ASSESSMENT OF THE IMPACT OF ABBATTOIR WASTE ON GROUND WATER QUALITY IN MINNA USING WATER QUALITY INDEX

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Abstract
This study is aimed at evaluating the impact of abattoir operations on quality of ground water in Tayi Village located in Minna, Niger State employing the National Sanitation Foundation Water Quality Index. This was done by subjecting water samples from the selected wells and pond to comprehensive physicochemical analysis using APHA standard methods of analysis. The values of the samples were compared with the World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) permissible limits. Respective rating using the NSFWQI was achieved by selecting the results of parameters such as Dissolved Oxygen, E-coli, pH, BOD_5, Nitrite and Temperature for each sample and transferring them to a weighing curve chart which converted each selected parameter in their various standards units into a unit-less sub-index (Q-value). Weighs were assigned to the parameters based on their importance in drinking water. The NSFWQI for each sample was obtained by adding the product of Q-value with their associated weight for each parameter. The water quality rating for wells A, B, C and D62.809,59.27, 60.98 and 77.14 which fell within the medium range, hence not good for drinking.

Keyword: Abbattoir, water quality index, water quality, ground water

1.0 Introduction

Ground water also called subsurface water are water that occurs below the surface of the earth. It is an important component of the hydrologic cycle and constitutes about two-third of the fresh water resources of the world (Garg, 2005). The value of groundwater lies not only in its wide spread occurrence and availability but also in its consistent good quality, which makes it an ideal supply for drinking water (UNESCO, 2000). Groundwater is harvested through construction of boreholes and wells in Nigeria as well as in Africa.

The reliance on ground water can be traced back to the early times as it was exploited for domestic use, livestock and irrigation (Garg, 2005). In the present times, many of the major cities of Africa and its rural environs are ground water dependent. For many millions more, particularly in Nigeria, who do not as yet have any form of improved supply, untreatedgroundwater supplies from unprotected wells with handpumps and boreholes are been resorted to, toprovide daily water need for domestic consumption, manufacturing and agriculture (Okeke and Igboanua, 2003).

Studies have shown that among many sources of pollutionthat could pose threat to surface and ground water sources, chief among is the indiscriminate discharge of untreated waste and/or effluent from abattoir (Osinbajo and Aide, 2007; Balogun et al., 2012; Ekpetere et al., 2019). Anthropogenic activities by man throughmechanizedagricultural practices, increased population density and rapid urbanization as well as domestic and industrial usage are also threats faced by this precious resource (Ashafa, 2020). The pollution load on a water body from abattoir effluent can be quite high (Hassan et al., 2014). Literatures in relation to impact of abattoir effluent in some cities in Nigeria showed very high contaminant level in abattoir effluent (Osinbajo and Aide, 2007; Balogun et al., 2012, Ekpetere et al., 2019). Most of these are known to be hazardous to human beings and aquatic life. Furthermore, indiscriminate disposal of abattoir effluent from slaughter house to surrounding water bodies and land has been reported to be responsible for the cause of diseases such as *Bacillus*, *salmonella* infection, typhoid fever, asthma, Wool Sorter disease, respiratory and chest disease which include pneumonia, diarrhoea, typhoid fever, asthma (Ogboru, 2001; Oyedemi, 2000). The presence of abattoir in Minna breeds a ground for a potential environmental quality problem. Hence, it is pertinent to analyse the quality of the surrounding ground water sources to ascertain the level of contamination.

Nouri et al. (2008) defines an abattoir (also called slaughter house) as a place approved and registered by the controlling authority for hygienic slaughtering and inspection of animals, processing and effective preservation and storage of meat products for human consumption. Hassan et al. (2014) opined that although butchering of animals brings about significant meat supplies and production of useful by-products, the processing activities involved could constitute environmental hazard to human and animal health when not regulated.The characteristics of abattoir wastes and effluents vary from day to day depending on the number and type of stocks being processed (Omole and Longe, 2008; Pejman et al., 2009). However, Weobong and Adinyira (2011) reveal that waste from slaughter house can affect water, land and air qualities if proper practices are not followed.Furthermore, wells in vicinity of abattoir which serves as source of water to abattoir constitute high risk for the butchers and users of the wells as they are prone to be contaminated (Hassan et al., 2014).

Water quality of any specific source can be assessed using physical, chemical and biological parameters. The values of these parameters pose a serious threat to human health if they exceed the defined limits (Tyagi, Shweta *et al.*, 2013). Therefore, the adequacy of water sources for human consumption can be determined using water quality index (WQI) which is one of the most effective tools to describe water quality. Water quality index (WQI) is a rating or a single number that expresses overall water quality at a specified location based on several water quality parameters. The use of individual water quality parameter to produce complex water quality data is not easily understandable to the layman, therefore the WQI reduces the mass of information into a single value to express the data in simplified and logical form (Tyagi, Shweta *et al.*, 2013).

The improper disposal of waste and/or effluent due to poor facility management in Minna abattoir and many others in Nigeria could lead to environmental pandemic. It is as result of this, that this study is aimed assessing the impact of abattoir waste on ground water quality in Tayi Village Minna, Niger state and to establish respective water quality index for the surrounding water source.

2.0 Materials and Methods

2.1 Study Area

Tayi village is a sub-district of Minna located in Bosso Local Government Area of Niger state. Top soil of loamy sand to sandy loam covers the top layer of the study area (King and Williams, 2020). Tayi has a latitude and longitude of $9^{o}39'02''$ N, $6^{o}33'12''$ E and the area is found at an altitude of 259.14 m. The major economic activities are farming, trading, service rendering like dry-cleaning and “okada” transportation. The abattoir is located in Tayi villa along Bosso road. The design of the abattoir is such that four matured cows can be butchered at once. The abattoir consists of the slaughtering section, the processing section where skiing and bone removal is carried out and waste dumping site.

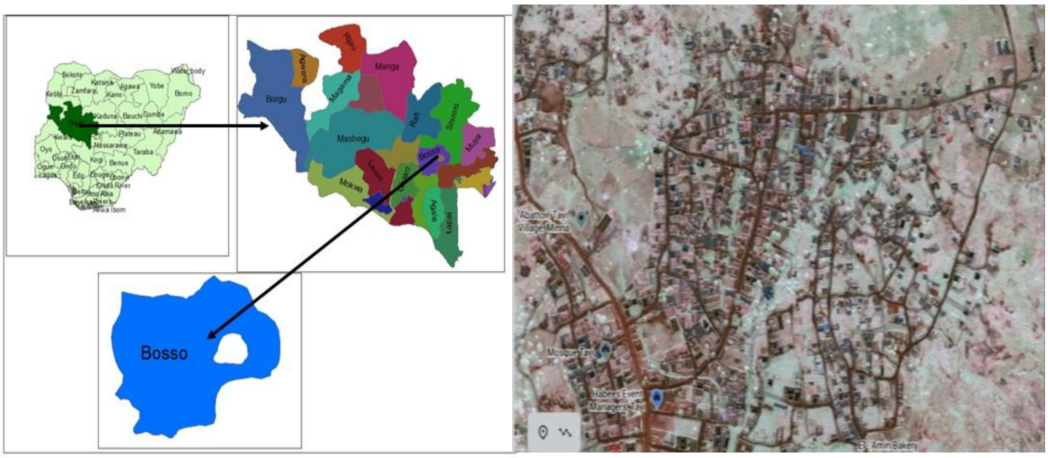

Fig. 1: Tayi Village.

Source: Google Map

2.2 Methods / Experiments

Four samples from hand dug wells labeled well A to well D located 40m away from the slaughter house were collected. In details the description of each sample is given as follows:
Well A: ground water sample selected from the neighborhood about 40m away from abattoir
Well B: well water sample obtained 10m away from the slaughter house
Well C: well water sample obtained 20 away from the slaughter house
Well D: well water sample obtained 30 away from the slaughter house
The samples were then transported to the department of Water Resources, Aquaculture and Fisheries technology for analysis using recommended standard procedures of American Public Health Association (APHA).

2.3 Water Quality Index determination

The National Sanitation Foundation Water Quality Index (NSF-WQI) was adopted to evaluate the quality of water samples of wells. Water samples from wells were used because in the study area the water source is mainly used for cooking, drinking and laundry. To achieve this, DO, E-coli, pH, $BOD_{5,}$ Nitrate, $PO_{4,}$ and temperature were selected which is in line with the work of Brown et al, (1970). The results of the physical, chemical and biological analysis were transferred to a weighing curve chart which converted standard unit of the selected parameters into a unit-less sub index also called Q-value. Associated weights were assigned to the parameters based on their importance in drinking water. The numerical values obtained from the quality index curve were multiplied by the associated weight. The total water quality index was then obtained by summing up water quality index (parameter index) for each of the selected parameter using equation 1. The obtained index value was compared against a range of value for water quality rating as given in table 1 in order to rank it appropriately as described by Tyagi, Shweta *et, al* (2013).

Table1: NSF WQI Analysis and Weights

Parameter	WQI Weight
Dissolved Oxygen	0.17
Faecal Coliform Density	0.15
pH	0.12
BOD_5	0.10
Nitrates	0.10
Total Phosphates	0.10
Temperature	0.10
Turbidity	0.08
Total Solids	0.08

Source: Martin and Kim (1996)

$$\text{The NSFWQI} = \sum_{i=1}^{n} q_i \, w_i \qquad (1)$$

Where: Q_i = sub-index for ith water quality parameter.

W_i = weight associated with ithwater quality parameter.

n = number of water quality parameter

Less than nine parameters (six or more), the WQI is calculated as:

$$\text{The NSFWQI} = \frac{\sum_{i=1}^{n} q_i \, w_i}{\sum w_i} \qquad (2)$$

Tyagi, Shweta *et al*. (2013) summarized a water quality rating based on NSF computation as seen in table 2.

Table 2: Water quality rating based on NSF

Numerical Range	Quality
0-25	Very bad
26-50	Bad
51-70	Medium
71-90	Good
91-100	Excellent

Source: Tyagi, Shweta *et al.* (2013)

3.0 Results and Discussions

3.1 Physico-chemical Analysis of ground water samples.

The pH for well A to well B ranged from 6.80 to 7.42 with a mean value of 7.20. The values fell within WHO standards of 6.5 to 8.5, which is in line with the study conducted by Ojekunle and Lateef (2017).

Temperatures for samples collected at well A to D were in-situ tested. Well B has a temperature of 28.2^{o}C being the highest value amongst the samples, while well A has a temperature of 27.8^{o}C the samples are a little bit above ambient temperature as specified by WHO standards.

The TDS value of the result obtained from the analysis of well B has the highest value 474.6mg/l while well A has the lowest value of 101.36mg/l. Although, the value ranged from 101.36mg/l to 474.16mg/l for the well samples, all the values obtained fell below the NSWDQ standard

(500mg/l). According to Ojekunle and Lateef (2017) high concentration of TDS are caused by the presence of potassium, chloride and sodium.

Electrical conductivity is the ease to which a substance allows free flow of electricity through the ions in electrolytes of water samples (Ojekunle and Lateef, 2017). Well B has a value of 1476mg/l which is above WHO standard of 1200mg/l and NSDWQ standard of 1000mg/l. All other ground water samples fell within both WHO and NSDWQ standard. Efe (2001) asserted that any concentration above WHO standard can pose health risk of defective endocrine functions and also total brain damage with prolong exposure. Hence, well B pose a high-risk level since its value is higher than the maximum permissible of both standards.

The chloride values ranged from 19.60mg/l to 107.8mg/l which falls within the WHO standard NSDWQ standard of 250mg/l. Well A and D have the same value of 19.60mg/l while well B and C have 107.8mg/l and 91.14mg/l respectively. Excess chlorides make water unpalatable for drinking.

Nitrate is a polyatomic ion and it is a problem when it is above the permissible limit in drinking water (Ekpetere et al, 2019). The result of this analysis shows that well C has high concentration of nitrate while well A, B, and D has concentration levels 0.8, 3.56 and 2.10mg/l respectively. However, all the samples were found to be below the permissible limit of 50mg/l set by NSDWQ.

The result obtained from the analysis reveals that the BOD in well B and C are slightly above the prescribed standard of 10mg/l. This could be related to the distance of the wells to the abattoir. The value of Well B and C are 13.0 and 11.0 mg/l respectively. This implies that water from both wells needs treatment as high BOD leads to dissolve oxygen which is detrimental to life. While wells A and D have concentration value of 8mg/l and 7 mg/l respectively which are within permissible limit of WHO and NSDWQ.

The hardness in the wells ranged from 90mg/l to 270mg/l. Well B and C are at variance with NSDWQ standard of 150mg/l, while Well A and D have concentrations that are within the permissible limit. The concentrations of calcium are found to be within the permissible limit of 200mg/l as set by WHO as it from 29.43 to 92.5mg/l. Well A and D have the same value of 29.43mg/l. The magnesium level for the four wells is all within NSDWQ standard of 200mg/l. Ogbonaya (2008) reveals that magnesium is essential for plant growth and development, and high concentration can result to hardness of water.

Phosphate was found to be within the permissible limit in the water samples. The average concentration of phosphate was found to be 2.09mg/l which is within the limits of 5mg/l by WHO while the iron concentration of the samples exceeded WHO 2004 limit 0.3mg/l.

The total coliform of the water samples from the wells ranged between 4cfu/100ml to 38cfu/100ml, this is above the WHO set permissible limit. Ekptere et al. (2019) asserts that the total coliform concentration above that set by WHO has health implications such as urinary tract infection, diarrhea and acute renal failure. Meanwhile the total bacteria plate count falls within the WHO standard of 100cfu/ml. These results agree with previous studies made by Oyedemi (2000) in Ogbomosho town that abattoir waste water has considerable range of biological and chemical pollutants.

Table 3: Physical parameters of wells A, B, C and D

Parameters	A	B	C	D
Temperature (^oC)	27.8	28.2	27.9	28.0
Conducting (µ/cm)	324	1476	1190	399
TDS (mg/l)	101.36	474.16	376.14	125.48
pH	7.62	6.80	6.97	7.42

Table 4: Biological parameters of wells A, B, C and D

Parameters	A	B	C	D
Total Coli form Count (cfu/100ml)	38	17	12	4
Total Bacteria Count (cfu/100ml)	48	68	68	72

Table 5: Chemical parameters of wells A, B, C and D

Parameters	A	B	C	D
Iron (mg/l)	3.50	2.70	1.10	2.30
Total Hardness (mg/l)	90	270	186	98
Total Acidity (mg/l)	72	76	142	108
Calcium (mg/l)	29.43	92.51	63.07	29.48
Magnesium (mg/l)	4.02	9.51	6.95	5.97
Chlorine (mg/l)	19.60	107.8	91.14	19.60
BOD	8.00	13.00	11.00	7.00
COD	40.00	44.60	28.00	80.00
Phosphate (mg/l)	2.30	2.55	1.82	1.70
Nitrate (mg/l)	0.80	3.56	5.88	2.10

3.2 Water Quality Index Computation

The WQI for each of the sources under investigation was determined using NSF-WQI. In line with the work of Brown *et al*, (1970), the parameters which were selected according to order of importance for physico-chemical and bacteriological analysis were DO, E-coli, pH, BOD_5, Nitrate, Phosphate, Temperature and total solid. Tables 6, 7, 8 and 9 present the value of Q_i and W_i with their respective parameter index or subtotal for Well A to Well D. Well A has a DO value of 7.41mg/l, which is equal to 90% saturation when converted to percentage saturation of oxygen using a level of oxygen saturation chart. The corresponding values of Qi and Wi gave 95 and 0.17 and their product gave subtotal of 16.15 The overall water quality index was obtained by adding the total parameter indices and dividing the result by the summation of the total weight factor to give WQI of 62.802. This shows that Well A can be rated as medium. Well B having a total coliform count of 17 cfu/100ml and corresponding values Q_i and W_i as 65.4 and 0.15 respectively has a subtotal of 9.81. The overall WQI was obtained like that of Well A which gives value of 65.08. Well B is rated as medium. The same procedure was used to obtain ratings for wells C and D. The result of the WQI for the water sources showed that none of wells can be used as a source of drinking water without proper treatment.

Table 6: Well A WQI

Parameter	Test Value	Mean Q-value (Qi)	Weight Factor (Wi)	Parameter Index (Qi Wi)
Dissolved Oxygen (% sat)	90	95	0.17	16.15
E.colicfu/100mc	38	57	0.15	8.55
pH	7.62	91.2	0.12	10.944
BODS (mg/l)	8	40	0.10	4
Nitrate (mg/l)	0.80	94.8	0.10	9.48
Phosphate (mg/l)	2.30	24.5	0.10	2.45
Temperature	27.8	11.76	0.10	1.176
		Total	0.84	52.6
			WQI	62.802

Table 7: Well B WQI

Parameter	Test Value	Mean Q-value (Qi)	Weight Factor (Wi)	Parameter Index (Qi Wi)
Dissolved Oxygen	102.5	96.5	0.17	16.405
E.coli	17	65.4	0.15	9.81
pH	6.80	83	0.12	9.96
BOD	13.00	24.8	0.10	2.48
Nitrate (mg/l)	3.56	76.6	0.10	7.66
Phosphate (mg/l)	2.55	23.25	0.10	2.325
Temperature	28.2	11.44	0.10	1.144
		Total	0.84	49.784
			WQI	59.27

Table 8: Well C WQI

Parameter	Test Value	Mean Q-value (Qi)	Weight Factor (Wi)	Parameter Index (Qi Wi)
Dissolved Oxygen	100	99	0.17	16.83
E.coli				
pH	12	69.4	0.15	10.41
BOD	6.97	90	0.12	10.8
Nitrate	11	30.2	0.10	3.02
Phosphate	5.88	62.54	0.10	6.254
Temperature	1.8	27.44	0.10	2.744
	27.9	11.74	0.10	1.1714
		Total	0.84	51.2294
			WQI	60.987

Table 9: Well D WQI

Parameter	Test Value	Mean Q-value (Qi)	Weight Factor (Wi)	Parameter Index (Qi Wi)
Dissolved Oxygen	95	97.5	0.17	16.58
E.coli	4	83	0.15	12.45
pH	7.42	92.73	0.12	11.13
BOD	7.00	69	0.10	6.0
Nitrate	2.10	90	0.10	9.0
Phosphate	1.70	28.4	0.10	2.84
Temperature	28.0	11.6	0.10	1.16
		Total	0.84	60.06
			WQI	71.4

Table 10: Water Quality Rating (WQR) for the selected wells

Sample	$\sum_{i-1}^{n} Qiwi/\sum$Wi	WQR
Well A	62.809	Medium
Well B	59.27	Medium
Well C	60.987	Medium
Well D	71.4	Medium

4.0 Conclusion

The physico-chemical and bacteriological parameters of water samples obtained from ground water samples around Minna abattoir in Tayi village were analyzed with a view to determining their quality. The results of the analysis were compared with those presented by World Health Organization and Nigerian Standard for Drinking Water Quality which showed that among all samples analyzed, wells B and well C have high concentrations of parameters above the WHO and NSDWQ standard of drinking water. The result obtained for the National Sanitation Foundation Water Quality Index (NSF-WQI) further indicated that all the samples drawn from each wellcan be classified as medium, that is, none of the three samples is qualified for usage as drinking water. Hence there is the need for proper treatment of the well before it can be used for drinking.This present study demonstrates the application of water quality index in understanding and appraising the quality of water. Hence the technique is a vital tool useful for the overall assessment of water quality.

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