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Slaughter waste effluents and river catchment watershed contamination in Cagayan de Oro City, Philippines

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Abstract

Slaughterhouse waste products are commonly known globally to pollute nearby communities and receiving bodies of water. The main aim of this study was to analyze the effluents disposed by Cagayan de Oro City Slaughterhouse to river catchment watershed. Standard methods were utilized in sampling and analyzing water quality parameters to determine the levels of nitrates, BOD, COD, total coliform, and lead. It was found out that the majority of wastes produced are internal organs, blood and urine mixtures, and manures. The study also revealed that all parameters tested crossed the permissible limits set by the government for effluent and inland water except for BOD and nitrates, in the river watershed. It was also determined that during wet seasons, major contaminants like lead and nitrates were diluted resulting to lower levels when compared to national standards. The result of this study also revealed the need for further remediation of the river water quality and intervention strategies to sustainably manage and prevent disposal of untreated effluents.

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Introduction

The high demand for meat consumption has led to high volume of wastes produced by different meat industries and slaughterhouses where animals are prepared for consumption as meat products (Adeyemi & Adeyemo, 2016; Maranan *et al.*, 2008). Slaughterhouse effluents are commonly known worldwide to contaminate or degrade their surrounding environments whether directly or indirectly by utilizing huge amount of water and producing enormous amounts of wastewater (Amorim, de Nardi, & Del Nery, 2007; Bustillo-Lecompte & Mehrvar, 2015). The effluent contains high concentrations of organic matter due to presence of manure, blood, hair, and undigested feeds from the different livestock animals.

Slaughterhouses produce a broad range of wastes. In Cagayan de Oro City Slaughterhouse, various wastes are produced ranging from nails, hairs, internal organs, animal manure, blood, and urine. The type of livestock that here slaughtered are hogs (300-450 heads daily), cattle (50-100 heads daily), goats (20 heads daily), and ostrich (20 heads daily), these live animals are delivered by hog growers and farmers and unloaded it to the designated pens. A pre-mortem examination and inspection is then conducted by the City Veterinary Office and the National Meat Inspection Commission to determine quality of livestock. Sickly livestock or those with disease are then separated and disposed of accordingly. On average daily, around 35.76Kg of internal organs are produced and 37.9L mixture of blood and urine are produced from animals being butchered and carcass being dressed. This mixture of blood and urine are then washed away by running water leading towards the drainage then to the holding pond.

Continuous discharge of untreated effluents from slaughterhouse industries to different bodies of water can lead to potential hazards to the public if left unmanaged (Bustillo-Lecompte & Mehrvar, 2015). This polluting effluent can directly affect the dissolved oxygen (DO) by decreasing it significantly. It can also increase the heterotrophic bacterial count, BOD, nitrates, and phosphates levels of the receiving body of water (Benka-Coker & Ojior, 1995). When effluents are released to receiving streams, not just the point of discharge will be affected but also all other parts of downstream where DO, BOD, TDS will be greatly affected but minimal compared to those directly receiving the effluents (Olayinka, Adedeji, & Oladeru, 2013).

Improper disposal and management of these harmful wastes leads to various contamination to the soil, air, and water quality resulting to serious environmental hazards which can lead to broad spectrum of health complications and diseases (Jiban Singh, Biswas, Sagar, Suneel, & Akolkar, 2016; Kosamu, Mawenda, & Mapoma, 2011). The environmental and health hazards these wastes bring are not just limited to humans and other terrestrial animals but also aquatic life near the point of discharge and the receiving bodies of water (Kosamu *et al.*, 2011; Mulu, Ayenew, & Berhe, 2015). Thus, the main aim of this study was to analyze the pollution effects of the effluents released by the nearby slaughterhouse to Cugman River, Cagayan de Oro City. Thus, it specifically aims to: (1) determine the type of wastes produced by the slaughterhouse; (2) determine the concentration and levels of nitrates, COD, BOD, Total Coliform, and lead in the effluent and receiving river; (3) compare the parameters determined with the national standards of water quality and effluent; and (4) compare the concentration and levels in the three sampling sites (drainage, holding pond, and river).

Materials and Methods

Study Area

Cagayan de Oro City Slaughterhouse is located at Zone 2, Barangay Cugman, Cagayan de Oro City with the coordinates 8°28'04.2"N 124°42'18.6"E.It occupies an area of 2.45 hectares owned by the City Government. A barangay road, which has a width of about 10 meters, connects the project site from the junction of the national highway. It has a distance of about 600 meters.

The main drainage in the area is Cugman River, which is located some 200 meters east. Cugman River empties into Macajalar Bay, which is about 1.0 kilometer away from the project site. Residential houses are located just outside the perimeter fence of the complex.

Fig. 1. Geographical location (top) and sampling sites (bottom) in Barangay Cugman, Cagayan de Oro City. Red dot= Site A, Blue dot= Site B, Yellow dot= Site C

Three sampling sites were established as shown in Fig. 1. Site A refers to the drainage area inside the slaughterhouse establishment as shown in Fig. 2A.

Fig. 2. The different sampling sites in Barangay Cugman, Cagayan de Oro City.

The drainage area receives the mixture of blood, urine, and water used to wash carcasses from scalding bath and evisceration area.

Site B on the other hand refers to the holding pond used to store the wastewater temporarily before releasing it to the nearby river as shown in Fig. 2B. Lastly, Site C is the receiving body of water of the effluents released by the slaughterhouse (Fig. 2C).

Sample Collection and Analyses

Before the actual sampling, containers were pre-treated two days before with liquid detergent and were rinsed with water thoroughly to remove soap residues. The sampling containers were then rinsed with distilled water twice and with nitric acid for one hour successively. Finally, the containers were rinsed with water to remove nitric acid residues and were treated with acetone to dry off excess water (Prendez & Carrasco, 2003).

Samplings were made three times during dry season (November 2012 to April 2013) and wet season (June 2013 to September 2013) in the three sampling sites established as shown in Fig. 1 and 2. Standard methods were employed to determine the levels and concentration of nitrates, COD, BOD, total coliform, and lead (APHA, AWWA, & WEF, 1999). Ion selective and brucine-sulfanilic acid methods were used to determine the concentration of nitrates as nitrogen in mg/L. BOD levels were determined at $20^{\circ}C$ using azide modification method (dilution technique) and open reflux dichromate method was used to determine COD while multiple tube fermentation technique was used to determine the total coliform and Flame AAS for lead concentration in the samples.

Results and Discussion

Types, amounts, and sources of waste produced by the slaughterhouse were determined through oral interview with butchers employed in the facility acquired from their daily records. As shown in Table 1, different types of wastes are produced through the different stages in the production of meat in the facility. Majority of the waste comes from the internal organs removed from animals butchered. These internal organs include the lungs, liver, and intestines of the animals to name a few.

Liver and intestines of hogs are generally sold to locals in the nearby community at a cheaper price. Some of the clients of the slaughterhouse also requests that these internal organs be given to them. These internal organs can be utilized as food and as an energy source through biogas production similar in the study conducted by Budiyono, Widiasa, Johari, & Sunarso(2011)and Afazeli, Jafari, Rafiee, & Nosrati, (2014)which also includes the rumen, intestines, stomach, manure from heavy and light animals and wastewater.

Nails and hairs are disposed through the City Government's garbage collecting agency and are dumped to the city's landfill while the blood, urine, and manure are the main constituents of the effluent produced by the facility. All of these liquid wastes (blood, urine, manure) are washed away by water producing the primary effluent of the slaughterhouse. Effluents are channeled towards the drainage area (Fig. 2A) which collects all liquid wastes of the facility.

Table 1. Composition of wastes generated in the slaughterhouse daily.

Type of Waste	Source	Quantity
Internal Organs	Insides removal	35.76 kg
Manure	Receiving area	15.00 kg
Nails	Dehairing	5.50 kg
Hairs	Dehairing	3.20 kg
Blood/Urine	Killing floor	37.9 L

Standard procedures were taken into account in determining physicochemical parameters chosen in the study in the effluent produced and the quality of water of the receiving river. As shown in Table 2, the mean and standard deviation of nitrate, chemical oxygen demand (COD), biological oxygen demand, lead, and total coliform levels were determined in the three different sites during dry season which lasted from November 2012 to April 2013. Site A is the drainage area and Site B is the holding pond of the facility thus both are classified as effluents. Site C on the other hand is the receiving river of all the effluents produced by the facility and waste products produced by the nearby community. The data further showed that all sites crossed the permissible limits set by the Department of Environment and Natural Resources both as Class C effluent and inland water except for the nitrate and BOD levels in Site C. The results of the study are similar to the study conducted by Mulu *et al.*(2015) in Central Ethiopia and Olayinka *et al.* (2013) in Nigeria where nitrates, COD, BOD, and total coliform exceeded the allowable concentrations. BOD and COD are important parameters in determining whether the water is polluted or not. The higher the concentration of BOD and COD the more polluted the water is (Mulu *et al.*, 2015). The nitrate, total coliform, BOD and COD in site Aare very high which is expected since Site A receives the primary effluent from the operation of the facility. These pollutants come from the manure, blood, urine and other inorganic wastes washed from the different animals slaughtered daily.

Table 2. Mean values of physicochemical parameters and lead concentration in the different sampling sites during dry season.

Parameter	Standard[1]	Standard[2]	Site A[x]	Site B[x]	Site C[y]
Nitrate (mg/L)	14	7	35.80±2.16	5.20±0.72	4.10±0.26
COD (mg/L)	100	7	2654± 138.32	35.00± 7.00	27.00± 3.13
BOD (mg/L)	50	7	1081 ± 9.54	3.00± 2.23	2.00± 1.86
Lead (mg/L)	0.1	0.05	0.30± 0.02	0.14± 0.01	0.32± 0.02
Total Coliform (MPN/100mL)	$1.00 x 10^4$	200	$1.65 x 10^8 \pm 1.50 x 10^7$	$9.20 x 10^6 \pm 1.91 x 10^5$	$4.30 x 10^6 \pm 3.32 x 10^5$

[1]DENR Administrative Order No. 08 S. 2016 Class C Effluent Standards; [2]DENR Administrative Order No. 08 S. 2016 Class C Water Quality Standards; [x]Class C Effluent; [y]Class C Inland Waters.

The more wastes are produced by the facility, the higher is the BOD concentration. Moreover, the amounts and concentrations of the different pollutants decreases from Site A to Site C, this is due to the fact that before the wastewater and effluent are released to the river (Site C), enough time is given to allow the effluent to stay still in the holding pond (Site B) pollutants to settle down.

This may be the reason why Site C has the least concentration of nitrate, COD, BOD, and total coliform. The high total coliform is attributed to the amount of manure produced by the facility at around 15Kg daily and 35.76Kg of internal organs where coliforms naturally inhabit in animals. These wastes are washed out then channeled to the drainage area, thus high levels of fecal coliform is expected in Site A and B. Lead has the highest concentration in Site C compared to Site A and Site B. This can be attributed to the fact that Site C is also considered as receiving body of water of the solid and liquid wastes coming from the nearby communities and wet market.

It is also good to note that during wet season from June 2013 to September 2013 as shown in Table 3, all the physicochemical parameters in all sites were below the permissible limits except for the total coliform. Generally, pollutants in wastewater and rivers are diluted during wet seasons thus resulting to a lower detected concentrations (Longe & Ogundipe, 2010). Though the total coliform during the wet season is lower compared to during dry season, it still crossed the permissible limit. This can be due to the fact that the population of coliform does not decrease or cannot be diluted during significant addition of rainwater due to the fact that the coliform can reproduce exponentially.

Table 3. Mean Values of physicochemical parameters and lead concentration in the different sampling sites during wet season.

Parameter	Standard[1]	Standard[2]	Site A[x]	Site B[x]	Site C[y]
Nitrate (mg/L)	14	7	0.96 ± 0.22	1.00 ± 0.05	0.50 ± 0.21
COD (mg/L)	100	7	14.00 ± 3.61	24.00 ± 2.55	2.00 ± 0.93
BOD (mg/L)	50	7	17.49 ± 1.56	23.53 ± 0.86	1.94 ± 0.95
Lead (mg/L)	0.1	0.05	0.001 ± 0.00	0.001 ± 0.00	0.001 ± 0.00
Total Coliform (MPN/100mL)	$1.00x10^4$	200	$2.22x10^5$± $1.04x10^4$	$4.83x10^4$± $2.52x10^3$	$4.82x10^4$± $1.26x10^3$

[1]DENR Administrative Order No. 08 S. 2016 Class C Effluent Standards; [2]DENR Administrative Order No. 08 S. 2016 Class C Water Quality Standards; [x]Class C Effluent; [y]Class C Inland Waters.

Statistical analyses were also done using One-way ANOVA to compare the differences of means of physicochemical parameter considered in the study as summarized in Table 4 for dry season and Table 5 for wet season and Tukey HSD Mean Test was used to compare the means pair-wise. Site A has the highest concentrations of nitrate, COD, BOD, Total Coliform compared to Sites B and C at 0.01significant levels. While both Site A and C is higher compared to Site B in terms of lead concentration at 0.01 significant levels. These results are expected since Site A is the point source of the effluents thus yielding higher results in the parameters considered in the study.

Table 4. Results of One-way ANOVA and Tukey HSD Mean Test comparing physicochemical parameters and lead concentration during dry season.

Parameter	Mean			F Statistic	Tukey HSD Mean Comparison
	Site A	Site B	Site C		
Nitrate (mg/L)	35.80	5.20	4.10	552.88**	A > B, C
COD (mg/L)	2654.00	35.00	27.00	1075.59**	A > B, C
BOD (mg/L)	1081.00	3.00	2.00	35247.36**	A > B, C
Total Coliform(MPN/100mL)	$1.65x10^8$	$9.20x10^6$	$4.30x10^6$	333.93**	A > B, C
Lead (mg/L)	0.30	0.14	0.32	90.09**	A, C > B

* $p< 0.05$; ** $p< 0.01$; NS, not significant at the $\alpha = 0.05$ level.

During wet season, when the physicochemical parameters were compared, it was noted that both Site A and Site B had higher concentration of nitrates than Site C at $\alpha = 0.05$ level of significance. For BOD and COD, Site B had the highest levels when compared to Site A and Site C though Site A is higher than Site C at $\alpha=0.01$. This result can be due to the fact that nitrates level in Site B is higher compared to Site C which can increase the oxidizable inorganic matter in the water.

Lead concentration on the other hand did not differ significantly in all sites during wet season. This can be attributed to dilution of concentration during excessive amounts of rainfall in the months of June 2013 to September 2013.

Table 5. Results of One-way ANOVA and Tukey HSD Mean Test comparing physicochemical parameters and lead concentration during wet season.

Parameter	Mean			F Statistic	Tukey HSD Mean Comparison
	Site A	Site B	Site C		
Nitrate (mg/L)	0.96	1.00	0.50	7.69*	A, B > C
COD (mg/L)	14.00	24.00	2.00	53.69**	B > A > C
BOD (mg/L)	17.49	23.53	1.94	273.94**	B > A > C
Total Coliform (MPN/100mL)	2.22×10^5	4.83×10^4	4.82×10^4	776.09**	A > B, C
Lead (mg/L)	0.001	0.001	0.001	0.03^{NS}	A, B, C

* *p*< 0.05; ** *p*< 0.01; NS, not significant at the α = 0.05 level.

Conclusion

The untreated effluents coming from the slaughterhouse facility have a considerable effect towards the water quality of the receiving water. These effluents and contaminants came from wastes produced by the facility ranging from hairs, nails, internal organs, and mixtures of blood and urine. These wastes have deterrent effects towards the water quality of the river. Water quality was measured in terms of levels of nitrate, COD, BOD, total coliform, and lead contamination. It was found out that during dry season, all parameters exceeded the allowable and permissible limits of the Department of Environment and Natural Resources for effluent and inland water except for BOD and nitrates in Site C. It was also determined that during wet seasons, major contaminants like lead and nitrates were diluted thus resulting to lower levels when compared to national standards. The results of this study suggests and recommends for further remediation of the river water quality and intervention strategies to prevent disposal of untreated effluents. Sustainable management practices should also be taken into account to protect the integrity and quality of the riverine environment and the ecosystems nearby.

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