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Physiochemical Effects of Orie Emene Abattoir Discharge on the Quality of Ekulu River and Nearby Well

Agbo Chekwube Chikwelu[1*], Orakwe Louis Chukwuemeka[1]

[1]Department of Agricultural and Bioresources Engineering, Nnamdi Azikiwe University Awka,

[*]Corresponding Author's E-mail: chikwesagbo@gmail.com

Abstract

The problem of getting quality water is increasing as untreated effluents are discharged into water bodies. The study assessed the impact of abattoir effluents on surface and ground water bodies at Orie Emene. The effects of discharged untreated abattoir waste on water quality and the interrelationship between analyzed physiochemical parameters were studied. Samples were collected at four locations namely: point of effluent discharge[1], effluent entry into Ekulu river[2], Ekulu River[3] and nearby well[4], basic water quality parameters were determined. These samples were collected across three intervals of rainy season (Beginning[A] (April), Peak[B] (July) and End[C] (October) of rainy season). Laboratory analysis was carried out to ascertain the physical and chemical variables present in the samples collected, various variables analyzed were recorded. SPSS model of multivariate analysis of variance (MANOVA) was used to Collate the result gotten from the laboratory, variables with its effects to the water bodies were determined. Total solid (TS), SULPHATE, NITRATE, had a higher concentration in season C. P^H, Total dissolved solid (TDS), Electrical conductivity (EC), Chemical oxygen demand (COD) and Dissolved oxygen (DO) were higher in season A, Chloride (CL) was higher in season B, There was no significant difference ($p>0.05$) in all the variables correlated across seasons. Across locations, most of the variables had a higher concentration in location 1, except DO that is higher in location 4. There was no significant difference ($p>0.05$) in P^H. other variables had significant difference ($p<0.05$) in most of the locations. Graphical representation of the results was drawn and compared Using Federal environmental protection agency (FEPA, 1991) and World health organization (WHO, 2006), it was found that P^H, TDS, NITRATE fall within the permissible limits across some seasons and locations of collection, whereas TS, EC, COD, CL were higher, DO and SULPHATE were far below the permissible limit. These showed a very high treat to the water bodies as most variables present, due to its low or high concentration made the waters unfit for domestic use.

Keywords: abattoir, effluents, discharge, Ekulu River, underground well.

1. Introduction

Water pollution has now become a global problem due to the ever-increasing population of the earth which constantly is in need of fresh water (Alfonso-Muniozguren et al., 2018; Meng et al., 2018). There has been an increasing study on treatment of wastewater before discharge into the water bodies, some of which were studied by (Akyol et al., 2013; Badejo et al., 2017; Emenike et al., 2017; Ogbiye et al., 2018 and Adebanji S. et al., 2018).

The continuous drive to increase meat production for the protein need of the ever-increasing world population has been accompanied by some pollution problems (Adesemoye et al., 2006; Nafarnda et al., 2012). In Nigeria, the abattoir is an important component of the livestock industry providing domestic meat supply to over 150 million people and employment opportunities for the teaming population (Nafarnda et al., 2012). Adeyemi and Adeyemo (2007) reported that cities face serious problems of high volume of wastes from abattoir due to inadequate disposal technologies and high cost of management. In Nigeria, adequate abattoir waste management is lacking in all public abattoirs such that large solid wastes and untreated effluents are common sites, and many disposed directly into streams and rivers without any form of treatment and in some cases, slaughted meat is washed with same water already contaminated, unlike in developed countries where these facilities are adequately provided (Ogbonnaya, 2008; Adelegan, 2004; Durotoye et al., 2018). Abattoir sludge which originates from high strength wastewater needs to be properly disposed of (Eryuruk et al., 2018a) as abattoir wastes could be a source of embarrassment since conventional methods of waste management have been grossly neglected (Adedipe, 2002; Adeyemi & Adeyemo, 2007).

The resulting pollution not only cause problems related to odour, flies and hygiene, but surface and ground water can be polluted with pathogens and undesirable chemical compounds (Eryuruk et al., 2018b; Ozdemir et al., 2018). The processing activities involved sometimes result in environmental pollution and other health hazards that may threaten animal and human health. According to World Health Organization (WHO, 2011), More than 3.4million people die each year from waterborne disease, most of whom are young children. The need for regular surveillance, pre-treatment and treatment of water bodies' is of utmost importance in this generation, so as to maintain the sustainability of the environment (Khan et al., 2016; Nkansh et al., 2019; Tyagi et al., 2013). Previous studies have shown that the characteristics of abattoir wastes and effluents vary from day to day depending on the numbers and type of stocks being processed, these influences the type of waste produced.

The River Ekulu originates somewhere from the base of Udi hill close to Onyeama coal mine. It receives acid mine effluent from the mine and plays host to effluents from peri-urban areas along its bank. This river plays a significant role to Emene community as it serves as the main source of water supply to the vastly average to low income inhabitants. The municipal pipe-borne water from Enugu state water board is either absent or completely moribund in most of the areas, hence the River Ekulu is the mainstay of water supply to this important peri-urban of Enugu State. River Ekulu supports essential domestic and recreational activities. Small and medium scale businesses such as car washing, Agricultural purposes and block molding depend heavily on the river for survival. Abattoir house is sited within close distance of the river's bank. Effluent-runoffs from these houses find its way into the river. They could be from improper disposal of production waste liquids laden with both suspended and dissolved contaminants. They can enter the river environment from rain or from improper disposal habits of factories disposing them. The immediate and long-term implication to the receiving water body is often dire. Both aquatic organisms and man that depends on it suffer from one problem to another.

With the above mentioned problem, the research work aim at determining the physiochemical effect of this discharged abattoir effluent to Ekulu river and nearby well. This will be achieved with the collection of samples from the abattoir site, the Ekulu river and the nearby well for 3 intervals of rainy season (beginning, peak and end), run the laboratory analysis and determine the variables with the highest effect using SPSS model of MANOVA (multivariate analysis of variance).

2.0 Material and methods

2.1 Study Area

The Ekulu River originates somewhere in the Ajali sand stone near Onyeama mines, passing through G.R.A. in the south of the area to the East into Nyaba river (Ezeigbo and Ezeanyim, 1993). The anticipated problem is the release of Abattoir waste from the Orie Emene Abattoir into the portion of the river close to it which tends to be harmful to the dependants of these Rivers.

2.2. Sampling periods and collections

Samples were collected randomly from 4 different locations of the site, namely; (point of effluent discharge, point of entry into Ekulu river, Ekulu river and nearby well) within 2months interval, same time for the period of rainy season, (the beginning, peak and ending). The collection was done in the morning by 7.00am before the start of the daily events in d area for various physical and chemical analyses. Observation of the sampling sites was made with respect to physical changes and activities during each visit (Ademoroti, 2002). These samples were collected using 1 litre of clean dry plastic bottles in a way that the water will not mix with any external impurities, sample bottles were rinsed twice with the water obtained from the designated location prior to collecting samples for testing and sample bottles were filled completely to prevent any loss of dissolved gases from the samples. The sample bottles were labeled appropriately using a marker with the information on collection point and transported to the laboratory for analysis. Water samples were preserved in a refrigerator with a temperature between 0ºC and 4ºC.

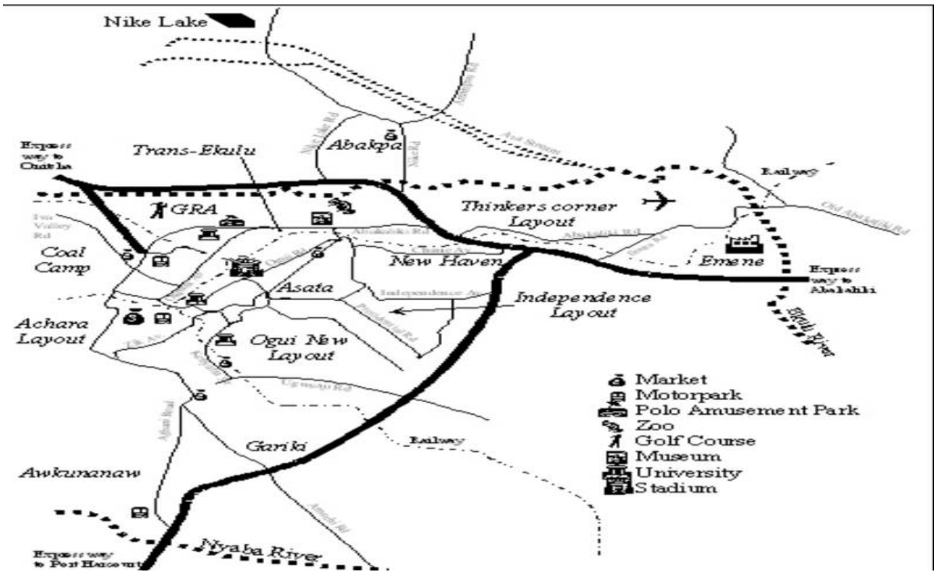

Figure 2.1. Map of Enugu Metropolis showing Emene and the passage of Ekulu River with a bold dotted line.

2.3. Samples collected

The physical test analysis of samples is aimed to determine the level of impurities; some of the parameters include; P^H, Total solid (TS), Total dissolved solids (TDS), electrical conductivity (EC). The chemical tests are quantified in terms of organic and inorganic constituents present in the samples. Some of the chemical parameters include Chemical oxygen demand (COD), Chlorine (CL), Dissolved oxygen (DO), Sulphate, Nitrate. According to Chukwu (2008) these physiochemical parameters were used to determine the effect of abattoir waste to the quality of water bodies. He stated the importance of determining the quantities available as they are of great importance in water quality modeling.

These parameters were determined by instrumental methods and conducted following standard analytical method using American public Health Association (APHA, 1995, 2005, 2012) procedure. The amount of salt dissolved in the samples was measured by silver nitrate titration. CL and COD content of the samples were determined by titrimetric method of analysis, using various reagents. The TDS and TS were determined using the gravimetric method (Kiely, 1998). DO was determined using the Winkler's titration method. Nitrate concentration was determined using brucine method as described by Allen, 1974 and the sulphate was determined using turbidimetric method. The physiochemical results will be compared with World health organization (WHO, 2006) and Federal environmental protection agency (FEPA, 1991).

3.0 Results and Discussions

Multivariate test across seasons: this presents the data collected and the variations that occurred across seasons when the samples were collected. Tables 3.1 & 3.2 are the multivariate analysis of variance of the parameters collected within 3 periods of rainy season: Tables 3.1 showed the actual result, looking at the second effect labeled "Season", and the Wilk's Lambda row (highlighted in lemon). The "Sig" column from the table is 0.652 which means p>.05. Therefore we can conclude "There was no statistically significant difference in the seasons of collection, F=0.892, P>.05= 0.652, Wilk's Λ = 0.12.

Table 3.2 presents the mean and standard error, with the significant variations that occurred across the seasons, it was computed using 'TURKEY HSD'; it had 95% confident intervals. It was shown that parameters p^H, TDS,EC, COD &D0, had a higher concentration of variables in season A than the rest of the seasons, though no significant difference (P>0.05)shown. Parameter TS, SULPHATE & NITRATE, shows a higher concentration in season C with p>0.05 and parameter CL shows higher concentration in season B with P>0.05.

Table 3.1: Manova test across seasons, highlighting wilks' Lambda as the most acceptable theory and result.

	Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[d]
Intercept	Pillai's Trace	1.000	290.790[b]	9.000	1.000	.045	1.000	2617.110	.729
	Wilks' Lambda	.000	290.790[b]	9.000	1.000	.045	1.000	2617.110	.729
	Hotelling's Trace	2617.110	290.790[b]	9.000	1.000	.045	1.000	2617.110	.729
	Roy's Largest Root	2617.110	290.790[b]	9.000	1.000	.045	1.000	2617.110	.729
Seasons	Pillai's Trace	1.529	.721	18.000	4.000	.722	.765	12.986	.122
	Wilks' Lambda	.012	.892[b]	18.000	2.000	.652	.889	16.063	.092
	Hotelling's Trace	36.415	.000	18.000	.000	.	.948	.000	.
	Roy's Largest Root	35.159	7.813[c]	9.000	2.000	.119	.972	70.318	.362

Table 3.2: The significant variations

Arameters	Season A	Season B	Season C
P^H	6.35±0.34	5.99±0.34	6.03±0.34
TDS	1323.02±1123.20	1312.50±1123.20	1285.75±1123.20
TS	69000±67216.25	68825±67216.25	71517.50±67216.25
EC	2525.50±2013.21	2411.50±2013.21	2480±2013.21
COD	5830±5007.89	5645±5007.89	55585±5007.89
CL	364.15±196.79	510.41±196.79	452.16±196.79
DO	5.05±2.72	4.15±2.72	4.60±2.72
SULPHATE	52.93±45.24	53.21±45.24	53.98±45.25
NITRATE	4.75±4.03	4.74±4.03	5.29±4.03

Table 3.3: Multivariate Tests Across location with Wilks' highlighted

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1.000	12618.559[b]	5.000	4.000	.000
	Wilks' Lambda	.000	12618.559[b]	5.000	4.000	.000
	Hotelling's Trace	15773.199	12618.559[b]	5.000	4.000	.000
	Roy's Largest Root	15773.199	12618.559[b]	5.000	4.000	.000
LOCATION	Pillai's Trace	2.427	5.085	15.000	18.000	.001
	Wilks' Lambda	.000	132.828	15.000	11.444	.000
	Hotelling's Trace	35150.196	6248.924	15.000	8.000	.000
	Roy's Largest Root	35126.779	42152.135[c]	5.000	6.000	.000

Table 3.4: The significant variations

Parameters	Location 1	Location2	Location3	Location4
p^H	6.85±0.36	5.83±0.36	5.99±0.36	6.06±0.36
TDS	4673.33 ± 19.20^a	304.33 ± 19.20^b	$65.33\pm19.20\ ^c$	185.33 ± 19.20^d
TS	27140 ± 1653.35^b	2366.67 ± 1653.35^a	2556.67 ± 1653.35^a	2800 ± 1653.35^a
EC	8470 ± 181.53^c	989 ± 181.53^b	116.33 ± 181.53^a	314 ± 181.53^{ab}
COD	20666.67 ± 180.38^c	1703.33 ± 180.38^b	193.33 ± 180.38^a	183.33 ± 180.38^a
CL	861.82 ± 143.91^b	465.65 ± 143.91^{ab}	81.47 ± 143.91^a	360.03 ± 143.91^{ab}
DO	0.00 ± 0.55^a	0.00 ± 0.55^a	8.13 ± 0.55^b	10.27 ± 0.55^b
SULPHATE	188.65 ± 0.65^c	18.29 ± 0.65^b	4.173 ± 0.65^a	2.38 ± 0.65^a
NITRATE	17.00 ± 0.36^b	0.97 ± 0.36^a	0.93 ± 0.36^a	0.80 ± 0.36^a

Tables 3.3 and 3.4 are the multivariate analysis of variance of the parameters collected within 4 locations: Location1 is the abattoir pavement drainage; Location 2 is the runoff entrance to the river; Location 3 is the Ekulu River and Location4 is the nearby well. Tables 4, shows the actual result is, looking at the second effect labeled "Location", and the Wilk's Lambda row (highlighted in yellow). The "Sig" column from the table is .000 which means p<.05. Therefore we can conclude "There was a statistically significant difference in the seasons of collection, F=132.828, P<.05= 0.000, Wilk's Λ = 0.000.

Table 3.4 presents the mean and standard error with the significant variations that occurred across the seasons, it was computed using 'TURKEY HSD'; it had 95% confident intervals. Here, p^H value showed a higher concentration in location 1 with no significant difference p>0.05 in all locations of the variables above. TDS shows a higher concentration when compared to other location with a significant difference P<0.05 in all locations. TS shows a higher concentration in location 1 with a significant difference P<0.05 from the other location, whereas location 2, 3 & 4 shows no significant difference P>0.05. EC also showed a higher concentration in location 1 with a significant difference P<0.05 with all location, P<0.05 in location 2 & 3 but no significant difference P>0.05 when compared with location 4. Value COD had a higher significant concentration in location 1 with P<0.05 when compared with location 2, 3 & 4, but no significant difference P>0.05 between location 3 & 4. CL also showed a higher concentration in location 1 with a significant difference p<0.05 with location 3, but no significant difference P>0.05 with location 2 &4 when compared with location 1 &3. DO showed a higher concentration in location 4 with P<0.05 in location 3 & 4, but p>0.05 with location 2. There was no significant difference between location 3 & 4. Sulphate had a higher concentration in location 1 with a significant difference P<0.05 in all the locations, p>0.05 between location 3 & 4. Nitrate also had a higher concentration in location 1with P<0.05 in all location, no significant difference P>0.05 in location 2, 3 & 4.

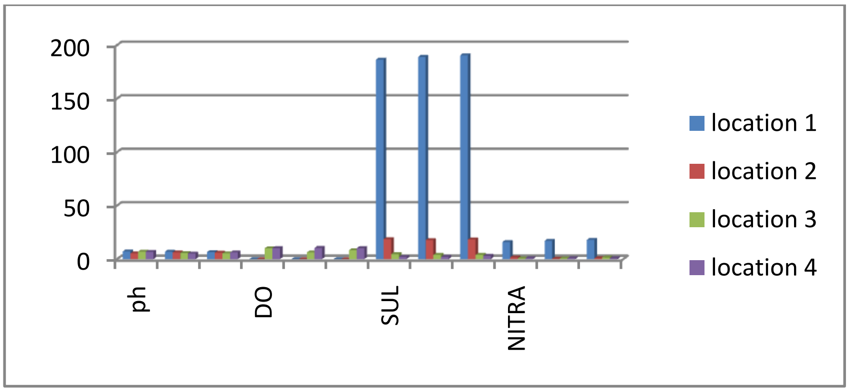

Fig. 3.1: Manova graph of ph, DO, Sulphate and Nitrate

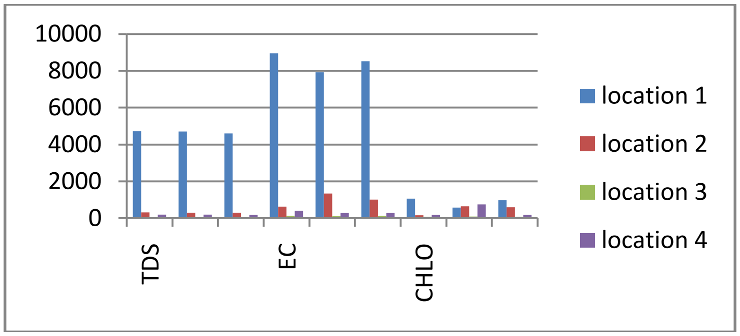

Fig. 3.2: Manova graph of TDS, EC and Chloride

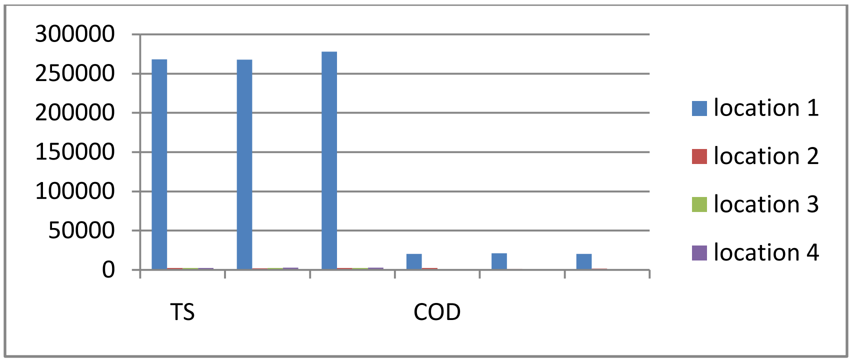

Fig. 3.3: Manova graph of TS and COD

Result Discussion for The Graphical Analysis

Since there was a statistical significance result, there would be a follow up test which is summarized below;

The P^H content: ranged from 5.9-6.4 across season and 5.83-6.84 across location (fig 3.1) which shows that season A had the highest value of P^H and it was also observed that it was high at location 1. This shows they fall within the FEPA range of 6-9 and WHO permissible standard of 6.5-8.5 for domestic water, whereas the others didn't fall within its standards. This indicated an interference as there were increase in rain which lead to increased runoff which affected other seasons and also as a result of seepage to the ground which affected the P^H Value of location 2 and its introduction into the river poses a threat to the water as it is too acidic. However, P^H plays a significant role in determining the bacterial population growth and diversity in surface water. Microorganism frequently change P^H of their own habitat by producing acidic or basic metabolic waste products (Preschoh C.M etal, 1999)

The Total dissolved solid: Fig 3.2 is TDS value of the result obtained from season A 1323mg/L with location 1 has the highest value of 4500mg/L while season C and location 3 has the lowest with 400mg/L value. Some of the values obtained fall below FEPA limits of 2000mg/L and WHO standard of 1200mg/L. High levels of TDS are caused by the presence of potassium, chloride and sodium and interfere with the taste of foods and beverages, and makes them less desirable to consume. This poses a variety of health hazards to living organisms dependent on the water and as reported by Efe are an indication of the degree of dissolved substances such as metal ions in the water (Efe S.T, 2001).

The Total suspended solid: TS values of all samples analyzed ranges from 68825-71517mg/L across seasons and 2366-271400mg/L across locations (Fig 3.3) which is way above the FEPA limits of 30mg/L and WHO standard of

1000mg/L. this indicates that the high concentration of TS in the water makes it unfit for domestic purpose. As its presence measures the physical or visual observable dirtiness of water.

Electrical conductivity content: is the ease to which a substance allows free flow of electricity through the ions in electrolyte of water samples. This is also a measure of the dissolved ionic component and total dissolved substitution in water (Yilmaz, E. and Koc, C. 2014). The values ranged 2411-2525µs/cm across seasons and 116-8470µs/cm across locations (Fig 3.2), where season A had the highest value with location 1 as the more concentrated area across locations. The seasons and Location 1&2 are above the permissible standard of 900µs/cm which poses a threat and shows the samples is saline, whereas location 3&4 are within the permissible value. Any level above WHO standard can pose health risk of defective endocrine functions and also total brain damage with prolong exposure.

The COD content: In fig 3.3 values have highest concentration of 20666mg/L at location 1. Across seasons ranges from 5585-5830mg/L which shows a higher concentrate with location 1& 2 been higher compare to the FEPA permissible limits of 80mg/L and of 1000G/L of WHO , this indicates the presence of chemical oxidants in the effluent. Location 3&4 are below which indicates the absent of the oxidants. High COD could likely cause nutrient fixation in the soil resulting to reduced rate of nutrient availability to plants. Chemical oxidants affects water treatment plants by causing rapid development of rust (Chukwu, 2008)

The Chloride content: values ranges from 364-510mg/L across season and 360-861mg/L across location(Fig 3.2) which is high when compared with WHO permissible limit of <250mg/L. This could be as a result of the presence of soluble salt (NaCl and KCl.). Chlorides are important in the detection of sewage contamination of groundwater; other sources include storm waters containing road salts, the use of artificial fertilizers, landfill leachates, septic tank waste waters, and animal feeds (Igbinosa, I.H. and Uwidia, I.E. 2018)

The dissolved oxygen content: the DO value ranges from 4-5mg/L across seasons and 0.000-10.3mg/L across locations (Fig 3.1). DO is a measure of the degree of pollution by organic matter, the destruction of organic substances as well as self-purification capacity of the water body. The standard for sustaining aquatic level is 5mg/L. concentration below this level adversely affect aquatic biological life, while concentration below 2mg/L may lead to death of most fishes (Chapman D, 1992) as seen in fig 3.7, were location 3&4 are below 2mg/L , this means the water is unfit for use. Most game fish require at least 4-5mg/L level of DO to thrive (Corson, 1990).The higher the concentration of Do, the better the water quality, this is the case season A and B citing location 1&2 with high concentration.

Sulphate content: Sulphate does not have a health-based guideline value. The sulphate value obtained ranges from 52-53mg/L across seasons and 2.4-188.85mg/L (Fig 3.1). however the WHO recommends that a concentration higher than 450mg/L is unhygienic due to problems to the gastro intestinal tract. All the samples collected have lower values than the given limit.

Nitrate content: In fig 3.1 Nitrate value ranges from 4.75- 5.30mg/L across the season and 0.8-17.00mg/L across location. This falls within the permissible range. Nitrate stimulates the growth of plankton and water weeds that provides food for fish and also in crop production as a major ingredient in fertilizer. If algae grows too wildly, oxygen levels will be reduced to toxic nitrates in human intestines, many babies have been seriously poisoned by water containing high level of nitrate-nitrogen (causing 'blue baby diseases').

4.0. Conclusion

This research on impact of orie Emene abattoir effluent on the quality of Ekulu River and underground well, revealed the important contribution of raw untreated abattoir effluent to the pollution of the two water bodies. These water bodies are of great importance to the inhabitant of these study area, as it is used for domestic purposes.

In conclusion, the result shows that the analyzed water body is contaminated by variety of sources. With the direct discharge of the untreated abattoir waste, been a major contributor to the poor health of the water body. Abattoir waste, like every other waste, is a resource, and could be utilized in several operation within and outside the activities of the abattoir, such as provision of bio-energy for a self-sustaining cycle (Budiyono et al, 2014), composting in agriculture (Sadik et al, 2010) etc. findings from these current study indicate that the meat processing industry in Nigeria has a potential to worsen scarcity of clean water availability, thereby adversely affecting the range of uses of such water bodies.

5.0 Recommendation

The following recommendations are advocated for effective management of effects of abattoir effluents.

- The waste water should be recycled for interest of the public.
- There should be sewage treatments constructed for managing abattoir effluents.
- Abattoir operators should be trained with respect to public health implication of their activities.

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