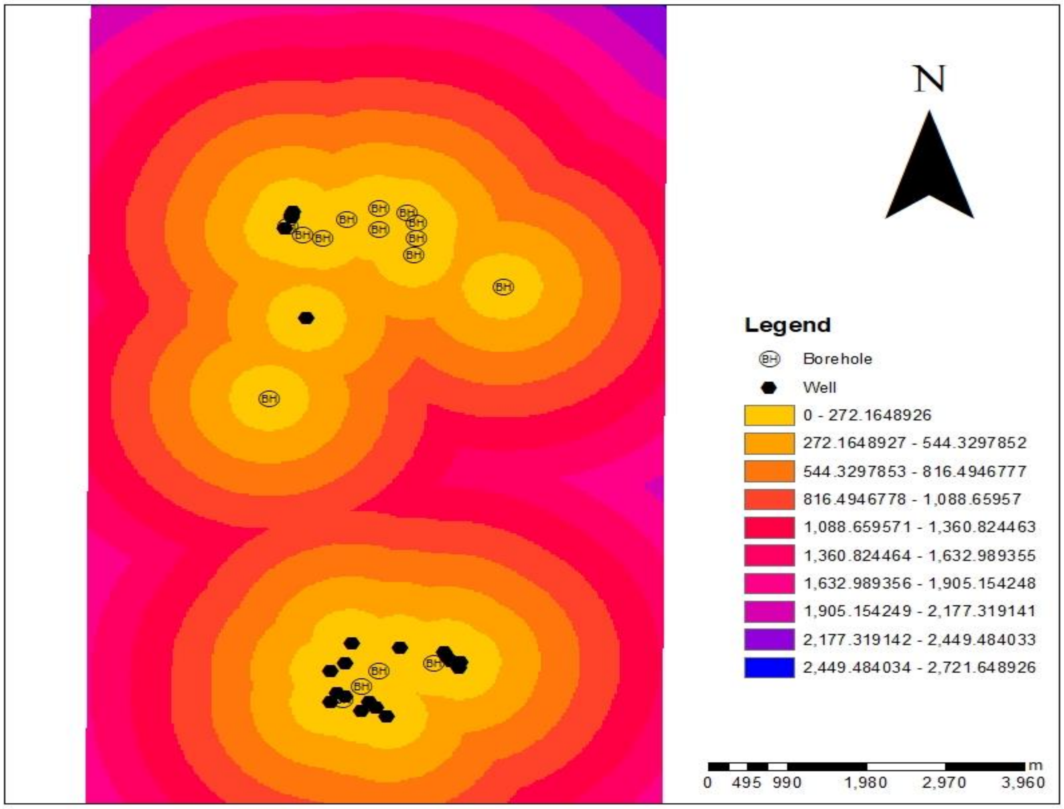

Figure 4. 38 : Euclidean Distance Analysis for Boreholes and wells Data Map Layer

Source: Author's Data Analysis

4.6.2 Reclassification Result

To create a ranked map of potential areas to site Solid waste dumpsite, i compared the values of classes between layers by assigning numeric values to classes within each map layer, it is called reclassifying.

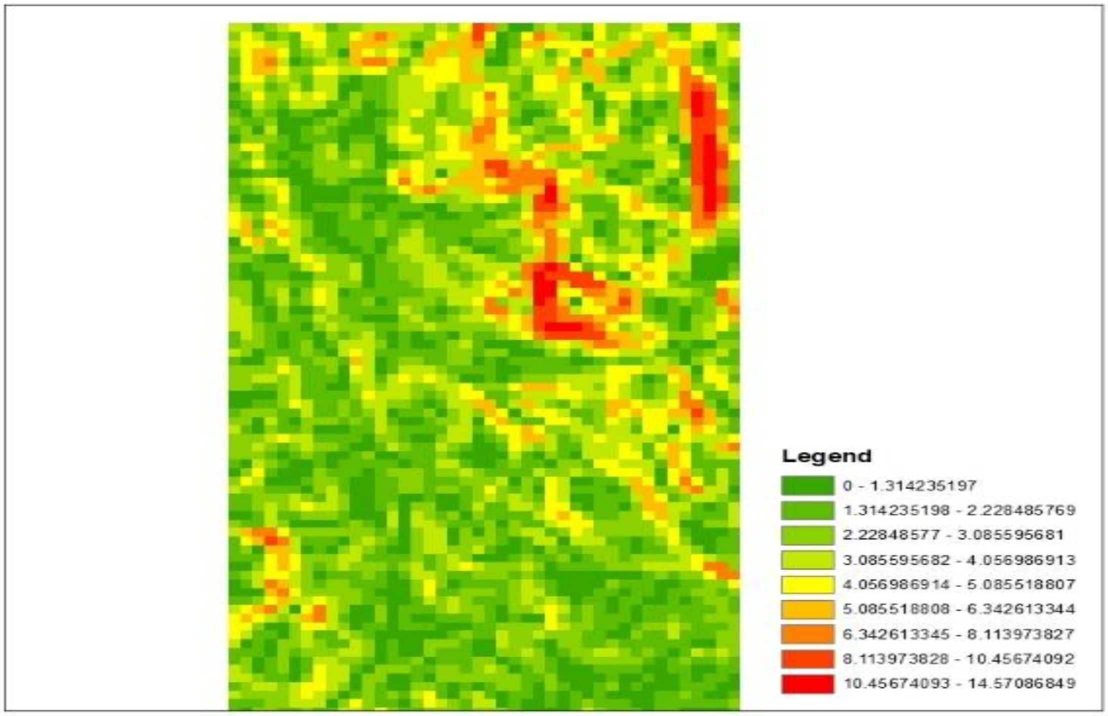

Figure 4. 39 Slope Map of the Study Area

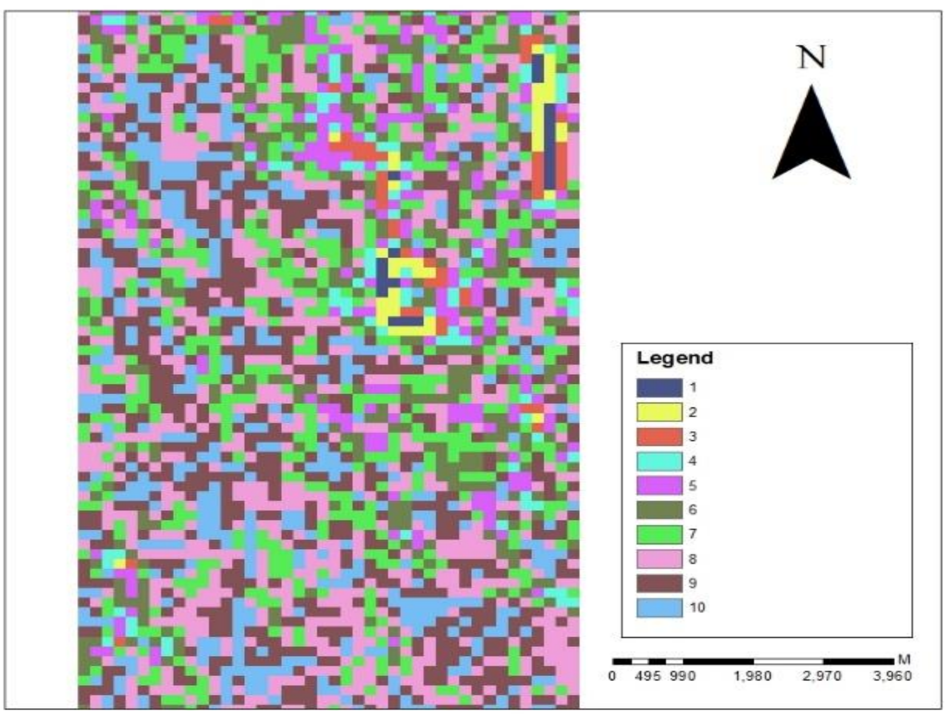

Figure 4. 40 reclassified Slope

Source: Author's Data Analysis

Figure 4. 41: Reclassified Road

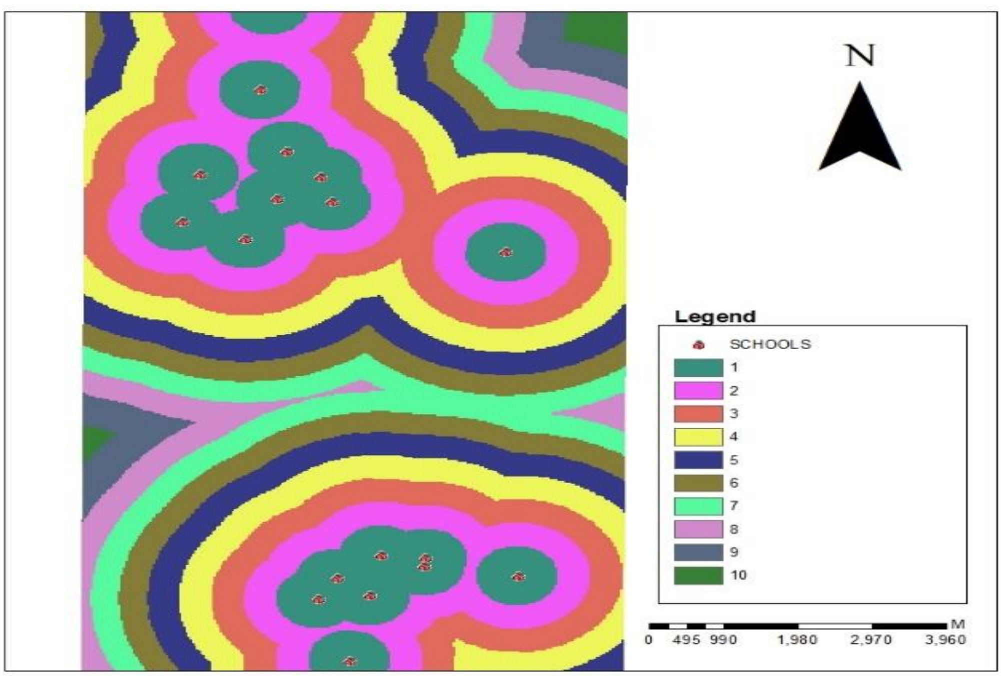

Figure 4. 42: Reclassified School

Source: Author’s Data Analysis

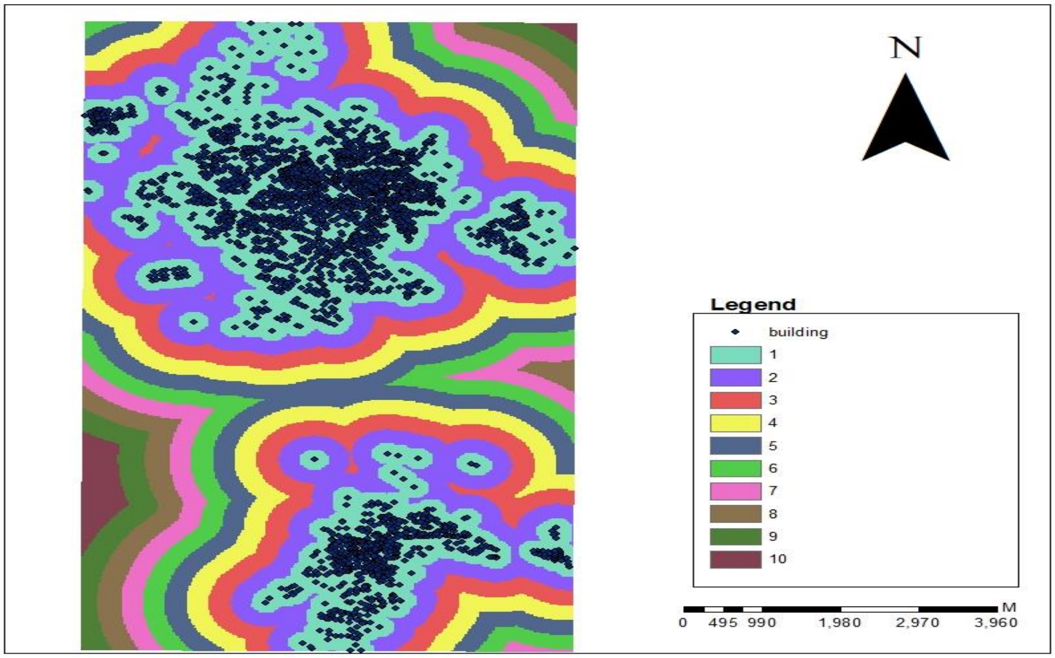

Figure 4. 43: Reclassified Building

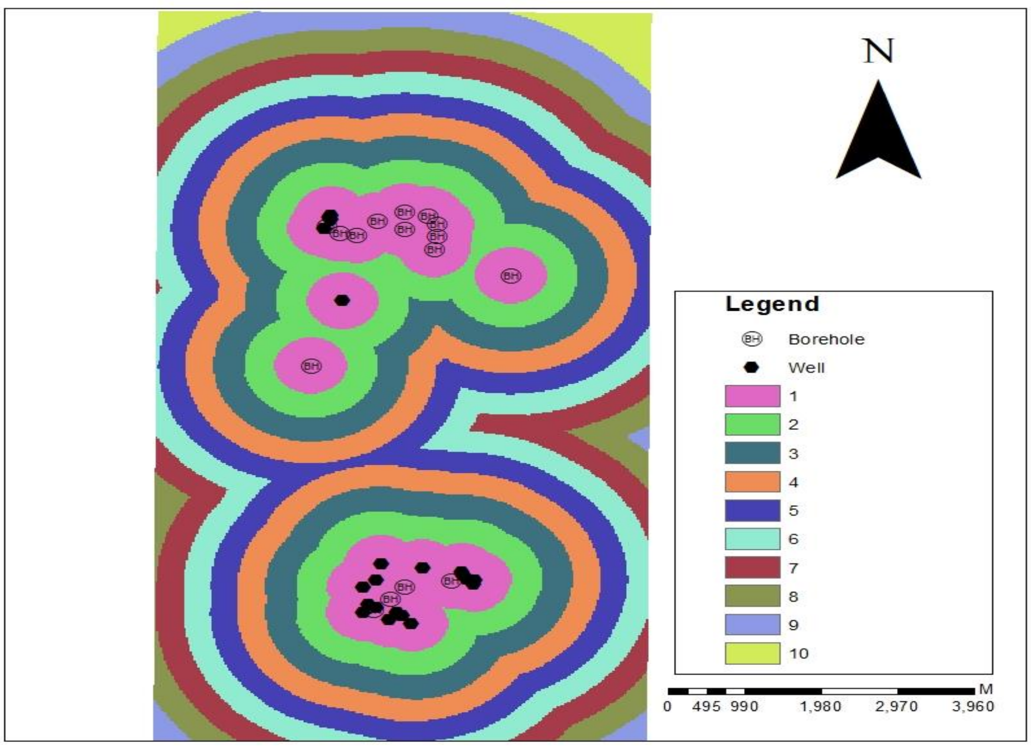

Figure 4. 44: Reclassified Wells and Boreholes

Source: Author's Data Analysis

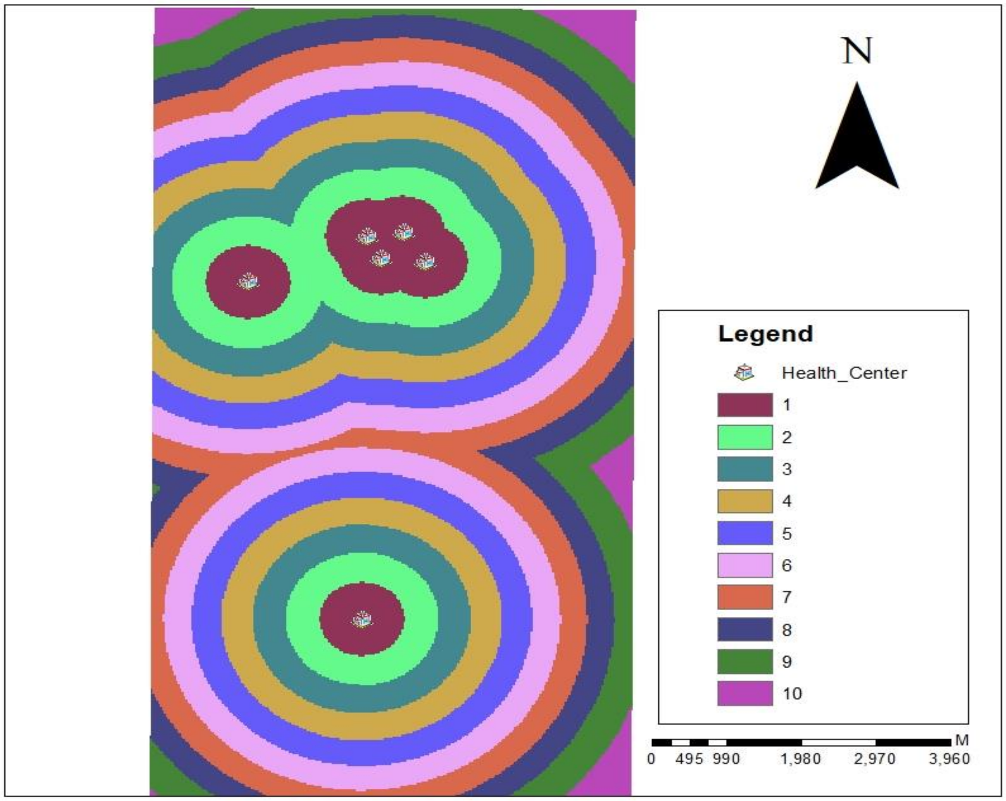

Figure 4. 45: Reclassified Health Center

Source: Author's Data Analysis

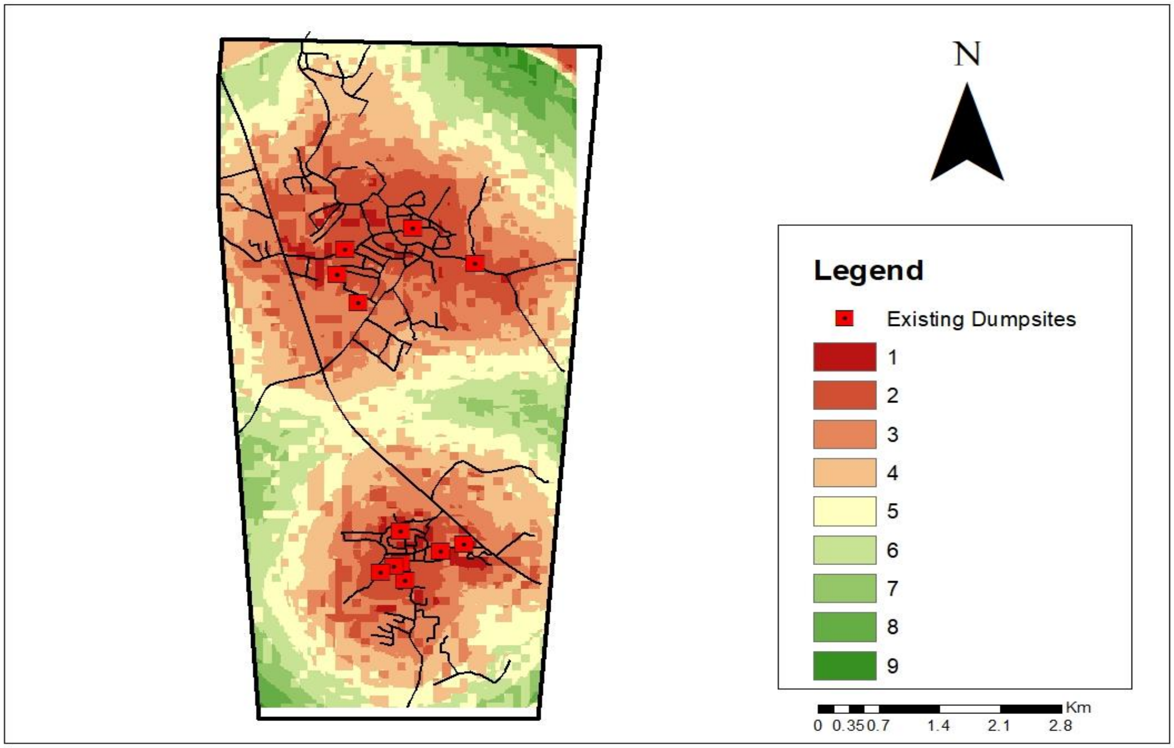

Figure 4. 46: Weighted overlay result showing existing dumpsites and road

Source: Author's Data Analysis

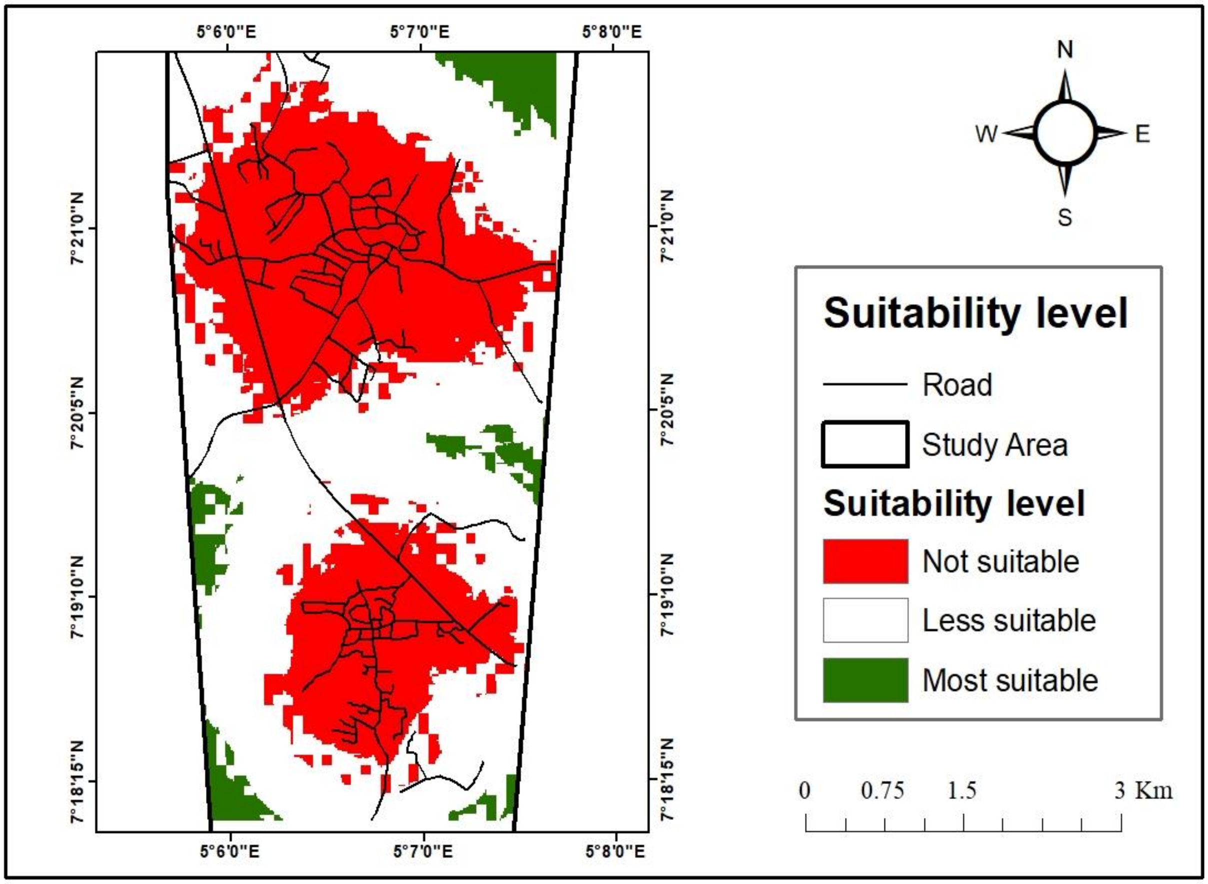

Figure 4. 47: Solid Waste Dumpsites Suitability Map

Source: Author's Data Analysis

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 DISCUSSION

5.1.1 Spectral Reflectance of the Soil

IBULE SAMPLE A: sample A exhibits a high reflectance of up to 0.65, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions. At wavelength of 50um there was an abrupt change due to the reflective property of the material.

Peaks at 0.65 which denotes High reflectance at 890um wavelengths, indicating strong reflection.

Valleys at 0.21 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.49 to 0.25 suggest rapid changes in reflectance, often due to material transitions or distinct features. Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

IBULE SAMPLE B: sample B exhibits a reflectance of up to 0.64, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions.

Peaks at 0.64 which denotes High reflectance at 890um wavelengths, indicating strong reflection.

Valleys at 0.22 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.46 to 0.23 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

IBULE SAMPLE C**:** sample C exhibits a high reflectance of up to 0.66, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions.

Peaks at 0.66 which denotes High reflectance at 880um wavelengths, indicating strong reflection.

Valleys at 0.21 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.47 to 0.21 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

IBULE SAMPLE D: sample D exhibits a reflectance of 0.63, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions.

Peaks at 0.63 which denotes High reflectance at 880um wavelengths, indicating strong reflection.

Valleys at 0.21 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.45 to 0.22 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

IBULE SAMPLE E: sample E exhibits a high reflectance of up to 0.66, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions.

Peaks at 0.66 which denotes High reflectance at 880um wavelengths, indicating strong reflection.

Valleys at 0.22 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.47 to 0.22 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

IBULE SAMPLE F**:** sample F exhibits a high reflectance of up to 0.66, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions.

Peaks at 0.66 which denotes High reflectance at 890um wavelengths, indicating strong reflection.

Valleys at 0.21 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.47 to 0.21 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

IBULE SAMPLE G: sample G exhibits a high reflectance of up to 0.63, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions.

Peaks at 0.61 which denotes High reflectance at 880um wavelengths, indicating strong reflection.

Valleys at 0.21 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.44 to 0.21 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

IBULE SAMPLE H: sample H exhibits a high reflectance of up to 0.62, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions. Surface texture also plays a role, with rough surfaces scattering light more and exhibiting lower overall reflectance.

Peaks at 0.62 which denotes High reflectance at 870um wavelengths, indicating strong reflection.

Valleys at 0.21 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.52 to 0.21 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

ILARA SAMPLE A: sample A exhibits a high reflectance of up to 0.63, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions. Surface texture also plays a role, with rough surfaces scattering light more and exhibiting lower overall reflectance.

Peaks at 0.63 which denotes High reflectance at 890um wavelengths, indicating strong reflection.

Valleys at 0.22 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.47 to 0.22 suggest rapid changes in reflectance, often due to material transitions or distinct features.

ILARA SAMPLE B: sample B exhibits a high reflectance of up to 0.63, spanning across a spectrum from visible to infrared wavelengths. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions. Surface texture also plays a role, with rough surfaces scattering light more and exhibiting lower overall reflectance.

Peaks at 0.63 which denotes High reflectance at 890um wavelengths, indicating strong reflection.

Valleys at 0.22 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.47 to 0.22 suggest rapid changes in reflectance, often due to material transitions or distinct features. Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

Anomalies and Changes: Sudden changes in reflectance values at 0.50 indicate environmental changes, disturbances, or the presence of specific features such as pollutants.

ILARA SAMPLE C: sample C exhibits a high reflectance of up to 0.63, spanning across a spectrum from visible to infrared wavelengths. Surface texture also plays a role, with rough surfaces scattering light more and exhibiting lower overall reflectance.

Peaks at 0.64 which denotes High reflectance at 890um wavelengths, indicating strong reflection.

Valleys at 0.23 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.47 to 0.23 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

Anomalies and Changes: Sudden changes in reflectance values at 0.50 indicate environmental changes, disturbances, or the presence of specific features such as pollutants.

ILARA SAMPLE D: sample D exhibits a high reflectance of up to 0.66, spanning across a spectrum from visible to infrared wavelengths. Surface texture also plays a role, with rough surfaces scattering light more and exhibiting lower overall reflectance. This characteristic observation not only provides valuable information about the type of material spectral properties but also contributes to our understanding of its potential health and environmental interactions

Peaks at 0.66 which denotes High reflectance at 890um wavelengths, indicating strong reflection.

Valleys at 0.22 which is a Low reflectance, signifying strong absorption

Slopes: Steep slopes from 0.47 to 0.22 suggest rapid changes in reflectance, often due to material transitions or distinct features.

Overall Shape: Smooth curves indicate homogenous materials, while jagged curves suggest mixtures or complex structures.

Anomalies and Changes: Sudden changes in reflectance values at 0.50 indicate environmental changes, disturbances, or the presence of specific features such as pollutants.

5.1.2 Concentration of Heavy Metals in Soil Samples

The concentration of the heavy metals in the soil samples collected from selected sites. The concentrations of the heavy metals (Cu, Co, Cr, Cd, Fe, Ni, Pb, AS) in the soil sample from the dumpsites were determined, and the degree of heavy metal pollution in the soils was assessed. The ranges of concentration (mg/kg) of heavy metals in the 10 studied areas are as follows.

1. **Copper (Cu):** The concentration of copper in the soil sample has the highest in the sample Ibule F (0.127mg/kg) and the lowest concentration in the sample Ilara A (0.112mg/kg). Comparing the results with W.H.O maximum allowable limit for copper in the soil, no sample collected at all location has value above the recommended level of 100 mg/kg This implies that the concentration of copper in all the locations are still permissible.

2. Iron (Fe): The concentration of iron in the soil sample has the highest in the sample Ilara B (0.120 mg/kg) and the lowest concentration in the sample Ibule C (0.086 mg/kg). Comparing the results with W.H.O maximum allowable limit for iron in the soil, no sample collected at all location has value above the recommended level of 50,000 mg/kg. This implies that the concentration of iron in all the locations are still permissible.

3. Cadmium (Cd): The concentration of cadmium in the soil sample has the highest in the sample Ibule H (0.04mg/kg) and the lowest concentration in the sample Ibule F (0.003mg/kg), Cadmium was detected from four sample out of ten. Comparing the results for cadmium with W.H.O maximum allowable limit for cadmium, all samples collected are below the limit of 3mg/kg. This implies that the concentration of cadmium in all the locations are still permissible.

4. Lead (Pb): The concentration of lead in the soil sample has the highest in the sample Ilara A (0.04mg/kg) and the lowest concentration in the sample Ibule F (0.02mg/kg), Cadmium was detected from four sample out of ten. Comparing the results with W.H.O maximum allowable limit for Lead in the soil, no sample collected at all location has value above the recommended level of 1000 mg/kg. This implies that the concentration of lead in all the locations are still permissible.

5. Cobalt (Co): The concentration of Cobalt in the soil sample has the highest in the sample Ibule F (0.36 mg/kg) and the lowest concentration in the sample Ibule B (0.02mg/kg), Cobalt was detected from six sample out of ten. . Comparing the results with W.H.O maximum allowable limit for cobalt in the soil, no sample collected at all location has value above the recommended level of 50 mg/kg. This implies that the concentration of cobalt in all the locations are still permissible.

6. Chromium (Cr): The concentration of chromium in the soil sample has the highest in the sample Ilara A (0.07mg/kg) and the lowest concentration in the sample Ibule C (0.027mg/kg), Chromium was detected from seven samples out of ten samples. Comparing the results with W.H.O maximum allowable limit for chromium in the soil, no sample collected at all location has value above the recommended level of 100 mg/kg. This implies that the concentration of chromium in all the locations are still permissible.

7. Nickel (Ni): The concentration of Nickel in the soil sample has the highest in the samples Ibule D and Ilara B (0.06mg/kg) and the lowest concentration in the sample Ibule A (0.01mg/kg), Nickel was detected from all the samples. Comparing the results with W.H.O maximum allowable limit for nickel in the soil, no sample collected at all location has value above the recommended level of 30 mg/kg. This implies that the concentration of nickel in all the locations are still permissible.

Arsenic (As): The concentration of arsenic in the soil sample has the highest in the sample Ilara A (0.02mg/kg) and the lowest concentration in the sample Ilara C (0.01mg/kg), arsenic was detected from five sample out of ten. Comparing the results with W.H.O maximum allowable limit for arsenic in the soil, no sample collected at all location has value above the recommended level of 20 mg/kg. This implies that the concentration of arsenic in all the locations are still permissible.

5.1.3 Land Use/Land Cover Classification

In year 2023, Vegetation covered the majority of the area (64.7%) followed by Built up and Bareland which covers 33.9% and 1.3% respectively.

5.1.4 Buffering

The dumpsites in the study area were buffered at 100m 200m and 300m respectively with the aim to determine infrastructures around the dumpsites that are at high risk.

The high, medium and low risks represent buffer of 100m, 200m and 300m respectively for the dumpsites in Ibule-soro, 7 dumpsites, 1 market, 1 health center, 14 churches, 1 mosque, 8 schools, 4 boreholes and 20 wells were geo-located around the dumpsites. The market is located around the 100m buffer zones indicating potential high risk of impact of the dumpsites, the health center is located within the buffer zone of 300m indicating low potential risks of impacts of the dumpsites, 3 worships center are located within the high risk buffer (100m), 6 churches within 200m buffer, 4 churches within the 300m buffer and 2 churches are located outside the buffer zone (safe zone). 2 schools are located within the 100m buffer, 4 schools within the 200m buffer and 2 schools are located outside the buffer zones. For boreholes and wells, 3 boreholes and 12 wells sited within 100m buffer indicating high risk of potential impact of the dumpsites. The remaining borehole is found within the 200m buffer.

From the above map, high, medium and low risks represent buffer of 100, 200 and 300meters respectively for the dumpsites in Ilara-mokin, five dumpsites, 2 market, 5 health center, 9 churches, 2 mosque, 10 schools, 12 boreholes and 5 wells sited around the dumpsites. 1 market is located within the 200m buffer zones indicating potential mid risk of impacts of the dumpsites and the other market is located outside the buffer zone, 1 health center is located within the high risk zone, 3 health center are located within the buffer zone of 300m indicating low potential risks of the dumpsites and one of the health center is located outside the buffer zones. One of the worships center is found within the high risk buffer (100m), 5 within 200m buffer, 2 churches within the 300m buffer and 4 churches are found outside the buffer zone (safe zone). 1 school is discovered within the 100m buffer, 2 within the 300 buffer and 7 are discovered outside the buffer zones. For boreholes and wells, 1 boreholes and 1 wells were found within 100m buffer indicating high risk of potential impact of the dumpsites. 2 boreholes within the 200m buffer zone, 7 boreholes within 300m buffer and 2 boreholes are discovered outside buffer indicating safe zone.

5.1.5 Site suitability Assessment of Solid Waste Dumpsites

5.1.5.1 The Euclidean distance

Figure 4.37, 4.38, 4.39, 4.40 and 4.41 shows the result of Euclidean distance. The Euclidean distance output raster contains the measured distance from every cell to the nearest source.

5.1.5.2 Reclassification Result

To create a ranked map of potential areas to site Solid waste dumpsite, i compared the values of classes between layers by assigning numeric values to classes within each map layer, it is called reclassifying. The scores of '10 to 1' are used to identify the differences among areas of suitability. The slope dataset is reclassified at a score of 1 to 10 in order of priority (i.e. the lesser the slope the more suitable the area) so the scaling was reversed, while building, road, health center, school, wells and borehole were reclassified at a score of 10 to 1 (i.e. the farther the feature the more suitable the area).

a. Reclassification of distance from residential areas, boreholes, schools and health centers at a range of 1 (the least suitable) to 10 (the most suitable).

b. Reclassification of distance for road at a range of 1 (the least suitable) to 10 (the most suitable). This ranking is based on the criterion which addresses required distance from road.

c. Reclassification of degree of slope of the terrain at a range of 1 to 10. 1 (the least suitable) to 10 (the most suitable). This ranking is based on the criterion which addresses the degree of slope suitable for the location of a dumpsite. The plainer the better.

5.1.5.3 Weighted Overlay Result

The final suitability map for locating dumpsites is seen in figure six raster layers are ranked for development suitability on a scale of 1 to 10. And the weighted overlay results are further reclassified to a scale of 1 to 3. The result shows that the red portion of the map is not suitable and the green area is highly suitable.

5.2 CONCLUSION

The use of GIS technology in dumpsite impact mapping of Ibule-soro and Ilara-mokin has proven that this study has provided an insight into the prevalence of dumpsites and its impact assessment in ibule and ilara mokin.

- Generally, the spectral reflectance of the soil from the 10 sampling points with peaks around (0.62- 0.66) reflectance. Sample Ilara D shows a distinctly higher peak reflectance at 0.66, implying it has different properties than other Ilara Samples (A, B and C). Sample Ibule H has the lowest peak at 0.62 reflectance, likely indicating a material difference or particle size variation

- The assessment of heavy metals contamination (Cu, Co, Cd, Cr, Mn, Ni, Fe, Pb and As) in the soils from selected dumpsites in Ibule-soro and Ilara-mokin, the concentration of these metals in the soil is profiled according to W.H.O maximum allowable limit in soil for heavy metals and the results show that the concentrations of these heavy metals at the dumpsites were below the W.H.O maximum allowable limit for heavy metal in soil, the overall soil quality appears fair, though risks can persist even at low contaminant levels. Ongoing monitoring is recommended.

- The overall buffer analysis shows that dumpsites near infrastructure provide serious risks due to contamination, disease vectors, and other exposure pathways. It identified and visualized the potential spatial impact zones from waste dumpsites, highlighting the level of community exposure, this research helped to identify schools, boreholes, and wells, place of worships and health centers that would be more vulnerable to the negative environmental effects of dumpsites. This analysis highlighted that many of these infrastructures are within risky proximity to dumpsites.

- The Suitability analysis results shows suitable area for Dumpsites in the study area, by the use of Geoinformation technique realizing that sitting of Solid waste Dumpsites is a big issue in Ibule and Ilara. This project describes the methodology and was a case study for identifying the best area suitable for dumpsites. Specifically, this project shows Spatial

Modeling Analysis to build the area suitable for sitting dumpsite using multi-criteria analysis within the GIS environment. The considered criteria include distance from schools, distance from boreholes, distance from health centers, distance from major roads, residential areas and the slope.

5.3 RECOMMENDATION

- Encourage community participation in sustainable waste management solutions by educating them about best practices for dumpsites.
- Create buffer zones around dumpsites where access or certain development are prohibited. Typically, buffers of at least 300 m are recommended.
- Within the high risk buffer zone, contaminated soil and water can be improved by using phytoremediation techniques, using specific plant species to absorb pollutants.
- Implement proper siting and containment techniques when establishing new dumpsites to mitigate risks. Locate away from dense populations, water bodies, and other sensitive areas. Construct appropriate liners, berms, and leachate capture systems.
- Having identified the area best for sitting dumpsites, in their levels of suitability using a Suitability Analysis Model Builder, it is recommended that the Environmental Department of the Local Government Areas within the study area and the Town Planning Authority have the site suitability analysis model in their finger-tips so that it will serve as a guide before a site can be approved for dumpsite, since it has taken care of all the criteria as regards suitable locations for dumpsite in its analysis. A step can still be taken further to incorporating within the model a procedure to enable identification of optimum site for locating a Solid waste dumpsite.

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