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Spatial Characteristics of Heavy Metal Pollution and Potential Environmental Risk Assessment of Urban Soils around Cemeteries in Benin City, Nigeria

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Abstract

The study's objective was to ascertain whether burial customs in a working cemetery had an effect on the soil nearby. A total of twenty-four randomly selected sampling points were chosen from the three cemeteries, with eight from each cemetery location. The city center, equidistant from each of the three cemeteries served as the location for the control sample. Using a SKYRAY EDXRF type EDX3600B, the samples were digested, and their elemental composition was analyzed. Risk assessment models, such as the contamination factor and pollution load index were employed to estimate the degree of soil deterioration caused by heavy metal pollution. Nine out of the twenty-seven metals were found to have reasonable levels of concentration from the elemental composition study. In addition, a computed PLI value of less than 1 was employed to validate the result of the contamination factor (CF), and support the findings that the level of metal pollution around the cemeteries is minimal.

1. Introduction

Cemetery activities in urban areas undoubtedly present a significant threat to both the ecological balance and the general well-being of the human population [1, 2, 3]. The potential negative impact of the funeral business on the environment has become a cause for concern within the international community. The conventional burial process releases ions into the soil and water, manifesting as heavy metals, bacteria, fungi, and viruses. Simultaneously, cremation generates small particles, trace gases like sulphur dioxide, and hazardous organic volatiles. Both processes can produce effluents that pose an imminent threat to the environment and human health in general [4, 5, 6]. In burial locations lacking a system for capturing and treating necroleachate, toxic effluents containing organic materials and inorganic components resulting from the decomposition of bodies can infiltrate into the underlying aquifer, becoming a significant source of pollution for both humans and the environment [7].

In many third-world countries, such as Nigeria, public cemeteries are often inadequately managed, potentially serving as sources of soil and groundwater pollution, especially when constructed on highly porous and permeable soils underlain by a saturated geological zone of lower thickness. This can lead to the infiltration and percolation of decomposed toxic products. Several researchers have attested to the poor management of cemeteries in Nigeria. For instance, [8] conducted a study

on Atan Cemetery in Lagos and noted that the graves were overgrown with weeds, serving as grazing grounds for sheep and goats. This finding was supported by [9], who described Atan and Matori cemeteries in Lagos as eyesores, emphasizing the decrepit state of public cemeteries in the city. The study concluded that this state of neglect reflects a lack of value for history, disregard for culture, a lack of knowledge about the importance of preservation, and a lack of respect for the departed souls. Another study by [10] on the European Cemetery in Lokoja observed that it was overgrown with dry elephant grass, weeds, shrubs, and climbers, with residents using it as a site for refuse dumping. [11] Focused on public cemeteries in Rivers State, Nigeria, highlighting challenges related to space, access, and location. The study noted poor management, aging facilities, and instances of graves being unknowingly reused due to overstretched capacities.

Cemeteries are recognized as potential sources of soil and groundwater contamination [12, 13, 14, 15]. The high precipitation rates typical of Nigeria's coastal region, coupled with apparent neglect of graves, contribute to the accelerated spread of necroleachate in and around cemetery locations [16, 10]. The movement of harmful substances like necroleachate in the ground depends on factors such as the number of times bodies have been buried, the depth of underground water, the soil's permeability, including the type of clay minerals and their capacity to exchange particles [17]. Necroleachate from human decomposition are significant sources of toxic heavy metals, posing serious threats to both human health and the environment [18, 19, 20, 21, 22]. High concentrations of heavy metals in soil, whether in ionic or organometallic form, can be harmful to both human and animal health [23]. For example, long-term exposure to cadmium through soil intake can lead to various health issues, including prostatic proliferative lesions, hypertension, bone fractures, pulmonary adenocarcinomas, kidney dysfunction, and lung cancer [24]. Long-term exposure to mercury has been linked to damage to the heart, kidneys, digestive system, and central and autonomic nervous systems [25, 26].

Heavy metal pollution of soil and water remains a significant environmental issue, only second to air pollution [27, 28, 29, 30, 31, 32]. Unlike organic contaminants, heavy metals do not break down into inert byproducts, and their presence in the environment leads to bioaccumulation in living organisms, causing various health challenges [33, 34, 35, 36, 37]. Even essential heavy metals required by the human body in trace amounts, such as manganese, zinc, and iron, can be detrimental to health when present in excess, underscoring the importance of protecting the environment from heavy metal pollution [38, 39, 40, 41]. The deposition of heavy metals resulting from anthropogenic activities such as cemetery operations, poses a severe threat to the environment and human existence, attracting significant attention within research communities [42, 33]. Various processes, including biological, chemical, and physical interactions, contribute to the movement of heavy metals in soil, making polluted soils sources of dispersion of heavy metals in the environment, potentially entering the food chain and web [43, 44]. The persistent and non-degradable nature of heavy metals in soil poses long-term risks to public health and the environment [45, 46].

Most previous studies have focused specifically on the administration and management of cemetery [47, 48, 49, 18, 16] without adequately considering the environmental implications of burial activities. In this study, a comprehensive assessment of heavy metal pollution in the soil around cemeteries in Benin City was conducted with the aim of providing precise and adequate information on the negative impact of necroleachate emanating from burial activities on the environment. The adoption of selected pollution indices such as contamination factors (CF), pollution load indices (PLI) etc in assessing the degree of soil deterioration due to heavy metal pollution further attest to the relevance of this study.

2. Materials and Methods

2.1. Research Design

The research design provides a simplified detail of the methodology employed in sample collection, sample preparation, method of sample analysis, data generation and the procedure for data analysis.

2.2. Description of Study Area

Benin City, the capital of Edo State, serves as the focal point for this research. Positioned as a nodal town, it stands as one of the largest cities in Nigeria. Situated between latitude 6°20′17″ N and longitude 5°37′32″ E, the city resides in the southern part of the country, boasting an elevation of 88 meters above sea level. The climatic conditions in Benin City are characterized by two distinct seasons: the wet season, spanning from March to October, and the dry season, lasting from October to March. As of the 2006 national census, the city was home to a population of 1.15 million individuals. Predominantly inhabited by the Bini-speaking people of Edo ethnic nationality, the city projects a population of 5.5 million by the year 2050, based on the National Population Commission's growth rate of 3.5% per annum for urban centers. Within the city, three primary public cemeteries are present: the 1st Cemetery, 2nd Cemetery, and 3rd Cemetery. The 1st and 3rd Cemeteries are situated in the Ikpoba-Okha local government area, while the 2nd Cemetery is located in the Oredo local government area. Figure 1 provides a 3D-study area map depicting the spatial arrangement of these cemeteries.

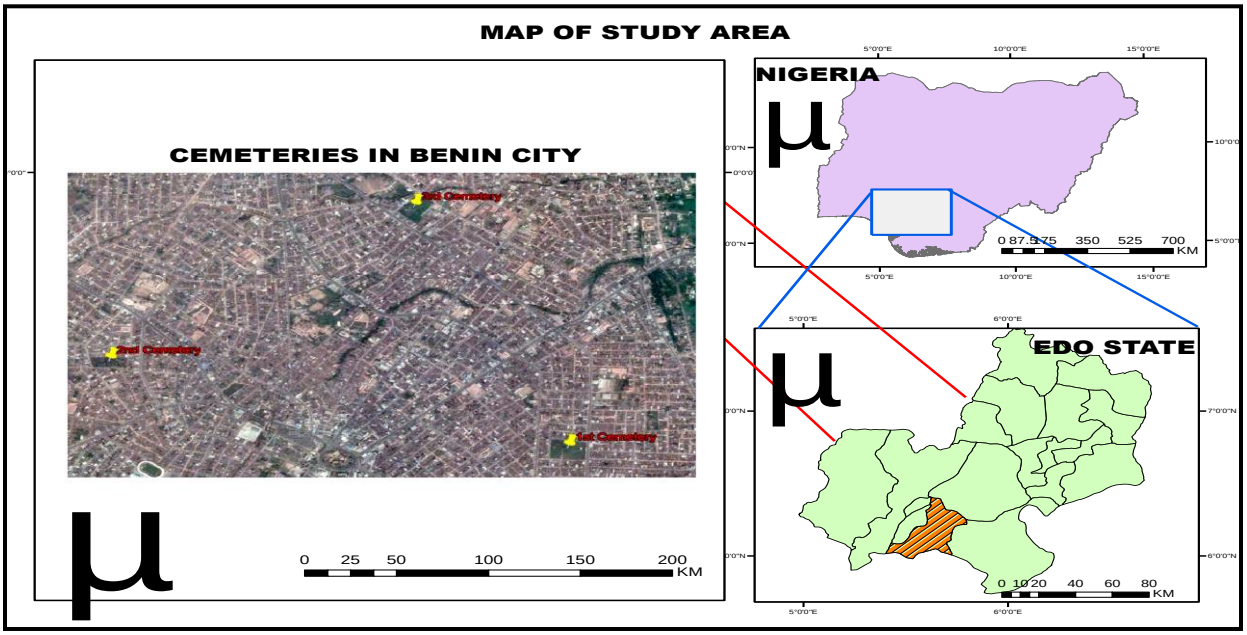

Figure 1: Study area map showing the three cemeteries

2.3. Geology of the Study Area

The Benin formation is underlain by sedimentary features of the South Sedimentary Basin [50] and extends from the west across the whole of the Niger Delta area and southward beyond the present coastline. The Benin formation contains mainly of over 90% sandstone that is blended with shale. The geology of Benin formation is mainly characterized by top reddish earth which is composed of literalized clay sand [51, 52]. In addition to the top reddish earth, there is also the

presence of fine to coarse grains that is poorly sorted to a well-rounded lignite streak combined with wood fragment.

2.4. Sample Collection/Preparation/Analysis

Soil sampling was conducted randomly at eight (8) georeferenced points from each cemetery location, resulting in a total of twenty-four (24) samples from the three cemeteries. The control sample was obtained from the city center, equidistant from the three cemeteries under study. The sampling process involved collecting soil samples from the topsoil down to a depth of 15 cm, utilizing a stainless-steel auger. Following the methodology outlined by [53], a representative soil sample from each location was acquired using the quartering technique. In this technique, three samples obtained from a specific location were thoroughly mixed to create a composite sample. Subsequently, the composite sample was divided into four equal portions, and one-quarter of it was further subdivided into four different portions to obtain the representative sample. These representative soil samples were then air-dried for 24-36 hours, crushed in a mortar with a pestle, and sieved through a 2mm mesh standard sieve to eliminate large debris and achieve a uniform particle size. The sieved soil samples were carefully stored in polythene bags, preserving them for subsequent analysis. Employing the wet digestion technique, 1:1 mixture of nitric acid and sulphuric acid was used as the extraction liquid. In this method, one gram (1g) of the dried homogenized representative sample was mixed with 10mL of the extraction solution in a 50mL conical flask. The mixture was heated at a temperature of 95-100^{0}C and then refluxed for 15 minutes without boiling. The content was allowed to cool in a desiccator and thereafter 5mL of concentrated nitric acid was added and again the content was refluxed for 35minutes until the emission of fumes with brownish colouration was observed. Finally, the content was filtered using Whatman N0, 42 filter paper and the filtrate was analyzed using SKYRAY EDXRF model EDX3600B. X-ray fluorescence spectrometer applies the XRF technology for the analysis of complex composition. The wet digestion technique was chosen for sample preparation in X-ray fluorescence (XRF) analysis due to its several advantages over alternative methods. Firstly, wet digestion offers a versatile and widely applicable approach for the preparation of solid samples across various sample types, including soils, sediments, rocks, minerals, metals, and environmental samples. Its ability to dissolve a wide range of sample matrices makes it suitable for the extraction and quantification of both trace elements and major components present in the sample. Additionally, wet digestion facilitates the efficient release of analyte elements into solution, ensuring high extraction efficiency and accuracy in subsequent elemental analysis. Moreover, the digestion process can be tailored by selecting specific acids or acid mixtures depending on the nature of the sample and the elements of interest, allowing for customization to meet the analytical requirements of different sample matrices. Furthermore, wet digestion is a relatively simple and cost-effective method compared to alternative techniques, such as fusion digestion or solid-phase extraction, making it accessible to laboratories with basic equipment and resources.

2.5. Procedure for Data Analysis

In this study, descriptive statistics and Pearson's product moment correlation coefficient were utilized to assess the relationships between metal concentrations at a study location. Hierarchical cluster analysis was employed to group metals with a very strong relationship in terms of interaction and contamination source linkage. Geospatial analysis, using inverse distance weighting (IDW), was employed to generate a spatial distribution map of selected metals around the study area. For the spatial distribution analysis, a reasonable distance of not less than 200m

from the cemetery gate was maintained among the sampling points to ensure effective map generation.

2.6. Determination of Pollution Indices

Pollution indices are very useful in processing, analyzing, and conveying raw environmental information to the public and decision-makers [54]. Geoaccumulation index, contamination factor, pollution load index, and enrichment factor were the indices used to measure the extent of heavy metal pollution, while the ecological risk index was used to assess the ecological risk associated with the heavy metals' pollution in the study area.

2.6.1. Enrichment Factor (EF)

The enrichment factor is the index used to determine the amount of metal added to soil compared to the average occurrence of that metal in the Earth's crust [55]. It was calculated based on equation (1) using Fe as a reference element due to its abundance in soil [56].

$$EF = \frac{Msample}{\mathrm{Re}\,sample}, \frac{Mref}{\mathrm{Re}\,ref} \quad (1)$$

Where; EF is enrichment factor, Msample and Resample are the concentrations of the metal and the reference metal (Iron), respectively, in the contaminated soil and Mref and Reref are concentrations of the metal and the reference metal in the reference soil, respectively [57, 58, 59]. Five contamination categories are classified based on enrichment factors [60]. These include: < 2, deficient to minimal enrichment; 2 < 5, moderate enrichment; 5 < 20, significant enrichment; 20 < 40, very high enrichment; and ≥ 40, extremely high enrichment.

2.6.2. Geoaccumulation Index (Igeo)

An index of geoaccumulation was used to define and determine metal contamination in the soils. This was done, by comparing current concentrations with pre-contamination levels. It was computed using equation 2 [61].

$$I_{geo} = \log_2 \frac{C_n}{1.5B_n} \quad (2)$$

Cn stands for measured concentration of the examined metal n in the soil and Bn stands for reference value or geochemical background concentration of the metal n (mg/kg) in the soil. Factor 1.5 was used to take into account the possible variations in background values for a given metal in the environment and the small anthropogenic influences [62, 63]. Seven classes of geoaccumulation index (Igeo) were identified [64]; these are: ≤ 0 as Class 0; unpolluted: 0.1–1.0 as Class 1; unpolluted to moderately polluted: 1.1–2.0 as Class 2; moderately polluted: 2.1–3.0 as Class 3; moderately to strongly polluted: 3.1–4.0 as Class 4; strongly polluted: 4.1–5.0 as Class 5; strongly to extremely polluted; and > 5 as Class 6; extremely polluted as class 7.

2.6.3. Contamination Factor (CF)

The contamination factor is an index used to define the contamination or pollution range of a certain metal. It was calculated by employing the model set by [65] presented in equation 3

$$CF = \frac{Concentration \text{ of the metal in the soil}}{T\,\mathrm{arg}\,et\ \left(Background\right)\ \text{Value}} \quad (3)$$

The background/target value is a reference value for the maximum allowable concentration of metals in the Nigerian soil [66]. Values less than one define the contamination range, while values greater than one defines the pollution range. Ten contamination categories are recognized based on contamination factor (CF) [65]., and these are: < 0.1 very slight contamination; 0.10–0.25, slight contamination; 0.26–0.5, moderate contamination; 0.51 0.75, severe contamination; 0.76–1.00, very severe contamination; 1.1–2.0, slight pollution; 2.1–4.0, moderate pollution; 4.1–8.0, severe pollution; 8.1–16.0, very severe pollution; and > 16 excessive pollutions.

2.6.4. Pollution Load Index (PLI)

This is the sum total of the CFs of the heavy metals under study, proposed by [67]; It gives an estimate of the combined metal contamination status and the necessary action that should be taken. It was computed using equation 4

$$(\text{PLI}) = \left(CF_1 \prime\ CF_2 \prime\ CF_3 \prime\ \text{- - - -}\ \text{CF}_\text{n}\right)^{\frac{1}{n}} \quad (4)$$

Where; n stands for the number of metals studied and CF is the contamination factor calculated from equation 3. The value of PLI was divided into four groups (Wang et al., 2010), i.e., < 1 – no pollution; 1.0 < 2—moderate pollution; 2.0 < 3—heavy pollution; and ≥ 3.0—extreme pollution.

2.6.5. Ecological Risk Factor (ErF)

This is an index that quantitatively expresses the potential ecological risk associated with a given single contaminant [68], calculated as:

$$ErF = T_r^1 \prime\ CF^1 \quad (5)$$

Where; T_r^1 is toxic response factor of a metal (Pb = 5, Zn = 1, Cd = 30, Cr = 2, Ni = 5) and CF^1 is the contamination factor. Five terminologies are used to define ecological risks based on Hakanson, 1980. These are < 40, low potential ecological risk; 40 < 80, moderate potential ecological risk; 80 < 160, considerable potential ecological risk; 160 < 320, high potential ecological risk; and ≥ 320, very high ecological risk.

2.6.6. Potential Ecological Risk Index (RI)

This index is the sum of all the ecological risk factors of the metals under study, taking into account the cumulative effects of the metals under study [68]. It is calculated thus:

$$RI = \left(ErF1 + ErF2 + ErF3 + ErF4 \text{- - - -} + ErFn\right) \quad (6)$$

Where; ErF is the ecological risk factor and n is the number of elements studied. The following terminologies have been used for the potential ecological risk index [68]: < 150, low ecological risk; 150 < 300, moderate ecological risk; 300 < 600, considerable ecological risk; and ≥ 600, very high ecological risk.

3. Results and Discussion

3.1. Physico-Chemical Properties of Soil

The physico-chemical property of the soil around the vicinity of cemeteries is presented in Table 1. The pH values recorded for these soils ranged from 6.7 to 9.5, with 90% of the soils falling under the alkaline region. Electrical conductivity ranged between 127 and 402 µS/cm. This indicates the presence of dissolved salts/ions apparently emanating from the effects of burial activities. The cation exchange capacity recorded for the soil ranged from 5.06 to 7.98meq/100g and these according to the ratings of [69] ranged from low to moderate which indicates that the soil has low to moderate nutrient retention capacity. Organic carbon ranged from 0.33 to 2.46 gkg−1, these can be classified as moderate (> 2%) based on [70] ratings, and this could be due to the aftermath of organic decomposition. Total nitrogen content of all the soils ranged from 1.78 to 5.80 gkg−1 and rated moderate according to [70]. This could be due to moderate organic matter contents of the soil.

3.2. Heavy Metal Analysis

From the heavy metal analysis results, it was observed that nine (9) out of the twenty-seven (27) metals analyzed, namely; Al, Si, Fe, Ni, Cu, Zn, Mo, Sn and Sb possess appreciable concentration when compared to their concentration in the control sample. The maximum concentration of these metals was compared against international regulatory standard as observed in Table 2.

The standards in Table 2 are grouped under threshold and permissible limits. These limits have been applied across the globe to measure the heavy metal contents in agricultural soils as reported by [71]. The threshold limit was employed to ascertain the minimum toxicity level in soil around the cemeteries while the permissible limit was used to evaluate the suitability of the soil for agricultural purpose. If the values of the heavy metals exceed the permissible limit, such soil is regarded as contaminated hence, cannot be employed for agricultural purpose [71, 72].

Result of Table 2 also revealed that the measured parameters of the soil around the study area are below the maximum permissible limit of concentration provided by the World Health Organization (WHO). At a monitoring depth of 15cm below the soil surface, the highest concentration of aluminium around first cemetery was 2.5162mg.kg^{-1} compared to the control sample having aluminium concentration of 1.0976mg.kg^{-1}. Although, the cemetery activities can be seen as responsible for the increase in aluminium concentration, the increment is still within the permissible limit of 300,000mg.kg^{-1} as recommended by World Health Organization. The typical range of aluminum in soils is from 1% to 30% (10,000 to 300,000 mg Al kg-1) according to [73, 74]. Aluminium toxicity is a major constraint for crop production in acidic soil. When the soil pH is lower than 5, Al^{3+} is released to the soil and enters into the root tip cell and ceases root development of plant. In acid soil with high mineral content, Al is the major cause of phytotoxicity according to [75, 76]. The limit of silicon in soil as established by World Health Organization is 122mg kg^{-1}. Based on this limit, soils were classified into low Si content (< 122mg kg^{-1}), medium Si content (122 to 181mg kg^{-1}) and high Si content (> 181mg kg^{-1}) according to [77]. From the soil investigation, the highest concentration of silicon was observed around third cemetery with a concentration of 12.4519 mg kg^{-1} compared to the control concentration of 4.0521 mg kg^{-1}. Since the maximum concentration was observed to be lower than the permissible limit, it was concluded that the cemetery environment is not susceptible to pollution arising from silicon. For iron, the highest concentration was observed around first cemetery with a concentration of 25.6290 mg kg^{-1} compared to the control concentration of 5.4085 mg kg^{-1}. The concentration of iron around first

cemetery was observed to be very close to the threshold limit of 35.0 mg kg^{-1} an indication of likely iron pollution with time. Iron (Fe) is an element relatively abundant in many cultivated soils with an average total concentration of 20 to 40 g kg-1 according to [78]. Research has shown that Iron plays significant roles in plant physiology [79, 80]. For nickel, the highest concentration was observed around third cemetery with a concentration of 0.2134 mg kg^{-1} compared to the control concentration of 0.1034 mg kg^{-1}.

Table 1: Range of pH and concentration of ions in soils around cemeteries in Benin City

Cemetery Location	Measured Parameters							
	pH	**Nitrate (mg/kg)**	**Nitrite (mg/kg)**	**Ammonia (mg/kg)**	**EC (µS/cm)**	**CEC** meq/100g	**Total Nitrogen Content** gkg−1	**Total Organic Carbon** gkg−1
First Cemetery	6.7-9.2	34-70.3	13-28.4	23-46.5	234-306	5.67- 7.98	1.78 - 5.22	0.33 – 2.29
Second Cemetery	6.9-9.5	46-75.5	16-19.8	15-54.2	187-402	5.06 - 7.03	1.81 – 5.80	0.41 – 2.33
Third Cemetery	6.8-8.7	23-68.4	17-23.2	16-37.3	127-377	5.46 – 6.47	1.86 – 5.61	0.39 - 2.46

Table 2: Maximum concentration of heavy metals in soil around cemeteries in Benin City

Variables	**Threshold limit ($mg.kg^{-1}$) WHO**	**Permissible limit ($mg.kg^{-1}$) WHO**	**1st Cemetery**	**2nd Cemetery**	**3rd Cemetery**	**Control ($mg.kg^{-1}$)**
			Max. ($mg.kg^{-1}$)	**Max. ($mg.kg^{-1}$)**	**Max. ($mg.kg^{-1}$)**	
Aluminium	10,000	300,000	2.5162	2.0488	1.7056	1.09760
Silicon	100	200	10.353	9.992	12.4519	4.05210
Iron	35.0	40.70	25.6290	11.3216	12.2358	5.40850
Nickel	30.0	35.0	.1787	.2002	.2134	0.10340
Copper	90.0	100.0	.3996	.3949	.3968	0.16042
Zinc	200.0	250.0	.2643	3.6010	.2766	0.10920
Molybdenum	1.0	2.0	.389	.4838	.5090	0.29841
Tin	2.0	200.0	7.3749	7.6430	7.1439	0.40320
Antimony	10.0	36.0	6.3488	6.7851	6.4844	0.05420

The concentration of nickel around third cemetery was observed to be very low compared to the threshold limit of 30.0 mg kg^{-1}. In addition, the concentration of Ni was also found to be relatively lower than the permissible limit for edible plant of 1.67mg/kg according to [81, 82, 83]. The concentration of copper was observed to be relatively the same around the three cemeteries with a concentration of 0.3456-0.3996mg kg^{-1}. This value was observed to be very low when compared to the threshold limit of 90.0 mg kg^{-1} as recommended by World Health Organization. According to [84], increased concentration of Cu in soils causes decreases in enzymatic action especially earthworms which increase proper aeration for plant growth. For zinc, the highest concentration was recorded around third cemetery with a concentration of 3.6010 mg/kg^{-1} compared to the control concentration of 1.0092 mg kg^{-1}. This concentration is below the maximum permissible limit of 250.0 mg kg^{-1}. The highest concentration of Molybdenum was observed around third cemetery with a concentration of 0.5090 mg/kg^{-1} compared to the control concentration of 0.29841mg kg^{-1}. For Tin and Antimony, their concentrations were observed to be very low when compared to the maximum permissible limit of 200 mg kg^{-1} and 36.0 mg kg^{-1} respectively.

3.3. Pollution Assessment Study

The accumulation of heavy metals in the soil around cemeteries in Benin City was evaluated using the enrichment factor and result is presented in Table 3.

Table 3: Enrichment factor of the heavy metals in soils around cemeteries in Benin City

Variables	Enrichment Factor					
	First Cemetery		Second Cemetery		Third Cemetery	
	EF	Class	EF	Class	EF	Class
Al	0.484	D	0.892	D	0.687	D
Si	0.539	D	1.178	D	1.358	D
Ni	0.365	D	0.925	D	0.912	D
Cu	0.526	D	1.176	D	1.093	D
Zn	0.511	D	15.753	D	1.120	D
Mo	0.275	D	0.775	D	0.754	D
Sn	3.860	M	9.055	S	7.832	S
Sb	24.719	V	59.803	E	52.883	E

Enrichment factor categories: D, deficient to minimal enrichment; M, moderate enrichment; S, significant enrichment; V, very high enrichment; E, extremely high enrichment

From the result, it was observed that all the soils from different locations within the cemeteries are deficient to minimal enrichment. This indicates that cemetery activities did not impact alarming accumulation of Al, Si, Ni, Cu, Zn, Mo, Sn and Sb with the natural background levels in the study areas.

The index of geoaccumulation was used to determine metal contamination in the soils and result is presented in Table 4.

Table 4: Geoaccumulation index of heavy metals in soils around cemeteries in Benin City

Variables	Geoaccumulation Index					
	First Cemetery		Second Cemetery		Third Cemetery	
	GI	Class	GI	Class	GI	Class
Al	0.612	UMP	0.315	UMP	0.051	UMP

Si	0.768	UMP	0.717	UMP	1.035	MP
Fe	1.660	MP	0.481	MP	0.593	UMP
Ni	0.204	UMP	0.368	UMP	0.460	UMP
Cu	0.732	UMP	0.715	UMP	0.722	UMP
Zn	0.690	UMP	4.458	SEP	0.756	UMP
Mo	-0.202	UP	0.112	UMP	0.185	UMP
Sn	3.608	SP	3.660	SP	3.562	SP
Sb	6.287	EP	6.383	EP	6.318	EP

Geoaccumulation index classes: UP, unpolluted; UMP, unpolluted to moderately polluted; MP, moderately polluted; MSP, moderately to strongly polluted, SP, strongly polluted; SEP, strongly to extremely polluted; EP, extremely polluted

The calculated Igeo for the soils ranged from 0.051 to 0.612 for Al, 0.717 to 1.035 for Si, 0.481 to 1.660 for Fe, 0.204 to 0.460 for Ni, 0.715 to 0.732 for Cu, 0.690 to 4.458 for Zn, -0.202 to 0.185 for Mo, 3.562 to 3.660 for Sn and 6.287 to 6.383 for Sb. For first cemetery and environs, it was classified as unpolluted with respect to Mo, unpolluted to moderate pollution with respect to Al, Si, Ni, Cu and Zn, moderate pollution with respect to Fe, strongly polluted with respect to Sn and extremely polluted with respect to Sb. For second cemetery and environs, it was classified as unpolluted to moderate pollution with respect to Al, Si, Ni, Cu and Mo, moderate pollution with respect to Fe, strongly polluted with respect to Sn, extremely polluted with respect to Sb and strongly to extremely polluted with respect Zn. For third cemetery and environs, it was classified as unpolluted to moderate pollution with respect to Al, Fe, Ni, Cu, Zn and Mo, moderate pollution with respect to Si, strongly polluted with respect to Sn, extremely polluted with respect to Sb
To examine the extent of heavy metal pollution around each of the cemetery, contamination factor (CF) was employed according to [85, 67] and result obtained is presented in Table 5. The soil contamination factor (CF) shows the following ranges; Al (0.00001-0.00001); Si (0.04996–0.06226); Fe (0.27817–0.62971); Ni (0.00511-0.00610); Cu (0.00395-0.00400); Zn (0.00106-0.01440); Mo (0.19450-0.25450); Sn (0.03572-0.03822) and Sb (0.17636-0.18848). The order of CF of metal composition in soil is Fe > Mo > Sb > Sn > Si > Zn > Ni > Cu > Al. Based on the calculated CF values, the soils from the three cemeteries were generally classified as very slightly contaminated with Al, Si, Sn, Ni, Cu, Zn, and slightly contaminated with Sb and Mo while the soil from first cemetery was severely contaminated with Fe

Table 5: Contamination factor of heavy metals in soils around cemeteries in Benin City

Variables	**Contamination Factor**					
	First Cemetery		**Second Cemetery**		**Third Cemetery**	
	CF	**Class**	**CF**	**Class**	**CF**	**Class**
Al	0.00001	VSlC	0.00001	VSlC	0.00001	VSlC
Si	0.05177	VSlC	0.04996	VSlC	0.06226	VSlC
Fe	0.62971	SeC	0.27817	MC	0.30063	MC
Ni	0.00511	VSlC	0.00572	VSlC	0.00610	VSlC
Cu	0.00400	VSlC	0.00395	VSlC	0.00397	VSlC
Zn	0.00106	VSlC	0.01440	VSlC	0.00111	VSlC
Mo	0.19450	SlC	0.24190	SlC	0.25450	SlC

Sn	0.03687	VSlC	0.03822	VSlC	0.03572	VSlC
Sb	0.17636	SlC	0.18848	SlC	0.18012	SlC

Contamination factor categories: VSlC, very slightly contamination; SlC, slight contamination; MC, moderate contamination; SeC, severe contamination; VSeC, very severe contamination; SlP, slight pollution; MP, moderate pollution; SeP, severe pollution; VSeP, very severe pollution; EP, excessive pollution

Result of the estimated pollution load index of soils around the study area is presented in Table 6.

Table 6: Pollution load index of heavy metals in soil around cemeteries in Benin City

Sample Stations			
Heavy Metals mg/kg	**First Cemetery**	**Second Cemetery**	**Third Cemetery**
Al Si Fe Ni Cu Zn Mo Sn Sb	0.012502	0.015571	0.011866

From the result, it was observed that the calculated PLI values for all the cemetery location is < 1, showing baseline levels of low metal pollution. Although, the pollution load index presented in Table 6 indicates that there is no pollution, there is increasing potential for rising pollution levels in virtually all the study sites owing to cemetery activities. This calls for proper management of cemetery operations by government and other concerned agencies

From the ecological risk assessment result, it was observed that ecological risk factors for Fe, Ni, Cu, and Zn were below 40, thus indicating low potential ecological risk. To quantify the overall potential ecological risk of observed metals around the cemeteries, the risk index (RI) was calculated as the sum of all the four risk factors as presented in Table 7.

Table 7: Overall risk index of the heavy metals in soils around cemeteries in Benin City

Metals	**ErF**	**ErF**	**ErF**	**Risk Index**
Fe	0.62971	0.27817	0.30063	1.20851
Ni	0.02555	0.0286	0.0305	0.08465
Cu	0.02	0.01975	0.01985	0.0596
Zn	0.00106	0.0144	0.00111	0.01657

Risk index could characterize the sensitivity of the local ecosystem to the toxic metals and represent ecological risk result from the overall contamination. Result of the risk index computation indicates that the study area has very low ecological risk to Fe, Ni, Cu and Zn.

3.4. Statistical Analysis

3.4.1 Correlation Analysis

Correlation analyses using Pearson correlation was done to evaluate the relationship that exists among the variables. Result of the estimated correlation coefficient is presented in Tables 8, 9 and 10.

Table 8: Correlation coefficient (r) between conc. of metals around first cemetery

	Al	Si	Fe	Ni	Cu	Zn	Mo	Sn	Sb
Al	1								
Si	-.799*	1							
Fe	.670	-.788*	1						
Ni	-.518	.595	-.917**	1					
Cu	-.463	.573	-.847**	.866**	1				
Zn	-.720*	.848**	-.868**	.795*	.802*	1			
Mo	-.630	.292	-.365	.374	.354	.606	1		
Sn	-.624	.687	-.967**	.864**	.880**	.818*	.404	1	
Sb	-.520	.685	-.968**	.882**	.869**	.761*	.203	.973**	1

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

**. Correlation is significant at the 0.01 level (2-tailed)

Table 9: Correlation coefficient (r) between conc. of metals around second cemetery

	Al	Si	Fe	Ni	Cu	Zn	Mo	Sn	Sb
Al	1								
Si	.772*	1							
Fe	.418	.003	1						
Ni	-.393	-.328	-.435	1					
Cu	-.945**	-.791*	-.443	.492	1				
Zn	-.281	-.445	.377	.399	.409	1			
Mo	-.262	-.290	-.664	.481	.477	-.104	1		
Sn	-.440	-.023	-.749*	.354	.304	-.561	.298	1	
Sb	-.427	.054	-.669	.108	.271	-.629	.204	.943**	1

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

**. Correlation is significant at the 0.01 level (2-tailed)

Table 10: Correlation coefficient (r) between conc. of metals around third cemetery

	Al	Si	Fe	Ni	Cu	Zn	Mo	Sn	Sb
Al	1								
Si	.549	1							
Fe	.226	-.597	1						
Ni	.303	.865**	-.752*	1					
Cu	-.270	.134	-.190	.106	1				
Zn	-.056	.018	-.137	.106	.326	1			
Mo	-.170	-.094	-.299	.228	-.467	.272	1		
Sn	-.478	.284	-.865**	.577	.398	.139	.370	1	

Sb	-.528	.231	-.864**	.569	.326	.358	.403	.924**	1

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

The strength of a relationship can be anywhere between -1 and +1 and the stronger the correlation, the closer the correlation coefficient comes to ±1. If the coefficient is a positive number, the variables are directly related while an inverse relationship is inferred when the variables are negatively correlated.

The results in Table 8 representing first cemetery show that there is significant positive correlation between Si and Zn at 1% significant level since the probability value (P-value) of 0.008 (P< 0.05) and a correlation coefficient of 0.848 was obtained. The positive correlation coefficient implies that as the quantity of Si increases, the quantity of Zn also increases. This further implies that Si has strong positive association with Zn. Other associations which were found to be positively correlated at the 1% significant level include; Ni and Cu with p-value of 0.005 and a correlation coefficient of 0.866, Ni and Sn with p-value of 0.006 and r value of 0.864, Ni and Sb with p-value of 0.004 and r value of 0.882. Similarly, other association which were found to be negatively correlated at the 1% significant level include; Fe and Ni with p-value of 0.001 and r value of -0.917, Fe and Cu with p-value of 0.008 and r value of -0.847, Fe and Zn with p-value of 0.005 and r value of -0.868, Fe and Sn with p-value of 0.000 and r value of -0.967.

The result in Table 9 representing second cemetery shows there is significant positive correlation between Sb and Sn at 1% significant level since the probability value (P-value) of 0.000 (P< 0.05) was obtained and a correlation coefficient of 0.945. The positive correlation coefficient implies that Sb has strong positive association with Sn. Other associations which were found to be positively correlated at the 5% significant level include; Si and Al with p-value of 0.025 and correlation coefficient of 0.772. Similarly, it was observed that there is a significant negative correlation between Al and Cu at the 1% level of significance with p-value of 0.000 and r value of -0.945. Other associations which were found to be negatively correlated at the 5% significant level include; Si and Cu with p-value of 0.019 and r value of -0.791, Fe and Sn with p-value of 0.033 and r value of -0.749.

The result in Table 10 representing third cemetery shows there is significant positive correlation between Si and Ni at 1% significant level since the probability value (P-value) of 0.005 (P< 0.05) was obtained and a correlation coefficient of 0.865. The positive correlation coefficient implies that as the quantity of Si increases, the quantity of Ni also increases which further implies that Si has strong positive association with Ni. Other associations which were found to be positively correlated at the 1% significant level include; Sn and Sb with p-value of 0.001 and correlation coefficient of 0.924. Similarly, it was observed that there is a significant negative correlation between Fe and Sn at the 1% level of significance with p-value of 0.006 and r value of 0.865. Other associations which were found to be negatively correlated at the 1% and 5% significant level include; Fe and Sb with p-value of 0.006 and r value of 0.864, Ni and Fe with p-value of 0.031 and r value of 0.752. The result of correlation analysis is in tandem with [86].

3.4.2 Principal Component Analysis

Given that some of the metals are significantly correlated, the presence of a given metal can be used to account for the presence of another metal that is correlated with it. Therefore, a principal component analysis was employed to identify the component metals that can account for variation in the other metals using the total variance explained. The total variance explained indicate how

much of the variable in the data has been modelled by the extracted factors knowing that the PCA will produce as many components as possible. Generally speaking, in PCA, only the first few components which account for the majority of the total variance are needed to be retained for interpretation. It simply means that an eigenvalue less than 1 indicates that the component explained less variance than a value would have and therefore should not be retained. Factors with eigen values greater than one represent the number of component factors needed to describe the underlying variation of heavy metals. This are the component factors that contributes an adequate amount to the variation in the soil quality around the cemeteries.

The PCA result presented in Table 11 representing first cemetery shows that only two components (PC1 and PC2) with variance percentage of 73.990% and 12.977% are significant in explaining the variations among the selected variables. The result further shows that these two components explained about 86.968% of the total variation. The eigenvalue and variability for PC1 are 6.659 and 73.990 while the eigenvalue and variability of PC2 was observed to be 1.168 and 12.977. The PCA result presented in Table 12 representing second cemetery shows that three components group (PC1, PC2 and PC3) with variance percentage of 45.113%, 30.564% and 12.230% are significant in explaining the variations among the selected variables. The result further shows that these three components account for about 87.906% of the total variance explained while the PCA result presented in Table 13 representing third cemetery shows that four components group (PC1, PC2, PC3 and PC4) with variance percentage of 43.920%, 23.310%, 16.687% and 11.621% are significant in explaining the variations among the selected variables. The result further shows that these four components account for about 95.538% of the total variance explained**.**

To understand the correlation between the metals in each component group **t**he extracted component matrix and rotated component matrix were employed. In regression terms, the component matrix is the standardized regression coefficient between the observed values and the component factors. Higher factor loading indicates that a parameter is closely associated with the component factor. To determine the metals that are most highly correlated with the component factors, horizontal decentralization of the component matrix was done and the best-favoured parameters were selected as members of that particular component factor. To understand the metals that most highly contributed to the total variance explained, vertical decentralization of the rotated component matrix was done. Result of horizontal decentralization of the component matrix and vertical decentralization of the rotated component matrix are presented in Tables 14, 15 and 16.

Table 11: PCA total variance explained for first cemetery

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.659	73.990	73.990	6.659	73.990	73.990	5.288	58.760	58.760
2	1.168	12.977	86.968	1.168	12.977	86.968	2.539	28.207	86.968
3	.664	7.381	94.348						
4	.240	2.670	97.018						
5	.146	1.620	98.638						
6	.120	1.329	99.967						
7	.003	.033	100.000						
8	8.752E-16	9.725E-15	100.000						
9	-1.313E-16	-1.458E-15	100.000						

Extraction Method: Principal Component

Table 12: PCA total variance explained for second cemetery

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.060	45.113	45.113	4.060	45.113	45.113	2.988	33.201	33.201
2	2.751	30.564	75.677	2.751	30.564	75.677	2.914	32.380	65.581
3	1.101	12.230	87.906	1.101	12.230	87.906	2.009	22.325	87.906
4	.672	7.464	95.371						
5	.309	3.429	98.800						
6	.101	1.126	99.926						
7	.007	.074	100.000						
8	-8.566E-17	-9.518E-16	100.000						
9	-3.233E-16	-3.592E-15	100.000						

Extraction Method: Principal Component Analysis.

Table 13: PCA total variance explained for third cemetery

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.953	43.920	43.920	3.953	43.920	43.920	3.575	39.727	39.727
2	2.098	23.310	67.230	2.098	23.310	67.230	2.310	25.666	65.392
3	1.502	16.687	83.917	1.502	16.687	83.917	1.499	16.659	82.051
4	1.046	11.621	95.538	1.046	11.621	95.538	1.214	13.487	95.538
5	.226	2.511	98.049						
6	.096	1.063	99.113						
7	.080	.887	100.000						
8	1.337E-16	1.486E-15	100.000						
9	-2.126E-16	-2.362E-15	100.000						

Extraction Method: Principal Component Analysis.

Table 14: Result of matrix decentralization for first cemetery

Element	Component Matrix			Rotated Component Matrix	
	PC1	PC2		PC1	PC2
Fe					
Sn	.953				
Zn	.935				
Sb	.919			.975	
Ni	.901				
Cu	.882				
Si	.819				
Al		.532			.880
Mo	.505				

Table 15: Result of matrix decentralization for second cemetery

	Component Matrix			Rotated Component Matrix		
	PC1	PC2	PC3	PC1	PC2	PC3
Cu	.834			.964	.	
Al			.406			
Fe						
Sn	.742					
Mo	.637					
Ni	.614				.900	
Zn			.111			
Si		.682				.853
Sb		.657				

Result of Table 14 shows that PC1 is most highly correlated with Sn, Zn, Sb, Ni, Cu and Si while PC2 is most highly correlated with Al. The metals that account for the highest variance **of** 86.968% are Ni and Al. These are the metals that significantly influenced the contamination status of the soil around first cemetery. Result of Table 15 shows that PC1 is most highly correlated with Cu, Sn, Mo and Ni, PC2 is most highly correlated with Si and Sb while PC3 is most highly correlated with Al and Zn. The metals that account for the highest variance of 87.906% are Cu, Ni and Si. These are the metals that significantly influenced the contamination status of the soil around second cemetery**.** Result of Table 16 shows that PC1 is most highly correlated with Sb, Sn, Ni and Mo. PC2 is most highly correlated with Al and Si. PC3 is most highly correlated with Cu while PC4 is most highly correlated with Fe and Zn. The metals that account for the highest variance of 95.538% are Fe, Ni, Cu and Zn**.** These are the metals that significantly influenced the contamination status of the soil around second cemetery. Ni was observed to significantly contribute to the total variance explained for soil around first cemetery, second cemetery and third cemetery**.**

Table 16: Result of matrix decentralization for third cemetery

	Component Matrix				Rotated Component Matrix			
	PC1	PC2	PC3	PC4	PC1	PC2	PC3	PC4
Fe				.174	.972			
Sb	.934							
Sn	.925							
Ni	.785					.947		
Al		.897						
Si		.813						
Cu			.876				.862	
Mo	.373							
Zn				.914				.985

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3.4.3 *Hierarchical Cluster Analysis*

In order to study the inter-relationship between the soil sampling points and justify the sampling points along the same source of contamination, hierarchical cluster analysis using the Squared Euclidean Distance method was performed and the generated dendrogram for first, second and third cemetery are presented in Figures 2, 3 and 4.

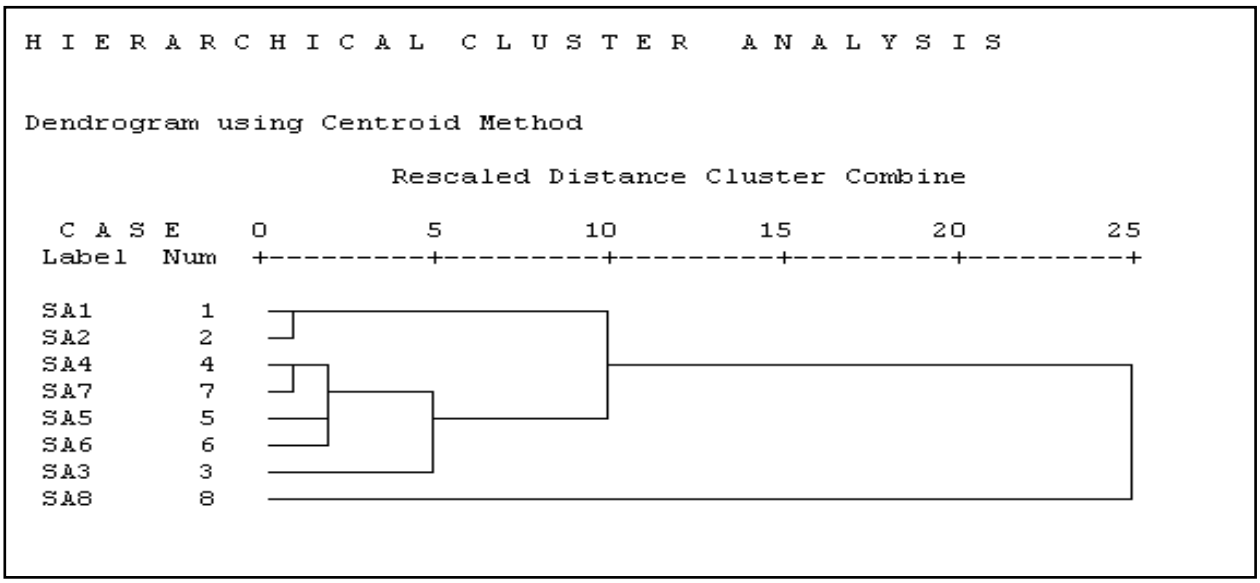

Figure 2: Dendrogram using centroid method showing inter-relationship of heavy metals in soil around first cemetery

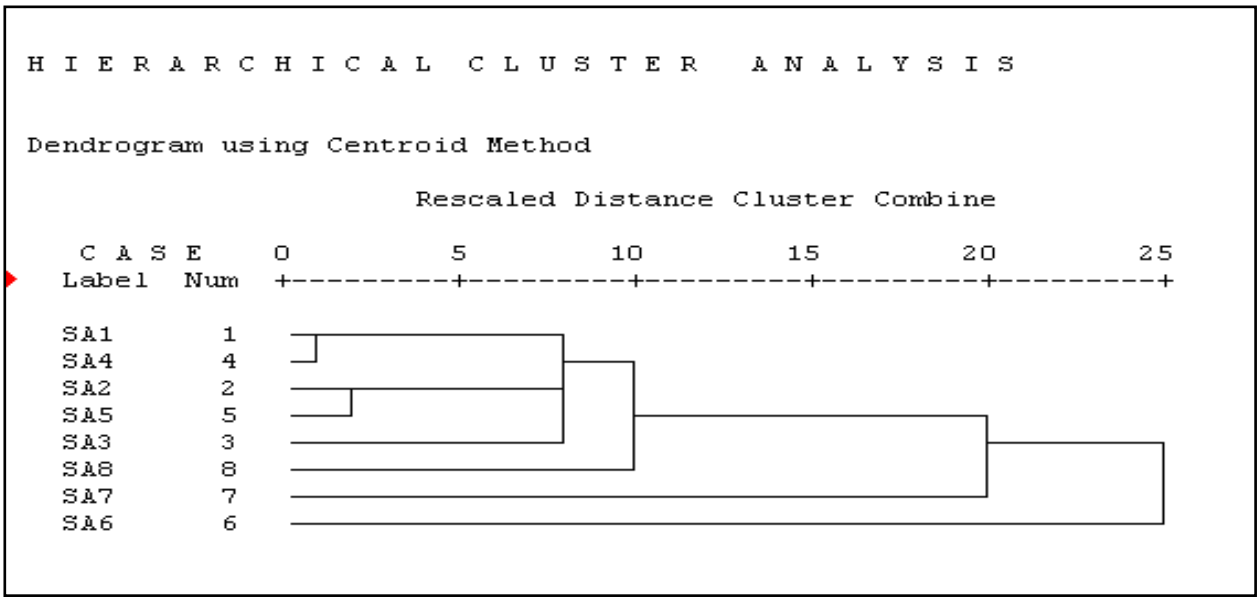

Figure 3: Dendrogram using centroid method showing inter-relationship of heavy metals in soil around second cemetery

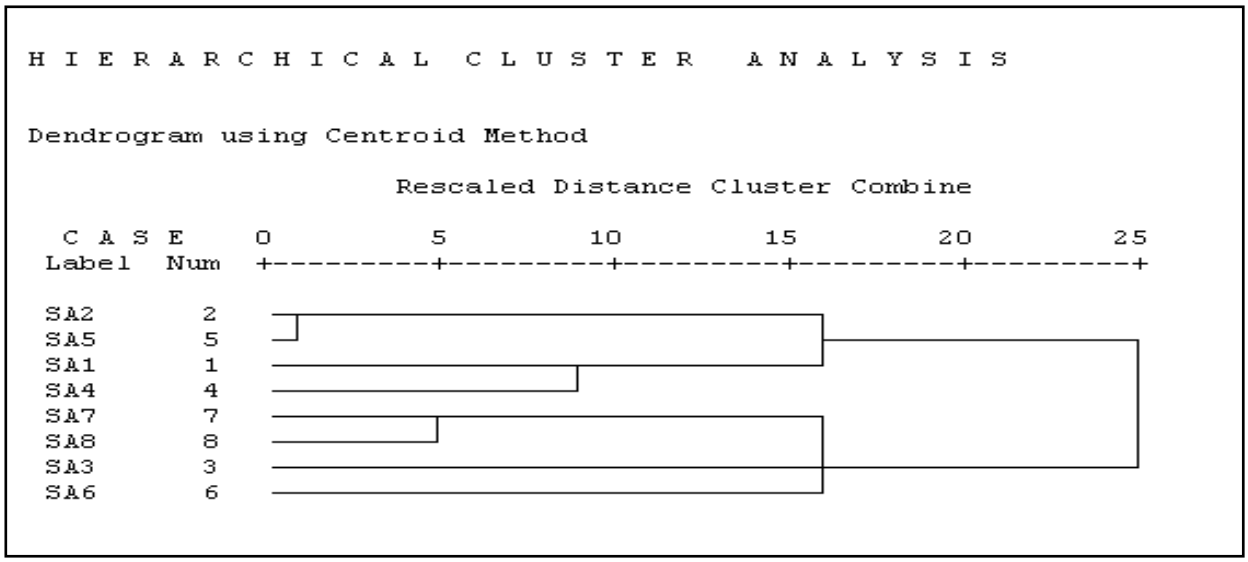

Figure 4: Dendrogram using centroid method showing inter-relationship of heavy metals in soil around third cemetery

The dendrogram divides the metals into group of clusters which can be employed to describe the metal-contaminant linkage interactions. From the dendrogram of Figure 2 representing first cemetery, it was observed that sample 1 and 2 (SA1 and SA2) has close relationship in terms of metal composition and contamination source linkage. In addition, samples SA4, SA5, SA6 and SA7 have close relationship in terms of metal composition and contamination source linkage. From the dendrogram of Figure 3 representing second cemetery, it was observed that sample SA1, SA2, SA4 and SA5 has close relationship in terms of metal composition and contamination source linkage. The dendrogram result also revealed that sample SA8 is closely related with (SA1, SA2, SA4 and SA5) and from the dendrogram of Figure 4 representing third cemetery, it was observed that sample SA1, SA2 and SA5 are closely related in terms of metal composition and contamination source linkage.

3.4.4 Spatial Distribution Analysis

Prediction map of heavy metals in the study area was obtained by means of an interpolation technique known as inverse distance weighting (IDW). Some of the interpolation results are shown in Figures 5a-i, 6a-i and 7a-i representing first, second and third cemetery.

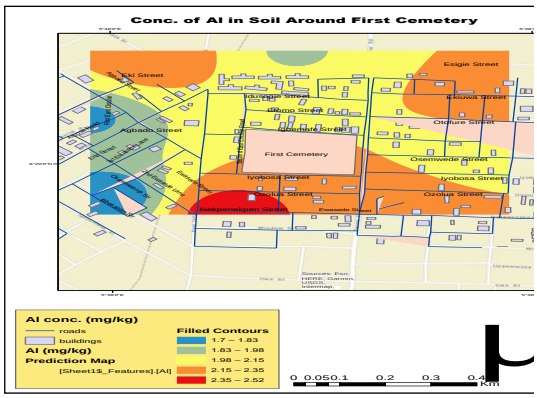

Figure 5a: Spatial distribution map of Al around first cemetery

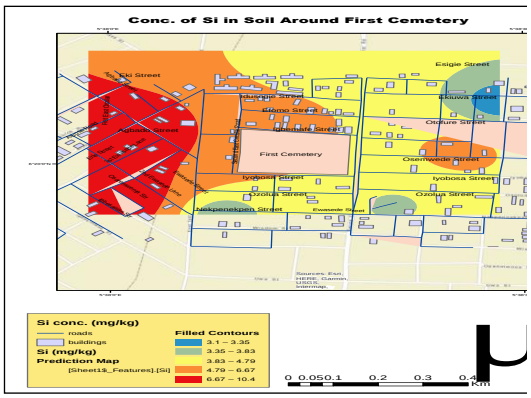

Figure 5b: Spatial distribution map of Si around first cemetery

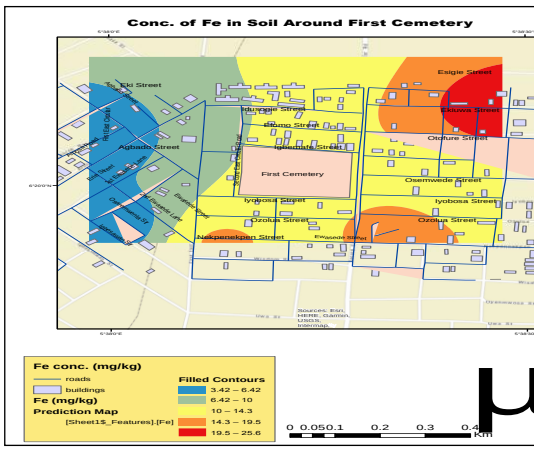

Figure 5c: Spatial distribution map of Fe around first cemetery

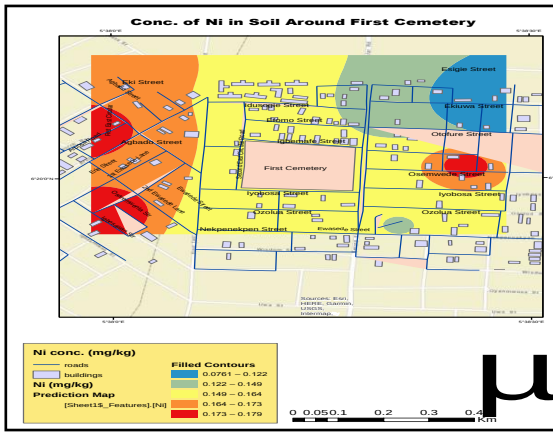

Figure 5d: Spatial distribution map of Ni around first cemetery

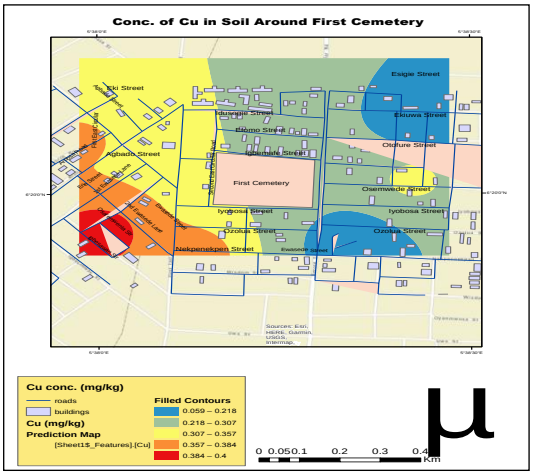

Figure 5e: Spatial distribution map of Cu around first cemetery

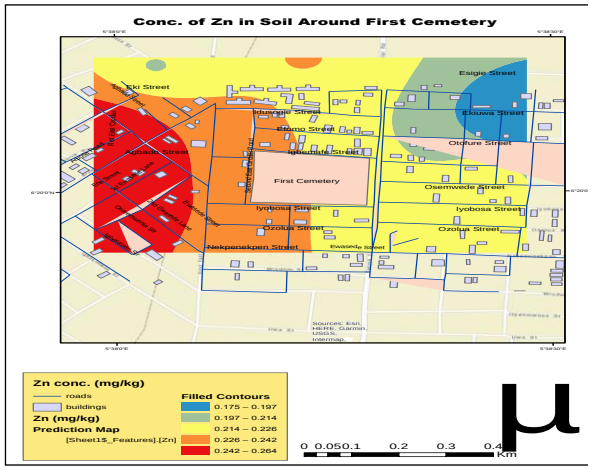

Figure 5f: Spatial distribution map of Zn around first cemetery

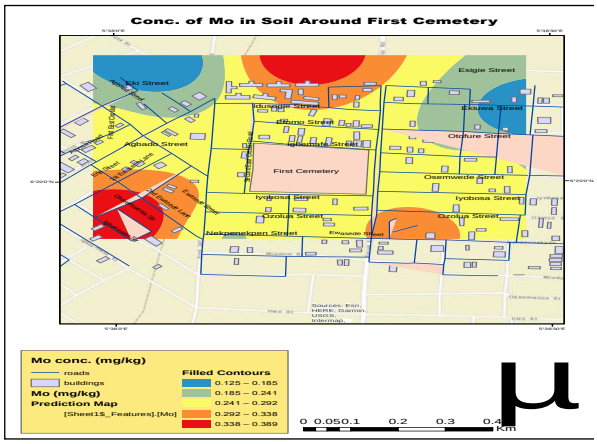

Figure 5g: Spatial distribution map of Mo around first cemetery

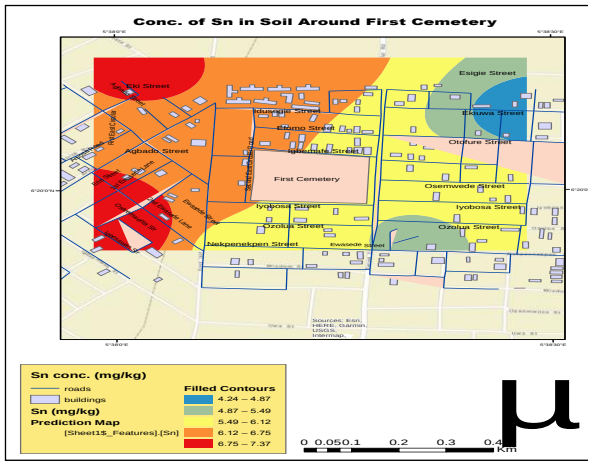

Figure 5h: Spatial distribution map of Sn around first cemetery

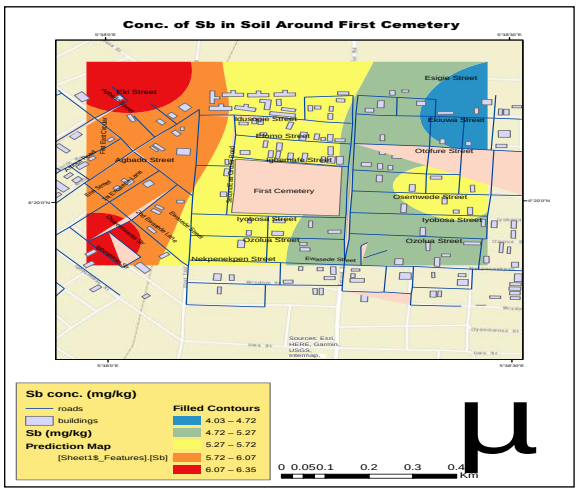

Figure 5i: Spatial distribution map of Sb around first cemetery

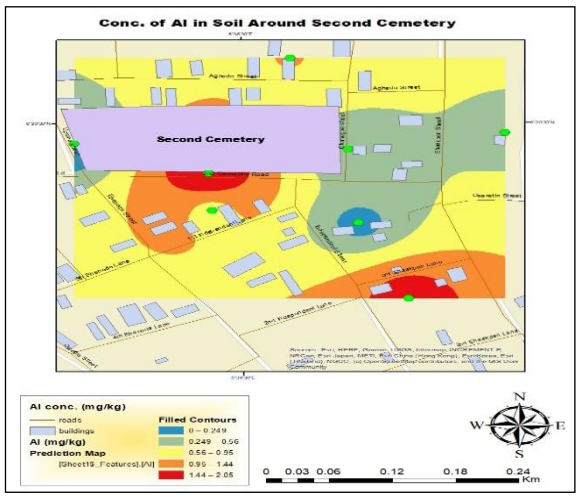

Figure 6a: Spatial distribution map of Al around second cemetery

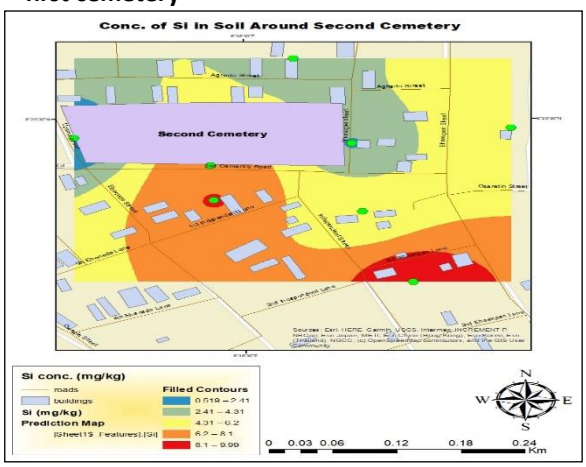

Figure 6b: Spatial distribution map of Si around second cemetery

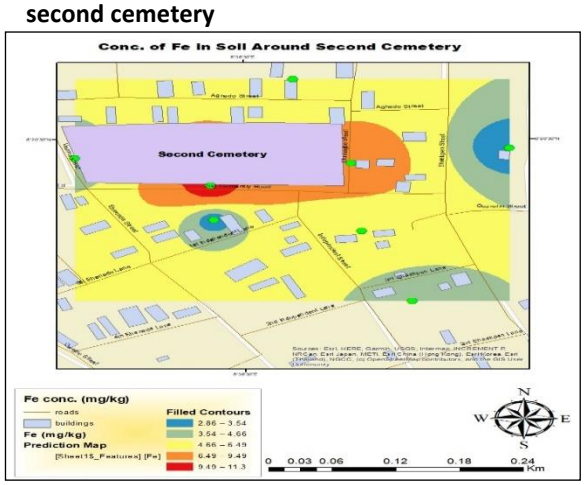

Figure 6c: Spatial distribution map of Fe around second cemetery

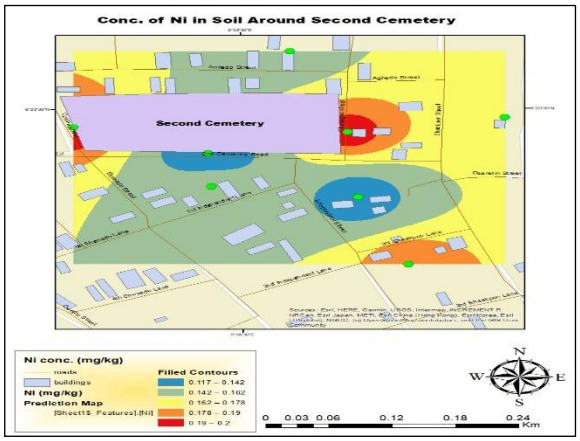

Figure 6d: Spatial distribution map of Ni around second cemetery

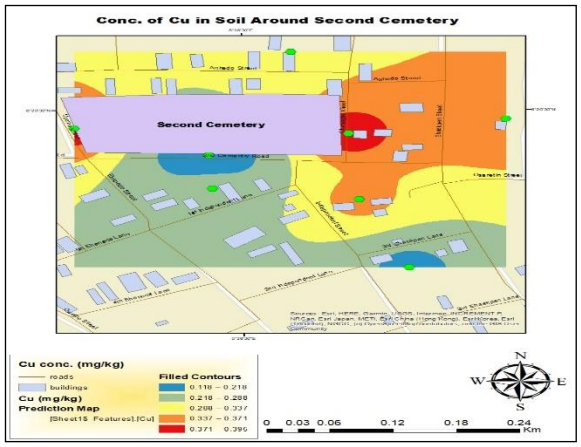

Figure 6e: Spatial distribution map of Cu around second cemetery

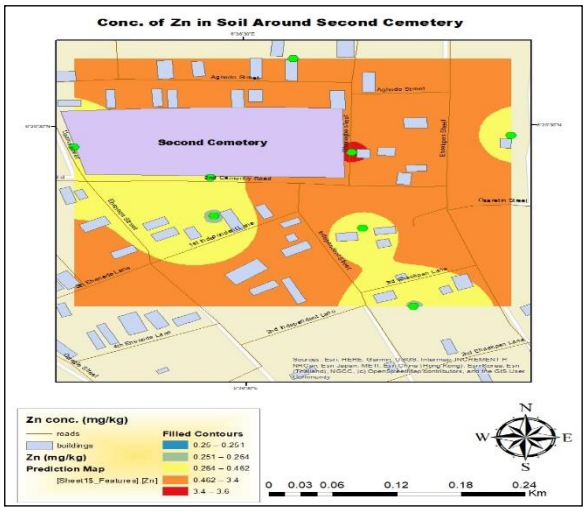

Figure 6f: Spatial distribution map of Zn around second cemetery

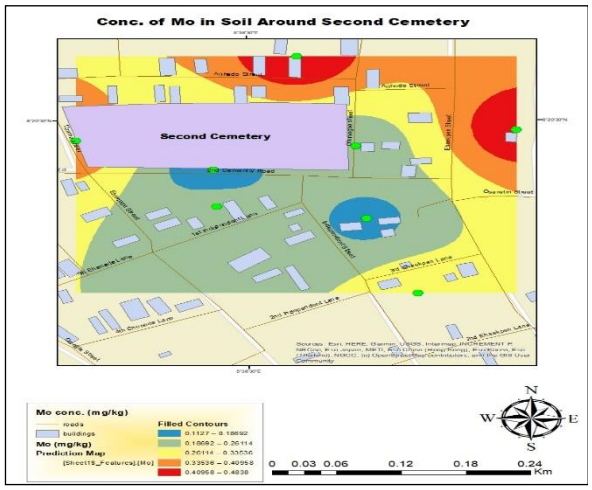

Figure 6g: Spatial distribution map of Mo around second cemetery

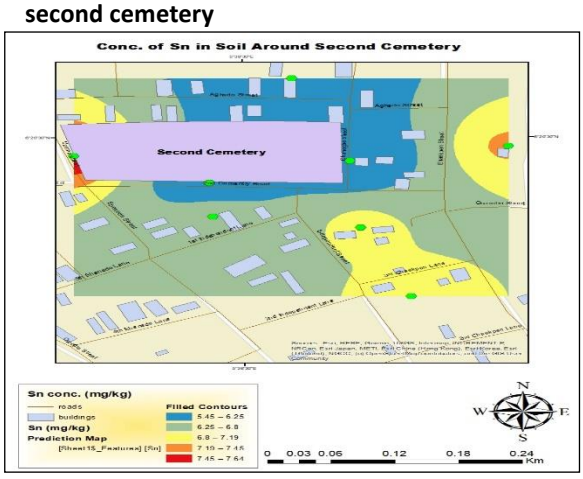

Figure 6h: Spatial distribution map of Sn around second cemetery

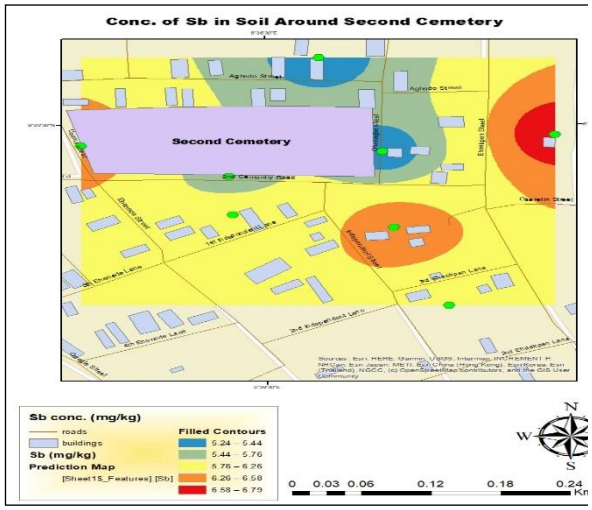

Figure 6i: Spatial distribution map of Sb around second cemetery

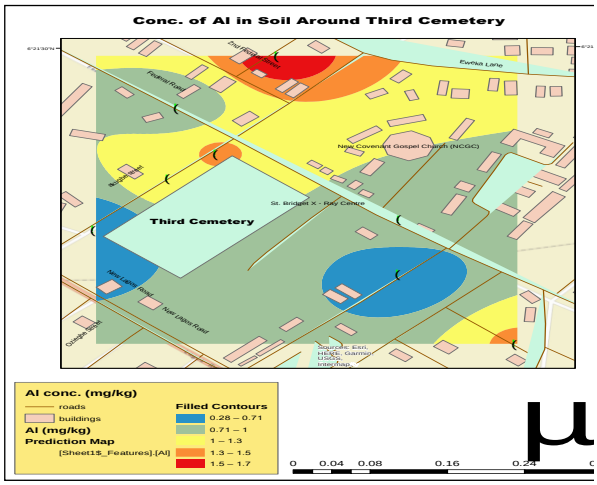

Figure 7a: Spatial distribution map of Al around third cemetery

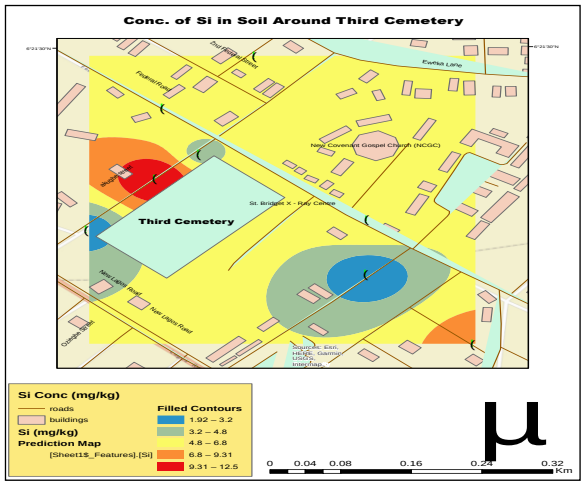

Figure 7b: Spatial distribution map of Si around third cemetery

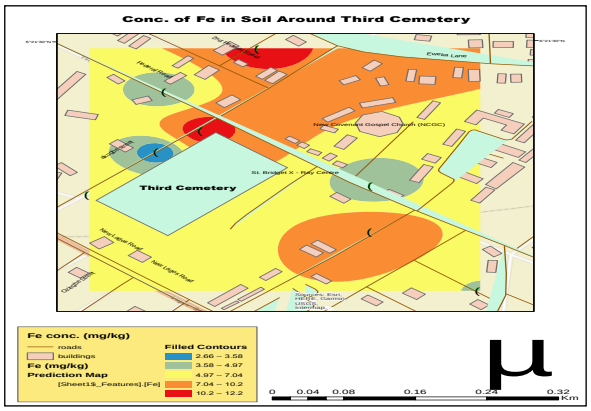

Figure 7c: Spatial distribution map of Fe around third cemetery

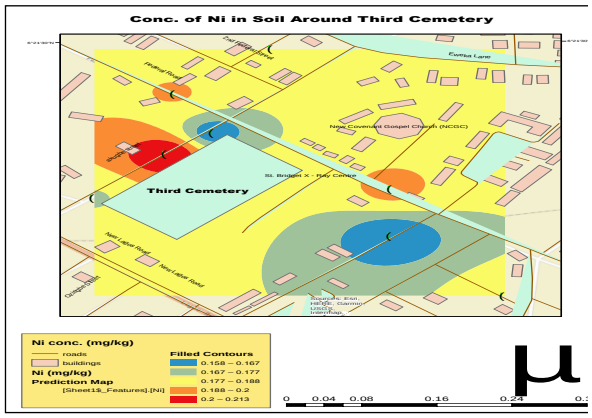

Figure 7d: Spatial distribution map of Ni around third cemetery

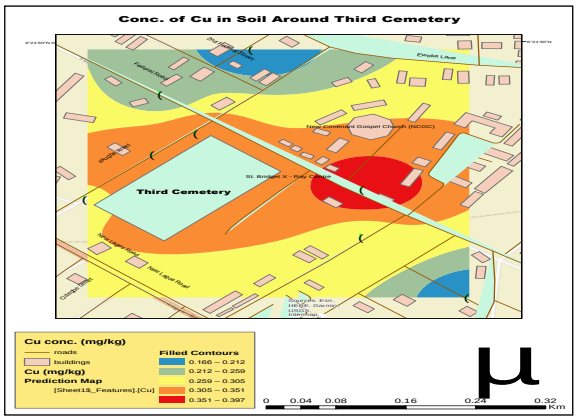

Figure 7e: Spatial distribution map of Cu around third cemetery

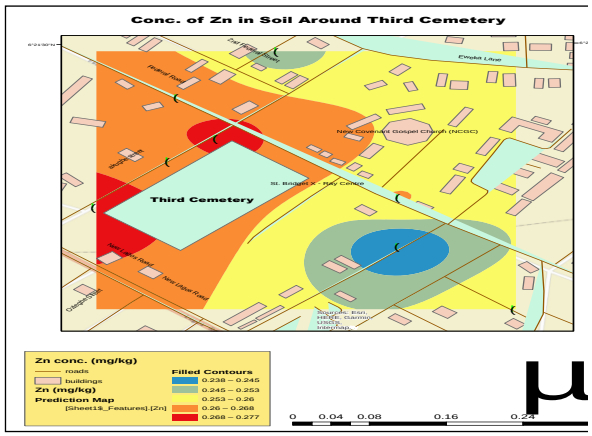

Figure 7f: Spatial distribution map of Zn

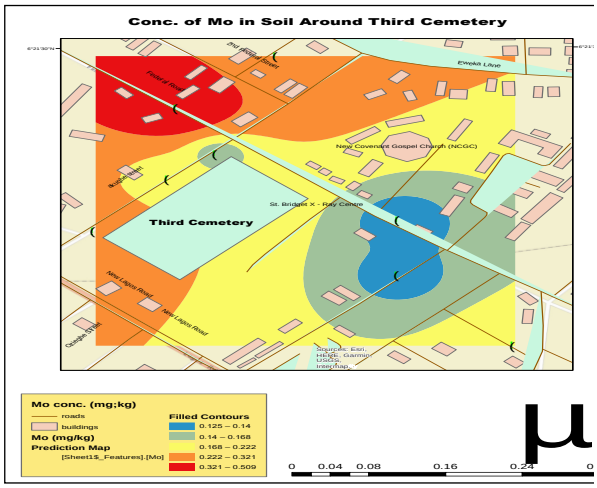

Figure 7g: Spatial distribution map of Mo around third cemetery

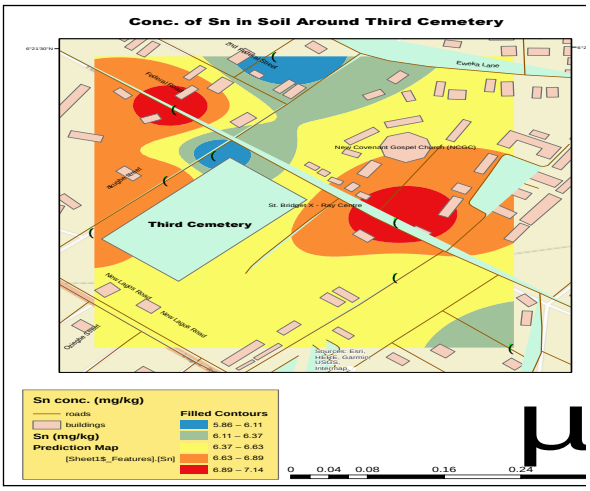

Figure 7i: Spatial distribution map of Sn around third cemetery

As observed in Figures 5a-i, the Southern region of first cemetery comprising of Nekpenenkpe Street and Ozulua Street are experiencing low level of Aluminium concentration which is lower than the WHO permissible standard of Al in soil. low level of Si, Cu, Mo, Sn, Sb and Zn which is lower than the WHO permissible standard concentration was observed in the Northwest region of first cemetery comprising of Agbado Street, Erie Street including 1st/2nd Ewasede lane. The spatial interpolation map of Fe shows a low level of concentration in the Northeast region comprising of Ekiuwa Street and environs while low concentration of Ni was observed around the Northwest and Northeast region of first cemetery comprising of 2nd Ewasede land, Osemwede Street and parts of Agbado Street.

As observed in Figures 6a-i, the Southeast and Southwest region of second cemetery are experiencing low level of Aluminium concentration which is lower than the WHO permissible standard of Al in soil. Low level of Si concentration which is lower than the WHO permissible standard was experienced in the Southeast region of second cemetery while moderate amount of Fe which is lower than the WHO permissible standard was experienced in the Northwest region of the study area. For Cu and Mo, a low patch which is lower than the WHO permissible standard was noticed at the Northeast region of the study area. Same applies to Figure 7a-i representing third cemetery.

4. Conclusion

Within the scope of this study, the following conclusions were reached;

1. Out of the 27 elements studied, 9 metals were observed to have appreciable level of concentration. These metals which include; Aluminum, Silicon, Nickel, Iron, Zinc, Copper, Molybdenum, Tin and Antimony were employed to assess the impact of cemetery activities on soil quality.
2. From the study, it was discovered that none of the nine metals exceeded the maximum permissible limit of metals in soil as recommended by World Health Organization (WHO) hence; it was concluded that the soil around the cemetery environment is presently healthy and free of metal contamination.
3. The outcome of the computed contamination factor (CF) and pollution load index (PLI) further attest to the fact that the soil around the vicinity of the cemeteries is free from metal contamination since CF and PLI less than 1 indicates baseline level of very low metal pollution. Although, the Pearson product moment correlation analysis shows a significant

positive correlation between selected metals, the fact that these metals exist within the barest minimum concentration demand no cause for alarm.

4. It is worthy of note that the maximum concentration of iron and silicon around the vicinity of the cemeteries are above their concentration in the control sample. Hence, the need for constant monitoring of these metals so as not to overshoot the maximum permissible limit which may otherwise result in metal pollution.

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