Advances in Biological Research 6 (5): 196-201, 2012
ISSN 1992-0067

DOI: 10.5829/idosi.abr.2012.6.5.6672

Effluent Qualities of Government and Private Abattoirs and Their Effects on Ikpoba River, Benin City, Edo State, Nigeria

[1]E.I. Atuanya, [2]N.A. Nwogu and [1]E.A. Akpor

[1]Department of Microbiology, University of Benin, P.M.B 1154, Benin City, Edo State, Nigeria
[2]Nigerian Institute for Oceanography and Marine Research, P.M.B. 4015, Sapele, Delta State, Nigeria

Abstract: Surface waters are always polluted because they are exposed to direct contaminants and therefore do not usually meet the quality standards for potable water. This study examined the bacteriological and physico-chemical effluent qualities of one government and two private abattoirs and their effects on Ikpoba River, Benin City, Nigeria. Five river sampling points located at 10 meters intervals upstream before effluent discharge of these three abattoirs and another five river - sampling points located at same intervals downstream after the discharge of the abattoir effluents were selected. Mean heterotrophic bacterial counts of abattoir effluent were 5.76 and 6.3 x 10^5 CFU/ml for government and private abattoirs respectively. The mean heterotrophic bacterial counts for Ikpoba River water were 1.29 and 1.97 x 10^4 CFU/ml for upstream and downstream river water samples, respectively. *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Enterobacter aerogenes* and *Bacillus* spp were isolated from abattoir effluents. The significant variations in the bacteriological and physico-chemical qualities of downstream river water samples when compared with upstream river water samples clearly signify the impacts of these abattoir effluent discharges on Ikpoba River.

Key words: Pathogens · Effluent · Diseases · Abattoirs · Pollutants

INTRODUCTION

Environmental problems have increased over the last four decades with improper management practices being largely responsible for the gross pollution of aquatic environment with concomitant increase in water-borne diseases especially typhoid fever, cholera, diarrhea and dysentery. Abattoirs are generally known all over the world to pollute the environment either directly or indirectly from their various processes [1].

Ouinn and McFarlane [2] observed that effluent discharged from slaughter-houses has caused the deoxygenation of rivers. Effluent from slaughter-houses has also been known to contaminate ground water [3].

Trift and Schuchardt [4] reported during a study that blood, one of the major dissolved pollutants in slaughter effluent, has a chemical oxygen demand (COD) value of 375,000 mg/L. This impacts high organic pollutants, on the receiving waters and consequently creating high competition for oxygen within the ecosystem. This chemical oxygen demand (COD) value is far higher than the maximum limit of 80 mg/L set by Federal Environmental Protection Agency/Federal Ministry of Environment, Nigeria [5].

Hinton *et al*. [6] reported that the slaughter of animals in abattoirs of developing countries is carried-out in unsuitable buildings by untrained slaughter-men and butchers that are unaware of sanitary principles. Waste generated by abattoirs include solid waste, made up of paunch content, bones, horns and faecal components, slurry of suspended solids, fat, blood and soluble materials [3].

Coker *et al*. [7] showed that abattoir waste can affect water, land and air qualities if proper practices of management are not followed.

In Nigeria, many abattoirs dispose their effluents directly into streams and rivers without any form of treatment and slaughtered meats are washed by the same river water [1]. Such is the situation in several private and government abattoirs in most parts of the country. Reports have also shown that indiscriminate disposal of abattoir waste may introduce enteric pathogens into surface and ground water [8] and the pathogens isolated from abattoir waste - waters can survive in the environment and pose danger to humans and animals [7].

Corresponding Author: N.A. Nwogu, Nigerian Institute for Oceanography and Marine Research, P.M.B. 4015, Sapele, Delta State, Nigeria. Tel: +234-8050518175.

Although there are reports on the microbial attributes and toxic effects of different industrial wastes as well leachates [9] there is paucity of knowledge on polluted rivers that receive pollutants from multiple sources [9]. One of such rivers in Benin City is Ikpoba River. This river flow through a dense rainforest and is subjected to pollution from storm run-off in all areas as it flows through Benin City [10].

The river serves as a source of water for domestic purpose including drinking and cooking. Most of the activities around the river and its upper reaches are agriculture, fishing, crop farming and car-washing activities. The government abattoir managed by local government administration (LGA) is sited along the bank of Ikpoba River together with other private abattoirs. The government abattoir was established in 1967 and about 50 cows and goats are slaughtered daily.

Coker *et al*. [7] identified seven pathogenic species of bacteria in abattoir effluent in south western Nigeria. The species included *Staphylococcus* sp., *Streptococcus* sp. in harsh environmental condition; hence they affect animal and human health. Sangodoyin *et al*. [3] investigated the pollution load of effluent from four abattoirs at Ibadan and found that all parameters except pH are higher than permissible limit set by national and international regulatory bodies. This study examined the bacteriological and physico-chemical effluent characteristics of government and private abattoirs in Benin City, Nigeria and their effects on Ikpoba River the effluent receiving stream.

MATERIALS AND METHODS

Collection of Samples: Abattoir waste-water samples were collected from five sampling points at government and two private abattoirs located along Ikpoba River, a fourth order stream, located in Benin City, Edo State in South-Western Nigeria (Lat. 6.5°N, longitude 5 – 8°E). The five effluent sampling points depict different activities within and outside the abattoirs. Sampling points A to C were located at channel within the slaughter houses while sampling points D and E were located in drainage outlets just outside the slaughter – houses. In order to examine effects of these abattoir effluent discharges on Ikpoba River, five river sampling points were located along the River. These were located at 10 meters intervals upstream before the discharge of these three abattoirs and downstream after the discharge of these abattoirs at same intervals. Both abattoir effluents and Ikpoba River water samplings were collected fortnightly for a period of two and half months (June- August, 2010).

Samples for bacteriological and physico-chemical analyses were collected in two sets of sterile plastic bottles. Samples for analyses of dissolved oxygen (DO) and biochemical oxygen demand (BOD) were collected separately in pre-sterilized brown bottles. The oxygen in the DO containers was fixed on site by adding 1.2 ml each of Winkler's solution. Samples for other physico-chemical analyses were collected in ethanol sterilized 2 liters plastic containers and were sent to the laboratory in ice-packed coolers. Those samples that could not be analyzed the same day were stored in a refrigerator at a temperature of 4°C.

Bacteriological Analysis of Effluents and River Water Samples: The total heterotrophic and aerobic pathogenic bacterial loads of effluents and water samples were determined using pour plate technique with molten nutrient agar at 28±2°C and 37±2°C respectively for 48 hrs [11].

Bacteria isolates obtained were then purified into pure culture and identified based on their morphological, cultural and biochemical tests [11]. The total coliform counts of effluent/water samples were determined using the most probable number techniques [12]. The enumeration of *Clostridium Perfringens* in the water samples was done by inoculating 1ml pre-heated water samples (80°C for 10 min) into 9 ml cooked meat medium in MacConkey bottles [12]. Positive tubes showing turbidity, with the production of acid and gas but not digestion of the meat were inoculated into tubes containing litmus milk medium. Tubes containing C. *perfringens* showed "stormy clot" [12]. Serially diluted samples from positive tubes were then inoculated into sterile petri-dishes and molten nutrient agar was poured. The plates were then incubated at 37°C for 24 hrs and the *C. perfringens* load was enumerated.

Physico-chemical Analysis of Collected Water Samples: Dissolved oxygen and biochemical oxygen demand (BOD_5) of effluent/water samples were evaluated using the Azide method, a modified Winkler's method [12]. The closed reflux titrimetric method was used for determination of chemical oxygen demand (COD). Total suspended solids (TSS) and total dissolved solids were determined using the gravimetric methods [12]. The pH and conductivity were measured using pH-meter model 3020 of Jenway limited. The nitrate, phosphate, sulphate and heavy metals contents of effluent/water samples were determined colorimetrically using the Million ROY spectronic 21D spectrophotometer. Level of significance between varying data was determined using multi-samples comparison [13].

RESULTS AND DISCUSSION

Mean Bacterial Counts of Abattoirs Effluents: The aquatic environment has the ability to accept and absorb certain amount of waste while maintaining a near to normal functions. Table 1 shows mean bacterial counts of effluents from government and private abattoirs. From the table, the highest bacterial load (9.8 x 10^5 CFU/ml) was recorded in effluent sample collected at sampling point A of private abattoir, while the lowest bacterial load (4.1 x 10^5 CFU/ml) was recorded at sample point B of government abattoir. Table 1 also shows the total coliform counts on Eosin methylene-blue agar and *Escherichia coli* counts on MacConkey agar from abattoir effluent samples. Abattoir effluent containing high level of organic matter and essential nutrients bring about changes in the microflora quantity and quality [14]. The results shown in table 1 indicated that private abattoirs were more contaminated bacteriologically. The high bacterial loads observed in both private and government abattoir effluents were primarily due to poor hygienic practices in these abattoirs. The presence of coliform bacteria and *E. coli* in the abattoir effluent is due to fecal pollution and has been used as an index of recent or heavy fecal pollution [10].

Mean Bacterial Counts of River Water Samples: Table 2 shows mean heterotrophic bacterial and coliform counts from Ikpoba River water samples to enable us to assess the effects of these slaughter houses on the river. Variations in heterotrophic bacterial and coliform loads showed that downstream Ikpoba River samples have higher bacterial loads than upstream samples. Sample 1 (downstream) had highest mean bacterial count of 2.2 x 10^4 CFU/ml while sample 4 (upstream) showed least mean bacterial count of 1.1 x 10^4 CFU/ml. High microbial population in water body can be interpreted as a reflection of the input of microorganisms from extra aquatic sources as well as describing trophic conditions of given habitat [15]. Equally, as shown in table 2 total coliform counts were generally higher in downstream samples than upstream samples. This again is a result of abattoir effluent discharges. The presence of coliforms especially *E. coli* in water has been used an indicator of recent fecal pollution [12].

A total of five bacterial isolates were consistently isolated from abattoirs effluents. These included *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Enterobacter aerogenes* and *Bacillus* sp. *S. aureus* was the most dominant isolate with frequency of isolation of 36.1%, followed by *Bacillus* sp. as shown in Table 3. The bacterial isolates consistently isolated from Ikpoba River water as shown in Table 3 were S*taphylococcus aureus,* fecal *streptococcus, Escherichia coli* and *Klebsiella* spp. *Klebsiella* and *Enterobacter* species are considered as potential health hazard members of the coliform group [16]. The presence of these bacteria in Ikpoba River water samples indicated that pollution of river water is due to effluent discharges from abattoirs and other human activities.

Table 1: Mean bacterial counts of effluents collected from abattoirs in Benin City

	Government Abattoir					Private Abattoir				
PARAMETER	Sample A	Sample B	Sample C	Sample D	Sample E	Sample A	Sample B	Sample C	Sample D	Sample E
Total bacterial count x 10^5 CFU/ml	9.3	4.1	5.5	4.9	5.0	9.8	6.4	4.4	5.6	5.3
Total coliform x 10^3 CFU/ml	2.4	1.8	2.8	2.0	2.2	3.3	2.6	3.0	2.4	2.1
E.coli x 10^5 CFU/ml	0.19	0.11	0.20	0.13	0.10	0.22	0.16	0.14	0.15	0.12

Sample A – C (Effluent samples from the channel in the slaughter house).

Sample D and E (Effluent samples from drainage outlet just outside the slaughter house).

N.B: Results are means of triplicate samples.

Table 2: Mean viable bacterial counts (CFU/ml) of Ikpoba River water samples

	Upstream					Downstream				
PARAMETER	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Total bacterial count x 10^4 CFU	1.44	1.3	1.20	1.10	1.45	2.20	2.0	1.89	1.68	2.10
Total coliforms x 10^4CFU	0.22	0.18	0.16	0.20	0.19	0.28	0.24	0.19	0.22	0.30

Sample 1 –5 (five different locations upstream and downstream of Ikpoba River).

N.B: Results are means of triplicate samples.

Table 3: Dominant bacterial isolates from abattoir effluents and water samples from Ikpoba River

Isolates	Percent Isolation frequency
Isolates from Abattoir effluents	
Staphylococcus aureus	36.1
Escherichia coli	17.9
Pseudomonas aeruginosa	13.5
Enterobacter spp.	13.3
Bacillus spp.	18.3
Isolates from Ikpoba	
River water samples	
Escherichia coli	48.3
Fecal *Streptococcus*	16.1
Staphylococcus aureus	15.1
Klebsiella species	20.5

Table 4: Bacterial isolates from Ikpoba River upstream and downstream locations

Isolates	Upstream	Downstream
Escherichia coli	+	+
Fecal *Streptococci*	-	+
Clostridium perfringens	-	-
Staphylococcus aureus	+	-
Klebsiella species	+	+

Occurrence and Distribution of Bacterial Isolates: Table 4 gives an indication of the occurrence and distribution of these bacterial isolates in Ikpoba River water. The presence of *Staphylococcus aureus* in Ikpoba River sample from upstream location and absence from downstream location water samples could be due to human activities.

Results of coliform counts from abattoir effluents and Ikpoba River water samples by most probable number (MPN) indicated variations in coliform counts which range between 4 and 11MPN per 100 ml.

Atlas and Bartha [15] used fecal streptococcus as an indicator of recent fecal pollution whereas *C. perfringens* is indicative of earlier fecal pollution [17]. Results shown in table 5 showed presence of fecal streptococci in downstream sampling locations of Ikpoba river water samples but absent in upstream river water samples. This result reflected a major impact of abattoir effluent discharges into Ikpoba River water. Slaughter house waste- water contains high concentration of suspended solids (SS) including pieces of fats, hair, feathers, fresh manure, grits and undigested feeds [17].

This is confirmed by the turbid appearance and high concentration of total suspended solid (TSS) of 56 mg/L for government abattoir effluent and 61 mg/L for private abattoir effluent as shown in table 5. These total suspended solid values are far above Federal Ministry of Environment permissible limit of 30 mg/L [5].

Table 5: Physico-chemical characteristics of effluents from private and government abattoirs

Parameter	Government abattoir	Private abattoir	FMENV Limit
Appearance	Turbid	Turbid	
Temperature (°C)	2.6	27	<40
pH	4.8	5.3	6 – 9
Biological oxygen Demand (mg/L)	30	34	50
Dissolved oxygen (mg/L)	5.50	5.62	
Total suspended Solid (mg/L)	56	61	30
Chemical oxygen demand (mg/L)	98	49	80
Sulphate ion (SO_4) (mg/L)	16	14	
Nitrate (NO_3)	1.34	0	20
Phosphate (PO_4)	32	24.5	<5
Chloride (mg/L)	33	28	250

NB: Results are mean values of triplicate samples

FMENV Limit means Federal Ministry of Environment limit.

Table 6: Physico-chemical characteristics of Ikpoba River samples

Parameter	Upstream	Downstream
Temperature (°C)	27 – 9	28.2
pH	6.45	6.14
D O (mg/L)	9.04	7.48
BOD (mg/L)	4.01	6.14
COD (mg/L)	8.00	14.0
Total Suspended Solid (mg/L)	16.03	24.01
Fe (mg/L)	0.35	0.82
Zn (mg/L)	0.06	1.30
Cu (mg/L)	0.02	0.04
Sulphate (mg/L)	0.24	0.36
Phosphate (mg/L)	0.13	0.18

NB: Results are mean values of triplicate samples

Physico-Chemical Parameters of Examined Water Samples: Table 5 and 6 showed the physico-chemical qualities of abattoirs effluent and Ikpoba River water respectively. The mean temperature was 27°C for private abattoirs and 26°C for government abattoir. The pH values were 4.8 ± 0.3 and 5.3 ± 0.45 for private and government abattoir respectively. The pH range obtained in this study was acidic and falls outside Federal Ministry of Environment (FMENV) effluent limit of 6 – 9 [5]. It could be inferred that more hydrogen – ions become available; lowering the pH – value of the effluent and affecting the pattern of microbial loads in the abattoirs effluents. Changes in the microbial loads of abattoirs effluents have been observed by different authors and reported in literature [18]. The microbial loads could depend on many factors [19], the type, quantity or

concentration of contaminants and the level of toxicity are very important. Thus, the acidic quality of the effluent could be responsible for the moderate effluent bacterial load in this study. The temperature range obtained in this study was moderate signifying that the abattoirs effluents did not contain much hot-water. This temperature range 26- 27°C is comparable with previous work [20] and in compliance with the Federal Ministry of Environment effluent permissible limits of <40°C [5].

As shown in table 5, the chemical oxygen demand (COD) values were 98 and 49 mg/L for government and private abattoirs respectively. High COD values could be due to high organic load. Since abattoir effluent is rich in blood signifying high organic content. The COD values of effluent samples from government abattoir were higher than 80 mg/L permissible limit set by Federal ministry of Environment (FMENV). The dissolved oxygen (DO) values were 5.50 and 5.62 mg/L for government and private abattoirs respectively. Welch [21] stated that for successful spawning of fish, dissolved oxygen content should be between 7.25 to 9.9 mg/L. This low dissolve oxygen values obtained in this study will affect the breading of fish in the effluent receiving river (Ikpoba River). Dissolved oxygen levels below 5.0 mg/L have been known to cause septic conditions that are detrimental to the survival of many fishes [22].

Phosphate levels for government and private abattoirs effluents were 24.5 and 32 mg/L, respectively as shown in table 5 are comparable with previous works [3, 20] but the values were far higher than permissible limits of FMENV. This high phosphate levels could probably be due to detergents used in washing the slaughter houses. Nitrate values ranged from 0- 1.34 mg/L. Sources of nitrate could be from oxidation of other forms of nitrogen compounds like ammonia and nitrite into nitrate. Nitrate values in table 5 were far lower than the limit of 20 mg/L set by Federal Ministry of Environment. Chloride values ranged from 28 – 33 mg/L, chloride sources could be soluble salts (NaCl and KCl) from blood discharged into the effluent. All chloride values were lower than acceptable limits of 250 mg/L set by Federal Ministry of Environment.

As could be seen in tables 2 and 6 the effects of these abattoir effluents discharges into Ikpoba River are evident in the downstream water qualities of the river water. The reduction in the downstream physico-chemical qualities of Ikpoba River compared to physico-chemical values of abattoirs effluent could be attributed to net dilution and decomposition of organic loads leading to self-purification of the river water. Table 6 equally shows some variations between the upstream and downstream physico-chemical qualities of Ikpoba River water. The concentrations of zinc, iron, copper, sulphate, phosphate, COD, BOD and TSS were generally higher in the downstream locations of river than in the upstream locations.

Results from this study have clearly shown that abattoirs discharge their effluents directly into receiving stream without any form of treatment. Poor hygienic practices in these abattoirs introduced enteric pathogens to receiving surface water. Thus, there is an urgent need to put in place effluent treatment facilities to treat wastes from abattoirs in Nigeria.

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