IMPACT: International Journal of Research in Engineering & Technology
ISSN(P): 2347-4599; ISSN(E): 2321-8843
Vol. 6, Issue 5, May 2018, 37- 48
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THE EFFECTS OF ABATTOIR WASTE ON GROUNDWATER QUALITY AT YOLA MAIN SLAUGTER SLAB, ADAMAWA STATE, NIGERIA

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Received: 23 Apr 2018 **Accepted:** 23 May 2018 **Published:** 02 Jun 2018

ABSTRACT

The study assessed the impact of abattoir waste on groundwater quality around Yola main slaughtering slab. Untreated wastes from the abattoir are discharged directly onto the surrounding, which has no drainage channel to convey the waste away from the area. Leachates from dumped and decomposed wastes have also been observed to percolate into soil to contaminate the groundwater. Six water samples were collected from different sources at different distances and depth, within and outside the abattoir which include four boreholes and two wells. Physical, chemical and biological parameters of the samples were determined. The mean values for the hand dug well water samples were found to be temperature (25.35^{o}C), pH (7.04), Conductivity (581.50µs/cm^{-1}), TDS (289.50mg/l), TSS (50.50mg/l), DO (0.00mg/l), COD (6200.00mg/l), BOD (2.03mg/l), NH_4^+ (0.11mg/l), NO_3^- (8.63mg/l), PO_4 (43.30mg/l), total coli form (30.00cfu), feacal coli form (0.00cfu), turbidity (46.75NTU) and color (415.00pt). Student t –test, and the Analysis of Variance was utilized to determine variations of the analyzed parameters. It was discovered that most of the analyzed parameters for boreholes samples such as temperature (23.95^{o}C), PH (7.08), Conductivity (458.75 µs/cm^{-1}), TDS (229.25mg/l), TSS (2.25mg/l), DO (0.00mg/l), BOD (4.47mg/l), Nitrate (5.12mg/l), Coli form Bacteria (0.00cfu), Feacal Coli form (0.00cfu) and Turbidity (1.15NTU) are in compliance with FEPA acceptable limits, and for hand dug wells samples, only Temperature, pH, Conductivity, TDS, DO, Feacal Coli form, and Nitrate are in compliance with FEPA acceptable limits. The study therefore, concluded that the water from hand dug wells is 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**: Abattoir, Contamination, Groundwater, Leachates, Quality Parameters*

INTRODUCTION

Abattoirs are important in Nigeria as they play a major role in the 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 of directly on the environment without proper treatment.

An abattoir is a facility where animals are killed for consumption as food products.

Approximately, 45-50% of the animal can be edible products, the remaining parts of the animal are turned into byproducts such as leather, chalk, soaps, candle (tallow), and adhesives to mention but a few. (Adeyemo *et al*., 2010).

According to Tove (1985), zoonatic diseases (i.e. diseases of animals that are transmissible to humans and vice versa) are yet to be eliminated or fully controlled over 80% of the public abattoirs in Nigeria. Thus, they pose serious environmental health risks to the public with the infectious disease like; Tuberculosis, Calibacillosis, Brucellosis and Helmiyhoses.

Wastewater is generated during Slaughtering, processing and general clean up of both the carcasses and the abattoir infrastructure (Tove, 1985).

The most common form of treatment for abattoir effluent is to discharge the effluent into anaerobic fermentation ponds a process that significantly reduces nutrient content, and also alters the chemical makeup. Even after treatment in anaerobic fermentation ponds, an abattoir effluent contains a nitrogen concentration of 100-250mg/l and dissolved phosphorus concentration of 20 to 50mg/l (Sangodoyin and Agbawe, 1992).

The presence of fecal contamination is an indication of a potential health risk for individuals exposed to this water. Fecal coli form may occur in ambient water as a result of the overflow of domestic sewage non point source of human and animal waste. Typhoid and Cholera are caused by a relatively fragile organism whose only major reservoir is man. These two diseases occur most dramatically as a common source outbreak where the community water supplies get contaminated by fecal or from a person suffering from one of the diseases (Ifeadi, 1982). In hygienic water testing, emphasis is mainly placed on testing for the presence of fecal coli form and e.coli (APHA, 1998 and NSDW, 2007).

Drinking unsafe water is harmful to human health which may cause waterborne diseases. The effluents at Yola main slaughter slab (along Federal Collage of Education) consist of blood, hair, horns, human and animal faeces, dirty water etc are dispose directly to the ground surface in the abattoir premises which have no water channel or drainage to convey the wastewater away from the area. The wastewater percolates to the ground surface and contaminates the water underground, in fact, there has being no sewage treatment facility constructed for managing wastewater from the abattoir at Yola, Adamawa state.

World health organization (WHO, 2005) report that every 24 hours 13,000 children under the age of one (1) will die primarily because of water borne diseases and only about 22% of the rural population in the developing countries had access to safe drinking water. People device alternative sources to pipe borne water which includes rainfall, surface and ground water.

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 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 composed of dissolved solids, blood, gut contents, urine and water (Adeyemo et al., 2002). The improper disposal of these wastes onto the lands and into water bodies leads to the contamination of the environment (Abdul-gafar, 2006; Chukwu *et al.*, 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, 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 surface water and 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, odor, 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 odor, 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 primary contaminants associated with manure and livestock processing include nitrate and ammonia, coli form 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 (UNESCO, 2006).

The water from stream, rivers, lakes, reservoirs seeps or percolates through the soil to the underground water which rarely need treatment before consumption or use for domestic activities. The quality and quantity of those constituents depend on geological and environmental factors, and they are continuously changing as a result of reactions of water with the contact medium and human activities (Krantz and Kiffierstein, 2005).

In Nigeria, abattoirs get water for sanitary purposes mostly from surrounding wells which are not far from the drains where the wastewater discharges to the stream. Most of the drains are not properly lined and this causes seepage of wastewater back into the surrounding wells or boreholes. This wastewater is contaminated with blood, faeces nitrates, phosphates, ammonia, acidity (PH), and the presence of pathogenic organisms etc which affects the physical, chemical and biological state of the well or borehole water. This constitutes a potential danger to the surrounding ecosystems and the health of the users of these boreholes and wells (Mbaya, 2004).

Most of the liquid wastes generated from Yola main abattoir are disposed directly onto the ground surface without any form of treatment; a situation which may likely pose a threat to the quality of water within the area. 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 qualitative, quantitative and microbial analysis of groundwater samples taken from different existing boreholes and wells of different depths and at various distances within the abattoir and the surrounding environment. In essence, the main aim of this work is to assess the quality of groundwater water in the vicinity of the abattoir in order to provide basic information on the suitability of the water for human consumption.

METHODOLOGY

The Study Area

Yola North local Government area of Adamawa State in North-Eastern Nigeria lies between latitudes 7^{o}N and 11^{o}N of the equator and 11^{o}E and 14^{o}E of the Greenwich meridian and is bordered with river Benue to the north, Yola south local government to the south and Demas local government to the west. The study area covers an approximate land area of about 8,068sq/km and is located along the Benue valley and with a population of about 392,845 (Census, 2006).

Adamawa state is multi-ethnic and multi-lingual with about 478 communities in its 37 districts. The major tribes include the Fulani, Chamba, Higgi etc; The town has a tropical climate with rainy reason from April to October and dry season from November to march or April. The temperature in the area vary, the hottest month is April with monthly average maximum temperature of 39^{o}C while the coldest months are December and January with minimum average temperature of 16^{o}C. (Adebayo and Tukur, 1999).

The abattoir is a small-scale business enterprise managed by an association of independent butchers. The area measures 200m^2 in size, fenced with sandcrete block while the floor is made of concrete slab. The premises are a natural ground with no floor with a relatively flat topography. The soil beneath the abattoir is an alluvial deposit. There are four boreholes within and two wells outside the abattoir which serve as the main water sources. Normal abattoir operations are carried out from Monday to Saturday.

Method of Data Collection, Sampling and Laboratory Analysis

Water samples were collected from six water sources. The first source is from a borehole at the entrance of the abattoir of about 35m depth and a distance of 150m from the effluents source. The second source is a borehole of about 120m distance from the pollutant source with a depth of about 40m, the third source is from a borehole of about 90m distance from the pollutant source and a depth of 45m.All the three boreholes can be said to be more or less arrange in a straight line. The fourth source is from a borehole opposite to the second source with a depth of about 45m and a distance of 95m from the pollutant source. All the four boreholes are within the abattoir premises. The fifth sample is from a hand dug well outside the abattoir with a 7m depth and a distance of about 20m from the wall of the abattoir where the main slaughtering square is located and where most of the wastes are produced. The sixth source is from a well at an interval of about 60m from the slaughter square and a depth of about 8m. The samples were labeled according sources of collection. Samples for microbiological analysis were collected in 750ml sterilized bottles at ambient temperature with its mouth Stoppard with foil and rubber band. The physical, chemical and microbiological analysis of water quality parameters were conducted in the Laboratory of Bauchi State Water Board using standard analytical methods, equipments and machines (Qualitative, Quantitative and microbial Analysis) in accordance with (APHA, AWWA and WPCF, 1980). The results of the laboratory analysis were subjected to statistical analysis using student t-test and Analysis of variance (ANOVA). The results were also compared with standards of the Federal Environmental Protection Agency (FEPA, 1991).

The Samples Collected Were Analyzed in the Laboratory to Determine the Following Parameters;

- Temperature ^{o}C

- pH
- Conductivity (µs/cm^{-1})
- Total Dissolved Solids (TDS) mg/l
- Total Suspended Solids (TSS) mg/l
- Chemical Oxygen Demand (COD) mg/l
- Biochemical Oxygen Demand (BOD) mg/l
- Ammonia (NH^+_4) mg/l
- Nitrate(NO^-_3)mg/l
- Phosphate(PO^+_4)mg/l
- Total and fecal coliform (cfu Mgl^{-1})
- Turbidity (NTU)
- Colour pt

RESULTS AND DISCUSSIONS

The results obtained from the laboratory analysis are presented in table 1.

Table 1: Laboratory Result of Physical, Chemical and Microbiological Parameters

Sample	Distance(m)	Temp^{0}C	pH	Condu µs/cm^1	TDS mg/l	TSS mg/l	COD mg/l	BOD mg/l	NH_4^+ mg/l	NO_3^- mg/l	PO_4^- mg/l	Coli Form cfu mg/l	Feacal cfu mg/l	Turbidity NTU	Colour pt
S_1	150	24.30	7.19	530.00	266.00	3.00	140.00	4.78	0.17	5.22	14.30	0.00	0.00	2.79	25.00
S_2	120	34.0	7.14	490.00	245.00	3.00	150.00	4.79	0.00	3.99	7.30	0.00	0.00	0.87	0.00
S_3	90	23.8	6.93	445.00	223.00	1.00	500.00	3.83	0.00	4.95	5.90	0.00	0.00	0.14	5.00
S_4	95	23.7	7.13	368.00	183.00	2.00	200.00	4.49	0.01	6.33	9.60	0.00	0.00	0.83	5.00
S_5	20	25.4	7.13	683.00	339.00	58.00	7900.00	0.75	0.11	10.80	41.80	46.00	0.00	37.10	390.00
S_6	60	25.3	6.95	480.00	240.00	43.00	4500.00	3.32	0.12	6.47	44.80	14.00	0.00	56.40	440.00

After subjecting the results obtained from the laboratory analysis of borehole samples located at different distances and varying depths to ANOVA, it was found out that there are no significant differences in the quality parameters (F cal. 0.097 < F tab. 3.678). The t-test also shows that there are no significant differences between the quality parameters of the samples from the two wells located at different distances (F cal. 0.4053 < F tab. 2.0769).

The results obtained from the laboratory analysis of borehole samples were subjected to simple descriptive statistical analysis as presented in table 2.

Table 2: Descriptive Statistical Analysis of Laboratory Results for Boreholes Samples

Parameters mg/l	Range	Mean	Standard Deviation	Coefficient of Variation	Statistical Significance
Temperature ^{0}C	23.70-24.30	23.95	0.26	0.01	Insignificant
Ph	6.93-7.14	7.08	0.10	0.01	Insignificant
Conductivity µs/cm	368.00-530.00	458.75	69.77	0.15	Insignificant
Total dissolved solids mg/l	183.00-266.00	229.25	35.48	0.15	Insignificant
Total suspended solids mg/l	1.00-3.00	2.25	0.95	0.42	Insignificant
Dissolved oxygen mg/l	0.00-0.00	0.00	0.00	0.00	Insignificant
Chemical oxygen demand mg/l	140.00-500.00	247.50	170.36	0.68	Significant
BOD mg/l	3.83-4.79	4.47	0.45	0.10	Insignificant
Ammonia NH^+_4 mg/l	0.00-0.17	0.45	0.83	1.85	Insignificant
Nitrate NO_3 mg/l	3.99-6.33	5.12	0.96	0.18	Insignificant
Phosphate PO_4 mg/l	5.90-14.30	9.27	3.68	0.39	Insignificant
Coli form bacteria cfu	0.00-0.00	0.00	0.00	0.00	Insignificant
Feacal coli form cfu	0.00-0.00	0.00	0.00	0.00	Insignificant
Turbidity NTU	0.14-2.79	1.15	1.13	0.98	Significant
Colour pt	0.00-25.00	8.75	11.08	1.26	Insignificant

The results obtained from the laboratory analysis of hand dug wells samples were subjected to simple descriptive statistical analysis as presented in table 3.

Table 3: Descriptive Statistical Analysis of Laboratory Result for Hand Dug Wells Samples

Parameters mg/l	Range	Mean	Standard Deviation	Coefficient of Variation	Statistical Significance
Temperature ^{0}C	25.30-25.40	25.35	0.70	0.03	Insignificant
pH	6.95-7.14	7.04	0.13	0.02	Insignificant
Conductivity us/cm	480.00-683.00	581.50	143.54	0.25	Insignificant
Total dissolved solutes mg/l	240.00-339.00	289.50	70.00	0.24	Insignificant
Total suspended solids mg/l	43.00-58.00	50.50	10.60	0.21	Insignificant
Dissolved oxygen mg/l	0.00-0.00	0.00	0.00	0.00	Insignificant
COD mg/l	4500-7900.00	6200.00	2406.16	0.38	Insignificant
BOD mg/l	0.75-3.30	2.03	1.81	0.89	Significant
Ammonia NH^+_4 mg/l	0.11-0.12	0.11	0.01	0.06	Insignificant
Nitrate NO_3 mg/l	6.47-10.80	8.63	3.06	0.35	Insignificant
Phosphate PO_4 mg/l	41.80-44.80	43.30	2.12	0.04	Insignificant
Coliform bacteria cfu	14.00-46.00	30.00	22.62	0.75	Significant
Feacal coliform cfu	0.00-0.00	0.00	0.00	0.00	Insignificant
Turbidity NTU	37.10-56.40	46.75	13.64	0.29	Insignificant
Colour pt	390.00-440.00	415.00	35.35	0.08	Insignificant

The results of the analyzed borehole water samples were compared with FEPA acceptable limits as presented in table 4.

Table 4: Comparison of the Analyzed Boreholes Samples with FEPA Acceptable Limits

Parameters	Mean Value	FEPA Limit	Deviation	Remark
Temperature ^{0}C	23.95	<40	-16.05	Satisfactory
PH	7.08	6-9	1.08 - -1.94	Satisfactory
Conductivity µs/cm	458.75	1000	-541.25	Satisfactory
Total Dissolved solids mg/l	229.25	2000	-1770.75	Satisfactory
Total Suspended Solids mg/l	2.25	30	-27.75	Satisfactory
Dissolved oxygen mg/l	0.00	7.5	-7.5	Satisfactory
COD mg/l	247.50	80	167.5	Unsatisfactory

Table 4: Contd.,

BOD mg/l	4.47	30	-25.53	Satisfactory
Ammonia NH^+_4 mg/l	0.45	0.1	0.35	Unsatisfactory
Nitrate NO_3 mg/l	5.12	20	-14.88	Satisfactory
Phosphate PO_4 mg/l	9.27	5	4.27	Unsatisfactory
Coliform bacteria cfu	0.00	0	0	Satisfactory
Feacal coliform cfu	0.00	0	0	Satisfactory
Turbidity NTU	1.15	10	-8.85	Satisfactory
Colour pt	8.75	7	1.75	Unsatisfactory

The results of the analysed hand dug wells water samples were compared with FEPA acceptable limits as presented in table 5.

Table 5: Comparison of the Analyzed Hand Dug Wells Samples with FEPA Permissible Limits

Parameters	Mean Value	FEPA Limit	Deviation	Remark
Temperature ^{0}C	25.35	<40	-14.65	Satisfactory
PH	7.04	6-9	1.04- -1.96	Satisfactory
Conductivity µs/cm	581.50	1000	-418.5	Satisfactory
Total Dissolved solids mg/l	289.50	2000	-1710.5	Satisfactory
Total Suspended Solids mg/l	50.50	30	20.5	Unsatisfactory
Dissolved oxygen mg/l	0.00	7.5	-7.5	Satisfactory
COD mg/l	6200.00	80	6120	Unsatisfactory
BOD mg/l	2.03	30	-27.97	Satisfactory
Ammonia NH^+_4 mg/l	0.11	0.1	0.01	Unsatisfactory
Nitrate NO_3 mg/l	8.63	20	-11.37	satisfactory
Phosphate PO_4 mg/l	43.30	5	38.3	Unsatisfactory
Coliform bacteria cfu	30.00	0	30	Unsatisfactory
Feacal coli form cfu	0.00	0	0	Satisfactory
Turbidity NTV	46.75	10	36.75	Unsatisfactory
Colour pt	415.00	7	408	Unsatisfactory

The overall analyses of the results are discussed as follows;

The temperature of the groundwater samples is varied, with wells having a mean temperature of 25.35^{0}C, it decreased slightly in Boreholes to 23.95^{0}C. This is in compliance with the (FEPA 1991) effluent permissible limit of 40^{0}C as shown in table 4 and 5 above. High water temperature enhances the growth of microorganisms and this may increase taste and odor.

Wells has the least pH mean value of 7.04. This, however increased to 7.08 in boreholes respectively. This implies that well samples are slightly less alkaline than those of boreholes. An acceptable pH for drinking water is between 6 - 9 (FEPA, 1991). Therefore, both samples are within the acceptable limit, and less than those found by Adeyemo, *et al.* (2002), which were 7.0 - 8.3, and 6.92 - 8.18, respectively. This implies that the pollution level of this study is relatively fair compared with that of Adeyemo *et al*., (2002)

The electrical conductivity of well samples are higher 581.50µscm/l than those of boreholes 458.75µscm/l as shown in Table 4 and 5, both are lower than FEPA limit for portable drinking water, they are nevertheless higher than FAO recommended limit for agricultural purposes such as irrigation.(Chukwu *et al.*, 2008).

There was a marked decrease in total dissolved solids from wells samples to those of boreholes (289.50mg/l, 229.25mg/l). This is due to the proximity of the wells to the abattoir vicinity. The TDS for both wells and boreholes are within the (FEPA, 1991) tolerance limits (Table 4 and 5).

The mean values for total suspended solids of wells and boreholes samples are 50.50mg/l and 2.25mg/l respectively. This indicates an increase in TSS for wells due to their proximity to abattoir effluents and are therefore above (FEPA, 1991) recommended limit of 30mg/l.

Dissolved oxygen for both wells and boreholes samples were found to be zero and are far below the (FEPA, 1991) permissible limit. The low dissolved oxygen in boreholes may be due to the fact that dissolved oxygen decreases with increase in temperature, and for wells, may be due to their proximity with effluents discharged in the vicinity.

The COD mean value for borehole samples is 247.50mg/l while that of hand dug well is 6200mg/l, both results indicate a very high COD value higher than the recommended FEPA standard of 80mg/l. This could probably be due to the rate of dilution of the pollutant that leads to a very large margin between the two samples. It is to be noted that high level of COD value is an indication of the presence of chemical oxidants in the effluents while low COD indicates otherwise. Chemical oxidants affects water treatment plants by causing rapid development of rust *(*Chukwu *et al., 2008).*

The biological oxygen demand for the groundwater samples from boreholes is 4.47mg/l and for wells 2.03mg/l from table (4 and 5). All the Groundwater samples have BOD values which are lower than the maximum permissible limit for FEPA 30mg/l.

Ammonia appears to be slightly above FEPA maximum permissible limit 0.1mg/l in both groundwater samples, with hand dug well, having a lower value of 0.11mg/l and borehole 0.45mh/l.

The amount of nitrate in the groundwater samples as obtained in table 4 and 5 above indicates a mean value of 8.63mg/l for hand dug wells and 5.12mg/l for borehole samples. The figures are within the FEPA (1991) 20mg/l guideline value for drinking water.

The mean value of phosphate from the borehole samples is 9.27mg/l and that of hand dug wells is 43.30mg/l. Both groundwater samples have a mean values which are higher than FEPA (1991) 5mg/l permissible limit. This may be due to the abattoir effluents percolation in to the groundwater or due to the geochemistry of the aquifers.

Coli form bacteria are found to be zero count for groundwater samples from boreholes and 30mg/l for wells samples. The maximum tolerance value for these organisms in drinking water as recommended by FEPA, (1991) is 0 fcu/100ml. This indicates that the water from wells is contaminated due to the abattoir effluents discharge and percolation to groundwater.

Feacal Coli form bacteria are found to be zero count for both boreholes and well water samples. The maximum tolerance value for these organisms in drinking water as recommended by FEPA is 0cfu/100ml. The absence of feacal coli form in a water sample is an indication of water not contaminated with feaces or not in contact with feacal material of ruminant animals.

The mean turbidity value of wells sample is 46.75NTU, higher than (FEPA, 1991) acceptable limit. That of the borehole water sample is 1.15NTU within the acceptable limit. The high turbidity of the wells 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 samples from boreholes are clearer than those from wells.

The color means value for boreholes samples is 8.75pt and that for hand dug wells is 415pt.The maximum tolerance limit recommended by FEPA is 7pt. Thus, indicating that borehole samples are slightly above the recommended limit, while the hand dug wells samples exceeded by far the recommended limit.

CONCLUSIONS

The result of the study revealed that the quality of groundwater from wells had been lowered, as most of the analyzed parameters were above the recommended standards. This is most likely due to the proximity of the wells to the abattoir and hence they bear the effect of the percolation of the abattoir effluents into the soil. This therefore rendered the water from these wells unfit for human consumption unless they are adequately treated. Residents living in abattoir vicinity may in no distant time begin to experience severe consequences of pollutants from abattoir activities located in their neighborhood if wells in the area remain their only source of water. On the other hand the study also revealed that most of the parameters analyzed from boreholes were in accordance with the standard, except for color, phosphate and ammonia that are slightly above the recommended limit. Chemical oxygen demand is found to be far above the limit. Thus requires very minimal treatment prior to consumption. The analysis of variance (ANOVA) and t-test also revealed that there is no significant variation between parameters of samples collected from boreholes at different distances and depths. For hand dug wells samples, the t-test indicated that there are no significant differences in the parameters of samples collected from the hand dug wells at different distances.

RECOMMENDATIONS

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

- There is a need for the treatment of the abattoir effluents before they are disposed into the environment so as to minimize the pollution of the groundwater around the abattoir.
- Aggressive public awareness and enlightenment on possible impacts of pollution from abattoir wastes should be embarked upon by relevant agencies.
- 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 a comprehensive monitoring programme by concern authorities.
- Wells should be lined with concrete rings as this will reduce seepage of contaminants from the side wall.

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