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Effect of abattoir wastes on stream quality in the Bolgatanga municipality, Ghana-west Africa

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This research was undertaken to determine abattoir wastes effect on the stream quality along Kollaa stream in Sawaba area of Bolgatanga municipality. The study also determined the microbiological quality and some physicochemical parameters of the stream that takes delivery of untreated waste from the abattoir and the extent of pollution through discharge of waste from abattoir sites into stream water. Three water samples were collected from (effluent discharge point, upstream and downstream) in the stream using sterile containers. Biological oxygen demand (BOD) was determined by calculating the difference in the initial and final dissolved oxygen. Dissolved oxygen (DO) was determined using dissolved oxygen probe and meter. Total dissolved solids were determined using HM Digital TDS meter. Fecal and total coliform coliforms counts were investigated by using multiple tube fermentation methods. Salmonella and total bacterial count and were determined using standard plate count method and pour plate method. The study results revealed that the stream contained high coliform counts attributable to the release of abattoir waste into the stream. Water samples from effluent discharge point had the highest BOD value of 60.5 mg/L, DO had 1.1 mg/L and TDS had 80 mg/L. Effluent discharge also had fecal coliform count of 80 mpn/100 ml, total coliform count of 500 mpn/100 ml and total bacteria count of 30 cfu/ml x 10^5. Upstream sample had BOD value of 2.1 mg/L, DO had 0.9 mg/L, TDS had 74 mg/L, fecal coliform count was 20 mpn/100 ml, total coliform count was 80 mpn/100 ml and total bacteria count was 10 cfu/ml × 10^5. Downstream sample also had BOD value of 2.1 mg/L, DO was 0.6mg/L, TDS was 70 mg/L, fecal coliform counts was 41 mpn/100 ml, total coliform was 70 mpn/100 ml and total bacteria counts was 20 cfu/ml × 10^5. All samples had no Salmonella count. Presence of the bacterial in the stream made it unwholesome for drinking purposes.

Key words: Abattoir, pathogens, stream quality, effluent discharge, physical qualities, microbiological quality, upstream, downstream.

INTRODUCTION

Abattoir is a designated area where animals are killed for their meat. An Abattoir is a registered and an approved premise for hygienic killing and inspection of animals meats, possessing and storage or preservation of meat for human consumption (Nouri et al., 2008). The processing activities of cow result in essential meat

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provisions. It is a vital protein source and beneficial by-product production such as skin, leather and bones. This sometimes cause pollution of the environment and other health threatening hazards to humans and. (Nouri et al., 2008) defines meat hygiene as a system of principle designed to ensure the safety of meat product and that they are wholesome and processed under hygienic condition that makes them worthy of human consumption. When waste from the slaughter house are not well treated and released into running water, it has very high chance of contaminating surface water with enteric pathogens and other nutrients. In practices of these natures, it becomes a major pollutant of the country towns and cities. The abattoir wastes that consist of liquid, solid and fats could be a source of high organic matter. The solid component of the wastes is made up of hairs, condensed meat, bones, aborted fetus and undigested ingest. The liquid part in the other vein comprise of blood, dissolved solids, urine, guts contents and water, while fat waste primarily is made up of fat. Water resources pollution often brings about the destruction of primary producers. This in turn causes diminishing effect of fish stock consequently leading to the decrease in tertiary diet (Aina and Adedipe, 1991).

Waste from killed Animals is mostly contaminated by microbes living normally or entering it from the environments such as those resulting from processing operations (UNESCO, 2006). Abattoir can serve as a valuable source of nutrients for crops when decomposed. The same material poses greater threat to water quality. Animal waste may also contain heavy metals traces, organic solid, salts, trace, viruses, bacteria, other microbes and sediments. Abattoir discharge composition is complex and could be extremely harmful. Its adverse effects on the environment could reduce oxygen content of stream; hence depriving aquatic life of oxygen. Unhealthy discharge of animal waste can also result in the transmission of zoonotic diseases onto humans subjects by contact with animal feces (Raymond, 1977). Untreated Abattoir discharge in streams brings about high utilization of phosphorous, oxygen and nitrogen (Weobong and Adinyira, 2011). For instance, animal blood discharged into stream could exhaust the Dissolved (DO) of the water body. Improper discharge of paunch manure may increase oxygen requirements on the receiving environment or produce huge population of decomposers (microorganisms) which may be pathogenic. Furthermore, improper disposal of animal feces may cause oxygen-depletion in the receiving environment. It could also lead to nutrient-over enrichment of the receiving system and increase accumulation rate of toxins in biological systems (Nwachukwu et al., 2011). Unhygienic discharge of abattoir waste could also bring about transmission of pathogenic microbes onto humans that may cause outbreaks of water borne diseases such as cholera, typhoid, diarrhea, fever, and wool sorter diseases.

Escherichia coli infection source was revealed to have come from raw beef contaminated in the slaughterhouse with feces containing bacterium (Bello and Odeyemi, 2009). Discharge from abattoir is responsible for the contamination of underground and surface waters bodies, quality of air as well as reduction in quality of health of residents within the catchment areas of abattoir (Katarzyna et al., 2009; Odoemelan and Ajunwa, 2008). This study therefore investigates some of the physical and bacteriological characteristics of discharged abattoir effluents into surrounding stream as it affects humans lives who use the stream water domestically. The outcome will help create public consciousness on the state and health implications of abattoir discharge on the water bodies.

MATERIALS AND METHODS

Study area

The study was conducted at the Bolgatanga Abattoir in Bolgatanga Municipality, Upper East Region of Ghana from January to April, 2015. The abattoir is located at Sawaba area in the municipal. The samples were collected along Kuulaa stream where most of the abattoir wastes are discharged. The wastes from the slaughtering and the dressing grounds in the abattoir are washed into open drainages untreated and are carried into a nearby stream. Bolgatanga is the Regional capital of the Upper East city in the Northeastern part of Ghana. The Municipality forms part of the 13 Districts and Municipals in the Region. The region is the largest urban area among the districts in the Region. Bolgatanga is bounded with Bongo District to the North, Nabdam District to the east, Talensi District to the south and Kassena Nankana Municipal to the west. Bolgatanga is the administrative capital of the municipality. (Figures 1 to 3) The climate is tropical one and characterized by a single season rainfall regime (May to October) and a longer dry season with that stretches October to April without rainfall. Temperatures can rise to maximum of 40°C in March/April and a minimum 12°C for November/December. The vegetation of the municipality is that of the savanna type with notable trees such as baobab, and acacia trees. The low vegetation is destroyed by fire during the dry season or dried by the sun. The inhabitants of the district belong predominantly to different peoples of Northern extradition of Ghana. Bolgatanga is cosmopolitan town. There are different peoples in the north, but members of the major ethnic groups include the Akan, Ewe, and Ga peoples. Majority of the population in the 1990s lived, in spite of the urban structure of the district, from agriculture, 19% commercial, 12% industry, mainly handicrafts, and just 7.4% were employed in public services. There are some jobs in the mining and construction and in the form of some metal-working companies, repair shops, painting companies etc.; but these represent a very small minority. The Bolgatanga Municipal is the home of the Upper East Regional capital. The Municipality forms part of the 13 Districts and Municipals in the Region. This, of course, makes it the largest urban centre in the Region. The population of the municipality according to 2010 population and housing census stands at 131,550 with 62,783 males and 68,767 females (Ghana Statistical Service, 2014).

Sampling design

Sampling was carried out three times at three strategic points of the stream along the stream using random grab sampling. Samples

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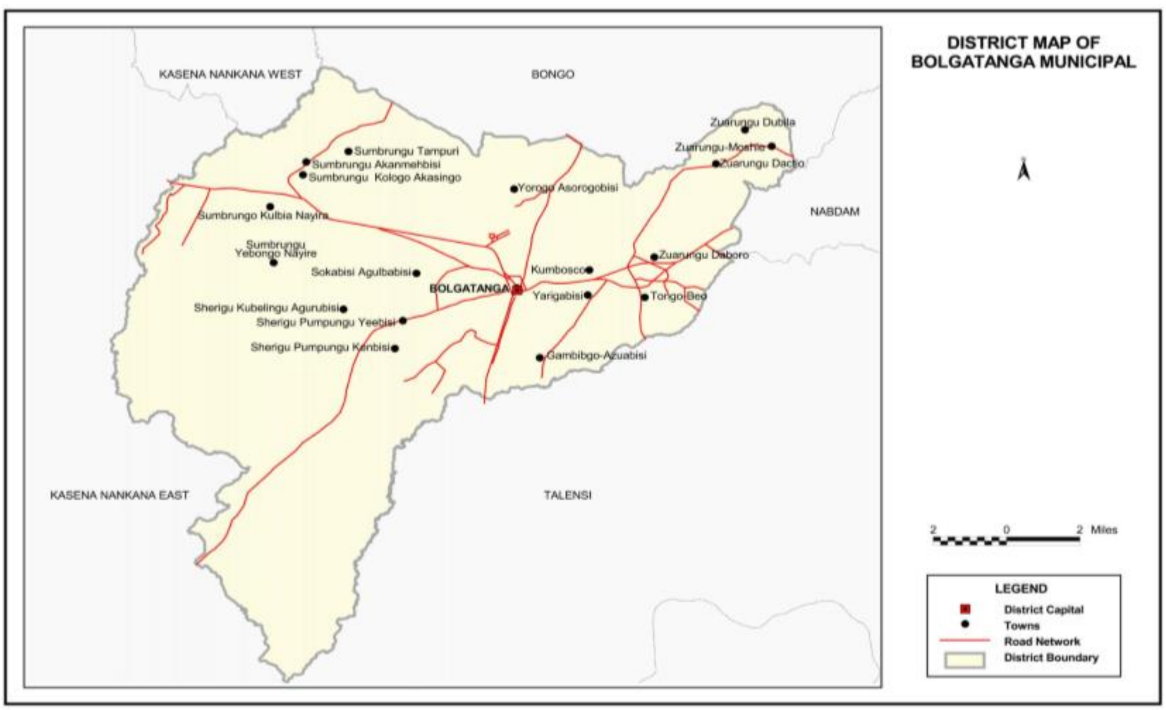
Figure 1. Ghana map.



Source: Ghana Statistical Service GIS

Figure 2. Bolgatanga municipal map.

Figure 3. Maps indicating the Abattoir and Kuula stream in Bolgatanga. Yellow spot = abattoir; blue spot =school; red lines = contours; light blue = effluent discharge**;** white dotted lines = dagmew; deep blue = kuula stream; green triangle = bridge.

were taken in duplicate to enhance the dependability of data. Samples collection point was the mid-width of the stream. 1.0 litre sterile plastic container cleaned with 10% nitric acid and rinsed thrice with distilled water was used for sample collections. Three one-litre samples were collected at each of the three sampling points designated Up Stream (US), Effluent Discharge (ED) and Down Stream (DS).

Sample analysis

The standard methods adopted in investigating physicochemical characteristics of water and wastewater samples and bacteriological determination were in consistence with the American Public Health Association series of Standard Methods of Examination of Water and Effluent (APHA, 2005).

Collection and analysis of water samples

To enhance aseptic conditions in the laboratory before analysis, all the equipment and apparatus used were sterilized using hot air oven and autoclave. All media used were prepared aseptically according to manufacturer instructions and were subjected to moist heat sterilization at 121°C for 15 min using the autoclave. Samples of water were collected into sterilized 2.5 ml dark bottles that contain dissolved oxygen and transported in a dark environment to the Danida Laboratory of UDS for analysis (Table 1). The bottles were aseptically used to collect water samples from three points along the stream where the abattoir waste is drained analysis. The control and the first sample were collected from about 100 m upstream away from the abattoir. This is used to determine the different in the stream water quality after effluent discharged. The second sample was taken at the discharge point of the abattoir effluent into the stream. The remaining point was at point down the stream (downstream) 100 m away and sampling was conducted at about 11:30 am so as to allow the effluent enough time to reach the stream from the abattoir. Sample containers were concealed in ice chest with ice packs imbedded and transported to the laboratory. Samples of water were picked fortnightly within a four-month period (January- April, dry season) (Table 2). There was a total of eight collections (twice a month) from each sampling point for the effluent and downstream and influent.

Bacteriological and physicochemical analysis

The methods used for the analysis were standard methods for examination of bacteriological and physical characteristics of wastewater as laid down by the American Public Health Association

Table 1. Description of sampling points.

Sampling point	Description
Point 1- Upstream	About 100 m to the point of introduction of abattoir waste
Point 2 - Midstream	Point of effluent discharge
Point 3- Downstream	100 m away where the effluent mixes with the receiving water body.

Table 2. Periods of the samples collection.

Month	1st week	2nd week	3rd week	4th week
January	x	x		
February		x	x	
March		x	x	
April			x	X

Table 3. Mean physicochemical characteristics of samples.

Sample	Parameter		
	DO mg/L	BOD mg/L	TDS mg/L
Upstream (US)	0.9 ±1.41	2.1± 2.84	74 ± 1.41
Downstream (DS)	0.6 ± 1.41	2.4 ± 2.84	70 ± 1.41
Effluent Discharged (ED)	1.1 ± 1.41	60.5 ± 4.24	80 ± 2.84
EPA Ghana/ GSB standard for drinking water influent	4 - 15	0.5	1000
EPA Ghana standard for effluent	>50	<50	>75

US= Upstream, DS= downstream, ed= effluent discharge. Source: Environmental Protection Agency, Ghana.

series of standard methods of examination of water and effluent (APHA, 2005). Physical characteristics such as dissolved oxygen (DO), biochemical oxygen demand (BOD5), total dissolved solids (TDS) were used to examine the quality of water and pollution effects of waste from abattoir. Initial dissolved oxygen (DO) content was done using a modified azide method. Biochemical oxygen demand (BOD5) was calculated by taking the numerical difference between the initial DO and final DO (APHA, 2005). Total bacteria count was determined using Standard plate count method and pour plate method. Total and fecal coliform loads were determined using Multiple tube fermentation/ Most probable number method. Both single and double strength Lactose broth were used for the analysis. Fecal coliform and Total coliform bacteria were incubated for 24 h at 44 ± 1°C and 36 ± 1°C respectively.

RESULTS

From Table 3, dissolved oxygen in effluent discharge was 1.1 mg/L, upstream recorded 0.9 mg/l and downstream was 0.6 mg/L. Biochemical oxygen demand in the effluent discharge was 60.5 mg/L, downstream had 2.4 mg/L and upstream had 2.1 mg/L. Total dissolved solids in effluent discharge had 80 mg/L, upstream had 74 mg/L and downstream had 70 mg/L. From Table 4, the fecal coliform in downstream water sample was 41mpn/100ml, effluent discharge had 80 mpn/100 ml and upstream water sample had 20 mpn/100 ml. The total coliform count in effluent discharge was 500mpn/100ml, upstream water sample had 80 mpn/100 ml and downstream water sample had 70 mpn/100 ml. Total bacterial count in effluent discharge was 30cfu/ml x 10^5, upstream had 10 mpn/100 ml and downstream had 20 mpn/100 ml. *Salmonella* count was not detected in all the samples collected. There is no significant difference (P<0.05) between the discharged effluents water and other stream water sample because all samples were polluted.

DISCUSSION

The result as presented in (Table 1) showed that the concentration of dissolved oxygen (DO) is lower downstream with (0.6 mg/L) followed by upstream (0.9 mg/L) and higher at the discharge point with (1.1 mg/L). Animal blood is known to possess high oxygen demand. Blood from beef cattle had a BOD which accounted for the high dissolved oxygen at the discharge point. The implication of this fact is that discharge of waste containing blood of animal onto streams could critically reduce the dissolved oxygen (DO) of the aquatic environment.

Table 4. Bacteriological quality of samples.

Sample	Parameter			
	Fecal coliform Bacteria (MPN/100 ml)	**Total coliform bacteria (MPN/100 ml)**	**Total bacterial counts × 10^5cfu/ml**	***Salmonella* counts × 10^2 cfu/ml**
Upstream (US)	20 ± 2.82	80 ±4.82	10 ± 2.12	0 ± 0.00
Downstream (DS)	41 ± 4.82	70 ± 4.82	20 ± 2.12	0 ± 0.00
Effluent Discharged (ED)	80 ± 4.82	500 ± 0.00	30 ± 2.82	0 ±0.00
EPA Ghana/ GSB standard for drinking water influent	0	<10	0	0
EPA Ghana standard for effluent	<10	<400	<10	<10

US= Upstream, DS= downstream, ED= effluent discharge. Source: Environmental Protection Agency, Ghana.

Similarly, the levels of BOD differs across the stream, with the discharge source obtaining the highest value of 60.5mg/l, while the upstream had the least value of 2.1 mg/L. BOD deals with the quantity of oxygen needed for aerobic decomposition of organic materials. It shows the amount of oxygen required for microbes to breakdown organic matter (Chukwu, 2008). The high BOD value recorded at the point of discharge is an indicative that there are higher amounts of biodegradable materials from the abattoir. The observed high BOD in effluent discharge can be linked to excessive organic matter load arising from waste meat, blood, skins, salts, and rumen ingest discharge. This scenario is not unique to the Bolgatanta Abattoir (Bush, 2000). BOD is a very vital indicator for water quality parameter and is used as a vehicle for water quality assessment. However, higher BOD is dependent on higher organic matter content in the discharged abattoir waste.

This high BOD obtained at the discharge point perhaps correlates with the high DO levels observe at this point. The contents BOD obtained in this study is higher than the stipulated value of potable drinking water. The high BOD obtained for this study could be attributed to the release of huge amounts of abattoir effluents into the stream. The high BOD observed in this research is in agreement with the value as revealed by Omole and Longe (2008), Akan et al. (2010). High BOD in some stream could be attributed to the discharge of large quantities of abattoir effluents. Furthermore, the level of total dissolved solid (TDS) ranged from 70 to 80 mg/L, with discharge point having 80 mg/l; while the downstream had 70 mg/L (Table 3). The values of TDS upstream and downstream are within EPA standard of drinking water. According to Ewa et al. (2011), total or fecal coliform bacteria are usually present in water polluted by waste animals and humans subjects. The result in (Table 4) showed that the discharge point has the highest amount of total coliform of 500mpn/ml, followed by the downstream with value of 70mpn/ml. The high content at the point of discharge was apparent, as it is the point of organic waste entry into the river from the intestinal contents of the slaughtered animals. High counts in the effluent is a powerful indicator of excessive pollution and therefore not hygienic to be disposed in the environment. The high counts could be because of the excreta from the intestines of the cattle, goat and cows, which is washed to the effluent. The presence of fecal coliform in the effluent show recent fecal pollution – this reveal that greater risk of pathogen presence (Figueras, 2000; Cadmus et al., 1999; Coker et al., 2001). The reduction in TDS, Fecal coliform bacteria, Total coliform bacteria and total bacterial in downstream may be attributed to the self-purification capacity of effluent through the stream course. However, high value at the discharge point is linked to the discharge of many materials of solid wastes from the slaughtered animals as well as lack of sedimentation facility to separate the solid wastes from the liquid wastes before discharge. It could also be attributed to the fact that lesser water is used for washing animal carcass in this section of stream (Osibanjo and Adie, 2007; Akan et al., 2010). Microbiological analysis was positive due to the presence of coliform, apparently due to fecal contamination from the abattoir wastewater that seeped into surrounding stream water. The result of bacterial analysis of stream water sample reveals that the bacterial count of water from the Kuula stream in Bolgatanga exceeds EPA standard of drinking water in Ghana. EPA guideline requires that water intended for drinking should not contain any pathogen or micro-organisms indicative of fecal contamination. Thus, the stream has trace of fecal coliform or total coliform. The presence of bacterial count mean that the stream is receiving organic pollutants not only from the abattoir effluents, but also from other source of organic pollution like agricultural and household wastes. Reduction in bacterial counts downstream may be due to activities of other antagonistic organisms that utilized them. There was no *Salmonella* detected in the samples collected. More so, foul odor of the cow feces deposited and other activities going on around the abattoir place caused air pollution and had negative impact on the health of the community people living around the place.

Conclusion

The study showed that physical characteristics of the stream water samples are within tolerable limits; microbiological in the other vein exceeds the limits. Solid and liquid wastes generated at the abattoir pollute the stream water. Physical and microbiological qualities of the effluent exceeded the EPA-Ghana standards. The discharge of abattoir waste into streams in Bolgatanga had negative impacts on the microbiological quality of streams, especially at mid-stream for humans' consumption. This may have adverse effect on the health of consumers drinking at the mid-stream and downstream. However, it is recommended that the sanitation in the local meat processing industries should be closely monitored. There should be adequate waste treatment before abattoir wastes are discharged and waste management practices must be ensured to reduce waste disposal. Environmental regulatory bodies should embrace re-use and recycling of waste in order to protect the water resources from negative impacts of abattoir wastes.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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