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Research Paper

Impacts of effluents on River Nggada water quality in Maiduguri, Nigeria

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Abstract. Evaluation of abattoir effluent waste and management operations on receiving stream of Maiduguri main abattoir (Kasuwan Shanu) Borno State was done in 2013.In the present study, water samples were taken from water sources in the abattoir and were assessed for biological and chemical analysis, Using the standard methods of examination of water and waste water (APHA,1992). The biological and chemical parameters ranged between 2 - 18mg/l DO and 10 - 45mg/l BOD_5 98 -789mg/l CL, 29.8 - 855mg/l $SO_{4,}$ 3.50 - 19mg/l PO_4 for different sampling point in the study area and were above the WHO Standards for effluent discharge from industries. The rise and fall pattern of DO and BOD confirms the process of self-purification of the receiving stream with distance. The result implies that no sufficient measures or facilities to treat abattoir wastewater for environmental safety in Maiduguri abattoir. Thus, the need to treat this wastewater before discharging it to the environment is needed.

Keywords: effluent discharge, self-purification, River Ngadda.

INTRODUCTION

The quality of water is defined in physical, chemical and biological forms in each category and the water quality parameters are selected on the basis of their intended use. The discharge of industrial effluent into water bodies is one of the main causes of environmental pollution and degradation in many cities, especially in developing countries. Many of these industries lack liquid and solid waste regulations and proper disposal facilities. Such waste may be infectious, toxic or radioactive. (World Health Organization [WHO], 2004).In most countries the principal risks to human health associated with the consumption of polluted water are microbiological in nature as well as chemical contamination. An estimated 80% of all diseases and over one-third of deaths in developing countries are caused by the consumption of contaminated water and on average as much as one-tenth of each person's productive time is sacrificed to water-related diseases. Tortora *et al.* (2007) noted that following the discharge of untreated wastewater into soil, certain elements such as iron, lead, calcium, phosphorus and zinc which were previously absent or present in minute quantities will be introduced thus leading to bioaccumulation of these chemicals. Some of these chemicals may be toxic to the microbial, floral and faunal communities of the soil.

Contaminants are usually of varied composition ranging from simple organic substances to complex inorganic compounds with varying degree of toxicity. Pollution of surface water and natural habitat for aquatic animals could have consequential impact on man either directly or indirectly since less than 1% of the world freshwater and 0.007% of all water on the earth surface is readily accessible for direct human uses (Krantz and Kifferstein, 2005; UNESCO, 2006). Available reports cite gross contamination of most major river bodies across the globe through the discharge of industrial effluents, sewage and agricultural wastes among others (World Bank, 1995). Contamination of river body by abattoir waste could constitute a significant environmental and health hazard (World Bank, 1995; Coker *et al.*, 2001, Nafarnda *et al.*, 2006; Osibanjo and Adie, 2007). Abattoirs are usually located near water bodies to ease the accessibility of water for meat processing and discharge of wastewater. The animal blood and the wash water released untreated and the consumable parts of the slaughtered animal which are washed with the water drawn from the water or the beef is washed directly into the flowing stream constitute a great risk to the water body receiving the discharge (Adelegan, 2002). Sangodoyin and Agbawhe (1992) identified improper management and supervision of abattoir activities as a major risk to public health in South Western Nigeria .It is to be noted that waste from slaughter houses typically contains fat, grease, hair, feathers, flesh, manure, grit and undigested food, blood, bones and process water which are generally characterized by high organic level. This water pollution infected our food in addition to groundwater contamination when used to irrigate crops and poses great risks to public health. Blood constitutes the highest pollution load of all the components of abattoir effluents, followed by fat. Blood, one of the major dissolved pollutants in abattoir wastewater, has the highest COD of any effluent from abattoir operations. If the blood from a single cow carcass is allowed to discharge directly into a sewer line, the effluent load would be equivalent to the total sewage produced by 50 people on an average day (Aniebo *et al.*, 2009).

The major characteristics of abattoir wastes are high level organic strength, sufficient organic biological nutrients, adequate alkalinity, relatively high temperature (20 to 30°C) and are relatively free of toxic material. Abattoir wastewaters with the above characteristics are well suited to anaerobic treatment and the efficiency in reducing the BOD_5 ranged between 60 and 90% (Chukwu, 2008). The high concentration of nitrates in abattoir wastewater also shows that they could be treated by biological processes. Due to the economic situation in Nigeria, little interest has been shown on the effects of wastes from abattoirs on the environment. The main aim of the study is to assess the abattoir operations and the effects of effluent discharge on the receiving stream. The objectives of the research are to:

- The use of guide control standard in this locality.
- The use of guide to curtail environmental degradation.
- Evaluate the guide suitability for abattoir wastewater treatment before discharge.
- Evaluate suitability of mixing abattoir effluent with the stream flow for irrigation.

METHODOLOGY

STUDY AREA

Maiduguri main abattoir is located north–eastern part of Nigeria. It lies within the latitude 11◦51' N and 13◦40'N and longitude 10◦0' E and 13◦40'E and has common borders with Chad and Cameroun nations. The land area of Maiduguri is about 543km^2 (Figure. 1). The area falls under the Sahel zone of West Africa which is noted for its high climate and season variation (Alaku and Moruppa, 1983).The city practically experience two distinct climate seasons yearly. These are: a short rainy season usually from the month of June to September and a long dry season from October to May. March, April and May being the hottest months of the year having a temperature between 30˚C – 43˚C and a fall is experienced during the rains with a temperature between 25˚C - 30 ˚C. There is a serious decrease in temperature during the harmattan months, which extends from October to February. In June, extreme temperatures of 43◦C and 20◦C have been recorded. Relative humidity is about 45% in August and decreases to about 5% in the drier season between December and January. Day length varies from 11–12 hours (Alaku and Moruppa, 1983, Umar *et al.*, 2002).

TYPES OF DATA COLLECTED

Samples and data were collected from the Maiduguri main abattoir at 9 different locations at distance 10, 20 and 30m before discharge, 40, 50 and 60m at the point of discharge and 70, 80 and 90m after discharge at a depth of 1m. Months of January- March-May were selected for sample collection during the dry season for best reflection of pollution because of the high concentration of the effluent in the river since during the rainy season, the river is completely diluted. The parameters analyzed were: physical, chemical and bacteriological. The analyses following the procedures described in APHA (1992) S1,S2,S3,S4,S5,S6,S7,S8,S9.The sampling method was employed was to represent conditions before discharge, at the point of discharge and after discharge further down the river with emphasis on mixing of river with abattoir effluent. The samples were subjected to laboratory analysis to determine physical, chemical and microbiological parameters of the abattoir effluent before, at point of discharge and after discharge further down the river. Results of laboratory analysis specifically the chemical parameters were subjected to statistical analysis and the Streeter – Phelps modeling to determines the relationship between the dissolved oxygen concentration and the biological oxygen demand over the travel distance.

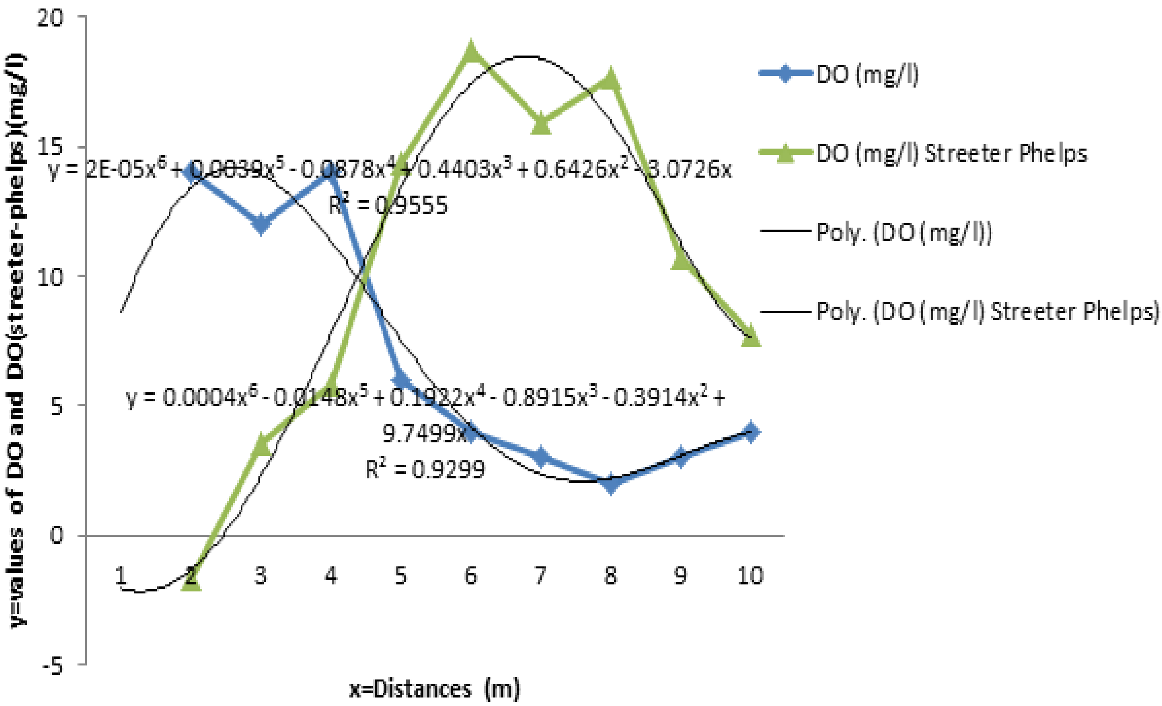

Figure 1 a: Regression of DO and DO (Streeter-phelps) as a function of Distance for January 2013.

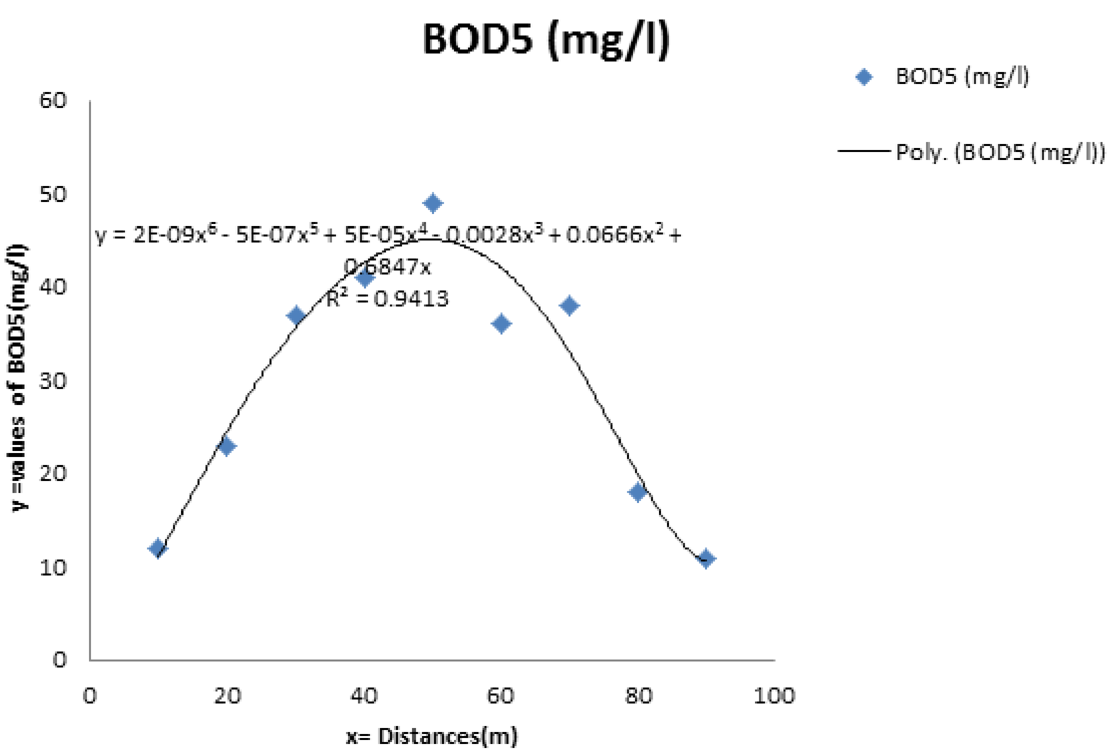

Figure 1 b: Regression of BOD_5 as a function of Distance for January 2013

Table 1: Chemical parameters of stream (S1-S3), abattoir effluent (S4-S6) and after stream effluent (S6-S9) during January 2013

Parameters (mg/l)	Abattoir discharge	Normal stream flow	Stream flow with effluent
Chloride(CL)	637	784	490
Nitrate(NO_3^-)	26.3	12.4	2.5
Sulphate (SO_4)	39.9	852.9	260.5
Phosphate (PO_4)	17.0	14.77	12.87
Dissolved Oxygen(Do)	14	6	4
BOD_5	**37**	**49**	**38**
COD	**27**	**66**	**68**
TSS	6.52	12.52	14.05

Table 2: Chemical parameters of stream (S1-S3), abattoir effluent (S4-S6) and after stream effluent (S6-S9) during March 2013.

Parameters (mg/l)	Abattoir discharge	Normal stream flow	Stream flow with effluent
Chloride(CL)	630	789	489
Nitrate(NO_3^-)	26.0	13.0	2.7
Sulphate (SO_4)	40.0	855.0	262.0
Phosphate (PO_4)	19.0	17.7	14.7
Dissolved Oxygen(Do)	18	8	6
BOD_5	**40**	**45**	**38**
COD	**28**	**68**	**70**
TSS	6.70	12.60	14.17

Table 3: Chemical parameters of stream (S1-S3), abattoir effluent (S4-S6) and after stream effluent (S6-S9) during May 2013.

Parameters (mg/l)	Abattoir discharge	Normal stream flow	Stream flow with effluent
Chloride(CL)	635	788	480
Nitrate(NO_3^-)	26.5	13.0	7.0
Sulphate (SO_4)	38.1	850.0	240.5
Phosphate (PO_4)	16.4	12.10	11.3
Dissolved Oxygen(Do)	18	6	5
BOD_5	**36**	**45**	**37**
COD	**26**	**66**	**65**
TSS	6.50	12.50	14.0

Source: Field Survey (2013)

The Streeter-Phelps equation is expressed as follows.

$$D = \frac{(K_d L_a)}{K_r - K_d}\left(e^{-k_d t} - e^{-k_r t}\right) + D_a e^{k_r t} \quad (1)$$

Where D=deficit, DO concentration (Do_{sat}-Do_t) in mg/l
K_d= deoxygenation rate (day^{-1})
K_r= reaeration rate (day^{-1})
La=ultimate BoD of the river (mg/l)
t =travel time (days)
D_a=initial Oxygen deficit (mg/l)

Reaeration rate, $K_r=3.9v^{0.5}/H^{1.5}$ (2)

Where V and H are: flow velocity (m/s) and depth of stream (m) respectively.
To translate to K_r ambient temperature,

$K_t= K_{20}\ \theta^{T-20}$ .where θ=1.024 (3)

Deoxygenation rate, K_d=K+(V/H)((η) (4)

Where K =Constant i.e where K at 20ºC= 0.13/day, V=flow velocity (m/s). H= Depth of stream (m).
To translate K_d to ambient temperature,

$K_d= K_{20}\ \theta^{T-20}$. Where θ=1.056 (5)

Flow velocity, V=d/t. (6)

Where, d=distance (m) and t=travel time (s)

Table 4: BOD and DO data during January 2013 samples

Sample	DO (mg/l)	BOD_5 (mg/l)	DO (mg/l) Streeter Phelps model
S1	14	12	-1.67
S2	12	23	3.58
S3	14	37	5.85
S4	6	41	14.32
S5	4	49	18.74
S6	3	36	15.96
S7	2	38	17.70
S8	3	18	10.70
S9	4	11	7.73

Table 5: BOD and DO data during March 2013

Sample	DO (mg/l)	BOD_5 (mg/l)	DO(mg/l) Streeter Phelps model
S1	18	16	-4.36
S2	15	28	2.17
S3	18	40	2.87
S4	8	45	13.50
S5	5	32	12.80
S6	4	`34	14.41
S7	3	38	16.73
S8	5	15	7.85
S9	6	10	5.49

Table 6: BOD and DO data during May 2013

Sample	DO (mg/l)	BOD_5 (mg/l)	DO (mg/l) Streeter Phelps model
S1	18	12	2.07
S2	14	23	1.64
S3	12	36	7.49
S4	6	40	14.02
S5	3	45	18.54
S6	4	36	14.99
S7	3	37	16.48
S8	4	17	9.44
S9	5	10	6.43

Table 7: Bacteriological parameters

parameters	Values (CFU /ml)
TC	372×10^3
E. coli	33×10^3
FC	>180/100ml

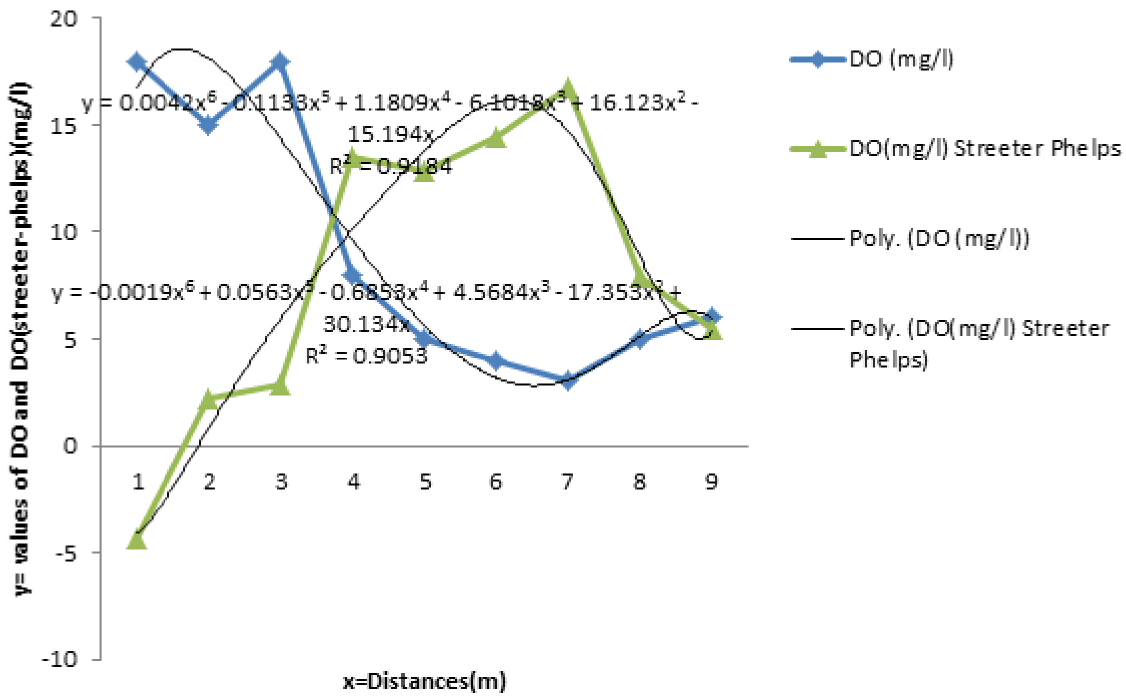

Figure 2 a: Regression of DO and DO (Streeter-phelps) as a function of Distance for March 2013

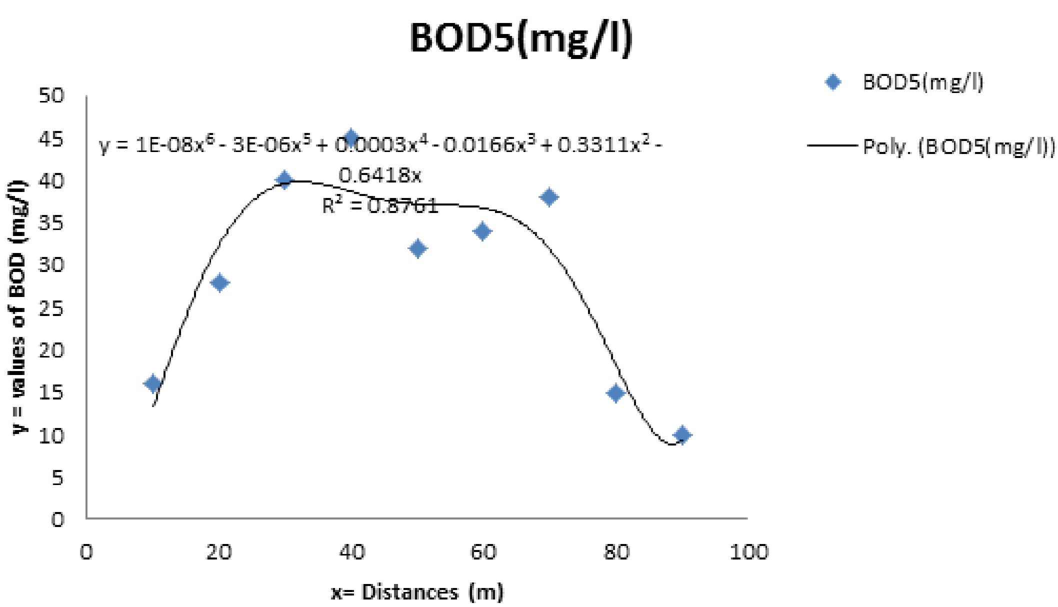

Figure 2 b: Regression of BOD_5 as a function of Distance for March 2013

DISCUSSION OF RESULTS

The result of the analysis of the abattoir effluent for the three categories for the 3 months showed high level of organic matter with high strength and complex composition during abattoir discharge (Table1 to 3).*The effluent* contains high concentration of DO (18mg/l) and PO_4 (19mg/l). While stream flow in the absence of

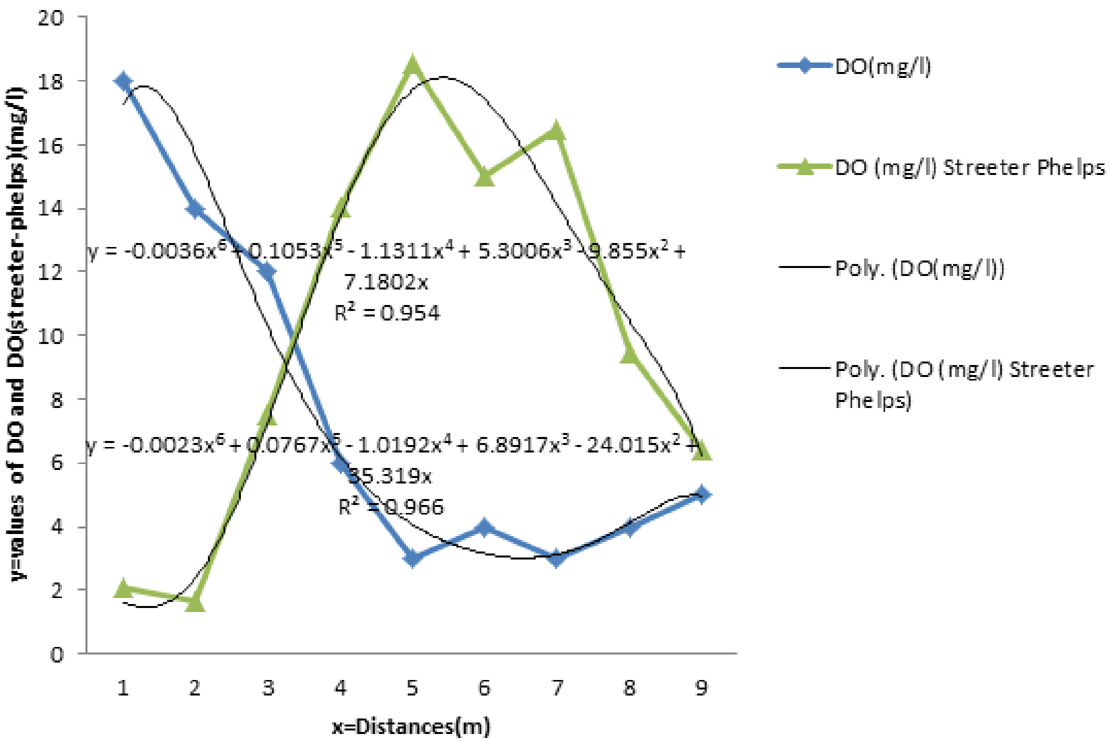

Figure 3 a: Regression of DO and DO (streeter-phelps) as a function of Distance for May 2013

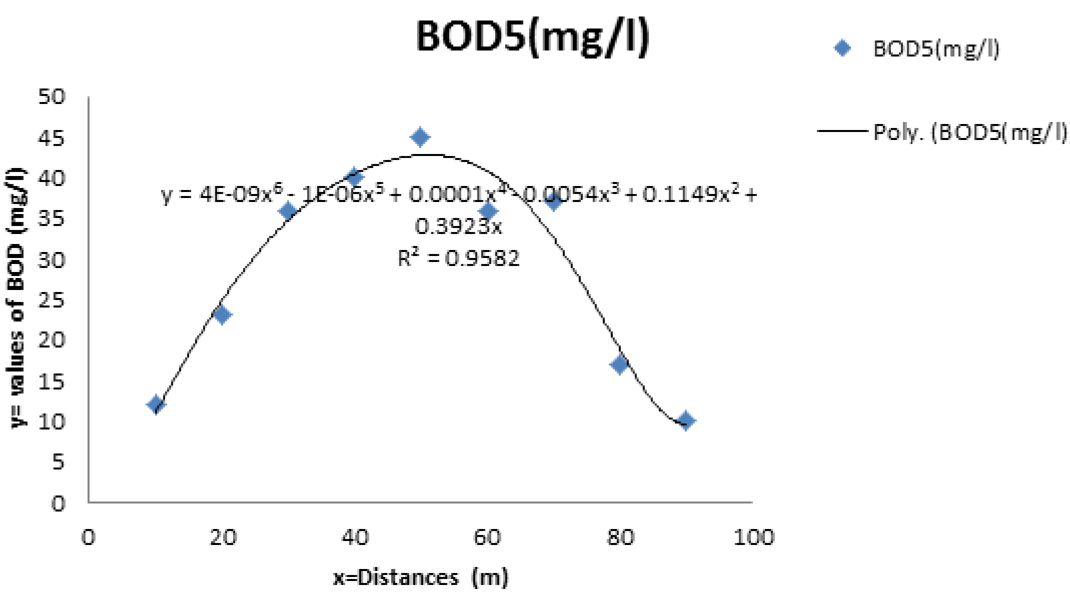

Figure 3b: Regression of BOD_5 as a function of Distance for May 2013

abattoir discharge has mean values for CL, SO_4, COD and DO of 789mg/l,855mg/l,70mg/l and 18mg/l respectively, above the WHO standards permissible value. Indicating increase in the pollution potential of the river with the abattoir effluent being the major contributor to the deteriorating quality in line with (Chukwu, 2008).

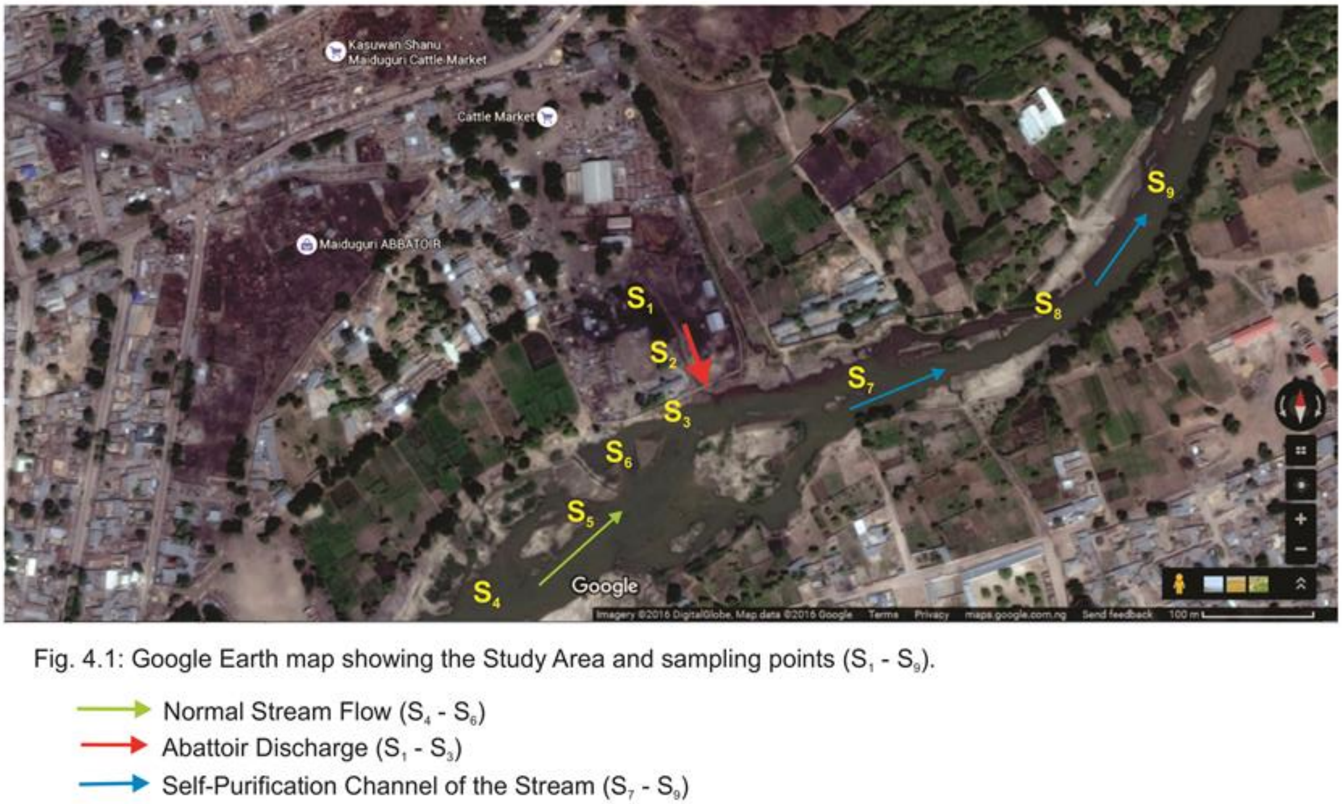

Figure 4. Google Earth showing the study area sampling points (S_1-S_9).

Comparing abattoir discharge and the normal stream flow, the results showed reduction in all the parameters of normal stream flow indicating self-purification Blood constitutes the highest pollution load of all the components of abattoir effluents, followed by fat. Blood, one of the major dissolved pollutants in abattoir wastewater, has the highest COD of any effluent from abattoir operations. If the blood from a single cow carcass is allowed to discharge directly into a sewer line, the effluent load would be equivalent to the total sewage produced by 50 people on an average day (Aniebo *et al.*, 2009) being effective after discharge in line with Streeter-Phelps modeling (Table 4 to 6). The abattoir effluent discharged into the receiving streams indicated high values of Total Coliform count (372 x 10^3Cfu), Total differential Escherichia Coliform or E. coli count (33 x 10^3Cfu) and Faecal Coliform count >180/100ml indicates the presences of pathogenic organism (Table 7).

CONCLUSION

The chemical and biological (BOD, E. coli etc) parameters indicate high value above WHO standards. The Streeter-Phelps DO model used in the present study showed clear evidence of self-purification as the stream advance from the point of discharge of abattoir effluent. The validity of Streeter-Phelps modeling is evidence with regression of the obtained and calculated values of DO and BOD for Figure 1 to 3 with (R^2 =-0.966) of 6th Order polynomial indicating high significant relationship.

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