STUDY OF EFFLUENT WATER QUALITY INDEX FROM PIG FARMING AREA IN KAMPUNG SELAMAT, PULAU PINANG

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**SCHOOL OF CIVIL ENGINEERING
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FARMING AREA IN KAMPUNG SELAMAT, PULAU PINANG

by

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ABSTRAK

Penternakan khinzir merupakan salah satu sektor yang penting di dunia. Kandang khinzir mengeluarkan efluen yang tinggi dengan AN, BOD, COD dan SS. Efluen kandang khinzir yang tak dirawat sangat berbahaya kerana ia boleh menyebabkan parameter yang disebut menjadi tinggi dan menyebabkan masalah alam sekitar. Kajian pencemaran penternakan khinzir boleh dikatakan jarang dilakukan di Malaysia kerana permintaan daging khinzir kurang berbanding daging lembu dan unggas. Di Malaysia, kajian tentang perkara ini dan pencirian efluen kandang khinzir kurang mendapat perhatian masyarakat walaupun ia merupakan salah satu pencemaran yang membimbangkan. Tujuan kajian ini adalah untuk menyiasat punca pencemaran Sungai Kereh yang menunjukkan jadual pencemaran yang berasal dari Kampung Selamat. Kajian ini akan menjadi salah satu rujukan untuk kajian-kajian berkenaan masalah ini pada masa hadapan. Kaedah yang digunakan di dalam kajian ini adalah dengan menggunakan WQI dan Standard Pelepasan Efluen yang diisukan oleh Jabatan Alam Sekitar Malaysia. Kaedah ini tertumpu terhadap BOD, COD, DO, SS, AN dan pH efluen dan air Sungai Kereh. Parameter ini ditentukan nilainya melalui ujian makmal mengikut kaedah standard APHA. Kajian ini menunjukkan bahawa semua efluen kandang khinzir yang disampelkan telah menepati nilai maksimum yang dibenarkan untuk Standard B dari Standard Pelepasan Efluen Kumbahan (2009) kecuali untuk nilai SS dan AN. Nilai SS yang melebihi standard B, 50 mg/L adalah dari P2 dan P3 dengan nilai 104, 131 mg/L manakala untuk AN, hanya P3 dan P4 melebihi nilai standard, 50 mg/L iaitu 123.92 dan 104.5 mg/L. Untuk WQI Sungai Kereh, SK2b, SK2c dan SK4 berada dalam kelas III manakan SK1, SK2a dan SK3 berada dalam kelas IV. Melalui WQI dan standard efluen, tahap pencemaran Sungai Kereh dapat ditentukan dan ia juga boleh untuk memeriksa jika efluen yang dilepaskan mematuhi standard yang telah ditetapkan atau tidak.

ABSTRACT

Pig farming is one of the vital livestock farming in the world. Pig farms produce effluents that are high in Ammonia Nitrogen, BOD, COD and SS. Untreated pig farm effluents are hazardous as they can cause the parameters mentioned to be very high and cause environmental problems. Pig farming pollution studies are rare in Malaysia as pork demand is not high compared to beef and poultry. However, in Malaysia, the research regarding this activity and the characterisation of pig farming effluent does not garner much public attention even though it is one of the biggest pollution concerns. The purpose of this study is to investigate the source of pollution Sungai Kereh that shows pollution inventory comes from Kampung Selamat. This study can be a reference for future studies regarding pig farming pollution that has been a concern these days. The method used for this study is by using WQI and Effluent Discharge Standards issued by the Department of Environment Malaysia. This method mainly focused on the BOD, COD, DO, SS, AN and pH of the effluent and Sungai Kereh. Laboratory tests determined the parameters according to APHA standard methods. This study shows that all the pig farms discharged effluents within the maximum permissible value for Standard B of Effluent Discharge Standard of Sewage (2009) except for SS and AN values where P2 and P3 exceed the maximum permitted value of 50 mg/L with 104 and 131 mg/L respectively for SS. Next, for AN value, only P3 and P4 exceed the maximum value of 50 mg/L with values of 123.92 and 104.58 mg/L accordingly. For the WQI of Sungai Kereh, SK2b, SK2c and SK4 falls into class III and SK1, SK2a and SK3 falls into class IV. Through this WQI and effluent standard, the level of pollution can be determined and check whether the effluent discharged complies with the standard.

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AN   Ammoniacal Nitrogen

APHA   American Public Health Association

BOD   Biochemical Oxygen Demand

COD   Chemical Oxygen Demand

DO   Dissolved Oxygen

DOE   Department of Environment

NPS   Non-point Source

PS   Point Source

SS   Suspended Solids

CHAPTER 1

INTRODUCTION

1.1   Background Study

Livestock farms pollution is a common type of pollution worldwide because the meat industry is expanding due to consumers' mass demand. However, the number of pig farms in Malaysia has decreased from 542 farms in 2013 (Singh and Wai, 2016) to 501 farms in 2018 (The Swine Industry, 2021). Even though the number of pig farms in Malaysia has dropped, this does not include the number of illegal pig farms that operates illegally without the acknowledgement by related agencies. This is because small pig farms were closed due to viability and environmental problem but the bigger farms had increased their pork production capacity and importing frozen pork cuts from neighboring countries to meet the demands (The Swine Industry, 2021). This is because small pig farms were closed due to viability and environmental problem (The Swine Industry, 2021). Pig farms produce wastes that are similar in composition of pollutants to poultry and ruminant farms. The livestock farms caused severe pollution in the rivers of Malaysia as the farms disposed the wastewater from the farms into the river nearby without proper treatment and the effluent discharged were not par with the National Water Quality Standards for Malaysia. These activities negatively impact the environment and the people who live around the farms (Kinson et al., 2001).

Pig farming is becoming one of the most extensive farming due to the demand by the consumer in the world. The pollution coming from pig farms are inevitable and the factor that controls the wastes production is how the pig farmers manage the wastes before being released to the nearest water body in the Malaysian context, where it is considered clean enough (Kinson et. al., 2001). The wastes from pig farming consist of accumulated urine and faeces washed away and collected in lagoons for minor treatment

before being released into nearby water bodies or for fertiliser. Pig farming activities produce wastes that are high in concentration of organic contents and vital nutrients such as nitrogen (N), phosphorus (P), and potassium (K) (Schneider et al., 2016).

In Malaysia, pig farm pollution problem does not get attention as much as the pollution studies from beef and poultry farms. Malaysian public does not aware of this problem unless they live nearby pig farms that release the pollution. The public awareness is very important in this matter as to achieve a more sustainable country and community.

1.2 Problem Statement

Pig farming produces many wastes that consist of a high amount of total nitrogen, which is one criterion to determine water quality. The surface water quality for the pig farming area in China was in the proportions of Class III and below Class II (Zhang, D., Wang, V., & Zhou, Z.,2017). The pig farming activities in Kampung Selamat disposed of their pig farming wastes and the slaughterhouse wastes into Sungai Kereh (Dermawan, A., 2020). Sungai Kereh has been severely polluted where many of the locals have made complaints and reports towards the authority. The pollution has also threatened the health of the residents who live along Sungai Kereh. A private lab has analysed Sungai Kereh water and the result shows that the health of the river deteriorates may be caused by the pig farming activities in Kampung Selamat (Zulkiffli, 2021).

The river water turns black and gives off an unpleasant smell to the Kampung Selamat villagers due to the waste dumping from pig farms in the same village into Sungai Kereh (Hilmy, 2020). This is the effect of the inorganic compounds that cannot be broken down into valuable substances for the environment. Sungai Kereh will overflow the riverbank during the rainy season and produces a very unpleasant smell (Isa, 2021). Methane gas is one of the factors for the foul smell and it is more potent as greenhouse gas compares to carbon dioxide as much as 25 times. When methanogenesis is low, the inorganic substances cannot be broken down and thus increase the water body's temperature. This will negatively impact the environment as it increases water temperature and kills the microorganisms and organisms in it (Zhou et al., 2011).

The untreated pig farm wastes can bring severe threats to humans to affect our daily life activities. The bacteria in the wastes may in be in the forms of pathogens that can cause death. It can also cause antibiotic resistance in humans where the constant

usage of antibiotics in animals' feed. Pig feed is mainly enriched with heavy metals in the form of copper and zinc that will end up as wastes that accumulate in the waste lagoon and become concentrated. Finally, it also brings discomfort to the people who live in the nearest residential areas as it pollutes the air with odour pollution. The ammonia nitrogen in the wastes can cause respiratory illness to the people who live within two miles of the pig farms (Kinson et. al., 2001).

Due to the lack of research on pig farming activities and their pollutions in Malaysia, this research will shed some light on one of the biggest causes of water pollution regarding wastewater from pig farming activities.

1.3   Objectives

1. To determine the point source locations of pig farms in Kampung Selamat and non-point source locations at Sungai Kereh.

2. To determine the COD, BOD, DO, pH, Ammonia Nitrogen, Suspended Solids and the WQI of the pig farms effluent and .

1.4 Scopes of Works

This case study mainly focuses on determining the location of points source pollutants from the pig farms in Kampung Selamat and the location of non-point source pollution at sungai Kereh. Next, the water quality index is calculated to determine the level of pollution of the point sources by using chemical and biochemicals tests according to its parameters: pH, biochemical oxygen demand, chemical oxygen demand, total suspended solids, and lastly, the Ammonia Nitrate.

The study started with a desk study to find the total number of pig farms and total number of pigs bred in Kampung Selamat, Tasek Gelugor, Pulau Pinang. Then, it is followed by the sampling and collection of data at Kampung Selamat. An in-situ test is also done at the site to obtain the point source effluent's temperature, pH, and DO.

Next, the samples collected at Kampung Selamat will be further tested for Water Quality Index Parameters to identify the level of pollution of the effluent of the pig farms. The parameters for WQI analysis are pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (SS) and ammonia nitrogen (AN).

1.5 Structure of Thesis

This thesis consists of five chapters in total, where the first chapter discussed the background and problem statement of pig farming pollution. Then, in the same chapter, the objectives of this study are stated to determine the main source of Sungai Kereh pollution and the level of pollution of the effluent from the pig farms in Kampung Selamat.

The second chapter consists of a literature review regarding the wastewater characteristics, water quality index, pig farms wastewater, comparison between pig

farms in the world and finally about Sungai Kereh pollution. The literature review in this chapter also discussed the effect of pig farms and slaughterhouse pollution to the environment as this pollution problem in Sungai Kereh has been decades old but lacks research papers on it.

Next, the third chapter explains the methodology used in collecting the data regarding water quality from the point sources of Sungai Kereh and the characterisation of the pollution. This includes the point source samplings method, in-situ testing using YSI 556 Multi-Probe system and determining the water quality index parameter through its characterisation. The determination of the water quality index parameter is through the laboratory experiments and the calculation of the water quality index for each sample.

In the fourth chapter, the discussion of the findings from this study will be presented for the level of pollution for the samples to determine the points source locations of pig farms that contributes the most pollutant into Sungai Kereh by using the results of BOD, COD, pH, Do and Ammonia Nitrogen as indicators. In the same chapter, the water quality index will also be discussed to show the level of pollution of the effluent from the pig farms in Kampung Selamat.

Finally, in the fifth chapter, the findings will be concluded and further recommendations are suggested.

CHAPTER 2

LITERATURE REVIEW

2.1 Pig Farming Pollution

Pollution due to pig farming is becoming a concern these days because of the mismanagement of the wastewater. The volume of water used for the farming activity consequently produces effluents; approximately 8.8 L of water consumed and 4.4 L of effluent produced by an adult pig (Tavares et al., 2014). The wastewater from the pig farms tends to cause seepage where it poses an environmental risk to the nearby plantations and fields (Dikonketso et al., 2016). This is because most of the farms store the wastewater in lagoons for a long period of time thus the pollutants will seep through the soil and also pollute the groundwater (Pachepsky et al., 2006).

The farm's floors are impermeable and the wastes from the livestock accumulated on the floors then will be washed into an open lagoon to store and minimally treated until it can be used as manure for plantations. In Malaysia, it is considered clean enough to be discharged into nearby water bodies such as rivers. Bigger farms may have a good treatment system where the effluent is considered acceptable compared to smaller farms that may be illegal. Clusters of small illegal farms that don't have proper treatment systems may pose a severe threat to the environment and humans (Kinson et al., 2001).

Pig farms are also mostly associated with slaughterhouses to process the meat and for distribution. High solids and nitrogen contents make the anaerobic digestion treatments almost impossible in their undiluted form (Borowski & Kubacki, 2015). According to *Water Pollution from Slaughterhouses* (2018) report, JBS USA processing plant in Breadstown, Illinois produced 1,849 pounds of nitrogen per day which is equivalent to the raw sewage of a city of 79,000 residents in 2017. The

wastewater from the pork processing plant in that town was released into an Illinois River tributary.

One of the pig farming areas in Malaysia in Kampung Selamat, Pulau Pinang, brought many concerns towards the locals who lived nearby the area and along Sungai Kereh. The residents of Kampung Selamat and along Sungai Kereh has lived with bad smell and black water that come from Sungai Kereh. Sungai Kereh is one of Sungai Perai tributaries. The pollution inventory of Sungai Perai shows the pollution trend from Sungai Kereh has contributed to the pollution of Sungai Perai.

Sungai Kereh is one of Sungai Perai tributaries. The pollution in Sungai Perai shows pollution inventory from Sungai Kereh. Further studies have been made and show that the pollution trend and inventory prove that the pollution came from Kampung Selamat. Another main reason this research focuses on pig farms in Kampung Selamat and Sungai Kereh is the 40 years old pollution problem at Sungai Kereh and the paddy farmers facing the losses due to the river water pollution. Sungai Kereh is one of the irrigations that waters the paddy fields downstream.

Other than that, the odour and water pollution in Sungai Kereh are very concern as the bad odour has made the residents who live in villages along Sungai Kereh uncomfortable. The black water that causes Sungai Kereh to change colour can be visibly seen flowing from Parit Cina. Parit Cina is a manmade drainage or stream that connects Kampung Selamat and Sungai Kereh. The drainage has only one purpose: to channel down the effluent from the factories and pig farms in Kampung Selamat into Sungai Kereh.

The colour of the water in Parit Cina is very significant because the water from Sungai Korok is brownish, while in Parit Cina, the water is blackish in colour. Sungai Korok flows into Sungai Kereh. The reasons for the colour to be blackish are the

disposal of pig slaughterhouses, farms, and factories. Based on the picture below, the blood presumably from slaughterhouses can be seen being discharged into Parit Cina.

Figure 2.1: Intersection of Parit Cina and Sungai Kereh

2.2   Study Area

Pig farming pollution has become a serious problem that can be seen in Kampung Selamat. In 2017, Singapore started to import live pigs again from Malaysia after 20 years ban, specifically from Sarawak pig farms from the report in New Straits Times, 2017. To meet the demand of Malaysians who consumed pork, the number of pig farms has increased significantly. In Kampung Selamat alone, based on the information given by Land Office Seberang Perai Utara, Pulau Pinang, approximately 86 pig farm lots are in operation and the number of pigs reared is about 130,000 (Zulkiffli, Z., 2021). The figure below shows the pig farm lots in Kampung Selamat.
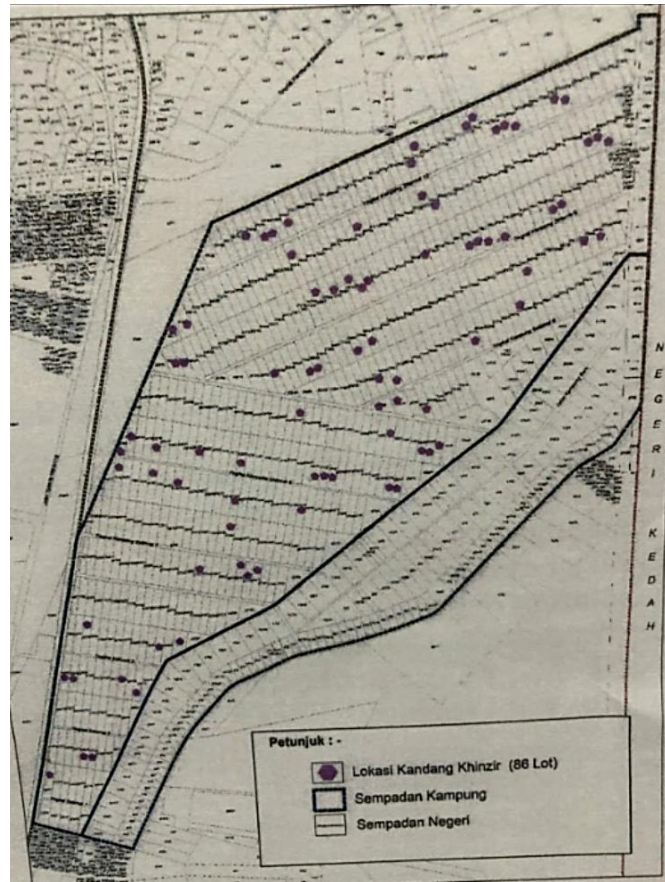
Figure 2.2: Pig farm lots in Kampung Selamat by Pejabat Tanah Seberang Perai Utara

Table 2.1: Results of parameter of Sungai Kereh (Arvin, 2019)

Sampling point	DO	BOD	COD	NH3	SS	pH
SK1	3.27	2.4	34	11	44	7.46
SK2	0.34	7.8	95	46	40	7.52
SK3	0.27	7.17	718	176	112	7.7
SK3a	0.33	7.11	509	343	120	7.73
SK3b	0.74	8.52	594	475	172	8.13
SK3c	1.04	7.38	244	123	40	7.9
SK3d	0.82	7.68	1055	83	116	7.4
SK4	0.39	8.19	120	57	56	7.67
SK4a	0.49	7.5	575	315	136	7.52
SK4b	0.91	6.42	82	29	16	7.71
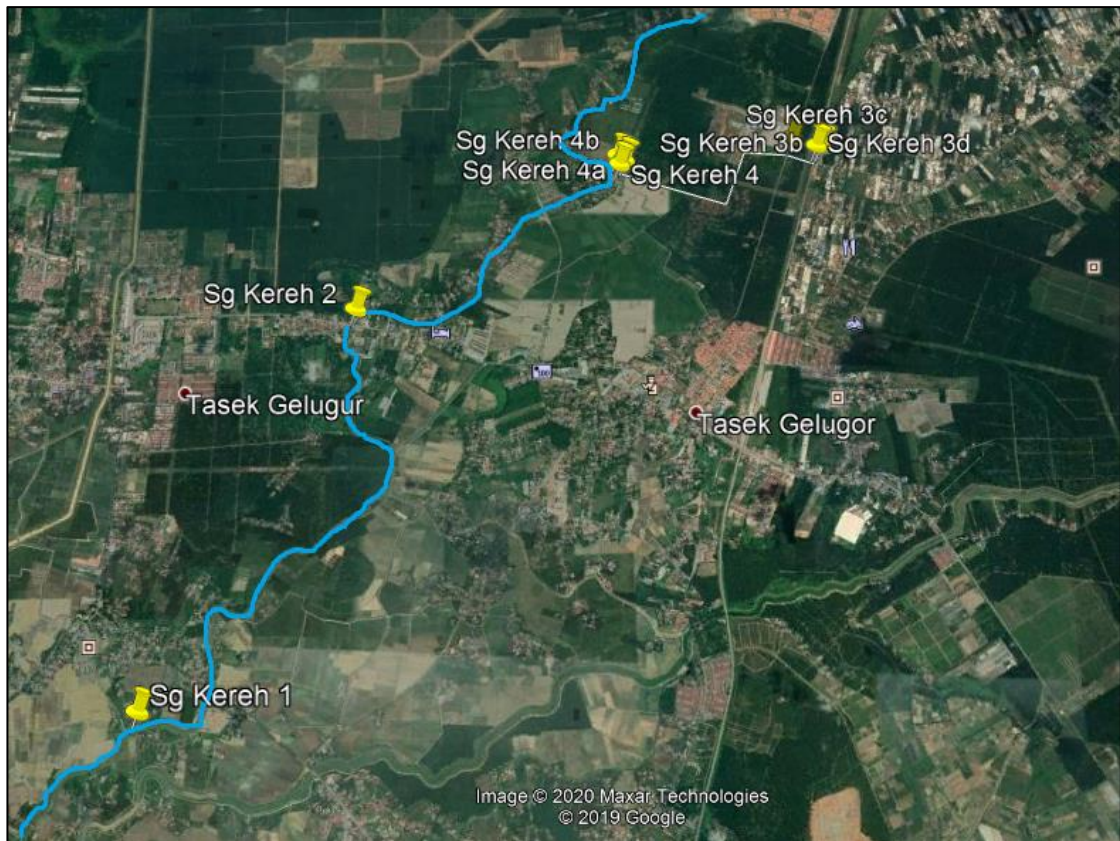
Figure 2.3: Non-point sources along Sungai Kereh (Arvvin, 2019)

Sungai Kereh is one of the tributaries of Sungai Perai. The study of Sungai Perai by IRBM and JPS, 2018 showed the pollution inventory of the pollutants that come from Sungai Kereh and this is proved by the study by Arvin, 2019 of Sungai Kereh pollutants inventory and trends. Referring to Table 2.1, Arvin, 2019 research shows that the pollution at point SK3 is terrible and is situated at Parit Cina. Parit Cina is a manmade channel to discharge the effluents from Kampung Selamat into Sungai Kereh. The table below shows the concentration of the parameter for each point of Sungai Kereh where SK1 is the downstream, SK4 points were located at the intersection of the upper stream of Sungai Kereh and Sungai Korok while SK3 is Parit Cina point. The study concludes that the pollution comes from upstream Sungai Kereh where Parit Cina connected to it.

2.3 Wastewater Characteristic

Characterising wastewater is important in order to obtain information on the level of pollution of the wastewater. Wastewater is characterised by two different types of parameters which are physical and chemical characteristics. Typically, they were determined by measuring pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (SS) and ammoniacal nitrogen (AN) (Roslan, 2019, p. 81).

Table 2.2: Malaysia Sewage Discharge Standard of Acceptable Conditions of Sewage of Standards A and B (DOE, 2009)

Parameter	Unit	Standard	
		A	B
Temperature	°C	40	40
pH	-	6.0-9.0	5.5-9.0
Suspended Solids	mg/L	50	100
BOD_5	mg/L	20	50
COD	mg/L	120	200
AN	mg/L	10	20

Swine wastewater is composed of high pollution parameters such as BOD, COD, SS, pH, and AN. The typical values of pollutants concentration from swine wastewater are 2000–30000 mg/L BOD, 200–2055 mg/L total nitrogen (TN), 110–1650 mg/L NH4-N, 100–620 mg/L total phosphorus (TP) (Cheng et al., 2019).

2.4 Water Quality Index

Water pollution is a very serious concern today as the water scarcity problem is worsens due to the mismanagement of water sources. Water Quality Index is the easiest way to determine the pollution in water bodies or effluent. WQI is normally used for the assessment and findings of water pollution or contamination. The characterisation of water pollution is done according to various parameters of water quality. Examples

of WQI parameters are Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), pH, Total Suspended Solids (SS) and Ammoniacal Nitrogen (AN) (Vinod et. al. 2013). Following tables show the Department of Environment Malaysia Water Quality Index Classification:

Table 2.3: DOE Water Quality Index Classification (DOE, 2009)

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
AN	mg/L	< 0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
BOD	mg/L	<1	1-3	3-6	6-12	>12
COD	mg/L	<10	10-25	25-50	50-100	>100
DO	mg/L	>7	5-7	3-5	1-3	<1
pH	-	>7	6-7	5-6	<5	>5
SS	mg/L	<25	25-50	50-150	150-300	>300
WQI		<92.7	76.5-92.7	51.9-76.5	31.0-519	<31.0

Table 2.4: Water Classes and Uses (DOE, 2009)

CLASS	USES
Class I	Conservation of natural environment Water Supply I – Practically no treatment necessary Fishery I – Very sensitive aquatic species
Class IIA	Water Supply II – Conventional treatment required Fishery II – Sensitive aquatic species
Class IIB	Recreational use with body contact
Class III	Water Supply III – Extensive treatment required Fishery III – Common, of economic value and tolerant species; livestock drinking
Class IV	Irrigation
Class V	None of the above

Table 2.5: DOE Water Quality Classification Based on Water Quality Index (DOE, 2009)

SUBINDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand (BOD)	91 – 100	80 - 90	0 – 79
Ammoniacal Nitrogen (NH$_3$-N)	92 – 100	71 – 91	0 – 70
Suspended Solids (SS)	76 – 100	70 – 75	0 – 69
Water Quality Index (WQI)	81 - 100	60 – 80	0 – 59

2.5   Effect of Pig Farming

The untreated pig farm wastes can bring serious threats to humans to affect our daily life activities. The bacteria in the wastes may in be in the forms of pathogens that can cause death. It can also cause antibiotic resistance in humans where the constant usage of antibiotics in animals' feed. Pig feed is mainly enriched with heavy metals in the form of copper and zinc that will end up as wastes that accumulate in the waste lagoon and become concentrated. Finally, it also brings discomfort to the people who lives in the nearest residential areas as it pollutes the air with odour pollution. The ammonia nitrogen in the wastes can cause respiratory illness to the people who live within two miles radius of the pig farms (Kinson et, al., 2001).

Environmental pollution has increased public concern due to excessive swine production. This is because swine farming activities concern is mainly on nitrogen (N) and phosphorus (P), pollution on the surface and groundwater and also the pollution of heavy metals on the soil and plants (Nahm, 2002). The high amount of nitrogen and phosphorus in pig manure has led to polluting the soil and is one of the main reasons of the eutrophication of surface water bodies such as water lagoons and rivers. Eutrophication is an indicator that shows severe pollution has occurred in particular