

Full Length Research Paper

An assessment of surface water pollution status around Gboko abattoir

S. T. Ubwa^{1*}, G. H. Atoo¹, J. O. Offem², J. Abah¹ and K. Asemave¹

¹Department of Chemistry, Benue State University, Makurdi, Nigeria.

²Department of Pure and Applied Chemistry, University of Calabar, Cross River State, Nigeria.

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An assessment of surface water around Gboko abattoir was conducted to ascertain the pollution status of water around the area. The results showed mean values as: total dissolved solids (TDS), 1026.78 mg/L; TSS, 565.22 mg/L; dissolved oxygen (DO), 5.0 mg/L; phosphate, 8.89 mg/L and biochemical oxygen demand (BOD), 484.64 mg/L. These values were above regulatory standards. The values of; pH (6.6), sulphate (86.91 mg/L), nitrate (41.45 mg/L) and chemical oxygen demand (COD) (903.30 mg/L) fell within WHO maximum permissible limits for drinking water. The mean concentrations of: Pb, 0.2892 ppm; Cr, 0.0598 ppm; Ni, 0.1031 ppm and Cd, 0.0110 ppm were above the control and standard safe limits for: Pb, 0.01 mg/L; Cr, 0.05 mg/L; Ni, 0.02 and 0.07 mg/L and Cd, 0.003 mg/L in water. Zn had mean concentration value of 0.7635 ppm which was below standards but higher than the control water sample. Correlation coefficients revealed positive and significant correlations between the pairs of metals in water. The results of this study showed that the activities at the abattoir were contributing to the pollution load of water in the area. It is therefore recommended that the activities of the abattoir should be monitored closely by relevant agencies in order to prevent full-blown environmental problems and attendance health hazards in the near future.

Key words: Abattoir, surface water, heavy metals, physico-chemical parameters, correlation coefficient.

INTRODUCTION

Environmental pollution has generally become a threat to the existence of mankind and the ecosystem. Some pollution effects may lead to metabolic disorders and undesirable changes which in many cases cause severe injuries and health hazards (Yahaya et al., 2009). Abattoir activities may be another source of pollution since human activities such as animal production and meat processing have been reported to impact negatively on soil and natural water composition leading to pollution of the soil, natural water resources and the entire environment (Adesemoye et al., 2006). It has also been reported that animals which graze on contaminated plants and drink from polluted waters, as well as marine lives that breed in heavy metal polluted waters also accumulate such metals in their tissues and milk if lactating (Yahaya et al., 2009).

When such animals are killed, these metals are released in the soil as natural sink but subsequently leached out into nearby streams or water bodies. Abattoir can be defined as a premise approved and registered by controlling authorities for hygienic slaughtering, inspection, processing, effective preservation and storage of meat products for human consumption (Alorge, 1992). However, meat processing activities in Nigeria are generally carried out in unsuitable buildings and by untrained personnel or butchers who are most of the time unaware of sanitary principles (Olanike, 2002). The major activities involved in the operations of an abattoir are: receiving and holding of livestock; slaughter and carcass dressing of animals; chilling of carcass products; carcass boning and packaging; freezing of finished carcass and

*Corresponding author. E-mail: simon.ubwa@yahoo.com.

cartooned product; rendering processes; drying of skins; treatment of wastes and transport of processed material.

Abattoir activities are aimed at optimizing the recovery of edible portions of the meat processing cycle for human consumption. However, significant quantities of secondary waste materials are also generated during this process. For example, blood, fat, organic and inorganic solids, salts and chemicals added during processing operations are produced as wastes (Red Meat Abattoir Association, 2010; Steffen and Kirsten Inc., 1989).

Various parts of cattle such as muscle, blood, liver, kidney, viscera and hair have been found to contain heavy metals (Kruslin et al., 1999; Jukna et al., 2006). In ruminants, the first stomach or paunch contains undigested materials called paunch manure, which can contain long hairs, whole grain and large plant fragments. The faeces of livestock (animal manure) consist of undigested food, most of which are: cellulose-fibre; undigested protein; excess nitrogen from digested protein; residue from digested fluids; waste mineral matter; worn-out cells from intestinal linings; mucus and bacteria. Other components of undigested food include; foreign matter such as dirt consumed, calcium, magnesium, iron, phosphorous, sodium, etc (Ezeoha and Ugwuishiwu, 2011). Abattoir effluent wastewater has a complex composition and can be very harmful to the environment. For example, discharge of animal blood into streams would deplete the dissolved oxygen (DO) of the aquatic environment. Improper disposal of paunch manure may exert oxygen demand on the receiving environment or breed large population of decomposers (micro-organisms), some of which may be pathogenic. Also improper disposal of animal faeces may cause oxygen-depletion in the receiving environment. It could also lead to eutrophication of the receiving system and increase rate of toxins accumulation in biological systems (Nwachukwu et al., 2011).

Mohammed and Musa (2012) reported that the improper disposal of abattoir effluent could lead to transmission of pathogens to human which may cause an outbreak of water borne diseases e.g. diarrhoea, pneumonia, typhoid fever, asthma, wool sorter diseases, respiratory and chest diseases, etc. Studies have shown that *Escherichia coli* infection source was reported to be undercooked beef which has been contaminated in abattoirs with faeces containing the bacterium (Bello and Oyedemi, 2009; Patra, 2007). It had also been reported that abattoir activities are responsible for the pollution of surface and underground waters, reduction of air quality as well as quality of health of residents within the surrounding environment (Katarzyna et al., 2009; Odoemelan and Ajunwa, 2008).

The main purpose of this work therefore, is to study the pollution status of surface water around Gboko abattoir and assess whether the pollution load is sufficient to affect the health of the inhabitants of the area who depend on this stream as their source of domestic and irrigation water.

The results of the study will assist the regulatory bodies monitor more closely the activities at the abattoir as well as create public awareness about the health implications of abattoir activities on the environment and also establish a data bank for future reference.

MATERIALS AND METHODS

Study area

Gboko is one of the largest and most populous Local Government Areas in Benue State. It has a land mass of: Area, 1,835 km²; Density, 196.9 inh./km² with a population of 361, 325 people according to National Population Commission census of (2006). It is bounded by Tarka Local Government on the North, Ushongo Local Government to the south, Buruku Local Government on the east, Gwer on the west. It lies between latitude 7°05'–7°31'N and longitude 9°13'–9°35'E in the savannah region of Nigeria with typical savannah vegetation and climate.

The integrated Gboko abattoir is located on km 8 Gboko-Aliade road and close to a stream. Several animals (cows, goats, sheep and pigs) are slaughtered in this abattoir. Normal abattoir operations are carried out every week from Monday to Saturday during morning hours (6 am -11 am) (Figure 1).

Sample collection

Six sampling stations were mapped out along the course of the stream in the abattoir area at a distance of 50 m from each other. The sampling stations were coded AW, BW, CW, DW, EW and FW. Six replicate samples were collected from each of these stations and pooled together to obtain a representative sample for that station. A water sample (coded GWctrl) was collected at a point 60 m upstream, and served as a control. Water samples were collected in plastic containers previously cleaned by washing in non-ionic (Omo) detergent. They were rinsed with tap water and thereafter soaked in 10% HNO₃ for 24 h and finally rinsed with de-ionized water and ready for use (Akan, 2010). During sampling, sample bottles were first rinsed with the sampled water three times and then filled to the brim. The samples were labeled and transported to the laboratory, stored in a refrigerator at about 4°C prior to analysis. A total of forty two samples were collected for investigation. The field investigation was carried out between the months of July and August (peak of rainy season) during which the waste from abattoir was expected to leach or drain down to the stream.

Sample preparation and analysis

Each sample (100 ml) was transferred into a beaker and 5 ml of concentrated HNO₃ was added. The beaker with the content was placed on a hot plate and evaporated down to about 20 ml. The beaker was cooled and another 5 ml of concentrated HNO₃ added. Each beaker was then covered with a watch glass and returned to the hot plate for more heating with the addition of few drops of HNO₃ until the solution appeared light coloured and clear. The walls of the beaker and the watch glass were washed down with distilled water and the sample filtered to remove insoluble materials that could clog the atomizer. The volumes of the samples were made up to the mark (100 ml) with distilled water (Radojevic and Bashkin, 1999). A blank sample was similarly treated so as to give room for blank correction. This was done by transferring 100 ml of distilled water into a beaker and digested as described above. Calibration standards were prepared from stock solutions by dilution and were matrix matched with the acid concentration of the digested samples. The digested samples were then analyzed for heavy

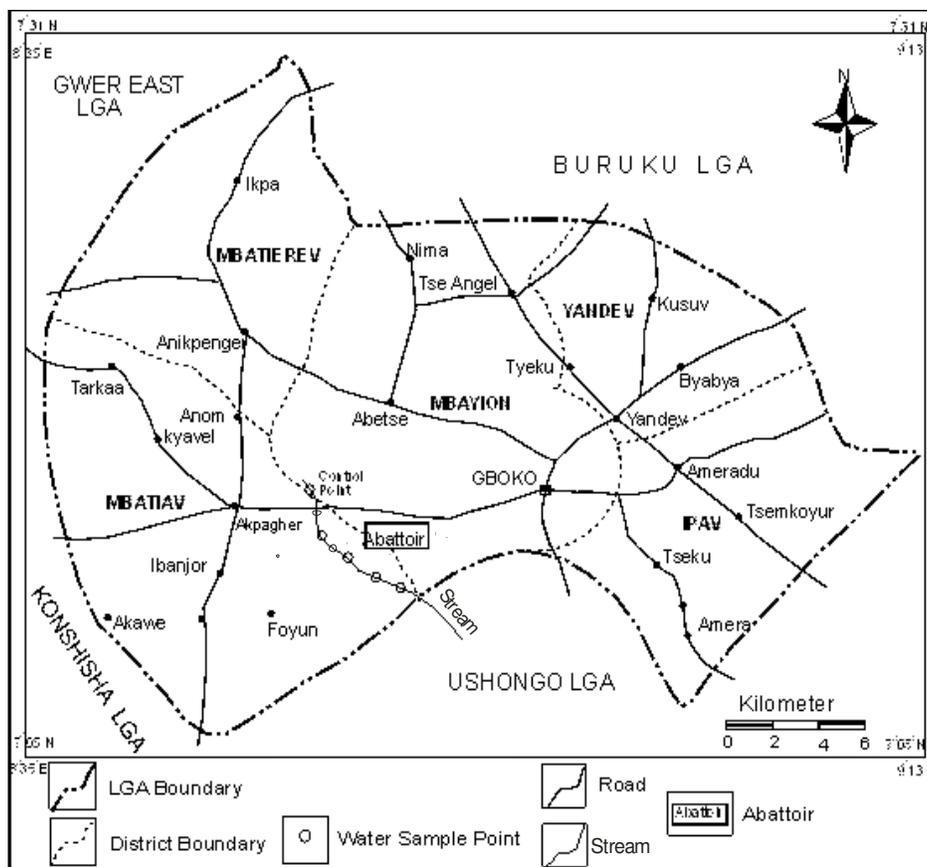


Figure 1. Map of Gboko local government area showing the location of abattoir and water sample points. Source: Ministry of lands and survey Makurdi.

metals using Atomic Absorption Spectrophotometer (model AA6800 Shimadzu-automated) at National Research Institute for Chemical Technology (NARICT), Zaria.

pH determination

The pH meter (Hanna HI9024 Microcomputer pH) was calibrated with two buffer standard solutions (pH 4 buffer and pH 9 buffer). After that, the pH reading of the water sample was taken on the spot.

Temperature

The temperature of the water sample was taken on the spot using a mercury thermometer.

Total suspended solids (TSS)

100 ml of each water sample was filtered through a pre-weighed filter paper. The filter paper was dried at 103- 105°C. TSS was determined by using the following formula (Anon, 1992).

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

Total dissolved solids (TDS)

This was by the evaporation method. Evaporation dish was weighed and later 100 ml of the water sample introduced into the weighed dish and dried in an oven operated at 103°C for one hour to a constant weight. After drying, it was transferred to a desiccator and left to cool for one hour. The dish was finally weighed with its content. The difference in mass gives a measure of the total dissolved solids of the sample (HachWater Analysis Hand book, 1983).

Dissolved oxygen (DO)

Dissolved oxygen was determined using Winkler Titration Method as described by (Ademoroti, 1996).

$$DO(mg/L) = \frac{16000 \times M \times V}{V_1 - 2.0}$$

Where M = Molarity of the thiosulphate solution, V = Volume of thiosulphate used for titration, V₁ = Volume of the bottle with the stopper in place.

Biochemical oxygen demand (BOD)

The BOD was determined using Winkler titration method. The water

Table 1. Mean concentration (ppm) of heavy metal in abattoir adjacent stream.

Sampling point	Metal				
	Cd	Zn	Ni	Cr	Pb
AW	0.0115 ± 0.0043	0.1860 ± 0.0303	0.0569 ± 0.0243	0.0617 ± 0.0161	0.2076 ± 0.0209
BW	0.0056 ± 0.0049	0.2788 ± 0.2046	0.1827 ± 0.2172	0.0868 ± 0.0552	0.3040 ± 0.1993
CW	0.0131 ± 0.0010	3.7445 ± 1.7111	0.0967 ± 0.0730	0.0453 ± 0.0035	0.2892 ± 0.0944
DW	0.0135 ± 0.0005	0.1124 ± 0.0092	0.0847 ± 0.1011	0.0365 ± 0.0124	0.1780 ± 0.1258
EW	0.0135 ± 0.0005	0.1135 ± 0.0530	0.1086 ± 0.0299	0.0503 ± 0.0000	0.3782 ± 0.0735
FW	0.0090 ± 0.0019	0.1458 ± 0.0218	0.0887 ± 0.0580	0.0780 ± 0.0214	0.3782 ± 0.0105
GW (ctrl)	0.0012 ± 0.0006	0.0164 ± 0.0082	0.0038 ± 0.0017	0.0012 ± 0.0006	0.0002 ± 0.0001
MEAN	0.0110 ± 0.0020	0.7635 ± 0.0260	0.1031 ± 0.0430	0.0598 ± 0.0037	0.2892 ± 0.072
RANGE	0.0056 - 0.0135	0.1124 - 3.7445	0.0569 - 0.1827	0.0365 - 0.0868	0.1780 - 0.3782

sample was collected in the BOD bottle and incubated at 20°C in the dark for 5 days. The BOD on day five was determined using the same procedure for DO above. The mass of oxygen obtained in day 5 was subtracted from the mass of oxygen on day 1 to determine the BOD (mg/L) using the formula (Ademoroti, 1996).

$$\text{BOD}_5 \text{ (mg/L)} = (\text{DO}_1 - \text{DO}_5)$$

Chemical oxygen demand (COD)

Titrimetric method was employed in the determination of COD. A 10 ml of 0.125 M $\text{K}_2\text{Cr}_2\text{O}_7$ was added to 20 ml of the water sample using a pipette in a refluxing flask. Glass beads or anti-bumping chips were added. Then 30 ml of concentrated H_2SO_4 was added slowly and with gentle swirling. The flask was connected to the condenser and refluxed for 2 h. After that, the flask was cooled and the condenser washed with distilled water into the flask and diluted to about 150 ml. The excess dichromate was titrated with 0.05 M ferrous ammonium sulphate (FAS) using 2 drops of ferroin as indicator. A blank mixture was prepared and treated using the same procedure (Ademoroti, 1996).

$$\text{mg/L COD} = \frac{(V_b - V_s) \times M \times 16000}{\text{mL sample}}$$

Where: V_b = mL FAS used for blank, V_s = mL FAS used for sample, M = molarity of FAS.

Total phosphate (PO_4^{3-})

One milliliter of concentrated H_2SO_4 was added to 10 ml of the water sample drop wise and mixed. The mixture was boiled for about five minutes, filtered and allowed to cool. The filtrate was titrated with 5 M NaOH solution to phenolphthalein end point. This mixture was transferred to a 50 ml volumetric flask and diluted to 40 ml. A few drops of H_2SO_4 were added until the solution turned clear again. Thereafter, a solution of ammonium molybdenum was added followed by solid ascorbic acid and made to mark. An intense blue complex of molybdenum blue was formed which was measured using a UV-Visible spectrophotometer (model Jenway 6305) at a wavelength of 882 nm.

Sulphate (SO_4^{2-})

50 ml of the water sample was measured into a beaker and the pH

adjusted to 5.0 using methyl red indicator with HCl solution. The sample was heated to boiling and BaCl_2 solution was added slowly until complete precipitation was achieved. The precipitate was digested at 80°C for 2 h and filtered through a weighed Whatman No.42 filter paper and then washed with small portions of warm distilled water followed by AgNO_3 solution. The filter paper was dried at 100°C in an oven for 1 h, cooled and weighed. Amount of SO_4^{2-} was calculated using the formula (Emmanuel et al., 2012).

$$\text{SO}_4^{2-} \text{ (mg/L)} = \frac{\text{mg of BaSO}_4}{\text{Volume of sample}} + 411.5$$

Nitrate (NO_3^-)

Nitrate was determined using UV-Vis. spectrophotometer (HACH DR 2000). The stored programme number for nitrate (355) was entered and the wavelength dialed to 500 nm. A sample cell was filled with distilled water and placed in the sample holder of the spectrophotometer. This serves as the blank. Another sample cell was filled with the water sample to which one nitrate powder pillow was added and swirled and allowed to react for two minutes. The sample cell was placed in the sample holder and closed. The result was read directly (Emmanuel et al., 2012).

RESULTS AND DISCUSSION

Table 1, Figures 2 and 3 present the mean concentrations (ppm) of heavy metal in water of the stream adjacent to the abattoir. The results show differences in metal concentrations at various sampling stations and their controls. Zinc was the most abundant metal (Figure 3) recorded ranging from 0.1124-3.7449 ppm and a mean value of 0.7635 ppm. The maximum value of 3.7445 ppm is slightly higher than maximum permissible limit of 3 mg/L for zinc in water (WHO, 2006, 2004) but lower than Nigeria's permissible limits of 5 mg/L (SON, 2003). The concentration of lead ranged from 0.1780-0.3782 ppm and a mean of 0.2892 ppm. This value is higher than the maximum permissible limit of 0.01 mg/L for the concentration of lead in water (WHO, 2006; EU, 1998, SON, 2003). The high concentration of Pb in water could be due to anthropogenic activities taking place at the abattoir. Cd, Ni and Cr levels ranged

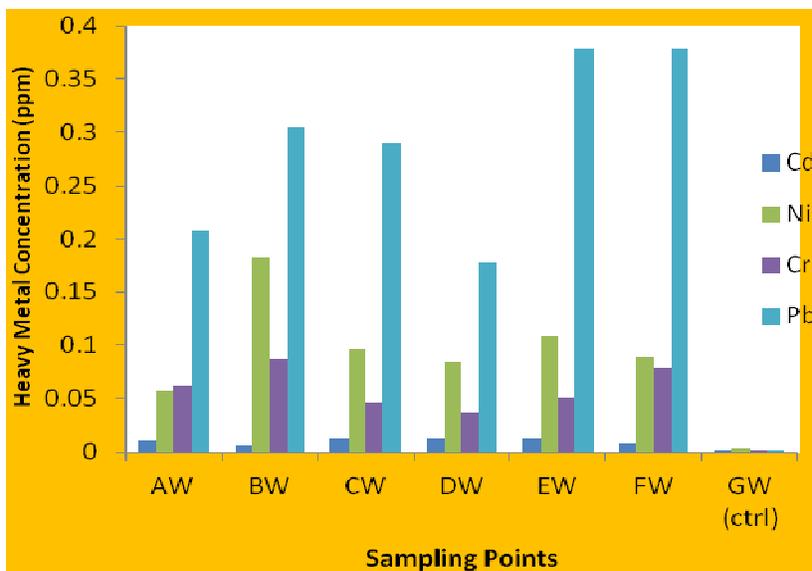


Figure 2. Mean concentration (ppm) of heavy metal in abattoir adjacent stream.

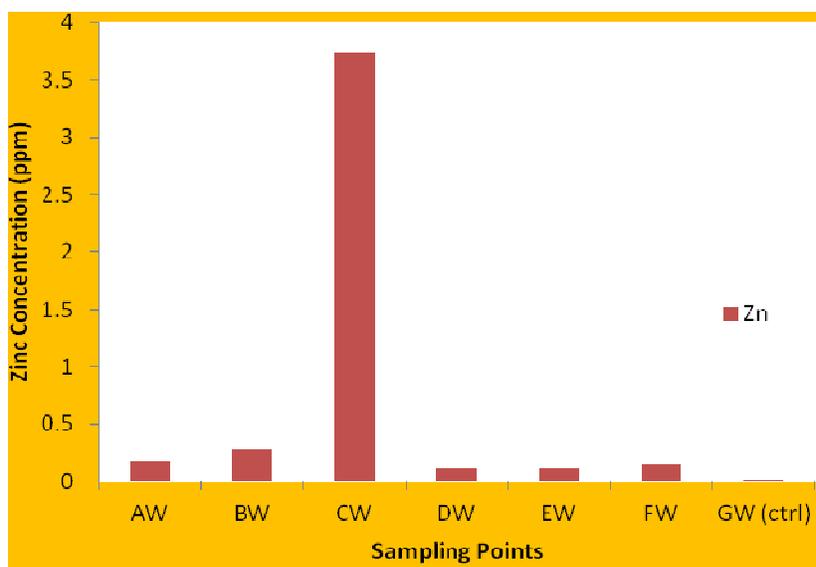


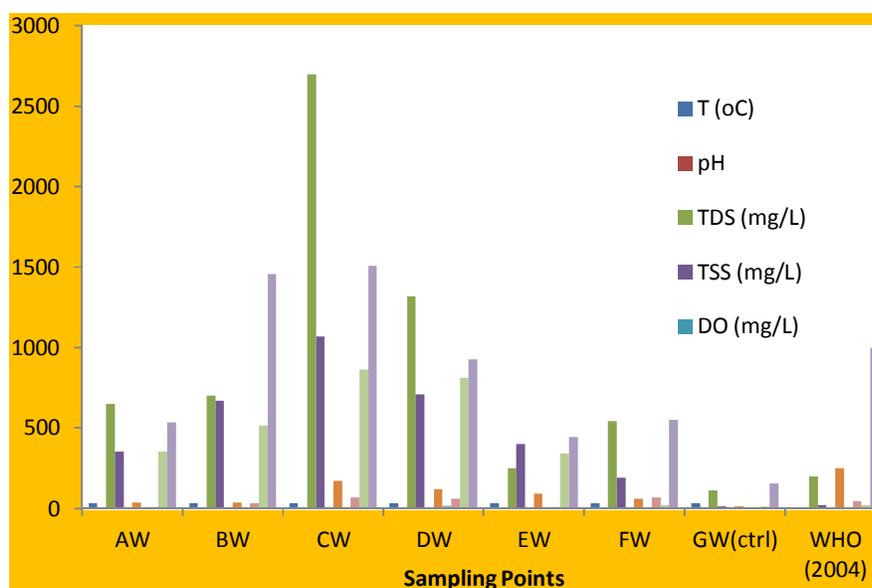
Figure 3. Mean concentration (ppm) of Zinc in abattoir adjacent stream.

from 0.0056-0.0135, 0.0569-0.1827 and 0.0365-0.0868 ppm, respectively which are also higher than set standards. Generally, the concentration of metals in water in the study area is higher than the control and standards set by Nigeria and international organizations that monitor quality of drinking water. It has been reported that heavy metals, reaching excessive levels, can exert serious impact on humans, animals and plants because they are not biodegradable as they are retained indefinitely in the ecological systems and in the food chain (OmPrakash et al., 2011). Table 2 and Figure 4 are

results of the physicochemical parameters of the abattoir's adjacent stream. The temperature ranges from 30.20 to 30.80°C and is lower than 32 to 34°C reported by Osibanjo and Adie (2007). Temperature influences the amount of dissolved oxygen in water which in turn influences the survival of aquatic organisms. The pH ranged from 6.50-6.70 with a mean value of 6.60 and falls within WHO standards and compares well with 4.9 to 7.2 reported by Masse and Masse (2002). TSS and TDS values ranged from 190.00 to 710.14 and 250.00 to 2700.00 mg/L, respectively. Their mean values are

Table 2. Mean physicochemical properties of water.

Parameter	AW	BW	CW	DW	EW	FW	GW(ctrl)	Range
T (°C)	30.20 ± 1.23	30.30 ± 0.10	30.70 ± 2.10	30.80 ± 1.00	30.50 ± 0.09	30.40 ± 1.15	30.40 ± 0.11	30.2 - 30.8
pH	6.70 ± 0.09	6.55 ± 2.11	6.50 ± 1.70	6.50 ± 0.73	6.56 ± 0.91	6.51 ± 0.27	6.70 ± 1.42	6.50 - 6.70
TDS (mg/L)	650.0 ± 3.17	700.0 ± 3.10	2700.0 ± 1.08	1320.0 ± 2.10	250.0 ± 1.00	540.7 ± 2.40	110.0 ± 5.10	250 - 700
TSS (mg/L)	350.6 ± 2.01	670.4 ± 1.70	1070.0 ± 0.97	710.14 ± 2.14	400.23 ± 0.9	190.0 ± 1.01	12.0 ± 0.09	190 - 710
DO (mg/L)	3.20 ± 0.00	2.60 ± 0.10	9.00 ± 0.07	8.00 ± 0.00	2.00 ± 0.01	5.00 ± 2.01	5.90 ± 0.02	2.00 - 9.00
Sulphate (mg/L)	38.46 ± 0.67	40.00 ± 0.89	170.00 ± 0.90	120.00 ± 1.00	93.00 ± 2.00	60.00 ± 5.01	12.00 ± 0.03	38.46 - 170
Phosphate (mg/L)	8.00 ± 1.00	6.50 ± 0.03	10.1 ± 3.01	16.00 ± 1.09	8.00 ± 0.90	4.70 ± 0.10	2.10 ± 0.03	4.70 - 16.0
Nitrate (mg/L)	9.40 ± 0.25	34.00 ± 3.00	68.00 ± 1.08	62.00 ± 0.04	9.30 ± 0.10	66.00 ± 4.02	5.00 ± 0.00	9.30 - 68.0
BOD (mg/L)	356.50 ± 5.01	516.00 ± 0.05	861.70 ± 4.07	812.60 ± 0.90	342.00 ± 0.30	19.00 ± 1.04	12.00 ± 0.08	19.00 - 861
COD (mg/L)	536.00 ± 1.06	1456.0 ± 5.01	1508.0 ± 9.03	928.0 ± 0.98	444.0 ± 3.04	548.0 ± 1.90	156.0 ± 0.06	444 - 1508

**Figure 4.** Mean physicochemical properties of water.

565.22 and 1,026.78 mg/L TSS and TDS respectively which is above the WHO maximum permissible limit for TSS (20 mg/L) and TDS (200 mg/L) and also higher than the control. TSS relatively measures the physical or visual observable dirtiness of a water resource. TDS are an indication of the degree of dissolved substances such as metal ions in the water (Efe, 2005). DO have a range of 2.0-9.0 mg/L with a mean value of 50 mg/L. This value is higher than WHO permissible limit of 4 mg/L and also, higher than the control. Low DO may result in anaerobic conditions that cause bad odour. BOD and COD ranges between 19.0-861.7 and 444-1508 mg/L with mean values of 484.63 and 903.3 mg/L, respectively. The mean value for BOD is higher than the control and WHO allowable limit of 20 mg/L (WHO, 2006). COD has a mean value lower than the permissible limit of 1000 mg/L (WHO, 2006). Though, the mean value of COD is lower, some points like BW and CW have values of 1,456 and

1,508 mg/L respectively which are higher than the WHO standards. BOD and COD are indices of organic pollution. BOD is not a specific pollutant indicator, but rather a measure of the amount of oxygen required by bacteria and other microorganisms engaged in stabilizing decomposable organic matter over a specified period of time. A high oxygen demand indicates the potential for developing a DO sag as the microbiota oxidizes the organic matter in the water. Since nearly all organic compounds are oxidized in the COD test, COD results are always higher than BOD results. This was confirmed in this study with some samples (BW and CW) exceeding the value of 1000 mg/L set by WHO.

Nitrate concentration ranges from 9.4-68 mg/L with a mean value of 41.45 mg/L. Even though the mean concentration value is low, some points analyzed have values higher than the set standards. It is reported that nitrate concentration above the permissible value by

Table 3. Correlation matrix for pairs of the analyzed elements in water.

Element	Cd	Zn	Ni	Cr	Pb
Cd	1.000				
Zn	0.334	1.000			
Ni	0.240	0.113	1.000		
Cr	0.249	-0.042	0.787*	1.000	
Pb	0.552	0.169	0.712	0.797*	1.000

*Correlation is significant at the 0.05 level (2-tailed).

45 mg/L is dangerous to pregnant women and poses a serious health threat to infants less than three to six months of age because of its ability to cause methaemoglobinaemia (Gelperim et al., 1975). Nitrates have a high potential to migrate to ground water since they are very soluble and do not bind to soil (Punmia and Jain, 1998). Phosphates were at relatively high concentration. All the water samples were above 5 mg/L maximum permissible limit except for FW (4.7 mg/L). Phosphate enter water ways from human, animal waste and other sources like phosphorus rich bedrock, industrial effluents, fertilizer run-off, laundry and cleaning. Phosphates in water increase the tendency of troublesome algae to grow in the water (Esry, 1991). This causes eutrophication or over fertilization as it chokes up the water ways and uses up large amounts of oxygen.

Sulphate concentration ranges from 40-170 mg/L with a mean value of 86.91 mg/L. This is lower than the maximum permissible limit of 250 mg/L set by WHO but higher than the control value of 12 mg/L. This implies that the activities in the abattoir are contributing to the pollution load of the stream and long term effect may subsequently lead to contamination of the surrounding water body. The result of the correlation analysis using Pearson's correlation coefficient (Table 3) showed that all the metals were positively correlated except for Cr and Zn which were negatively correlated. Pb, Cr, and Ni were significantly correlated. The positive and significant correlations between metals in stream water samples suggest similar source.

Conclusion

The results of this study revealed that the physicochemical parameters of the surface water around Gboko abattoir exceeded WHO, EU, SON/NAFDAC recommended safe limits (2004). The mean concentrations of Pb, Cr, Ni and Cd were also higher than the regulatory permissible limits. The positive correlations between the pairs of metals in the surface water suggest common anthropogenic source. Generally, the values of the physicochemical parameters and heavy metals were higher in the surface water around the abattoir than the control samples. This implies that the

activities at the Gboko abattoir were contributing to the pollution load of the surface water in the area and this has potential for full-blown environmental problems in the near future if no controlled.

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