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Analysis of Groundwater Pollution from Abattoir Waste in Minna, Nigeria

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Abstract: Abattoir wastes are hazardous as many contain small quantities of components which are potentially dangerous to man and the environment. These wastes can seep through the ground and contaminate groundwater with nitrate and bacteria. This study analyzed the effects of pollution on groundwater around an abattoir using Minna abattoir as a case study. Physical, Chemical and Organic parameters of two wells (W_1 and W_2) around the abattoir were analyzed. The values of the parameters obtained from the analyses were: Turbidity (115.0, 11.0 FTU), electrical conductivity (260.0, 250.0 mg L^{-1}), pH (8.4, 8.4), Hardness (72.0, 113.0 mg L^{-1}), Iron Content (0.44, 0.51 mg L^{-1}), Nitrate (1.0, 0.6 mg L^{-1}), Phosphate (2.04, 0.6 mg L^{-1}), Magnesium (10.5, 16.5 mg L^{-1}), Nitrite (0.152, 0.016 mg L^{-1}), BOD (3.25, 2.41 mg L^{-1}), COD (2.11, 1.92 mg L^{-1}) and DO (1.50, 0.86 mg L^{-1}). The first value in each bracket is for W_1 (well1) and the second value is for W_2 (well 2). The results of the analyses of the wells when compared with World Health Organization (WHO) standards for drinking water were higher than recommended limits; this implies that the portability of the tested groundwater is not acceptable. The well water should be treated before use.

Key words: Abattoir waste, analysis, groundwater, hazard, pollution, wells

INTRODUCTION

Waste could be hazardous or non hazardous. Hazardous waste is defined as the waste that poses Ssubstantial harm to human health or the environment when not properly treated, stored, transported or disposed off or otherwise managed, while non hazardous waste refers to the waste that is converted into economical use either by analysis or treatment (Gilbert, 1998). The regulations governing varieties of waste use describe the different types of wastes including controlled, household, industrial, commercial, abattoir and special wastes. In such cases, strict definitions of waste have financial and legal implications for businesses, local authorities and government. In addition, for the requirements of a legal definition of waste, agreements on definitions and classification of waste are required for local, regional and national waste management planning. In Nigeria, Federal Environmental Protection Agency (FEPA) now Federal Ministry of Environment (FME) is responsible for the collection of data on waste which are used by local authorities and planning departments in the preparation of their local plans for waste management.

Abattoir waste or meat processing waste is another form of agricultural waste. Slaughter house waste include intestinal content, rumen, scraps of tissues, horns, bones, blood, faecal matter, fatty and proteinous materials. Abattoir waste just like any other waste can be detrimental to humans and the environment if definite precautions are not taken. In general, the major environmental problem associated with abattoir waste is the large amount of suspended solid and liquid wastes as well as contamination of the environment with odour (Abdul Gafar, 2006).

Sources of waste in red meat abattoirs: The different sources of waste in red meat abattoirs could be categorized as animal pens; bleeding, carcass processing, offal and by-products processes and processing.

Types of waste

Solid waste: The processing of meat material is the beginning of solid waste generation. Solid waste is classified into garbage and rubbish. Garbage are putrefied waste from food processing industries, while rubbish are non-perishable wastes that are either combustible or non-combustible such as paper, carton and wood.

Liquid waste: The meat processing industry generates large quantities of effluent rich in organic compounds/ nutrients and plants require the best tools available to manage wastewater effectively. Wastewater may be defined as a combination of liquid or waste water removed from residues, institutions and commercial and industrial establishments, together with such groundwater, surface water and storm water as may be present (Metcalf and Eddy, 1991). If untreated wastewater is allowed to accumulate, the decomposition of the organic materials it contains can lead to the production of large quantities of mal-odorous gases.

Gaseous waste: Greenhouse gas emission and pollution are two serious environmental side-effects of abattoirs. Abattoir effluent adversely impacts human health, agriculture, portable water and the ecology of aquatic species and has become a significant problem for many urban communities in Nigeria. There are currently no waste treatment plants for abattoirs in Nigeria. Legislation for the protection of water sources is inadequate and there is no clearly established and coordinated policy framework to tackle water pollution and greenhouse gas emission.

At present in Minna, Niger State, Nigeria, little attention is given to abattoir waste management. Abattoir wastes are hazardous as many contain small quantities of components, which are dangerous or potentially dangerous to the environment. It is not a pleasant statistics that a 100 cow diary herd can produce as much waste as 2,400 people. But that is not the only unpleasant fact, in certain types of soil this waste can seep through the ground and reach groundwater, polluting it with nitrate and bacteria. Meat processing industries (abattoirs) are generally less developed in developing countries like Nigeria unlike advanced countries, where waste generation, analysis and treatment are considered before constructing the abattoir. This study would therefore, be a step towards realizing this goal. The main objectives of this research are to carry out qualitative analysis of wastes (suspended solid and liquid) and also to analyze the effect of the wastes on groundwater and then identify the necessary treatments the wastes generated by the abattoir can undergo.

MATERIALS AND METHODS

Description of minna abattoir: Minna town lies on latitude 9°30'N and longitude 6°3'E in Niger state, Nigeria. The Abattoir is located in an area called Tayi Village, along Bosso Road, Minna. It is constructed in such a way to accommodate 3-4 slaughtering at a time. The abattoir is divided into three sections namely, the slaughtering section, the processing section (skin and bone removal/ skin burning) and waste dumping site.

Collection of samples and method of analysis: For groundwater analysis, samples were taken from two wells around the abattoir. Sample designated as sample A is an old well within the abattoir premises. It is about 10-12 m away from the slaughtering section. Sample B was collected from a well in a residential compound, which is 300-320 m away from the abattoir. The samples were collected using 0.50 L plastic containers and were taken to the laboratory for further analysis. The method and the procedure of the analysis were those developed by the American Public Health Association (APHA, 1995, 2000).

RESULTS AND DISCUSSION

The results of the analysis based on APHA (2000) for the physical parameters of the water samples from the two wells are presented in Table 1.

Electrical conductivity (Ec): Electrical conductivity is a method for obtaining an estimate of dissolved solids in waste water samples. The samples A and B had 260 and 250 μs cm^{-1}, respectively (Table 1). According to Rhoades *et al.* (1992), these values are within the allowable limit for groundwater though on a very high side for drinking water. The high values may be likely due to increase in dissolved solids and/or due to the presence of metallic ions.

Total dissolved solids and suspended solids: The total dissolved solids for sample A and sample B (Table1) are, respectively within FEPA limits of 2000 mg L^{-1} and WHO tolerance limits of 500 mg L^{-1} (WHO, 2004). Thus, the contamination is not high enough to be worrisome. The Suspended Solids in sample A (Table 1) far exceed the allowable limit of FEPA which is 30 mg L^{-1}. This may likely be related to the presence of organic matter and mainly to the fact that the abattoir does not treat its waste at all. This high value obtained indicates high potential of leachates to cause gross organic pollution.

Temperature: Samples A and B have the same temperature of 26.2°C (Table 1). Comparing this value to FEPA (1991) standard (35-40°C), it would not have any effect on the environment though if allowed to exceed the FEPA limit it would greatly reduce the level of dissolved oxygen.

Table 1: Physical parameters of the groundwater samples

Parameter	A	B
Electrical conductivity (μs cm^{-1})	260	250
Total dissolved solids (mg L^{-1})	130	120
Temperature (°C)	26.2	26.2
Ph	8.4	8.4
Odour	Free	Free
Suspended solids	83	0
Turbidity (FTU)	115	11

FTU = Formazin Turbidity Units

Odour: Both samples A and B were free of odour. This might likely be related to the distance of the collection points from the abattoir.

pH: Samples A and B have pH value of 8.4. When, this value is compared to FEPA pH range of 6-9 and WHO pH range of 6.5-8.5, it shows that it is within the tolerance limit, though it is too close for comfort.

Turbidity: Turbidity is associated with suspended solids concentrations. It was observed that size and concentrations of particles influenced the measurement of turbidity. Sample A had 115 FTU and sample B had 11 FTU (Table 1). WHO (2004) allows 5 FTU. The turbidity values of samples A and B are above the allowable limit with sample A having great potentials to be deleterious. The large difference between the two may be related to the distances of the wells from the abattoir. The nature of the solids causing the turbidity may have some health implications.

The results of the analysis based on APHA (2000), for the organic parameters of the water samples from the 2 wells are presented in Table 2.

Biological oxygen demand and Chemical Oxygen Demand (COD): Biological oxygen demand is the most commonly used index in water quality management. It represents the amount of oxygen required for the biological decomposition of organic matter under aerobic condition at a standardized temperature (20°C) and time of incubation (usually 5 days). It is an expression of how much oxygen is needed for microbes to oxidize a given quantity of organic matter. However, organic matter will undergo chemical oxidization even in the absence of decomposers. The amount of oxygen needed to achieve this is called the chemical oxygen demand.

The wells generally had low BOD content with well 1 having 3.25 mg L^{-1} and well 2 having 2.41 mg L^{-1} (Table 2). This may be related to the distance of the wells from the abattoir. These values are within the allowable limits of 40 mg L^{-1} for FEPA and 20 mg L^{-1} for FAO for water used for agricultural purposes. The values are however, at variance with the WHO (2004), permissible limit of 0.0 mg L^{-1} for drinking water. This implies that it is dangerous to drink the water from the wells without treatment. This is because high BOD leads to less dissolved oxygen, which is detrimental to life.

Table 2: Organic parameters of the samples

Parameter (mg L^{-1})	A	B
Biological Oxygen Demand (BOD)	3.25	2.41
Chemical Oxygen Demand (COD)	2.11	1.92
Dissolved Oxygen (DO)	1.50	0.86

The COD for the wells are 2.11 mg L^{-1} for well 1 and 1.98 mg L^{-1} for well 2. These values do not exceed FEPA's maximum limit of 80 mg L^{-1}. High level of COD indicates the presence of chemical oxidants in the wells and low COD indicates otherwise. High COD could likely cause nutrient fixation in the soil resulting to reduced rate of nutrient availability to plants. In addition, chemical oxidation affects water treatment plants by causing rapid development of rust. This would reduce the service life of the plant (Chukwu, 2005).

Dissolved Oxygen (DO): The dissolved oxygen in the wells was found to be 1.40 mg L^{-1} for well 1 and 0.86 mg L^{-1} for well 2. These are within FEPA's allowable limit of 30.0 mg L^{-1}. Most game fish require at least 4-5 mg L^{-1} level of DO to thrive (Corson, 1990). It therefore, means that water from the wells can not be used for the breeding of fish in fish ponds.

Complete absence of DO results to anaerobic condition, putrefaction and the development of foul odour. DO in liquids provides a source of oxygen needed for the oxidation of organic matter when the concentration is high and lack of it in acute cases may cause the water body to become dead or devoid of aquatic life. Another, important factor is the temperature of the well water. This is because cold water holds more oxygen in solution than warm water. Moderately, high dissolved oxygen content is necessary for the maintenance of healthy aquatic ecosystems and particularly for the most prized game fish such as salmon and trout (Chukwu *et al*., 2007).

The results of the analysis based on APHA (2000), for the chemical parameters of the water samples from the two wells are presented in Table 3.

Iron content: The beneficial effects of iron include: Chlorophyll synthesis, oxidation-reduction in respiration, constituent of certain enzymes and proteins. The iron

Table 3: Chemical parameters of the samples

Parameter (mg L^{-1})	A	B
Total hardness	72	113
Total alkalinity	128	171
Hardness (Ca) as $CaCO_3$	28.8	45.3
Hardness (Mg) as $MgCO_3$	43.2	67.7
Iron content	0.44	0.51
Nitrate as nitrogen	1.0	0.6
Nitrate	4.4	2.64
Sulphate	8	15
Phosphate	2.04	0.60
Calcium	11.52	18.12
Magnesium	10.50	16.45
Nitrite	0.512	0.050
Nitrite as nitrogen	0.155	0.016
Nickel	0.010	0.020
Copper	0.00	0.00

concentrations of the samples compared to FEPA's limit of 20 mg L^{-1} and FAO limit of 5 mg L^{-1} were okay but exceeded the WHO (2004) limit of 0.30 mg L^{-1}.

Sulphate: The sulphate concentrations of the samples were 8.0 and 15.0 mg L^{-1} for sample A and sample B, respectively. These concentrations were far below the FEPA and WHO (2004) requirements of 50 and 250 mg L^{-1}, respectively. Sulphate is an essential constituent of volatile crops such as onion and garlic. It gives them their characteristic fragrance.

Calcium: The calcium content for sample A and sample B were 11.52 and 18.12 mg L^{-1}, respectively. These values are far below the calcium requirement allowed by FEPA (2001). This could be related to the wastewater mixing with fresh water.

Magnesium: High content of Magnesium and calcium results to hardness of water. Magnesium has also been known to be essential for plant growth and development. From the results of the analysis, the Magnesium content for sample A was 10.50 mg L^{-1} and sample B was 16.45 mg L^{-1}. This is far below the FEPA's requirement of 200 mg L^{-1}.

Conclusion and recommendations: Physical, Chemical and Organic Analyses of two wells around Minna Central abattoir were carried out. The results of the analyses were then compared to FAO, FEPA and WHO standards. From the comparisons, it was concluded that the essential elements required in drinking water were below expectation and that the water was slightly polluted. It was therefore, recommended that the water be treated before drinking and that the various regulatory measures put in place by FAO, FEPA and WHO should be vigorously ensured to reduce further contamination of the groundwater within the vicinity of Minna Central abattoir. This can be achieved by ensuring strict compliance by polluters and follow-up by a comprehensive monitoring programme.

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