Physical and Chemical Parameters in Abattoir Wastewater Sample, Maiduguri Metropolis, Nigeria.

Joseph C. Akan, Ph.D.*; Fanna I. Abdulrahman, Ph.D.; and Emmanuel Yusuf, B.Sc.

Department of Chemistry, University of Maiduguri, Maiduguri, Nigeria

*E-mail: joechemakan@yahoo.com
*Telephone: +2348036000506

ABSTRACT

The physical and chemical parameters in Abattoir wastewater from Maiduguri Metropolis, Nigeria were determined. Abattoir wastewater were collected for the determination of pH, temperature, conductivity, turbidity, chloride, nitrate, sulphate, phosphate, total suspended solid (TSS), total dissolved solid (TDS), dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), and heavy metals using standard procedures. The mean concentration of 0.74 mg/l for Cd; 0.36 mg/l Pb and 0.41 mg/l Ni exceeded the WHO/USEPA standard of 0.03 mg/l Cd; 0.10 mg/l Pb and 0.10 mg/l Ni for the discharged of wastewater into river, while the levels of turbidity, nitrate, TSS and TDS were also higher than the WHO limits for the discharged of wastewater into river. The mean values of 2.2 mg/l, 718.0 mg/l and 1421.0 mg/l for DO, BOD and COD exceeded the WHO permissible limit of 4mg/l for DO, 20 mg/l for BOD and 1000 mg/l for COD for the discharged of wastewater from industries into river. From the results of this study, the abattoir wastewater was found to contained high levels of pollutant. Based on these findings, the abattoir wastewater should be monitor strictly by relevant agencies in order to prevent environmental pollution and reduced health hazards caused by activities of abattoir wastewater.

(Keywords: physical, chemical, abattoir, wastewater, pollution, water quality)

INTRODUCTION

In Nigeria, available reports site gross contamination of most major river bodies across the nation by discharge of industrial effluents, sewage, and agricultural waste among others (World Bank, 1995). Contamination of river bodies from abattoir wastes could constitute a significant environmental and health hazard (World Bank, 1995; Coker et al., 2001; Nafanda et al., 2006; Osibajo and Adie, 2007). The location and operation of abattoirs are generally unregulated. They are usually located near water bodies where access to water for processing is guaranteed. The animal blood is released untreated into the flowing stream while the consumable parts of the slaughtered animals are washed directly into the following water (Adelegan, 2002). Sangodoyin and Agbawe (1992) identified improper management and supervision of abattoir activities as a major source of risk to public health in Southwestern Nigeria. Wastes from slaughterhouses typically contain fat, grease, hair, feathers, flesh, manure, grit and undigested feed, blood, bones, and process water which are characterized with high organic levels (Bull et al., 1982; Coker et al., 2001; Nafamda et al., 2006).

The total amount of waste produced per animal slaughtered is approximately 35% its body weight (World Bank, 1998). In an earlier study, Verheijen et al., (1996) found out that, for every 1,000 kg of carcass weight, a slaughtered cow produces 5.5 kg of manure (excluding rumen contents or stockyard manure) and 100 kg of paunch manure (partially digested food). The weight of a matured cow varies with size, ranging from 400 kg for a thin animal, 55 kg for a moderate one, to 750 kg for the extremely fat one (Hammack and Gill, 2002). Scahill (2003) gave more detailed statistics on both the live and dead weight of a cow in his study. A cow weighing 400 kg would have its carcass weight reduced to about 200 kg after slaughter. Furthermore, it loses about one-third fat and bone after passing through the butcher. Hence a 400 kg live weight animal will give about 140 kg of edible meat which represents only 35% of its weight. The remaining 65% are either solid or liquid wastes.

Corroborating the above findings, Gannon et al., (2004) showed in their study that a slaughtered cow produced 13.6 kg of blood (with bovine blood density ranging between 0.01 and $0.15g^{cc-1}$). Moreover, the volume of water required for meat rendering or processing ranged between 1.5 and $10m^3t^{-1}$ of product for hogs, 2.5 and $40m^3t^{-1}$ of product for cattle and 6 and $30m^3t^{-1}$ product for poultry.

The organic load from abattoirs could be very high. Tritt and Schuchardt (1992) reported a COD level as high as 2,785,000 mgL^{-1} for raw bovine blood. Comparatively, in another study conducted by Mittal (2004), on abattoirs in Quebec, Canada, typical values for a range of parameters in abattoirs wash down were given: TS concentrations (2,333-8,620mgL^{-1}); TSS (736-2,099 mgL^{-1}); while average levels of nitrogen and phosphorus were evaluated at 6 and 2.3 mgL^{-1}, respectively. Hence, abattoir effluents could considerably increase levels of nitrogen, phosphorus, and total solids in the receiving water body.

Excess nutrients can cause the water body to become choked with organic substances and organisms. When organic matter exceeds the capacity of the micro-organisms in water that break down and recycle the organic matter, it leads to eutrophication and encourages rapid growth, or blooms, of algae. Equally, improper disposal systems of wastes from slaughterhouses could lead to transmission of pathogens to humans and cause zoonotic disease such as *E. coli*, *bacillosis, salmonellosis, brucellosis*, and *helminthes* (Cadmus et al., 1999). Improper management of abattoir wastes and subsequent disposal either directly or indirectly into river bodies portends serious environmental and health hazards both to aquatic life and humans.

In Borno State, the abattoir is located in Kashua Shanu, Maiduguri Metropolis Nigeria. Animals (cows, goats, sheep, and camels) are slaughtered daily throughout the year. The wastewater generated flows directly into river Ngada without treatments. This river is also used for irrigation of vegetables along the river bank. The activities of this Abattoir remain unregulated, due to this the present study therefore aimed at assessing the Abattoir wastewater samples from Kashua Shanu for physical and chemical properties. Data obtained could be helpful in defining future waste management practices in the Abattoir.

MATERIALS AND METHODS

Sample Area and Collection

Effluent samples were collected from the abattoir area in Kashua Shanu Maiduguri, Borno State. Numbers of animals (cows, goats, sheep, and camels) are slaughter in this abattoir. Normal abattoir operations are carried out from Monday to Saturday. The blood wash and the process water from the abattoir are channeled directly into river Ngada.

Abattoir wastewater samples were collected in plastic containers previously cleaned by washing in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO_3 for 24 hours and finally rinsed with demonized water prior to usage. During sampling, sample bottles were rinsed with sampled water three times and then filled to the brim. The samples were labeled and transported to the laboratory, stored in the refrigerator at about 4^OC prior to analysis. Samples were collected from the month of February to September 2009.

Determination of Physical and Chemical Properties

Temperature, pH, and salinity were determined using a pH/conductivity meter; while the levels of total dissolved solid (TDS) and conductivity were determined by using a C0150 conductivity meter at the point of sample collections. Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD) were determined by dissolved oxygen meter model Acorn DO using standard methods 4500-OG and 5210B, respectively. Chemical Oxygen Demand (COD) was determined using closed reflux method. Turbidity was estimated by nephelometeric method using Lamotte 2020 portable turbidity meter. Total Suspended Solid (TSS), 100ml of the wastewater samples were filtered through a pre weighed filtered paper. The filtered papers were dried at 103-105^OC. TSS was determined by using the following formula (Anon, 1992).

$$TSS\ (mg/l) = \frac{final\ wt - initial\ wt)}{Amount\ of\ sample\ taken} \times 1000$$

In the determination of chloride, one hundred (100) milliliters of the wastewater sample was measured into a 250ml conical flask and pH was adjusted to 8 with 1M NaOH. One ml of K_2CrO_4

indicator was then added and titrated with the $AgNO_3$ solution. A blank titration was carried out using distilled water. Chloride (mg/l) was calculated as follows (Ademoroti, 1996).

$$\text{Chloride (mg/l)} = 70900 \times M \frac{(V_1 - V_2)}{Vs}$$

V_1 = Volume of titrant for the sample,
V_2 = Volume of titrant for the blank
M = Molarity of $AgNO_3$, Vs = Volume of sample used (100ml)

Determination of Heavy Metals in Abattoir Wastewater Samples

The water samples were digested as follows. The samples ($100cm^3$) were transferred into a beaker and 5ml concentrated HNO_3 was added. The beaker with the content was placed on a hot plate and evaporated down to about 20ml. The beakers were cooled and another 5ml of concentrated HNO_3 was added. The beakers were covered with watch glass and returned to the hot plate. The heating was continued, and then small portion of HNO_3 was added until the solutions appear light colored and clear. The beaker wall and watch glass were washed with distilled water and the samples were filtered to remove some insoluble materials that could clog the atomizer. The volume of the samples was adjusted to $100cm^3$ with distilled water (Radojevic and Bashkin, 1999). A blank sample was digested so as to allow a blank correction to be made. This was done by transferring 100ml of distilled water into a beaker and digested as described above.

Determination of Cu, Zn, Co, Mn, Mg, Fe, Cr, Cd, As, Ni, and Pb were made directly on each final solution using a Perkin-Elmer AAnalyst 300 Atomic Absorption Spectroscopy (AAS).

Determination of Some Anions in Abattoir Wastewater Samples

The concentration of nitrate, nitrite, sulphate, and phosphate were determined using a DR/2010 HACH Portable Data Logging Spectrophotometer. The spectrophotometers were checked for malfunctioning by passing standard solutions of all the parameters to be measured. Blank samples (deionized water) were passed between every three measurements of water samples to check for any eventual contamination or abnormal response of equipment. Nitrate as N was determined by the cadmium reduction metal method 8036 (Standard methods, 1976., DWAF, 1992). The cadmium metal in the added reagent reduced all nitrate in the sample to nitrite; while sulphate was determined by using Sulfa Ver methods 8051 (Standard methods, 1976., DWAF, 1992). Phosphate was determined by using Ascorbic Acid method 8048 (Powder Pillows) (Standard methods, 1976; DWAF, 1992).

RESULTS AND DISCUSSION

The pH of the abattoir wastewater sample is basic with pH values ranging from 76-8.2 (Table 1). pH is the measure of acidity and alkalinity of water. However, the mean pH level of 8.0 was within the WHO tolerance limits of 6.0-9.0 for the discharged of wastewater from all industries into river.

The level of temperature in the abattoir wastewater ranged from 26-29C. The conductivity levels in the wastewater sample ranged from 317-325 µS cm^{-1}. The mean value of 320 µS cm^{-1} was within the tolerance limit. Similarly, turbidity values ranged from 410-660 NTU (Table 1). The mean value of 575 NTU was higher than the WHO quidline of 5 NTU for the discharged of wastewater into river or stream.

The levels of chloride in the wastewater sample ranged from 45.0-64.0 mg/l with mean concentration of 58.0 mg/l (Table 1). The concentration of nitrate ranged from 38.0-62.1 mg/l; 50.0-59.0 mg/l sulphate and 11.0-20.0 mg/l phosphate. The mean nitrate levels of 51.0 mg/l exceeded the WHO limits of 45mg/l and South Africa guideline of 0.25 mg/l for nitrate in wastewater, while the mean sulphate level of 56.5 was below the WHO limit of 250 mg/l. The mean phosphate level of 17.5 mg/l was higher than the WHO limit of 5mg/l for the discharged of wastewater into river. The levels of nitrate in the abattoir wastewater may give rise to methaemoglobinemia, also the levels of nitrate reported in this study in addition to phosphate levels can cause eutrophication and may pose a problem if discharged into river or stream.

Dissolved oxygen (DO) values obtained from the abattoir wastewater ranged between 1.2-3.0 mg/l (Table 1). DO is a measure of the degree of pollution by organic matter, the destructive of organic substances as well as the self purification capacity of the water body.

Table 1: Physicochemical Parameters in Abattoir Wastewater Sample.

Parameters (mg/l)	Range	Mean	Standard Deviation
pH	7.6-8.2	8.0	0.12
T (^{O}C)	26-29	28.2	0.02
Cond (µS cm^{-1})	317-325	320	1.31
Turbidity (NTU)	410.0-660.0	575.0	4.87
Chloride	45.0-64.0	58.0	3.87
Nitrate	38.0-62.0	51.0	2.56
Sulphate	50.0-59.0	56.5	7.45
Phosphate	11.0-20.0	17.5	1.54
DO	1.2-3.0	2.2	2.74
TSS	856.0-1080.0	946.0	16.34
BOD	709.0-748.0	718.0	11.23
TDS	3200.0-3480.0	3353.0	38.75
COD	340.0-1550.0	1421.0	45.98

The standard for sustaining aquatic life is stipulated at 5mg/l a concentration below this value adversely affects aquatic biological life, while concentration below 2mg/l may lead to death for most fishes (Chapman, 1997). The mean DO value of 2.2 mg/l was below the WHO (2004) and USEPA (1999) permissible limit of 4mg/l and 5mg/l for the discharged of wastewater from industries into river. For BOD level, the values ranged from 709.0-748.0 mg/l, while that of COD ranged from 1340.0-1550.0 mg/l (Table 1). The concentration of TDS in the abattoir wastewater sample ranged from 3200.0-3480.0 mg/l and that of TSS ranged from 856.0-1080.0 mg/l (Table 1). Both BOD and COD are important water quality parameters and are very essential in water quality assessment (Chapman, 1997). Therefore, the more organic material presents in the abattoir wastewater, the higher the BOD and COD.

From the results of this study, the mean values of 718.0 mg/l and 1421.0 mg/l for BOD and COD were higher than WHO recommended standard limits of 20mg/l and 1000mg/l for the discharged of wastewater into surface water. The mean TSS level of 946.0 mg/l was higher than WHO standard value of 20 mg/l. Such elevated value for TSS in the abattoir wastewater might be attributed to various materials of solid waste from the slaughtered animals. Also the mean TDS value of 3353.0 mg/l was higher than WHO limit of 200mg/l for the discharged of wastewater into river.

An attempt was made to investigate any relationship between BOD and DO. The correlation coefficient as shown in Figures 1 and 2 revealed an inverse linear correlation showing that as BOD and COD increases in values DO decreases with correlation of r = -0.67 and r = -0.70. The correlation of -0.67 and -0.70 between BOD, COD, and DO suggest similar sources. The relationship between dissolved oxygen (DO) and total dissolved solid (TDS) in the abattoir wastewater sample are as presented in Figure 3, while TDS and BOD are as presented in Figure 4.

A plot of DO and TDS gives an inverse linear correlation showing that as TDS increases in values DO decrease. The TDS values were noted to be high corresponding to low DO values. The finding is in line with what (Ademoroti, 1996) reported that a low DO usually depicts a high TDS values. The plot of DO against TDS values also emphasized this fact, with correlation of r = -0.63. High TDS concentration also corresponds to high COD Figure 5. A plot of TDS versus BOD, COD gives a linear correlation showing that as TDS increase BOD and COD also increase. These correlation shows that levels of TDS, BOD and COD are affected by same activities within the study area.

The concentration of heavy metals in Abattoir wastewater sample is as presented in Table 2.

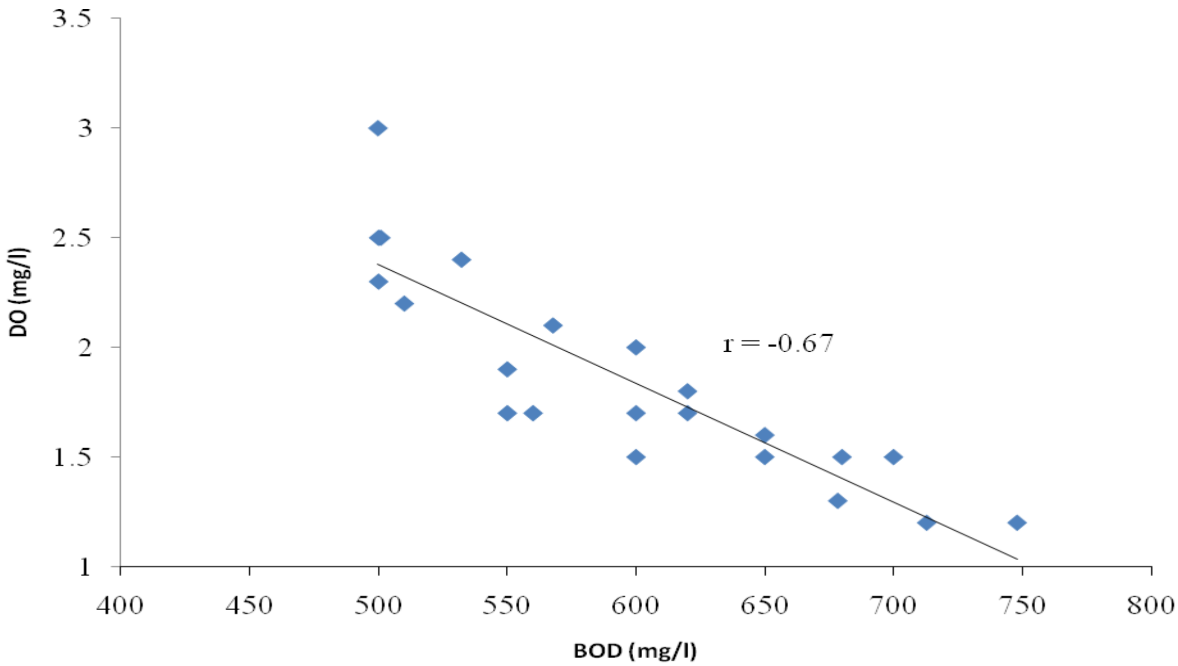

Figure 1: Scattergram of DO and BOD in Abattoir Wastewater.

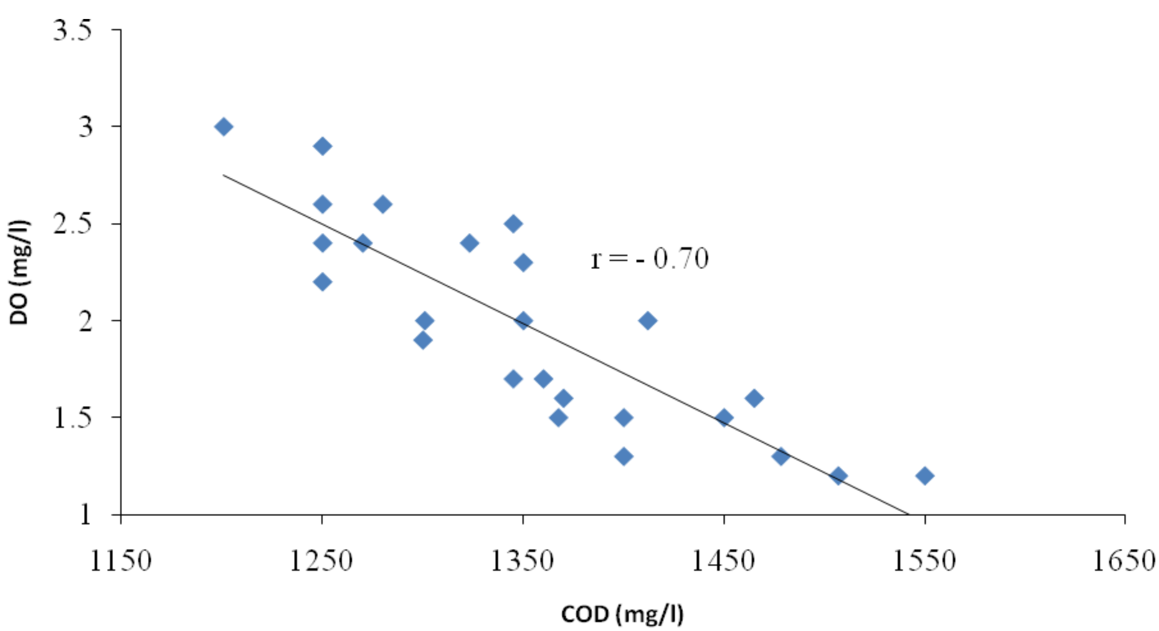

Figure 2: Scattergram of DO and COD in Abattoir Wastewater.

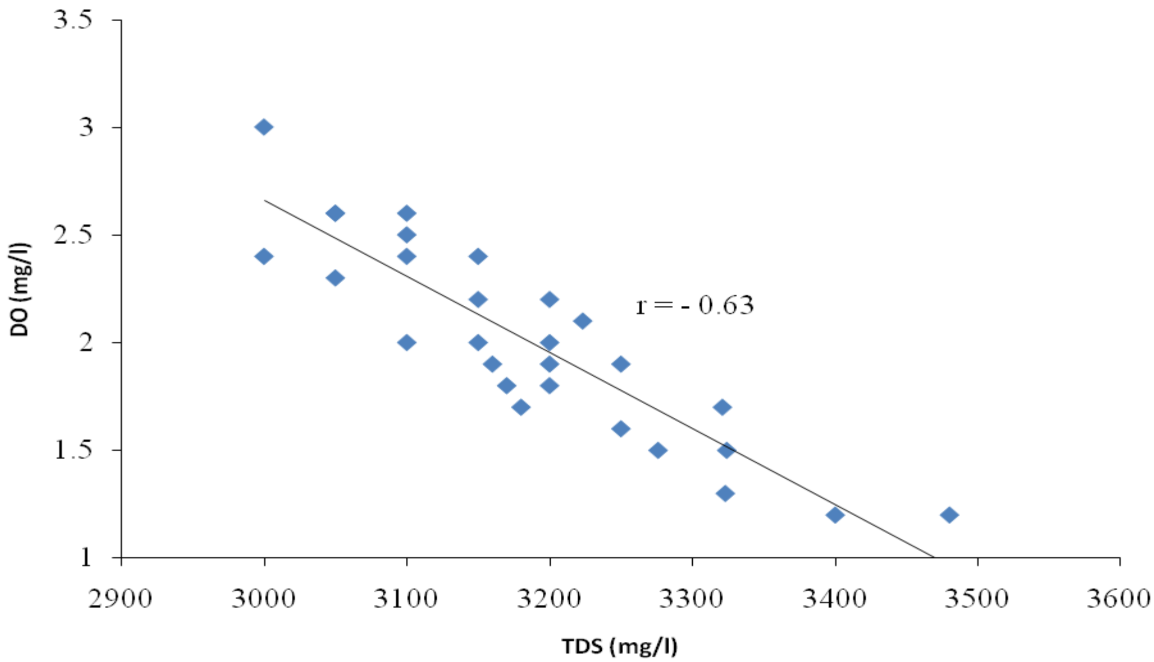

Figure 3: Scattergram of DO and TDS in Abattoir Wastewater.

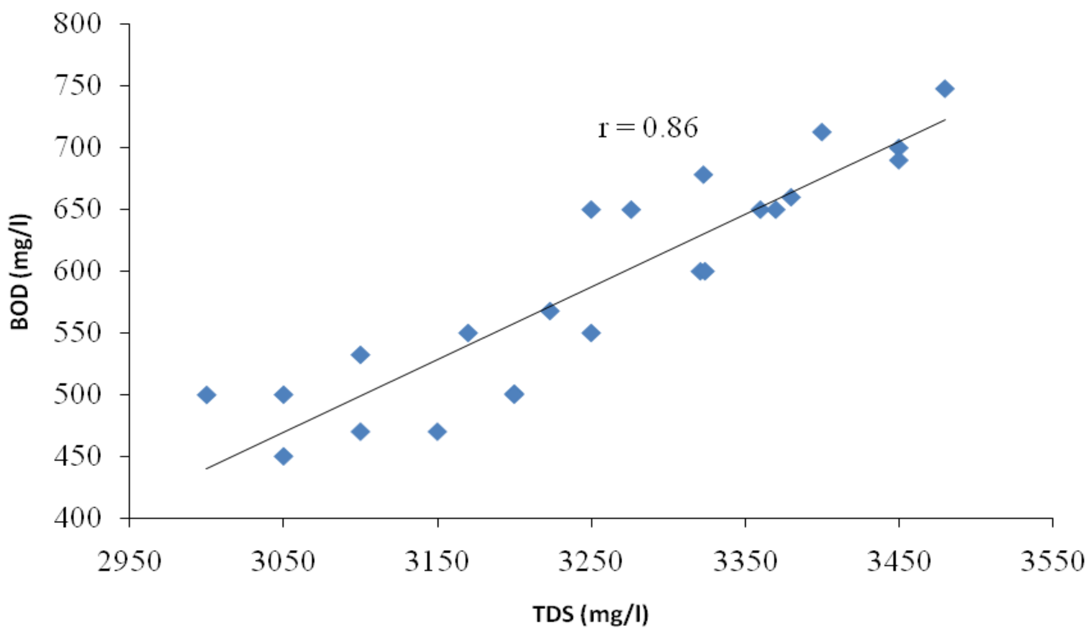

Figure 4: Scattergram of BOD and TDS in Abattoir Wastewater.

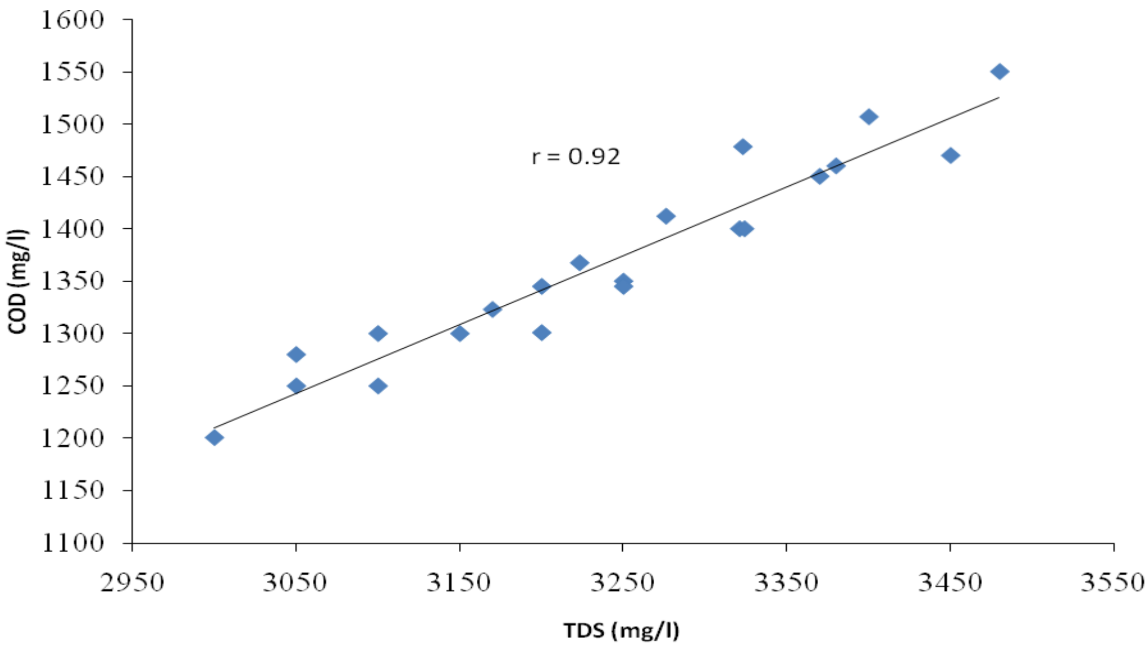

Figure 5: Scattergram of COD and TDS in Abattoir Wastewater.

Table 2: Concentration of Heavy Metals (mg/l) in Abattoir Wastewater Sample.

Elements	Range	Mean	Standard Deviation
Cd	0.71-0.81	0.74	0.12
Cr	0.16-0.24	0.22	0.02
Co	0.01-0.03	0.02	0.01
Pb	0.24-0.40	0.36	0.07
Mn	0.30-0.42	0.38	0.02
Mg	0.21-0.61	0.52	0.05
Ni	0.14-0.50	0.41	0.01
Fe	0.08-0.12	0.10	0.02
Cu	0.12-0.32	0.27	0.04
Zn	0.15-0.31	0.25	0.01

The levels of Cd ranged from 0.71-0.81 mg/l, 0.16-0.24 mg/l Cr; 0.01-0.03 mg/l Co. 0.24-0.40 mg/l Pb, 0.30-0.42 mg/l Mn; 0.21-0.61 mg/l Mg; 0.14-0.50 mg/l Ni; 0.08-0.12 mg/l Fe; 0.12-0.32 mg/l Cu and 0.15-0.31 mg/l Zn. Cd was found to have the highest concentration in the abattoir wastewater, while Fe shows the least concentration. However, the mean concentration of 0.22 mg/l for Cr was higher than the WHO/USEPA standard of 0.10 mg/l for the discharge of wastewater into river. Also, the mean concentration of 0.74 mg/l for Cd; 0.36 mg/l Pb and 0.41 mg/l Ni exceeded the WHO/USEPA standard of 0.03 mg/l Cd; 0.10 mg/l Pb and 0.10 mg/l Ni for the discharged of wastewater into river. An attempt was made to investigate any relationship between the metals in the abattoir wastewater.

The correlation coefficient as shown in Table 3 revealed positive correlation between all the metals in the wastewater samples. Positive correlation between metals in the wastewater samples suggests similar sources.

Table 3: Peason's Correlation Matrix for Pairs of the Analyzed Elements

	Cd	Cr	Co	Pb	Mn	Mg	Ni	Fe	Cu	Zn
Cd	1									
Cr	0.76	1								
Co	0.54	0.87	1							
Pb	0.76	0.97	0.77	1						
Mn	0.98	0.76	0.83	0.95	1					
Mg	0.65	0.55	0.92	0.87	0.59	1				
Ni	0.67	0.62	0.88	0.91	0.87	0.88	1			
Fe	0.87	0.89	0.74	0.89	0.92	0.79	0.66	1		
Cu	0.87	0.67	0.88	0.77	0.81	0.64	0.79	0.91	1	
Zn	0.66	0.77	0.87	0.72	0.65	0.72	0.64	0.76	0.75	1

CONCLUSION

From the result of this study, the levels of DO, BOD, COD, TDS and TSS were higher than FEPA, 1991; FMEvn, 2001; USEPA, 1999; and WHO, 2004 regulatory limits for discharged of wastewater from abattoir into river or streams. Hence, the discharged of this abattoir wastewater into river Ngada would raise the levels of these contaminates thereby putting the river unsafe for usage by residence along the river and for farming activities. Based on the results obtained, the abattoir wastewater should be monitor strictly by relevant agencies in order to prevent environmental pollution and reduced health hazards caused by activities of abattoir wastewater.

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