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Assessment of Physicochemical Quality of Abattoir-Effluent Impacted Iyi-Etu River and other Water Sources at the Amansea Livestock Market Settlement, Anambra State, Nigeria

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ABSTRACT: The pollution load and anthropogenic pressure on different water sources may be reflected in the physicochemical quality evaluation of drinking water sources. This study was undertaken to evaluate the physicochemical quality of the Iyi-Etu River and other water sources such as well and borehole used by the Amansea livestock market settlement for drinking and domestic purpose. A total of 96 (36 river, 12 well, 12 borehole, 12 effluent, and 24 sachet water samples) samples were collected from these sources over 12 months. The water samples were collected using a composite sampling technique and temperature, pH, electrical conductivity, and total dissolved solids were measured onsite in triplicates using a water quality meter. Temperature, pH, electrical conductivity, and total dissolved solids recorded in this study ranged as follows: 23.8-32.6 ˚C, 5.2-8.6, 3.9×10^1 to 3.8×10^3 µS/cm and 1.9×10^1 to 1.9×10^3 mg/L respectively. The mean pH and temperature of all sample types were within WHO standard guidelines for drinking water. All sample types except well and effluent samples were within the limit of WHO guidelines for electrical conductivity of drinking water. Measurements of EC and TDS were lower upstream (112.2 µS/cm; 56.5 mg/L) than downstream 1 (203.3 µS/cm; 108.2 mg/L) and downstream 2 (197.1 µS/cm; 98.1 mg/L). These figures reveal the possible contamination of the Iyi-Etu River with abattoir effluent coming from the Amansea abattoir that is near the river. The Iyi-Etu River and well water are contaminated with different sources of contamination and serve as a public health hazard to all those using it for drinking and or domestic purposes.

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The state of the health of terrestrial and aquatic ecosystems has continuously deteriorated since the beginning of the industrial revolution and mass production in the 1900s to fulfill the demands of the ever-increasing population of humans around the world, resulting in an environmental crisis. By-products of human activities are scattered throughout the environment, and when they reach the food chain, they have long-term implications, affecting the planet's health (Olaniran *et al*., 2019). One prominent human activity is the operation of abattoirs which are often associated with pollution of the environment. Air, water, food, and soil pollution are all issues that need to be addressed. An abattoir or a slaughterhouse is a location certified and registered by the regulatory authorities for sanitary killing and processing of meat for human consumption (Igbinosa and Uwidia, 2018). There are several slaughterhouses scattered around Nigeria to meet the rising demand of the country's rapidly growing population (Olaniran *et al*., 2019; Nafarnda *et al*., 2012). Because its various untreated waste streams are frequently released into surrounding watercourses, Nigeria's meat processing sector has been identified as a key contributor to the ongoing contamination of the aquatic environment. The bulk of underdeveloped countries lack treatment facilities for abattoir effluents. The improper disposal of slaughterhouse wastes could result in infections such as cholera, salmonellosis, dysentery, and helminthiasis. Abattoir effluent pollution of aquatic

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bodies may pose significant environmental and public health risks (Neboh *et al*., 2013; Chukwu, 2008; Osibanjo and Adie, 2007). . One such abattoir is the Amansea abattoir, which is located close to the Iyi-Etu River and alongside the Enugu-Onitsha old road in the Awka North Local Government area. The Iyi-Etu River is used by the Amansea livestock market settlement for drinking and other domestic purposes. There is no data available on the physicochemical quality of the Iyi-Etu River. This study aimed at evaluating the physicochemical quality of the abattoir effluent impacted Iyi-Etu River and other drinking water sources such as well, borehole and sachet water at the Amansea livestock market settlement area.

METHODS AND METHODS

Study area: SW1 and SW2 are the geographical coordinates for two sachet water vendors and LMS is the geographical coordinate for the livestock market settlement. This study was conducted in Amansea, Anambra State, Nigeria, which is part of the Awka-North Local Government Area. Awka is located between latitude 612'N and longitude 706'E in the tropical rainforest zone. It has a humid environment with a daily average relative humidity of 79.4%. The typical daily maximum and lowest air temperatures are 32.2°C and 23.3°C, respectively, and the yearly rainfall ranges from 2000mm to 3000mm. Low-lying fertile land plains make up the Awka area. Civil servants, craftsmen, farmers, and traders make up the majority of the population (Iwueze *et al*., 2013). The population of Awka was estimated to be 189, 654 thousand (96, 902 males and 92, 752 females) in the 2006 National Population Census (Oji *et al*., 2018). The abattoir in Amansea is extremely important to the people of Amansea and Awka as a whole because it provides a plentiful supply of meat. Despite its economic importance, the abattoir poses a significant public health threat to the Amansea population due to the vast amounts of effluents and paunch manure generated, which are not treated and instead discharged into the Iyi-Etu River. The livestock market settlement uses this River for irrigation, recreation, and domestic reasons. Unfortunately, the majority of abattoirs in Nigeria are poorly run, located, and constructed. The abattoir in Amansea is not left out. The abattoir at Amansea is made up simply of a rough concrete floor without walls and a roof (Plate 1). All non-segregated and untreated effluents are discharged into the neighboring Iyi-Etu River, which drains into the Mamu River. Figure 1 shows the map of the Amansea cattle market settlement.

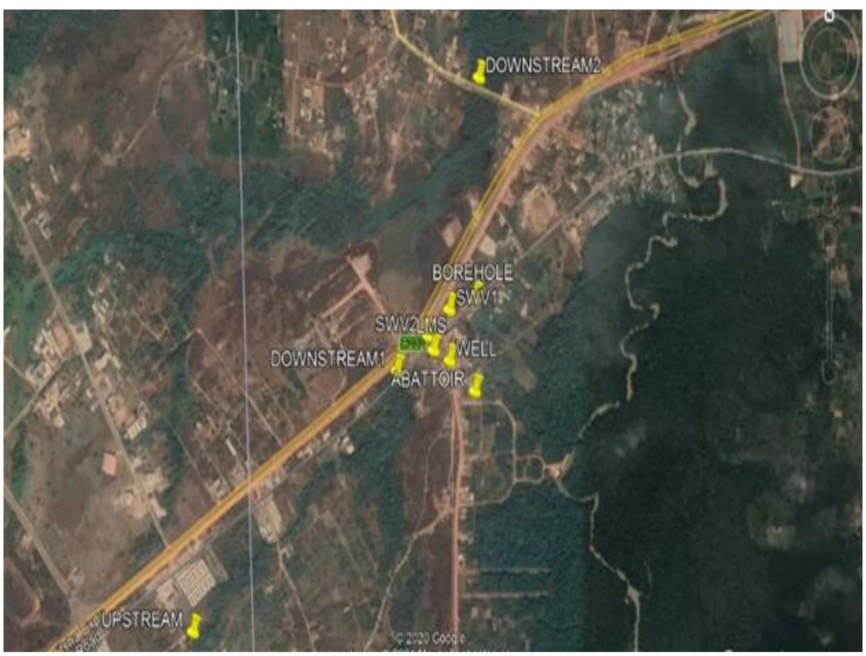

Fig 1. Map of study area (Amansea)

Sample analysis: A total of 96 (36 river, 12 well, 12 borehole, 12 effluent, and 24 sachet water samples) samples were analyzed from the water sources over 12 months. A multiple-parameter water quality analyzer (YINMIK, EZ-9908, Guangdong-China) was used to evaluate some physicochemical qualities of the water sample on-site. After calibration and during sample collection, the probe was rinsed with distilled water and then introduced directly into the water in situ, and the values of electrical conductivity, total dissolved solids, pH, and temperature were observed and recorded in triplicates (Bichi and Amatobi, 2013).

Plate 1: Amansea abattoir and some water sampling points. A= Upstream, B=Downstream point 1, C= Downstream point 2, D=Abattoir: Slaughtering going on and blood not recovered, E=Pipe channeling untreated effluent from abattoir to exterior. F= Well polluted with wastes.

RESULTS AND DISCUSSION

Table 2 compares the mean values of physicochemical water quality parameters for the three river sampling sites on the Iyi-Etu River and other water sources at Amansea livestock market settlement for the 12-month study period to reveal spatial variation. Table 3 shows the seasonal variations in the physicochemical quality parameters.

The temperature of all sampled water sources varied from 23.8 °C to 32.6 °C. Downstream 1 recorded the least mean temperature (26.6 °C) while effluent recorded the highest mean temperature (28.6 °C) (Table 2). One-way ANOVA revealed that there is a significant difference in the mean temperature across all samples ($F = 7.61$, $P < 0.05$). However, Turkey's post hoc test revealed that there is no significant difference in the temperatures between the samples in subset 1 (upstream, downstream 1, and downstream 2) ($P = 0.234$), subset 2 (upstream, downstream 2, borehole, sachet 1 and sachet 2) ($P = 0.102$) and subset 3 (sachet 1, sachet 2, borehole, well and effluent) ($P = 0.314$) but that the significant difference in temperatures of samples exists between the temperatures of samples in subset 1, subset 2 and subset 3. There was no significant difference ($P>0.05$) in the seasonal variation of temperature across all sampling sites except for downstream point 2 ($P=0.014$). The pH of all sampled water sources ranged from 5.2 to 8.6. Sachets 1 and 2 recorded the least mean pH (6.5) while effluent recorded the highest mean pH (7.7) (Table 2). One-way ANOVA revealed that there is a significant difference in the mean pH across all samples ($F = 29.72$, $P < 0.05$). However, Turkey's post hoc test revealed that there is no significant difference in the pH of the samples in subset 1 (sachet 1 and sachet 2) ($P = 1.000$), subset 2 (upstream, downstream 1, and downstream 2 and well) ($P = 0.109$), subset 3 (downstream 1 and borehole) ($P = 0.139$) and subset 4 (Borehole and effluent) ($P = 0.752$) but that the significant difference in pH exists between the pH of samples in subset 1, subset 2, subset 3 and subset 4. Although there was a seasonal variation across all samples, some samples (downstream 1, downstream 2, well, and borehole) had higher pH in the dry season and others (Upstream, Effluent, Sachet 2) had higher pH in the rainy season (Table 3). Sachet 1 showed no seasonal variation. Student t-test revealed that there is a significant seasonal variation ($P<0.05$) in the pH of the borehole, downstream point 1, well and sachet 2, and no significant seasonal variation

(PH>0.05) in the pH of downstream point 2 and effluent.

The electrical conductivity of the samples ranged from 39 to 38S/cm. The upstream sample had the least mean electrical conductivity (112.2 µS/cm) while the effluent sample had the highest mean electrical conductivity (1945 µS/cm) (Table 2). One-way ANOVA showed that there exists a significant difference in the mean electrical conductivity of all samples (F = 147.267, P < 0.05). Although Turkey's post hoc test revealed that there is no significant difference in the electrical conductivity of samples in subset 1 (upstream, downstream 1, downstream 2, borehole, sachet 1, and sachet 2) (P = 0.051), subset 2 (well) (P = 1.000) and subset 3 (effluent) (P = 1.000), it also reveals that the significant difference in electrical conductivity exists between the electrical conductivities of samples in subset 1, subset 2 and subset 3. There was no significant seasonal variation (P>0.05) in the EC of all samples except for Downstream point 2 (t=0.045) and effluent (t=0.021) samples. The total dissolved solids of the samples ranged from 19 to 1930 mg/L. The upstream sample had the least mean total dissolved solids (56.5 mg/L) while the effluent sample had the highest mean total dissolved solids (959.4 mg/L) (Table 2). One-way ANOVA showed that there exists a significant difference in the mean total dissolved solids of all samples (F = 124.19, P < 0.05). Although Turkey's post hoc test revealed that there is no significant difference in the total dissolved solids of samples in subset 1 (upstream, downstream 1, downstream 2, borehole, sachet 1, and sachet 2) (P = 0.059), subset 2 (well) (P = 1.000) and subset 3 (effluent) (P = 1.000), it also reveals that the significant difference in total dissolved solids exists between the total dissolved solids of samples in subset 1, subset 2, subset 3. There was a significant seasonal variation (P<0.05) in the TDS of all samples except for well (t=0.094) and both sachet (t=0.257; t=0.208) water sample types.

Table 1: Guidelines for drinking water.

Parameter	Maximum Permitted level	
	WHO guideline	NSDW guideline
Total dissolved solids	600 mg/l	500 mg/l
Electrical conductivity	400 µS/cm	1000 µS/cm
Temperature	25 ˚C-30 ˚C	25 ˚C
PH	6.5-8.5	6.5-8.5

Source (WHO, 2017; SON, 2015; Meride & Ayenew, 2016). NSDW: Nigerian standards for drinking water. WHO: World Health Organization.

Table 2: Spatial variations in the physicochemical characteristics of Iyi-Etu River and other water sources at Amansea livestock market settlement

Sampling site		**Temperature**	**PH**	**EC**	**TDS**
Upstream	Mean ± SD	27.1±1.2	6.9±0.5	112.2±47.9	56.5±24
	Range	24.7-30.3	5.9-7.6	39-226	19-113
Downstream 1	Mean ± SD	26.6±1.3	7.3±0.5	203.3±135	108.2±76.2
	Range	24.1-28.7	6.2-8.3	51-426	25-235
Downstream 2	Mean ± SD	27.4±2.1	7.2±0.5	197.1±98.2	98.1±50
	Range	23.8-32.6	6.2-8.3	72-356	36-180
Well	Mean ± SD	28.5±1.6	7.1±0.4	852.8±126.5	445±19.1
	Range	26-32.4	6.2-7.7	454-963	404-482
Borehole	Mean ± SD	28.0±1.1	7.6±0.4	334.1±52.8	173.9±4.8
	Range	26.1-31.1	6.8-8.4	163-361	163-181
Effluent	Mean ± SD	28.6±1.6	7.7±0.5	1945.7±840	959.4±458
	Range	26-32.4	7.1-8.6	945-3810	445-1930
Sachet 1	Mean ± SD	28.1±1.2	6.5±0.5	200.4±54.7	99.9±27.2
	Range	26.1-29.9	5.2-7.5	117-329	59-164
Sachet 2	Mean ± SD	27.8±1.5	6.5±0.5	235.7±64.7	116.6±31.3
	Range	25.3-29.9	5.9-7.6	113-327	57-159

The pollution load and anthropogenic pressure on different water sources may be reflected in the physicochemical quality evaluation of the drinking water sources. Although the mean temperature of all water sampling points exceeded the standard limits by NSDW for portable water, they were all within WHO standard guidelines for drinking water (Table 1). High temperatures have a negative impact on water quality because they encourage the growth of bacteria, which can lead to an increase in taste. Water's biological, physical, and chemical activity are all affected by temperature. The temperature recorded in this study was significantly different (P<0.05) across all sampling sites. Considering temperature records from each sampling point during all sampling trips, the effluent recorded the highest mean (28.6 ˚C) (Table 2). This may be due to the human activities going on at the abattoir that increase the temperature of the effluent water. Firstly, the temperature of the cattle is 37 ˚C. After slaughtering and evisceration of the bowel, the bowel is immediately moved to a container with water where it is washed and rinsed. This activity is expected to raise the temperature of the water in the container from which effluent was collected. This effluent is then poured and may end up contaminating the nearby Iyi-Etu River. Temperature is important for aquatic life. Aquatic animals are most vulnerable to lowered dissolved oxygen levels and warm water holds less oxygen than cold water. All temperature values were within the range of a tropical aquatic system (<40 ˚C) (EPA, 2012). Generally, across all samples, the temperature was higher in the dry season than in the rainy season. This finding is supported by a study that was done by Adeogun *et al*., (2011). The high temperatures associated with the dry season may have had a bearing on the sampled water sources. Although the highest mean PH was from the effluent water source (7.7), followed by a borehole (7.6) and the lowest mean PH came from both sachet water brands (6.5), the mean PH of all sampling points was within the standard limit (6.5-8.5) set by both WHO and NSDW guidelines for drinking water (Table 1). PH affects the survival of aquatic microorganisms and most aquatic species will die at PH≤4 or PH≥11 (Nwineewii, 2018).

Table 3: Seasonal variations in the physicochemical characteristics of Iyi-Etu River and other water sources at Amansea livestock market settlement

Sampling site	Season	Temperature	PH	EC	TDS
Upstream	Dry	27.2±1.1	6.8±0.6	94.2±45.9	47.2±22.9
	Rainy	27.0±1.3	7.1±0.4	125±46.1	63.1±23.0
Downstream 1	Dry	26.5±1.2	7.5±0.7	252.7±131.7	142.7±79.8
	Rainy	26.6±1.3	7.1±0.4	167.9±129.1	83.5±50.9
Downstream 2	Dry	26.5±1.2	7.2±0.5	235.5±85.6	117.5±43.1
	Rainy	28.1±2.3	7.1±0.5	169.6±99.2	84.1±50.9
Well	Dry	28.4±0.9	7.3±0.2	874±38.3	438.7±17.9
	Rainy	28.7±2.0	6.9±0.5	837.6±162.5	449.5±19.1
Borehole	Dry	28.1±0.4	7.8±0.4	355.6±3.7	177.2±2.5
	Rainy	27.9±1.4	7.4±0.3	318.81±65.4	171.6±4.7
Effluent	Dry	28.6±2.6	7.7±0.4	2365.5±1018	1253.8±539.2
	Rainy	28.5±1.2	7.8±0.6	1645.9±533.2	749.1±230
Sachet 1	Dry	28.4±1.1	6.5±0.4	188.9±46.0	218.9±28.0
	Rainy	27.8±1.2	6.5±0.6	208.6±60.0	247.7±80.0
Sachet 2	Dry	28.0±1.7	6.3±0.1	93.7±22.3	109.6±14.2
	Rainy	27.6±1.4	6.7±0.5	104.3±30.0	121.5±38.9

Electrical conductivity refers to a medium's ability to carry an electric current, in this case, water. The presence of dissolved minerals (solutes) in water samples, such as calcium, chloride, and magnesium, conveys the electric current through water. Mean electrical conductivity and total dissolved solids were recorded at high levels in the effluent (1945.7 µS/cm; 1253.8 mg/L) and well water (852.8 µS/cm; 445 mg/L) samples and least in upstream samples (112.2 µS/cm; 56.5 mg/L) (Table 2). Similar high TDS, EC, and temperature of effluent samples have been reported by Atuanya *et al*., (2018). The higher the soluble salt content of a liquid the higher its conductivity and total dissolved solutes concentration. The blood which is often discharged in the effluent is high in salts. Cattle faeces also contains salts though in negligible amounts. The effluent sampled in this study was rich in cattle faeces and blood. This may have accounted for the high EC and TDS values in the effluent. The high EC and TDS values recorded in the well accounts for the fact that this well is heavily contaminated with wastes. Plate 1 shows heavy pollution at the well. EC and TDS values were lower upstream (112.2 µS/cm; 56.5 mg/L) than downstream 1 (203.3 µS/cm; 108.2 mg/L) and downstream 2 (197.1 µS/cm; 98.1 mg/L). These figures show the possible contamination of the Iyi-Etu River with abattoir effluent coming from the Amansea abattoir that is near the River. Similar low EC and TDS values upstream as opposed to downstream have been reported by Osayomwanbo *et al*., (2019) and Igbinosa and Uwidia, (2018). We recorded higher EC and TDS at downstream point 1 compared to downstream point 2. This reduction in EC and TDS from downstream point 1 to downstream point 2 may be due to the river's intrinsic ability to self-purification Generally, EC values in the different sampling sources were higher in the dry season than in the rainy season. This may be because the volume of the water sources reduces in the dry season leading to the accumulation of salts and other dissolved solutes. All sample types other than effluent samples were within the limit of NSDW guidelines for electrical conductivity of drinking water while all sample types except well and effluent samples were within the limit of WHO guidelines for electrical conductivity of drinking water. All sample types other than effluent samples were within the limit of WHO and NSDW guidelines for total dissolved solids in drinking water (Table 1).

Conclusion: This study revealed that the Iyi-Etu River is impacted by the untreated effluent discharged from the Amansea abattoir. The well water was found to be heavily contaminated; hence, the elevated levels of EC and TDS observed which did not correspond with the WHO international standards for drinking water, consequently, making the well water unfit for drinking. Further studies are needed to cover other physicochemical parameters such as dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, salinity, turbidity, total suspended solids, and so on.

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