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Investigation of the Environmental Impact of Selected Motor Parks in FCT on the Quality of the Soil

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ABSTRACT

The issue of transportation and the environment is paradoxical since transportation conveys substantial socioeconomic benefits, but at the same time, transportation is impacting systems. This *study investigates the soil quality, of Zuba, Dei Dei, and Utako motor parks with respect to the Heavy metals, physicochemical parameters and microbiology of the study areas. The study aimed to assess the effect of the anthropogenic activities on the soil of these areas. The 2005 American Public Health Association (APHA) and Atomic Absorption Spectroscopic Methods were used for the analysis. The results of this study revealed the soil in Zuba, Deidei and Utako Motor Parks are significantly contaminated with Zinc, Nickel, Chromium, Lead with concentration above the WHO's permissible limits for residential area. Most of the physicochemical parameters determined were within the standard limits for residential and agricultural soils. The microbiological results showed no trace amounts of total coliform count or E. coli present in all the samples. Both positive and negative correlations were observed among some of the parameters determined. Long term exposure to the soils can lead to severe ecological impacts, therefore stringent pollution control measures are needed to prevent further degradation of soil quality.*

Key words: Investigation, Heavy metals, Physicochemical, Zuba, Utako and Deidei

Introduction

Rapid increase in urbanization and transportation in Nigeria has led to a rise in automotive traffic, necessitating the development and management of motor parks. These parks are vital hubs for commuters using commercial vehicles, facilitating both intra and interstate travel [1]. Recognized by authorities, motor parks significantly impact traffic management and congestion in cities. However, activities at these parks, such as car exhaust emissions and the use of fossil fuels, contribute environmental pollution[2].The issue of transportation and the environment is paradoxical since transportation conveys substantial socioeconomic benefits, but at the same time, transportation is impacting environmental systems [3]. On one side, transportation activities support increasing mobility demands for passengers and freight, while on the other, transport activities are associated with environmental impacts that can have negative effects [3].

This environmental issue is a global concern, affecting both developed and developing nations, and has been linked to higher illness and death rates [2]. Among the environmental pollutants resulting from the vehicular movement is the buildup of harmful heavy metals in the soil which are detrimental to both human health and the environment [4]. It is well known that areas with strong industrial and traffic activity release large amounts of heavy metals into the environment. The soil and dust around many of these transportation facilities can become contaminated with heavy metals and polycyclic aromatic hydrocarbons [5], affecting biotic life. In these regions, plants are able to take up heavy metals through the soil through their roots or from air pollutants through their leaves [4]. According, to estimates from the World Health Organization (WHO), extended exposure to environmental pollution is thought tube the cause of about 25% of human ailments [6]. Soil pollution is a significant problem since it frequently serves as the main location for pollutants discharged into the environment [7]. Soil is essential to the growth and development of both plants and animals, but it can also contain toxins and other dangerous materials that pose a hazard to these living things. According to [8], these materials get into the soil when industrial waste is improperly disposed of. The primary cause of organic and inorganic components found in polluted soil is the careless discharge of untreated garbage onto the ground.

Knowing the types and concentrations of contaminants in these facilities can assist in identifying probable pollution sources and creating solutions. Evaluating the facilities is critical to determining potential health concerns to those working at the transportation facility or living nearby. The study's findings may affect future urban planning and the design of public transport infrastructure in order to lessen their environmental effect. The aim of this research is to investigate the impact of the activities conducted at Deidei, Zuba and Utako Motor Park in Abuja on soil in the surrounding environment.

Materials and Methods

Study Area

Three distinct study locations were chosen within the Federal Capital Territory (FCT) of Nigeria, situated in the North Central Region. These sites include Zuba, Utako, and Dei Dei Motor Park. Zuba Motor Park, Located in Zuba town, within the Gwagwalada Area Council of the FCT, Nigeria. It is situated at Latitude 9°5'47" N and Longitude 7°12'46" E, with an elevation of 432 meters above sea level. Zuba borders Madalla in Niger State and experiences a warm, humid rainy season as well as a hot, dry season. Utako Motor Park: Located in the Utako area within the Abuja Municipal Area Council of the FCT, Nigeria. Situated at Latitude 9.0640° N and Longitude 7.4326° E, this location serves as a major transportation hub in the region.Dei Dei Motor Park: Positioned along the Kubwa-Zuba Expressway, near Zuba, within the Bwari Area Council of the FCT, Abuja.

Figure 1: Map of Zuba Motor Park

Figure 2: Map of Deidei Motor Park

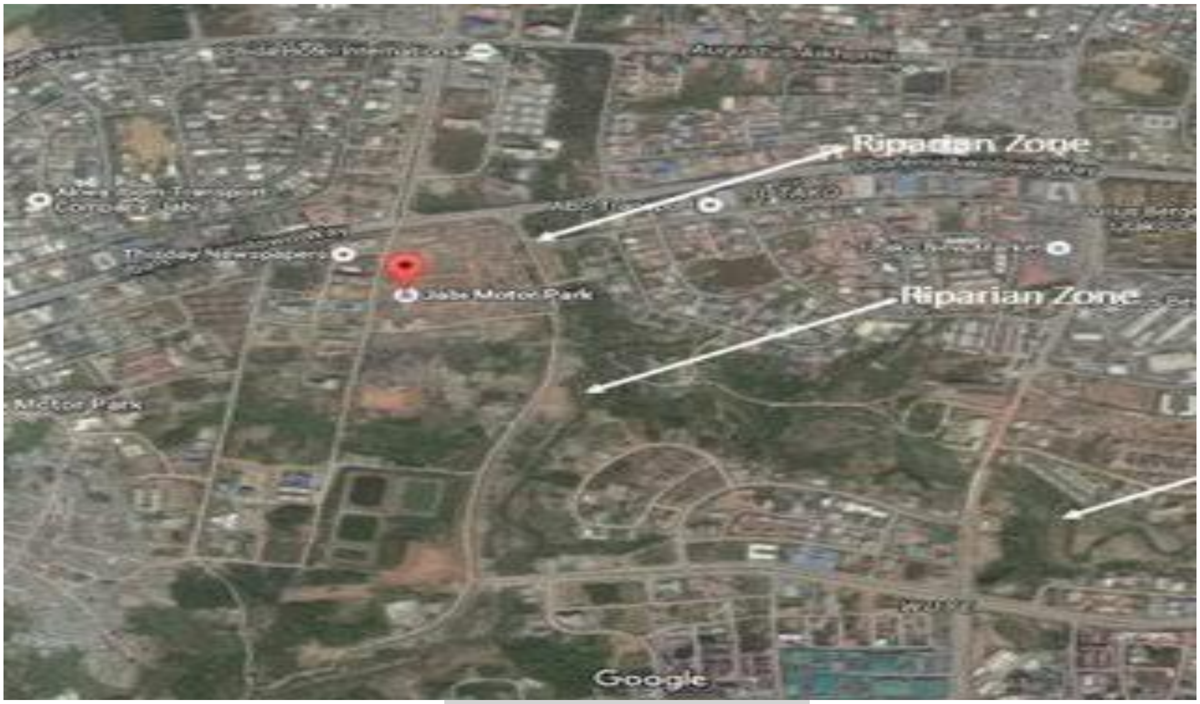


Figure 3: Map of Jabi Motor Park

Sampling and Sample Preparation

Soil samples were carefully collected using a soil auger, with sampling restricted to within two meters of the sampled wells. The exact geographic coordinates (x, y, z) of all sampling points were recorded using a hand-held Global Positioning System (GPS) device, specifically the Garmin 76CSx model, known for its accuracy within 2-3 meters. Samples were pretreated for clean up before analysis. Samples were air dried in the laboratory for 2 weeks and sieved with 100mm mesh one after another to get a uniform mass. The dried samples were taken to and heated at 105°C for about 12 hours each. ng air drying in the laboratory.

Physiochemical Parameters

This study provided a comprehensive analysis of various parameters, including both physical and chemical indicators, and heavy metals. The parameters examined include Temperature (°C), pH, Nitrate (NO_3), Sulfate, Phosphate, Acidity, Electrical Conductivity (EC), Color and Texture as well as heavy metals such as Iron (Fe), Chromium (Cr^{3+}), Cadmium (Cd), and Lead (Pb).

Temperature

The soil temperature was determined by making a hole into the soils at the different sampling points and placing thermometer into the soil 3-4 inches deep for three minutes after which the thermometer reading was obtained. The process was repeated three times and the average reading was taken for each location of the sites.

Determination of soil electrical conductivity

Soil electrical conductivity was measured using electrical conductivity probe on wet samples in the laboratory [9]. 20.00g each of the soil samples was taken and placed in a beaker containing 20.00cm³ of distilled water, after total mixing, the conductor meter tip was placed in each container and stirred, until constant readings were observed. Average of three replicates of readings was taken as mean values for samples [10].

Determination of soil pH

pH values of soil samples were determined using a calibrated pH meter in the laboratory [11]. 20.00cm³ of distilled water was added to about 20.00g sample of each of soil samples and mixed by stirring. The calibrated pH meter was inserted in each of the sample containers using stirring rod to stir the mixture simultaneously until pH meter displays constant reading. Readings from each sample were taken in replicates of three and the average was taken as the mean value for each [12].

Determination of Percentage Total Nitrogen

The Kjeldahl method was used to determine the total nitrogen (TN), as prescribed [13]. It entails digestion, distillation, and titration. The sample soil was broken down in hot, concentrated sulfuric acid, which produced ammonium sulphate from the bound nitrogen. By adding excess concentrated sodium hydroxide, the sulfuric acid was neutralized, turning the solution alkaline. The ammonia that has been released during this process was then distilled into a solution of boric acid, and the amount of nitrogen was measured by titration with a standard acid.

$$\frac{mg}{Kg}N = \frac{Absorbance\ of\ sample\ X\ Conc\ Std}{Absorbance\ of\ Standard} \quad (1)$$

$$\frac{mg}{Kg}NO3 = \frac{mg}{Kg}N\ X\ 4.43 \quad (2)$$

Determination of soil SO_4

Soil suspension (1:5) was filtered after rapid shaking. Then about 50ml of solution was taken in a conical flask, its pH was made up to 4.5 to 5.00 by addition of 50% HCl solution. A few drops of methyl red indicator (0.1%) were added to the solution and finally excess amount of $BaCl_2$ solution (100g $BaCl_2$ in 1 litre solution) for some time (about 20 minutes). Finally, warmed after cooling, the precipitate was filtered through pre-weighed Whatman filter paper 42. Then the precipitate was washed by warm water and then the precipitate was oven-dried along with filter paper to obtain the weight of the precipitate of $BaSO_4$ [14]

Determination of Phosphate

Phosphate concentrations of the soils were also in tandem with the method adopted by [15]. The amount of phosphorus extracted is determined by measuring the intensity of the blue colour developed through the Murphy-Riley Method. The colour is measured with a Brinkman PC 900 probe colorimeter at 880 nm.

Sample Digestion for Metals

Sieved soil samples were digested by adding 10mL each (from 1 mole of HCl and HNO_3) at 1:1:1 HCl-HNO_3-H_2O mixture to 20.00g of soil samples and heated at 98^0C for 1 hour. Heated samples were allowed to cool and then centrifuged at 3500xs for 10 minutes. An aliquot of the supernatant was pipetted and made to volume with 5% conc. HCl. Samples were kept in 50mL capacity polythene bottles for instrumental analysis for Fe, Zn,Mn, Pb, Cu, Cd, Cr, Ni [16]

Analytical Techniques and Laboratory Analysis

The 2005 standard recommendations outlined by the American Public Health Association (APHA) were strictly adhered to during the examination of soil parameter. All samples underwent comprehensive analysis, which includes selected physical, chemical, and heavy metal parameters, using established methods. For heavy metals analysis, an Atomic Absorption Spectrophotometer (AAS) was used. Each 100 ml sample underwent digestion with 5 ml of nitric acid (HNO_3) to liberate organic molecules, heated within the temperature range of 45°C to 65°C, and then transported to Baze University Chemistry Laboratory. Chemical parameters were identified through various titrations tailored to each variable.

Microbiological analysis:

The soil sample was mixed, and a suspension of 1 g (dry weight equivalent) in 10 ml of sterile water was prepared. One ml of the soil suspension was then diluted serially (ten-fold) and used in the estimation of aerobic heterotrophic bacterial and fungal populations by standard spread-plate dilution method. For Bacteriological analyses, various tests were performed in a step-wise pattern to confirm the presence of Pathogens in soil samples.

Total Bacteria Counts

28 grams of nutrient agar was suspended in 1000ml of distilled water by heating and stirring. It was autoclaved for 15 minutes at 121°C, refrigerated and divided into Petri dishes and allowed to cool down at room temperature. The spread plate method was used. Serial dilution of each of the samples of soil was prepared. Of each soil sample, 0.1ml was spread on the nutrient Agar plate and incubated for 24 hours at 37°C. The number of colonies per plate, and the units of colony formation per ml (CFU/ml) were calculated. For the identification of bacterial species, sub cultures were carried out on MacConkey and mannitol salt Agars.

Total Coliform Count

The total coliform count was determined by most probable number (MPN) index method. Serial dilution of the sample was prepared. The 1st set of five tubes had 10ml of double strength MacConkeybroth, the second and third set had 10ml single strength of lactose broth with all the test tubes containing Durham tubes. All the tubes received 1ml of the water samples. These were incubated at 37°C for 24 hours for total coliform count. Acid production was determined by color changes in the tubes to yellow and gas production was determined by the gas trapped in the Durham tubes.

Fecal Coliform Count

The fecal coliform count was estimated using EMB (Eosin Methylene blue Agar) streaking method. A loop of broth from the positive tubes was streaked on EMB Agar. The plates were incubated at 37°C for 24 hours. The Colonies on the EMB plate is metallic green which confirmed the presence of *Escherichia coli strains.*

Statistical analysis

All statistical analysis was performed using Heat map in SPSS11.0 software

Results and Discussion

Heavy metals

The results of the concentration of the selected Heavy metals in the study areas are as presented in table 1, 2 and 3.

Table 1: Results of Concentration of Selected Metals in Soil of Zuba Motor Park

	I (Mg/kg)	II (Mg/kg)	III (Mg/kg)	IV (Mg/kg)	V (Mg/kg)	Mean	Standard Deviation	Control Site (Mg/kg)	WHO (mg/kg)
Ni	40.16	41.17	41.82	39.99	40.00	40.63	0.83	34.96	35
Cu	38.62	37.71	38.10	39.00	37.45	38.19	0.64	36.03	36
Pb	85.05	85.47	85.92	86.14	85.72	85.66	0.86	84.74	85
Mn	512.10	508.21	510.22	512.00	509.61	509.84	1.79	501.1	500
Cd	1.45	1.72	1.00	1.22	1.64	1.41	0.46	0.76	0.8
Cr	108	108.45	106.72	108.92	108.92	108.13	0.85	100.94	100
Zn	82.50	81.62	83.00	80.00	80.00	81.89	1.16	51.3	50
Fe	122	121.78	121.90	122.00	122.00	121.77	0.27	74.62	5000

i

Table 2: Results of Concentration of Selected Metals in Soil in Deidei Motor Park

	I (Mg/kg)	II (Mg/kg)	III (Mg/kg)	IV (Mg/kg)	V (Mg/kg)	Mean	Standard Deviation	Control Site (Mg/kg)	WHO (Mg/kg)
Ni	37.42	36.84	36.10	40.10	39.56	38.06	1.44	35.03	35
Cu	38.14	38.10	42.17	40.16	38.18	39.35	1.80	34.58	36
Pb	86.72	86.45	86.53	86.21	86.17	86.42	0.47	82.16	85
Mn	510.67	515.10	518.14	512.61	514.62	514.23	2.80	500.78	500
Cd	1.21	1.05	1.19	1.24	1.20	1.18	0.23	0.64	0.8
Cr	102.51	103.62	102.78	106.43	101.54	103.38	1.86	98.78	100
Zn	64.80	70.12	72.18	69.45	71.50	69.61	2.88	49.92	50
Fe	92.91	96.02	90.76	92.84	90.16	92.54	2.12	81.60	5000

Table 3.0: Results of Concentration of Selected Metals in Soil in Utako Motor Park

	I (Mg/kg)	II (Mg/kg)	III (Mg/kg)	IV (Mg/kg)	V (Mg/kg)	Mean	Standard Deviation	Control Site (Mg/kg)	WHO (Mg/kg)
Ni	42.23	42.64	43.01	41.17	42.84	42.38	0.74	33.21	35
Cu	40.20	39.69	43.14	40.62	41.04	41.04	1.35	35.68	36
Pb	85.94	86.20	85.91	85.98	86.04	86.04	0.13	85.02	85
Mn	508.10	507.89	505.45	510.10	507.74	507.74	1.73	499.62	500
Cd	0.98	0.96	1.10	0.94	1.02	1.02	0.08	0.83	0.8
Cr	101.75	101.62	102.34	101.96	102.22	102.22	0.74	100.12	100
Zn	57.86	54.11	55.86	59.10	56.25	56.25	3.35	50.69	50
Fe	87.45	88.9	87.23	84.92	87.398	87.398	1.47	85.23	5000

The mean concentrations of Zinc examined across the three motor parks ranged between 56.25-81.89 mg/kg with Zuba having the highest concentration of 81.89mg/kg. This indicates a higher Zinc concentration in the soil of these motor parks compared to the control site, underscoring the impact of Zinc in the area. Notably, all recorded Zinc concentrations exceeded the WHO's permissible limit of 50mg/kg and also higher than a mean zinc content of 31.59±2.032mg/kg and 48.52±3.647mg/kg at the lower and upper zones as obtained by [7]. It is also higher than zinc mean concentration range of 0.09 - 1.18 mg/kg obtained by [17]. The elevated Zinc levels are attributed to vehicular movement where Zinc is commonly found in lubricating oils. Various factors such as the age of the cars, workload, lubricant preferences, waste disposal practices, and soil type may contribute to this phenomenon.

The mean concentrations of Iron examined across the three motor parks ranged between 7.39 – 121.00 mg/kg with Zuba having the highest of 121.00 mg/kg. This indicates a higher Iron concentration in the soil of the motor parks compared to the control site, highlighting the influence of automobile activities in the area. However, all recorded Iron concentrations fall within the WHO's permissible limit, which poses no immediate threat to human health or agricultural activities. The increased Iron content in the soil is likely attributed to the various wastes generated in the parks, including solvents, hydraulic fluids, spent lubricants, metalworking activities, welding residues, and iron debris. Although Fe is not classified as a toxic metal, its concentrations and chemical form can influence the speciation of Pb and its toxicity [18]. The mean concentrations of Nickel examined across the three motor parks ranged between 38.06mg/kg - 42.38 mg/kgwith Utako motor having the highest values of 42.38 mg/kg. This indicates a higher Nickel concentration in the soil of auto mechanic workshops compared to the control sites. Nickel's mean concentrations in the parks exceed the WHO standard, suggesting potential negative impacts on human health. These Nickel concentrations in the study area could be particles emitted by braking and tire wear from vehicles which contain significant amounts of nickel, further contributing to its presence in the environment. Human exposure to highly nickel-polluted environments has the potential to produce a variety of pathological effects. Among them are skin allergies, lung fibrosis, cancer of the respiratory tract and iatrogenic nickel poisoning [19, 20].

The mean concentrations of copper examined across the three motor parks ranges from 38.19 mg/kg to 41.04 mg/kg with Utako having the highest value. Notably, the Copper concentration at the motor parks exceeded that of the control site. The value is higher than0.18 – 0.19 mg/kg obtained by Mohammed et al [17] in the study of the soil of some selected motor parks within Maiduguri metropolis. Again, the mean Copper concentration recorded from the three motor parks surpasses the WHO permissible limit, indicating significant soil contamination. Presence of copper could be ascribed to the wearing of metal bearings and babbit metal bushings [17]. It has been reported that improperly discarded oils which leaches into the soil contain high proportion of copper as well as lead and antimony [21].

The Manganese mean concentrations examined across the three motor parks ranges from 507.74 mg/kg to 514.23 mg/kg. Deidei Motor Park has the highest concentration of 514.23mg/kg. From the results, it’s evident that the Manganese concentration at the motor parks exceeded that of the control site, which shows the impact of Manganese concentration in the soil. Again, all recorded Manganese concentrations surpassed the WHO's permissible limit, indicating significant soil contamination across all sites. The Chromium mean concentrations examined across various motor parks ranges from 102.22 -108 mg/kg. Zuba has the highest value of 108 mg/kg. This indicates a higher Chromium concentration at motor parks compared to the control site. The result is also higher than 0.06 – 0.11 mg/kg obtained by Magaji *et al* [22]. Again, all recorded Chromium concentrations exceed the WHO's permissible limit, indicating significant soil contamination. Pistol rings of automobile and seals could likely be a source of chromium to the soils. A chromium compound is carcinogenic and causes gastrointestinal hemorrhage, hemolysis and acute renal failure [17].

The Mean concentration of Lead (Pb) examined at various motor parks ranges from 85.66 - 86.42mg/kg. Dei dei has the highest concentration of 86.42 mg/kg. The higher Lead concentration at the motor parks indicates the impact of automotive activities on soil contamination. From the results obtained, it shows that the mean concentration of lead in the three motor parks exceeds the WHO permissible limit. Soil Pb concentrations greater than 1.0 mg/kg generally indicate a local source of pollution [23]. The high lead contents in motor park soil samples could further be linked up with the automobile tail-pipe which accounts roughly two-thirds emission of Pb into the atmosphere [24]. The results of the analysis as shown in table 1, 2 and 3 for the selected areas proves that the content of heavy metals in the soils was restricted to top soil [25]

Physicochemical Parameters

The results of the physicochemical parameters in the study areas are as presented in table 4, 5and 7.

Table 4: Physicochemical Parameters of Soil Obtain From Zuba Motor Park

Parameters	Sample I	Sample II	Sample III	Mean Value	WHO
PH	6.20	6.16	6.14	6.17	6.8.5
Temperature (⁰C)	28.1	27.9	27.6	28.3	25
Conductivity (μs/cm)	29.8	27.6	29.2	28.9	110-570
Color	Reddish Brown	Reddish Brown	Reddish Brown		
Texture	Sandy loamy clay	Sandy loamy clay	Sandy loamy clay		
Acidity (mg/l)	0.56	0.48	0.64	0.56	5.0
Nitrate (mg/l)	12.90	13.24	13.61	13.25	10
Sulfate(mg/l)	186	174	192	184	8000
Phosphate(mg/l)	1.45	1.30	1.22	1.32	0.2

Table 5: Physicochemical Parameters of Soil Obtain from Deidei Motor Park

Parameters	Sample I	Sample II	Sample III	Mean Value	WHO
PH	6.13	6.18	6.21	6.17	6-8.5
Temperature (⁰C)	27.2	27.8	28.0	21	25

Conductivity(µs/cm)	34.2	30.6	30.8	31.9	110-570
Color	Dark Brown	Dark Brown	Dark Brown		
Texture	Silt clay loamy	Silt clay loamy	Silt clay loamy		
Acidity (mg/l)	0.21	0.16	0.24	0.2	5.0
Nitrate(mg/l)	10.8	10.30	12.12	11.07	10
Sulfate(mg/l)	108	112	143	121	8000
Phosphate (mg/l)	3.19	3.38	2.46	1.32	0.2

Table 6: Physicochemical Parameters of Soil Obtain from Utako Motor Park

Parameters	**Sample I**	**Sample II**	**Sample III**	**Mean Value**	**WHO**
PH	6.24	6.26	6.05	6.18	6.85
Temperature(^{0}C)	28.0	28.4	28.2	28.2	25
Conductivity (µs/cm)	52.5	48.9	51.2	50.9	110-570
Color	Reddish Brown	Reddish Brown	Reddish Brown		
Texture	Sandy loamy clay	Sandy loamy clay	Sandy loamy clay		
Acidity (mg/l)	0.67	0.72	0.52	0.64	5.0
Nitrate (mg/l)	17.20	16.86	16.57	16.88	10
Sulfate (mg/l)	120	189	124	144.3	8000
Phosphate (mg/l)	5.62	6.87	5.94	6.14	0.2

The average values of pH of the soils from the motor parks ranged from 6.17- 6.18. The values observed in this study are similar with the values reported elsewhere [26, 27], but higher than the values reported in some similar studies [28, 29]. The soil acidity could be due to the anthropogenic activities in the study area. The degree of acidity and/or alkalinity is a key parameter controlling heavy metal transfer behavior and is considered a master variable that affects nearly all soil properties.

The average Ec values for soil in the study areas ranged from 28.9 to 50.9 µs/cm with Utako Motor Park having the highest mean value of 50.9 µs/cm. The values are however higher than those reported in another study [30], but lower than the values reported in some other studies [31]. In general, the presence of ions in the soil, which raises Ec, is what causes the high Ec in the study area. The high conductivity values recorded in this study might have resulted from the presence of some metal scraps and some spilled acids probably from abandoned motor batteries.

The average values of the Nitrate ions in the soil of the study areas ranged from 11.07- 16.88 mg/l. Utako has the highest value of 16.88 mg/l. All the values from the soil samples fall within the WHO permissible limit of 10 mg/L. The results of nitrates at all the locations were found to be in conformity when compared with USEPA permissible value of 8000 mg/kg for uncontaminated soil.

The average values of the Sulfate ions in the soil of the study areas ranged from 121-184 mg/l. Zuba has the highest value of 184 mg/l. The soil samples from the three motor parks are less than WHO limit of 8000mg/l. The elimination of sulfate ions by bacterial action is most likely the cause of the low sulphate ion concentration in the soil samples.

The average temperatures for the three motor parks are 28.3^{0}C, 21^{0}C, 28.2^{0}C for Zuba, dei dei and Utako motor parks respectively. Zuba and Utako soils have quite high temperatures, higher than WHO permissible limit of 25^{0}C which suggest that the soils are impacted by the anthropogenic activities. Heavy metals are emitted during high temperature processes such as oil combustion in automobiles, electric power stations, and industrial plants as well as refuse incineration.

The color of the soil samples appeared to be reddish brown, dark brown. This color variation might have resulted from excess iron concentration in soils which imparts a reddish color, and increases the turbidity of water. Variation in physicochemical and heavy metal parameters is the function of waste management strategies and seasons.

The textural soil class of Sandy clay loam, Sandy loamy clay, sandy loamy clay Silty clay loamy, Silty clay loamy, Silt clay loam, Sandy clay loam, Sandy loamy clay, sandy loamy clay using the United State Department of Agriculture (USDA) textural class triangle of all profiles were obtained from the soil samples. It's possible that erosion removed loose particles from the surface, resulting in the higher level of clay seen in majority of the samples. Since textural classes with high silt and clay content typically have greater soil organic matter, the textural class results for the samples likewise match those with high organic matter.

Microbiological Parameters

Results of microbiological parameters of soil from the three motor parks are shown in table 7, 8 and 9 respectively.

Table 7: Results of the Microbiological Parameters of Soil Samples Obtained From Zuba Motor Park

Parameters	TBC (CFU/mL)	TCC (CFU/mL)	E. *coli*(CFU/mL)
Soil Sample I	54	Nil	Nil
Soil Sample II	61	Nil	Nil

Table 8: Results of the Microbiological parameters of Soil Samples Obtained From Deidei Motor Park

Parameters	TBC (CFU/mL)	TCC (CFU/mL)	E. *coli*(CFU/mL)
Soil Sample I	85	Nil	Nil
Soil Sample II	72	Nil	Nil

Table 9.0: Results of the Microbiological parameters of Soil Samples Obtained From Utako Motor Park

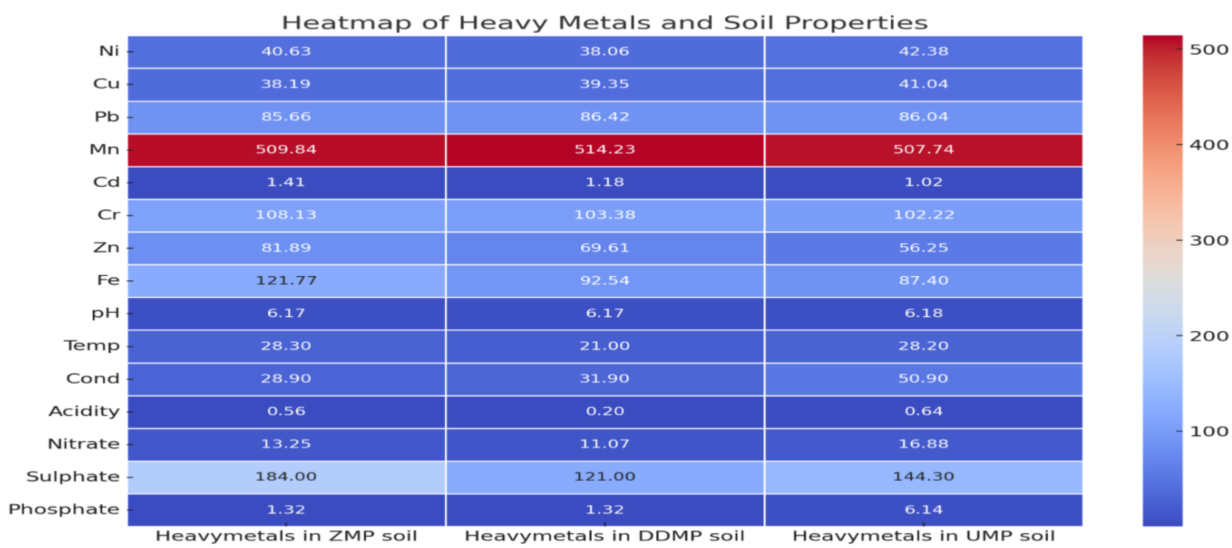
Parameters	TBC (CFU/mL)	TCC (CFU/mL)	E. *coli*(CFU/mL)
Soil Sample I	66	Nil	Nil
Soil Sample II	71	Nil	Nil

For soil samples, the following parameters were analyzed: total bacteria count, total coliform count, and E. coli. In accordance with WHO standards, the concentration of total coliform count and E. coli should be absent, negative, or less than one colony forming unit per 100ml (cfu/100ml). As shown in the table 7, 8 and 9, there was no trace amount of total coliform count or E. coli present. Also from the results, the total count of bacteria was found to bebelow WHO permissible limit of 100CFU/mL. The coliform group of bacteria is the principal indicator of faecal pollution of human wastes, while the presence of E. coli in the soil indicates the possibility of the presence of disease-causing organism.

The Result of the Correlations of the parameters determined in the soils

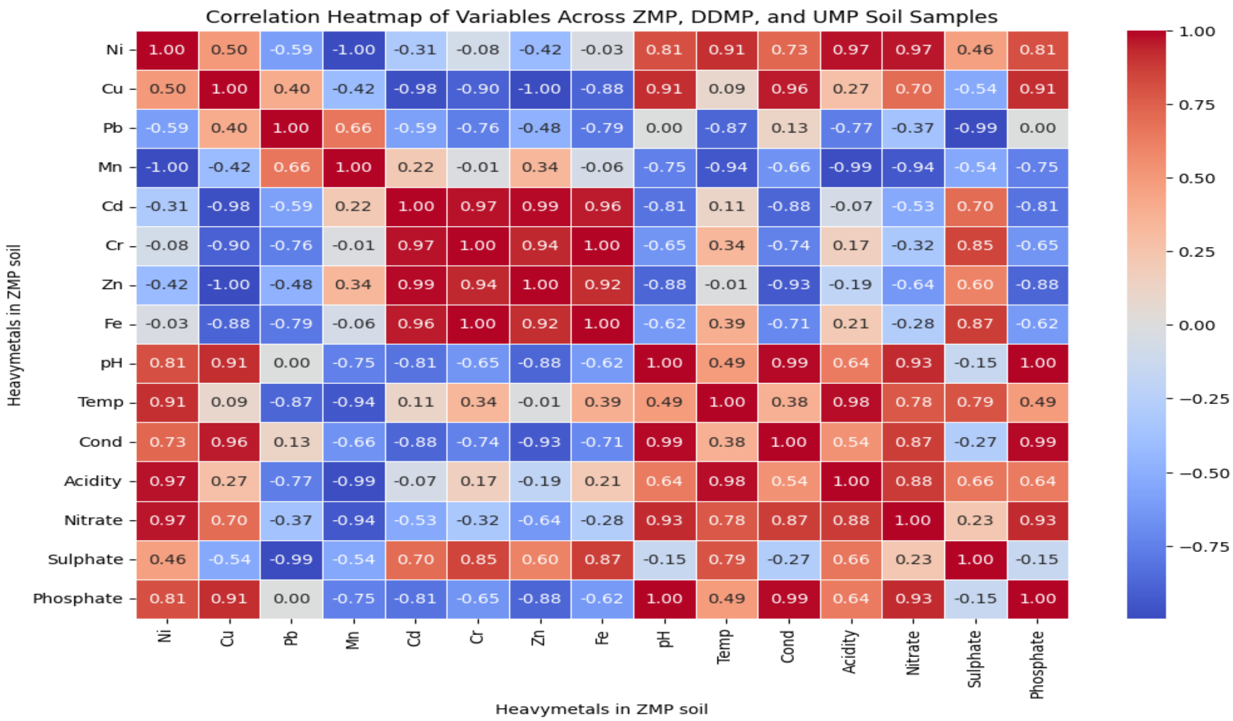
The results of correlation of physicochemical properties and Heavy metals of the soils of the study areas are shown in table 10 and 11 respectively.

Heatmap of Heavy Metals and Soil Properties



The color gradient on the right side of the heat map in table 10 shows a range from blue to red, where blue represents lower values, and red represents higher values. The scale ranges from around 0 to 500.Mn is the most prominent in all three soil samples, with values exceeding 500, which is why these rows are highlighted in red. Most other elements and properties are in the lower range, with blue shades, indicating relatively lower concentrations. For example, Cd, Cu, Ni, and pH have lower values across all soils.

Table 1: Correlations Heatmap of Variables Across the Three Motor Parks and Soil Samples



From the table 11.0, Fe and Cr, Zn, Cd showed very high positive correlations with each other, with coefficients close to +1, indicating they tend to increase together across the soil samples. pH is positively correlated with Phosphate and Nitrate, suggesting that higher pH (less acidic) conditions are associated with higher concentrations of these nutrients. Mn has strong Negative Correlations with Ni, Cu, Pb, Cr, Zn, Fe indicating that when Mn concentrations are high, the levels of these metals are low, and vice versa. Acidity shows a strong negative correlation with Cr, Zn and Fe, which might suggest that more acidic conditions reduce the availability or concentration of these metals in the soil. Temperature shows moderate negative correlations with Cu and Pb, suggesting that higher temperatures may be associated with lower concentrations of these metals. Nickel (Ni) and Manganese (Mn) exhibit a strong negative correlation (-1.00), suggesting that in these soil samples, when Ni levels are high, Mn levels are very low.

Conclusion

The results of this study revealed the soil in Zuba, Deidei and Utako Motor Parks are significantly contaminated with Zinc, Nickel, Chromium, Lead with concentration above the WHO's permissible limits for residential area. Most of the physicochemical parameters determined were within the standard limits for residential and agricultural soils. The microbiological results showed no trace amounts of total coliform count or E. coli present in all the samples. Both strong positive and negative correlations were observed among the parameters determined. Various environmental mismanagement practices like improper disposal of toxic lubricants, accumulation of scrap metals, oil leakage, improper handling and disposal of car batteries, brake pads, and engine parts must have led to the level of contamination observed in these study areas. Long term exposure to these pollutants can have severe ecological impacts, including reduced soil fertility, disruption of plant growth, and bioaccumulation of toxins in the food chain. The presence of these contaminants shows the need for stringent pollution control measures to prevent further degradation of soil quality.

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