LAND POLLUTION ASSESSMENT FROM SLAUGHTERHOUSES WASTE DISCHARGE IN PORT HAROURT.

ABSTRACT

Aim: The study aimed at evaluating pollutants present in soil due to slaughterhouse wastewater discharge into surrounding land mass as well as comparing land deposition as an alternative means of discharge.

Study Design: The study design was based on Investigative Survey Research Approach (ISRA). The ISRA for obtaining data entailed schedule of series of visits to slaughterhouse facilities. The tasks accomplished during such visits included the following: Inspection and witnessing processing operations within and around the sampled slaughterhouses; interviewing relevant and competent staff of the slaughterhouses and residents living in areas close to the slaughterhouses; Collection of soil samples at specified depth intervals within the discharge points of selected land based slaughterhouses for laboratory analysis.

Methodology: A total of twelve composite samples were collected from three different land discharged locations. Three composite samples each were collected from the sampling locations at a depth of 0 to 10cm, 10 to 20cm, 20 to 30cm and 30 to 40cm. Four composite samples each were collected for analysis from the three sampling locations on specified sampling dates. The samples were then placed in sterile polythene bags and transported to the laboratory for processing.

Results: A high build-up of heavy metal concentration was observed in soil samples from all the sampled locations across their examined depths. Mn had the highest average concentration across the depths followed by Zn, Pb and Cd as shown from sampled results of LA1, LA2 and LA3. The average concentrations of Mn, Zn, Pb, and Mn decreased across the depths for all examined sites except for a truncated build-up of Zn and Mn at depths 30-40cm and 10-20 cm respectively.

Conclusion: From the results obtained therefore, it was revealed that effluent/solid wastes generated from the slaughterhouse is highly polluted and has a huge effect in nutrient build-up, hence, there is an urgent need for basic treatment of wastes before discharge to land.

Keywords: Slaughterhouse, Land discharge, Total Bacteria Count.

1. INTRODUCTION

Livestock production is considered a potential food for the world's needy people. It however, becomes a major pollutant of the country site and cities when the slaughter wastes are not properly managed and especially discharged into waterways, as such practices can introduce enteric pathogens and excess nutrients into surface water [1]. The wastes from slaughterhouse operations which are often separated into solid, liquid and fats could be highly organic. The solid part of the wastes consist of condensed meat,

undigested ingest, bones, hairs, and aborted foetuses. The liquid aspect on the other hand consists of dissolved solids, blood, guts contents, urine and water, while fat waste consists of fats and oil. The pollution of water resources often results in the destruction of primary producers, which in turn leads to an immediate diminishing impact on fish yields, with the resultant consequence of decrease in diet [2].

The continuous drive to increase meat production for the protein needs of the ever increasing world population has some pollution problems attached. Pollution arises from activities in meat production as a result of failure in adhering to Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP) [3]. Consideration is hardly given to safety practices during animal transport to the slaughterhouse, slaughter and dressing. Slaughterhouse waste just like any other waste can be detrimental to humans and the environment if definite precautions are not taken. In the Nigerian livestock industry, slaughterhouses are littered with non-meat products and wastes that need to be recycled into useful by-products for further agricultural and other industrial uses [1].This constitutes public health risks and nuisance in most slaughterhouses spread across Nigerian markets, producing air, soil, and water pollution as well as infestation of flies and other disease vectors. For hygienic reasons, slaughterhouses use large amount of water in processing operations; this produces large amount of wastewater. The major environmental problem associated with this slaughterhouse wastewater is the large amount of suspended solids and liquid waste as well as odour generation [4] .

In Nigeria, nearly every town and neighborhood is provided with a slaughterhouse or slaughter slab. Ampofo and Awortwe (2017) [5] observed that slaughterhouses may be situated in urban, rural and nominated industrial sites, and that each has advantages and disadvantages. Simeon and Friday (2017) [6] also reported that, a cow brought for slaughtering produces 328.4kg of waste in form of dung, bone, blood, horn and hoof. The disposal of waste products is a problem that has always dominated the slaughter sector, and on the average, 45 percent of each live beef animal, 53 per cent of each sheep, and 34 per cent of each pig consist of non-meat substances. The characteristics of slaughterhouse wastes and effluents vary from day to day depending on the number, types of stock being processed, and the processing method [4]. Clean water resources used for drinking, sustaining aquatic and terrestrial ecology, industry and aesthetic values along with breathable air, rank as the most fundamental and important need of all viable communities. These water resources should remain within specific quality limits, and therefore require stringent and conservative protection measures. Akinnibosun and Ayejuyoni (2015) reported that animal wastes can affect water, land or air qualities if proper practices of management are not adhered to. The same wastes however, can be valuable for crops but can also cause water quality impairment. It also contains organic solids, trace heavy metals, salts, bacteria, viruses, other microorganisms and sediment. The waste from animals can also be washed into streams if not protected and reduces oxygen in water, thereby endangering aquatic life. Akinnibosun and Ayejuyoni (2015) [7] also reported that improper animal waste disposal can lead to animal diseases being transmitted to humans through contact with animal faeces. Mohammed and Musa (2012), [2] reported that slaughterhouse effluents reaching streams contribute significant levels of nitrogen, phosphorous and biochemical oxygen demand, as well as other nutrients, resulting in stream pollution.

Elemile et al (2019) [8] also reported that the ground water quality in vicinity of the slaughterhouse was adversely affected by seepage of slaughterhouse effluent as well as water quality of receiving stream that was located away from the slaughterhouse.

The Port Harcourt slaughterhouses serve the entire town, hence most of their locations beside fallow land mass have facilitated easy disposal of the wastes into soil profile without any proper treatment. This study would attempt to assess, appraise the consequence of this practice on soil properties of selected slaughterhouse environment.

METHODOLOGY

2.1 STUDY AREA

Appropriate study sites were selected based on the accessibility of the location and the bench mark of long term level of pollution from slaughterhouse wastes in at least a minimum of six (6) years after a general review of various slaughterhouses was conducted within the study area. A total of three (3) slaughterhouses for land discharge were analyzed. Study area focused on Obio Akpor and Ikwere Local Government Areas of Rivers State, with estimated population of 649,600 and 265,400 respectively all in Port Harcourt, Nigeria [9]; as shown in Figure 1.

The selected slaughterhouses evaluated are as listed below;

1) Omuigwe Slaughterhouse
2) Rukpokwu Slaughterhouse
3) Rumuekini Slaughterhouse

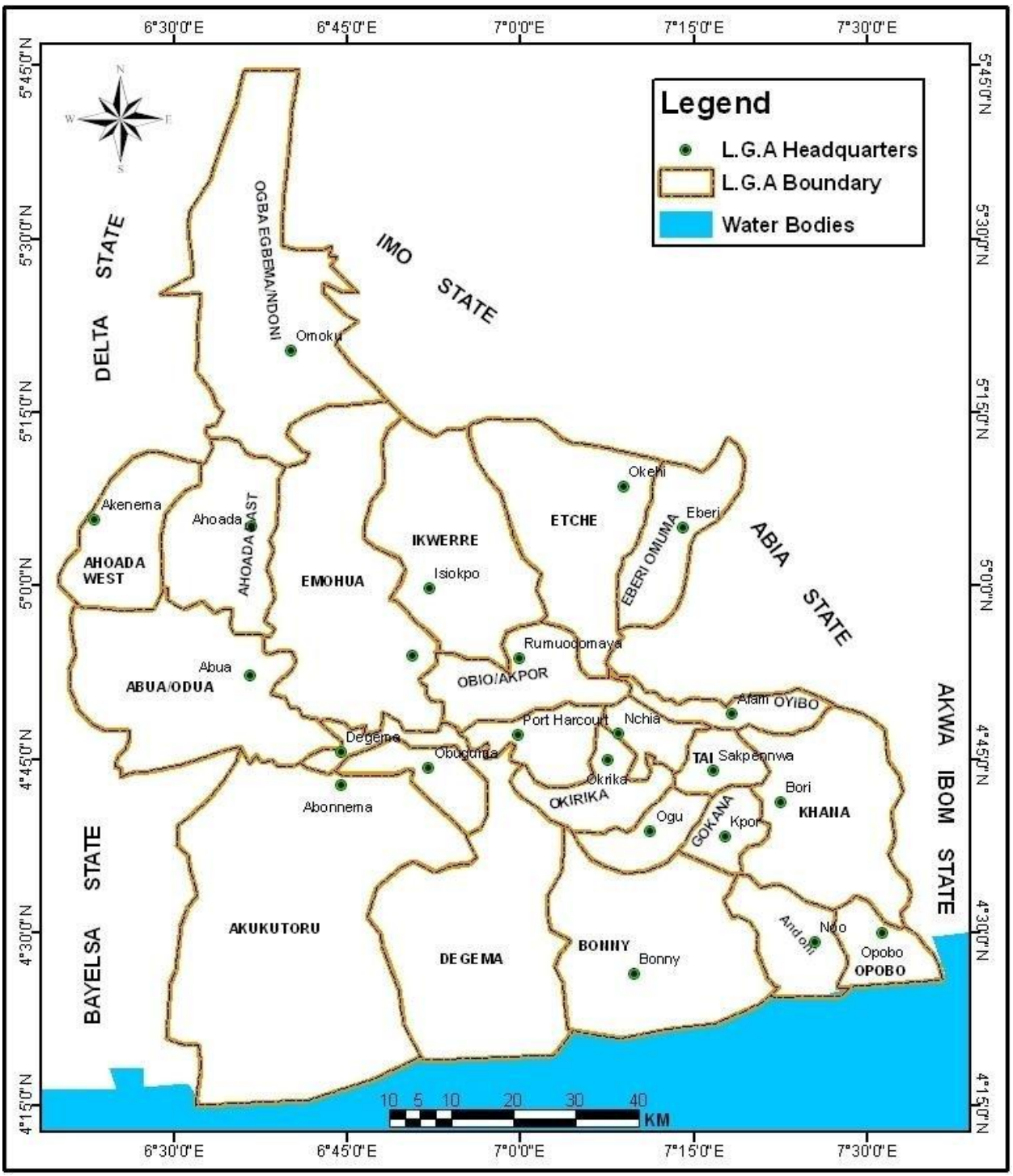

Figure 1: Map of Rivers State Showing the Local Government Area

2.2 SAMPLE AND SAMPLING TECHNIQUES

A total of twelve composite samples were collected from three different land discharged locations. The three composite samples each were collected from the sampling locations at a depth of 0 to 10cm, 10 to 20cm, 20 to 30cm and 30 to 40cm. Four composite samples each were collected for analysis from the three sampling locations on specified sampling dates. The samples were then placed in sterile polythene bags and transported to the laboratory for processing. Soil samples were collected from each sampling site with clean polyethylene bottles. The containers were washed with dilute HCl and then rinsed with the wastewater from the slaughterhouse so as to neutralize or reduce the effect of external contaminants. The samples were appropriately labelled and transported to the laboratory, stored in the refrigerator at 4^0 C prior to being analyzed for the physical, chemical and biological parameters present.

2.3 NATURE AND SOURCES OF DATA

Data was strictly for laboratory analysis of the various soil parameters being considered. The soil samples were analysed for physico-chemical parameters that included: pH, turbidity, total dissolved solids (TDS), electrical conductivity (EC), total alkalinity (TA), total hardness (TH), Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NO^{3-}, SO_4^{2-}, Cl-, Cu^{2+}, Fe^{2+} and Mn^{2+} ions. Various experimental and instrumental techniques were employed to analyze the different chemical components. Summaries of these methods are presented in section 3.6 below, while a complete description of the methods can be found in Standard Methods for the Examination of Water and Wastewater, 20th Edition [10].

2.4 METHODS OF DATA COLLECTION AND INSTRUMENTATION

Collected wastewater samples were analyzed according to Standard Methods for Examination of Water and Wastewater [10]. The following parameters were analyzed for the purpose of this study.

1. pH
2. Temperature
3. Conductivity
4. Biochemical oxygen demand (BOD)
5. Chemical oxygen demand (COD)
6. Total solids (TS)
7. Phosphates
8. Nitrates
9. Fecal Coliform
10. Sulphate

11. Fluoride
12. Zinc
13. Lead
14. Manganese
15. Cadmium
16. Carbonate

2.4.1 pH Measurement

The pH is a measurement of the hydrogen ion (H+) concentration in the samples. The measurement was done with the Mettler Delta 340 pH meter. The pH meter was first calibrated using standard buffer solutions of pH 4.01 and 7.0. The electrode was rinsed with distilled water and dipped into the test sample. The pH value displaced (displayed) on the screen, which remained unchanged for 5 minutes, was recorded as the pH value of the test sample.

2.4.2 Total Solids (TS)

The gravimetric method according to standard method was used. 250ml capacity beaker was thoroughly washed, rinsed with distilled water, dried in the oven at 105^0 C for 1 hour and then cooled in the desiccator. The beaker was weighed and 50ml of test sample was introduced into the beaker. The sample was heated to dryness and the beaker containing the residue was cooled in the desiccator and reweighed.

The TS in mg/l of the sample was calculated thus:

$$TS\left(\frac{mg}{l}\right) = \left(\frac{(B - A) \times 1000}{V}\right)$$

Where:

A= weight of empty beaker (mg)

B= weight of beaker + residue (mg)

V=volume of sample used (ml)

1000= conversion to litre.

2.4.3 Phosphate Determination

The ascorbic acid method was used in this determination. 5.0ml of sample was pipetted into a clean dry test tube and a drop of phenolphthalein indicator was added. No red color developed. Then 1ml of combined reagents (50ml of 5N H_2SO_4; and 5ml of potassium antimonyl tartrate solution) was added and the solution was thoroughly mixed. It was allowed to stand for 10 minutes and the absorbance was measured at 470nm using spectrophotometer and blank as reference solution. The amount of phosphate in mg/L in the sample was calculated from the relation:

$$PO_4^3(\frac{mg}{l}) = \frac{A \times 1000}{ml\ of\ sample}$$

Where:

A = mg PO_4^3 from curve

1000 = Conversion to litre

2.4.4 Nitrate Determination

The Brucine method was used to determine nitrate in the samples. One millilitre of sample was introduced into a clean test-tube and 0.5ml of 25% brucine reagent (2.5g of brucine or brucine sulphate in 100ml of glacial acetic acid). One millilitre of dilute nitrate standard solution (0.2 □g NO3-N per millilitre) was added and then 2ml of concentrated sulphuric acid was added rapidly and shaken well. This solution was mixed for 30 seconds and allowed to stand for 5 minutes. A light yellow colour was developed. The solution was mixed again and 2ml of distilled water was added and mixing continued for another 30 seconds. Then a curvette was filled with the solution and the absorbance was read at 470nm. The amount of nitrate in the sample was calculated thus:

$$NO_{3-}(\frac{mg}{l}) = \frac{C \times 100}{ml\ of\ sample}$$

Where:

C = mg nitrate in sample from curve

2.4.5 Zinc – Spectrophotometric Method

Amounts of Zinc in the samples were determined by HACH DR2 spectrophotometer using zinc powder pillows at wavelength of 560nm. The results were expressed in mg/l.

2.4.6 Manganese – Spectrophotometric Method

Amounts of manganese in the samples were determined by HACH DR2 spectrophotometer using manganous powder pillows at wavelength of 526nm. The results were expressed in mg/l.

Other parameters including Lead and Cadmium were also analysed by spectrophotometric method.

2.4.7 Total bacteria

Total bacteria was estimated using the standard spread-plate dilution method. Samples of the soil and wastewater contaminated with the abattoir wastes were serially diluted in ten folds. Total viable heterotrophic aerobic counts were determined using pour plate technique. Then the molten nutrient agar, TCBS, MacConkey and Sabouraud dextrose agar at 45^0 C were poured into the Petri dishes containing 1ml of the appropriate dilution for the isolation of the total heterotrophic bacteria and fungi, Vibrio cholerae and coliforms respectively. They were swirled to mix and colony counts were taken after incubating the plates at room temperature for 48h and preserved by sub culturing into nutrient agar slants which were used for biochemical tests.

2.4.8 Laboratory Analysis for Soil Samples

Preliminary routine laboratory practices of air drying, crushing and sieving were done. Soil pH was determined using the ratio 1:1 of soil to distilled water, and measured with a glass electrode pH meter. Percentage organic carbon (OC) and organic matter (OM) were determined using Walkley-Black method. Total nitrogen (N) was measured using micro Kjedhal digestion distillation method. Available phosphorus (P) was also evaluated using Bray-1 method. Exchangeable cation was determined using ammonium acetate (NH_4OAC) extraction solution method; sodium (Na) and potassium (K) were measured using Flame Photometer, calcium (Ca) and magnesium (Mg) were measured using EDTA titration. Cation exchange capacity (CEC) was evaluated using 1N neutral ammonium acetate (NH_4OAC) solution.

3. RESULTS AND DISCUSSION

3.1 Land Discharged Slaughterhouse Analysis

Results and data plots of Boundary/Omuigwe land slaughter house (LA1) with different analysed parameters are as presented in Table 1.

Table 1: Parameter results of Boundary/Omigwe Land slaughterhouse (LA1) at different depth.

Parameter	Depth (0-10cm)	Depth (10-20cm)	Depth (20-30cm)	Depth (30-40cm)
pH	6.64	6.86	6.76	6.85
Moisture content	22.16	18.21	19.32	18.36
Bulk density	1.48	1.63	1.72	1.83
Sand (%)	58.32	62.4	64.21	60.3
Clay (%)	4.86	5.62	6.53	6.62
Silt (%)	30.22	26.24	28.72	29.4
Organic Carbon (OC) (%)	3.26	3.74	2.93	2.75
Total Organic Matter (TOM) (%)	6.22	10.64	22.4	26.82
Porosity (%)	50.18	51.21	50.62	50.49
Zinc (Zn) (mg/kg)	324.27	256.4	215	222.6
Lead (Pb) (mg/kg)	26.34	23.38	19.24	18.6
Manganese (Mn) (mg/kg)	528.36	621	584.8	566.3
Nitrate (mg/kg)	13.49	14.32	10.44	9.63
Phosphate (mg/kg)	53.06	49.28	32.31	26.1
Cadmium (Cd) (mg/kg)	0.48	0.36	0.32	0.26
Carbonate (mg/kg)	3.52	3.82	4.18	3.93
Total bacteria count (Cfu/g)	34800	38200	46200	53700

A plot of all the analysed physical parameters for Boundary/Omuigwe slaughterhouse is as shown in Figure 2.

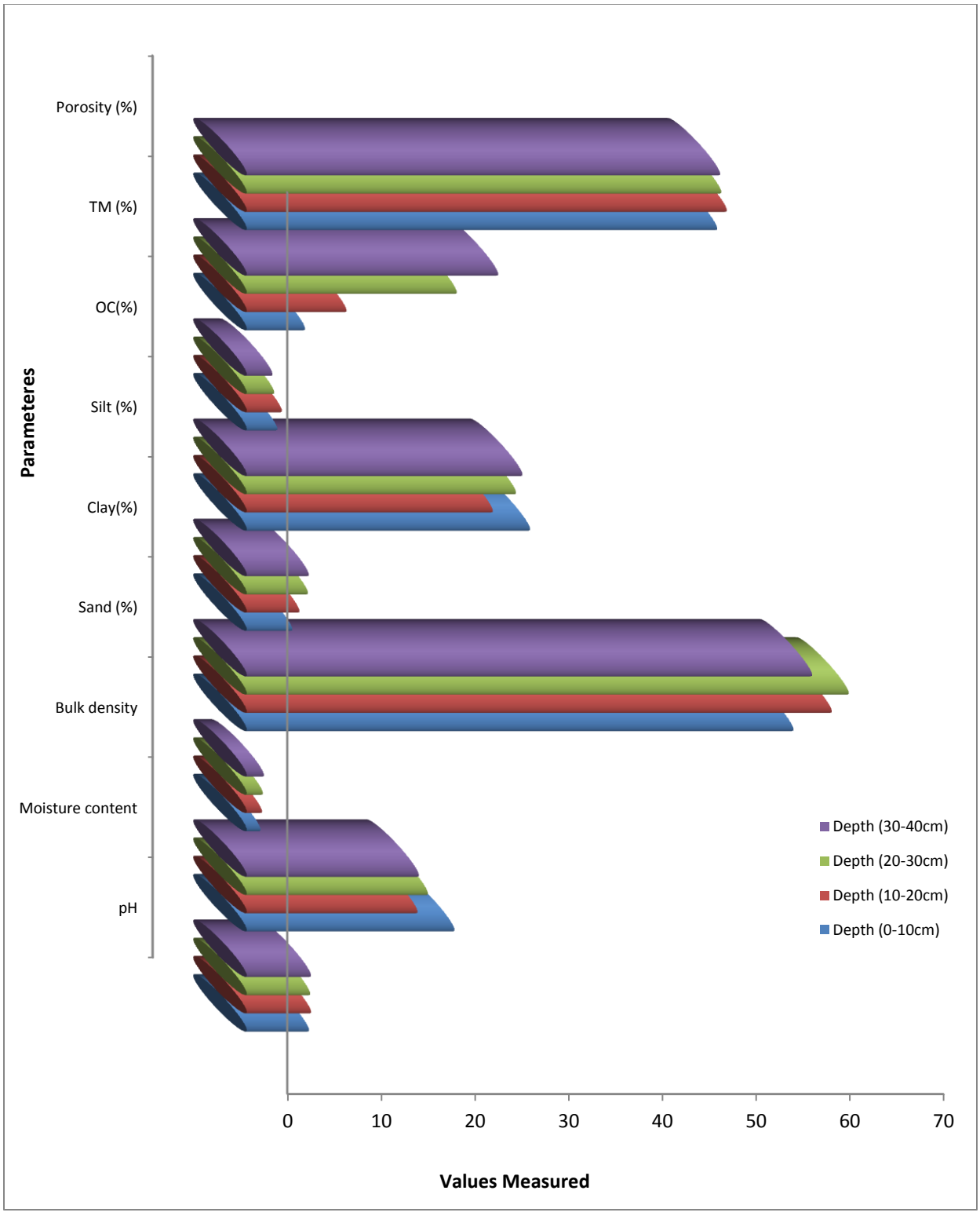

Figure 2: Bar chart plot of Physical Parameters for Boundary/Omigwe Land Discharge Slaughterhouse

A plot of all the analysed chemical parameters for Boundary/Omuigwe slaughterhouse is also as presented in Figure 3.

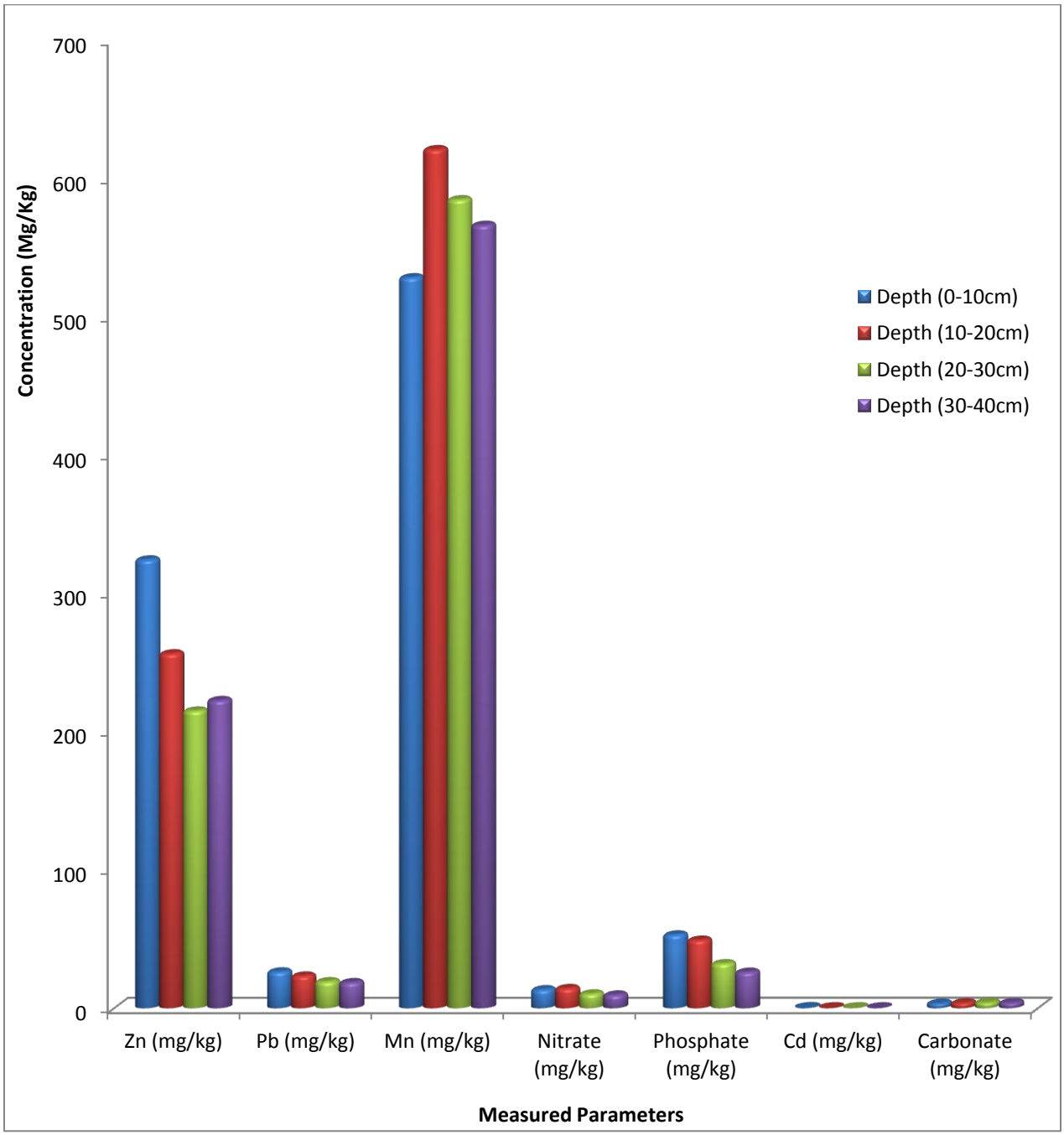

Figure 3: Chart plot for Chemical Parameters Measured for Boundary /Omigwe Land Discharge Slaughterhouse

Also, a chart plot showing the variation of total bacteria count at different analysed depth for Boundary/Omigwe slaughterhouse is as shown in Figure 4.

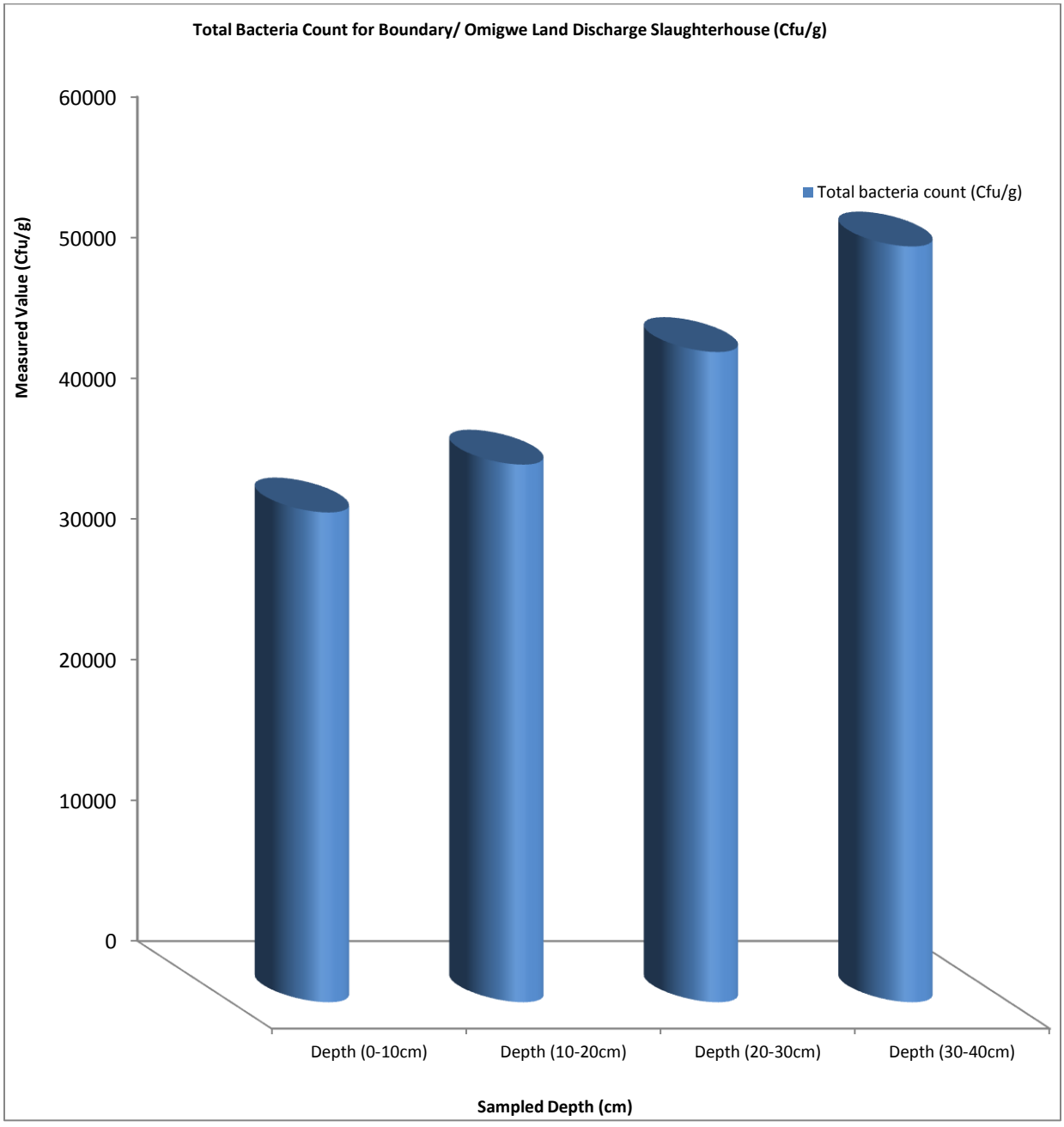

Figure 4: Chart plot of Total Bacteria Count for Boundary/ Omigwe Land Discharge Slaughterhouse

Results and data plots of Rukporkwu land slaughter house (LA2) with different analysed parameters are as presented in Table 2.

Table 2: Parameter results of Rukporkwu Land slaughterhouse (LA2) at different depth.

Parameter	Depth (0-10cm)	Depth (10-20cm)	Depth (20-30cm)	Depth (30-40cm)
pH	7.52	7.34	7.4	7.28
Moisture content	30.36	23.51	22.6	24.56
Bulk density	1.9	1.95	2.16	2.09
Sand (%)	63.64	72.92	74.41	68.68
Clay (%)	7.7	8.88	9.77	9.94
Silt (%)	38.58	35.6	36.58	39.61
Organic Carbon (OC) (%)	5.37	5.8	4.55	3.79
Total Organic Matter (TOM) (%)	7.54	13.9	28.72	37.5
Porosity (%)	52.8	53.21	51.94	52.12
Zinc (Zn) (mg/kg)	425.99	419.24	317.4	398.9
Lead (Pb) (mg/kg)	31.58	27.7	22.06	20.52
Manganese (Mn) (mg/kg)	652.56	767.3	719	693.9
Nitrate (mg/kg)	16.09	17.64	11.92	10.89
Phosphate (mg/kg)	56.52	52	34.23	27.21
Cadmium (Cd) (mg/kg)	0.56	0.38	0.34	0.27
Carbonate (mg/kg)	4.74	5.43	5.52	5.45
Total bacteria count (Cfu/g)	45900	51300	58400	64900

A plot of all the analysed physical parameters for Rukporkwu slaughterhouse is as shown in Figure 5.

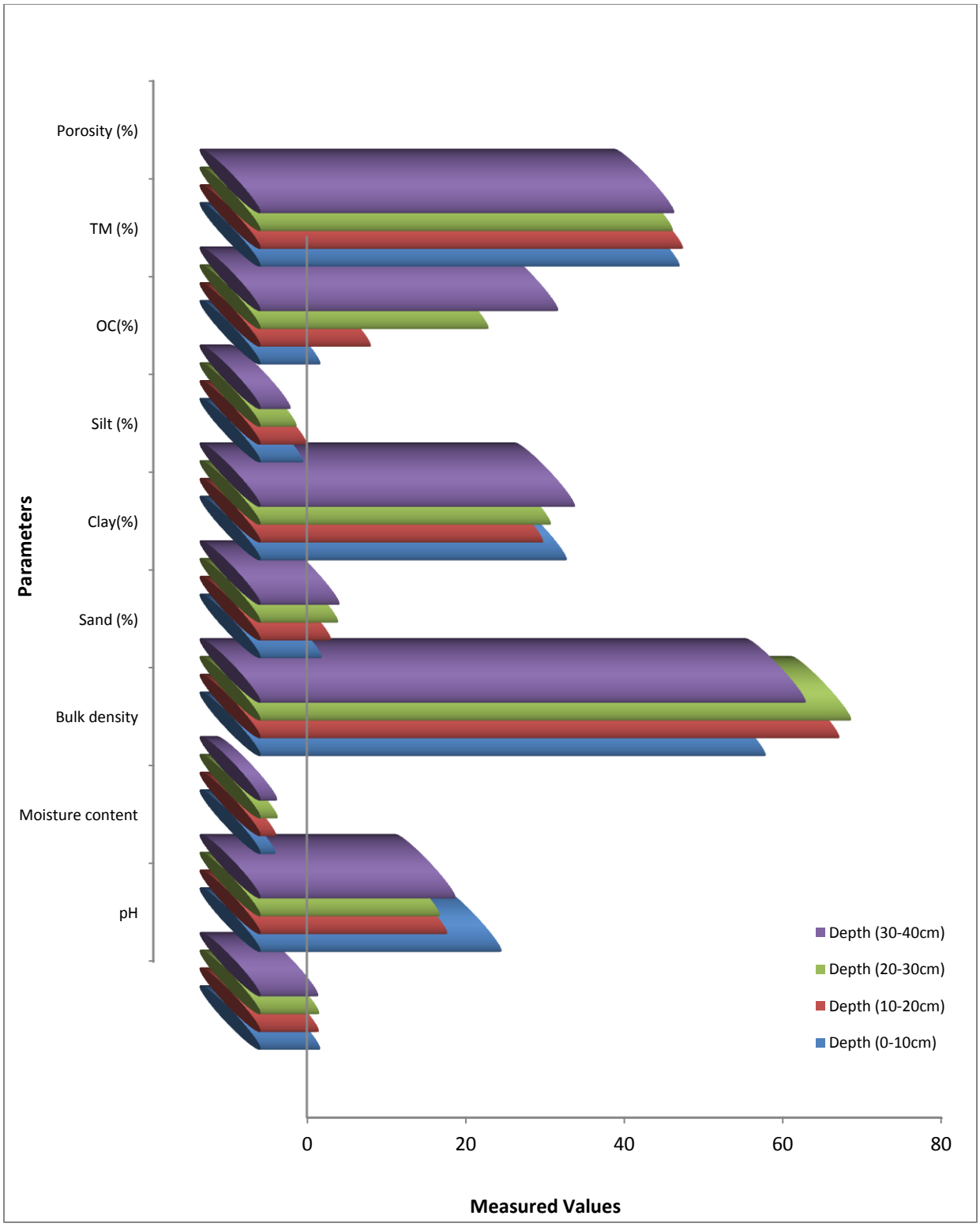

Figure 5: Bar chart plot of Physical Parameters for Rukporkwu Land Discharge Slaughterhouse

A plot of all the analysed chemical parameters for Rukporkwu slaughterhouse is also as presented in Figure 6.

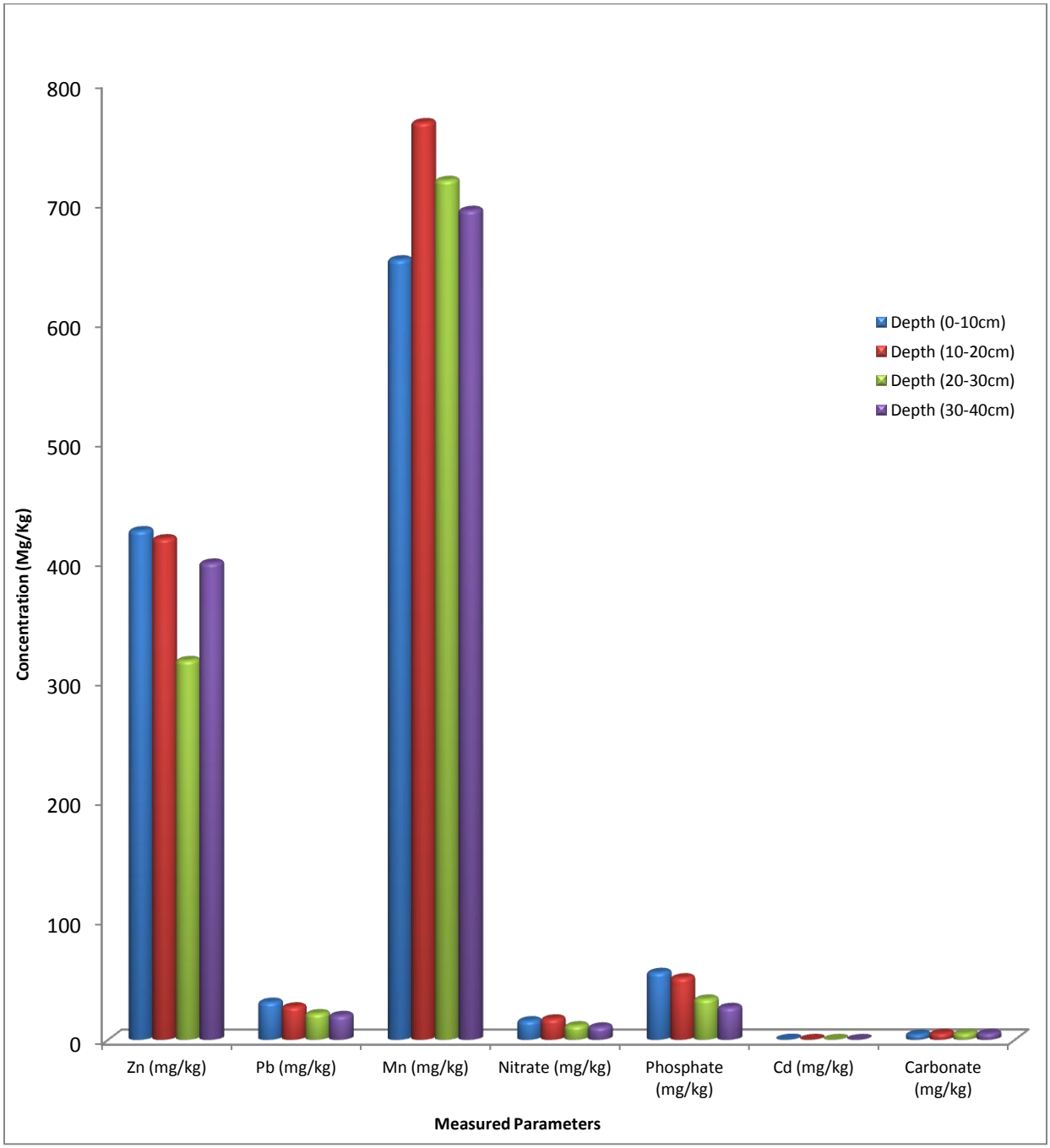

Figure 6: Chart plot for Chemical Parameters Measured for Rukporkwu Land Discharge Slaughterhouse

Also, a chart plot showing the variation of total bacteria count at different analysed depth for Rukporkwu slaughterhouse is as shown in Figure 7.

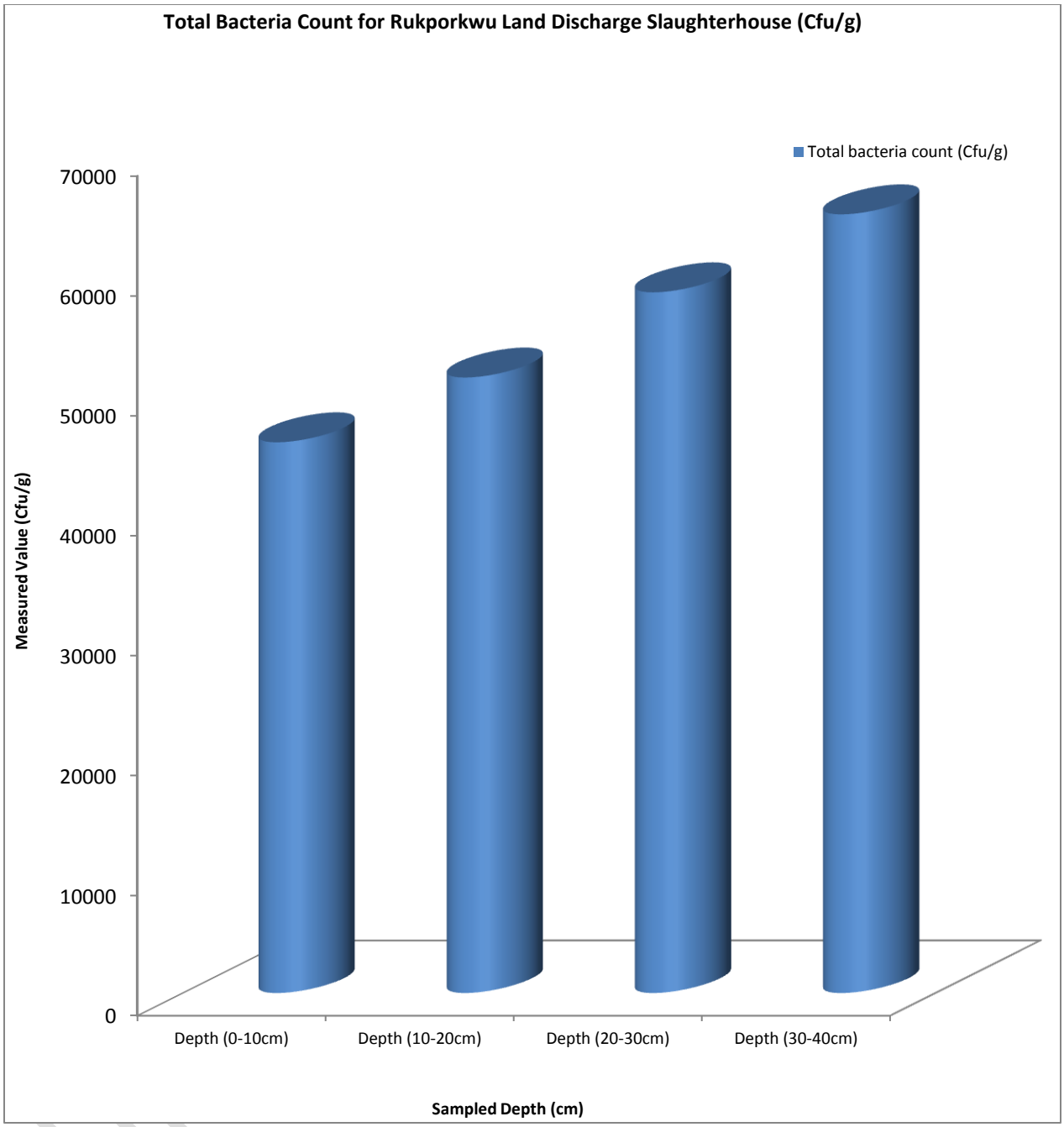

Figure 7: Chart plot of Total Bacteria Count for Rupkorkwu Land Discharge Slaughterhouse

Results and data plots of Rumuekini land slaughter house (LA3) with different analysed parameters are as presented in Table 3.

Table 3: Parameter results of Rumuekini Land slaughterhouse (LA3) at different depth.

Parameter	Depth (0-10cm)	Depth (10-20cm)	Depth (20-30cm)	Depth (30-40cm)

pH	5.76	6.38	6.12	6.42
Moisture content	13.96	12.91	16.04	12.16
Bulk density	1.06	1.31	1.28	1.57
Sand (%)	53	51.88	54.01	51.92
Clay (%)	2.02	2.36	3.29	3.3
Silt (%)	31.86	16.88	20.86	19.19
Organic Carbon (OC) (%)	1.15	1.68	1.31	1.71
Total Organic Matter (TOM) (%)	4.9	7.38	16.08	16.14
Porosity (%)	47.56	49.21	49.3	48.86
Zinc (Zn) (mg/kg)	222.55	93.56	112.6	46.3
Lead (Pb) (mg/kg)	21.1	19.06	16.42	16.68
Manganese (Mn) (mg/kg)	404.16	474.7	450.6	438.7
Nitrate (mg/kg)	10.89	11	8.96	8.37
Phosphate (mg/kg)	49.6	46.56	30.39	24.99
Cadmium (Cd) (mg/kg)	0.4	0.34	0.3	0.25
Carbonate (mg/kg)	2.3	2.21	2.84	2.41
Total bacteria count (Cfu/g)	23700	25100	34000	42500

A plot of all the analysed physical parameters for Rumuekini slaughterhouse is as shown in Figure 8.

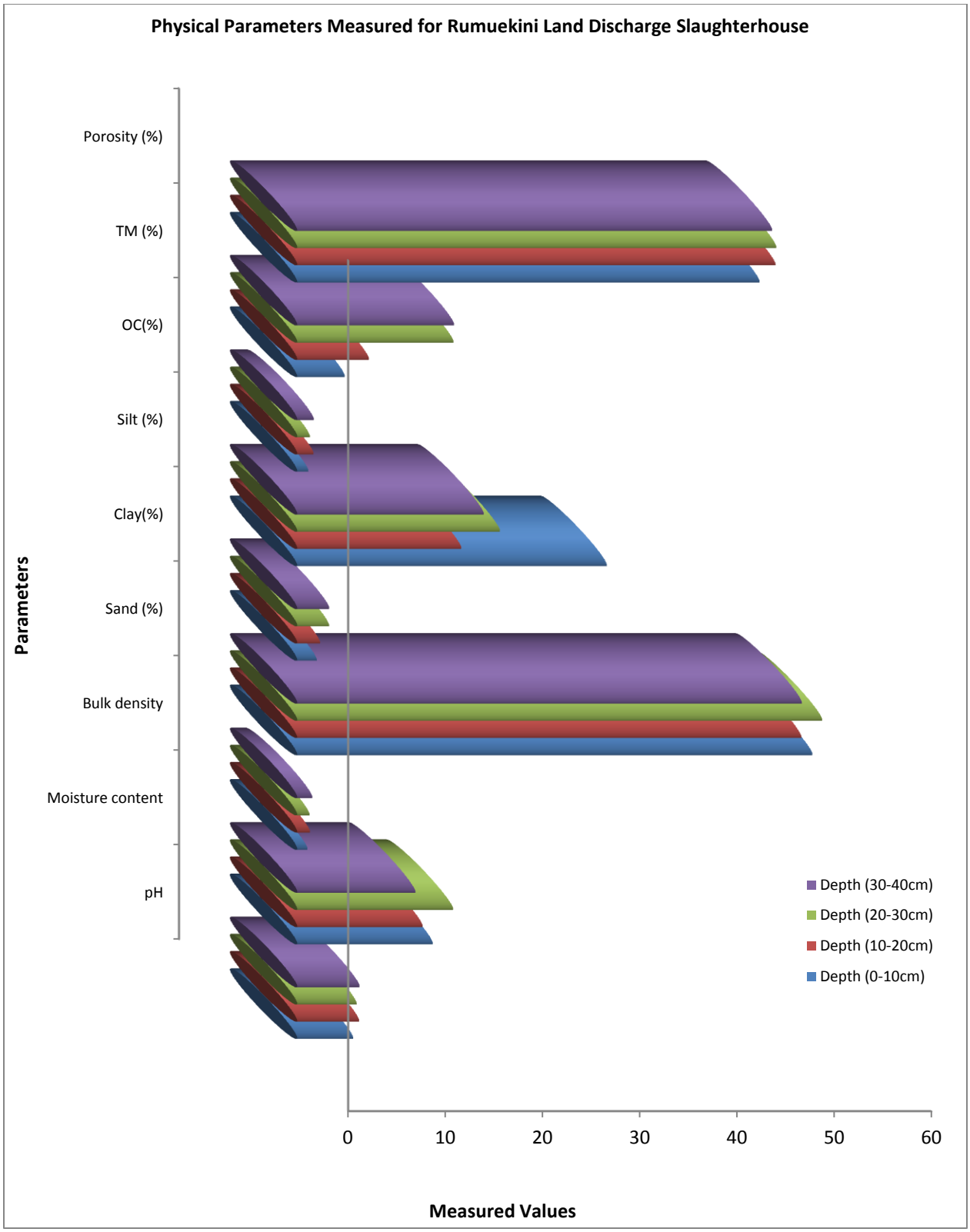

Figure 8: Bar chart plot of Physical Parameters for Rumuekini Land Discharge Slaughterhouse

A plot of all the analysed chemical parameters for Rumuekini slaughterhouse is also as presented in Figure 9.

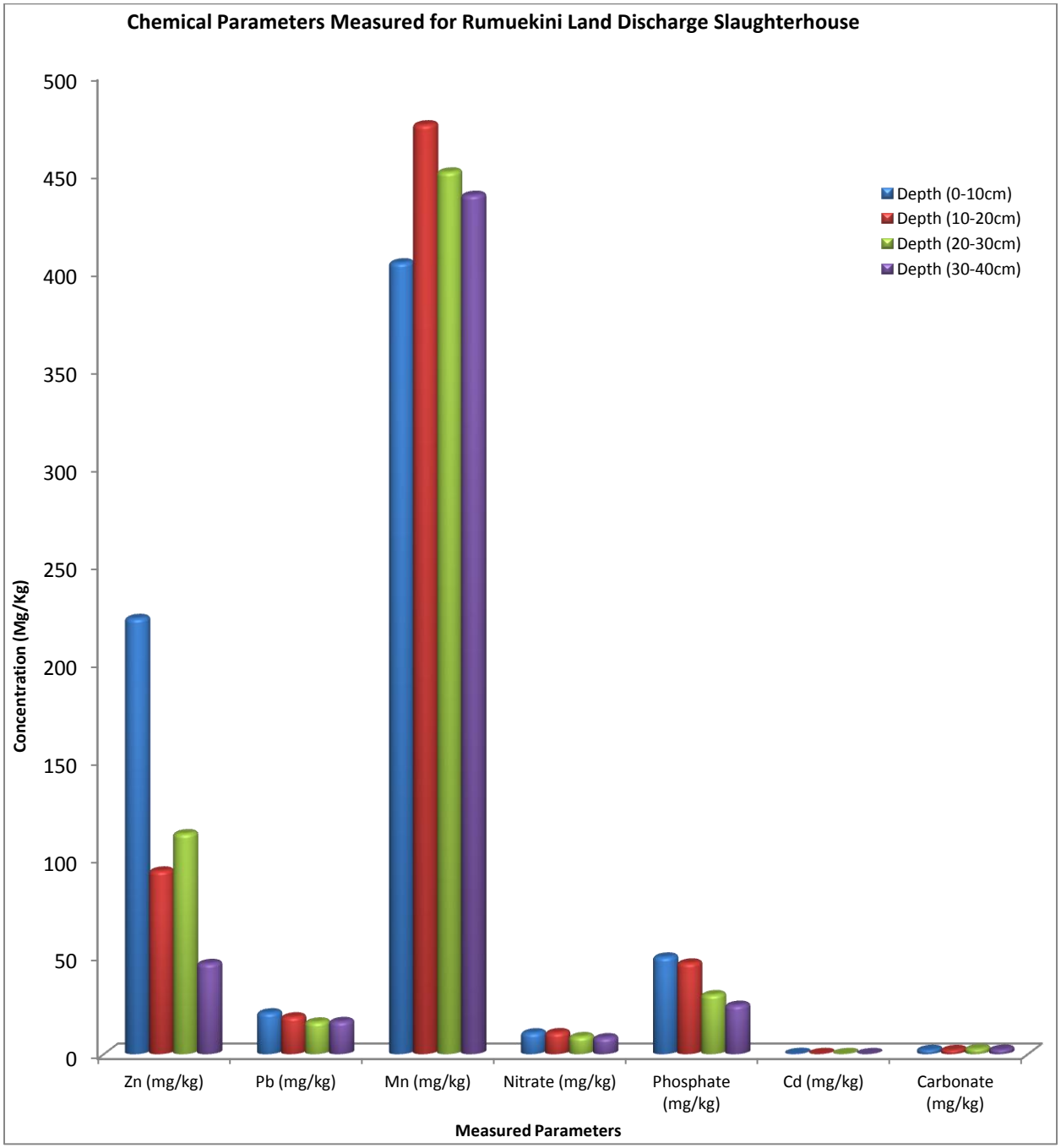

Figure 9: Chart plot for Chemical Parameters Measured for Rumuekini Land Discharge Slaughterhouse

Also, a chart plot showing the variation of total bacteria count at different analysed depth for Rumuekini slaughterhouse is as shown in Figure 10.

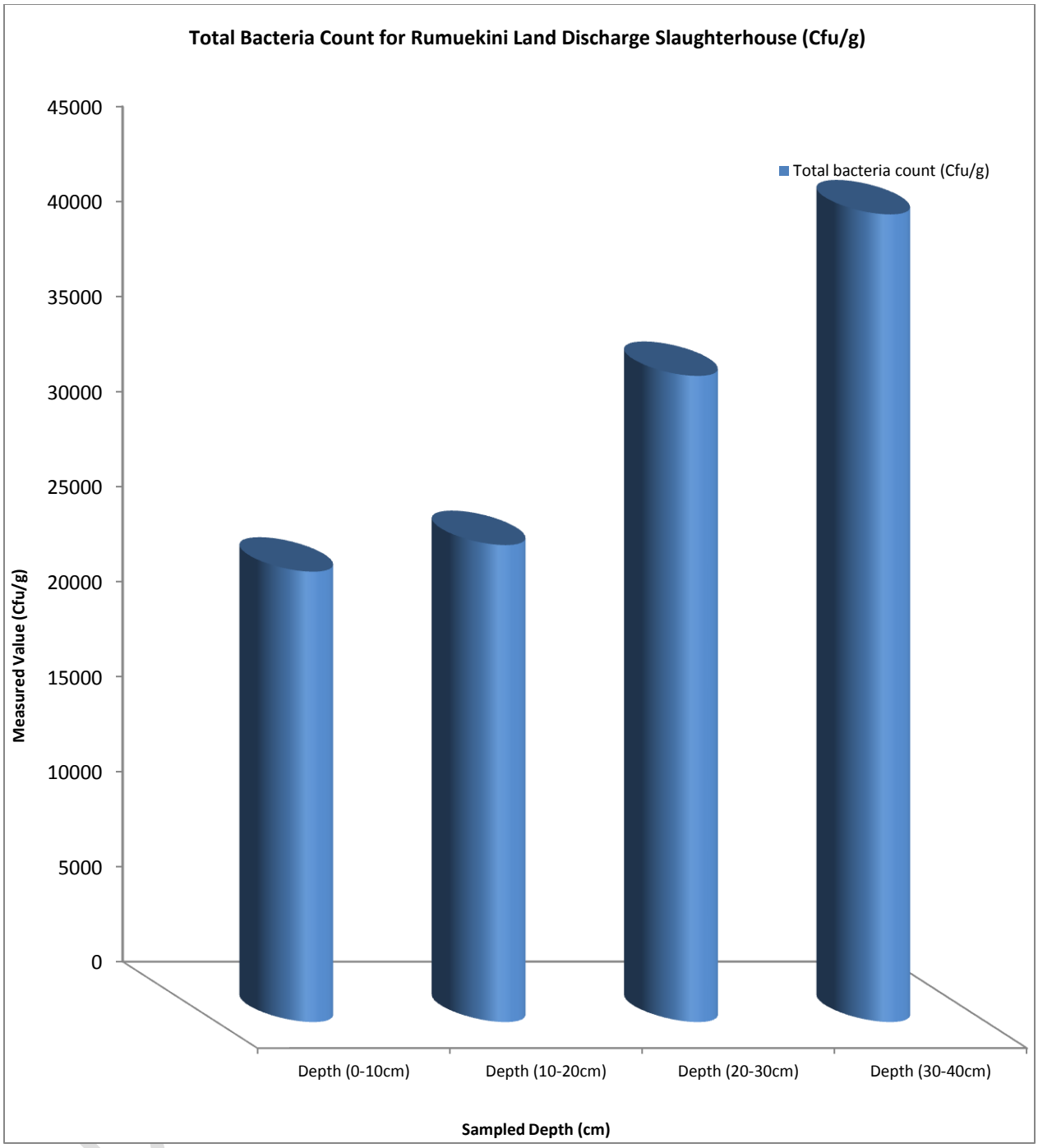

Figure 10: Chart plot of Total Bacteria Count for Rumuekini Land Discharge Slaughterhouse.

3.2 DISCUSSION

Soil samples from boundary/Omigwe slaughterhouse (LA1) showed mean pH values of 6.64, 6.86, 6.76 and 6.85 at depths of 0-10cm, 10-20cm, 20-30cm and 30-40cm respectively. Soil pH values observed in this study were slightly acidic tending to neutral as indicated by Benton, (2002) [11]. The highest mean pH value was observed at depth 10-20 cm while lowest at 0-10 cm depth, the range value was slightly acidic. The pH values in this study were lower than those values reported by Osakwe (2014) [12]. Low pH from

these anthropogenic sites could be as a result of the decomposition of organic matter that releases carbon (iv) oxide which reacts with water to form carbonic acid which eventually reduces soil pH. This low pH enhances solubility and mobility of heavy metals [13] and the presence of humic acid which is the major acid in soil organic matter. Heavy metal mobility decreases with increasing soil pH, hence most of the sites with low pH had relatively high concentration of selected heavy metals. Soil moisture content in the abattoirs varied with depth having 22.16, 18.21, 19.32 and 18.36 % at 0-10 cm, 10-20 cm, 20-30cm and 30-40 cm respectively. Soil moisture contents were found to vary with depth and this may be due to the amount of clay (Andrade et al. 2011) and nature of the activities on the sites. Bulk density ranged from 1.48 gcm^{-3} to 1.83 gcm-3 across the depths in abattoirs. Soil compaction resulting from different anthropogenic activities on the sites may have caused the relatively higher bulk density. The values of bulk density were below mean value of 2gcm-3 reported by Onwermadu et al. (2007) [14], except for the 2.16 and 2.09 gcm^{-3} recorded in Rukporkwu Slaughterhouse (LA2) soil at depths 20-30 cm and 30-40cm respectively, but agreed with the report of Jintao et al. (2011). The reason for the low values at depths of Rumuekini slaughterhouse (LA3) and (LA1) sites could be due to low or less disturbance on the sites. Bulk density values obtained in this study were within the ranges expected in most mineral soils as indicated by Mbagwu (2003) [15]. High bulk density ($1.5gcm^{-3}$) reduces water infiltration and plant root penetration resulting in increased surface water pollution (Ahmed, 2002). Particle size distribution at 0-10 cm showed 58.32±5.32 % of sand, 30.22±8.36 % of silt and 4.86±2.84 % of clay in LA1, LA2 and LA3. Particle size distribution in this study showed that sand fractions were predominant, while clay was very low in most sites. The clay contents obtained were lower than the report of Dauda and Odoh, (2012) [16]. Egharevba and Odjada (2002) [17] reported similar observation of low percentage of clay in some soil samples. Soil texture plays an important role in mobility of metals in soil. The textural class for all the sites were sandy loamy. This was similar to the report of Osakwe (2014) [12]. Also, soil organic carbon in the sites decreased with depths with average of 3.74±2.06 % at 10-20 cm depth and 2.75±1.04 % at 30-40 cm depth.

The Total Organic Matter (TOM) increased with depth at all sites with an average of 6.22±1.32% at depth 0-10cm and 26.82±10.68% at depth 30-40 cm. Similarly, Ayolagha and Onwugbuta (2001) [17] also demonstrated that organic matter greater than 2.0% or organic carbon greater than 1.2% create great conducive medium for heavy metal chelation formation. Sites with relatively high soil organic carbon had higher concentration of heavy metals.

Mean values of organic matter content at abattoir solid wastes were on a high level. This is apparent because the clay particles unlike the sand particles have substantial exchange surface areas and therefore adsorb and stabilize organic matter and heavy metals [18]. Considering the three soil depths, the highest average soil organic carbon was observed at 0-5 cm depth, followed by depth 5-10 cm and lowest at 10-15 cm depth, hence the soil organic carbon decreases as the depth increases.

There is a high build-up of heavy metal concentration in soil samples from all the sampled locations across their examined depths. Mn had the highest average concentration across the depths followed by Zn, Pb and Cd as shown from sampled results of LA1, LA2 and LA3. Average concentration of Mn, Zn, Pb, and Mn decreased across depths for all examined sites except for a truncated build-up of Zn and Mn at depths 30-40cm and 10-20 cm respectively. Increase in concentration of manganese in the sites may be attributed to the decay of metal scraps dumped around some of the sites [1].

4. CONCLUSION

The study has provided data base for which waste from the various abattoirs can be estimated which would help engineers in taking the necessary procedure or precaution while trying to proffer solutions to the problems associated with abattoirs.

It should be noted that due to urbanization, there would always be increase in population which would in turn increase consumption of meat, therefore, good information on slaughterhouse wastes will go a long way in estimating possible problems and proffering suggestions on how to curb the menace created by abattoir wastes.

Moreover, the recent practice of land discharge of wastes from slaughterhouses can complement the water discharge practice, hence leading to a more sustainable development scheme, if only management policies are set right.

Based on the key findings of the study, the following conclusions can be drawn:

1. Indiscriminant dumping of abattoir/slaughterhouse wastes on land impact directly on the constituent composition of the soil, hence, results in increased build-up of nutrients and pollutants which if not checked could contaminate groundwater.
2. Slaughterhouse operational management in the sampled locations was confirmed as disorganized, inefficient and highly compromised as a result of inadequate funding, weak regulatory and operational frameworks, poor public awareness and participation, as well as a high prevalence of corruption.
3. In order to reduce the rate of pollution, it is recommended that the excrement be discharged into soil at rates not exceeding the recommended rates given by the Federal Environmental Protection Agency (FEPA).

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