EFFECTS OF ABATTOIR OPERATIONS ON SEDIMENT AND WATER PROPERTIES OF ABA RIVER, ABIA STATE*

By
Imoh Ukpong
&
Chinwe Stella Anukwu
Department of Geography & Natural Resources Management
University of Uyo, Nigeria

Abstract

The study investigated the level of sediment and water pollution associated with abattoir operations along Aba River, Abia State. Systematic sampling technique was employed for the collection of sediment and water samples from effluent point source, upstream and downstream along the Aba River. To achieve the aim of study, information on the physiochemical properties of the sediment and water were obtained from laboratory analysis of the samples. T-test were used to analyze the data. Results showed that there were significant increases in mean values of properties when comparing abattoir site with control site for sediment properties (organic matter, total nitrogen and available phosphorus; and water properties (BOD, DO, nitrate, TDS). Also when comparing mean values of water properties obtained at different sampling points, results indicated that DO values for upstream(3.10mg/l), source-point(0.74mg/l) and downstream(2.49mg/l) were below FMenv permissible limits for surface water. However, nitrate values (19.94m/l) and TDS (589.33mg/l) were above permissible limits at the point-source. Therefore abattoir operations have made the Aba River unsuitable as potable water source. Hence it endangers human life and discourages alternative uses such as recreation and irrigation. It is recommended that effective environmental monitoring plan be adopted to prevent further pollution, while incorporating effluent treatment mechanisms to tackle pollution.

**Paper presented at the 2nd Biennial International Conference on Rivers and Deltas in Africa. October 16-17, 2017, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria*

INTRODUCTION AND BACKGROUND TO THE STUDY

Both soil/ sediment and water properties are known to perform essential roles in terms of human health, fisheries, marine life and overall well-being of the aquatic environment. According to Iwara, Njar, Deekor and Ita (2012), the quality of water is determined by both natural and anthropogenic forces. The natural forces include; precipitation rate, weathering process and soil erosion, while the anthropogenic forces are urban and agricultural activities such as municipal, industrial and agricultural wastes (Pejman, Bidhendi, Karbassi, Mehrdadi, and Bidhendi 2009). These forces result in the pollution of surface water at different spatial and temporal scales. The most polluting among these are sewage and industrial wastes discharged into rivers. Sediment quality is also at risk from a number of threats driven by a range of man-made and natural pressures including climate change, land use change and land management practices. Among these forces, the human aspect e.g. anthropogenic discharge of effluent, which include activities carried out by abattoirs operators constitutes the primary force, (Omole and Longe, (2008); Iwara et al., 2012).

A slaughterhouse also called an "abattoir" is a facility where animals are killed and processed into meat product (FAO, 1991). Also, according to the Federal Ministry of Environment (2005), an abattoir or slaughterhouse can simply be defined as a place where animals are killed in a sanitary condition to ensure its safety and wholesomeness for human consumption. In Nigeria, slaughterhouses are small private businesses while abattoirs are bigger and serve communities of appreciable population size and usually owned by Government. In developed countries such as in the United States of America, Australia etc. slaughtering is carried out in large and well developed facilities with fully mechanized lines. The workstations and carcasses move on a conveyor system from station to station until the slaughter process is completed. Abattoir activities are carried out in two basic lines of operation, the clean and unclean operations. The unclean operations include stunning, bleeding, defeathering (poultry), dehairing (pigs), and dehiding (cattle and small ruminants), while the clean operations include evisceration, carcass splitting and carcass dressing. In carrying out these operations very high amount of effluent and waste are generated. According to Kosamu, Mawenda and Mahomet (2011), total amount of waste produced per animal slaughtered is approximately 65% of its weight, which include blood, fats, grease, hair, grit and undigested feeds.

Also, in developed countries where abattoirs are adequately financed and designed, such facilities have specialized equipment that aid in carrying out stunning, bleeding and processing of carcasses. However, in most developing countries like Nigeria this is not the case, because these countries do not have proper facilities for meat processing and where they are available, they exist and operate illegally in most instances. The location of these abattoirs are often situated where there is cheap and unhampered access to water, such as near larger water bodies (streams and rivers), in order to provide the much needed water for meat processing. In some cases the slaughtering is often either carried out under a tree or in deteriorated and outdated slaughter units without any waste treatment facilities (Nwanta, Onunkwo, Ezenduka, Phil-Eze and Egege, 2008). During the slaughtering operations, the surrounding land and water are impacted through uncontrolled release of waste and effluents (FAO, 2013). The numerous wastes produced by abattoir operation not only pose a significant challenge to effective environmental management but also are associated with decreased air quality of the environment, potential transferable antimicrobial resistance patterns, and several infectious agents that can be pathogenic to humans. Aim and Objectives

The main aim of this study is to investigate the level of pollution of sediment and water properties associated with abattoir operations. The objectives of this research are to examine the physicochemical properties in water and soil quality as a result of abattoir operations, analyse seasonal differences on the physicochemical properties in water and sediment quality, and determine the effects of abattoir operations on the physiochemical characteristics of the sediment and water in the environs of the abattoir. We also sought to investigate community perceptions of the effects of the abattoir operation on their environment. Consequently, we hypothesized that there was no significant difference in the physicochemical properties of sediment and water between the abattoir site and surrounding environment, and that the effect of abattoir operations did not show seasonal variations.

Study Area

The study area was located at Aba, Abia State, Nigeria. Aba town is situated between latitudes 50 03' N and 50 07' and longitudes 7017' E and 70 24' E in Abia State of Nigeria as seen in Fig 1.1 and Fig 1.2. Aba is about 60 km south of Umuahia, the state capital and is made up of two local government areas (Aba North and Aba South), (Abia State Government, 2012). The town lies on a plain with Aba River Valley on its eastern side as the only prominent physical feature. Aba urban area is bounded by the rural communities of Osisioma on the west and north, Obingwa rural communities by the east and Ugwunagbo rural communities on the south. Aba occupies a land mass of 3,837 square kilometres. Aba is located within the sub-equatorial climate belt in the southeast of Nigeria, characterized by high intensive rainfall, high temperature and high humidity. There is hardly any month of the year that does not receive rainfall, however the rainfall regime in Aba is rather seasonal with a short dry season (December to March) where little showers of convectional rainfall occurs. The total annual rainfall usually ranges from 2000mm-2300mm, with a monthly average of 180mm. Temperature is usually high with an annual average temperature of about 270C. The highest temperatures are recorded between the months of February to March and do not exceed 370C, while lower temperatures usually fall between the months of July and September with average minimum of 220C. Aba is dominated by flat and low-lying land, generally less than 100m above sea-level like most part of the state, but with characteristics of undulating land. Aba urban has a low and relatively even topography which could also be called Peneplain. Its lowest relief is along the Aba River with about 12 metres (40 feet) and the highest relief is about 21 metres along PortHarcourt-Aba express way near Alaoji area in Aba. Aba urban area is mainly drained by the Aba River and other streams such as Okpuloumuobu stream etc (Njoku, Amanagabara and Duru, 2013). The indigenous people of Aba are Igbos and speak "Igbo" language. They are predominately traders and farmers. According to the National Population Commission, the 2006 population census indicates that a total of one million fourteen thousand twenty nine persons (1,014,029) reside in Aba. About 80% of the population are commercially oriented, and15% are into agrarian activities, while the remaining 5% are engaged in the civil service and public sector (Abia State Government, 2012).

REVIEW OF RELATED LITERATURE

The Effects of Abattoir Operations on the Environment

Abattoir operations involve series of processes from stunning to processing of carcasses. During these operations wastes and effluents that constitute hazards are generated. Reports from various studies/researches have shown how abattoir operations affect the environment. For instance, Weobong and Adinyira (2011) in Ghana reported that the effluent has a high pollutant capacity and did not meet the set standards for effluent allowed to be discharge into the environment. Kosamu et al. (2010) who assessed of effluent from Shire Valley Abattoir on the physico-chemical parameters of Mchesa Stream in Blantyre showed that BOD, SS and DO water parameters were of significant deviation from WHO standards. In Nigeria, Osibanjo and Adie (2007) studied the impact of effluent from Bodija abattoir on the physicochemical parameters of Oshunkaye stream in Ibadan City, Nigeria, and obtained results which showed that Oshunkaye stream fell in the class of grossly polluted water after mixing with effluent from the abattoir. The study suggested that abattoir effluent needs to be treated before it is discharged into the receiving stream to reduce health hazards. Iwara et al. (2012) to examine the effect of abattoir effluent on water quality of Calabar River in Adiabo, Odukpani Local Government Area of Cross Rivers State, Nigeria, and found out that the bacterial count (total coliform) of the river exceeded WHO recommended standard for drinking water. Chukwu (2008) examined the effect of Minna abattoir on surface water quality in the area which showed variations with World Health Organization (WHO) allowable limits. Based on his results, he concluded that abattoir effluents lowered the quality of the receiving stream. Also, Saidu and Musa (2012) found out that samples from abattoir effluent on River Landzu, Bida, Nigeria were all above the WHO standard which made the river water unsafe to both human and aquatic life.

The effect on the microbiological and physicochemical properties of sediments contaminated with abattoir effluents was conducted in Sokoto metropolis of Nigeria, by Rabah et al. (2010). Their assessment revealed that the high mean count of bacteria and fungi on the contaminated soil were higher than that of the control soil. The presence of these organisms they said is a pointer to possible pollution and may have an effect on the soil ecological balance. Also, Radha, Nithya, Himakiram, Sridevi and Narasimha (2011), who studied the effect of abattoir waste disposal on soil physicochemical, biological properties and enzymes activities obtained results that soil contaminated with abattoir waste had grey colour with bad smell and had high electrical conductivity and water holding capacity, reduced pH, increased organic carbon content, potassium and phosphate contents.

In a similar study carried out by Oyeleke, Duada, Oyewole, Sumayya and Okollegbe (2011), on the effect of abattoir effluent waste water on soil of Gandu area of Sokoto State, Nigeria; the study revealed that microbiological and some of the physicochemical properties of abattoir waste water, abattoir well water and soil were not within the limits specified by FEPA and WHO. Therefore, the authors concluded that abattoir effluents pose threats to health of Gandu community.

Aim and Objectives of the Study

The main aim of this study was to investigate the level of pollution of soil/sediment and water properties associated with abattoir operations in Aba River area. It was broadly hypothesized that there was no significant difference in the physicochemical properties of soil and water between the abattoir sites and surrounding environment.

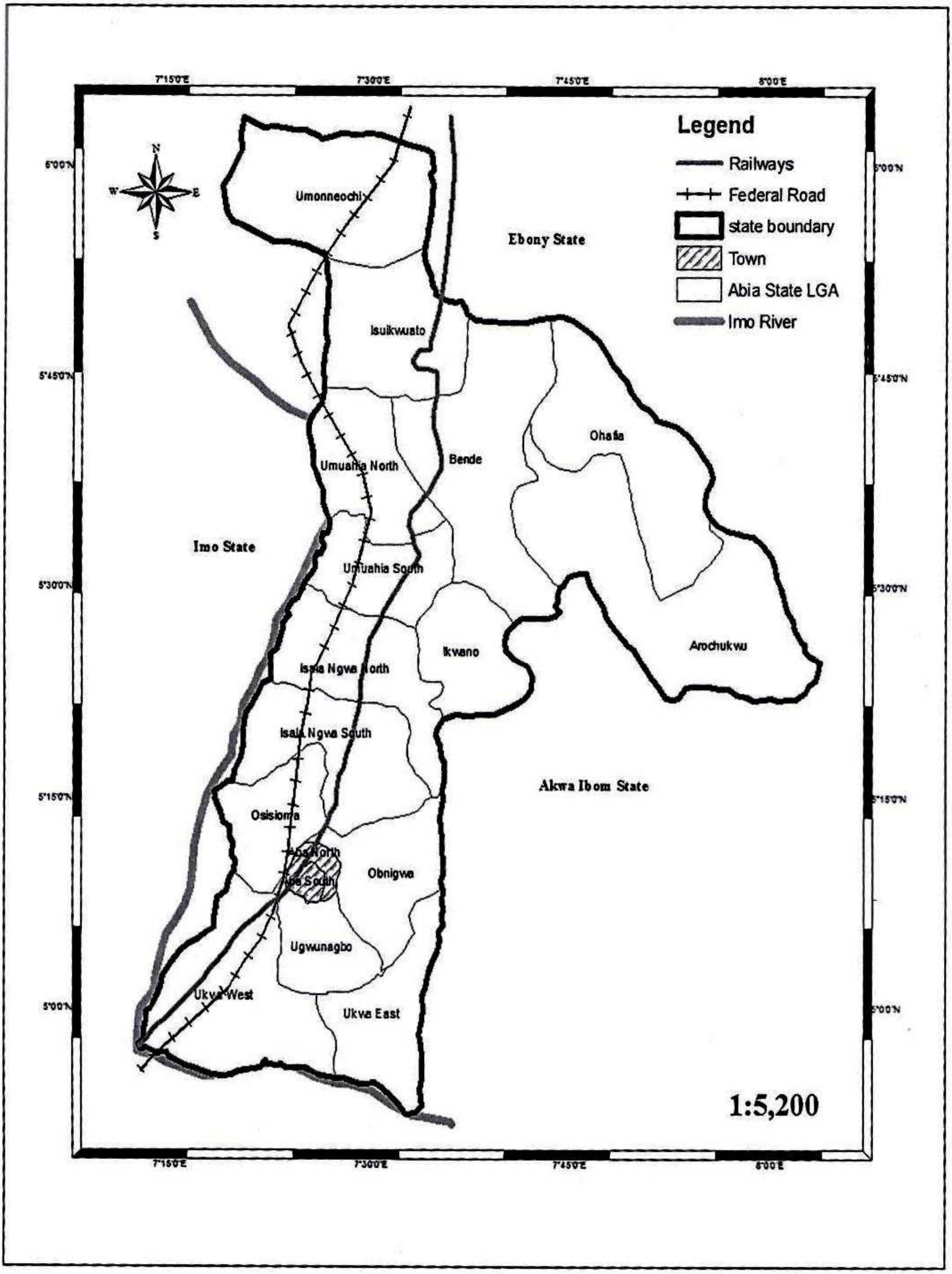

Figure 1: Location of Aba Town on the Map of Abia State

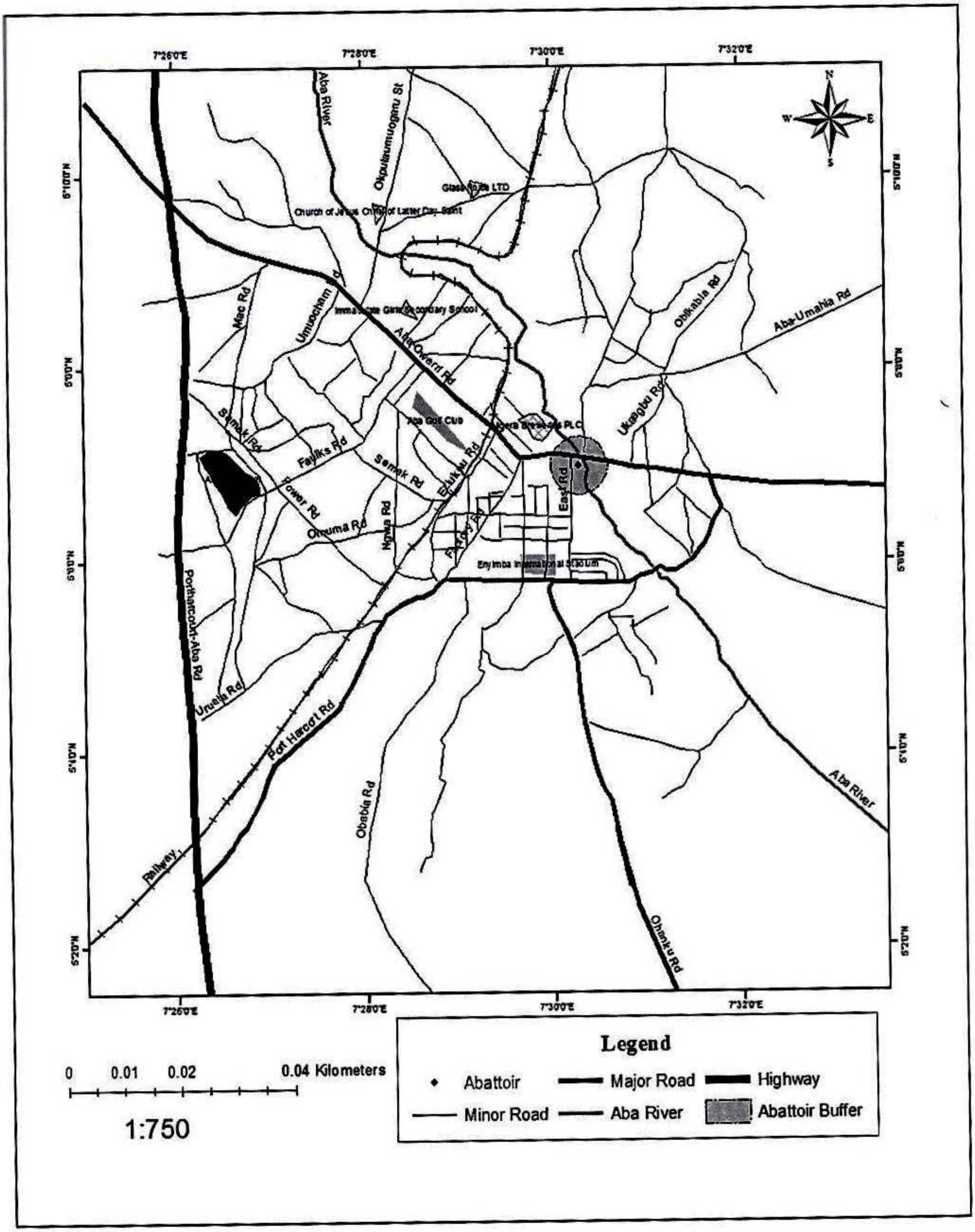

Figure 2: Location of Abattoir Site on the Map of Aba Town

METHODOLOGY

Sampling Techniques

Sediment/soil samples were collected using soil auger at depth 0cm - 15cm depth, and at 50 m interval from the abattoir site along transects to the bank of Aba River. The samples collected upstream from the abattoir site were assumed to be relatively un-impacted and were termed control samples. Samples were also collected at the abattoir site on weekly basis for a period of two months (February and March) in the dry season and two months (June and July) in the wet season. A total of sixteen soil samples were collected from the abattoir site and sixteen samples from control site, given an overall total of thirty-two soil samples. The samples were stored in sterile cellophane bags, labeled and taken for laboratory analysis.

Water samples were collected with sterilized 500ml containers at a depth of approximated 20-30cm from the Aba River at an interval of 20m along three transect (upstream, effluent point source and downstream). The upstream samples served as control samples which were assumed to be relatively un-impacted upon by abattoir activities, while the downstream samples were assumed to be impacted. The same temporal pattern used for collection of soil and sediment was adopted. An overall total of forty-eight water samples were collected for analysis in the laboratory.

Laboratory Analysis

Sediment/soil Analysis: All sediment/soil samples were air-dried and and passed through a 2mm sieve: pH level was determined in 1:2, soils: water ratio using pH meter with glass electrode (Thomas, 1996); Organic matter was determined by dichromate wet-oxidation method as described by Nelson and Sommers (1996); Exchangeable Bases (Ca^{2+}, Mg^{2+}, K^{2+}, Na^{2+}) were extracted with neutral ammonia acid (NH_4OA) pH 7 solution. Potassium and sodium in the extract were determined using Flame Analyser Model FP 640, while Calcium and Magnesium were determined in the extract by EDTA titration as described by Udo, Ibia, Ogunwale and Esu (2009); Exchange acidity was extracted with 1M potassium chloride solution and acidity in the extract measured by titration as described by Thomas (1996); Electrical conductivity was measured in the extract obtained from 1:2:5 soil:water suspension using conductivity bridge; Available phosphorus was determined by the Bray-1 method as described by Kuo (1996); Total nitrogen was determined by the microkjeldahl digestion and distillation method as described by Bremmer (1996); Effective Cation Exchange Capacity (ECEC) determined as the summation of the exchangeable bases and the exchange acidity by a method described by Summer and Miller (1989); Percentage Base Saturation: was computed as the summation of total exchangeable bases (TEB) divided by the effective cations exchange capacity (ECEC) multiplied by a hundred (100).Particle Size Distribution: Particle size (sand, silt and clay) is used to determine the texture of soils. Soil texture determines their suitability for variety of purposes. Particle size is determined by the hydrometer method as described by Gee and Bauder (1986);

Water Analysis: Biological Oxygen Demand (BOD) was determined using a DO meter; Chloride was determined using K2C1O4 indicator and titrated with 1MAgNO3 as described in Ademoroti (1996) Nitrate was obtained by reading the absorbance with Brucine reagent and H2SO4at470nm using visible spectrometer as described by Ademoroti (1996); Phosphate was determined by reading an absorbance with varadatemelybdate reagent at 470mm using visible spectrometer as described in Ademoroti (1996); Sulphate was determined by reading an absorbance with gelatin-BaCl2 reagent at 420mm using a visible spectrometer as described in Ademoroti (1996); Total Dissolved Solids was determined by EDTA titration solution (with 0.01 MEDTA using 2ml of buffer solution and Eriochrome black T indicator as described in A.O.A.C (1995)); Dissolved Oxygen was determined using a DO meter; Electrical Conductivity was determined using an EC meter; Calcium: Calcium in the form of Ca^{2+}ion was determined by reading an absorbance with hydrochloric acid reagent at 470mm using visible spectrometer as described in Ademoroti (1996); Magnesium was determined using Grignard reagent at 470mm visible spectrometer as described in Ademoroti (1996);e samples.

Data Analysis and Hypothesis

The results obtained from the laboratory analysis and field survey were subjected to statistical analysis using the SSPS and Minitab software packages. The hypotheses that there were no significant differences in the physicochemical properties of soil and water between the abattoir environment and its surroundings were tested using the student' s independent t-test.

RESULTS AND DISCUSSION OF FINDINGS

Characteristics of Sediment/Soil Properties

The pattern and characteristic of parameters of soil in the abattoir site and control site is presented in Tables 1.

Table 1: Summary statistics of soil parameters for abattoir site (observed) and control site

	Abattoir Site (Observed)				Control site			
Parameters	Dry Season		Wet Season		Dry Season		Wet Season	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
pH	0.61	0.51	7.85	0.49	0.11	0.41	8.10	0.48
EC (ds/m)	20.88	0.64	0.59	0.18	1.51	0.61	0.27	0.08
Organic matter (%)	3.15	2.12	20.88	3.96	1.84	0.58	0.69	0.40
Total Nitrogen (%)	26.76	0.82	0.37	0.12	7.74	0.05	0.13	0.10
Avail. Phosphorus (mg/kg)	0.54	5.96	12.93	4.15	0.22	8.60	33.87	3.24
Exchangeable Calcium (cmol/kg)	0.74	0.30	3.36	0.39	0.34	0.84	3.78	1.28
Exchangeable Magnesium (cmol/kg)	8.47	0.40	2.36	0.28	2.24	0.15	1.78	0.35
Exchangeable Sodium (cmol/kg)	16.35	0.11	0.35	0.09	12.63	0.26	1.85	0.69
Exchangeable Potassium (cmol/kg)	4.56	0.15	1.08	0.15	4.23	0.56	0.95	0.23
Exchangeable Acidity (cmol/kg)	1.28	2.89	5.40	1.23	1.22	0.45	1.79	0.24
ECEC (cmol/kg)	1.79	0.46	7.07	1.08	8.20	0.86	9.61	0.40
Base Saturation (%)	9.90	7.91	52.63	9.31	9.19	2.16	82.65	4.85
Sand (%)	82.64	6.98	59.11	10.50	73.75	0.73	80.31	3.83
Silt (%)	36.39	6.31	22.37	10.54	15.38	0.92	7.74	1.65
Clay (%)	56.94	2.74	16.30	2.78	80.31	1.06	12.63	2.37

Table 1 shows the mean distributions and standard deviation of soil variables for observed and control site in both the dry and wet seasons. The table indicates that at the abattoir site, mean values for EC, total nitrogen, available phosphorus, exchangeable calcium, magnesium, sodium, potassium, acidity, ECEC, base saturation, sand, silt and clay were higher in value in the dry than wet seasons, but had lower values for pH levels and organic matter. While for control site, mean values were high in the dry season than in the wet season for all variables expect for total nitrogen, available phosphorus, base saturation and clay. However, when comparing soil variables between sites their mean values show that in both dry and wet season, samples from abattoir site were generally higher in concentration than samples obtained from control site.

Overall, the general distributions in the mean values of sediment/soil properties seem to portray increases in levels at the abattoir site than that obtained from the control site. Seemingly, these increments can be attributed to abattoir operations, given that blood, paunch and other animal waste have high loadings in organic contents. Also, the intensity of rainfall during the wet season could be attributed to the decrement in the mean values observed for most mean values in both the observed and control locations. This may be as a result of run-off washing away most of the soil surface materials and thereby reducing the level of nutrient concentrations at the top soil.

Characteristics of Water Properties

The pattern and characteristics of water parameters for upstream, point-source and downstream are presented in Tables 2.

Table 2 Summary Statistics of Water Parameters for Upstream, Point-source and Downstream

Parameters	Upstream		Point-source		Downstream	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
pH	7.94 ±0.66	8.13±0.34	7.84±0.95	8.19 ±0.38	7.75 ± 0.85	7.89 ± 0.49
EC	44.63±4.98	43.75±7.13	62.00±8.95	7.63±10.10	80.88±13.49	81.79±30.02
DO (mg/l)	2.49±0.42	1.89±0.22	3.10±0.37	2.20±0.14	0.74 ±0.31	2.07±0.58
BOD (mg/l)	1.63±0.38	3.13±1.10	1.52±0.24	0.79±0.18	9.81±0.44	6.79±1.42
Acidity (mg/l)	153.63±33.57	132.7±24.42	197±60.17	274.3±88.47	2402±630.9	1242±545.4
Alkalinity(mg/l) as CaCO3	71.76±28.20	52.21±24.40	143±33.02	97.25±38.01	2155±564.9	1253±361.0
TDS (mg/l)	19.50±2.78	17.88±1.46	22.26±5.51	57.38±6.63	654.2±61.88	524.5±67.42
Sulphate (mg/l)	3.05±0.07	3.05±0.00	3.23±0.26	3.08±0.04	15.95±2.81	11.78±2.30
Phosphate (mg/l)	0.27±0.18	0.28±0.05	0.48±0.12	0.33±0.12	3.50±0.68	4.58±0.51
Nitrate (mg/l)	4.69±0.09	4.36±0.42	4.04±0.28	3.99±0.41	19.94±0.47	19.05±0.45
Chloride (mg/l)	90.85±19.38	86.06±15.32	109.9±6.82	107.9±3.51	573.3±53.02	416.1±75.17
Sodium (mg/l)	1.21±0.19	1.10±0.24	1.32±0.31	1.53±0.54	8.2±12.54	7.11±1.64
Potassium(mg/l)	2.71±0.52	2.50±0.22	4.06±1.17	5.29±1.82	5.59±1.71	6.06±1.52
Calcium(mg/l)	27.61±13.19	30.99±8.80	41.94±16.14	51.65±15.10	61.38±24.45	62.00±14.65
Magnesium(mg/l)	18.80±2.66	22.81±3.95	19.00±4.96	20.05±3.11	128.3±13.85	115.6±8.30

Table 2 revealed that apart from Dissolved Oxygen, all other variables recorded highest mean value at point-source, while the lowest mean values were recorded mostly during the wet season upstream. The mean values for all upstream variables were slightly higher in the dry than in the wet season except for sulphate whose mean value did not change from 3.05mg/l. At the point source, variables were higher in mean values during the dry season than the wet season except for phosphate, potassium and calcium. Mean values for pH, alkalinity, TDS, potassium, calcium, sodium and magnesium were higher in the wet season than the dry season downstream, whereas mean values for EC, acidity, DO, BOD, alkalinity, sulphate, phosphate, and nitrate were higher in value in the dry season than in the wet season downstream.

There seems to be a general increase in mean values of all water variables at the source point; this could be attributed as direct discharge of abattoir effluents into the river. Also mean values obtained downstream showed to be slightly higher in values than those obtained upstream for most variables; this too could be attributed to the effect of abattoir operation. These assumptions are on the basis that upstream points were assumed to be un-impacted by abattoir operation, hence variations in mean value at source point and downstream was influenced by abattoir operations.

These values were used to determine direct and residual effect. These effects can only be of serious concern where they affect water quality.

Tables 3 and 4 present the mean values of variables obtained from the different sample locations for both dry and wet season respectively compared with FEMnv permissible limit for surface water.

Table 3: Water quality assessment using FMEnv's permissible limit (dry season)

Parameters	Source point	Upstream	Downstream	FMEnv
pH	7.75	7.94	7.84	6.5-8.5
EC	80.88	44.63	62.00	200
Dissolved Oxygen (mg/l)	0.74	3.10	2.49	4-7.5
BOD (mg/l)	9.81	1.52	1. 63	30
Acidity (mg/l) as CaCO□	2402	153.63	197	N/A
Alkalinity (mg/l) as CaCO□	2155	71.76	143	600
TDS (mg/l)	654.2	19.50	22.26	500
Sulphate (mg/l)	15.95	3.05	3.23	450
Phosphate (mg/l)	3.50	0.27	0.48	5
Nitrate (mg/l)	19.94	4.04	4.69	20
Chloride (mg/l)	573.3	90.85	109.90	200
Sodium (mg/l)	8.21	1.21	1.32	NA
Potassium (mg/l)	5.59	2.71	4.06	NA
Calcium (mg/l)	61.38	27.61	41.94	65
Magnesium (mg/l)	128.3	18.80	19.00	30

Table 3 indicates that chloride (573.3), and TDS (654.2) are above the permissible limits at point source, while DO mean values were below permissible limit at all sampling locations point-source (0.74), upstream (3.10) and downstream (2.49).

Table 4: Water quality assessment using FMEnv's permissible limit (wet season)

Parameters	Source point	Upstream	Downstream	FMEnv
pH	7.89	8.13	8.19	6.5-8.5
EC	81.79	43.75	47.63	200
Dissolved Oxygen (mg/l)	1.89	2.20	2.07	4-7.5
BOD (mg/l)	6.79	0.79	3.13	30
Acidity (mg/l) as CaCO□	1242	132.7	274.3	N/A
Alkalinity (mg/l) as CaCO□	1253	52.21	97.25	600
TDS (mg/l)	524.5	17.88	57.38	500
Sulphate (mg/l)	11.78	3.05	3.08	450
Phosphate (mg/l)	4.58	0.28	0.33	5
Nitrate (mg/l)	19.05	3.99	4.35	20
Chloride (mg/l)	416.1	86.06	107.90	200
Sodium (mg/l)	7.11	1.10	1.53	NA
Potassium (mg/l)	6.06	2.50	5.29	NA

Calcium (mg/l)	62.00	30.99	51.65	65
Magnesium (mg/l)	115.6	22.81	20.05	30

As indicated on Table 4, during the wet season the mean values for DO were below permissible limit at all points (point-source (1.89), upstream (2.20), and downstream (2.07)). Other variables that were above permissible limit were TDS (524.5), chloride (416.1), nitrate (21.4) and magnesium (115) at point-source only.

The relative low level of dissolved oxygen in Aba River gives an indication that the water does not suitably support aquatic life adequately. According to Greenberg (1995), streams with high dissolved oxygen concentrations (greater than 8 mg/L for Ozark streams) are usually considered healthy streams. They are able to support a greater diversity of aquatic organisms. They are typified by cold, clear water, with enough riffles to provide sufficient mixing of atmospheric oxygen into the water. DO levels less than 3 mg/L are stressful to most aquatic organisms. Most fish die at 1-2 mg/L. However, fish can move away from low DO areas. Water with low DO from 2 – 0.5 mg/L are considered hypoxic; waters with less than 0.5 mg/L are anoxic. Nitrate was reported high and above permissible limit only at point-source, implying that the concentration of nitrate has increased. Although nitrate generally occurs in trace quantities in surface water, it is the essential nutrient for many photosynthetic autotrophs and has been identified as the growth limit nutrient where it is relatively nontoxic to aquatic organisms. However, when nitrate concentrations become excessive and other essential nutrient factors are present, eutrophication and associated algal blooms can be become a problem (Chukwu, 2008).

The high level of TDS at both seasons is an indication that at the source point the river is heavily loaded with dissolved solids from the abattoir, such as blood, fat, grease etc. which may have affected the clarity of the river and its overall purity. Waste water from agricultural run-off is one of the ways in which chloride is found in surface water. The high concentration of chloride at the source point could be directly attributed to this. Thus, the quality of water at this point could be affected as large concentrations of chloride make water unpleasant to drink.

Changes in Sediment/Soil and Water Properties Due to Abattoir Operations

The student independent t-test was used to determine the difference between soil variables from observed site (soil impacted by abattoir operations) and control site and off-site (soil seemingly un-impacted by abattoir operations) as presented in Tables 5 and 6.

Table 5 Summary statistics and independent t-test on physiochemical properties of soil during the dry season

Parameters	Observed		Control		t-test
	Mean	SD	Mean	SD	
Total Nitrogen (%)	0.61	0.08	0.11	0.05	14.45*
Organic Matter (%)	20.88	2.12	1.51	0.50	12.69*
Exchangeable Magnesium (cmol/kg)	3.15	0.40	1.84	.15	8.75*
Silt (%)	26.76	6.31	7.74	1.65	8.24*
Exchangeable Sodium (cmol/kg)	0.54	0.11	0.22	0.03	7.68*
EC (ds/m)	0.74	0.06	0.34	0.16	6.93*
Exchangeable Acidity (cmol/kg)	8.47	2.89	2.24	0.45	6.03*
Clay (%)	16.35	2.74	12.63	2.37	2.90*
Exchangeable Calcium (cmol/kg)	4.56	0.30	4.23	0.84	1.11

Exchangeable potassium (cmol/kg)	1.28	0.15	1.22	0.56	0.29
pH	7.79	0.65	8.20	0.41	-1.52
ECEC (cmol/kg)	9.90	0.46	9.19	0.86	-2.07
Base Saturation (%)	82.64	7.91	73.75	2.16	-2.01
Avail Phosphorus (mg/kg)	36.39	5.96	15.38	8.60	5.69*
Sand (%)	56.94	6.98	80.31	3.83	-8.30*

**significant at 0.05 alpha level; df 14; t-critical value 2.14*

Table 5 presents the physiochemical properties of sediments/soil during the dry season, their mean values, standard deviations and their calculated t-values. The calculated t-value was tested for significance by comparing it with the critical value (T-table value) 2.14 at 0.05 level and 14 degree of freedom. The calculated t-values were higher than the critical value for total nitrogen (14.45), Organic matter (12.69), exchangeable magnesium (8.75), silt (8.24), sodium (7.68), EC (6.93), available phosphorus (-5.69) and sand (-8.30) variables, indicating that there were significant differences between the samples. However, the calculated t-values for pH (-1.52), ECEC (-2.07), base saturation (-3.70), calcium (1.11), clay (2.90) and potassium (-0.29) variables were lower than the critical t-value. These values indicate that there were no significant differences between the samples.

Table 6: Summary statistics and independent t-test on physiochemical properties of soil during the wet season

Parameters	Observed		Control		t-test
	Mean	SD	Mean	SD	
Organic Matter (%)	11.36	3.96	0.69	0.40	14.34*
Exchangeable Magnesium (cmol/kg)	2.86	0.28	1.76	0.35	6.84*
Clay (%)	16.30	2.75	11.24	1.06	4.81*
EC (ds/m)	0.59	0.18	0.27	0.08	4.63*
Total Nitrogen (%)	0.37	0.13	0.15	0.11	3.77*
Exchangeable Sodium (cmol/kg)	0.35	0.09	0.19	0.07	2.09
Exchangeable potassium (cmol/kg)	1.08	0.15	0.95	0.23	1.34
Exchangeable Calcium (cmol/kg)	3.86	0.40	3.78	1.28	0.18
pH	7.85	0.49	8.10	0.45	-1.03
ECEC (cmol/kg)	9.61	1.08	8.08	0.40	2.02
Base Saturation (%)	52.63	9.31	62.84	4.85	-2.13
Sand (%)	59.10	10.50	80.98	0.73	-5.87*
Silt (%)	22.40	10.20	7.73	1.65	-5.87*
Exchangeable Acidity (cmol/kg)	5.40	1.23	1.79	0.24	-6.26*
Avail Phosphorus (mg/kg)	33.89	4.15	12.93	3.24	11.25*

*significant at 0.05 alpha level; df 14; t-critical value 2.14

The mean values for sediment/soil variables as indicated in Table 6 shows that during the wet season, there was a significant increase in values for organic matter (14.34), exchangeable magnesium (6.84), clay (4.81), EC (4.63), total nitrogen level (3.77), and available phosphorus (11.25); while significant decrease in mean values were recorder for sand (-5.87), silt (-5.87), and exchangeable acidity (-6.26). The most significantly increased variables between sites were observed in organic matter (14.43). Exchangeable calcium (0.18), potassium (1.34) and pH (-1.03) and did not show significant difference between observed and control sites. From the results of the t-test it can be deduced that abattoir operations have contributed to the difference between the observed and control sites. The overall effect could be attributed to the high loadings observed in organic matter, exchangeable magnesium, total nitrogen, clay and EC. According to Chukwu (2008), abattoir waste is characterized with high organic content from blood, fat, and grease. The increase of silt and clay in abattoir site could also be attributed to abattoir operation. This is because dumping of abattoir waste on bare soil may have increased the level of microbial organism which breaks down this waste into compost, thereby adding to the soil's loamy content. There also seem to be an increase in the soil's nutrient content by the increase of essential ions of sodium, calcium, total nitrogen, as observed at the abattoir site. Although most of these nutrients are not significant, it is important to note that abattoir waste load highly on nitrogen and phosphorus ions.

The Effects of Seasonal Variation on Abattoir Operations

Values obtained from both soil and water variable at the abattoir site, could be used to determine the direct effect of abattoir operations on the environment. These values were collected and recorded during dry and wet season. In order to determine the contribution of seasons on the values obtained, an independent t-test was conducted. The independent t-test is employed to determine whether there is a significant variation on the values obtained soil and water variables as result of seasonal change.

Table 7: Independent t-test on sediment/ soil variables between dry and wet season at abattoir site

Parameter	Paired Differences			T
	Mean	Std. Deviation	Std. Error Mean	
EC	0.18	0.22	0.08	2.23
Organic matter	9.53	3.43	1.21	7.85*
Total nitrogen	0.24	0.08	0.03	8.53*
Avail Phosphorus	2.41	4.37	1.55	1.56
Calcium	-0.71	0.26	0.09	-7.79*
Magnesium	0.29	0.60	0.21	1.36
Sodium	0.19	0.15	0.05	3.60
Potassium	0.14	0.14	0.05	2.84*
Exchangeable acidity	3.07	3.63	1.28	2.39*
ECEC	2.11	1.07	0.38	5.58*
Base saturation	21.11	14.99	5.30	3.98*
Sand	-2.18	11.58	4.09	-0.53
Silt	4.39	10.78	3.81	1.15
Clay	0.05	4.76	1.68	0.03
pH	-0.06	0.83	0.29	-0.205

***Significant at 0.05 level, t-critical 2.14**

Table 7 shows the t-cal values of soil parameters between the wet and dry season. Calcium (-7.79) indicates that wet season samples were significantly higher in levels than that of the dry season, while total nitrogen (8.52), organic matter (7.85), potassium (2.84), ECEC (5.58), and base saturation were significantly higher in levels in the dry season than in the wet season. However, the mean values for EC (2.23), available phosphorus (1.56), magnesium (1.36), sodium (3.60), sand (-0.53), silt (1.15), clay (0.03) and pH (-0.205) did not show significant variation between seasons.

From the result of the t-test it could be concluded that the effects of abattoir operations seems to vary between seasons. This is attributed to the fact that some soil variables differ significantly between seasons. The variation observed on organic matter, potassium, ECEC, calcium, total nitrogen and base saturation could be attributed to the erosion and leaching of soil nutrient by run-off. This assumption corresponds to findings on the studies on the intensity of run-off increase during heavy rainfall (Chukwukwa, 2013), such that nutrients maybe eventually washed out of the soil and into ground or surface water. Also, the climatic pattern in Aba as described in the study area could be used to explain why there was no disparity in other variables (sand, silt, clay, pH, sodium etc.) that did not show significant difference between wet and dry season. This is because rainfall occurs almost throughout the year.

Table 8 Independent t-test on water variables between dry and wet season

Parameter	Paired Differences			T
	Mean	Std. Deviation	Std. Error Mean	
pH	-0.14	1.07	0.38	-0.36
EC	-0.91	31.25	11.05	-0.08
DO	-1.33	0.67	0.24	-5.62*
BOD	3.02	1.49	0.53	5.74*
Acidity	1160.13	600.65	212.36	5.46*
Alkalinity	901.25	377.41	133.44	6.75*
TDS	129.76	69.29	24.50	5.30*
Phosphate	-1.04	0.86	0.30	-3.41*
Sulphate	4.18	4.36	1.54	2.71*
Nitrate	0.89	0.65	0.23	3.90*
Chloride	157.13	108.90	38.50	4.08*
Sodium	1.10	2.87	1.02	1.08
Potassium	-0.48	2.07	0.73	-0.65
Calcium	-0.63	32.63	11.54	-0.05
Magnesium	7.71	18.53	6.55	1.18

*significant at 0.05 level

The result of the independent t-test conducted on water variables as presented in Table 8, indicates that values for pH (-0.36), EC (-0.08), sodium (1.08), potassium (-0.65), calcium(-0.05), and magnesium (1.18) did not differ significantly between season. However, there were significant increases in values for DO (-5.62) and phosphate (-3.41) during the wet season than in the dry season. Mean values for BOD (5.74), acidity (5.46), alkalinity (6.75), sulphate (2.71), nitrate (3.90), and chloride (4.08) showed significant increase during the dry season than wet season. Variables that show significant increase in the dry season agree with the findings of Chukwu (2008) that the concentration in heavy metals on receiving water decreases in concentration as rainfall persists in the rainy season.

Based on this result, it could be interpreted that the effect of abattoir operations tends to vary with season. This is because some water variables show significant variation in mean values while others do not.

The Effects of Abattoir Operations on the Physiochemical Properties of Soil

From the results obtained from the laboratory analyses, the soil pH level, organic matter and some other soil nutrients such as Magnesium, total nitrogen and potassium were higher than those of the adjourning environment where there are no abattoir operations. The analyses further show that there are significant differences at 95% confidence level exiting in most of the soil parameters between observed and control sites. This is an indication that the presence of abattoir operation has caused some changes in the physicochemical properties of the soil where there are abattoir operations. This result corresponds to the findings of Radha, Nithya, Babu, Sridevi, Narasimha and Prasad (2011) that direct disposal of abattoir waste alters the physicochemical and biological properties of the soil. Furthermore, the results obtained from multiple regression analyses show that at $p<0.05$, there are significant causal relationships existing between soil properties (organic matter, total nitrogen and ECEC), and the abattoir operations (Blood and Paunch waste). These results are in agreement with Chukwu, Adeoyo and Chidiebere (2011), who identified that major abattoir wastes have high organic content. According to Woodleaf farm (1980), increase in concentrations of organic matter leads to the increase in total nitrogen, ECEC, and available phosphorus levels. Thus the general increase of nitrogen, phosphorus, and other micronutrient as observed at the abattoir can be clearly attributed to abattoir operations. Although, crops absorb nutrients required from soil in order to grow, it is important to ensure that soil meets the crops' needs by having the proper nutrients and environment to produce optimal quality yields (Mikkedsen, 2004). The high concentration of nutrients observed at the abattoir site therefore poses serious concern, in order to ensure that the soil is not over loaded with nutrients. According to Chukwuka (2013), there is a limited amount of nutrients that plants can actually use, hence excess nutrients remain in the soil when too much is applied. Given that the major nutrient pollutant released by animal waste is nitrogen, the increase in total nitrogen can led to excess nitrogen in the soil which could cause delays in plant's maturity and potential nitrate poisoning of livestock. Other nutrients when found in excess also have negative effect on plants and ultimately on man.

The Effect of Abattoir Operations on Physicochemical Properties of Water

Based on the result, it was determined that water quality is affected by abattoir. The difference between point-source variables with upstream variables is a clear indication that apart from pH all other variables differ significantly at 95% confidence levels. While downstream variables also differ significantly for BOD, Calcium, nitrate, phosphate, potassium, sulphate, magnesium, chloride, TDS, alkalinity and acidity properties at $p<0.005$, increases in both the wet and dry seasons. These results were in agreement with the findings of Chukwu et al. (2011) who observed that physicochemical properties of water were mostly affected by the receiving stream than hand dug wells and bore holes; and that direct discharge points are more affected than residual locations. The result of the multiple regression analyses also identified that BOD, DO, nitrate, and phosphate values had significant causal relationship with abattoir operations. These results confirm Mittal (2004) views that abattoir effluent could considerably increase the level of nitrogen, phosphorus and dissolved solids in receiving water body. Furthermore, the value of water parameters obtained from the different sample location along the river source is a clear indication that the presence of abattoir activities has adversely increased nutrient, organic matter and bacteria concentration. This result synchronizes with the findings of Meadows (1995) who he reported that livestock waste spill can introduce enteric pathogens and excess nutrients into surface water. For instant, excessive nitrate and phosphate promotes eutrophication, increase in BOD reduces the purifying capacity of river,, while decrease in DO content slows down organic matter degradation etc. (Meadows, 1995). The effects of these changes could lead to toxic poisoning in plants and animals, causing chronic diseases and sometimes death.

However, given that the mean values of downstream parameter were lower than that of the source point parameters, Aba River is said to be resilient (able to restore itself, and can recover from pollutant and contaminants). Bello and Oyedemi (2009) also remarked that excess nutrients can cause the water body to become chocked with organic substances and organism. When organic matter exceeds the capacity of micro-organisms in water that breaks down and recycles the organic matter, it leads to eutrophication and encourages rapid growth or blooms of algae. According to Keating (1994), an estimated 80% of all diseases and over one third of deaths are caused by consuming contaminated water in developing countries.

Overall, the effect of uncontrolled disposal system renders surface waters and underground water systems unsafe for human, agricultural and recreational use, destroys biotic life, poisons the natural ecosystems, poses a threat to human life and is therefore against the principles of sustainable development (Adelagan, 2002). There is need to subject Aba River to adequate and proper monitoring, which would help define water quality and remove interference. This would create differs uses of the river's resources such as recreational, fishing and sporting etc. by establishing vital and legitimate water quality, rather than subjecting it to a particular use with affects it negatively.

CONCLUSION AND RECOMMENDATIONS

The results revealed that the abattoir operations have significantly altered some of the physicochemical properties of soil and water. In dry season, it has led to the increase in soil properties for organic matter, total nitrogen, ECEC, exchangeable magnesium, clay, EC and a decrease in the values of sand and silt; while during the wet season it led to the increase in value of soil properties for Magnesium, clay, EC, total nitrogen, and available phosphorus; and decreased in values for slit, sand and exchangeable acidity. Moreso, for water properties there were significant variation among the three points where samples were collected (upstream, point-source, and downstream) in all the variables apart from pH levels in the dry season. While in the wet season significant variations were indicated among all variables expect pH level and dissolved oxygen. The significant increase in the mean values of BOD, EC, acidity, alkalinity, TDS, phosphate, sulphate, nitrate, chloride, sodium and magnesium; and in the decrease in the value of DO could be attributed to the direct discharge of effluent into the river. Generally, the effect of abattoir operations did not vary significantly for water properties as it did for soil properties between seasons. This was because more soil properties exhibited significant difference in mean value than water properties.

Also, the result obtained by comparing water properties with FMEnv permissible limit for surface water, revealed that apart for DO which was below the recommended standard at all water sampling locations; values of nitrate, TDS, BOD, chloride, and phosphate were above FMEnv standard at only point-source location in both wet and dry season.

CONCLUSION

Based on the findings in this study, abattoir operations have contributed to the degradation of soil and water quality of the Aba River and its surroundings. This is as a result of discharge of untreated materials into the water and the dumping of such materials on soil surface without proper disposal methods taken into account. The overall consequences of these effects are detrimental to man's health, plant and aquatic life.

5.3 Recommendations

i. The effects of abattoir operations on the soil and water quality of Aba, Abia State as presented by this study has contributed significantly in decreasing the environmental and health quality of man, plants and aquatic life. Hence, there is need to involve individuals, communities, stakeholders and government to pay more attention to their environmental. This can be done by creating awareness programmes, publishing researches such as this and making them available as a means of educating the public on the menace of abattoir operations to the environment.

ii. It is therefore recommended that relevant and adequate measures be undertaken to mitigate the present situation and prevent further pollution of the environment (soil and water).These may involve ensuring the availability of funds to treat already polluted areas, through land remediation methods and establishing water treatment facilities. Also, it is recommended that a management system be a requisite for the establishment and operation of any abattoir facility, thereby ensuring that wastewater, effluent and other forms of waste be properly treated before disposal or discharge. Waste obtained from abattoir operations can be useful when it is properly converted into manure and feedlots. Therefore government and interested organization can create relevant agro-industries which will not only help in buttressing the use of these waste products but would create jobs within the community.

iii. According to the World Health Organisation's guidelines on small slaughterhouse and meat hygiene for developing countries, the layout of an abattoir is required to meet a minimum space of 200 metres squared and an approved distance of 15 kilometres away from urban development. Findings in this research reveal that the Aba abattoir is located at the center of Aba town and thus falls short of this requirement. It is therefore recommended that abattoir be relocated to a more suitable location that meets with WHO standards/guidelines.

iv. Finally, government should ensure that proper environmental monitoring programmes be designed and be regularly carried out. This would provide a means of checkmating relevant pollution indicators and ensuring that good and suitable environmental quality is obtained.

5.4: REFERENCES

Abia State Government. (2012). About Abia State. Available at www.abiastate.gove.ng/ Retrieved 18th January, 2013.

Adams, E. D (1992). *Defining Water Quality: Clean Water for Washington,* Washington State University, Washington: Extension Bulletin Cooperatives.

Adelagan, J. A. (2002). Environmental Policy and Slaughter House Waste in Nigeria. In: Proceedings of the 28th WEDC Conference, India. pp 64 – 80.

Ademoroti, C. M. A. (1996). *Standard Methods for Water and Effluent Analysis (IUPAC Systems).* Ibadan: Floudex Press Limited, pp 49-56.

Akan, J. C., Abdulrahman, F. I. and Yusuf, E. (2010). Physical and Chemical Parameters in Abattoir Wastewater Sample. *Pacific Journal of Science and Technology*, 11(1): 640-648.

Association of Official Analytic Chemists (AOAC). (1995). 15th ed., Virginia, USA: Sage Publishers, pp 83-91.

Bello, Y. O. and Oyedemic, P. T. A. (2009). The Impact of Abattoir Activities and Management in Residential Neighbourhood. A Case Study of Ogbomoso, Nigeria. *Journal of Social Sciences*, 19 (2): 121-127.

Bremmer, J. M. (1996). Total Nitrogen. In: Sparks, D. L. (Ed.), *Methods of Soil Analysis Part 3 Chemical Methods*. Wisconsin: SSSA Book Series 5, pp. 1088-1123.

Cadumus, S.I., Olugasa, B. O. and Ogundipe, G. A. (1999). The Prevalance of Zoonotic Importance of Bovine Turberculosis in Ibadan, Nigeria. In: Proceeding of 37th Annual Congress of the Nigeria Veterinary Medical Association, pp. 65-71.

Chukwu, O. (2008). Analysis of Groundwater Pollution from Abattoir Waste in Minna, Nigeria *Research Journal of Dairy Science*, 2 (4):74-77.

Chukwu, O., Adeoyo, P. A. and Chidiebere, I. (2011). Abattoir Waste Generation, Management and the Environment: A Case of Minna, North Central Nigeria. *International Journal of Biosciences,* 1 (6): 100-109.

Chukwukwa, C.O. (2013). Effect on the Physicochmeical Properties of Iyiokwu River in Abakaliki. Available at www.doublegist.com/abattor-effluent-effect-physicochemical-properties-iyiokwu-river-abakaliki Retrieved 21st June, 2014.

Ekanem, E. M. (2010). Climatic Characteristics. In: Usoro, E. J. and Akpan, P. A. (Eds.), *Akwa Ibom State: A Geographic Perceptive.* Enugu-Nigeria: Immaculate Publication, pp. 91-101.

Enderlein, U., Enderlein, R. and Williams, P. (1997). Water Requirement in Water Pollution Control. In: Helmer, R. and Hespanhol, I. (Eds.), *A Guide to the Use of Water Quality Management Principles.* London: E & FN Spon, pp. 56-89, Available at www.who.int/water_sanitation_health/resourcesquality/wpcchap2.pdf. Retrieved 21stJanuary, 2013.

Emeka, U. J., Braide, S. A. and Chindah, A. C. (2009). Impact of Abattoir Wastes Based on Some Physicochemical Parameters on Woji Creek, Port Harcourt, Nigeria. *Management of Environmental Quality: An International Journal*, 20 (5): 581 – 591.

ESCAP. (2003). Virtual Conference Integrating Environmental Consideration into Economic Policy Making Process. Available at www.escap.org/drpad/ve/conference/bg_vu_46_vet.htm 11th January, 2013.

Federal Environmental Protection Agency/Federal Ministry of Environment. (1991). *Guidelines and Standards for Environmental Pollution Control in Nigeria.* Lagos, Nigeria. Available at www.faolex.fao.org/docs/texts/nig18380.doc. Retrieved 18th January, 2013.

Federal Ministry of Environment (2005). *Policy Guidelines on Market and Abattoir Sanitation.* Abuja: FMEvn.

Food and Agriculture Organisation of the United Nations. (1991). *Guidelines for Slaughtering, Meat Cutting and Further Processing.* Rome, Italy. Available at www.fao.org/docrep/004/T0279E/T0279E00.HTM. Retrieved 12th March, 2014.

Food and Agriculture Organization of the United Nations. (2013). *Rural Infrastructure and Agro-Industries Division- Abattoirs.* United Nations. Available at www.fao.org/ag/ags/rural-infrastructure/abattoirs/en/ Retrieved 21st January, 2013.

Gee, G. W. and Bander, J. W. (1986). Particle Size Analysis. In: Klute, A. (Ed.), *Methods of Soil Analysis, Part 1- Physical and Mineralogical Methods.* Wisconsin: SSSA Book Series 5, pp. 383-412.

Greenberg, A.E. (1995). *Standard Methods for the Examination of Water and Wastewater.* 19th Edition., USA: America Public Health Association, pp. 254.

Iwara, A. I., Njar, G. N., Deekor, T. N. and Ita, A. E. (2012). Effect of Adiabo Abattoir on the Water Quality Status of Calabar River in Odukpani, Cross River State, Nigeria. *Continental Journal Environmental Sciences, 6* (2): 36 – 43.

Keating, M. (1994). The Earth Summit Agenda for Change. In: Proceedings of A Plain Language Version of Agenda 21, p. 32.

Kosamu, I. B. M., Mawenda, J. and Mahomet, H. W. T. (2011). Water Quality Changes Due to Abattoir Effluent: A Case on Mchesa Stream in Blantyre, Malawi. *African Journal of Environmental Science and Technology,* 5 (8) 589-594.

Kuo, O. (1996). Phosphorus. In: Spark, D. L. (Ed.), *Methods of Soil Analysis Part 3-Chemical Methods*. Wisconsin: SSSA Books Series, pp. 869-919.

Meadows, R. (1995). *Livestock Legacy Environmental Health Perspective.* Available at www.livestock_legacy_environmental_health_perspective/doc/pdf. Retrieved 8th August, 2013.

Mittal, G. S. (2004). *Characterization of Effluent Wastewater from Abattoir for Land Application.* Available at http://www.informaworld.com/smpp/content=9713626332· Retrieved 21st January, 2013.

Mikkdsen, R. I. (2004). Balanced Crop Nutrition-Nurture the Crop and the Soil. *A Regional Newsletter, Potash and Phosphate Institute of Canada,* Available at www.ipni.net/ppiweb/ppinew.nsf&webcontent/19B7F662F77CA85256F3A0033184/&file/Balanced+Nutrition.pdf· Retrieved 10th June, 2014.

Missouri Department of Natural Resources. (2010). *Environmental Services Programme- Water Quality Parameters*. Available at www.dnr.mo.gov/env/esp/waterqualty-parameters.htm 10th June, 2014.

National Population Commission (2006). *The Nigeria Population Census, 2006.* Available at www.population.gov.ng/index.php?option=com_content&view=artide&id-89 Retrieved 22nd June, 2013.

Nelson, D. M. and Sommers, L. E. (1996). Total Carbon, Organic Carbon and Organic Matter. In: Sparks, D. L. (Ed.), *Methods of Soil Analysis Part 3- Chemical Methods*. Wisconsin: SSSA Book Series 5, pp. 961-1010.

Njoku, J. D., Amangabara, G. T., Duru, P. N. (2013). Spatial Assessment Of Urban Flood Risk in Aba Metropolis, Using Geographical Information System Techniques. *Global Advance Research Journal of Environmental Sciences and Toxicology*, 2 (3):082-092. Available at www.garj.org/garjest/index.htm Retrieved 22nd May, 2013.

Nsogho, P. (2012). Stakeholders Lament Sanitary Condition at Abattoir. *The Independent Television & Radio,* 27th April, 2011. Available at www.itv-radio.com/all_about_the_news/2012/04/27/stakeholders-lament-sanitory-condition-at-abattoir/ Retrieved 21st January, 2013.

Nwanta, J. A., Onunkwo, J. I., Ezenduka, V. E., Phil-Eze, P. O. and Egege, S. C. (2008). Abattoir Operations and Waste Management in Nigeria: A review of Challenges and Prospects, Sokoto. *Journal of Veterinary Science,* 7 (2): 61-67.

Nwoko, A. (2013). Flooding in Nigerian Cities: Problem and Prospects. A case study of Aba Urban, Abia State, Nigeria. *Academia.edu.* Available at www.academia.edu/3669614/FLOODING_IN_NIGERIAN_CITIES_PROBLEMS_AND_PROSPECTS_A_case_study_of_Aba_Urban_Abia_State_Nigeria. Retrieved 19th June, 2013.

Ogban, P. (2009). Soil, Air and Water Quality. In: Ukpong, I. E (Ed.), *Perspectives on Environmental Management.* Uyo, Akwa Ibom State: Environmental System Club Inc, pp. 94-130.

Omole, D. O. and Longe, E. O. (2008). An Assessment of the Impact of Abattoir Effluents on River Illo, Ota, Nigeria. *Journal of Environmental Science and Technology, 1: 56-64.* Available at http://scialert.net/abstract/?doi=jest.2008.56.64. Retrieved 18th January, 2013.

Osemwota, O. I. (2010). Effect of Abattoir Effluents on the Physical and Chemical Properties of Soil. *Journal of Environmental Monitoring and Assessments*, 1-4(167): 399- 413

Osibanjo, O. and Adie, G. U. (2007). Impact of Effluent from Bodija Abattoir on the Physicochemical Parameters of Oshunkaye Stream in Ibadan City, Nigeria. *African Journal of Biotechnology,* 6 (15):1806-1811.

Oyeleke, S. B., Duada, B., Oyewola, O. A., Sumayya, B. U. and Okollegbe, I. N. (2011). The Effect of Abattoir Effluent Waste Water on Soils Of Gandu Area of Sokoto, Sokoto State, Nigeria, *International Journal of Tropical Agriculture and Food System*, 5 (3): 128-141.

Pejman, A. H., Bidhendi, G. R. N., Karbassi, A. R., Mehrdadi, N. and Bidhendi, M. E. (2009). Evaluation of Spatial and Seasonal Variations in Surface Water Quality Using Multivariate Statistical Techniques. *International Journal of Environmental Science and Technology,* 6 (3): 467 – 476.

Phipps, E. (1995). *Pollution Prevention Concept and Principles.* Michigan: The National Pollution Prevention Center for Higher Education University of Michigan. Available at www.nmich.edu/_nppcpub/ Retrieved 11thJune, 2013.

Preul, H. (1993). *Water Pollution Control- A Guide to the Use of Water.* London: United Nations on behalf of WHO by F &FnSpon. Avialble at www.earthprint.com Retrieved 23rdJune, 2013.

Rabah, A. B., Oyeleke, S. B., Manga, S. B., Hassan, I. 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.

Radha, S., Nithya, V.J., Himakiram, B., Sridevi, A., Narasimha, G. and Prasad, E. (2011). Effect of Abattoir Waste Disposal on the Physicochemical, Biological Properties and Enzymes Activities. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences.* (13) 4: 673-676.

Saidu, M. and Musa, J. J. (2012). Impact of Abattoir Effluent on River Landzu, Bida, Nigeria. *Journal of Chemical, Biological and Physical Sciences,* 2 (1): 132-136.

Shobayo, I. (2010). Abattoir of Diseases. *Sunday Tribune*, 18th, July, 2012. Available at www.sundaytribune.com.ng/index.php/features/8970-abattoir-of-diseases Retrieved January, 2013.

Spiegel, J. and Maystre, L. (1998). Water Pollution Control. *Encyclopedia of Occupational Health and Safety*. Geneva: International Labor Organization. Available at www.ilocis.org/document/chpt55e Retrieved 21st June, 2013.

Ştefanic, G. (1994). Biological Definition, Quantifying Method and Agricultural Interpretation of Soil Fertility. *Romanian Agricultural Research*, 2; 107-116.

Summer, M. E. and Miller, W. P. (1989). Cation Exchange Capacity and Exchange Coefficients In: Sparks, D. and Bartels, J. M. (Eds.), *Methods of Soil Analysis Part 3 Chemical Methods*. Madison: ASA and SSSA, pp. 1201-1230.

Sullivan, M (2007). *Statistics: Informed Decision Using Data.* New Jersey: Pearson Prentice Hall, Pearson Education Inc, p.45.

The Enviropedia. (2002). *Sustainable Development*. Available at www.enviropaedia.com Retrieved 23rd January, 2013.

Thomas, G.W. (1996). Soil pH and Soil Acidity. In: Spark, D.L (Ed.), *Methods of Soil Analysis Part 3-Chemical Methods*. Wisconsin, USA: SSCA Books Series, pp. 475- 490.

Udo, E. J., Ibia, J. A., Ogunwale, A. O. and Esu, I. E. (2009).*Manual of Soil, Plant and Water Analysis*. Lagos, Nigeria: Sibon Books Limited.

Udofia, E. P. (2011). *Applied Statistics with Multivariate Methods.* Enugu: Immaculate Publication Limited.

Udosen, E. (2009). Environmental Impact Evaluation and Assessment. In: Ukpong, I.E (Ed.), *Perspective on Environmental Management*, Uyo-Akwa Ibom State: Environmental Systems Club Inc., pp. 654-701.

Ukpong, I. E. (2010).Vegetation and Soil Relationship in Fallow System. In: Usoro E. J. and Akpan, P. A (Eds.), *Akwa Ibom State: A Geographic Perceptive,* Enugu-Nigeria: Immaculate Publication, pp. 66-90.

Ukpong, I. E. (2009). Environmental Monitoring. In: Ukpong, I. E. (Ed.), *Perspective on Environmental Management*, Uyo, Akwa Ibom State: Environmental System Club Inc., pp. 530-592.

University of Minnesota/Extension (2014). Nutrient Cycling and Maintaining Soil Fertility in Fruit and Vegetable Crop System Avaliable at www.extension.umn.edu/garden/fruit-vegetable/nutrient-cycling-and-fertility/ Retrieved January, 2014.

Uzoagulu, A. E. (1998). *Practical Guide to Writing Research Projects Reports in Tertiary Institutions*. Enugu-Nigeria: John Jacob's Publishers Limited.

Weobong, C. A. and Adinyira, E. Y. (2011).Operational Impacts of the Tamale Abattoir on the Environment. *Journal of Public Health and Epidemiology,* 3(9): 386-393.