SPATIAL VARIATION IN GROUNDWATER POLLUTION BY EFFLUENTS FROM KARU ABATTOIR IN ABUJA, NIGERIA

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Abstract

This study assessed the spatial pollution of groundwater around Karu abattoir by the abattoir effluents by analysing the physical, chemical and biological parameters of water samples collected from different wells at different distances around the abattoir comprising Group A (within abattoir), Group B (60m from abattoir) and Group C (200-300m from abattoir). Parameters analysed were temperature, turbidity, TDS, TSS, pH, DO, BOD, total hardness, conductivity, iron content, nitrate, sulphate, E.coli and faecal streptococci. Result of the analyses showed that the concentrations are higher in Group A water samples, and reduced slightly in the Group B and then the Group C samples, for parameters such as temperature, turbidity, TDS, TSS, BOD, sulphate, iron content, E.coli and faecal streptococci. Values for the concentration of electrical conductivity, total hardness and nitrate were inconsistent across the Groups; Group A samples were more acidic and the acidity reduces with distance from the abattoir; they also have reduced DO but the values increased slightly with Groups B and C. The analysis of variance (ANOVA) at $P \leq 0.05$ showed significant variation in the concentration of the parameters except for temperature, turbidity, pH and electrical conductivity which showed no significant variation. The parameters were at different compliance level with the WHO and NSDWQ standards. The study therefore concluded that the water in Groups A and B, was not fit for drinking unless adequately treated. It was recommended that there is the need for the treatment of the abattoir effluents before discharging them into the environment.

Keywords: *Spatial variation, Groundwater, Pollution, Abattoir, Effluents, Water quality.*

Introduction

Abattoirs are important in Nigeria and they play a major role in domestic meat supply industry as well as provide employment opportunities to many members of communities where they are located. Abattoirs however pose contamination risks to water resources if the effluents are disposed without proper treatment. Chukwu *et al.,* (2008) observed that abattoir wastes are hazardous as they may contain varying quantities of components which are dangerous or potentially dangerous to the environment. Abattoir operations produce a characteristic highly organic waste with relatively high levels of suspended solid, liquid and fat. The solid wastes include condemned meat, undigested food substances, bones, horns, hairs and aborted fetuses. The liquid waste is usually composed of dissolved solids, blood, gut contents, urine and water (Adeyemo *et al.*, 2002). The improper disposal of these wastes onto lands and into water bodies leads to the contamination of the environment (Abdul-Gafar, 2006; Chukwu, 2008). Some of these wastes, especially the liquid ones, dissolve in water and percolate into the soil, and consequently contaminate the groundwater (Alonge, 1991; Asthana and Asthana, 2001).

Water is regarded as being polluted when it is unfit for its intended use. The self-purification process of groundwater is a function of the depth of the soil and the concentration of the pollutant in the percolating water (Ifeadi, 1982). The water used for drinking must therefore meet the stipulated standards and potable water is one that does not contain chemical substances or microorganisms in amounts that could cause hazards to health (Alonge, 1991; Ifeadi, 1982).

Leachates from abattoir, as observed by Ifeadi (1982), consist largely of solids, microbial organisms and in special situations, chemicals, and shallow wells like hand-dug wells are more dangerously polluted. As population grows and urbanization increases, more water is required and greater demand is made on ground and

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surface water and an even greater amount of organic and inorganic wastes are produced, which contaminate water sources so that less potable water becomes available (Amuda and Odubella, 1991; Adegbola and Adewoye, 2012).

The presence of groundwater pollutants of organic nature is made known through taste, odour, foaming or damage to crops which have been irrigated with this water (Ezeoha and Ugwuishiwu, 2011). A study of nitrate in soils under feed-lots noted accumulations from almost zero to 3783kg per acre in a 4m soil profile (Murphy and Gosch, 1970). Furthermore, Samples of groundwater under feed-lots in the south Platte River Valley, an area containing most of the cattle in Colorado, U.S.A, has been observed to contain ammonium nitrogen up to 38mg/L, organic carbon up to 300mg/L, and to have had an offensive odour, and viral diseases have been caused by such groundwater pollution (Wilber, 1971).

The contamination of the groundwater has many factors which makes it very different from surface water contamination. Magaji (2009) explained that because we cannot observe groundwater, we typically discover that the groundwater is contaminated once a well or surface water body becomes contaminated. Unlike surface water, groundwater contamination may commence long after the waste source is in place. The slow release rate causes it to take a longer time to move through the groundwater flow regime and groundwater can sometimes be difficult to remediate. He further explained that the primary contaminants associated with manure and livestock processing include nitrate and ammonia, coliform bacteria, Phosphorus and endocrine disrupters, these have impaired the quality of water resources on local and regional bases. The after effect of the improper disposal of abattoir wastes is the impairment of water quality.

Most of the liquid wastes generated from Karu abattoir are disposed directly into the nearby Tauga stream without any form of treatment; a situation which may likely pose a threat to the quality of water within the stream, especially for downstream users (Makwe, 2012). There is also the possibility that these waste can percolate into the soil to contaminate the groundwater. This study therefore seeks to determine the extent of pollution of the groundwater from the abattoir wastes through the qualitative analysis of groundwater samples taken from different wells at various distances from the abattoir. The study was based on the hypothesis that there is no significant variation in the concentration of the parameters in the groundwater samples collected at various distances from the abattoir.

Study Area

Karu is one of the satellite towns in Abuja Municipal Area Council (AMAC) of the Federal Capital Territory, Nigeria.

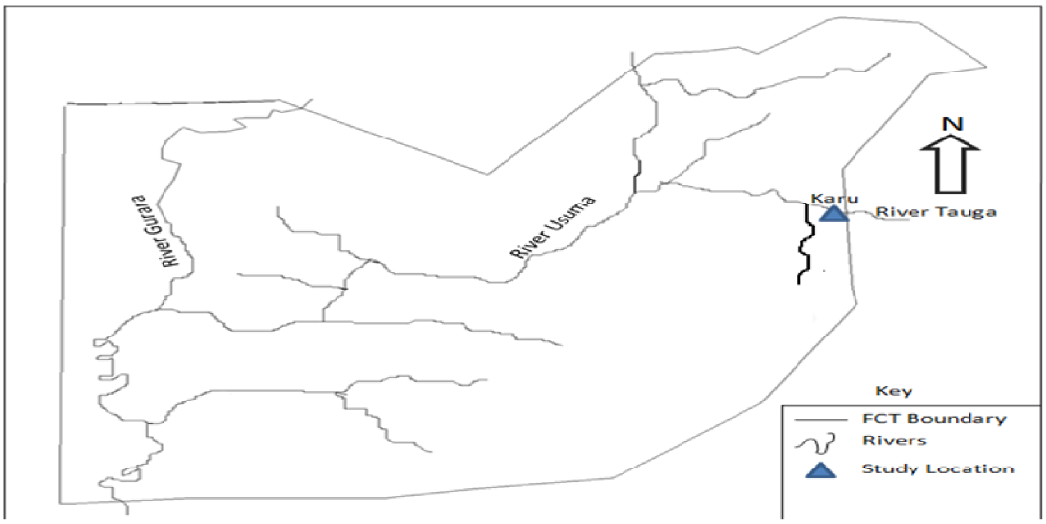

Figure 1 Location of the Study Area

Source: A.G.I.S. (2011)

It is located about 7km north east of the Federal Capital City (FCC), off the Abuja–Keffi express way. It lies between latitudes 8^o 59' 38.6"N and 9^o 01' 39.6"N and longitudes 7^o 33' 17.19"E and 7^o 34' 49.61"E.Karu has an area of about 275 square kilometers. It is bordered to the north by Nyanya, to the south by Jikoyi, to the west by Kugbo and to the east by Mararaba (in Nasarawa State). Karu abattoir, which is the study area, is located close to a residential area. Its location therefore poses health risk to the residents due to the nature of wastes generated from the abattoir. Effluents from the abattoir are discharged into Tauga stream, which flows adjacent to the abattoir. These effluents can seep into and contaminate the groundwater sources such as wells and boreholes. The stream is characterized by flash floods due to increase in its volume during the rainy season and have a considerably reduced flow during the dry season (Adakayi, 2000; Balogun, 2001).

Materials and Methods

Collection of Water Samples

Three groups of groundwater samples were collected from existing wells around the abattoir. Each group is made up of three water samples.

Group A samples: collected within the abattoir

Group B samples: collected 60m away from the abattoir

Group C samples: collected 200-300m away from the abattoir

Parameters such as temperature, turbidity, odour and colour were determined at the point of collection of the water samples. The water samples were conveyed to Sheda Science and Technology Complex (SHESTCO), Abuja, where they were analysed for selected physical, chemical and biological properties accordingly. Other parameters analysed includes; total dissolved solids (TDS), total suspended solids (TSS), pH, dissolved oxygen (DO), biological oxygen demand (BOD), total hardness, electrical conductivity, iron content, nitrate, sulphate, coliform bacteria (*Escherichia coli*) and faecal streptococci. The results obtained from the laboratory analyses were statistically analysed using the analyses of variance (ANOVA). The groundwater quality was also compared with the World Health Organisation (2008) guideline for drinking water quality.

Methods of Analyses

Temperature was determined by dipping a mercury-in-glass portable thermometer into the water samples at the point of collection, to obtain the reading; Turbidity, by the nephelometric method (using HACH 2100AN turbid meter) (APHA, 1998); total dissolved solids, by Gravimetric Method (Kazi *et al*., 2009); total suspended solids, by running a given amount of the water sample through a filter. The filter and residue were dried in oven. TSS was then calculated by subtracting weight of filter from that of filter and residue, and divided by the volume of water (Kazi *et al*., 2009); electrical conductivity was determined using the Jenway conductivity meter (4510 model), by dipping the probe into the container of the water samples until a stable reading was obtained and recorded; pH level was determined by the use of HANNA pH meter (Model HI 28129). Total hardness, by using standard solution of sulphuric acid with solochrome black T as indicator (Ekwebelem, 2010). Dissolved oxygen was determined using the Winkler azide method (Pejman *et al*, 2009); Biological Oxygen Demand (BOD) was determined using the relationship BOD= DO_1-DO_2 (Agbaire and Obi, 2009), same as in DO above (Winkler azide method) but was titrated after five days; Iron content, by the Atomic Absorption Spectrophotometry (ASS), the concentration was read using UV spectrophotometer (Model: 01-0960-00) at 510nm. Nitrate was analyzed by cadmium reduction and ascorbic acid method (using HACH DR2800 spectrophotometer); and Sulphate by turbid metric method using barium chloride and concentration reading through UV spectrophotometer (Model: UV-1601) (Ademoriti, 1996). The fecal bacteria (E.coli and faecal streptococci) was determined using the membrane filter technique. This technique determines the number of colony forming units per 100 mL (cfu/100 ml) of water sample (APHA, 1998). The mean for each of the parameters of the water samples collected were calculated and the analysis of variance (ANOVA) statistical technique was used to test the hypothesis earlier stated.

Results and Discussion

Temperature: The temperature of the groundwater samples are varied across the groups with Group A having a temperature of 28.65^{o}C, it decreased slightly in Group B (28.53^{o}C) and further decreased in Group C (28.33^{o}C) as shown in Table 1. High water temperature enhances the growth of micro organisms and this may increase taste, odour and corrosion problems. There is no guideline value recommended for drinking water temperature since its control is usually impracticable (WHO, 2008).

Turbidity: The mean turbidity value of the Group A groundwater samples is higher (2.33NTU) than those of the Group B water samples (1.93NTU), followed by those for Group C samples (1.38NTU). The high turbidity of the Group A groundwater samples is possibly as a result of the discharge of the abattoir effluents and the distance between the wells and the abattoir. This implies that the Group C water samples are clearer than those of Groups B and A. All the groundwater samples collected across the groups have turbidity value of less than 5 Nephelometric Turbidity Units (NTU) and they therefore meet the WHO (2008) standards (Table 1).

Total Dissolved Solids: There was a marked decrease in total dissolved solids from the Group A groundwater samples to those of Groups B and C (36.88mg/l, 27.67mg/l and 18.57mg/l respectively). This is due to the proximity of the Group A wells to the abattoir vicinity. The TDS for Groups A, B and C are within the WHO (2008) 1000mg/l tolerance limits (Table 1).

Total Suspended Solids: The mean values for total suspended solids of the groundwater samples were 36.32mg/l, 31.73mg/l and 24.72mg/l for the Group A, Group B and Group C water samples respectively (see Table 1). This indicates increase in TSS at the Group A wells due to their proximity to the abattoir effluents. Groundwater samples from Groups A and B are above the WHO (2008) guideline limit. However, the Group C water samples are within the recommended limit.

Electrical Conductivity: The electrical conductivity of the groundwater samples is higher in the Group C water samples (422.58µs cm/l) followed by the Group A water samples (386.67µs cm/l) and then the Group B samples (324.18µs cm/l) as shown in Table 1. The W.H.O. (2008) do not have any proposed guideline value for the electrical conductivity of drinking water.

pH: Group A sample has the least pH value of 6.05. This however increased to 6.30 and 6.87 in Group B and Group C samples respectively. This implies that the water samples in Group A are more acidic than those of Groups B and C due to the nature of effluents that are discharged from the abattoir. An acceptable pH for drinking water is between 6.5 and 8.5 (WHO, 2008). The pH for Group A and Group B are below the acceptable values and is therefore more acidic than normal. Group C water samples are however within the acceptable values (Table 1).

Dissolved Oxygen: As shown in Table 1, the dissolved oxygen in the groundwater samples were found to be lower in the Group A water samples (9.25mg/l). This increased to 12.72mg/l and 20.12mg/l in Groups B and C respectively. The low dissolved oxygen recorded in the Group A water samples could be due to the proximity of the wells to the abattoir vicinity where the effluents are discharged. All the groundwater samples collected across the groups have Dissolved Oxygen below 30mg/litre and therefore do not meet the guideline value recommended for dissolved oxygen in drinking water (WHO, 2008).

Biological Oxygen Demand: The biological oxygen demand for the groundwater samples are 5.28mg/l, 5.17mg/l and 3.55mg/l for Groups A, B and C respectively (see Table 1). The BOD is higher in the Group A samples possibly as a result of the effluents from the abattoir. All the Groundwater samples have BOD values which are higher than the WHO (2008) 0.0mg/l permissible limit

Total Hardness: The values for the groundwater samples are not consistent. Group A samples have a total hardness of 140.35mg/l, Group B samples have total hardness of 111.00mg/l and Group C samples have the highest total hardness value of 237.13mg/l. All the water samples are within the WHO (2008) 100-300mg/l guideline limit for drinking water

(Table 1). The increased hardness recorded in the Group C samples may likely be due to other environmental factors, and not necessarily due to the direct contact with the abattoir effluents, considering the distance between Group C samples and the abattoir (200-300m from the abattoir).

Nitrate: The amount of nitrate in the groundwater samples as obtained from the laboratory analysis is as follows: 0.02mg/l, 0.05mg/l and 0.01mg/l for Groups A, B and C respectively as shown in Table 1. The figures are inconsistent; however the lowest amount of nitrate in the Group C water samples could be due to the distance between the abattoir and the Group C wells. These nitrate values are within the WHO (2008) guideline value for drinking water.

Sulphate: The amount of sulphate present in the groundwater samples range from 4.42mg/l to 8.42mg/l with the Group A samples having the highest amount of sulphates. This is possibly as a result of the discharge of abattoir wastewater which percolates into the soil and pollutes the groundwater. All the groundwater has sulphate values which are within the WHO (2008) guideline value for drinking water (Table 1).

Iron: The iron content of Group A groundwater samples is 0.15mg/l. The value reduces with distance from the abattoir, with Group B water samples having iron content of 0.07mg/l and 0.05mg/l for Group C water samples (Table 1). The high iron content in the Group A water samples can be attributed to the percolation of the blood-rich abattoir effluents into the soil and the proximity of the Group A wells to the abattoir. However, they are all within the 0.30mg/l WHO (2008) guideline value for iron content in drinking water.

Escherichia coli. The Group A and Group B groundwater samples have high mean bacterial count. The Group A samples has *E. coli* count of 95.23cfu/100ml, while the Group B water samples has *E. coli* count of 14.22cfu/100ml. This is against the WHO (2008) recommended 0cfu/100ml (as in Table 1). *E. coli* is absent in Group C groundwater samples due to the distance from the abattoir which ensures very little or no contact with the abattoir effluents. These pathogenic organisms isolated from the groundwater around the abattoir makes the water unsafe for human consumption.

Faecal streptococci: The mean Faecal streptococci count in the groundwater samples around the abattoir are as follows: 53.68cfu/100ml, 9.32cfu/100ml and 0.0cfu/100ml for Groups A, B and C water samples respectively (see Table 1). The WHO (2008) recommends 0cfu/100ml for all faecal bacteria. The absence of Faecal streptococci in Group C groundwater samples is an indication that the abattoir effluents do not have direct effects on the Group C wells. These fecal indicators themselves are not harmful, but because they live in the same portion of the digestive system where disease causing microorganisms occur, their presence in water samples indicate that water might contain microorganisms harmful to human health (WHO, 2008).

Generally, the result of the laboratory analyses in Table 1 shows that there is increased concentration of most of the tested parameters in the Group A groundwater samples due to the proximity of the Group A wells to the point of disposal of the abattoir effluents which percolates into the soil to pollute the groundwater. The concentration of the parameters in the groundwater samples are reduced with distance from the abattoir, except for parameters such as Electrical conductivity, Total Hardness and Nitrate whose values are inconsistent. Values for pH and Dissolved Oxygen however increase with distance from the abattoir. This is an indication that the groundwater within the abattoir is more acidic than those of the surrounding areas; and that the amount of oxygen present in the water is reduced as one gets closer to the abattoir.

Statistical analyses using ANOVA as shown on Table 1 indicates that the calculated values ($F_{calculated}$) for parameters such as total dissolved solids, total suspended solids, dissolved oxygen, biological oxygen demand, total hardness, nitrate, sulphate, iron content, E. coli and Faecal streptococci are greater than the table values at $P \leq 0.05$, therefore they show significant variation across the different groups while others such as temperature, turbidity, electrical conductivity and pH indicate a non significant variation across the different groups as their calculated values ($F_{calculated}$) are less than the table values at $P \leq 0.05$. The null hypothesis earlier stated is therefore applicable to those groundwater parameters that show no significant variation (Temperature, turbidity, conductivity and pH). It is however rejected for those parameters that show significant variation in concentration across the Groups (A, B and C). This result corresponds with the results obtained from a similar study by Adeyemo, *et al* (2002) at Bodija abattoir in Ibadan, Oyo state. They reported that the concentration of these parameters vary progressively with distance while some of the parameters decline in concentration with distance.

Table 1 also shows that the values for parameters such as temperature, turbidity, total dissolved solids, electrical conductivity, dissolved oxygen, biological oxygen demand, nitrate, sulphate and iron content are found to be within the WHO (2008) recommended limit. The values for total suspended solids for groups A and B exceeds the normal recommended values while that of group C is within the normal limit. The pH value for group C is within the recommended limit but that of groups A and B are less than the 6.5-8.5 limit provided by WHO (2008). Groups A and B water sample were polluted by faecal organisms such as E. coli and Faecal streptococci and thus they have values that are above the WHO recommended limit. However, group C water sample is not polluted by these faecal organisms and is therefore within the normal limit. The presence of *Escherichia coli* and Faecal streptococci in groups A and B shows that the groundwater within the abattoir and about sixty meters away from the abattoir is harmful to human health and can cause urinary tract infection, diarrhea or meningitis. The group C groundwater (located about 200-300meters from the abattoir) can be used for drinking with little treatment.

Conclusion

The result of the laboratory analysis revealed that the quality of the groundwater in Groups A and B had been lowered because the concentration of most of the tested parameters were more in these groups than in the Group C water samples. This is most likely due to the proximity of Groups A and B wells to the abattoir and hence they bear the effect of the percolation of the abattoir effluents into the soil. This therefore made the water from the Group A and Group B well unfit for human consumption unless they are adequately treated. Water from Group C wells however require minimal treatment before consumption. The analyses of variance (ANOVA) test also revealed that most of the parameters show significant variation across the different groups except for parameters such as temperature, turbidity, electrical conductivity and pH which show a non significant variation across Groups A, B and C.

Recommendation

In view of the findings revealed by this study, the following recommendations are made:

There is the need for the treatment of the abattoir effluents before they are discharged into the environment so as to minimize the pollution of the groundwater around the abattoir.

In addition, public awareness and enlightenment on possible impact of pollution from abattoir effluents should be embarked upon by relevant agencies so that people can be sensitized on the dangers of using the wells and boreholes around the abattoir without adequate treatment.

Effort should be made to ensure that further pollution of the groundwater is stopped. This can be achieved by ensuring strict compliance by polluters and follow-up by comprehensive monitoring programmes by the relevant authorities.

Table 1: Mean Values of Groundwater Parameters, Analysis of Variance (ANOVA) for Variation in Concentration of Parameters and Comparison with W.H.O. Standard

Parameter	GROUP A	GROUP B	GROUP C	F calculated	P≤0.05	Rmks	WHO	Rmks
	Mean ±std. error	Mean ±std. error	Mean ±std. error					
Temperature (^oC)	28.65±0.42	28.53±0.35	28.33±0.30	1.284	5.79	NS	N/A	Not stated
Turbidity (NTU)	2.33±0.13	1.93±0.09	1.38±0.10	4.812	5.79	NS	5	Normal
TDS (mg/l)	36.88±1.57	27.67±2.06	18.57±1.76	21.085	5.79	S	1000	Normal
TSS (mg/l)	36.32±4.68	31.73±3.87	24.72±3.25	6.839	5.79	S	30	High
E.Conductivity (µs cm/l)	386.67±17.46	324.18±14.04	422.58±18.73	2.427	5.79	NS	N/A	Normal
Ph	6.05±0.11	6.30±0.15	6.87±0.09	5.672	5.79	NS	6.5-8.5	Low in A & B
DO(mg/l)	9.25±0.67	12.72±0.89	20.12±0.91	78.620	5.79	S	N/A	Low
BOD (mg/l)	5.28±0.15	5.17±0.20	3.55±0.13	13.855	5.79	S	0.0	Normal
T. Hardness(mg/l)	140.35±21.04	111.00±7.98	237.13±16.00	32.137	5.79	S	100-300	High in C
Nitrate (mg/l)	0.02±0.0	0.05±0.01	0.01±0.0	13.118	5.79	S	50	Normal
Sulphate(mg/l)	8.42±0.15	6.68±0.12	4.42±0.21	186.346	5.79	S	250	Normal
Iron Content (mg/l)	0.15±0.0	0.07±0.01	0.05±0.01	8.606	5.79	S	0.30	Normal
E.Coli (cfu/100ml)	95.23±5.41	14.22±0.88	0.0±0.0	229.557	5.79	S	0 in 100ml	High in A & B
F.streptococci (cfu/100ml)	53.68±3.70	9.32±2.35	0.0±0.0	74.028	5.79	S	0 in 100ml	High in A & B

d.f.: Between=2, Within=5, NS=Not significant, S=Significant, N/A=Not Available

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