CHARACTERISATION OF WASTEWATER QUALITY FROM A LOCAL RUMINANT ABATTOIR IN BANTING, SELANGOR, MALAYSIA

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ABSTRACT. Abattoir wastewater contains diluted blood, protein, fat and suspended solids, resulting in various concentrations of organic compounds in the effluent. The residues were partially soluble, leading to high risks of contaminating riverbeds and other water sources if left untreated. This study was carried out to evaluate the organic pollutant concentrations from the Banting Abattoir and to assess its compliance with Environment Quality Act, 1974. The wastewater samples were collected at the discharge points. Physical and chemical characteristics of the wastewater were determined by measuring the pH, total suspended solids (TSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), ammoniacal nitrogen (NH_3-N) and, oil and grease (O&G) using the procedure described in the APHA (2005) Standard Methods for the Examination of Water and Wastewater. The results showed that the mean values of TSS, BOD_5 and COD were 667 mg/L, 449 mg/L and 1,665 mg/L, respectively. It was found that the wastewater of this abattoir contains high levels of pollutants as it exceeded the permissible limits of 100 mg/L for TSS, 50 mg/L BOD_5 and 200 mg/L COD according to Standard B by the Department of Environment (DOE) of Malaysia pertaining to regulations of water discharge. Based on these findings, monitoring of the wastewater should be conducted more frequently to prevent environmental pollution and reduce health hazards caused by the activities of the abattoir. The abattoir management was advised to employ an effective wastewater treatment facility in order to comply with effluent discharge requirements of the Environmental Quality Act 1974.

Keywords: wastewater characterisation, abattoir, BOD_5, TSS, COD, NH_3-N, oil & grease

INTRODUCTION

An abattoir is defined as an approved and registered premise by the relevant authority in which animals were slaughtered and dressed for the consumption of humans (Codex, 1993). Generally, the operation of an abattoir includes the efficient processes and procedures of the storage and preservation of meat products in compliance with the specific guidelines for human consumption (Alonge, 1991). In Malaysia, there are several halal abattoirs that were used for the slaughtering process of livestock (Tamrin *et al.*, 2016). Abattoir wastewater is the

Table 1. Common types of wastewater effluent.

Category	Characteristics
Household effluent	Non-toxic and not directly polluting but liable to disturb the physical nature of the receiving water.
Slaughterhouse effluent	Non-toxic and polluting due to organic matter content having high oxygen demand.
Industrial effluent (e.g. factory waste)	Toxic, containing highly poisonous materials.
Industrial chemical effluent (e.g chemical fertiliser factory)	Toxic and polluting due to organic matter having high oxygen demand and toxicity.

Source: Irshad *et al.*, 2015

water that has been used for the cleaning of slaughtered farm animals such as cattle, goat and sheep, the floor of slaughtering halls, slaughtering personnel as well as the slaughtering equipment (Coker, 2001). The utilisation of water in the meat processing industry has been an essential part of meat processing routines mainly for the general processing and cleaning purposes (Mekonnen and Hoekstra, 2012).

As the number of slaughterhouses increase due to the two-fold increment of global meat production in the past decades, a higher volume of liquid and solid residues from slaughterhouses were released (Bustillo-Lecompte and Mehrvar, 2017). In Malaysia, the growth of the livestock industry has also significantly increased and accelerated every year (Ngo, 2004). The solid and liquid residues in an abattoir were often lumped together as "flow materials" in wastewater discharge (Tritt and Schuchardt, 1991). The discharge of effluent in abattoirs normally ranged from moderate to high strength complex as wastewater usually consists of 45% soluble and 55% coarse suspended organics (Manjunath *et al.*, 2000).

According to Irshad *et al.* (2015), wastewater effluent is commonly divided into four categories (as shown in Table 1). The effluent of slaughterhouses is described as non-toxic and polluting, due to the high oxygen demand of its organic content, which is less harmful compared to industrial and industrial chemical effluents. Still, Masse and Masse (2000) described that slaughterhouse wastewater is very harmful to the environment. During abattoir processing, organic waste from blood, manure, fat, meat tissue and urine are discharged into the wastewater stream, contributing to surface and groundwater contamination (Bello and Odeyemi, 2009).

Legislation of the Environmental Quality Act (EQA 1974, revised in 2009) is related to the prevention, abatement and control of pollution to the environment by restricting the discharge of waste which is in contravention of the acceptable conditions (DOE, 1974; DOE, 2009). As described in Table 2, the legislation of wastewater quality enacted by EQA to outline the standard parameters of water quality, mainly regulating pollutants at point of source. Abattoir management should also adhere to EQA regulations and adopt the proper waste minimisation strategies before the wastewater is released into the environment. Hence, the objective of this study is to evaluate the quality of wastewater discharged from a local abattoir in Banting, Selangor, to assess its compliance with EQA regulations.

MATERIALS AND METHODS

Study site

Wastewater samples were collected from a local abattoir located in Banting, Selangor. The animals slaughtered in this abattoir are mainly cattle, with occasional numbers of goats and sheep. Generally, the operation of this abattoir starts as early as 2 a.m. and ends at 11 a.m. from Mondays to Fridays, and sometimes includes the weekend or public holidays. The operating hours comprise of two diurnal cycles, the slaughtering cycle (Figure 1) and the cleaning cycle (Figure 2). The average number of cattle slaughtered were 7 heads per day, where blood and fibrous animal matter represent the most significant components in its wastewater discharge. The wastewater from the abattoir flowed into a drain (Figure 3) and then channelled into the solid trap compartment (Figure 4) before it entered into the collection sump.

Sample collection

The study was conducted in the month of August 2015, where a total of 35 wastewater samples were collected at the discharge point as shown in Figure 3. The wastewater sampling was carried out simultaneously with the wastewater generation and the sampling was conducted over 8 days (day 1, day 2, day 3, day 4, day 8, day 9, day 24 and day 29) to obtain the effluent trend and patterns. Each of the wastewater samples was collected with a plastic container that was previously cleaned by washing with non-ionic detergent. During the sampling process, the sampling containers were rinsed with the wastewater samples for three times and filled to the brim. Then, the samples were labelled appropriately, stored under 4 °C and taken to the laboratory to be analysed within 6 hours of collection.

Table 2. Wastewater discharge standards for Malaysia.

Parameter	Unit	Maximum Permitted Values	
		Standard A	Standard B
pH value	-	6.0 – 9.0	5.5 - 9.0
BOD_5 (at 20 °C)	mg/L	20	50
COD	mg/L	120	200
TSS	mg/L	50	100
Oil & grease	mg/L	5.0	10
Ammoniacal nitrogen	mg/L	10.0	20.0

Source: (DOE, 1974; DOE, 2009). *Note:* Standard A for discharge of upstream of water supply intake points/sensitive areas. Standard B used for discharge of downstream of water intake points/any other areas that do not fall under Standard B. Standard B was used in this study.

Figure 1. Slaughtering cycle of an abattoir in Banting which involved the removal of blood and intestinal contents from slaughtered animals.

Figure 2. Cleaning cycle of an abattoir in Banting which washed blood and solid waste into the open drains.

Figure 3. The abattoir wastewater flowed into the drain and solid waste was transferred into the dumping ground before being channeled into the solid trap tank.

Figure 4. The wastewater (mostly containing oil and grease) from the drain was collected in this concrete solid trap compartment.

The collected samples for NH_3-N, COD and O&G analysis were added with sulphuric acid to pH less than 2 to preserve the sample and then refrigerated prior to analysis. The preservation of samples is important to maintain the characteristics of the wastewater samples.

Determination of physical and chemical properties in abattoir wastewater samples

The pH of the abattoir wastewater was measured *in-situ* by using a pH meter (Mettler Toledo). In the laboratory, the chemical characteristics of the abattoir wastewater were determined by measuring the concentration of TSS, COD, BOD_5, NH_3-N and O&G according to the standard methods for the examination of water and wastewater (APHA, 2005). Each of the abattoir wastewater samples were analysed in triplicate to increase the accuracy in the reading. The results of the laboratory analyses were recorded accordingly and compared with the compliance standard of the EQA.

RESULTS AND DISCUSSION

The abattoir wastewater composition obtained from this study was analysed to check its compliance with local abattoirs and wastewater discharge standards of Malaysia (DOE 1974; DOE 2009) as presented in Table 2. Table 3 represents the characteristics of wastewater obtained in this study at the Banting Abbatoir, compared to other studies of local abattoirs. It was found that all the mean parameters measured, that is, BOD_5 (449 mg/L), COD (1,665 mg/L), TSS (667 mg/L) and O&G (87 mg/L), have exceeded the EQA regulations for Standard B except for pH values. COD parameter is one of the main chemical characteristics of wastewater, which reveals the level of organic contents. The high content of organic carbon and blood in abattoir waste has contributed to the high chemical reactions between these organic substances in wastewater. BOD_5 is an expression indicating the amount of oxygen used for the destruction of decomposable organic materials by biochemical processes. The high concentrations of BOD_5 show high microbial loads in the wastewater. A high BOD_5 will disturb organic matter decomposition in the wastewater, thus resulting in the failure of anaerobic digestion of its suspended solids. Consequently, it will deteriorate wastewater treatment processes (Henze and Comeau, 2008).

As indicated in Figure 5 and Figure 6, the characteristics of wastewater in this study tends to fluctuate over a wide range due to a variations of water quantity that was used in the daily management practices. High COD values could also be due to improper usage and unsuitable choice of detergents or disinfectants during the cleaning activities.

The BOD_5:COD ratio characterises the biodegradability of the effluent. The reduction of this ratio indicates an increasing amount of non-biodegradable organic materials. A ratio greater than 0.5 mg/L, is considered to be easily treatable by biological means (Tchobanoglous *et al.,* 2004). The discharged wastewater has a mean ratio, BOD_5:COD of 0.15 mg/L which indicates that the wastewater has low biodegradability. This also implies the presence of inhibitory products, such as oil, grease or a significant load of organic matter.

The pH value is important in determining the quality of wastewater effluents because most of the chemical reactions in an aquatic environment are controlled by changes in its value. Highly acidic or alkaline water could kill aquatic life. The pH of the wastewater in this study was within the standard of EQA, which correlates with the findings of earlier studies.

TSS, NH_3-N and O&G concentrations of the abattoir wastewater showed fluctuations in its values (Figures 7, 8 and 9). TSS and NH_3-N values were in the range of 180 to

Table 3. Comparative wastewater characteristics in the Banting abattoir with other studies of two abbatoirs.

Parameters	Abattoir				EQA Standard B
	Shah Alam[1]		Seremban[2]	Banting	
Animal slaughtered (per day)	cattle (19)	pigs (1,017)	cattle (3)	cattle (7)	-
pH	6.0-7.0	6.5-6.8	7.1-7.2	6.49 – 6.84	5.5 – 9.0
BOD_5 (mg/L)	102-954	384-1,254	232-307	225 – 930	50
COD (mg/L)	304-5,573	832-2,280	-	640 – 3,600	200
TSS (mg/L)	70-1,930	100-660	44-425	180 – 1,840	100
O&G (mg/L)	18-310	5-380	30-33	47 – 196	10
Ammoniacal nitrogen (mg/L)	-	-	29 - 70	55 - 144	20
Mean Total Flow/day (m^3)	223.90	288.37	27.37	46.72	-
Mean BOD_5:COD (mg/L)	0.21	0.47	-	0.15	-

Note: A dash indicates the data was not included. 1 = Data adapted from Choo P.Y. *et al.* (1990); 2 = Data adapted from Roslan M.Y. (1994)

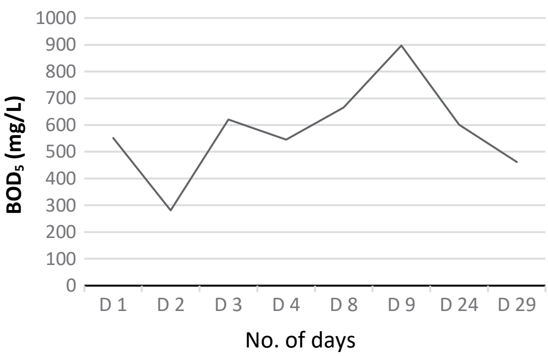

Figure 5. Biochemical oxygen demand (BOD_5) concentrations of the collected wastewater.

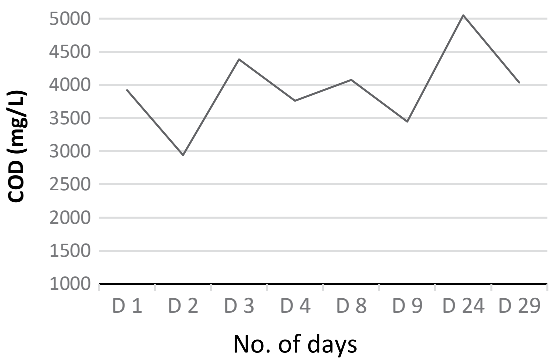

Figure 6. Chemical oxygen demand (COD) concentrations of the collected wastewater.

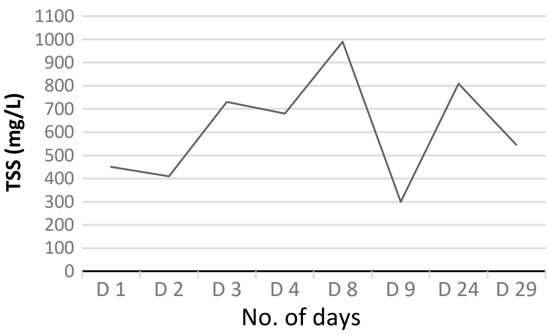

Figure 7. Total suspended solids (TSS) concentrations of the collected wastewater.

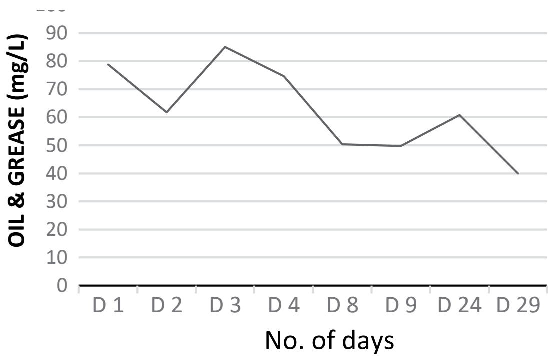

Figure 8. Oil and grease (O&G) concentrations of the collected wastewater.

1,840 and 55 to 144 mg/L, respectively. These exceeded the maximum permitted values of Standard B wastewater discharge (Table 2). This could be due to the non-environmental-friendly management system in the abattoir.

The concentration of suspended solids represents the amount of insoluble organic and inorganic particles in the wastewater. TSS values of the wastewater might be attributed to various materials of solid waste from slaughtered animals such as rumen contents (Joseph *et al.*, 2010). A high TSS can block light from reaching submerged vegetation and can cause many problems in the health of a stream and aquatic life (Dan-Azumin and Bichi, 2010).

BOD_5 can be decreased by the reduction of total solids in the wastewater. It is important that slaughterhouses remove as much total solids from the wastewater as possible. The concentrations of O&G and NH_3-N were also found to be significant in wastewater. It typically originates from wastes during slaughtering activities such as blood and animal fats. Due to the inefficient recovery system of the Banting abattoir, higher concentrations of organic and solid waste were discharged.

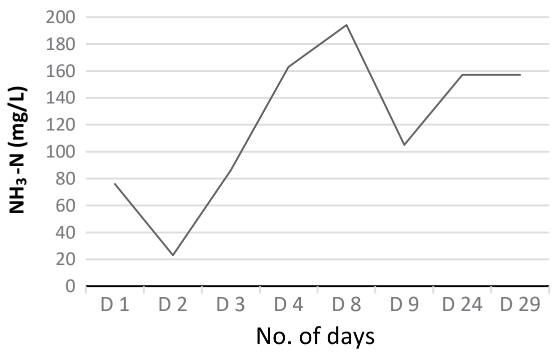

Figure 9. Ammoniacal nitrogen (NH_3-N) concentrations of the collected wastewater.

The quality or nature of abattoir wastewater is influenced by a few factors which includes the degree of by-products separation such as fat, blood, manure, undigested stomach contents, the usage of water as well as the type of animal that was slaughtered (Irshad *et al.*, 2015). According to Manjunath *et al.* (2000), the strength and composition of pollutants in the wastewater depends on the slaughtering management system as well as the number of animals that slaughtered. As the quality of surface water is degraded by pollutants from point sources (sewage, sullage, industrial effluent, etc.) and non-point sources (urban and rural runoff), proper management of the pollutants are important for sustainability of the environment (Mamun and Zainudin, 2013). Proper management and hygienic abattoir practices must be adhered to by the workers as they are exposed and among the high risk groups, with higher chances of getting infected with occupational zoonotic diseases (Tamrin *et al.*, 2016).

Removal of solid matter has several advantages such as reduction in water consumption as well as reducing the wastewater loads and strength. Good housekeeping practice by cleaning-up (collect in garbage bags as domestic waste) all surfaces and floors from any semi-solid waste (animal fats, clot blood, manure and residual meat tissue) before using the water for cleansing is also advisable.

Wastewater from slaughterhouses is one of the contamination sources contributing to harmful effects on the environment besides affecting water quality, (Masse and Masse, 2010). Provision of better abattoir wastewater treatment facilities is required to enhance the quality and reduce the contamination level of the wastewater effluents from the abattoir. To ensure this, it is crucial for the abattoir wastewater to be treated properly. For further treatment of biological materials, it is strongly recommended to eliminate the pollutants (BOD_5, COD, SS, pathogen, nutrients, etc.) in the wastewater. One of the best options for wastewater treatment is by combining the anaerobic and aerobic processes as this treatment is potentially beneficial for the resource recovery and high treatment efficiency for the industrial waste (Bustillo-Lecompte and Mehrvar, 2017). In Malaysia, Othman *et al.* (2013) demonstrated the aerobic granular sludge as a useful treatment for livestock wastewater by using a sequencing batch reactor (SBR) without the presence of support material. Therefore, it is hoped that by applying the proper treatment system, the final discharge of wastewater in abattoirs will be in compliance with DOE standards.

CONCLUSION

Characterisation of the slaughterhouse wastewater is important in order to ensure that discharged wastewater does not have a negative effect on the environment. The wastewater in an abattoir in Banting displayed heterogenous characteristics and does not meet some standard values stated in the EQA. Therefore, it is essential to improve the management and treatment systems in this abattoir by providing proper separation processes and treatment before its effluents are released into the river or water source. Continuous monitoring and evaluation of industrial effluents such as abattoir wastewater must also be carried out more effectively to ensure the safe discharge of wastewater into our environment. It is also necessary to conduct further analysis by other techniques to refine this characterisation and to improve the identification of possible contaminating sources. The use of chromatography coupled with spectroscopic technologies seems to be appropriate for a better contaminant characterisation, both qualitative and quantitative.

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