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Physicochemical, heavy metals and microbial pollution of surface and ground water in bodija Municipal Abattoir and its Environs

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Abstract— *Surface and ground water pollution is a major problem beclouding most developing nation and the poor method of abattoir effluent waste disposal system being one of the major causes of such pollution. The effluent disposal system of the abattoirs portends environmental and health hazards to the abattoir and its environs and therefore necessitating this study.*

This study was designed to assess physicochemical parameters, heavy metal concentrations and bacterial constituents of selected wells within Bodija municipal abattoir which serves as the main source of water used for meat processing. Samples of water from the wells in the abattoir and some wells in the neighborhood were collected and analyzed according to standard laboratory procedures.

The results obtained revealed the order of mean of heavy metal concentration in sampled abattoir wells (W_A) as Fe (0.67±0.26) > Mn (0.27±0.26) > Pb (0.16±0.08) and the order in sampled residential wells (W_R) as Pb (0.64±0.33) > Fe (0.54±0.22) > Cu (0.35±0.021) > Mn (0.20±0.03). Abattoir wells had significantly higher coliform and enterobactericeae counts than the residential wells. Virtually all the figures obtained were considerably higher than the permissible standard for drinking water.

The public health implication of these findings is especially important because of re-emergence of water borne disease. This survey also indicates that the health status, social and environmental qualities of residents of Bodija abattoir neighborhood will severely be affected.

Keywords— *Heavy metals, abattoir, Bodija, Pollution.*

I. INTRODUCTION

There is an ever increasing need for improved management of surface and ground water because they are the most readily available for human use, yet the most polluted as a result of anthropogenic activities (Ojekunle and Lateef, 2017). Groundwater is the commonest potable water source around the world and its elemental composition is an indicator of how safe it is for the consumption of humans, animals and plants (Batabyal and Chakraborty, 2015). Contamination and pollution of natural water bodies has emerged as a major challenge in developing and densely populated countries like Nigeria (Ezekoye *et al.*, 2013). Water pollution makes water to become unsuitable for human use and also it becomes more expensive in treatment for acceptable quality (Terrumun and Oliver, 2015). Human activities such as indiscriminate location of abattoirs in residential areas in developing countries impact negatively on natural water sources.

Abattoir can be defined as premises approved and registered by regulating authorities for safe and hygienic slaughtering, inspection, processing, effective preservation and storage of meat products for human consumption (Vershima *et al.*, 2015). The abattoir industry in Nigeria is an important section of the livestock industry that provides domestic meat supply to over 180 million people and also employment opportunities for a huge number of people (Nafarnda *et al.*, 2012). In Nigeria, there is lack of adequate waste management in all public abattoirs such that large solid wastes and untreated effluents are common (Adebowale *et al.*, 2010). Abattoirs usually releases wastewaters directly into the ecosystems without adequate treatment process thereby posing serious threats to surface water quality,

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general environmental safety and health (Tekenah *et al.*, 2014).

Pollutants from the abatoir commonly include blood, paunch manure, animal faeces, animal horns, bones, spent lubricants from machines like generators etc. (Ogbomida *et al.*, 2016). Also, there may be the presence of pathogenic microorganisms, such as *Salmonella, Escherichia coli* (including serotype 0157:H7), *Shigella*, parasite eggs and amoebic cysts (Adebowale *et al.*, 2010). Slaughtering process usually produces blood and paunch content from the intestine which may be flushed into open drains which are connected to surface water and may eventually enter into the groundwater (Adeyemo, 2002). Such contamination of water bodies from abattoir wastes could constitute major environmental and public health hazards (Osibanjo and Adie, 2007); it may also reduce oxygen in water, thereby endangers aquatic life.

Shallow wells surrounding abattoir sites are vulnerable to pollution from abattoir activities since the effluents may percolate into the soil and enter into the aquifer; whereas residents may not be aware of the health risk, as the water sometimes appears clean and potable for consumption. Assessing the water quality within the vicinity of abattoirs in residential areas will help to evaluate the risks on the health of residents who depend on the well waters for consumption and other domestic uses. However, this study analyzed the surface and ground water samples, by assessing the physiochemical properties, heavy metal concentrations and bacteriological constituents of selected wells within Bodija abattoir and its environs. This is very important because municipal/tap water is unavailable in the residential neighborhood of Bodija abattoir and people mostly dependent on wells as their readily water source.

II. MATERIALS AND METHODS

Description of study area

Bodija municipal abattoir, which id the study area is located in Ibadan North Local government Area of Oyo State, Nigeria. It is enclosed within latitude 7^0 441^1 and 7^0 426^1 and longitude 7^0 906^1 and 7^0 920^1 East. This study was carried out between June to July which falls within rainy season in Southwestern Nigeria.

Sampling design

The water samples were collected from ten wells designated W1-W10 selected in Bodija municipal abattoir and six (6) wells were selected systematically from the residential neighborhood R0-R5 which was at distance of 149m from the abattoir, thereafter samples wells were selected at 100m intervals. Global positioning system (GPS) was used to determine the coordinate points of the wells and the position of these sampled wells were located accurately on the map by using the 'add event theme' facility of the ArcGIS 9.3 software. 0.5 liters of water each were collected from all the wells in a clean, wide-mouthed sample bottles with tight screw dust proof stoppers for physiochemical parameters determination and 5ml in sterilized plastic for bacteriological examination.

Analyses

Determination of the parameters was based on the American Public Health Association (APHA) series of Standard Methods of Examination of Water and Effluent (APHA, 1998) while nitrate was determined using phenol disulphunic acid method (Marczenko, 1986). Heavy metals were determined using Atomic Absorption Spectroscopy (AAS) (Duada *et al.*, 2016).

III. RESULTS

Table 1: Physicochemical parameters of wells within the abattoir and outside the abattoir in the residential area.

Water Quality Parameters	Wells within the Abattoir	Wells outside the Abattoir
pH	6.15 ± 0.47	6.33 ± 0.26
Temperature	28.8 ± 0.31	29.1 ± 0.21
Conductivity	4.98 ± 2.00	1.60 ± 0.85
Dissolved Oxygen (DO) mg/l	4.79 ± 0.71	4.89 ± 0.70
Biochemical oxygen demand (BOD) mg/l	22.6 ± 13.1	18.8 ± 11.6
Total Solids (TS) mg/l	23.13 ± 19.8	173.0 ± 124.4
Total suspended solids (TSS) mg/l	94.9 ± 53.9	103.0 ± 52.1
Total dissolved solids (TDS) mg/l	137.4 ± 38.7	70.0 ± 25.5
Alkalinity (mg/l)	230.9 ± 128.3	142.5 ± 82.5

CO_2 (mg/l)	226.5 ± 62.5	207.5 ± 13.7
Hardness (mg/l)	572.8 ± 203.7	678.4 ± 442.1
Chloride (mg/l)	784.8 ± 442.1	665.0 ± 237.3
Nitrite (mg/l)	0.05 ± 0.03	0.04 ± 0.006
Nitrate (mg/l) (NO_3^-)	37.5 ± 8.2	51.3 ± 12.3

Table 2: Heavy metals detected in water samples from wells located within the abattoir (W_A)

Samples	Fe (mg/l)	Mn (mg/l)	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)
W1	0.74	0.04	ND	ND	ND
W2	0.46	ND	ND	ND	ND
W3	0.73	0.38	1.06	ND	ND
W4	0.78	0.08	ND	ND	ND
W5	0.57	0.06	ND	ND	ND
W6	0.70	0.90	ND	ND	ND
W7	0.83	0.12	ND	ND	ND
W8	0.94	0.26	ND	ND	ND
W9	0.81	0.36	ND	ND	ND
W10	0.85	0.46	ND	ND	ND
Mean ± SD	0.67 ± 0.26	0.27 ± 0.26	0.16 ± 0.08	0	0

Table 3: Heavy metals detected in water samples from wells located in residential area close to the abattoir

Samples	Fe (mg/l)	Mn (mg/l)	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)
RO (149m)	0.58	ND	ND	ND	ND
R1 (249m)	0.74	0.13	0.88	ND	0.02
R2 (349m)	0.52	0.62	0.40	ND	0.05
R3 (449m)	0.36	0.10	ND	ND	ND
R4 (549m)	0.20	0.14	ND	ND	ND
R5 (649m)	0.80	0.02	ND	ND	ND
Mean ± SD	0.54 ± 0.22	0.20 ± 0.03	0.64 ± 0.33	0	0.35 ± 0.021

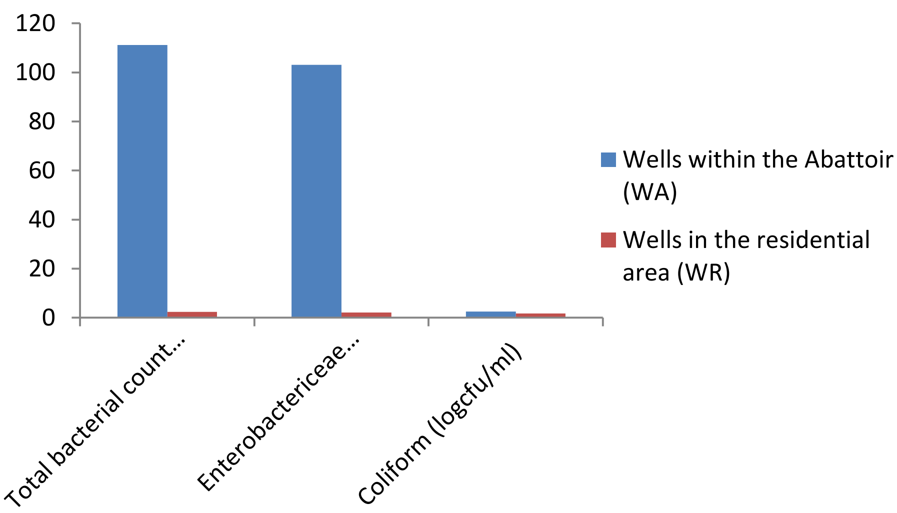

Fig 1: Bacteriological assessment of the water quality of wells within the abattoir and the residential area around the abattoir.

Table 4: The difference in bacteria, enterobactericeae and coliform counts according to distance from the abattoir

Wells in residential areas (W_R)	**Total bacterial count (logcfu/ml)**	**Enterobactericeae count (logcfu/ml)**	**Coliform (logcfu/ml)**
RO (149m)	4.19 ± 0.99	3.96 ± 0.97	3.28 ± 1.78
R1 (249m)	1.58 ± 0.75	1.70 ± 0.87	2.23 ± 0.52
R2 (349m)	2.14 ± 1.39	2.33 ± 0.95	1.16 ± 0.41
R3 (449m)	1.21 ± 0.53	0.95 ± 0.00	0.95 ± 0.00
R4 (549m)	1.82 ± 1.03	2.12 ± 1.00	2.46 ± 1.11
R5 (649m)	3.22 ± 0.64	1.72 ± 0.92	1.04 ± 0.18
F ratio	5.868	5.586	4.54
	.002	.003	.004

IV. DISCUSSION

The physic-chemical properties of wells within the abattoir and outside the abattoir in the residential area in Table 1 revealed a pH of 6.15 and 6.33 respectively which is acidic. This support earlier report of Kara Abattoir effluents on the water quality parameters on River Ogun, Nigeria (Adesina *et al.,* 2018). The temperature of where both were 28.8 and 29.1. Temperature is one of the most important environmental features in waste water as it controls behavioural characteristics of organisms, solubility of gases and salts in water (Joanne *et al.,* 2011). The results of both wells were similar with the report of previous studies (Yogendra and Puttaiah, 2008; Magaji and Chup, 2012) which reported a range of 27.8–28.3 °C. However, the values were within the WHO standard of the permissible limit of < 40 °C (WHO, 2004). The total hardness for both wells was 572.8 ± 203.7 and 678 ± 442.1 respectively but exceed the limits of the WHO permissible limits of 150 mg/L. This support reports that abattoir wastewater contribute to total hardness values (Yogendra and Puttaiah, 2008). Nitrate in both water samples are 37.5 and 51.3 respectively and exceeded the standard of 10mg/l. This result was in line with (Akan *et al.,* 2010) findings on the chemical properties of abattoir wastewater samples in Maiduguri, Nigeria. Such high values of nitrate could result in the blue-eye syndrome in little children and pregnant women (Speijers, 1996).

From the result, the dissolved oxygen, Biochemical oxygen demand (BOD) is above the accepted standard for wastewater. High Biochemical Oxygen Demand values at the discharge point could be attributed to the low Dissolved Oxygen level, since low Dissolved Oxygen will result in high Biochemical Oxygen Demand and which is a strong indication of pollution (Tekenah *et al.,* 2014). The Total Suspended Solids (TSS) of the samples was 94.8 and 103 which exceeded the acceptable standard of 20mg/l (WHO, 2011). The high values of solids could be due to lack of sedimentation facility to separate the solid wastes and the liquid wastes before discharge High TSS can cause an increase in surface water temperature, because the suspended particles absorb heat from sunlight and this can cause dissolved oxygen levels to fall even further which can harm aquatic life (Giller and Malmqvist, 1998). Chlorides are important in the detection of sewage contamination of groundwater. The value for the chloride is 784.8 ± 442.1 and 665.0 ± 237.3 which is higher than the WHO permissible limits of 250 mg/L. The values were higher than the values from earlier study (Igbinosa and Uwidia 2018). Well water with high concentrations of chloride ions could damage plants if used for irrigation and it could also give drinking water an unpleasant taste (WHO, 2004).

In most Nigerian rivers, the heavy metals present are found in concentrations well above acceptable and permissible levels: lead, copper, zinc, nickel, chromium, cadmium and iron (Olayinka and Alo, 2004). The value for the copper is 0.35 ± 0.021 mg/L from wells located in the residential area. The values were within the WHO permissible limits of 2.0 mg/L. The value for the lead is 0.16 ± 0.00 and 0.64 ± 0.33 mg/L from the well sample within the abattoir and residential area respectively. The values were above the WHO permissible limits of 0.015 mg/L. Lead got into human body through food, water and air (Nazir *et al.,* 2015). In exposed individual, lead impacts the central nervous system leading to delayed mental and physical growth in children and could also affect the attention span and learning abilities of children (Omole *et al.,* 2018). Iron concentrations in the collected samples from within and outside the abattoirs are 0.67± 0.26 and 0.54 ± 0.22 which is above the maximum contaminant levels of the iron content based on WHO of 0.3 mg/L. This high iron content may probably be due to influx of waste blood that is carried by runoff and deposited into the shallow wells and nearby water source. Cadmium which is toxic to kidney and liver and causes poisoning in various tissues and organs of animals (Yapici *et al.,* 2006) was not detected in the sample waters.

Microorganisms are ubiquitous and are known for important functions which include; decomposition of organic materials, bioaccumulation of chemicals and biogeochemical cycling of elements. Factors that greatly influence their presence, abundance and growth in the environment are pH, temperature, pressure, availability of nutrients and salinity (Ogbonna and Ideriah, 2014). Coliforms were isolated from all the samples collected within the abattoirs and its environs (2.55logcfu/ml and 1.69logcfu/ml). The values were all above the WHO value of zero The presence of this physiologic group in these samples is an indication of feacal contamination of the samples (Prescott *et al.,* 2005). This is possibly due to indiscriminate deposition of cow dung within and around the abattoir. Through surface run-off, these are carried to the nearby water body and this leads to the presence of coliforms in such water body. *E. coli* is the most prevalent member of the fecal coliform group harboured by livestock. The presence of *E. coli* in water is considered a specific indicator of fecal contamination and the presence of enteric pathogens; similar findings have early been reported (Coker *et al.,* 2001; Igbinosa and Uwidia 2018). The microbiological analysis revealed that the abattoir wastewater samples were highly contaminated with bacteria. High organic content, organic biological nutrients, sufficient alkalinity of wastewater and its components such as blood, fat, manure, animal and undigested feeds in abattoir effluent may have contributed to the high microbial contents in the wells (Rajaram and Das, 2008; Nafarnda *et al.,* 2012).

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