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Research Article

The pollution status of Abattoir effluent on the Otamiri River, Egbu Owerri, Imo State

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Abstract

The effects of abattoir effluent on the physicochemical and microbial properties of the Otamiri River in Imo State were examined using standard physicochemical and microbiological methods. The values of pH, temperature, total suspended solid (TSS), total dissolved solid (TDS), and electrical conductivity all fell within the WHO permissive limit for drinking water quality while the values of the dissolved oxygen (DO) and biochemical oxygen demand (BOD) far exceeded the WHO permissive limit. The total heterotrophic counts ranged from 2.5 x10^7cfu/ml – 5.2 x 10^7cfu/ml, total coliforms counts were between 1.0 x 10^7cfu/ml – 2.5 x 10^7cfu/ml while the total fungal counts ranged between 0.4 x 10^5cfu/ml – 1.8 x 10^5cfu/ml. The bacterial isolates were *Escherichia coli* (30.1%), *Bacillus spp* (18.8%), *Staphylococcus aureus* (15.0%), *Proteus spp* (10.5%), *Klebsiella spp* (10.5%), *Salmonella spp* (9.0%) and *Enterobacter spp* (6.0%) while the fungal isolates were *Aspergillus spp* (28.2%), *Fusarium spp* (25.4%), *Mucor spp* (21.1%), *Penicillium spp* (16.9%) and *Rhizopus spp* (8.5%). The high microbial counts recorded may be attributed to the high nutrient content of the abattoir effluent into the Otamiri River. Analyses of the results showed that the abattoir effluent was highly polluted and had a negative impact on the receiving water body. It is recommended that the abattoir effluent should be properly treated before it is discharged into the environment to prevent environmental pollution and water-borne diseases.

Keywords: Pollution, Abattoir, effluent, waterborne diseases, Otamiri River.

INTRODUCTION

Anthropogenic activities create an enormous number of diverse wastes and pollutants and the release of these materials into the soil, air, and water bodies most often poses serious health hazards. Abattoirs or slaughterhouses are specialized environments that harbour human activities including killing, washing, drying, skinning, packaging, and collecting animals such as cows, goats, sheep, and rams for their meat (Hornby, 2006) and skin (Ediene, 2016). Abattoir Act (1998) defined it as any premise(s) used in connection with the slaughter of animals whose meat is intended for human consumption but does not include a place situated on a farm (Bridges *et al.*, 2000). Abattoir effluents or wastes are the resultant or residual materials generated after the slaughter of these animals. These effluents comprise materials such as blood, bones, tissues, intestinal contents like urine and faeces, undissolved solids, gut contents, skin, water, etc. (Osemwora, 2010). Various organs of cattle such as muscles, liver, viscera, kidney and have been reported to contain heavy metals (Jukna et al., 2006). Abattoirs generally use large quantities of water for washing meat and cleaning process areas (Kuyeli, 2007). This waste water is a particularly concentrated source of oxygen-consuming waste (Girads, 2005). It has been established that poor waste management is responsible for the environmental and health hazards associated with abattoirs. The hazards have indirectly threatened or endangered the health of residents and the environment in general. The wastes generated from abattoirs are received in the soil, rivers, or the run-off gutters of adjoining buildings. Tortora et al., (2017) reported that following the discharge of untreated waste water into the soil, certain elements such as iron, lead, phosphorus, calcium, and zinc which were previously absent or present in minute quantities, are usually introduced into the environment resulting in increased quantities of these chemicals, thus

altering the physicochemical nature of the soil. Some of these chemicals may be toxic to the microbial flora and fauna communities of soil. This work is aimed at investigating the pollution status of effluent from the Egbu abattoir and its impact on the physicochemical and microbial properties of receiving water within the vicinity of the abattoirs.

MATERIALS AND METHODS

The Study Area

This study was carried out in an abattoir located in Egbu in Owerri Local Government Area of Imo State, within the coordinates of longitude 7.068^{o}E and latitude 5.4806^{o}N. The inhabitants of this area are mainly farmers, civil servants, traders, businessmen, and casual workers. The area experiences 70% of annual rainfall between April and August while 25% of the rainfall occurs from September to November, leaving December to March as the driest months within the year. Wastes from Egbu abattoir, through surface water run-off and soil erosion, are washed into Otamiri River as the recipient water body. In this study, samples were collected from abattoir effluent together with the water samples from Otamiri River as the river flows downstream from the point of discharge.

Sample Collection

Abattoir effluents together with the water samples from Otamiri River as the river flows downstream from the point of discharge were collected. Four liters (4L) of pre-sterilized transparent bottles with covers were used to collect samples. The samples collected were placed in an ice bath to avoid microbial proliferation and reduce metabolic processes that might lead to error. The collected samples were properly labeled for easy identification and transported to the laboratory for analysis.

Physicochemical Analysis

All samples were analyzed for physicochemical parameters. The method described by the Association of Official Analytical Chemists (AOAC, 1990) was adopted. The following parameters were analyzed; temperature, pH, total suspended solids, total dissolved solids, Chemical Oxygen demand (COD), Biochemical Oxygen demand (BOD), and electrical conductivity. The pH of the wastewater was determined using the Jenway pH meter 35100. The temperature was determined *in situ* using a mercury thermometer. Total dissolved solids (TDS) were determined electrometrically with a TDs meter while Total Suspended Solids (TSS) was determined according to APHA 209D. COD and BOD were determined using the dissolved oxygen meter.

Microbiological analysis

Total counts of heterotrophic bacteria, total coliforms, faecal coliforms, *Vibrio*, *Salmonella,* and *Shigella*, were carried out in duplicate plates on Nutrient agar, MacConkey agar, Brilliant Green Bile Lactose broth (BGLB), Lactose broth, Tryptose Lauryl agar, RAPID' *Escherichia coli* 2 agar, *Salmonella and Shigella Hektoen* enteric agar, Deoxycholate, Citrate –Lactose- Sucrose agar and Alkaline Saline Peptone water while Fungi counts were done on Sabouraud dextrose agar (SDA). All plates will be prepared according to the manufacturer's instructions.
Serial dilution was appropriately carried out on all the samples, using the stock as 10^{-1} and 0.1ml of each of the selected dilutions (10^{-4}) was plated using the spread plate technique. Enumeration of total bacteria count was done using nutrient agar (NA). Coliform counts were done using eosin methylene blue agar (EMBA). All cultures were incubated at 37^{0}C for 24 hours except cultures for fungal counts which were incubated at 25^{0}C for 72 hours. After incubation, the number of colonies on the plates with distinct growth was counted using a colony counter and recorded as colony-forming units per milliliter (CFU/ml). Sub-culturing was done until distinct colonies were obtained. Pure isolates were isolated and identified using biochemical tests (Cappucino and Sherman, 1998).

Identification and Characterization of Isolates

The methods described by Cheesbrough (2005) were adopted in the characterization of bacterial isolates. The following biochemical tests were carried out to aid in the characterization: Sugar fermentation test, Gram staining, Spore staining, Motility test, Catalase test, Citrate utilization test, Indole test, and Oxidase test. Distinct-looking colonies were sub-cultured, and the pure isolates were stored on nutrient agar slants at 4^{0}C for further confirmatory tests. Mounts of the

pure isolated fungi were viewed microscopically and identified using cultural and morphological features identified by standard methods (Williams et al., 2014).

RESULTS AND DISCUSSION

The result in Table 1 shows that the Otamiri River which receives the abattoir effluent is highly influenced by the direct discharge of these abattoir effluents. The pH concentration of the effluent and the Otamiri river water samples collected at different points showed a increase in acidity as the water flows downstream. The effluent had a pH of 7.5 which revealed the alkaline nature of the effluent while there was an increase in acidity of the water samples flow downstream, this could be attributed to discharge from other pollutants in the water samples. This finding is in agreement with the work of Idisi and Uguru (2020) who reported similar findings. The pH plays an important role in water chemistry and is associated with corrosives, coagulation, and carbon dioxide stability.

Temperature values obtained from the samples were from 27^{o}C - 28^{o}C and were within he WHO stipulated range of 40^{o}C. The results obtained were consistent with the reports of Adeyemi-Ale (2004); Eze and Eze (2018). A rise in temperature of the river increases the demand for oxygen by fish and an increase in stream temperature also causes a decrease in dissolved oxygen thereby limiting the amount of oxygen available to these aquatic organisms.

Total suspended solid (TSS) detected in the samples were from 0 -120 (mg/L). The TSS value of abattoir effluent (120mg/l) was the highest as compared to the other values recorded from the different points as the river flowed downstream. The high level of TSS discharge into the River increases the turbidity of water and causes a long term demand for organic oxygen because of the hydrolysis rate of the organic fraction of the materials. Increase in TSS causes decrease in water body to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increase water temperature and subsequently decrease levels of dissolved oxygen. Suspended solids can also harm fish directly by clogging gills, reducing growth rates, lowering resistance to disease, and movement of aquatic population is disrupted (Eze and Eze, 2018).

Total dissolved solids (TDS) values obtained from the samples were from 135 –250 (mg/L), a TDS value of 135 mg/l was recorded at the effluent discharge point, this value generally decreased as the water flowed downstream, 250mg /l at 30 cm away from the discharge point. The relatively low level of TDS observed in the water samples collected from the different points could be attributed to the ability of the river (water) to carry out self-purification process. The values of the TDS obtained show that the water falls within the WHO TDS standard level (500 mg/l) of quality drinking water. TDS is used as an indication of the presence of a broad array of chemical contaminants like calcium, phosphate, nitrates, sodium, magnesium, potassium and chloride. High TDS levels indicate hard water, which can cause scale build-up in pipes, valves, and filters, reducing performance and adding to system maintenance costs. TDS is highly toxic with the presence of abnormal pH, high turbidity, or reduced oxygen. Most aquatic organisms tolerate TDS of 1000mg/L (Chapman, 1997).

The dissolved oxygen (DO) values of the water samples showed an increase from 1.28mg/l to 3.92mg/l as the water flowed downstream, similar results were obtained by Omole and Longe (2008). Dissolved oxygen is a vital factor which is used to evaluate the water quality; therefore, the higher its concentration, the better the water quality (Omole and Longe, 2008). Dissolved oxygen is significant in the protection of aesthetic qualities of water, maintenance of water temperature, the quantity of sediment in the stream, the amount of oxygen taken out of the system by respiring and decaying organisms, and the stream flow, and the amount of oxygen put back into the system by photosynthesizing plants, of any organic materials present, which causes noxious gases, such as corrosion in water pipes. A Low DO level also prevents the detoxification of ammonia (Eze and Eze, 2018).

Biochemical oxygen demand (BOD) indicates the volume of oxygen that bacteria require to stabilize biodegradable materials under aerobic condition. BOD is a common biochemical parameter used for evaluating the suitability of water for human consumption, because it gives the approximate organic materials in water. The results of the BOD showed the effluent having the highest value of 300mg/l at the discharged point and declined as the river flowed downstream. The result revealed that the BOD values recorded far exceeded the WHO recommended value for BOD. High BOD level in water causes the depletion of oxygen and may be detrimental to fish and other aquatic organisms. The BOD result conforms to the previous findings of Idisi and Uguru, (2020). Electrical conductivity values obtained from the samples were from 90 –145 (µS/cm). The values obtained were below the stipulated value which indicated normal. Conductivity of solution increases with an increase in temperature, the warmer the water, the higher the conductivity. Presence of chloride, phosphate, and nitrate in water raises conductivity.

The total heterotrophic counts ranged from 2.5 x10^{7}cfu/ml – 5.2 x 10^{7}cfu/ml, total coliforms counts were from 1.0 x 10^{7}cfu/ml – 2.5 x 10^{7}cfu/ml while the total fungal counts ranged from 0.4 x 10^{5}cfu/ml – 1.8 x 10^{5}cfu/ml as reflected in Table 1. The microbial population reported is similar to the findings of Ire et al. (2017) who reported high heterotrophic bacteria, coliform and fungal counts in effluents and receiving water samples. The differences in the microbial population

of the effluents and receiving water body may be due to the dilution effects of the receiving water bodies and also the self-purification of the water as it flowed downstream. The high microbial counts recorded may be attributed to the high nutrient content of the abattoir effluent which helped in the proliferation of microorganisms. The Otamiri river water was contaminated beyond the level that it is not fit for domestic use without proper treatment. The World Health Organization recommends a permissible coliform count of 0 cfu/ ml for portable water.

Table 1. Physicochemical and microbial load of the abattoir effluent and Otamiri River water samples

Parameter	Effluent	10cm from point of Discharge	20cm from point of discharge	30cm from point of discharge	WHO Standard maximum permitted
pH	7.5	7.2	6.8	6.8	6.5 – 8.5
Temp (^{O}C)	27	27	28	27	< 40
TSS(mg/l)	120	110	80	100	-
TDS (mg/l)	135	170	200	250	500
DO (mg/l)	1.28	2.40	3.00	3.92	2.0
BOD (mg/l)	300	90	70	80	10
Conduc (µS/cm)	145	110	90	130	1000
THC 10^{7}cfu/ml	5.2	4.2	3.0	2.5	-
TCC 10^{7}cfu/ml	2.5	1.8	1.2	1.0	0
TFC 10^{5}cfu/ml	1.8	1.4	0.8	0.4	-

Key: Temp = temperature, TSS = Total suspended solid, TDS = Total dissolved solid, DO = Dissolved solid, BOD = Biochemical oxygen demand, Conduc = conductivity, THC = Total heterotrophic count, TCC = Total coliform count, TFH = Total fungal count, cfu = colony forming unit.

Table 2. Biochemical Characteristics and Carbohydrate Fermentation of Bacterial Isolates from Abattoir effluent and Otamiri river water samples

Colony code	Cultural characteristics	Gram reaction	Catalase	oxidase	coagulase	indole	Vogespro skaeeur	Citrate	Nitrate reduction	Urease	Glucose	Sucrose	Lactose	Maltose	Mannitol	Xylose	Arabinose	Methyl	Identity of Isolates
1	Golden yellow	+ve cocci in clusters	+	-	+	-	+	-	+	+	+	+	+	+	+	+	-	-	*Staphylococcus aureus*
2	Creamy swarming colonies	+ve rods	-	-	-	-	-	+	+	-	+	+	+	-	+		+	-	*Proteus* sp
3	Creamy fat dry colony with wavy edge	+ve rods	+	-	-	-	+	+	+	-	+	-	-	-	-	-	-	-	*Bacillus* sp
4	Yellowish slimy colonies	-ve rods	+	+	-	-	-	+	+	+	+	-	-	-	+	+	+	+	*Klebsiella* sp
5	Bluish muciod colony	-ve rods	+	-	-	+	+	-	+	-	+	-	+	-	-	+	-	+	*Escherichia coli*
6	Large pinkish mucoid colony	-ve rods	+	-	-	-	+	-	+	-	+	-	+	-	-	+	-	+	*Enterobacter* sp
7	Creamy colonies with black centers	-ve rods	+	-	-	-	+	+	+	+	+	-	+	-	-	+	-	+	*Salmonella* sp

Table 3. Colonial and Morphological Characteristics of Fungal Isolates From Abattoir effluent and Otamiri river water samples

Colony code	Colonial characteristics	Morphological characteristics	Fungal isolates
	Large whitish colony with purple center	Conidiophores produced conidia in clusters. Septate hyphae with canoe shaped macroconidia	*Fusarium*sp
2	Black filamentous colony with folding reverse	Septate conidiophore bearing conidispores	*Aspergillus* sp
3	White fluffy colony	Cotton-like with branched hypha	*Mucor* sp
4	Green colony with gray zones	Short conidiophores bearing aconidispores	*Penicillium* sp
5	Orange filamentous colony	Non-septate sporangiophore bearing sporangium	*Rhizopus* sp

The bacterial isolates from the abattoir effluent and Otamiri river water samples were *Staphylococcus aureus*, *Protues* sp, *Bacillus* sp, *Klebisiella* sp, *Esherichia coli*, *Enterobacter* sp, and *Salmonella* sp (for the bacterial as seen in Table 2 while the fungal isolates were *Fusarium* sp, *Aspergillus* sp. *Mucor* sp, *Pencillium* sp and *Rhizopus* sp as revealed in Table 3. Similiar microorganisms were reported in the work of Ire et al. (2017).

Bacteria isolated and frequency of occurrence as seen in Table 4 are; *Escherichia coli* (30.1%), *Bacillus* spp (18.8%), *Staphylococcus aureus* (15.0%), *Proteus* spp (10.5%), *Klebsiella* spp (10.5%), *Salmonella* spp (9.0%) and *Enterobacter* spp (6.0%) while the frequency of fungi isolated as seen in Table 5 include; *Aspergillus* spp (28.2%), *Fusarium* spp (25.4%), *Mucor* spp (21.1%), *Penicillium* spp (16.9%) and *Rhizopus* spp (8.5%). These microbial isolates from the abattoir effluent and receiving water samples revealed that the samples harbor potentially pathogenic microorganisms which can lead to serious illnesses when they are ingested. These organisms have been reported in previous studies on water bodies receiving effluents from abattoirs by Ire *et al*., (2017) and Adeyemi-Ale (2004). Some of these microorganisms have been implicated in causing illnesses such as diarrhea, and other health complications.

Table 4. The Percentage of Occurrence of the Bacterial Isolates from the Abattoir Efflulent and Otamiri river water samples (%)

S/NO	Bacterial isolates	Occurrence	Percentage of occurrence (%)
1	*Escherichia coli*	40	30.1
2	*Bacillus* sp	25	18.8
3	*Staphylococcus aureus*	20	15.0
4	*Proteus* sp	14	10.5
5	*Klebsiella* sp	14	10.5
6	*Salmonella* sp	12	9.0
7	*Enterobacter* sp	8	6.0

Table 5. The Percentage of Occurrence of the Fungal Isolates from the Abattoir effluent and Otamiri River samples (%)

S/NO	Fungal isolates	Occurrence	Percentage of occurrence (%)
1	*Aspergillus sp*	20	28.2
2	*Fusarium* sp	18	25.4
3	*Mucor sp*	15	21.1
4	*Penicillium* sp	12	16.9
5	*Rhizopus* sp	6	8.5

CONCLUSION

This study was conducted to evaluate the effect of abattoir effluent on the Microbiological and physicochemical properties of Otamiri River, located in Owerri, Imo State. Results obtained from this study showed poor water quality of Otamiri River as a result of the indiscriminate discharge of an abattoir effluent into the Otamiri River. This study has shown that these effluents contain high concentrations of potentially harmful substances. The abattoir effluents introduced to the receiving water bodies such as Otamiri River make them unsuitable for domestic use. It is recommended that the abattoir effluent should be properly treated before it is discharged into the environment to prevent environmental pollution, mostly the water bodies. It is also important to treat water gotten from surrounding rivers in residential areas before they are used for domestic purposes.

Conflict of interest

The authors have not declared any conflict of interest regarding this work.

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