



## Evaluation of Some Physico-Chemical Properties of Roadside Soils of Zaria-Giwa Road, Kaduna State, Nigeria

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### ABSTRACT

Studies on the evaluation of Particle size characterization, pH, Organic matter and Electrical conductivity in roadside soils of Zaria-Giwa road, Kaduna state, Nigeria was carried out. The soils were collected at four different locations namely: Ahmadu Bello University Teaching Hospital (ABUTH), National Animal Production Research Institute (NAPRI Shika), Marabar Guga and Ahmadu Bello University Dam Quarters (control). The samples were collected at a distance of 0, 5, 10, 20, 40 and 100 m away from the edge of the road. Standard procedures were used in the determination of Soil texture, pH, OM and EC. The data obtained were subjected to Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was used to separate the means where necessary. Vehicular density was computed. The result revealed that, soil texture was predominantly sandy loam at all locations except for ABUTH which was predominated by loam soil at all distances. The values recorded at ABUTH for all the parameters (6.54, 5.67% and 103.50  $\mu\text{scm}^{-1}$  for pH, OM and EC respectively) were found to be significantly higher than the control at ABU Dam Quarters (6.27, 2.73 % and 43.33  $\mu\text{scm}^{-1}$  for pH, OM and EC respectively). However, with respect to distance, the highest and lowest of all parameters were observed at 0 and 100 m respectively. Distance from the roadside and vehicular densities of the sampled locations had a significant effect on all the physicochemical properties assessed in the roadside soil. The texture of the soil, slight acidic nature of the soils as well as OM and EC values recorded in this study are suggestive of a higher heavy metal pollution index of the roadside soils of Zaria-Giwa road. In view of these findings, there is need for regular monitoring of physicochemical properties of the roadside soils as well as the heavy metal concentrations in soils because of the possibility of being transferred to man through food chain. Farmers are advised to keep some distance away from the roadside before planting of crops in order to reduce the negative impact of the aforementioned parameters.

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### INTRODUCTION

Pollution is a global issue with significant potential to affect people's health (Rehman, et al., 2021). Public awareness is being raised by the alarming extent of the pollution caused by cars and industrial effluents (Begum et

al., 2009). The ecology as a whole, plants, especially those found in tropical rain forests, and the health of people and animals are all suffering greatly from excessive pollution (Khan and Ghouri, 2011). Numerous ailments, affecting not just the elderly but also the young and active, as

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well as all animals and plants, are brought on by pollution (Kanmony, 2009).

In fact, the world health organization report points out that twenty million children worldwide suffer from pollution which has become critical because of overpopulation. According to Paul et al. (2015), soil is a naturally occurring body made up of layers of mineral ingredients that vary in thickness and have different morphological, physical, chemical, and mineralogical properties from the parent materials. It is made up of fractured rock fragments that have undergone physical, chemical, and environmental changes due to weathering and erosion. It also contains a mixture of solid, gaseous, and aqueous minerals and organic components (Chesworth, 2008). Both rural and urban ecosystems depend heavily on soil, and in both cases, land management is the key to high-quality soil (Numbere, 2019). Vehicular emission and industrial waste can affect the physicochemical properties of roadside soil and eventually result in heavy metal contamination leading to serious effect on plants and animals particularly when such soils are used for agricultural activities (Upahi et al., 2021).

The quality of soil depends on its physico-chemical properties which include Particle size distribution, pH, Organic matter and Electrical conductivity. These properties largely determine the suitability of a soil for all forms of pollution particularly heavy metals and the management requirements to keep it most productive. It is a fact that, the behaviour and fate of metals are governed by a range of different physico-chemical processes, which dictate their availability and mobility in the soil or sediment system (Osazee et al., 2013). Contamination of agricultural soil by heavy metals has become a critical environmental concern due to their potential adverse ecological effects. Such toxic elements are considered as soil pollutants due to their widespread occurrence and their acute and chronic toxic effect on plants grown on such soils

and the subsequent transfer of such metals to man through food chain (Upahi et al., 2021).

Zaria-Giwa road is a very important busy highway between Zaria and Giwa. This is because it serves as the major route to many important cities such as Funtua, Zamfara, Katsina and Sokoto state. Due to rapid urbanization, increased population and increased income of the populace, there has been an increase in the density of vehicles plying the road which can eventually increase the load of vehicular emissions on the road and by extension directly affects road side soils that remain in contact with these pollutants. Therefore, an assessment of roadside soil physicochemical properties is especially important for agricultural as well as non-cultivated areas due to the fact that, there exist a strong synergy between the soil properties and other elements that are potentially harmful to human health (Szynkowska et al., 2009). The ultimate aim of this study is to assess some Physico-chemical properties such as soil particle Size characterization, Soil pH, Organic matter and Electrical conductivity with respect to distance from the roadside and sampling locations across the study area.

## MATERIALS AND METHODS

### Area of Study

The study was carried out along Zaria-Giwa road. Zaria metropolis is located at latitude 11° 3'N and longitude 07° 40'N and is presently one of the most important cities in Northern Nigeria. As at 2007 Census, it had a population of 1,018,827 (TWG, 2007). The major activity of the people within the area is farming. Three sampling locations were selected along Zaria-Giwa road and the fourth location was at ABU Dam Quarters, along ABU Postgraduate School which served as the control site because of its low vehicular density. The locations include ABUTH, NAPRI-Shika, Maraba-guga and ABU Dam Quarters (control).

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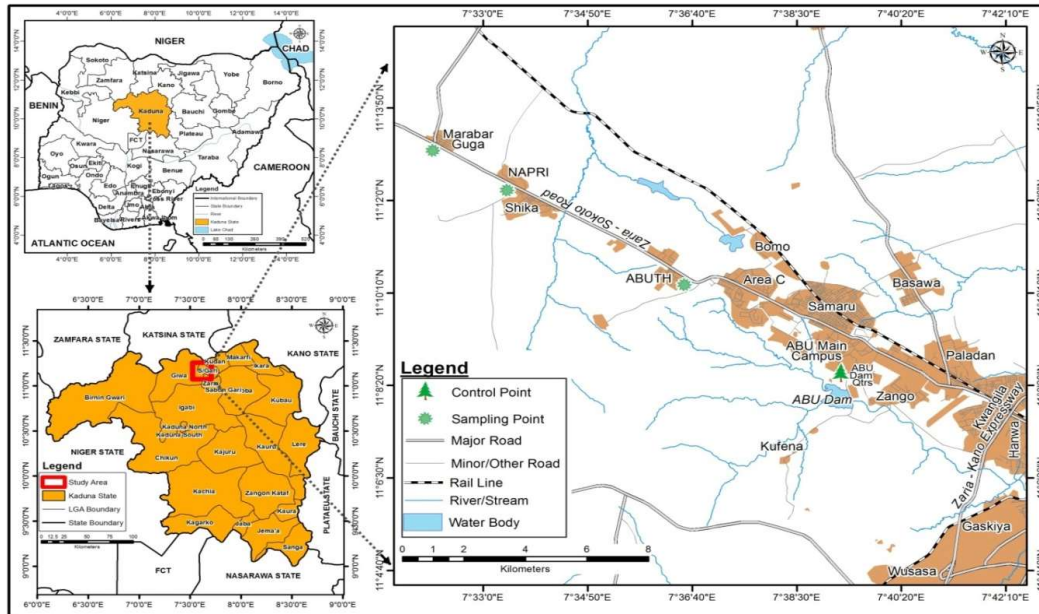


Figure 1: Map of Sabon Gari/Zaria showing the four sampling points

### Sample Collection and Preparation

The soil samples were collected from four different sampling locations along Zaria-Giwa road and along Ahmadu Bello University Dam Quarters, namely: Ahmadu Bello University Teaching Hospital (ABUTH-Shika), National Animal Production Research Institute (NAPRI-Shika), Maraba-guga and ABU Dam Quarters (control). The interval of separation between the sampling areas is about 3-5 km. Samples were collected at each of the sampling location at a distance of 0, 5, 10, 20, 40 and 100 m away from the edge of the road. At each sampling point, three topsoil samples were collected at a depth of 0-10 cm using a soil auger and thoroughly mixed to form a composite sample, and transferred immediately into labeled polythene bags after which they were transported to the laboratory in the Department of Biology, Ahmadu Bello University, Zaria where the samples were spread in plastic trays and air dried to constant weight. Stones, debris, clods etc. were removed and then passed through a 2 mm sieve to remove coarse particles and placed in polythene bags prior to analysis. (Upahi *et al.*, 2021).

### Physico-chemical Properties of Soil

Soil Physicochemical properties such as soil pH, soil conductivity, particle size distribution and organic matter were conducted at the Nitrogen Laboratory in the Department of Soil Science, Ahmadu Bello University, Zaria.

### Determination of Soil pH

Soil pH was determined using the method of Black (1965). 20 g of dried soil was weighed into a 50 ml beaker, 20 ml of distilled water was equally added into the beaker, and then the mixture was stirred with a glass rod and allowed to stand for 30 minutes. A pre calibrated, HANNA pH Meter (Model H1991000) was inserted into the slurry and the pH was recorded.

### Determination of Electrical conductivity

Electrical conductivity was determined using the method of Wilcox (1950). 25 g of an air-dried soil sample was placed in a 250 ml beaker, followed by addition of distilled water gradually over the entire soil surface in a uniform pattern, until the soil was completely wet. A stainless steel spatula was used to form a homogeneous soil

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paste. The beaker was then covered with a Petri – dish and 50 ml of distilled water was added and shaken for 1 hour by an electric shaker. The electrode of the conductivity meter was inserted and the readings of the electrical conductivity of the soil samples were taken.

#### Determination of organic matter

Organic matter was determined using the method of Walkey and Black (1937). 1 g of the soil sample was weighed into 250 ml conical flask and 10 ml of 0.2 M potassium dichromate ( $K_2CrO_7$ ) solution was added. The flask was swirled gently to disperse the soil in the solution, after which 20 ml of concentrated sulphuric acid ( $H_2SO_4$ ) was added quickly and then mixed thoroughly. The mixture was allowed to cool for 30 minutes after which 200 ml of water was added, followed by 10 ml of concentrated phosphoric acid and 2-3 drops of Ferriin indicator. The solution was titrated against 0.4 M ferrous ammonium sulphate solution. The colour changes from bluish green to brilliant green indicating the end point. A blank titration was carried out using distilled water without the soil sample. After which organic matter content was calculated through the following steps:

$$\% \text{ OM} = \frac{10(B-S)}{WB} \times \frac{12}{4000} \times \frac{1.729}{0.77} \times 100$$

Where B = volume of ferrous solution used in the blank titration, S = volume of ferrous solution used in the sample titration, WB= weight of soil sample used in the analysis, 1.729 = Factor for organic matter from carbon, 0.77 = Walkey's recovery factor,  $\frac{12}{4000}$  = meq weight of carbon, 10 = conversion factor for units. Therefore,  $\% \text{ OM} = \frac{(B-S) \times 6.7}{WB}$

#### Determination of soil particle size distribution / soil texture

The soil particle size distributions were determined using the method of Bougoucos (1951). 50 g of the prepared soil sample was weighed into a 250 ml plastic beaker after which 100 ml of 50 % calgon and 100 ml distilled water were added and then stirred with a glass rod. The beaker with its content were left to stand for 30

minutes with occasional stirring and then transferred into a 250 ml plastic container and shaken with an electrical shaker for ten minutes. The sample was then transferred into a 1000 ml measuring cylinder and made up to the mark with distilled water. The suspension in the cylinder was mixed vigorously using a long handle plunger making sure that the sediment at the bottom was thoroughly disturbed before the hydrometer reading was taken. Readings at 40 seconds and 2 hrs were taken. A blank solution was prepared without the soil sample by making 100 ml of the 50% calgon solution up to the 1000 ml marks with distilled water. The blank hydrometer reading was taken at 40 seconds and 2 hours interval. The temperature of the suspension and blank were also taken. The first reading was taken at 40 seconds which measured the % of silt in the suspension, through the formula:

$$\% \text{ silt} = \frac{\text{sample reading at 40 seconds} - \text{blank reading}}{\text{Weight of soil used in the analysis}} \times 100$$

The second reading taken 2 hours later measured the % of total clay in the suspension through the formula:

$$\% \text{ clay} = \frac{\text{sample reading at 2 hrs} - \text{blank reading}}{\text{Weight of soil used in the analysis}} \times 100$$

While the % sand was calculated using the formula:

$$\% \text{ Sand} = 100 - (\% \text{ clay} + \% \text{ silt})$$

Meanwhile, the results were all corrected to a temperature of 68° Fahrenheit (20°C) before the calculations. The soil texture was equally determined from the textural triangle.

#### Determination of Vehicular Density

Visual counting of vehicles plying the entire sampling sites was done for 2 hours daily for a period of one week and the average vehicular density per hour was computed (Akpan and William, 2014)

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### Statistical Analyses

The data obtained were subjected to Descriptive statistics, one-way Analysis of variance (ANOVA) was used to test the means. Where there was significant difference in means, Duncan's multiple range test (DMRT) at ( $P \leq 0.05$ ) was used to separate the means.

## RESULTS

### Particle Size Characterization of the Roadside soil

The particle size characterization of the soil across the sampling location is presented in Table 1. At NAPRI Shika and Marabar Guga, the soil textural class were all observed to be sandy loam at all distances from the road (Table 1). At NAPRI Shika, percentage clay, silt and sand were in the range of (11.00-13.00 %), (30.00-32.00 %), and (56.00-58.00 %) respectively. However, at Marabar Guga, percentage clay, silt and sand were in the range of (7.00-9.00 %), (35.40-39.10 %) and (53.10-56.20 %) respectively. The soil textural class observed at all distances from the road at ABUTH were all found to be loam and the percentage clay silt and sand were in the range of (8.00-11.50 %), (38.00-41.00 %) and (49.00-52.00 %) respectively. At ABU Dam Quarters (control) sandy loam soil was observed at 0, 5, 10 and 20 m away from the road while loam soil was observed at both 40 and 100 m from the road. However, the percentage clay, silt and sand at all distances in this location were in the range of (3.50-6.00 %), (40.00-45.20 %), and (50.00-56.00 %) respectively (Table 1).

### Physico-chemical Properties of Roadside soil across each of the sampled location

The physico-chemical properties of the roadside soil across the sampling location is presented in Table 2. The soil properties that were determined include pH, electrical conductivity and total organic matter (TOM). Generally, significant difference was observed across all the distances at the various locations. At ABUTH, the highest soil pH observed at 0 m was significantly higher than those observed at all the other distances. This was followed by that observed at 5 m from the roadside. The lowest value observed at 100 m

was significantly lower than all the other distances at ABUTH. Similar trend was observed at NAPRI Shika in the sense that, the highest soil pH observed at 0 m was significantly higher than those recorded at all the other distances across the sampling location. However, the lowest value observed at 40 m from the roadside was also significantly lower than all the other distances across NAPRI Shika (Table 2). At Marabar Guga, the highest soil pH observed at 0 m was similar to that at 20 m but significantly lower than those recorded at all the other distances across the sampling location. Also, the lowest value observed at 100 m from the roadside was also significantly lower than all the other distances across Marabar Guga (Table 2). At ABU Dam Quarters (control), the highest value recorded at 5 m was significantly higher than all the other distances. This was followed by that at 0 m which was similar to those at 10, 20 and 40 m from the roadside. The lowest value observed at 100 m from the roadside was also significantly lower than all the other distances across ABU Dam Quarters (Table 2).

The highest value of soil organic matter at ABUTH and Marabar Guga were observed at 0 m. this value was similar to that at 5 m but significantly higher than those recorded at all the other distances in across the two locations. Similar trend was observed at NAPRI Shika and ABU Dam Quarters (control) in the sense that the highest value observed at 0 m in the two locations were significantly higher than those recorded at all the other distances from the roadside. However, the lowest values of organic matter across the four sampling locations were observed at 100 m and they were significantly lower than those recorded at all the other distances from the road sides across the sampling locations (Table 2).

All the locations showed similar result for Electrical conductivity in the sense that, the highest value of EC was recorded at 0 m at each of the location and it was significantly higher than those recorded at all the other distances from the road. The lowest values of EC recorded at 100 m at ABUTH, Marabar Guga and ABU Dam Quarters were similar to that at 40 m in each of the location but significantly lower than those recorded at all the other distances from the roadside. However,

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the lowest value of EC recorded at 100 m at NAPRI Shika was significantly lower than those observed at all the other distances from the roadside in that location (Table 2).

### Physico-chemical Properties of Roadside Soil (Pooled data) based on Distance from the Road and Sampled Locations

Generally, the pooled data revealed that, significant difference was observed with respect to distance and location in all the parameters assessed (Table 3 and 4). The highest soil pH observed at 0 m was similar to that at 5 and 20 m from the roadside but significantly higher than those observed at all the other distances. This was followed by that observed at 10 m which was similar to that at 40 m from the roadside. The lowest value observed at 100 m was significantly lower than all the other distances in all the sampled locations (Table 3). The highest soil organic matter observed at 0 m was similar to that at 5 and 10 m from the roadside but significantly higher than those observed at all the other

distances. This was followed by that observed at 20 m which was similar to that at 40 m from the roadside. The lowest value observed at 100 m was significantly lower than all the other distances in all the sampled locations (Table 3). The highest soil EC observed at 0 m from the roadside was significantly higher than those observed at all the other distances. This was followed by that observed at 5 m which was similar to that at 10 and 20 m from the roadside. The lowest value observed at 100 m was significantly lower than all the other distances in all the sampled locations (Table 3).

The result based on location followed similar trend for Soil pH and EC in the sense that, the highest values observed at ABUTH in the two parameters were only significantly higher than the lowest value recorded at ABU Dam Qtrs (control). However, the highest value of Organic matter recorded at ABUTH was significantly higher than all the other locations across the study area (Table 4).

**Table 1:** Particle Size Characterization of the Roadside soils across the Study Area

Location	Distance(m)	Particle Size Characterization			Textural Class
		Clay (%)	Silt (%)	Sand (%)	
ABUTH	0	10.00	40.00	50.00	Loam
	5	9.50	40.50	50.00	Loam
	10	10.00	41.00	49.00	Loam
	20	11.50	38.00	50.50	Loam
	40	10.20	40.30	49.50	Loam
	100	8.00	40.00	52.00	Loam
NAPRI Shika	0	12.00	30.10	57.90	Sandy loam
	5	11.00	31.00	58.00	Sandy loam
	10	10.00	32.00	58.00	Sandy loam
	20	13.00	31.00	56.00	Sandy loam
	40	12.50	30.50	57.00	Sandy loam
	100	12.00	30.00	58.00	Sandy loam
Mrabar Guga	0	7.80	39.10	53.10	Sandy loam
	5	7.00	37.20	55.80	Sandy loam
	10	9.00	35.40	55.60	Sandy loam
	20	7.20	38.50	54.30	Sandy loam
	40	8.30	35.50	56.20	Sandy loam
	100	8.00	36.00	56.00	Sandy loam
ABU Dam Qtrs	0	4.00	40.00	56.00	Sandy loam
	5	3.50	40.50	56.00	Sandy loam

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10	4.80	42.20	53.00	Sandy loam
20	3.80	45.20	51.00	Sandy loam
40	6.00	44.00	50.00	Loam
100	5.20	42.50	52.30	Loam

**Table 2:** Physico-chemical Properties (pH, OM and EC) of the Roadside soils across the Study area

Location	Distance	Physico-chemical Parameters		
		pH	Organic Matter (%)	Electrical Conductivity ( $\mu\text{scm}^{-1}$ )
ABUTH	0	6.68±0.00 <sup>a</sup>	3.67±0.00 <sup>a</sup>	250.67±1.15 <sup>a</sup>
	5	6.65±0.01 <sup>b</sup>	3.67±0.01 <sup>a</sup>	99.67±0.57 <sup>b</sup>
	10	6.61±0.01 <sup>c</sup>	3.18±0.01 <sup>b</sup>	100.00±0.58 <sup>b</sup>
	20	6.52±0.01 <sup>d</sup>	2.13±0.06 <sup>c</sup>	91.00±0.58 <sup>c</sup>
	40	6.45±0.01 <sup>e</sup>	1.93±0.03 <sup>d</sup>	41.33±0.88 <sup>d</sup>
	100	6.33±0.00 <sup>f</sup>	1.16±0.04 <sup>e</sup>	38.33±0.88 <sup>d</sup>
	P value	0.000**	0.000**	0.000**
NAPRI-Shika	0	6.82±0.02 <sup>a</sup>	5.16±0.01 <sup>a</sup>	190.00±0.00 <sup>a</sup>
	5	6.53±0.00 <sup>d</sup>	4.50±0.01 <sup>b</sup>	150.00±0.00 <sup>b</sup>
	10	6.49±0.01 <sup>e</sup>	4.35±0.01 <sup>b</sup>	132.00±1.15 <sup>c</sup>
	20	6.56±0.00 <sup>c</sup>	4.56±0.00 <sup>b</sup>	120.33±0.33 <sup>d</sup>
	40	6.46±0.00 <sup>f</sup>	4.13±0.00 <sup>c</sup>	120.67±0.67 <sup>d</sup>
	100	6.67±0.00 <sup>b</sup>	2.56±0.17 <sup>d</sup>	40.33±0.33 <sup>e</sup>
	P value	0.000**	0.000**	0.000**
Marabar Guga	0	6.79±0.00 <sup>a</sup>	6.23±0.00 <sup>a</sup>	190.00±0.00 <sup>a</sup>
	5	6.68±0.00 <sup>b</sup>	6.22±0.00 <sup>a</sup>	150.00±0.00 <sup>b</sup>
	10	6.38±0.00 <sup>c</sup>	5.81±0.07 <sup>b</sup>	150.00±0.00 <sup>b</sup>
	20	6.84±0.00 <sup>a</sup>	5.67±0.03 <sup>c</sup>	140.00±0.00 <sup>bc</sup>
	40	6.71±0.00 <sup>b</sup>	5.31±0.01 <sup>d</sup>	130.00±0.00 <sup>c</sup>
	100	6.22±0.04 <sup>d</sup>	4.81±0.00 <sup>e</sup>	70.00±0.00 <sup>d</sup>
	P value	0.000**	0.000**	0.000**
ABU Dam Qtrs	0	6.30±0.01 <sup>b</sup>	3.93±0.01 <sup>a</sup>	80.00±0.00 <sup>a</sup>
	5	6.37±0.00 <sup>a</sup>	3.73±0.00 <sup>b</sup>	60.00±0.00 <sup>b</sup>
	10	6.26±0.01 <sup>b</sup>	3.59±0.00 <sup>b</sup>	50.00±0.00 <sup>c</sup>
	20	6.30±0.06 <sup>b</sup>	3.17±0.01 <sup>c</sup>	50.00±0.00 <sup>c</sup>

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	40	6.26±0.02 <sup>b</sup>	1.38±0.00 <sup>d</sup>	10.00±0.00 <sup>d</sup>
	100	6.16±0.01 <sup>c</sup>	0.58±0.15 <sup>e</sup>	10.00±0.00 <sup>d</sup>
P	value	0.02*	0.000**	0.000**

NB: Means with the same letter(s) within each column at each site are not significantly different ( $P \leq 0.05$ ), using DMRT. ns= non-significant \* =significant at  $P < 0.05$  \*\*= highly significant at  $P < 0.01$ .

**Table 3:** Physico-chemical properties of the Roadside soil based on distance from the road (pooled data) across the study area

Distance	Physico-chemical Parameters		
	Ph	Organic Matter (%)	Electrical Conductivity ( $\mu\text{scm}^{-1}$ )
0	6.65±0.01 <sup>a</sup>	4.75±0.03 <sup>a</sup>	177.67±0.67 <sup>a</sup>
5	6.56±0.00 <sup>a</sup>	4.53±0.00 <sup>a</sup>	114.92±0.92 <sup>b</sup>
10	6.44±0.00 <sup>b</sup>	4.23±0.02 <sup>a</sup>	108.00±0.00 <sup>b</sup>
20	6.56±0.00 <sup>a</sup>	3.88±0.06 <sup>b</sup>	100.33±0.33 <sup>b</sup>
40	6.47±0.01 <sup>b</sup>	3.19±0.01 <sup>b</sup>	88.00±0.00 <sup>c</sup>
100	6.35±0.02 <sup>c</sup>	2.28±0.04 <sup>c</sup>	52.89±0.88 <sup>d</sup>
P value	0.000**	0.000**	0.000**

NB: Means with the same letter(s) within each column are not significantly different ( $P \leq 0.05$ ), using DMRT. ns= non-significant \* =significant at  $P < 0.05$  \*\*= highly significant at  $P < 0.01$ .

**Table 4:** Physico-chemical Properties of the Roadside soils based on Sample Locations (Pooled data) across the study Area

Location	Physico-chemical Parameters		
	Ph	Organic Matter (%)	Electrical Conductivity ( $\mu\text{scm}^{-1}$ )
ABUTH	6.54±0.13 <sup>a</sup>	5.67±0.92 <sup>a</sup>	103.50±17.14 <sup>a</sup>
NAPRI shika	6.59±0.13 <sup>a</sup>	4.21±0.83 <sup>b</sup>	125.56±10.90 <sup>a</sup>
Marabar Guga	6.60±0.23 <sup>a</sup>	2.92±0.97 <sup>c</sup>	138.33±8.68 <sup>a</sup>
ABU Dam Qtrs	6.27±0.07 <sup>b</sup>	2.73±1.31 <sup>c</sup>	43.33±6.21 <sup>b</sup>
P Value	0.002*	0.000**	0.004*

NB: Means with the same letter(s) within each column are not significantly different ( $P \leq 0.05$ ), using DMRT. ns= non-significant \* =significant at  $P < 0.05$  \*\*= highly significant at  $P < 0.01$ .

**Table 5:** Vehicular density and GPRS across sampled locations in the study area

Location	Vehicular density/hr	Latitude	Longitude
ABUTH	1105	11° 10' 28.52"N	7° 36' 31.70"E
NAPRI Shika	893	11° 12' 15.35"N	7° 33' 31.98"E
Marabar guga	834	11° 13' 5.52"N	7° 32' 8.16"E
ABU Dam Quarters	46	11° 8' 35.13"N	7° 39' 16.06"E

## DISCUSSION

### Particle Size Characterization

The result of the particle size distribution of the Roadside soil shows that the textures of soil were predominantly sandy loam at all locations except for ABUTH which was predominated by loam soil at all distances. Also, the sand fraction was generally higher compared with the other fractions

at all distances and locations. High percentage of sand top soils is advantageous because it promotes seepage. Thereby leading to the transfer of major cations and anions to the deeper layers. Equally, sandy loam texture possesses high permeability as demonstrated by Paul *et al.*, (2015), which could also lead to transfer of ions from the topsoil to the subsoil leading to leaching

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of the soil. This leaching of the soil aids in the transfer of harmful metals to all sections of the soil thereby making it easily available for plant uptake.

### Physico-chemical Parameters of the Roadside Soil

pH has a great effect on solute concentration and absorption in the soil. According to Rai *et al.* (2019), it is a helpful indicator for determining the physical characteristics of the soil, the potency of any harmful compounds present in the soil, and the availability of nutrients. The level of alkalinity or acidity is thought to be a master variable that influences almost all physico-chemical characteristics of soil. While some species show significant resistance to even small pH fluctuations, others are unaffected by a fairly wide range of pH values. For instance, the availability of numerous nutrients for plant growth and maintenance depends on the acidity (or alkalinity) of the soil (Paul *et al.*, 2015).

The pH values obtained from soils at the study area ranged from 6.15 - 6.84 across all distances and locations which was slightly acidic. In this study area, slight but significant variations in pH were observed among the soil samples with respect to distance and location, this may be linked to the buffering effect of soil organic matter against pH change in addition to the release of carbonate minerals from the topsoil to the subsoil during the organic matter decomposition (Hu *et al.*, 2020). Also, metals tend to be more soluble in the soil solution at low pH, because of their acidic nature, thus more bioavailable to plants and hence causes severe toxicity challenges when in the acidic soil than it does in the alkaline soil (Ogundele *et al.*, 2017).

The percentage organic matter ranged from 0.42 - 6.23 % across all distances and locations in the study area. According to Okpanachi *et al.* (2016), organic matter in soils has the ability to bind harmful ions. It also immobilizes heavy metals in strongly acidic environments and mobilizes them in weakly acidic to alkaline environments by generating soluble or insoluble organic metal complexes. Positively charged ions are attracted to and retained by the

negatively charged sites on the surface of the soil's organic matter components by the action of electrostatic force. The organic content of spent lubricants discharged at the sites and the presence of degradable and compostable materials that boost microbial activity in the soils are two possible explanations for the range in variance of organic matter levels (Akoto *et al.*, 2008; Asati *et al.*, 2016).

Electrical Conductivity (EC) serves as a measure of the presence of soluble nutrients for both cations and anions. The EC values obtained in this study ranged from (10.00 – 250.67  $\mu\text{scm}^{-1}$ ) with significant variations across all distances and locations. The observed fluctuations in electrical conductivity within the study area's soils could potentially be attributed to varying concentrations of ions and soluble salts. These may have resulted from interactions between metals from vehicle scraps and acid spills on roadways, which eventually wash away into roadside soils and form soluble and ionizable inorganic salts. One hallmark of a high or considerable ion presence in soils is their high electrical conductivity. This is therefore, an indication of high presence of harmful metals in the soils of this study area

The result obtained based on distance across all locations revealed that, virtually all the physicochemical properties checked had higher concentration in soils adjacent to the road at (0 m) and decreased progressively with increase in distance from the roadside. The observed significant difference with respect to distance is an indication that, the contributory factor to all the parameters is vehicular emission which shows that, emissions from vehicles played a highly significant role in the level of these parameters on the roadside soil this is in line with Werkenthin *et al.* (2014) who stated that, distribution of physicochemical parameters and metals on roadside environment decreases with increasing distance from the road.

Also, the ANOVA of the combined data based on location showed that, ABUTH had the highest level of all the physicochemical properties of the roadside soil. This high level recorded in the roadside soil from a site with the highest vehicular density could be from the automobile exhaust

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which is as a result of the presence of some of these parameters in batteries, vehicle scraps, road surface materials and other vehicular components (Ogundele *et al.*, 2017). This observation suggests that, roadside soils may be contaminated from anthropogenic activities such as vehicle exhaust and fuel combustion. Dzung and Lee (2011) stated that, the degree of soil contamination is strongly influenced by the velocity and intensity of traffic densities. Also, sites with less level of the physicochemical properties (ABU Dam Quarters) may be attributed to the less vehicular density as it serves as the control.

### CONCLUSION

In this study, the result of the particle size distribution of the Roadside soil shows that the textures of soil were predominantly sandy loam at all locations except for ABUTH which was predominated by loam soil at all distances. The values recorded at ABUTH for all the parameters (6.54, 5.67% and 103.50  $\mu\text{scm}^{-1}$  for pH, Organic matter and Electrical conductivity respectively) were found to be significantly higher than the control at ABU Dam Quarters (6.27, 2.73 % and 43.33  $\mu\text{scm}^{-1}$  for pH, Organic matter and Electrical conductivity respectively). However, with respect to distance, the highest and lowest concentrations of all the elements were observed at 0 and 100 m respectively. Distance from the roadside and vehicular densities of the sampled locations had a significant effect on all the physicochemical properties assessed in the roadside soil. The texture of the soil, acidic nature of the soils as well as the values of the organic matter and electrical conductivity recorded in this study are suggestive of a higher heavy metal pollution index of the roadside soils of Zaria-Giwa road

In view of these findings, there is need for regular monitoring of physicochemical properties of the roadside soils as well as the heavy metal concentrations in soils because of the possibility of being transferred to man through food chain. Farmers are advised to keep some distance away from the roadside before planting of crops in order to reduce the negative impact of the aforementioned parameters.

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