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Effect of Mechanic Village Activities on Selected Soil Properties in Abakaliki Southeastern Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author CN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CNM, OE and JOA managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to evaluate the effect of mechanic village on selected soil physico-chemical properties and heavy metals content in Abakaliki Southeastern Nigeria. Five replicate soil samples were collected from arable land (Control), lorry automobile repair site (Lorry), motorcycle automobile repair site,(motorcycle) car and bus repair site(car and bus), automobile spare parts market (spare parts). These samples were taken to laboratory for the determination of selected soil physico-chemical properties and heavy metal content. The data obtained from this research was analysed using analysis of variance (ANOVA) based on CRD and difference between treatment means were dictated using F-LSD at $P < 0.05$. The result showed significantly ($p < 0.05$) adverse effect among the different automobile locations studied with respect to control in bulk density, total porosity, mean weight diameter and aggregate stability. The chemical properties of soils of mechanic village were also significantly adversely affected by mechanic village. The observed heavy metals in mechanic village were higher than the recommended ranges in soils. Therefore, it advisable that some agronomical practices that could increase the nutrients and lower the heavy metals level should be employed in order to get high crop yield and safe produce.

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1. INTRODUCTION

A mechanic village is a site allocated to automobile repair workers in an urban area. In Abakaliki we have the mechanic village at Ogoja road opposite back of College of Agricultural Science Campus, Ebonyi State Univerisity, Abakaliki. Apart from this mechanic village, we have other automobile repair shops popularly called roadside mechanic in many streets and roads at Abakaliki. According to [1] a typical city usually has one to three mechanic villages, in proportion to its population and activities, but some cities have more. [2] showed that the mechanic villages make aesthetic values of urban areas better by removing a large number of degraded makeshift workshops that scattered throughout the cities and poorly dressed workers from the public eyes. Mechanic villages also, provide accommodation for some of the trainees, space for spare parts shops, and restaurants, as well as yards for junk cars and unserviceable vehicles that would have otherwise constituted environmental nuisance in homes and public places. Mechanic villages are the largest generators of hazardous waste such as used oil and fluids, dirty shop rags, used parts, asbestors from brake pads and waste from solvents used for cleaning parts [3]. Many studies have shown that wastes from automobile are sources of heavy metal pollution [1,3,4,5,6] on their study of the effect of spent engine oil discharge on soil properties in an automobile mechanic village in Nekede, Imo State, Nigeria showed that there was lower exchangeable bases in automobile mechanic vallage than control. Also, [7] showed that the daily activities of auto-mechanic battery workshops have negative impacts on soil physicochemical properties such as bulk density, total porosity, available phosphorus and cation exchange capacity. On the other hand, [8] on his study of analyzing soil contamination status in garage and auto mechanical workshops of shashemane city: implication for hazardous waste management observed that heavy metals in auto mechanical soil were extremely higher than US EPA and EU regulation standards. Due to the scarcity of soils, population explosion and insufficient food to cater for the teeming population residents of Abakaliki mechanic village have been force to use the soils in the mechanic village for crop production. This prompt the study to enable us have information on the properties and heavy metals content of Abakaliki mechanic village soil. Therefore, the objective of this study was to determine the effect of mechanic village on selected soil physico-chemical properties and heavy metals content in Abakaliki Southeastern Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The research was carried out in Abakaliki Southeastern Nigeria in the year 2019. Abakaliki lies approximately between latitude 06^0 14' and 06^0 30' N with longitude 08^0 0' and 08^0 15' E. The rainfall pattern is bimodal (April to July and September to November), with dry spell in August usually referred to as “August Break”. It has annual rainfall of 1800 to 2000mm and annual mean of 1900mm. The study area has high temperature of 27°C and the topmost mean daily temperature of 31°C that is within the year. Humidity ranged between 60 - 80% during dry season and rainy season, respectively.

Geologically, the study site is sedimentary rock which is obtained from straight seawater retainer of the cretaceous periods and quaternary periods. As stated [9], agricultural zone of areas remains within ‘Asu River group’ and made up of olive brown sandy shale, small particles of mudstones and sandstone. The soil is not very deep with unconsolidated parent substances within 1 m of the sand uppermost layer.

2.2 Site Selection

A preliminary study of Abakaliki mechanic village was carried out and the following locations were selected for the study:

Control = Arable land
Lorry = Lorry automobile repair site
Motorcycle = Motorcycle automobile repair site
Car & buses = Car and buses automobile repair site
Spare parts = Automobile spare parts market

2.3 Soil Sampling and Analysis

Five replicate soil samples were collected at the depths of 0 – 20 cm using soil auger. Also, five replicate undisturbed core soil samples were also collected using a core of $156.40cm^3$ in 2019. Thus, the total auger and core soil samples collected for each location were five replicate auger and five replicate core soil samples, respectively. These soil samples were taken to laboratory for analyses immediately after collection.

2.4 Laboratory Determination of Physical Properties of the Soil

The following soil physical properties were determined:

2.4.1 Bulk Density (BD)

The bulk density was determined using the method described by [10].

2.4.2 Total Porosity (TP)

Total porosity was determined as describe by [11].

2.4.3 Aggregate Stability (AS)

Aggregate stability was determined by the wet technique for [12].

2.4.4 Mean Weight Diameter (MWD)

This was calculated thus;

$$MWD = \sum_{I=1}^{n} XiWi$$

where;

Xi = mean diameter of each size fraction (mm)
Wi = proportion of all the sample weight

2.4.5 Dispersion Ratio (DR)

This was determined using the method of [12].

2.5 Laboratory Determination of Chemical Properties of the Soil

2.5.1 Soil pH

Soil pH was determined by using a suspension of soil and distilled water in the ratio of 2:5 – soil: water [13].

2.5.2 Organic carbon

This was determined by the method of [14].

2.5.3 Total nitrogen

Total nitrogen was determined using modified kjeldahl digestion procedure [15].

2.5.4 Available phosphorous

Available phosphorous was determined by Bray 11 method [14].

2.5.5 Exchangeable bases

Exchangeable base was determined using Chapman method [16].

2.5.6 Exchangeable acidity

Exchangeable base was determined by the titration method [17].

2.5.7 Effective cation exchangeable capacity

This was determined by the summation and calculation [18].

2.5.8 Base saturation

Base saturation was calculated as follows:

$$\text{TEB/ECEC} \times 100$$

Where:

TEB = Total exchangeable bases,
ECEC = Effective Cation Exchangeable Capacity.

2.5.9 Heavy metals

Heavy metals (Pb, Cd, Cu and Zn) were determined by digesting the sample in a fume cupboard and reading transmittance of light using Atomic Absorption Spectrophotometer [19].

2.6 Data Analysis

The data obtained from this research was analysed using analysis of variance (ANOVA) based on CRD and difference between treatment means were dictated using F-LSD at $P < 0.05$ according to the method described by [20].

3. RESULTS AND DISCUSSION

3.1 Effect of Mechanic Village on Selected Soil Physical Properties

Table 1 shows the effect of mechanic village on soil bulk density, total porosity, mean weight diameter, aggregate stability and dispersion ratio. The result showed significant ($p < 0.05$) difference among the locations studied in bulk density, total porosity, mean weight diameter, aggregate stability. The lowest bulk density of 1.23 $gcm^{-3}$was observed in control whereas that of automobile sites ranged between 1.28 – 1.45 gcm^{-3} with highest bulk density observed in lorry. Control recorded the highest total porosity of 53.60%. This observed total porosity in control was higher than total porosity in lorry, motorcycle, car & buses and spare parts by 16, 6, 9 and 4%, respectively. The higher bulk density and lower total porosity in mechanic village soils mighty partly be attributed to higher compaction of the soils as result of the residents walking on the soils and to closure of air spaces by wastes such as used engine oils that are improperly disposed on mechanic village soils. [18] observed higher crop yields in soils with lower bulk density and higher total porosity. The order of increase in mean weight diameter was lorry < car & buses < motorcycle < spare parts < control. The highest aggregate stability of 58% was observed in control whereas aggregate stability in automobile sites ranged between 31 – 49% with lowest observed in lorry. Dispersion ratio showed non-significant ($p < 0.05$) change among the difference locations studied, however the order of increase was control < spare parts < motorcycle < car & buses < lorry. With regard to physical properties control improve more than soils of mechanic village. This confirmed the study of [7] who showed that wastes from mechanic villages are detrimental to soil physical properties.

3.2 Effect of Mechanic Village on Selected Soil Chemical Properties

Effect of mechanic village on soil pH, available P, total nitrogen, organic carbon and C/N ratio is presented on Table 2. There was significant ($p < 0.05$) changes in, available P, total nitrogen, organic carbon and C/N ratio among different locations studied. Control recorded lowest soil pH of 5.96. This recorded soil pH in control was lower than pH in lorry, motorcycle, car & buses and spare parts by 12, 13, 6 and 2%, respectively. Control had highest organic carbon of 30.30 gkg^{-1} whereas organic carbon in automobile sites ranged between 10.24 – 20.62 gkg^{-1} with motorcycle recording the lowest organic carbon. The order of increase in total nitrogen was motorcycle < spare parts < lorry < car & buses < control. Nitrogen concentrations was reduced in soils in mechanic village than control soil due to the Presence of automobile wastes introduced by anthropogenic sources, hence the effect could result in loss of soil nutrients. [7] on their study of effect of automobile battery wastes onphysico-chemical properties of soil in Benin city, Edo State recorded lower nitrogen content in soils contaminated with automobile battery than control which is in line with this study.Lorry and spare parts recorded highest and lowest C/N ratio of 16.10 and 9.40, respectively whereas C/N ratio of control is 12.10 which was second to the highest value. Table 3 shows the effect of mechanic village on soil exchangeable bases. There was significant ($p < 0.05$) changes in exchangeable bases among the different locations studied. The highest value of Ca of 3.40 $cmol_{(+)}kg^{-1}$was observed in control. This observed highest value of Ca in control was higher than Ca observed in lorry, motorcycle, car & buses and spare parts by 44, 24, 44 and 18%, respectively. The order of Mg increase was lorry < spare parts < motorcycle = car & buses < control. Control recorded the K value of 0.14 $cmol_{(+)}kg^{-1}$whereas K in automobile sites ranged between 0.08 – 0.14 with car & buses recording the lowest K content. The order of increase in Na content was spare parts < car & buses = motorcycle < lorry < control. The order of increase in available P was lorry < motorcycle < spare parts < car & buses < control.The effect of mechanic village on soil TEB, EA, ECEC and BS is as shown on Table 4. Table 4 also shows significant ($p < 0.05$) changes among locations studied with respect to TEB, EA, ECEC and BS. The highest TEB of 6.30 $cmol_{(+)}kg^{-1}$was observed in control. This observed highest TEB in control was higher than TEB in lorry, motorcycle, car & buses and spare parts by 41, 18, 27 and 19%, respectively. The lowest EA 0.23 $cmol_{(+)}kg^{-1}$was observed in control whereas EA in automobile sites ranged between 0.30 – 0.46 $cmol_{(+)}kg^{-1}$with highest recording in car & buses. The order of increase in ECEC was lorry < car & buses < spare parts < motorcycle < control. Highest BS of 97% was observed in control whereas BS in lorry, motorcycle, car & buses and spare parts were 88, 93, 90 and 94%, respectively. According to [21] soil chemical properties play vital role in the soil quality and these properties include cation exchange capacity and soilpH. These properties are adversely affected when soil is contaminated by automobile wastes and may be the reason why soils control recorded better values when compared to soils of mechanic village.

3.3 Effect of Mechanic Village on Soil Heavy Metals Pollution

Results of the study in Table 5 showed the effect of mechanic village on soil heavy metals. There was non-significant ($p < 0.05$) changes Cd among the locations studied. However, the order of increase in Cd was spare parts < control < car & buses < lorry. There was a significant ($p < 0.05$) changes in Cu, Pb and Sn among the different locations studied. The lowest Cu of 20.36 $mgkg^{-1}$was observed in control whereas Cu in automobile sites ranged between 252.01 – 949.10 $mgkg^{-1}$ with car &

Table 1. Effect of Mechanic village on Bulk Density (BD), Total Porosity (TP), Mean Weight Diameter (MWD), Aggregate Stability (AS) and Dispersion Ratio (DR)

Location	BD (gcm^{-3})	TP (%)	MWD (%)	AS (%)	DR
Control	1.23	53.60	2.36	58	0.49
Lorry	1.45	45.30	1.23	31	0.79
Motorcycle	1.31	50.60	1.98	46	0.68
Car & Bus	1.36	48.70	1.76	38	0.71
Spare parts	1.28	51.70	2.01	49	0.57
F-LSD (P < 0.05)	0.16	5.35	0.06	2.01	NS

Note: Control = arable land; Lorry = lorry automobile repair site; Motorcycle = motorcycle automobile repair site; Car and bus = car and bus repair site; Spare parts = automobile spare parts market

Table 2. Effect of Mechanic village on soil pH, available phosphorus, total nitrogen, Organic carbon and C/N ratio

Location	pH	Available P ($mgkg^{-1}$)	Organic C (gkg^{-1})	Total N (gkg^{-1})	C/N Ratio
Control	5.96	85.72	30.30	2.51	12.10
Lorry	6.85	21.60	20.62	1.28	16.10
Motorcycle	6.73	36.50	10.24	0.98	10.40
Car & Buses	6.31	45.90	20.19	1.98	10.20
Spare parts	6.05	38.50	10.39	1.11	9.40
F-LSD (P < 0.05)	0.08	6.14	2.63	0.78	1.78

Note: Control = arable land; Lorry = lorry automobile repair site; Motorcycle = motorcycle automobile repair site; Car and bus = car and bus repair site; Spare parts = automobile spare parts market

Table 3. Effect of Mechanic village on soil exchangeable bases (cmol(+)kg-1)

Location	Ca	Mg	K	Na
Control	3.40	2.40	0.14	0.33
Lorry	1.90	1.40	0.09	0.28
Motorcycle	2.60	2.30	0.10	0.22
Car & Buses	1.90	2.30	0.08	0.22
Spare parts	2.80	2.00	0.11	0.19
F-LSD (P < 0.05)	0.23	0.21	0.01	0.01

Note: Control = arable land; Lorry = lorry automobile repair site; Motorcycle = motorcycle automobile repair site; Car and bus = car and bus repair site; Spare parts = automobile spare parts market

Table 4. Effect of Mechanic Village on Soil Total Exchangeable Bases (TEB), Exchangeable Acidity (EA), Effective Cation Exchange Capacity (ECEC) and Base Saturation (BS)

Location	TEB ($cmol_{(+)}kg^{-1}$)	EA ($cmol_{(+)}kg^{-1}$)	ECEC ($cmol_{(+)}kg^{-1}$)	BS (%)
Control	6.30	0.23	6.50	97
Lorry	3.70	0.46	4.20	88
Motorcycle	5.20	0.38	5.60	93
Car & Buses	4.50	0.46	5.00	90
Spare parts	5.10	0.30	5.40	94
F-LSD (P < 0.05)	0.14	0.11	0.16	2.91

Note: Control = arable land; Lorry = lorry automobile repair site; Motorcycle = motorcycle automobile repair site; Car and bus = car and bus repair site; Spare parts = automobile spare parts market

Table 5. Effect of Mechanic Village on soil heavy metals (mgkg-1)

Location	Cd	Cu	Pb	Sn
Control	0.01	20.36	45.31	52.95
Lorry	0.3	949.10	526.41	352.17
Motorcycle	0.3	716.28	314.28	223.45
Car & Buses	0.2	823.98	438.10	471.01
Spare parts	0.1	252.01	398.41	198.23
F-LSD (P < 0.05)	0.02	50.36	16.08	30.25

Note: Control = arable land; Lorry = lorry automobile repair site; Motorcycle = motorcycle automobile repair site; Car and bus = car and bus repair site; Spare parts = automobile spare parts market, According to [22] normal ranges in soils are as follows: Cd = 0.01 – 0.08; Cu = 2 – 250; Pb = 2 – 300 and Sn = 1 – 200

buses recording the highest value. The order of increase in Pb was control < motorcycle<spare parts < car & buses < lorry. Control recorded the lowest Sn of 2.03 mgkg^{-1}. This lowest Sn in control was lower than Sn in lorry, motorcycle, car & buses and spare parts by 565, 322, 790 and 274%, respectively. The observed heavy metals are higher in mechanic village study than the standard whereas the heavy metals in control are with the standard as recommended by [22] and reviewed in [23,24]. Also, the content of Sn in the spare parts sites is within the standard. [25] reported heavy metals that are higher than standard in many countries of the world in their study of trace metal deposition in soil from auto-mechanic village to urban residential areas in Owerri which is in line with this study. Similarly, [26] observed higher heavy metals in abandoned mechanic site than non-mechanic site.

4. CONCLUSION

The result showed that soils in Abakaliki mechanic village have low nutrient status and also, heavy metals which are higher than the recommended ranges in soils. This portrayed that these soils are degraded and using it for crop production will result to low crop yield and productivity. The crops harvested in such degraded and contaminated soils if eaten by animal or man will result to food poison. Therefore, it advisable that some agronomical practices that could increase the nutrients and lower the heavy metals level should be employed in order to get high crop yield and safe produce.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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