© MAR 2026 | IRE Journals | Volume 9 Issue 9 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/IREV9I9-1714868

Physicochemical Assessment of Soil Around Abattoirs in Akwanga Local Government Area, Nasarawa State, Nigeria

ARIGU, A.D.[1], AZUA, E.T.[2], ICHOR, T.[3]
[1,2,3]*Environmental Science Unit, Joseph Sarwuan Tarka University Makurdi, Benue State, Nigeria*

Abstract- ***Abattoir waste eventually enters the surrounding soil, causing important environmental consequences that should be under constant surveillance. This calls for a need to investigate the physicochemical parameters of soils around abattoirs of Akwanga Local Government Area, Nasarawa State, Nigeria. Soil from eight (8) abattoirs with respective control sites were sampled and analyzed for physicochemical parameters. Findings were subjected to t-test, chi-square and correlation analysis at p<0.05. Results recorded the following highest mean values: Temperature, Magnesium and Dissolved Oxygen (29.50±0.55^{O} C, 0.13±0.07 mgkg^{-1} and 10.40±3.31 mgL^{-1} respectively at A. Ali), Electrical Conductivity (3794.26±386.02 µSm^{-1} at A. Tela), pH (6.83±0.95 at A. A. Koto), Calcium (0.60±0.00 mgkg^{-1} at A. Affi), Phosphorus, Potassium, Nitrate, Sodium and Base Solution (17.25±0.87, 0.45±0.03, 0.51±0.04, 0.33±0.02 mgkg^{-1} and 89.55±0.47 meq/100g respectively at A. Ogba), Exchangeable Acidity and Cation Exchange Capacity (1.05±0.44 and 1.78±0.37 meq/100g respectively at A. B. Koto). Most of these parameters were above readings of the control sites but within the WHO stipulated standards. However, elevated levels of Na^+, Mg, Ca, PO_4, and NO_3 in the soil were reported. It is therefore recommended that regular monitoring of the physicochemical properties of abattoir soil will trigger soil conditioning procedures for a more vibrant abattoir soil.***

Index Terms- ***Soil, Abattoir, Physicochemical, Soil heath, Control, Monitoring***

I. INTRODUCTION

Soil, the uttermost layer of the earth crust serves as a habitat for a number of organisms, (microscopic and macroscopic) with life support system of water, minerals and air. Among soil organisms are bacterial, algae, protozoa, nematodes, millipedes, slugs and snails (Leeper and Urene 2009). These constituents, collectively form soil biota which carryout prominent functions in nutrient recycling and soil water availability. Man is a principal factor contributing to soil environmental issues. Activities of man has generated large amount of waste in the environment, which has caused a lot of alteration to the soil balance and even human health. These activities include, urbanization, agriculture, and industrialization, with abattoir inclusive.

Abattoir is a premise used for the slaughter of animals for human consumption and other commercial purposes. The continuous quest to increase meat production for protein needs of increasing world population has notable problems attached. Osemwota (2010) reported that abattoir produce a lot of waste such as blood, urine, waste water, faeces, and bones, which are eventually discharged into the soil. The effluent discharged into the soil is rseported to have the capacity of lessening the amount of oxygen in the soil (electron receptor) and promote the activities of denitrifying bacteria to reduce available nitrate into gaseous nitrogen which enters the atmosphere with negative effects such as greenhouse effects and global warming. Osemwota (2010) further stressed that methane gas is five times more effective as a greenhouse gas than CO_2.

Sumayya *et al.* (2013) and Jukna *et al*. (2006) argued that various organs of cattle such as the blood, liver, kidney, muscle, viscera and hair have been found to contain heavy metals. Some of the metals maybe capable of interfering with the soil's physicochemical parameters. Metal Nahmani *et al.* (2005) reported that determination of physicochemical properties of soil is critical for understanding how bacterial, protozoa, fungi, archea and soil invertebrate interact and respond to multiple global change, habitat management and ecosystem evaluation. These indices are useful in quantification of soil macrofauna biodiversity pattern.

Like many towns among developing countries (Adebayo and Akinbile, 2016; Aliyu *et al.,* 2017;

Fawole and Oso, 2017; Odumade *et al.,* 2020), Akwanga, a major town in Nasarawa State of North central Nigeria, is faced with environmental challenges such as improper disposal of abattoir waste around the abattoirs. It is very common to find huge abattoir waste around abattoirs. This may have great impact of the surrounding soil. The disposal of untreated abattoir waste which is common has some environmental implications. Blood and faeces are among the major contents in abattoir waste. These pollutants can alter the quality of soil and make it unfit for certain usage. Generally, abattoir effluents are indiscriminately discharged into the surrounding environment. Reasoning behind this assertion is that the discharged effluent has its effects on abattoir soil. Justification of this reasoning will be positive only if abattoir soil is assessed for its content, physicochemical and health status, then compared to control sites and related standards. This work sought to assess the physiochemical properties of soil around abattoirs of Akwanga Local Area of Nasarawa State, Nigeria.

II. MATERIALS AND METHODS

The Study Area

This study was carried out in Akwanga Local Government Area of Nasarawa State (Fig.1), North Central Nigeria. Akwanga is located at latitude $8^0550^{"}$ North and Longitude $8^023'0"$ East, withan area of 996 km^2, having a population of 15,987 inhabitants. Eight (8) abattoirs were selected for the study. They include: A.A Koto, Angwan Tela, Angwan Affi, Angwan Ogba, A.B. Koto, Gwanje Loko, Angwan Ali and Angwan Kpandom

Sample Size Determination, Collection and Preparation

A total of 240 samples were collected from the purposive selected 8 abattoir using the formula of Uakarn *et al* (2021):

$$n = \frac{(Z)^2(\pi)(1-\pi)(N)}{(Z)^2(\pi)(1-\pi)+N(e)^2}$$

Where: n= Sample size; N= Population size; π= Population variance; Z= Z score at α significance level

In each abattoir, 5 soil sample points were strategically chosen from North, South, East, West and center of the abattoir. The soil samples were collected in a vertical profile depth of 10, 20 and 30 (cm) using soil auger (2.5 cm diameter) as demonstrated by Kodirov *et al*. (2018), giving a total of 15 samples for each abattoir. This same procedure was done for control samples of the respective abattoirs selected 300 m away from the abattoir. Collected soil samples in well labelled polyethylene bag were then transported to the laboratory for analysis. For further, physicochemical and soil particulate matter, the soil samples were air-dried in the laboratory for 2-3 days, then they were crushed in a porcelain mortar and pestle and sieve through 2 mm (10 mesh) standard sieve to obtain homogenous samples. The samples were stored in polythene bags and kept

Methods in Physiochemical Analysis of Soil Samples

Temperature

The temperature of each sample was determined at each sampling site using a thermometer. Before the sample was collected, a wooden spatula was used to dig up the soil and the thermometer pushed into the dug-up soil at 10 cm, 20 cm and 30 cm depth. The thermometer was left in the soil for at least one minute and was removed and the reading recorded for each depth. The mean of the reading in ^0C were then taken to serve as temperature for the composite sample obtained from that particular site.

Electrical conductivity

A 1:5 soil-water suspension was prepared by weighing 10 g air-dried soil into a bottle and adding 50 ml deionized water. The mixture was shaken mechanically to dissolve soluble salts. The conductivity meter was calibrated according to the manufacturer's instruction using the KCl reference solution to obtain the cell constant. The cell was then rinsed thoroughly and the electrical conductivity measured at 0.01 KCl at the same temperature as the soil suspension. The conductivity cell was then rinsed with the soil suspension and the cell refilled without disturbing the settled soil. The value indicated on the

conductivity meter was then recorded in mS/m. After every reading, the conductivity cell was rinsed with deionized water.

pH

Soil pH was measured in a soil suspension (1:10 w/v dilution) using the glass electrode pH meter as described by Amos-Tautua *et al.* (2014). Before measurement, Buffer in powder form was prepared for calibration of the pH meter as thus: for pH 4.0, 5.10 g of potassium hydrogen phthalate was dissolved in distilled water and made up of 500 ml. For pH 9.2, 9.54 g of sodium tetraborate (borax) was dissolved in distilled water and made up to 500 ml. The air-dried soil that passed through 2 mm sieve was weighed (20 g) and transferred into 50 ml beaker. Then, 20 ml of distilled water was added and allowed to stand for 30 minutes and occasionally stirred with a glass rod. The electrodes of the pH meter were inserted into the partly settled suspension and measurement taken. At every reading, the electrodes were rinsed with deionized water and wiped dry with tissue.

Calcium

Calcium (Ca) was determined in the soil samples using Jackson's soil chemical analysis as described by Tripathi and Misra (2012). Soil sample of 5 g was weighed and 30 ml of ammonium acetate (NH_4OAC) was added and shaken on a mechanical shaker for 2 hours. The solution was centrifuged at 2000 rpm for 10 minutes. The supernatant was carefully decanted and shaken for 30 minutes, centrifuged and supernatant transferred into the same volumetric flask. Then, NH_4OAC solution was used to make up the mark. Then Ca was determined using flame photometer, and results recorded in $mgkg^{-1}$.

Phosphorus

Available phosphorus was measured by the Bray II method as described by Okolo *et al.* (2013) and Amos-tautau *et al.* (2014). The soil was weighed to 1 g and sieved through a 2 mm mesh into a 15 ml centrifuge tube and 7 ml of the extracting solution added. The mixture was swirled for 1 minute on a mechanical shaker and centrifuged at 2000 rpm for 15 minute; the clear supernatant was pipetted into a 20 ml test tube. Then 5 ml of distilled water and 2 ml of ammonium molybdate solution were added in that order and mixed properly. Stannous chloride ($SnCl_2.2H_2O$) measured 1 ml was added to the solution and mixed again. After 5 minutes, percentage transmittance on the electrophotometer at 660 nm wave length was done. The extractable P was then calculated by preparing standard curve within the range of 0 – 1 ppm, plotting the optical density of standard solution against the ppm. Readings were taken in $mgkg^{-1}$.

Potassium

Potassium (K) was determined in the soil samples using Jackson's chemical analysis as described by Tripathi and Misra (2012). Soil sample of 5 g was weighed and 30 ml of 1 N ammonium acetate (NH_4OAC) was added and shaken on a mechanical shaker for 2 hours. The solution was centrifuged at 2000 rpm for 10 minutes. The supernatant was carefully decanted into a 100 ml volumetric flask. Again, 30 ml of NH_4OAC solution was added to the decanted supernatant and shaken for 30 minutes, centrifuged and supernatant transferred into the same volumetric flask. This was repeated and the supernatant again transferred into the same volumetric flask. NH_4OAC solution was then used to make up the mark. Then, K was determined using flame photometer, and result recorded in $mgkg^{-1}$.

Nitrate

Soil nitrate was determined by preparing extraction solution of sodium mixed with acetic acid and diluted with distilled water. Soil sample (5 g) was then transferred into a shaking bottle, 0.25 g of activated carbon added and 20 ml of extracting solution. The mixture was swirled and filtered. Then 1 ml of aliquot of the soil extract was transferred to a vial, followed by 0.5 ml of brucine reagent then 2 ml of sulphuric acid added and mixed for 30 seconds. Tubes were submerged in cold water for 5 minutes and transmittance measured at 470 nm (Ogunmodede *et al.* 2013). Results were recorded in $mgkg^{-1}$.

Sodium (Na)

Procedure for determination of sodium in soil is the same as that of phosphorus given above. Percentage transmittance on the electrophotometer at 660 nm wave length emits appropriate colour concentration for Na^+ and is recorded in $mgkg^{-1}$.

Magnesium (Mg)

The cation was determined by EDTA titration method (Jackson, 1956). To 5ml of the EDTA extract was added 10 drop of KCN NH_2OH_2 + HCl trietholamine, KOH and a pinch of murexide and mixture was titrated to a permanent purple colour, and results recorded in $mgkg^{-1}$.

Exchangeable Acidity

This was determined by leaching the soil with 1 N KCl solution and the extract titrated with standard NaOH solution. 50 ml of 1 N KCl was added to 5.0 g of the prepared soil sample, shaken for an hour and then filtered into a volumetric flask using a whatman filter paper over night. The volume was then made up to mark with 1 N KCl. To 25 ml of the clear supernatant (KCl extract), 100 ml of deionized water and 5 drops of phenolphthalein indicator were added into 250 ml Erlenmeyer flask and titrated with 0.05 N NaOH to a permanent pink end point. The volume of NaOH used was recorded as the total amount of acidity (H^+ and Al^{3+}) in the aliquot taken. One drop of 0.05 N HCl and 10 ml of NaF were added to the flask and titrated with 1.05 N HCl until the colour of the solution disappeared completely. The milli-equivalent of the acid used was recorded as the amount of exchangeable Al^{3+} and that of H^+ was calculated. The values were then expressed in meq/100 gram of soil.

Cation Exchange Capacity (CEC)

The CEC was determined by neutral, 1 N ammonium acetate method. To 25 g of the sieved soil sample weighed into 50 ml Erlenmeyer flask and 50 ml of neutral 1 N NH_4OAC solution to remove all the exchangeable bases, and to saturate the exchange sites of the colloids with NH_4^+, 30 ml of 99 % isoprophyl alcohol was added to the sample and the suspension was then shaken mechanically to remove excess NH_4OAC. The NH_4^+, saturated soil was then transferred to a 500 ml Kjeldahl flask and 200 ml of deionized water was added and also 3 g of magnesium oxide was added into the flask. The content of the flask was distilled into 50 ml of 4 % H_3BO_3 solution after methylene blue indicator was added. The ammonium absorbed in the distilled 4 % boric acid solution was titrated with standard 0.1 N hydrochloric acid. The total cation exchange capacity was then calculated and expressed as milli-equivalent per 100 g of soil. Blank determination was carried out following the same procedure but without soil sample.

Base Solution

This was calculated by dividing the sum of exchange bases by CEC and multiplying by 100 and results expressed as a percentage.

Dissolved Oxygen

This was done in-situ using Dissolved Oxygen meter. The probe (sensor) was carefully inserted into the soil at about 10 cm-30 cm in firm contact with the soil to get accurate readings and allowed for 15 minutes to stabilize and reach equilibrium with soil oxygen concentration. Then the reading was taken at different locations and depths to account for heterogeneity and data was recorded accordingly in mgL^{-1}.

III. RESULTS

The values of physiochemical parameter of abattoir soil obtained from A.A. Koto are presented on Table 1. Apart from temperature and base solution that were not statistically significant ($p>0.05$), significant differences ($p<0.05$) were established for other parameters. Also, only soil nitrate was higher than established standards for the sample site. The values of physiochemical parameters of abattoir soil obtained from Agwan Tela are presented on Table 2. Apart from Temperature, calcium, Electrical Conductivity and base solution that were not statistically significant ($p>0.05$), significant differences ($p<0.05$) were established for other parameters recorded. pH of the soil is acidic (5.22 + 4.45).

The physiochemical parameters of abattoir soil obtained from A. Affi are presented on Table 3. Apart from Temperature, Calcium, Phosphate, Exchangeable Acidity and Cation exchange capacity that were not statistically significant ($p>0.05$), significant differences ($p<0.05$) were established for other parameters. pH of the soil is acidic (5.21 + 0.40). The physiochemical parameters of abattoir soil obtained from A. Ogba are presented on Table 4. Apart from Temperature, Nitrate, Sodium, Exchangeable Acidity and base solution that were not statistically significant ($p>0.05$), significant

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DOI: https://doi.org/10.64388/IREV9I9-1714868

differences ($p<0.05$) were established for other parameters. The following parameters were not within the range of the set standard: Electrical conductivity, pH, Nitrate and Dissolved Oxygen. The values of physicochemical parameters of abattoir soil obtained from A.B. Koto are presented on Table 7. Apart from Temperature, Electrical Conductivity, Calcium and base solution that were not statistically significant ($p>0.05$), significant differences ($p<0.05$) were established for other parameters. All the tested parameters fall within the given environmental standards.

Table 1: Physiochemical Parameters of Abattoir and Control Soil obtained from A.A. Koto

Parm	Unit	Range	Sample Mean	Sample S.D	Control Mean	t-value	p-value	Standard
Temp	^oC	23.99 – 30.27	27.13	0.73	27.20	1.73	2.571	20-30
E.C	μSm^{-1}	-1630.70-4295.36	1332.33	689.08	1600.0	2.76	2.571	<2000
pH		6.18–8.62	6.83	0.95	7.42	2.69	2.571	6.00-9.00
Ca	$mgkg^{-1}$	0.41–0.43	0.42	0.002	0.41	2.62	2.571	< 4.5
P	$mgkg^{-1}$	9.42–17.30	13.38	0.92	13.21	2.88	2.571	<50
K	$mgkg^{-1}$	0.14 – 0.57	0.35	0.05	0.30	2.86	2.571	NS
NO_3	$mgkg^{-1}$	0.27–0.61	0.44	0.04	0.34	2.65	2.571	<0.25
Na	$mgkg^{-1}$	-0.03–0.57	0.27	0.07	0.21	2.76	2.571	<4.5
Mg	$mgkg^{-1}$	0.07–0.09	0.08	0.002	0.08	2.95	2.571	<4.5
EA	meq/100g	-0.13–0.65	0.26	0.09	0.19	3.11	2.571	NS
CEC	meq/100g	1.19–1.62	1.40	0.05	1.38	2.68	2.571	<18
DO	mg/L	0.79–1.65	1.22	0.10	1.34	2.83	2.571	<5.0
BS	meq/100g	50.47–109.51	79.97	6.87	80.50	1.87	2.571	NS

KEY: Na- Sodium; EC- Electrical conductivity, pH - Potential of hydrogen, EA - Exchangeable acidity; Temp – Temperature, Ca –Calcium; CEC – Cation exchange capacity; Parm – Parameter; P- Phosphorus; DO- Dissolved Oxygen; $_K$- Potassium; BS – Base solution; NO_3 – Nitrate; NS – Not Specified; SD – Standard Deviation

Table 2: Physiochemical Parameters of Abattoir and Control Soil obtained from A. Tela

Parm	Unit	Sample Range	Sample Mean	Sample S.D	Control Mean	t-value	p-value	Standard
Temp	^oC	27.87–29.67	28.77	0.21	28.62	1.73	2.571	20-30°C

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DOI: https://doi.org/10.64388/IREV9I9-1714868

E.C	μSm^{-1}	953.03–5700.32	3794.26	3867.02	3799..30	1.86	2.571	<2000
pH		3.28–7.16	5.42	0.45	6.60	2.89	2.571	6.00-9.00
Ca	$mgkg^{-1}$	0.30–0.31	0.31	0.001	0.30	1.87	2.571	< 4.5
P	$mgkg^{-1}$	-3.90–15.20	5.65	2.22	5.50	2.78	2.571	<50
K	$mgkg^{-1}$	-0.07 – 0.71	0.32	0.09	0.29	2.81	2.571	NS
NO_3	$mgkg^{-1}$	-0.25–0.69	0.22	0.11	0.20	2.89	2.571	<0.25
Na	$mgkg^{-1}$	-0.10–0.50	0.20	0.07	0.19	2.73	2.571	<4.5
Mg	$mgkg^{-1}$	0.02–0.10	0.06	0.01	0.05	2.86	2.571	<4.5
EA	meq/100g	-0.56–1.60	0.52	0.25	0.48	2.79	2.571	NS
CEC	meq/100g	0.97–1.91	1.44	0.11	1.38	2.84	2.571	<18
DO	mg/L	-0.56–3.56	1.50	0.48	1.70	2.88	2.571	<5.0
BS	$mgkg^{-1}$	-3.42–12.32	6.95	1.97	5.82	2.15	2.571	NS

KEY: Na- Sodium; EC- Electrical conductivity, pH - Potential of hydrogen, EA - Exchangeable acidity; Temp – Temperature, Ca –Calcium; CEC – Cation exchange capacity; Parm – Parameter; P- Phosphorus; DO- Dissolved Oxygen; K- Potassium; BS – Base solution; NO_3 – Nitrate; NS – Not Specified; SD – Standard Deviation

Table 3: Physiochemical Parameters of Abattoir and Control Soil obtained from A. Affi

Parm.	Unit	Sample Range	Sample Mean	Sample S.D	Control Mean	t-value	p-value	Standard
Temp	^oC	24.63–32.37	28.5	0.10	26.1	1.87	2.571	20-30
E.C	μSm^{-1}	771.66–1468.44	1120.05	81.02	1118.10	2.85	2.571	<2000
pH		3.75–7.01	5.29	0.40	6.7	2.84	2.571	6.00-9.00
Ca	$mgkg^{-1}$	0.40–0.61	0.601	0.002	0.59	1.57	2.571	< 4.5
P	$mgkg^{-1}$	9.36–20.36	14.86	1.28	13.83	2.12	2.571	<50
K	$mgkg^{-1}$	0.24 – 0.58	0.41	0.04	0.35	2.65	2.571	NS
NO_3	$mgkg^{-1}$	0.30–0.64	0.47	0.04	0.40	2.79	2.571	<0.25
Na	$mgkg^{-1}$	0.18–0.39	0.30	0.02	0.21	2.86	2.571	<4.5
Mg	$mgkg^{-1}$	0.01–0.11	0.10	0.02	0.09	2.77	2.571	<4.5

EA	meq/100g	-0.13–0.65	0.26	0.09	0.18	1.49	2.571	NS
CEC	meq/100g	1.50–1.84	1.67	0.04	1.48	1.86	2.571	<18
DO	mg/L	-0.67–3.21	1.27	0.45	2.11	2.98	2.571	<5.0
BS	$mgkg^{-1}$	61.38–105.76	83.57	5.16	82.3	2.68	2.571	NS

KEY: Na- Sodium; EC- Electrical conductivity, pH - Potential of hydrogen, EA - Exchangeable acidity; Temp – Temperature, Ca –Calcium; CEC – Cation exchange capacity; Parm – Parameter; P- Phosphorus; DO- Dissolved Oxygen; K- Potassium; BS – Base solution; NO_3 – Nitrate; NS – Not Specified; SD – Standard Deviation

Table 4: Physiochemical Parameters of Abattoir and Control Soil obtained from A. Ogba

Parm.	Unit	Sample Range	Sample Mean	Sample S.D	Control Mean	t-value	p-value	Standard
Temp	^oC	26.31–28.93	28.50	0.10	28.07	1.76	2.571	20-30
E.C	μSm^{-1}	-716.36–4839.76	2061.70	646.06	2020.11	2.88	2.571	<2000
pH		3.81–7.77	5.79	0.46	6.1	2.97	2.571	6.00-9.00
Ca	$mgkg^{-1}$	0.46–0.57	0.56	0.002	0.55	2.76	2.571	< 4.5
P	$mgkg^{-1}$	13.51–20.99	17.25	0.87	16.18	2.87	2.571	<50
K	$mgkg^{-1}$	0.32 – 0.58	0.45	0.03	0.38	2.64	2.571	NS
NO_3	$mgkg^{-1}$	0.34–0.68	0.51	0.04	0.37	1.87	2.571	<0.25
Na	$mgkg^{-1}$	0.24–0.42	0.33	0.02	0.25	1.65	2.571	<4.5
Mg	$mgkg^{-1}$	0.01–0.10	0.09	0.001	0.09	2.64	2.571	<4.5
EA	meq/100g	0.14–0.20	0.17	0.006	0.15	1.45	2.571	NS
CEC	meq/100g	1.43–1.77	1.60	0.04	1.52	2.76	2.571	<18
DO	mg/L	-3.95–14.19	5.12	2.11	5.00	2.97	2.571	<5.0
BS	meq/100g	76.59–91.57	89.55	0.47	87.53	1.56	2.571	NS

KEY: Na- Sodium; EC- Electrical conductivity, pH - Potential of hydrogen, EA - Exchangeable acidity; Temp – Temperature, Ca –Calcium; CEC – Cation exchange capacity; Parm – Parameter; P- Phosphorus; DO- Dissolved Oxygen; , K- Potassium; BS – Base solution; NO_3 – Nitrate; NS – Not Specified; SD – Standard Deviation

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DOI: https://doi.org/10.64388/IREV9I9-1714868

Table 5: Physiochemical Parameters of Abattoir and Control Soil obtained from A.B. Koto

Parm	Unit	Sample Range	Sample Mean	Sample S.D	Control Mean	t-value	p-value	Standard
Temp	^oC	26.07–28.93	28.50	0.10	26.22	1.62	2.571	20-30
E.C	μSm^{-1}	-124.85–750.55	312.85	101.79	258.73	1.45	2.571	<2000
pH		4.70–7.50	6.03	0.31	7.36	2. 9	2.571	6.00-9.00
Ca	$mgkg^{-1}$	0.10–0.12	0.11	0.001	0.11	1.23	2.571	< 4.5
P	$mgkg^{-1}$	-3.85–12.83	4.49	1.94	4.28	2.96	2.571	<50
K	$mgkg^{-1}$	-0.18 – 0.60	0.21	0.09	0.19	1.67	2.571	NS
NO_3	$mgkg^{-1}$	-0.31–0.63	0.16	0.11	0.10	2.93	2.571	<0.25
Na	$mgkg^{-1}$	0.09–0.15	0.11	0.03	0.10	2.79	2.571	<4.5
Mg	$mgkg^{-1}$	-0.06–0.20	0.07	0.003	0.03	2.91	2.571	<4.5
EA	meq/100g	-1.01–3.11	1.05	0.48	0.98	2.82	2.571	NS
CEC	meq/100g	1.19–3.37	1.78	0.37	1.21	2.89	2.571	<18
DO	mg/L	0.05–0.13	0.09	0.01	0.10	2.74	2.571	<5.0
BS	meq/100g	-24.82–86.30	30.74	12.92	35.11	1.89	2.571	NS

KEY: Na- Sodium; EC- Electrical conductivity, pH - Potential of hydrogen, EA - Exchangeable acidity; Temp – Temperature, Ca –Calcium; CEC – Cation exchange capacity; Parm – Parameter; P- Phosphorus; DO- Dissolved Oxygen; , K- Potassium; BS – Base solution; NO_3 – Nitrate; NS – Not Specified; SD – Standard Deviation

The physiochemical parameters of abattoir soil obtained from G. Loko are presented on Table 6. Nine parameters: Electrical Conductivity, pH, Calcium ion, Sodium, Magnesium, Exchangeable Acidity, Cation exchange capacity, dissolved oxygen and base solution were not statistically significant ($p>0.05$). Significant differences ($p<0.05$) were recorded for only temperature, Nitrate and Phosphorus. Mean Electrical Conductivity, Nitrate and Dissolved Oxygen values were above the given standards. The values of physiochemical parameters of abattoir soil obtained from A. Ali is presented on Table 7. Electrical Conductivity, Sodium ion, dissolved oxygen and base solution were not statistically significant ($p>0.05$), while significant differences ($p<0.05$) were established for the other

parameters. The recorded Dissolved Oxygen was above the given standard. The physiochemical parameters of abattoir soil obtained from A. Kpandom are presented on Table 8. Temperature, Electrical Conductivity, Exchangeable Acidity and dissolved oxygen were not statistically significant ($p>0.05$). Significant differences ($p<0.05$) were established for other parameters. Mean value for pH (5.62 + 0.50) was lower than the given pH standard.

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DOI: https://doi.org/10.64388/IREV9I9-1714868

Table 6: Physiochemical Parameters of Abattoir andControl Soil obtained from G. Loko

KEY: Na- Sodium; EC- Electrical conductivity, pH - Potential of hydrogen, EA - Exchangeable acidity; Temp – Temperature, Ca –Calcium; CEC – Cation exchange capacity; Parm – Parameter; P-Phosphorus; DO- Dissolved Oxygen; , K- Potassium; BS – Base solution; NO_3 – Nitrate; NS – Not Specified; SD – Standard Deviation

Parm	Unit	Sample Range	Sample Mean	Sample S.D	Control Mean	t-value	p-value	Standard
Temp	ºC	26.20–28.86	27.53	0.31	26.64	2.81	2.571	20-30
E.C	μSm^{-1}	2156.12–2383.68	2269.90	26.46	2193.63	1.47	2.571	<2000
pH		2.86–10.34	6.60	0.87	6.50	1.23	2.571	6.00-9.00
Ca	$mgkg^{-1}$	0.41–0.45	0.43	0.004	0.42	1.75	2.571	< 4.5
P	$mgkg^{-1}$	12.58–14.82	13.70	0.26	12.93	2.89	2.571	<50
K	$mgkg^{-1}$	-0.33 – 0.97	0.32	0.15	0.30	2.82	2.571	NS
NO_3	$mgkg^{-1}$	-0.72–1.52	0.40	0.04	0.38	2.78	2.571	<0.25
Na	$mgkg^{-1}$	0.27–0.34	0.31	0.006	0.30	1.62	2.571	<4.5
Mg	$mgkg^{-1}$	0.01–0.19	0.10	0.01	0.09	1.43	2.571	<4.5
EA	meq/100g	-0.13–0.65	0.26	0.09	0.20	1.67	2.571	NS
CEC	meq/100g	1.23–1.75	1.49	0.06	1.33	2.45	2.571	<18
DO	mg/L	-9.87–23.27	6.71	3.85	2.11	1.23	2.571	<5.0
BS	meq/100g	63.03–103.45	83.24	4.70	79.90	2.12	2.571	NS

Table 7: Physiochemical Properties of Abattoir and Control Soil obtained from A. Ali

Parm	Unit	Sample Range	Sample Mean	Sample S.D	Control Mean	t-value	p-value	Standard
Temp	ºC	27.13–31.87	29.50	0.55	27.60	2.91	2.571	20-30
E.C	μSm^{-1}	174.02–450.52	312.27	32.15	211.26	1.64	2.571	<2000
pH		0.34–12.38	6.36	1.40	6.70	2.9	2.571	6.00-9.00
Ca	$mgkg^{-1}$	-0.46–0.84	0.19	0.15	0.14	2.89	2.571	< 4.5
P	$mgkg^{-1}$	7.02–8.32	7.67	0.15	7.53	3.12	2.571	<50
K	$mgkg^{-1}$	0.27 – 0.35	0.31	0.01	0.28	1.87	2.571	NS
NO_3	$mgkg^{-1}$	-0.18–0.60	0.21	0.09	0.19	2.79	2.571	<0.25
Na	$mgkg^{-1}$	0.20–0.22	0.20	0.001	0.20	1.2	2.571	<4.5
Mg	$mgkg^{-1}$	-1.03–1.29	0.13	0.27	0.12	2.89	2.571	<4.5

EA	meq/100g	0.42–0.60	0.51	0.02	0.48	2.85	2.571	NS
CEC	meq/100g	1.28–1.54	1.41	0.03	1.32	2.67	2.571	<18
DO	mg/L	-3.83–24.63	10.40	3.31	3.32	1.24	2.571	<5.0
BS	meq/100g	60.72–66.74	63.73	0.70	61.71	1.76	2.571	NS

KEY: Na- Sodium; EC- Electrical conductivity, pH - Potential of hydrogen, EA - Exchangeable acidity; Temp – Temperature, Ca –Calcium; CEC – Cation exchange capacity; Parm – Parameter; P- Phosphorus; DO- Dissolved Oxygen; ; K- Potassium; BS – Base solution; NO_3 – Nitrate; NS – Not Specified; SD – Standard Deviation

Table 8: Physiochemical Properties of Abattoir and Control Soil obtained from A. Kpandom

Parm	Unit	Sample Range	Sample Mean	Sample S.D	Control Mean	t-value	p-value	Standard
Temp	^oC	27.19–29.35	28.27	0.25	27.20	2.21	2.571	20-30
E.C	μSm^{-1}	1735.54–2176.90	1956.22	51.32	1816.50	1.71	2.571	<2000
pH		3.47–7.77	5.62	0.50	6.20	2.78	2.571	6.00-9.00
Ca	$mgkg^{-1}$	0.42–0.50	0.46	0.01	0.43	2.89	2.571	< 4.5
P	$mgkg^{-1}$	15.13–16.93	16.03	0.21	15.30	2.75	2.571	<50
K	$mgkg^{-1}$	0.38 – 0.46	0.42	0.01	0.35	2.41	2.571	NS
NO_3	$mgkg^{-1}$	0.30–0.64	0.47	0.04	0.39	2.81	2.571	<0.25
Na	$mgkg^{-1}$	0.22–0.40	0.31	0.02	0.25	3.12	2.571	<4.5
Mg	$mgkg^{-1}$	0.11–0.13	0.12	0.002	0.11	2.86	2.571	<4.5
EA	meq/100g	-0.47–1.07	0.03	0.18	0.28	1.79	2.571	NS
CEC	meq/100g	1.31–1.65	1.48	0.04	1.35	2.73	2.571	<18
DO	mg/L	-2.40–6.64	2.12	1.05	2.00	1.92	2.571	<5.0
BS	meq/100g	85.89–91.91	88.90	0.70	86.51	2.96	2.571	NS

KEY: Na- Sodium; EC- Electrical conductivity, pH - Potential of hydrogen, EA - Exchangeable acidity; Temp – Temperature, Ca –Calcium; CEC – Cation exchange capacity; Parm – Parameter; P- Phosphorus; DO- Dissolved Oxygen; ; K- Potassium; BS – Base solution; NO_3 – Nitrate; NS – Not Specified; SD – Standard Deviation

IV. DISCUSSION

The physicochemical properties such as Na, Mg, NO_3, PO_4, and Ca exhibited significantly higher values compared to the control soil. This indicates a potential impact of the abattoir activities on the soil composition, soil fertility and nutrient availability.

The elevated levels may be attributed to the discharge of effluents, waste, and runoff from the abattoir, which contain various chemicals and nutrients. Calcium ions can help improve soil structure by binding soil particles together, which can increase soil porosity and water-holding capacity. They can also enhance the availability of other nutrients such

as nitrogen and phosphorus for plant uptake (Zhao *et al.,* 2020). A study conducted by Ezejiofor *et al*. (2020) on the levels of phosphate ion concentration in abattoir soil in Nigeria also found that the average concentration of phosphate ion in abattoir soil was higher than the recommended maximum limit of 50 ppm set by the World Health Organization (WHO).

A study by Brown *et al.* (2005) reported the same that impact of abattoir waste on the emission of ammonia and nitrous oxide application of abattoir waste resulted in a significant increase in ammonia and nitrous oxide emissions. In Nigeria, Hamidu *et al.* (2015) found out that the concentration of Na in abattoir soil was higher than the concentration in nearby non-abattoir soil. The authors suggested that the high concentration of Na in abattoir soil could be attributed to the use of salt and other preservatives in meat processing. This study conformed with the report by Omojola and Oluokun (2019) that different tissues of cows slaughtered in abattoirs in Nigeria has higher content of Mg in the liver, heart, kidney, and muscle which can be washed to the environment during processing, thereby increasing the level of magnesium content of the soil. Despite the variation in sample readings at the abattoir and control sites both values were within the WHO given standards, except for pH at A. Tela, A. Affi, A. Ogba and A. Kpandom; electrical conductivity at A. Ogba and A. Loko; Nitrate at A. Affi, A. Ogba, G. Loko and A. Kpandom; Dissolved Oxygen at A. Ogba, G. Loko and A. Ali.

Soil pH as one of the soil parameters is so important because it determines the availability of almost all essential plant nutrients. According to Burt (2014) soil pH around 6.5 makes many nutrient available whereas alkaline soils impede the availability of nutrients like iron, manganese etc. The pH range of the abattoir soil was observed to be between 5.5 and 6.5, which indicates slight acidity. In contrast, the control soil had a pH range between 6.9 and 7.8, indicating a more neutral to slightly alkaline pH. The decrease in abattoir soil pH could be linked to the release of acidic by-products from the abattoir operations, contributing to soil acidification. Bloom *et al.* (2012) reported that the activity of man in the soil induces decrease in soil pH which impacts negatively on the environment. This research confirms the report by Meneghetti (2008) that waste water especially in the production of pig, cattle, and effluents from slaughter houses discharged into the surrounding soil have the capacity to alter the physicochemical properties of soil.

In most of the abattoir, the levels of dissolved oxygen and base solution were lower than those in the control soil. Reduced levels of dissolved oxygen may result from the decomposition of organic matter in the effluent, which consumes oxygen during microbial breakdown. The report by Mohammed and Adebiyi (2019) support this study that the dissolved oxygen content decreased significantly with increasing concentrations of abattoir waste. They also opined that the decomposition of organic matter in abattoir waste could lead to a reduction in dissolved oxygen, which in turn affected the microbial community in the soil. The lower base solution indicates a decrease in soil alkalinity, potentially affecting nutrient availability and microbial activity. The result of this study negates the report by Amponsah *et al*. (2016) which found out that the pH of the abattoir soil was significantly higher than the control soil. However, they summit the same that a shift in base solution can affect nutrient availability and microbial activity in the soil. The temperature range in the sampled soils around the abattoir was slightly higher than the control soil samples. Elevated temperatures can affect soil microbial activity, nutrient cycling, and plant growth. This increase may be due to the heat generated by abattoir activities or changes in microclimate caused by land use changes in the vicinity. Cotrufo *et al*. (2015) discovered that temperature affects the rate and extent of organic matter decomposition, which in turn influences the cycling of nutrients in soil ecosystems. Higher temperatures were not only associated with increased rates of organic matter decomposition; they decreased soil carbon storage and increased greenhouse gas emissions.

V. CONCLUSION

The research findings revealed that the physiochemical parameters of the soil within and around the abattoirs were significantly impacted by the activities in the abattoir soil. Elevated levels of Na^+, Mg, Ca, PO_4, and NO_3 in the soil were reported.

Environmental Impact Assessment (EIA) should be conducted to understand the full extent of the abattoir's effects on the surrounding environment. Effective and sustainable waste management practices within the abattoir should be implemented. There is need to explore soil remediation techniques to address the elevated levels of Na^+, Mg, Ca, PO_4, and NO_3 in the soil.

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