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Abattoir Waste Management and Its Potential Effects on Humans and Surface Water Quality: South West Region, Cameroon

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Abstract: ***The study assesses abattoir waste management and its potential effects on humans and surface water quality the South West Region, Cameroon. Specifically, the structures, facilities and practices at eight (8) abattoirs were studied. Information was collected using survey, questionnaires, key informant interviews and direct observation. Additionally, water samples from nearby streams were collected and analyzed. The outcome of water sample analyses was further analyzed statistically using student t-test and correlation analyses. Findings indicated that only one abattoir had the required facilities for slaughtering and treatment of waste. Total Dissolved Solids (TDS) and Turbidity exceeded the WHO standards, while pH, Temperature, Conductivity, Biological Oxygen Demand (BOD) and Nitrates were below. Analyses of water samples collected indicated that the abattoirs generated pollutants. It isrecommended that abattoirs should be equipped with up-to-date slaughtering and waste collection/management facilities.***

Keywords: Abattoir, Waste Management, Effluent, Water quality, Pollution

1. Introduction

Water is the most common and vital liquid for all living things onearth of which man in particular, cannot live without suitable water [1].The World Health Organization [2]estimates that approximately a quarter of the diseases facing humanity today occur due to continued exposure to water pollution.Surface and ground water contamination is a major problem in most developing countries today [3]. The nature and source of contamination, however, vary from one nation to another. Even so, only a minor percentage of the population in these nations have access to safe and portable water while most surface water is either contaminated by industrial effluents or by municipal sewage. Usually, the pollution is either of a point source or non-point source [4]. All over the world, abattoirs are well-known to pollute the environment either directly or indirectly from their various processes [5].

Slaughterhouse industries consume large amounts of water for washing of car-casses after evisceration; equipment and facilities washing; cooling of mechanical equipmentetc.[6]. Such activities produce large volumes of wastewater together with other by-products that pollutes the water body. Such pollution of water bodies from abattoir waste could establish important ecological and public health dangers [7].Increasing disposal of wastes in the aquatic bodies means a great potential for environmental damage, and this underscores the need to monitor, protect and manage water resources. However, water quality should also be well-maintained from the viewpoints of living environment for biota and the ecosystem. Impact of water pollution on these means direct and indirect adverse effects on human beings through the food chain and disturbances in the ecosystem [8].

It is stipulated that “everyone has the right to a healthy environment, and the safety of the environment shall be the responsibility of every Cameroonian, with the state ensuring the protection and improvement of the environment” [9]but this is not the case.In the South West Region of Cameroon abattoirs are mostly located besides streams, wetlands and rivers, with the wastes and effluents generated deposited into the water bodies. This might have some implications on surface water quality, the surrounding communities as well as the aesthetic values of the region.This study therefore seeks to assess abattoir waste management and its potential effects on humans and surface water quality in the South West Region of Cameroon.Specifically, toassess the structures, facilities and practices of abattoir waste management; identify potential human health hazards associated with them;investigate the water quality of nearby streams and compare them with WHO standards.

2. Methods/Approach

2.1 Description of the study area

This study was carried out in the South West Region specifically in Fako Division situated between latitudes $4^{o}3$"and $4^{o}12$"N of the equator and longitudes $9^{o}2$" and $9^{o}9$"E of the Greenwich Meridian. The most noticeable physical feature of the area is the Mount (Mt) Cameroon and the area hasvolcanic soils. The topography is hilly and characterized by numerous springs and streams that are used for drinking and domestic purposes. The area is characterized by basaltic rock types which are dark in color, fine grained and is mostly extrusive resulting from lava flow from a volcanic eruption. The area is mostly cloudy with average sunrise at 06:16 and sunset at 18:10, having an equatorial climate with two major seasons. Rainy season which runs from April to October and Dry season, from November to March. Temperature ranges between 20^{o}C to 28^{o}C while, annual rainfall ranges between 12000 mm to 20000 mm.

2.2 Experimentation

This work was carried out from December 2016 to October 2017.The study used the investigative approach and eight

abattoirs were selected. Among the eight abattoirs selected, three(Ekona, Mutengene and Muea)are located besides streams, and the others besides degraded wetlands. A purposive convenient sampling was carried outwithin a radius coverage of $100m^2$ around the eight abattoirs and sixty neighbours were given questionnaires to fill in order to assess the health impacts of the abattoirs. Structured interviews were conducted with seventeen key informants using interview guide in order to capture information regarding waste management practices, and the required national standards for abattoir operation and effluent management in Cameroon.

Water samples were taken from the streams besides the abattoirs for physico-chemical analysis.Water samples were collected 50m before and 50m after the three abattoirs with a third water sample collected 100m downstream after the Muea abattoir because the water at that point is used for cooking, laundry, irrigation, and bathing. This gave a total of 7 water samples analysed. The samples were collected early in the morning between 5.30am and 8.00am at the center of the flowing stream to obtain a representative sample and were analyzed within 72 hours of collection.Physical parameters like temperature, pH and conductivity, were done in-situ while the other chemical parameters like Turbidity, 5-day Biochemical Oxygen Demand (BOD_5), Nitrates and Total Dissolved Solids (TDS) were analyzed in the Cameroon Baptist Convention (CBC) Central Pharmacy QA. Laboratory in Mutengene.

1L glass bottles were used to collect water from the stream using sterilized gloves. The bottles were tightly closed, labelled, using codes described in table 1 and placed in iced cold boxes to protect them from direct sunlight. During water sample collection, each bottle was rinsed with an appropriate amount of water from the point of collection before the actual water sample was collected. They were then transported to the laboratory for analysis.Samples were analyzed according to Standard Methods for Examination of Water and Waste water [10] and the Association of Official Analytical Chemists [11].Scores were assigned to existing abattoir structures, facilities and waste management practices in order to assess their standards as well as their pollution and health hazards potentials.

Table 1: Description of different samples collected from the field

Code	*Description*
E1	Water sample collected 50 meters before the abattoir in Ekona
E2	Water sample collected 50 meters after the abattoir in Ekona
MUT1	Water sample collected 50 meters before the abattoir in Mutengene
MUT2	Water sample collected 50 meters after the abattoir in Mutengene
MU1	Water sample collected 50 meters before the abattoir in Muea
MU2	Water sample collected 50 meters after the abattoir in Muea
MU3	Water sample collected 100 meters downstream after the abattoirs in Muea

2.3 Statistical Data Analysis

The data were analyzed using descriptive and inferential statistics. The descriptive statistics employed was to display the variation of results while inferential statistics employed the use of student t-test at 95 % confidence level to test for significant difference between the means of water quality parameters measured. Pearson's Correlation was also employed as an inferential statistics to test for relationships between the variables. All statistics were done with the help of the Statistical Package for Social Sciences (SPSS) version 21.0 and Microsoft office excel version 2007 tools. All tests were set at a 95% confidence limit. The results were then compared to that of WHO standards.

3. Results and Discussion

Results showed that only four among the eight abattoirs had slaughtering slabs and most butchers do not put on protective biosecurity wears such as hand gloves, aprons, nose mask and boots. Some butchers even use their legs (under of boots) to press and hold the carcass during dressing and slaughtering due to neglect and poor follow-up from the hygiene and sanitation department and this might lead to the transmission of diseases. [12]reports that there are severe hygienic problems in the slaughtering of cattle's in many places from where there is inadequate or no slaughter equipment available.It was observed with dismay that proper regular cleaning of the floor with disinfectants was not done but rather more animals were brought and slaughtered on the same spot containing large quantities of blood and animal waste.This can cause heavy bacterial loads on the meat through infectious diseases such as *Listeria monocytogenes*, which occurs due to dirty floors, and drains in slaughter houses.Effluents produced were channeled directly into the nearby water bodies without treatment(Figure 1).This result conforms to the findings of [13]who reported that there were no special waste disposal or treatment system in Ogbomoso abattoir in Nigeria and that the waste water containing blood and dung were discharged into a nearby stream without treatment which resulted in pollution of surface and underground water.

1(a)

1(b)

Figure 1 (a) & (b): Abattoir waste channeled directly into nearby streams

Most abattoirs studied did not have facilities to store water in case of water seizure as a result, they carried water from nearby streams for slaughtering purposesduring such periods and some even wash the intestinal content directly inside the nearby streams. Similar findings have been reported by[14]who reported that intestinal contents are being washed in the Asata stream in Nigeria. The irregular flow of pipe born water resulted to improper cleaning of theabattoirs leading tothe production of stench which causes nuisance to the environment.This result also corroborates the findings of[15]who reported thatshortage water supplies affected the cleanup of the abattoir in Jalingo Metropolis, Nigeria, and resulted to a stench from the improperly flushed animal blood and faecal matters.

Interviews revealed that condemned meat and foetus was buried in shallow holes around the abattoirs. The shallow disposal of these waste made it easier for it to be removed by stray dogs who fed on them and polluted the environment with left overs that generated unpleasant odours after decomposition. Another mal-practice noticed in one of the abattoirs, was the disposal of condemned meatinto a nearby open pit toilet which later caused pollution to the neighboring environment.

Result on structures and facilities as well as waste management practices carried out in all the abattoirs (except for those of the newly created abattoir) showed that, they do not conform to the required national standards for installation and operations. The scores of the abattoir structures, facilities and waste management practices are present in table 2.1[a] indicates structures and facilities that do not meet the required standard, while 2[a] indicate structures and facilities that meet the required standards. 1[b] indicates unsustainable practices while 2[b] indicates sustainable practices.

Table 2: Scores of structures, facilities and waste management practices of abattoirs in SWR of Cameroon

Abattoir Location	*Waste Management Practices Score*	*Structure and Facility Score*
Muyuka	1[b]	1[a]
Ekona	1[b]	1[a]
Muea	1[b]	1[a]
Buea Town	1[b]	1[a]
Mutengene	1[b]	1[a]
Tiko	1[b]	1[a]
Mile Four Limbe	2[b]	2[a]
New Town Limbe	1[b]	1[a]

Interviews with the key informantson wastes treatment before disposal indicated that, wastes from the abattoirs was emptied into the water bodies and wetlands without any form of treatment which resulted tosurface water contamination and pollution hazards.The results shows that 70% of the respondent who used the stream for domestic purposes experienced health problems such as itches and rashes. This result ties with the findings of[8]who reported that there were different health problems especially skin irritations experienced by women and children using the river around Nyabugogoabattoirin Kigali City, Rwanda for domestic purposes.

3.1 Water quality at point locations in nearby stream channels and comparison with WHO standards

Generally, most of the parameters analyzed had values lower than the WHO standard except for Total Dissolved Solids (TDS) and Turbidity whose concentrations were higher than normal.Values of the physico-chemical parameters considered for assessing water quality and their respective WHO standards are presented on Table 3.

Table 3: Values of physico-chemical parameters of water quality and WHO standards

		Location						
		Ekona		*Mutengene*		*Muea*		
Parameters	*WHO Standards*	*E1*	*E2*	*MUT1*	*MUT2*	*MU1*	*MU2*	*MU3*
TDS mg/L	**200**	177	202	145	179	158.5	255	200
BOD mg/L	**10**	39.22	5.93	19.33	3.74	24.25	2.53	9.82
Turbidity NTU	**5.0-50**	1.71	91	4.59	111	10.73	207	69
Ph	**6.5-8.5**	7.55	7.41	8.26	8.13	7.61	7.51	7.72
Temperature ^{o}C	**35-40**	22.6	23.7	22.6	22.2	21.95	21.7	21.7
Conductivity mS	**3**	0.26	0.29	0.22	0.27	0.24	0.37	0.29
Nitrates mg/L	**30**	27.45	12.9	29.2	12.6	15.75	12.3	12.3

E1= water sample collected 50 m before the abattoir at Ekona; E2 = water sample collected 50 m after the abattoir at Ekona; MTU1 = water sample collected 50 m before the abattoir at Mutengene; MTU2 = water sample collected 50 m after the abattoir at Mutengene; MU1 = water sample collected 50 m before the abattoir at Muea; MU2 = water sample collected 50 m after the abattoir at Muea; MU3 = water sample collected 100 m after the abattoir at Muea.

Table 4: Correlation matrix for water quality parameters considered under this study

	TDS	*BOD*	*Turbidity*	*pH*	*Temperature*	*Conductivity*	*Nitrates*
TDS	1						
BOD	-0.511	1					
Turbidity	0.888	-0.794	1				
Ph	-0.555	-0.162	-0.217	1			
Temperature	-0.179	0.077	-0.214	-0.048	1		
Conductivity	0.998	-0.497	0.879	-0.560	-0.215	1	
Nitrates	-0.576	0.667	-0.665	0.390	0.378	-0.593	1

The result shows that there exist a moderately negative correlation between Total Dissolve Solids and Biological Oxygen Demand (r = -0.511) indicating that an increase in TDS will lead to a decrease in BOD and vice-versa. There also exist a strong positive correlation (r = 0.888) between TDS and Turbidity of water indicating that an increase in the level of TDS will lead to a proportional increase in the turbidity of water. There equally exist a very strong positive correlation between TDS and conductivity of (r = 0.998) indicating that both TDS and conductivity directly proportional. A strong positive correlation of (r = 0.879) is equally observed for Turbidity and conductivity of the water samples indicating that an increase in turbidity will lead to an increase in the electrical conductivity of water. There exist no relationship between the BOD and temperature of the water samples (r = 0.076).

3.2 Analysis of Water Quality

There was a general increase in the concentration of Total Dissolved Solids (TDS) after the abattoirs discharge point with that of Muea and Ekona exceeding the WHO values. The high TDS level is probably due to the high organic contents of the abattoir wastewhich may affectaquatic life.TDS correlates negatively with BOD (r = -0.5) indicating that as TDS increases, BOD decreases. This results are in line with[16]who reported that discharge of wastewater with a high TDS level would have adverse impact on aquatic life due to its influence on BOD and may exacerbate corrosion in water networks. The TDS value at 100 m downstream Mueaabattoir has a lower TDS than that at 50 m. This is probably due to a dilution effect at that level downstream.[17]also, reported that the concentrations of most pollutants in the streams considered for his study, reduced down streams due to assimilation and dilution effects of the rivers.The student's t-test shows that there is no significant difference between the mean TDS values before and after the abattoir discharge points, the values at Ekona andMuea are higher than those of WHO standards and this might be attributed to the high amounts of organic materials contained in the effluent discharged, indicating there is a potential risk of eutrophication of these water body.The values before the abattoir discharge points in Ekona and Mueaare relatively high which can be attributed to agricultural activities identified up stream sinceagriculture can influent the TDSof surface water bodies.The values in this study are lower as compared to those reported by[18].

The BOD values decreased 50 m after the abattoir discharge points, in all the three locations considered under this study.The decrease of BOD after the abattoirs can be attributed to the high organic content in the effluent leading to a high TDS which has a moderately strong negative correlation coefficient (r = -0.511) with BOD.This inversely proportional relationship indicates that the higher the TDS, the lower the BOD level and vice versa resulting from increased amount of organic matter and dissolved oxygen in water.The results slightly increased 100 m downstream due to the assimilation and dilution effect of water at that distance downstream.The high values of BOD before the abattoirs indicates that the streams were already pollutedbefore the discharge of effluent supported by[19]who stated that the values of BOD remained higher upstream due to other non-point sources of pollution.This might result from the use of the water bodies as a dumpsite for human waste, sludge, sewage,washing of cars, clothes, chemical containers and spraying cans.The student t-test shows that BOD, had a significant difference ($P<0.05$) between the water samples at 50 m before and after the abattoir effluent discharge points. This implies that BOD is a parameter of the stream that have been significantly affected by pollution.The results also show that there is a moderate positive correlation coefficient (r=0.66) that exist between BOD and Nitrate thus a decrease in BOD probably resulted to a decrease in the Nitrate levels in these surface waters bodies.

Turbidity values increased at points after the abattoirs resulting from the discharge of effluents into the abattoir.There is a strong positive correlation between turbidity and conductivity (r = 0.878), indicating that the higher the turbidity, the higher the conductivity agreeing with the findings of[16]which states that the turbidity values are usually higher downstream after the effluent is discharged from the abattoir.This increase in turbidity deters the use of the water for domestic purposes.Similarly,[19] stated that turbidity values that grossly exceeds normal levels in water samples disqualifies the receiving water body for direct domestic use.The student t-test shows a significant difference ($P<0.05$) between the water samples at 50 m before and after the abattoir effluent discharge points, implying that turbidity is a parameter of the stream that have been significantly affected by pollution.

There is a decrease in the pH values after the abattoirs discharge pointsresulting from the high the organic content in the water body. There exist a moderately negative correlation between pH and conductivity (r = -0.560) indicating that the higher the pH, the lower the conductivity.The pH values before the abattoirs are higher resulting from activities such as car wash, laundry, sludge and human waste deposition carried out upstream.The pH values are lower as compared to the studies done at Msimbazi sub catchment by[20]and higher as compared to that carried out in Oshunkaye stream in Ibadan by[21].The t-test shows there is no significant difference ($P>0.05$)

between the water samples at 50 m before and after the abattoir.

The temperatures before the abattoirs were higher than those after the abattoirs with the exception of samples collected from Ekona. This low temperature may inhibit the activities of some species of bacteria that are useful in the decomposition of organic constitutes of wastewater and this result is confirmed by other authors [22], [23].The t-test shows there is no significant difference (*P>0.05*) between the water samples at 50 m before and after the abattoir. Conductivity increases after the abattoirs due to the decomposition of organic matter in water bodies leading to pollution hazards and this result corroborates the findings of[17].There exist a strong positive correlationbetween conductivity and TDS (r = 0.99) thusa high conductivity value indicates a high TDS.The t-test shows that generally, there is no significant difference (*P>0.05*) between the water samples at 50 m before and after the abattoir.There is a decrease in the nitrate content after the abattoirswhich can be attributed to low levels of dissolved oxygen in the waste discharged. There exist a moderate positive correlation between nitrate and BOD (r = 0.666) indicating that the higher the nitrate level, the higher the BOD.Before the abattoirs, the nitrate content is high probably because of pollution resulting from fertilizers leached from agricultural soils, washed spraying cans, sludge's from pig sty, toilets and septic systems which enter thestreams. This is in accordance with reports of [24]who showedthat the nitrate concentration in surface water is normally low but can reach high levels as a result of agricultural runoff, refuse dump runoff or contamination with human or animal wastes.Downstream the water is used for irrigationwhich might affect human health as supported by[17]who reports that the rivers around Luna and Kera Slaughterhouses in Central Ethiopia that were being used by the nearby residents for irrigating of vegetables and bathing caused human health risk.The t-test shows that generally, there was no significant difference (*P>0.05*) between the water samples at 50 m before and after the abattoir effluent discharge points.

Figure 2: Stream used in irrigating crops in Muea

4. Conclusion

Proper slaughtering facilities and effluent treatment structures are lacking in the study area.Most of the physico-chemical parameters analysed were below the WHO limit except for Total Dissolved Solids (TDS) and Turbidity which exceeded the limits, indicating an aspect of pollution of the surface water bodies.Apart from abattoir effluents, other sources of pollution upstream included agricultural fields, garage spillages, human waste, septic tanks, car wash facilities and house hold waste disposal. Although most of the water quality parameters falls within acceptable standards, the results provide indicators of water quality degradation, necessitating the need for proper care and water monitoring so as to protect thesewater bodies. The pollution rate of the streams might seriously affect the neighbourhood if something is not done immediately.

5. Future Scope

Further research should be carried out to investigate the hygienic condition of abattoirs and the purity of the water used during slaughtering and dressing of the carcass. Reason being that most research carried out on abattoirs rarely look at the purity of the water used during slaughtering and dressing of the carcass.

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