EFFECTIVENESS OF LAGOON IN IMPROVING WATER QUALITY OF DISCHARGE FROM PIG FARMS IN SAMARAHAN AREA

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DECLARATION

No portion of the work referred to in this dissertation has been submitted in support of an application for another degree of qualification of this or any other university or institution of higher learning.

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ABSTRACT

The main objective of this research is to study the efficiency of different lagoon system in improving the wastewater quality before being discharged to public watercourse. This study involved four pig farms with different lagoon systems namely single lagoon, double lagoon (with and without separator) and triple lagoon. The parameters examined were temperature, dissolved oxygen (DO), biochemical oxygen demand (BODs), total suspended solid (TSS), ammonia nitrogen (NH₃-N) and total phosphorus (TP). Result shows that the triple lagoon system farm was the most efficient in BODs (93.9%), TSS (92.7%), NH₃-N (85.5%) and TP (92.6%) removal. The double lagoon farm has least efficient in NH₃-N removal while the double lagoon system with separator show no TP removal. The Interim National Quality Standard of Malaysia (INWQS) was used to classify the water quality parameters. The parameters for DO, BODs, NH₃-N and TP were in Class IV – V. However, TSS was in Class I – III. Statistical analysis shows that there is significant difference in percent reduction of BODs and NH₃-N between each farm. While the double lagoon with separator was significantly different in reduction (%) of TSS compared to the double and triple lagoon farm. The triple lagoon farm showed significant difference in reduction (%) of TP when compared to two of the double lagoon farm (with and without separator). All the lagoons are likely anaerobic due to the low level of DO. This study shows that most of the treatment occurred in the second lagoon. It is recommended that proper lagoon management such as scheduled maintenance and work should be practiced to improve the treatment of the wastewater in lagoon system before being discharge to the watercourse.

Keyword: Lagoon, swine wastewater, water quality, effluent

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STUDY OF THE EFFECTIVENESS OF LAGOON IN IMPROVING WATER QUALITY OF DISCHARGE FROM PIG FARMS IN SAMARAHAN AREA

Objektif utama kajian ini adalah mengkaji efisiensi sistem lagun yang berbeza dalam memperbaiki kualiti air buangan sebelum dialirkan ke sistem saliran terbuka. Tinjauan ini melibatkan empat jenis lading babi dengan sistem lagun yang berbeza iaitu sistem satu lagun, sistem dua lagun (dengan dan tanpa separator) dan sistem tiga lagun. Parameter yang dikaui terhadap air buangan termasuklah suhu, oksigen terlarut (DO), permintaan oksigen biologi (BODs), jumlah pepejal terampai (TSS), ammonia nitrogen (NH₃-N) dan jumlah fosforus (TP). Tinjauan ini menunjukkan sistem tiga lagun adalah paling efektif dalam mengurangkan kandungan BODs (93.9%), TSS (92.7%), NH₃-N (85.5%) dan TP (92.6%). Sistem dua lagun mempunyai kempenyiaan yang rendah dalam mengurangkan kandungan NH₃-N dan lagun sistem dua lagun (dengan pengasing pepejal) tidak menunjukkan pengurangan dalam TP. Piawai Interim Kualiti Air Kebangsaan Malaysia (INWQS) telah digunakan sebagai panduan untuk mengelaskan parameter-parameter kualiti air. Parameter untuk DO, BODs, NH₃-N dan TP berada dalam kelas IV – V. Namun itu, TSS berada dalam kelas I – III. Analisis statistik menunjukkan terdapat perbezaan signifikan dalam peratus pengurangan BODs dan NH₃-N terhadap semua lading. Manakala, lading sistem dua lagun dengan pengasing pepejal menunjukkan perbezaan signifikan dalam peratus pengurangan TSS berbanding dengan lading sistem dua dan tiga lading. Lading sistem tiga lading mempunyai perbezaan signifikan dalam peratus pengurangan TP berbanding sistem dua lading (ada dan tanpa pengasing pepejal). Semua lading adalah anarobik disebabkan kandungan DO yang rendah. Kajian ini menunjukkan kebanyakan air buangan dalam lading dirawat dalam lading ke-dua. Adalah dicadangkan bahawa cara pengendalian yang sesuai ke atas sistem lading dapat diancamkan seperti pengendalian yang berskema dan prosedur dipraktiskan untuk memperbaiki kualiti dan mempercepatan proses rawatan air buangan dalam sistem lading sebelum disalurkan ke saliran terbuka.

Kata kunci: Lagun, air buangan babi, kualiti air, efllent

ABSTRAK

Objektif utama kajian ini adalah mengkaji efisiensi sistem lagun yang berbeza dalam memperbaiki kualiti air buangan sebelum dialirkan ke sistem saliran terbuka. Tinjauan ini melibatkan empat jenis lading babi dengan sistem lagun yang berbeza iaitu sistem satu lagun, sistem dua lagun (dengan dan tanpa separator) dan sistem tiga lagun. Parameter yang dikaui terhadap air buangan termasuklah suhu, oksigen terlarut (DO), permintaan oksigen biologi (BODs), jumlah pepejal terampai (TSS), ammonia nitrogen (NH₃-N) dan jumlah fosforus (TP). Tinjauan ini menunjukkan sistem tiga lagun adalah paling efektif dalam mengurangkan kandungan BODs (93.9%), TSS (92.7%), NH₃-N (85.5%) dan TP (92.6%). Lading sistem dua lading mempunyai kempenyiaan yang rendah dalam mengurangkan kandungan NH₃-N dan lading sistem dua lading (dengan pengasing pepejal) tidak menunjukkan pengurangan dalam TP. Piawai Interim Kualiti Air Kebangsaan Malaysia (INWQS) telah digunakan sebagai panduan untuk mengelaskan parameter-parameter kualiti air. Parameter untuk DO, BODs, NH₃-N dan TP berada dalam kelas IV – V. Namun itu, TSS berada dalam kelas I – III. Analisis statistik menunjukkan terdapat perbezaan signifikan dalam peratus pengurangan BODs dan NH₃-N terhadap semua lading. Manakala, lading sistem dua lading dengan pengasing pepejal menunjukkan perbezaan signifikan dalam peratus pengurangan TSS berbanding dengan lading sistem dua dan tiga lading. Lading sistem tiga lading pula menunjukkan perbezaan signifikan dalam peratus pengurangan TP berbanding sistem dua lading (ada dan tanpa pengasing pepejal). Semua lading adalah anarobik disebabkan kandungan DO yang rendah. Kajian ini menunjukkan kebanyakan air buangan dalam lading dirawat dalam lading ke-dua. Adalah dicadangkan bahawa cara pengendalian yang sesuai ke atas sistem lading dapat diancamkan seperti pengendalian yang berskema dan prosedur dipraktiskan untuk memperbaiki kualiti dan mempercepatan proses rawatan air buangan dalam sistem lading sebelum disalurkan ke saliran terbuka.

Kata kunci: Lagun, air buangan babi, kualiti air, effluent
Chapter 1

Introduction

1.1 Introduction

In Malaysia, as in other countries with tropical climatic conditions, pigs are hosed down with water twice a day, to clean the concrete pen floors, to cool the animals and also to remove hydraulically the wastes (Teoh *et al.*, 1988; Choo *et al.*, 1987). The wastewater carries away animal faeces, urine and spilled feed from the pig house through a network of open drain in the farms (Teoh *et al.*, 1988). Pig wastes are discharged as wastewater which flowing into public watercourse, causing water pollution and clogging drainage canals (Teoh *et al.*, 1988).

The types of water pollution generates from agriculture industry are such as eutrophication, turbidity and siltation, organic pollution, pesticide and veterinary medicine pollution and microbial pollution (DEFRA, 2003). According to the World Wide Fund Malaysia (2001), the largest pollutant in Malaysia is organic waste from sewage, animal waste and excessive soil deposits. According to Kinson (2001), pig industry is one of the industries identified as causing serious water pollution. Statistics from the Department of Environment Malaysia has shown that estimated 28% of river basins in Malaysia have been polluted from sewage and animal farm (Rahman, 2001). In addition, the contribution of water pollution from pig farm was estimated 7.5% and estimated 15.7% or 196 tonne/day BOD loads contributed from the pig farms in the year of 2000 (Rahman, 2001). An analysis of raw
wastewater taken during routine cleaning and bathing of pigs in the state of Melaka during the year of 1980 showed that a wide variation in the results as described in Table 1 (Appendix 1).

Water pollution from agricultural farms also has become a problem in some parts of Sarawak for the past few years and with the fast pace of development in the state, many farms formerly located far from settlements are now surrounded by built-up areas (NREB, 2001). Thus, the pollution and health problems these farms have brought, have given cause for concern about the industry (Davidson, 2002). Stated by Davidson (2002), a river in Serian, Sungai Rayang, had been declared a “dead river” as a result of pollution by nearby farms. The NREB, Control of Livestock Pollution Rules has gazetted the standard for the permitted discharge of treated water for existing farms in Table 2 (Appendix 2). The BOD concentration without treatment in an existing farm shall not exceed 3,000 mg/L (NREB, 2001). Table 3 shows the table of Interim National Water Quality Standards (INWQS) for Malaysia (Appendix 3) (DOE, 1994).

Wastewater treatment lagoons have been widely used for the treatment of human, industrial and animal wastewaters due to their low capital costs and simple operational and maintenance requirements compared with other biological treatment systems (Zhang, 2001). Originally, lagoons were viewed as a total disposal system especially in areas with a mild climate and limited land for field spreading (Humenik et al., 1980). North Carolina alone had about 2,500 swine lagoon as early 1968 (Humenik et al., 1980; Jones, 1968). Early animal wastewater lagoons were designed primarily based on the experiences with human wastewater lagoons (Zhang, 2001). Due to the high contents of nutrients and organics in the
animal wastewater, the treatment capacity of wastewater lagoons is often limited and effluent from the lagoons is not suitable for direct discharge into surface waters (Zhang, 2001).

Pig wastewater contains highly concentrated pollutants, including suspended solids, organics, and nutrients, and may deteriorate the quality of aquatic environments into which they are discharged (Lee et al., 2004; Stone et al., 1998). Pig manure consists of water, complex carbohydrates, nutrients, salts and pathogens (FSAE, 2000). A mature pig produces about three times the waste a human does. Manure production of a 150 kg pig would amount to approximately 21.1 kg/animal/day of solid material and 15.9 litre/animal/day of liquid (Kinson et al., 2001). Nutrient production as excreted by mature pig consists of 0.033 kg/animal/day of total nitrogen, 0.026 kg/animal/day of phosphorus P₂O₅ and 0.026 kg/animal/day of potassium K₂O (Kinson et al., 2001). There are approximately 2,340 farms in Sarawak with about animal population of 500,000. The industry generates estimated revenue of RM 60 million a year (Kinson et al., 2001). According to the agriculture statistic of Sarawak, a total of 461,289 of pigs were reported in the state of Sarawak while in Kuching division, approximately 111,972 of pig population was reported in the year of 2002 (SAD, 2002). Whereas, in Kota Samarahan alone, an estimated of 174,399 pigs was reported in the same year (SAD, 2002). The commercial pig farm distribution in 2002 was estimated 35 farms in the Samarahan, 51 farms in Kuching division and a total of 154 farms in the state of Sarawak (SAD, 2002). Figure 1 shows the estimated of standing pig population by division from 1993 – 2002 (SAD, 2002).
Thus, best management practices to dispose of animal waste must be implemented. These wastes can affect water quality if proper practices are not followed. The discharge of inadequately treated wastewater may cause adverse impacts such as water pollution, the spread of waterborne diseases, aesthetic and odour nuisances, depreciation in land value and decrease in tourism potential. Besides, the main purpose of investigating this pig waste treatment system is not only to achieve pollution control, but also for byproduct recovery and treated wastewater reuse (Yang et al., 1999).

This project aims to investigate the effectiveness of lagoons in pig farms in Kota Samarahan area in improving the wastewater quality before discharge into open watercourse such as rivers. This research can also benefit pig farmers in gaining better knowledge in animal waste treatment management especially the lagoon system treatment that applied to their farms, and of fiscal, environment legislation as well as actual regulation. Hopefully, pig
farmers can manage and treat the animal wastes more efficiently in order to reduce environmental pollution.

1.2 Literature Review

1.2.1 Wastewater Characteristics

Wastewater is characterized in the terms of its physical, chemical and biological composition (Tchobanoglous and Burton, 1991). In this project, the parameters that are being used to characterize the wastewater from pig farm are Biochemical Oxygen Demand (BOD$_5$), Dissolved Oxygen (DO), Total Suspended Solid (TSS), Ammonia- Nitrogen (NH$_3$-N) and Total Phosphorus (TP).

Five days biochemical oxygen demand (BOD$_5$) test is the most widely used parameter of organic pollution applied to both wastewater and surface water (Tchobanoglous and Burton, 1991). BOD$_5$ is used to determine the relative oxygen requirements of wastewaters. Application of the test to organic waste discharges allows calculation of the effect of the discharges on the oxygen resources of the receiving water.

Dissolved oxygen (DO) analysis measures the amount of gaseous oxygen (O$_2$) dissolved in an aqueous solution. Dissolved oxygen is required for respiration of aerobic microorganisms as well as all other aerobic life forms. However, oxygen is only slightly soluble in water (Tchobanoglous and Burton, 1991). The quantity of oxygen (other gases too) that can be present in solution is governed by the solubility of the gas, the partial pressure of
the gas in the atmosphere, the temperature and the purity (salinity, suspended solid and etc) of the water (Tchobanoglous and Burton, 1991). The level of DO in water fluctuates naturally from day until night due to the photosynthetic process by plants. The sustainable of DO concentration should not be less than 4.5 milligrams of oxygen per litre of water (called 60% saturation) (AWMA, 1999). If it falls below 4.5 mg/L, then fish will probably die.

Total Suspended Solids (TSS) is solids in water that can be trapped by a filter. TSS in natural water consists of a wide variety of material, such as silt, decaying plant and animal matter (Kinson et al., 2001). However, human activities alter and increase these potential pollutants. Besides the possible toxic effects attributable to substance leached out by water, suspended solid may kill fish and shellfish by causing abrasive injuries, clogging the gills and respiratory passage of various aquatic life, killing eggs and destroying spawning beds. Moreover, high TSS can block light from reaching submerged vegetation; this will slow down the photosynthesis processes. Thus less dissolved oxygen being released into the water by plants. Low dissolved oxygen can kill aquatic organisms.

Nitrogen appears in organic wastes in various forms. In wastewater, four types of nitrogen are common namely organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. The predominant forms of nitrogen in wastewater are organic nitrogen and ammonia (NH3). Removal of nitrogenous compounds is crucial as excessive amounts of ammonia and nitrite or nitrate levels are detrimental to water quality. Ammonia exerts an oxygen demand in aquatic environments; 4.7 grams of oxygen are required to oxidize one gram of ammonia (Anona, 2004). Low-level ammonia nitrogen may be present in water naturally as a result of the biological decay of plant and animal matter. High concentrations in
surface waters can indicate contamination from waste treatment facilities, industrial effluents or fertilizer run off. Excessive ammonia concentrations are toxic to aquatic life.

Wastewater is relatively rich in phosphorus compounds. It occurs in natural water and in wastewater almost solely as phosphates (Clesceri et al., 1998). These are classified as orthophosphates, condensed phosphates (pyro-, meta- and other polyphosphates) and originally bound phosphates (Clesceri et al., 1998). The discharge of wastewater containing phosphorus may cause algae growth in quantities sufficient to cause taste and odour problems in drinking water supplies. Phosphates in wastes are the primary source of excess amounts of nutrients in water (Kinson et al., 2001). For this reason, phosphorus removal is an essential role of wastewater treatment plants and testing for phosphorus in the plant effluent is critical.

1.2.2 Lagoon

Approaches to manure treatment can be generally categorized as biological (anaerobic or aerobic digestion), chemical (preservatives) or thermal (drying) (Sweeten, 1980; Loehr, 1974). Producers and designers may choose treatment processes for livestock and poultry wastes to achieve one or more of the following purposes: waste stabilization, solid reduction, odour control, nitrogen removal, nutrient conservation, pathogen destruction and fuel gas production (Sweeten, 1980).

Lagoon systems use natural and energy-efficient processes to provide low-cost wastewater treatment (Anonb, 1997). Lagoon systems include one or more pond-like bodies of water or basins designed to receive, hold, and treat wastewater for a predetermined period of time. While in the lagoon, wastewater receives treatment through a combination of
physical, biological, and chemical processes. Much of the treatment occurs naturally, but some systems are designed to also use aeration devices that increase the amount of oxygen in the wastewater. Aeration makes treatment more efficient, so that less land area is necessary, and aerators can be used to upgrade some existing systems to treat more wastewater.

Based on the presence of oxygen, the lagoons are classified as aerobic, mechanical aerated, anaerobic, and facultative. Bacteria are the primary microorganisms responsible for waste degradation in all types of lagoons. Algae live symbiotically with bacteria in aerobic and facultative lagoons and play an important role in removing nutrients from the wastewater.

1.2.3 Types of Lagoon

a. Aerobic Lagoons

Surface areas requires for naturally aerobic lagoons or oxidation ponds are enormous, even when these units are used as second stage lagoons to treat anaerobic lagoon discharge (Sweeten, 1980). Loading rates for this system range from 20 kg BOD$_5$/hd.day in cold climate to 50 kg BOD$_5$/hd.day in warm U. S. climate (Sweeten, 1980; White, 1977). Depths of 1 to 1.5 metres are desired (Sweeten, 1980). Solid concentrations must be kept below 0.5 percent (preferably below 0.2 percent) to keep turbidity low and to improve light penetration, therefore dilution water requirement are large (Sweeten, 1980). Wastewater usually must remain in aerobic lagoons from 3 to 50 days to receive adequate treatment (Anonb, 1997).

Aerobic lagoons contain dissolved oxygen in the water to sustain aerobic bacteria. Natural aeration is achieved by air diffusion at the water surface, by wind- or thermal gradient-induced mixing, and by photosynthesis (Zhang, 2001). The photosynthetic
microorganisms include algae and cyanobacteria (bluegreen algae) (Zhang, 2001). The general chemical reaction for aerobic degradation of organic compounds is as follows:

\[
\text{Organics compounds (C, H, O, N, S) + } \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{NH}_4^+ + \text{(or } \text{NO}_3^-) + \text{S(or } \text{SO}_4^{2-}) \quad (1)
\]

Under aerobic conditions, the nitrogenous compounds (proteins, peptides, and amino acids) are first converted to ammonium (NH$_4^+$) by heterotrophic bacteria (Zhang, 2001). If sufficient oxygen is available and the chemical environment is right, nitrification bacteria may be established and oxidize ammonium into nitrite and then into nitrate (Zhang, 2001). Therefore, the end products of nitrogen oxidation can be ammonium, nitrite, or nitrate, depending on how complete the oxidation is carried out by the bacteria (Zhang, 2001). Organic carbon is oxidized into carbon dioxide. Sulfur compounds (sulfur containing protein) in the wastes are converted to elemental sulfur (S) or sulfate (SO$_4^{2-}$) in the aerobic environment instead of odour-causing sulfides in the anaerobic environment (Zhang, 2001). The degree of oxidation depends on the amount of oxygen provided and the reaction time allowed in the treatment process.

b. Aerated lagoons

Mechanically aerated lagoons appear to be gaining producer acceptance as a manure treatment method despite growing concerns with energy costs (Sweeten, 1980). The main advantages are odour reduction, high treatment efficiency and small land area required relatives to anaerobic or naturally aerobic lagoons (Sweeten, 1980). An aerated lagoon resembles a waste stabilization pond, which is a shallow basin about 2 to 5 meters deep with
a large surface area and receives a continuous flow of wastewater. It differs from other lagoon types in that the oxygen for BOD removal is provided by mechanical aeration (Horan, 1993).

Recommended detention times vary from 20 days up to 1 year, depending upon whether the unit is a flow-through or an impounding lagoon (Sweeten, 1980). The aeration system can be designed according to three alternate objectives: complete mixing, complete oxygen-dispersion or surface layer oxygen-dispersion (Sweeten, 1980).

Aerated lagoons require less land area and shorter detention times for wastewater than other lagoons (Anonb, 1997). Since oxygen is supplied through mechanical means, algal photosynthesis in the mechanically aerated lagoons plays an insignificant role (Zhang, 2001).

c. Anaerobic lagoons

Anaerobic lagoons are most often used to treat animal wastes from dairies and pig farms, commercial or industrial wastes, or as the first treatment step in systems using two or more lagoons in a series (Anonb, 1997). As its name implies, an anaerobic lagoon lacks of dissolved oxygen and the active microbial population comprises facultative and strictly anaerobic microorganisms (Horan, 1993). The main disadvantages of this system are odours and sludge accumulation (Sweeten, 1980). Typically, anaerobic lagoons have retention time of 20 to 50 days or more (Anonb, 1997) and anaerobic lagoons are designed with depth range from 8 to 20 feet (MDEPa, 2003).
Under anaerobic conditions, two distinct reactions occur. In stage one, hydrolysis of organic compounds and conversion to intermediate organic acids are achieved by acid-forming bacteria called acidogens (Zhang, 2001). Then in stage two, the organic acids are converted to methane and carbon dioxide by methane-forming bacteria called methanogens (Zhang, 2001). The overall complete reaction of anaerobic degradation is:

\[
\text{Organics (C, H, O, N, S) } \rightarrow \text{CH}_4 + \text{CO}_2 + \text{NH}_4^+ + \text{H}_2\text{S} \quad (2)
\]

Methane (CH\(_4\)) and carbon dioxide (CO\(_2\)) are produced as the end products of organic carbon degradation. Methane has very low solubility in water and is readily emitted into the atmosphere as soon as it is formed. Ammonium (NH\(_4^+\)) and hydrogen sulfide are the end products of nitrogen and sulfur degradation, respectively (Zhang, 2001). Ammonium (NH\(_4^+\)) exists in equilibrium with ammonia (NH\(_3\)) in the wastewater. Carbon dioxide, ammonia, and hydrogen sulfide are three soluble gases.

Their potential for emission into the atmosphere is largely dependent on the pH and temperature of the lagoon water (Zhang, 2001). A high pH (>8) favors more ammonia emissions while a low pH (<6) favors more hydrogen sulfide and carbon dioxide emissions (Zhang, 2001). The optimum pH for methanogens is 6.8 to 7.5, with the lowest pH being 6.2 (Zhang, 2001). In comparison, acidogens are more versatile and have much wider working pH range, 5 to 8, with the optimum level being 5 to 6 (Zhang, 2001). Therefore, one way to suppress the methane production in anaerobic lagoons is to control the pH below 6.2 (Zhang, 2001). However, when methanogens are suppressed, the anaerobic degradation will not be
carried to completion, yielding much organic acids that may cause strong odor problems (Zhang, 2001).

d. Facultative lagoons

Both aerobic and anaerobic conditions exist in facultative lagoons. Facultative lagoon has depths range 1 to 2 metres (Sweeten, 1980). They are designed as lightly loaded anaerobic units and produces little odour (Sweeten, 1980). Facultative lagoon have more depth and smaller surface areas but still have good odour control capabilities because of the presence of the upper aerobic layer, where odourous compounds such as sulfides produced by the anaerobic degradation in the lower layer are oxidized before emission into the atmosphere (Anonb, 1997).

Biochemical reactions in the facultative lagoons are a combination of aerobic and anaerobic degradation reactions. Many second stage lagoons designed as naturally aerobic lagoons actually function in the facultative mode (Sweeten, 1980; White, 1977). The major role of facultative lagoons is for the removal of BOD (Horan, 1993). Facultative lagoons can be adapted for use in most climates, require no machinery, and treat wastewater naturally, using both aerobic and anaerobic processes. Waste is treated by bacterial action occurring in an upper aerobic layer, a facultative middle layer, and a lower anaerobic layer.

Aerobic bacteria degrade the waste in the upper layer where oxygen is provided by natural surface aeration and algal photosynthesis. Settleable solids are deposited on the lagoon bottom and degraded by anaerobic bacteria. The facultative bacteria in the middle
layer degrade the waste aerobically whenever dissolved oxygen is present and anaerobically otherwise. Figure 2 show microbial interactions and waste degradation pathways in a facultative lagoon (Zhang, 2001).

Figure 2: Facultative lagoons (adapted from Zhang, 2001; Crites and Tchobanoglous, 1998)

1.2.4 Advantages and Disadvantages of Lagoon Systems

Waste lagoons, if properly designed and managed, offer advantages such as lagoon systems can be cost-effective to design and construct in areas where land is inexpensive (Anonb, 1997). Besides that, the system requires less energy than most wastewater treatment methods. Lagoon systems are also very effective at removing disease-causing organisms (pathogens) from wastewater (Anonb, 1997). The effluent from lagoon systems also can be suitable for irrigation (where appropriate), because of its high-nutrient and low-pathogen content (Anonb, 1997).
However, there are also some actual and potential disadvantages associated with waste lagoon system, the major ones probably are that lagoon systems require more land than other treatment methods. They are less efficient in cold climates and may require additional land or longer detention times in these areas (Anonb, 1997). Odour can become a nuisance during algae blooms, spring thaw in cold climates, or with anaerobic lagoons and lagoons that are inadequately maintained. Unless they are properly maintained, lagoons can provide a breeding area for mosquitoes and other insects (Anonb, 1997). Besides, lagoon system is not very effective at removing heavy metals from wastewater (Anonb, 1997). Effluent from some types of lagoons contains algae and often requires additional treatment or "polishing" to meet local discharge standards (Anonb, 1997).

1.2.5 Problems from lagoon systems

Common problems that usually arise from lagoon systems in pig farms are such as, “dead spots” in the flow pattern, due to obstructions in the lagoon or to wind on the surface, can cause wastewater to leave the lagoon too quickly, resulting in inadequate treatment (Anonb, 1997). Besides that, lagoon systems need very large quantities of water to clean the farms and for pig bathing. The average of water usage daily is approximately 30 to 40 litres for standing pig population (Gutuk, 2003). When intensive pig farming occurs, pollution from nutrients contained in pig manure, namely phosphorus and nitrogen, is also one of the most serious problems, which may lead to excess algae growth, reducing the dissolved oxygen and thus lead to mass fish kills.
Most of the pig farms in Sarawak have insufficient waste treatment and it has becomes a routine that these effluents are directly discharge to open watercourse such as river (Gutuk, 2003). According to Gutuk (2003), Tarat, Engsengai, Panchor, Baki and Serian in Kota Samarahan were found that had been highly polluted by effluents from pig farms. The pigs population Kuching and Kota Samarahan are approximately 111,972 and 174,399, while, total pig farms in Kuching and Kota Samarahan are 51 and 35 farms respectively.

Besides that, lagoon spills also is one of the most common problems that can affect groundwater quality if liquid effluent is not properly contained within the basin. For example, in June 1995 in Onslow County, North Carolina, 22 million gallons of hog lagoon wastewater swept through crop fields, swamped a rural highway, and surged into the headwaters of the New River. One week after the spill the dead fish count stood at 2,600 (Kidwell, 1995).

1.2.6 Common design of lagoon

In general, pig wastes at the first stage are stored at first lagoon, which is also called the waste storage lagoon or holding tank. This is follow by pumping the waste to filtration pond. Here all the waste will be filtered and separated into liquid and solid forms. Solid waste will be taken out and dried for other utilizations. While, liquid waste will be flushed into the first oxidation lagoon. The waste usually will be retained at this lagoon for about 7 days. After 7 days, waste will be channel to second lagoon and the retention time is about 10 days and this is follow by channeling effluents to the third lagoon which is also final lagoon at about 15 days retention time (Gutuk, 2003). The treatment concept in lagoon is to suspend all the solid residues and flowing effluent from lagoon to lagoon before being discharge to