Assessment of the impact of abattoir activities on the physicochemical properties of soils within a residential area of Omu-Aran, Nigeria.

Assessment of the impact of abattoir activities on the physicochemical properties of soils within a residential area of Omu-Aran, Nigeria.

O O Elemile[1]*, O D Raphael[2], D O Omole[3], O E Oluwatuyi[1], E O Ajayi[1], O Umukoro[1] and M G Elemile[4]
[1]Department of Civil Engineering, College of Engineering, Landmark University, Omu-Aran, Nigeria
[2]Department of Agric and Bio-systems Engineering, College of Engineering, Landmark University Omu-Aran, Nigeria
[3] Department of Civil Engineering, College Engineering, Covenant University, Ota, Nigeria
[4]Department of Community Health Nursing, Faculty of Nursing Sciences, University of Medical Sciences, Ondo, Nigeria

***Correspondence Author:** elemile.olugbenga@lmu.edu.ng

Abstract. Waste effluents from abattoirs have been documented to have harmful effects on the soil media. There is little information about the level of contamination by abattoir effluents on the soil media in Omu-Aran. This study therefore assessed soil samples for possible contamination of physicochemical parameters and heavy metals from different points and some meters away from the mini abattoir in Omu-Aran, Kwara State, Nigeria. Soil samples which are 18 in number were collected from the soil around wells which are owned by individuals and a well designated as Control situated at distances which vary and different elevations to the abattoir. The physicochemical parameters of the soil samples were obtained by applying the standard methods. The analysis of data was achieved using descriptive statistics and ANOVA. The mean values of parameters in the soil samples collected around the studied wells ranged from 31.00±2.00–110.03±8.72 mg/L and 7.21±0.02–7.83±0.02 for electrical conductivity and pH respectively. Chloride, nitrate and phosphate had values of 6.37±0.13–9.13±0.21 mg/L, 3.67±0.07–4.50±0.31 mg/L and 3.86±0.07–5.41±0.30 mg/L respectively. However, average values for heavy metals (Ni, Cr and Pb) though slightly higher than the control site, were above permissible limits. Activities within Omu-Aran Abattoir impacts negatively on the surrounding arable soils; therefore, pollution control procedures which are sustainable should be implemented for abattoirs situated in residential areas.
Keywords: abattoir effluents, soil pollution, residential areas, Omu-Aran

1. Introduction

The ceaseless resolve to advance the production of meat in order to satisfy the nutritional requirements of the populace is often related with some challenges of air, water, food and soil pollution [1][2]. Abattoir waste has been reported as a category of waste which is of immense consideration to both urban and rural locations in Nigeria [2]. The slaughter house activities are a significant constituent of animal husbandry activities in Nigeria, which enables the provision of local beef to more than 160 million individuals and job prospects for the large populace [3]. Globally, abattoirs are directly or indirectly, identified as a source of environmental pollution via the numerous processes [4]. The meat industry utilizes great volumes of effluents which percolate into the surrounding environmental soil media [1]. Contamination of soils may be as a result of buildup of heavy metals and metalloids through releases from the speedily growing manufacturing zones, mine tailings, dumping of metal wastes of great volume, paints and gasoline which have high concentration of lead, application of fertilizers to the land, animal droppings, sludge cake, pesticides, effluent irrigation, firewood firing filths, oil spillage, and atmospheric deposition [5]. In Nigeria, there is no provision for infrastructure for handling of slaughterhouse wastewater which is different from what obtains in industrialised nations, where these amenities are available [6]. The abattoir in Omu-Aran is a relatively small one, despite that fact, there is no proper management of the waste emanating from the facility. The resultant consequences are the effect of human interaction with polluted soils. The existence and pervasiveness of toxic metals in the soil are dangerous to the microbes in the soil as well as the plants. Different body parts of livestock such as the flesh, blood, liver, kidney, innards and hair have been discovered to consist of heavy metals, as well leading to an increase of pH in the soil [7]. Crops thriving on these soils have exhibited a decrease in development and harvest [8]. With all this negative effect on the soil, this could lead to poor production of farm produce thereby affecting the economy of that environment in general. The situation in Nigeria, similar to what occurs in emerging nations still remains the battling with the challenge of the coordination and disposal of the unmanaged wastes into the environment, as the establishment of agencies such as Federal Environmental Protection Agency (FEPA) since 1998 has not made any difference [9]. Although a lot of work had been done on soil contamination, little is documented about the level of adulteration of soil media by abattoir activities in Omu-Aran, the study therefore assessed soil samples for possible contamination of physicochemical parameters and heavy metals from different points and some meters around the environs of the Odo- Eran abattoir situated in Ile Olupo Street, Omu-Aran.

2. Materials and methods

2.1. The Study area

Omu-Aran is located in the southern part of Kwara State, Nigeria. The town has latitude 8° 8′00″ N, longitude 5°6′00″ E and elevation of 564m [4]. Omu-Aran has a population of 148,610 and a land area of 73.7 square kilometers as documented in the 2006 Census [4]. The abattoir is sited 600 meters uphill of the well-known Areyin stream in Omu-Aran. The description of the different sampling locations showing the distance and elevation in meters from the abattoir is shown in Figure 1. The sample collection points which were the soils around the various wells were at 3.7, 537; 13.5, 537; 64.4, 536; 56.3,534; 61.7, 533 and 167.9, 538m for the distance from the abattoir and elevations for sampling points 1, 2, 3, 4, 5 and control location respectively. The bones stacked and leachates on the soil are shown in Plate 1. The control sampling point was selected because it is at a location which is situated at a higher distance and elevation of 167.9 and 538m respectively from the mini abattoir which is located at an elevation of 537m. The location of the control soil in terms of distance and higher elevation makes it difficult for the soil to be affected by the abattoir activities.

2.2. Sample collection, preparation and laboratory analysis

Eighteen soil samples, which consist of three soil samples were collected from around each of the five privately operated wells which are situated in the vicinity of the abattoir. Three other samples were obtained from around a single well which is situated at an elevation of 538m and a distance of 167.9m from the slaughterhouse identified as the control (Figure 1). The soil samples were collected along split lines at each sampling locations (Plate 2). The soil samples were obtained within the depth of 0-50 cm around the soils of the wells during the sunsets of Monday. The soil samples were collected for three successive weeks during the dry season. Samples were then dried in the air, crushed and sieved with a 2mm diameter mesh and kept in clean polythene bags and labelled appropriately before being stored at room temperature for laboratory analysis.

2.3. Determination of Physico-chemical parameters

The Physico-chemical parameters of the soil samples were obtained by applying the standard methods for analysis of soils according to [10] and [11]. A crushed part of the air-dried soil sample was completely mixed with water in the ratio of 1:1 by volume and a JENWAY 3015 pH/conductivity meter was utilized to determine the pH and electrical conductivity of the soil. The physicochemical parameters included: pH, Electrical conductivity (EC), sulphate (SO_4), nitrate (NO_3), chloride (Cl).

2.4. Determination of Heavy Metals

A portion (5g) of the soil sample which is dried in the air was digested in aqua-regia, the heavy metal was analysed applying methods earlier stated [12]. 100mL of the filtrate was prepared with distilled water and the concentrations of the heavy metals, Nickel (Ni), zinc (Zn), chromium (Cr), copper (Cu), lead (Pb) and iron (Fe) were determined utilizing atomic absorption spectrophotometer (AAS) (Perkin Elmer Analyst 200) following the standard procedures by the American Public Health Association [13].

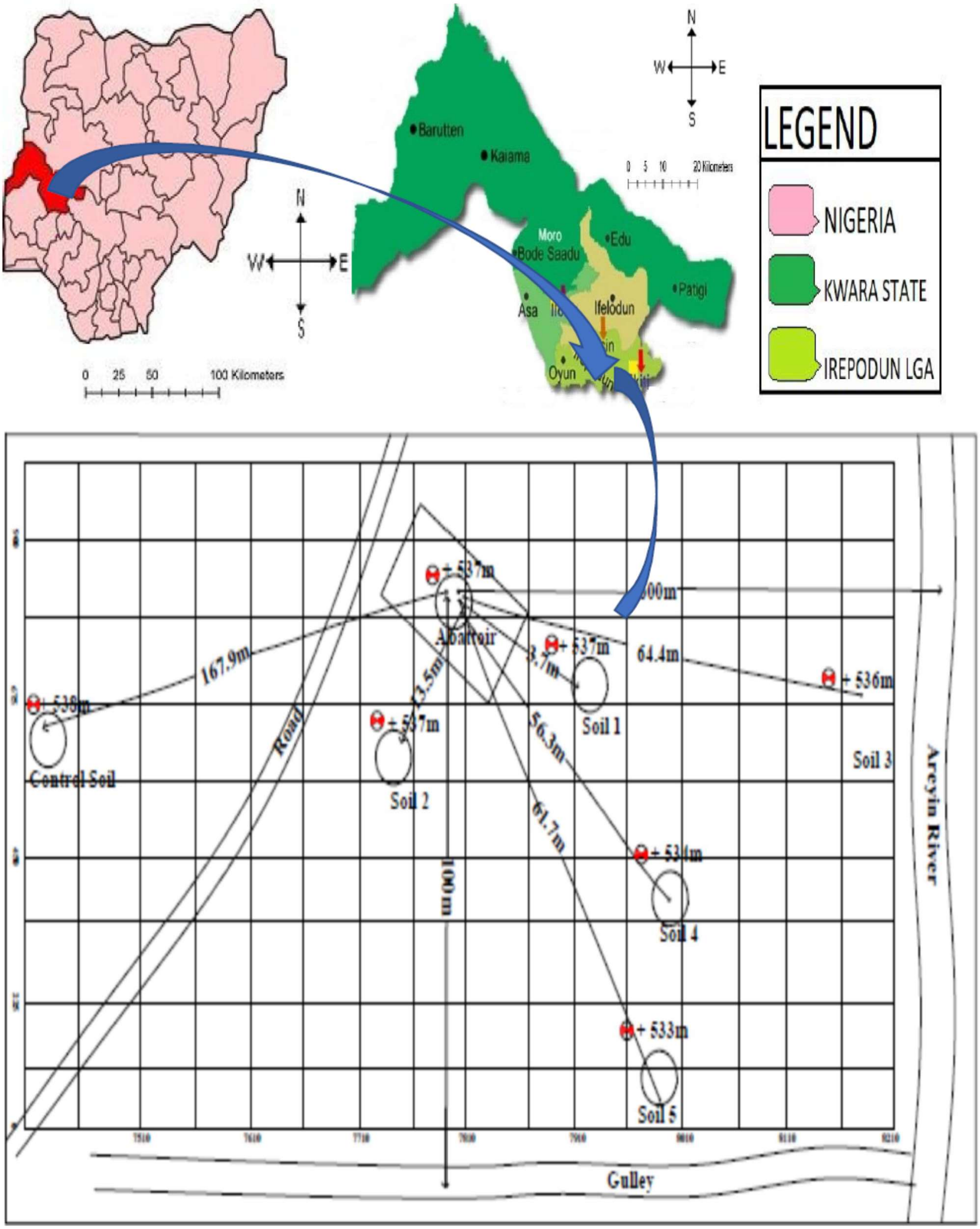

Figure 1: Map showing the location of the study area and the abattoir

Plate 1: *shows the bones stacked and leachates on the soil*

Plate 2: *Collection of soil samples*

2.5. Data Analysis and Management

The data analysis was carried out by means of the SPSS software Version 21.0 while ANOVA was used to compare soil samples parameters from different locations. The establishment of the difference between the average values of parameters that were measured at the soils around the various wells were determined by applying Duncan's multiple range comparison tests, using a 5% significance level ($p<0.05$). Descriptive statistics was used to data which were associated with the standard limits as set by the World Health Organization [14].

3. Results and Discussion

3.1. Physicochemical analysis of soil samples

The physical properties of the soil samples are presented in Table 1

3.1.1. pH

The results revealed that the mean values of pH are 7.19±0.25, 7.21±0.02, 7.25±0.04, 7.39±0.25, 7.70±0.05 and 7.83±0.02 for samples 2, 4,3,5,1 and the control sample respectively. The results varied significantly from each other, although the values fell within the WHO limits as the results showed that the abattoir effluents had lowered the pH of the soil as reported by [1]. The values were above the values of 6.22- 7.52 of a similar study [15]. High values of pH could be ascribed to the type of wastes such as dung, blood, fat, animal trimmings, stomach content and urine which are generated from the abattoir which results in lowered anaerobic activities in the soil [7]. This kind of soil conducive as most plants will thrive in a soil pH range of 5.5 to 7.5 [16].

3.1.2. Electrical Conductivity (EC)

The results revealed that the mean values of electrical conductivity ranged between 31.00±2.00, 42.33±2.89, 46.37±0.35, 55.43±4.94, 79.60±4.21 and 110.03±8.72 µs/cm for the control sample, samples 4, 3, 5, 1 and 2 respectively. The results varied significantly from each other, although the values fell within the WHO limits except the soil sample 2. The values were lower than the values of 60.00 - 110 of a similar study [17]. The increase in conductivity of the abattoir soils could be ascribed to the build-up of wastes such as bones, hairs, flesh and blood, salts in abattoir effluents between the soil openings [18]. The observation of high levels of EC in abattoir soils than in the control soil could be ascribed to low cation exchange capacity (CEC) of the control soil and variations in rates at which metallic salts and organic matter complexes are formed [19].

3.1.3. Sulphate

The results revealed that the mean values of sulphate ranged between 20.00±1.00, 26.00±1.73, 27.33±1.53, 29.67±1.53, 29.67±2.52 and 30.00±1.00 mg/L for the control sample, samples 2, 1, 4, 5 and 3 respectively. The results varied significantly from each other although the values fell within the WHO limits. The high values of sulphate found at the vicinity of the abattoir could be attributed to the increased microbial activities due to the large deposits of animal wastes [7]. It has been reported that although uptake in plants is not affected by additional intensification of concentration of sulphate, but plant development could have effects on crop production especially if above the permissible limits [20]

3.1.4. Nitrate

The results revealed that the mean values of nitrate ranged between 3.67±0.09, 4.16±0.17, 4.41±0.41, 4.43±0.30, 4.48±0.24 and 4.50±0.31mg/L for the control sample, samples 1, 5, 2, 3 and 4 respectively. The values were lower than the values of 24.08- 68.92mg/L of a similar study [7] although there were significant differences in the results, the values fell within the WHO limits. Nitrates is harmless at concentrations lower than permissible limits, but if it exceeds the limits it is harmful because of lowering in nitrites which can combine with amines and amides to form *"N-nitroso" composites* which is the major cause of cancer of the stomach [21]

3.1.5. Phosphate

The results revealed that the mean values of phosphate ranged between 1.48±0.15, 1.55±0.11, 1.57±0.1, 1.73±0.05, 1.76±0.21 and 1.78±0.16mg/L for the control sample, samples 3, 5, 2, 1 and 4 respectively. The results varied significantly from each other, although the values fell within the WHO limits except the soil sample 2. The values were lower than the values of 60.00 – 110mg/L of a similar study [7]. If the concentration of phosphorous of soil exceeds the acceptable limits, it could lead to underdevelopment of the plant in terms of growth. This is due to fact that great concentration of phosphorous restricts the uptake of nitrogen [22]

3.1.6. Chloride

The results revealed that the mean values of chloride ranged between 6.37±0.15, 7.57±0.68, 7.90±0.87, 8.33±0.25, 8.73±0.21and 9.13±0.21mg/L for the control sample, samples 5, 4, 3, 2, and 1 respectively. The results varied significantly from each other, although the values fell within the WHO limits. The values were lower than the values of 210- 380mg/L of a similar study [7]. The chloride level in the soil within the vicinity of the abattoir is okay as it is reported that high concentrations of chloride can cause toxicity problems in plants and reduce yield [23]

Table 1: Physico-Chemical Analysis of Soil Samples Collected from the Sampling Points

Parameters	**Units**	**Sampling Points**						**WHO [14]**
		S1	**S2**	**S3**	**S4**	**S5**	**Control**	
pH		7.70±0.05 ^{b}	7.19±0.25^{a}	7.25±0.04^{b}	7.21±0.02^{a}	7.39±0.05^{a}	7.83±0.02^{b}	6.5-8.5
Electrical Conductivity	µs/cm	79.60±4.21^{d}	110.03±8.72^{e}	46.37±0.35^{b}	42.33±2.89 ^{b}	55.43±4.94^{c}	31.00±2.00^{a}	< 100
Sulphate	mg/L	27.33±1.53^{bc}	26.00±1.73^{b}	30.00±1.00^{c}	29.67±1.53^{c}	29.67±2.52^{c}	20.00±1.00^{a}	100
Nitrate	mg/L	4.16±0.17^{ab}	4.43±0.30^{b}	4.48±0.24^{b}	4.50±0.31^{b}	4.41±0.41^{b}	3.67±0.09^{a}	50
Phosphate	mg/L	1.76±0.21^{b}	1.73±0.05^{ab}	1.55±0.11^{ab}	1.78±0.16^{b}	1.57±0.11^{ab}	1.48±0.15^{a}	50
Chloride	mg/L	9.13±0.21^{d}	8.73±0.21^{cd}	8.33±0.25^{bcd}	7.90±0.87^{bc}	7.57±0.68^{b}	6.37±0.15^{a}	250

For each parameter, means with the different letters (superscripts) are significantly different ($p < 0.05$), using Duncan's multiple range test.

.

3.2. Heavy metal analysis of well water samples
The results of the physicochemical analysis are presented in Table 2

3.2.1. Nickel
The results revealed that the mean values of nickel ranged between 1.15±0.02, 1.17±0.02, 1.17±0.02, 1.23±0.01, 1.23±0.03 and 1.26±0.01mg/L for the control sample, samples 5, 4, 2, 3, and 1 respectively. The control soil had the lowest concentration of nickel and the results varied significantly from each other with the values all above the WHO limits. The values were below the values of 2.86 and 4.86 mg/L of a similar study [7]. Nickel is found in abattoir effluents through the consumption of feeds and water by animals which is then excreted and percolates into the soil when washed [4]. It is reported that when the acceptable amounts are exceeded, it is dangerous because it is a major source of cancer [23]. Bioaccumulation of nickel has not been found up the food chain, but it is an important element in food for animals [24].

3.2.2. Zinc
The results showed that the mean values of zinc ranged between 1.40±0.20, 3.20±0.35, 3.30±0.36, 3.37±0.25, 3.50±0.36 and 3.77±0.40mg/L for the control sample, samples 5, 4, 3, 2, and 1 respectively. The control soil had the lowest concentration of zinc and the results varied significantly from each other with the values all below the WHO limits. The values were below the values of 15.80 and 17.00 mg/L of a similar study [16]. It is reported that zinc is a trace element which is important for man's well-being [24] and deficiency of zinc can cause congenital defects in babies [5][25][26]. It has also been identified by some researchers that zinc that is soluble in water which is found in soils can pollute groundwater [27].

3.2.3. Chromium
The results revealed that the mean values of chromium ranged between 0.21±0.03, 0.34±0.03, 0.35±0.02, 0.35±0.04, 0.35±0.04 and 0.37±0.04mg/L for the control sample, samples 3, 2, 4, 5, and 1 respectively. The results varied significantly from each other with the values all above the WHO limits although the values were below the values of 2.86 and 5.67 mg/L of a similar study [7]. Chromium has been linked with allergic dermatitis in human beings [28]. It is reported that chromium can easily be moved from the soil to surface waters by surface runoffs and it can be adsorbed from the soil into the groundwater [27].

3.2.4. Copper
The results revealed that the mean values of copper ranged between 1.19±0.04, 1.23±0.11, 1.26±0.01, 1.28±0.01, 1.36±0.10 and 1.40±0.15mg/L for the control sample, samples 1, 3, 4, 2, and 5 respectively. The results varied significantly from each other with the values all within the WHO limits and the values were below the mean values of 5.38 and 5.54mg/L of a similar study [16]. Copper is an important micronutrient which is needed in the development of both crops and animals, it also assists in the synthesis of blood [26]. High concentration of copper is responsible for blood deformation, liver and kidney diseases and gastric problems [15]. It is reported that when copper enters the environment it quickly becomes stable and transforms into a compound that is not dangerous to the environment [15].

3.2.5. Lead
The results revealed that the mean values of lead ranged between 1.93±0.07, 2.50±0.11, 2.52±0.15, 2.58±0.15, 2.61±0.18 and 2.71±0.15mg/L for the control sample, samples 1, 3, 4, 2, and 5 respectively. The results varied significantly from each other with the values all above the WHO limits which were below the mean values of 5.38 and 5.54mg/L of a similar study [16]. The observations of higher lead in abattoir soils than in the control soil is in agreement with [7] who stated that the values at the vicinity of abattoir is higher than that of the control site. Lead is reported as a hazardous element as it has the potential of bioaccumulation not only in man but in plants and animals [28], therefore it is

unsafe to consume food grown in soils that has lead in concentrations above permissible limits [29]. Lead has been reported to be responsible for growth retardation in children [4]

Table 2: Results of Heavy metals present in abattoir soil samples Collected from the Omu-Aran Abattoir Area

Parameters	Units	Sampling Points						WHO [14]
		S1	S2	S3	S4	S5	Control	
Nickel	mg/L	1.26±0.01 [b]	1.23±0.01[b]	1.23±0.03[b]	1.17±0.03[a]	1.17±0.02[a]	1.15±0.02[a]	0.02
Zinc	mg/L	3.77±0.40 [c]	3.50±0.36[bc]	3.37±0.25[a]	3.30±0.36[ab]	3.20±0.35[ab]	1.40±0.20 [a]	15
Chromium	mg/L	0.37±0.04[bc]	0.35±0.02[c]	0.34±0.03[b]	0.35±0.04[b]	0.35±0.04[b]	0.21±0.03 [a]	0.05
Copper	mg/L	1.40±0.15[b]	1.36±0.10[b]	1.28±0.01[b]	1.23±0.11[b]	1.26±0.01[b]	1.19±0.04[a]	1.5
Lead	mg/L	2.50±0.11[b]	2.61±0.18[b]	2.52±0.15[b]	2.58±0.15[b]	2.71±0.15[b]	1.93±0.07[a]	0.05

For each parameter, means with the different letters (superscripts) are significantly different ($p < 0.05$), using Duncan's multiple range test.

4. Conclusion

The assessment of the impact of abattoir activities on soil quality in the vicinity of the Omu-aran abattoir was investigated. It was revealed from the study that the impact of pollution from the values of physicochemical parameters of the soil within the vicinity of the abattoir were higher than those of the control samples except the pH. It was also seen that there were significant differences in all the parameters and all were within the WHO acceptable limits except nickel, chromium and lead. It is therefore concluded that activities within Omu-Aran Abattoir impacts negatively on the surrounding arable soils although not as much as in other areas where abattoirs are located; therefore, pollution control procedures which are sustainable should be implemented for abattoirs situated in residential areas

5. References

[1] Rabah A B, Oyeleke SB, Manga S B Hassan L G and Ijah U J J 2010 Microbiological and physico-chemical Assessment of soil contaminated with Abattoir effluents in Sokoto metropolis, Nigeria. *Science World Journal* 5(3): 1-4

[2] Ezeoha S and Ugwuishiwu B 2011 Status of abattoir waste research in Nigeria. *Nigerian Journal of technology* 30 (2): 143-148

[3] Nafarnda WD, Ajayi IE, Shawulu JC, Kawe MS, Omeiza GK Sani NA Tenuche O.Z Dantong DD and Tags SZ 2012 Bacteriological quality of Abattoir effluents discharged into water bodies in Abuja, Nigeria. ISRN *Veterinary Science.,* article I.D515689, //doi.org/10.5402/2012/51568 9

[4] Elemile OO, Raphael OD, Omole DO, Oloruntoba EO, Ajayi EO and Ohwavborua *NA* 2019. Assessment of the impact of abattoir effluent on the quality of groundwater in a residential area of Omu-Aran, Nigeria *Environmental Sciences Europe 31:16* https://doi.org/10.1186/s12302-019-0201-5

[5] Wuana RA and Okieimen F E 2011 Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation *Ecology* doi:10.5402/2011/402647; 1-20

[6] Ogbonnaya C 2008 Analysis of groundwater pollution from abattoir waste in Minna, Nigeria. *Resource Journal of Dairy Sciences* 2(4):74-77

[7] Chukwu UJ and Anuchi SO 2016 Impact of Abattoir Wastes on the Physicochemical Properties of Soils within Port Harcourt Metropolis. *The International Journal of Engineering and Science (IJES)*, 5(6):17-21

[8] Chibuike GU and Obiora, SC 2014 Heavy Metal Polluted Soils: Effect on Plants and Bioremediation Methods. *Applied and Environmental Soil Science*. Article ID 752708, http://dx.doi.org/10.1155/2014/752708; 1-13
[9] Adeyemo O.K 2003 Consequences of Pollution and Degradation of Nigerian Aquatic Environment on Fisheries Resources. *The Environmentalist 23*, 297-306
[10] Udo E J and Ogunwale J A 1986 Laboratory Manual for the Analysis of Soil, Plant and Water Samples,2nd Edition, University of Ibadan, Nigeria.
[11] Association of Official Analytical Chemists (AOAC) 1990 Methods of Analysis, 12th Edition, AOAC, Washington D. C., USA.
[12] Odu CTI, Esurosu O F, Nwaboshi I C and Ogunwale J A. 1985 Environmental study (Soil and Vegetation) of Nigeria Agip Oil Company Operation Area. A report submitted to Nigeria Agip Oil Company Limited, Lagos, Nigeria. 102-107
[13] American Public Health Association (APHA) 1998 Standard methods for examination of water and Waste water. American Public Health Association, American Water Works Association Water Pollution Control Federation.20th Edition. Washington DC, USA, 5-17.
[14] WHO 2004 Guideline for drinking water quality, 3rd Edition. World Health Organization, Geneva, 515. ISBN 92-4-154638-7
[15] Ediene VF and Iren OB 2017 Impact of Abattoir Effluents on the pH, Organic Matter, Heavy Metal Levels and Microbial Composition of Surrounding Soils in Calabar Municipality *Asian Journal of Environment and Technology* 2(3):1-10
[16] Hanlon EA 2015 Soil pH and Electrical Conductivity: A County Extension Soil Laboratory Manual http://edis.ifas.ufl.edu. Assessed on the 13th April, 2019
[17] Onwuka OA and Uzoukwu BA 2008 Studies on the physicochemical properties of soil from botanic garden *Scientia Africana*, 7: 156-164
[18] Radha S, Nithya VJ, Babu R.H, Sridevi A Narasimha G and Prasad N.B.L 2011 Effect of abattoir waste disposal on soil Physico-chemical, biological properties, and enzyme activities *Asian Journal of Microbiology, Biotechnology and Environmental Sciences* 13(4): 673-676
[19] Dan E, Fatunla K, Shuaibu S 2018 Influence of abattoir wastes on soil microbial and physicochemical properties *International Journal of Advance Research and Innovation* 6 (4): 253-261
[20] Shadia K A, Shalaby I A and Mortada R K 2016 Effect of Calcium Superphosphate Sulphur Fertilizer on the Growth, Herb Yield and Active Ingredient of Ambrosia maritime, *Middle East Journal of Applied* 6(2): 308-31
[21] Aires I, Carvalho R, Eduardo A S Rosa, EA and Saavedra, MJ 2013 Effects of agriculture production systems on nitrate and nitrite accumulation on baby-leaf salads *Food Science & Nutrition* 1(1): 3–7 doi: 10.1002/fsn3.1
[22] Oh Y, Nelson PV, Hesterberg D L and Niedziela C.E 2016 Efficacy of a Phosphate-Charged Soil Material in Supplying Phosphate for Plant Growth in Soilless Root Media *International Journal of Agronomy* Article ID 8296560 http://dx.doi.org/10.1155/2016/8296560
[23] Sumayya B. U, Usman B. U Aisha U. Shahida A. Mohammad A, Yakubu M S and Zainab M. 2013 Determination of Physiochemical Qualities of Abattoir Effluent on Soil and Water in Gandu, Sokoto *Journal of Environmental Science Toxicology and Food Technology* 4: 47-50
[24] Sreekanth TVM, Nagajyothi PC, Lee, T.N and Prasad, V.K.V. 2013 Occurrence, physiological responses and toxicity of nickel in plants. *International Journal of Science and Technology,* 10(5) 1129-1140.
[25] Alysson RBS, and Fábio C 2014 Risks of Heavy Metals Contamination of Soil-Pant System by Land Application of Sewage Sludge: A Review with Data from Brazil http://dx.doi.org/10.5772/58384
[26] Garba ZN, Hamza SA, and Galadima A 2010 Arsenic Level Speciation in Fresh Water from Karaye, Local Government Area, Kano State, Nigeria. *International Journal of. Chemistry*. 20(2):113-117

[27] Morgan SC, Relaix F, Sandell LL, and Loeken MR 2008 Oxidative stress during diabetic pregnancy disrupts cardiac neural crest migration and causes outflow tract defects. *Clinical Molecular Teratology*, 82(6): 453–463. DOI: 10.1002/bdra.20457
[28] Raymond AW and Felix EO 2011 Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation. International Scholarly Research Network, ISRN *Ecology*, doi:10.5402/2011/402647
[29] Musa JJ, Mustapha I, Bala J D, Ibrahim Y Y, Akos M P, Daniel E S, Oguche F M and Kuti I A 2017 Heavy Metals in Agricultural Soils in Nigeria: A Review *Arid Zone Journal of Engineering, Technology and Environment, October, 2017,* 13(5):593-603