Integrated Sequential Anoxic-Aerobic (ISA) Reactor for Wastewater Treatment

By

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FINAL PROJECT REPORT

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Department of Civil Engineering
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Approved by:

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UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

May 2013

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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Sara Tag-Elsir Elyass Gaib Alla

ABSTRACT

Wastewater treatment is the process of removing contaminants from raw water. The goal is to produce water that follows the standards, to meet the government standards which can be used for the specific purpose of human consumption. Rubber wastewater treatment includes removing of the particles, organic molecules, bacteria, algae, virus and toxic metals. The rubber industry is one of the industries that produce high amounts of the liquid and solid waste.

In this research the aerobic-anoxic treatment method will be used to treat rubber wastewater. The two methods combined in one reactor which is Aerobic-Anoxic Sequential Reactor (ISA). It consists of a cylindrical tube with 160 cm height and 6.5cm diameter. The upper part used as anoxic tank where nitrification take place. During nitrification process ammonia (NH4-N) is oxidized to nitrate (NO2-N) and then to nitrate (NO3-N). Nitrate produced in the upper part of the reactor. The effluent from this process is recycled back for oxidation reduction reactions in denitrification process, which convert nitrate to nitric oxide, nitrous oxide, and nitrogen gas.

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LIST OF ABBREVIATIONS

COD	Chemical Oxygen Demand
BOD	Biochemical Oxygen Demand
TSS	Total Suspended Solids
VSS	Volatile Suspended Solids
TKN	Total Kjeldah Nitrogen
EQA	Environmental Quality Act
ISA	Integration Sequential Anoxic-Aerobic
SND	Simultaneous Nitrification and Dinitrification
AOB	Ammonia Oxidizing Bacteria
NOB	Nitrate Oxidizing Bacteria

CHAPTER 1
INTRODUCTION

1.1 Background Study

Integrated Sequential Anoxic-Aerobic (ISA) Reactor offer many benefits compared to conventional biological wastewater treatment in term of efficiency, price and area required. The biodegradation of organic compounds found in industrial and municipal wastewater industry is one of the main steps to protect surface water quality. Aerobic biological techniques have proven effective for the pollutants. Wastewater treatment mainly focuses on organic matter (COD) and nutrient (Nitrogen) removal. Conventionally, COD is removed by aerobic biological degradation and nitrogen is removed by nitrification and denitrification. In this study, these processes were first conducted in a new integrated reactor (i.e. ISA reactor) using synthetic wastewater to establish the prove of concept. Then, rubber wastewater was treated using the reactor to test its applicability to industrial wastewater.

Natural rubber is a hydrocarbon polymer and flexible material that comes from the latex sap of rubber trees that grow in the tropics (such as Hevea Brazilensis trees). Thailand, Indonesia, Malaysia and India are the most important countries producing rubber in the world, where it is considered as one of their economic resources. In Malaysia, natural rubber production in 2011 amounted to 996,210 tons compared with 939,241 tons in 2010. The rapid growth of the industry has enabled Malaysia to become the world's largest consumer of natural rubber latex (Malaysian Investment Development Authority _MIDA_, 2012). The production of rubber products from natural rubber needs large amount of water for its operation. The rapid growth of the industry has produced large quantities of effluent from this processing (Leong et al., 2003; Rungruang and Babel, 2008). However, 1 ton of natural rubber concentrated latex produced only approximately 18 m^3 wastewater (Nguyen, 2003). In the rubber industry wastewater treatment there are many treatment methods, it could be aerobic or anaerobic treatment methods.

1.2 Problem Statement

Wastewater from the rubber industry may have affect adverse on the environment. The continual growth of this industry produces wastewater effluents from the processing operation which cause water pollution. Wastewater pollution from natural rubber latex processing is due to high suspended solids, organic matter and nitrogen (Organic-N, NH_3-N). The presence of nitrogen in the wastewater is not considered as a risk in itself, but high amounts of nitrate may cause eutrophication, which means the increase in nutrients values that leading to reduction in dissolved oxygen. That could kill the fish and other organisms in rivers and water bodies. The presence of ammonia maybe very toxic to the fish.

Characteristics of rubber wastewater vary from country to country due to difference in raw latex and applied technique in the process. The characteristics of rubber wastewater are presented in Table 1.1

Table 1.1: Typical characteristics of rubber industry wastewater

Parameter	Typical range
Biochemical Oxygen Demand (BOD)	1500 – 7000 mg/L
Chemical Oxygen Demand (COD)	3500 – 14000 mg/L
Suspended Solids	200 – 700 mg/L
Sulphate	500 – 2000 mg/L
Total nitrogen	200 – 1800 mg/L
pH	3.7 – 5.5

The treatment process should comply with the environmental quality regulations for natural rubber industry as described under Environment Quality Act (EQA 1974 Act 127). The effluent discharge limits are presented in Table 1.2.

Table 1.2: Standards for the effluent discharge limits in the rubber industry (EQA 1974 Act 127)

Parameter	Concentration
Biochemical Oxygen Demand (BOD)	100 mg/L
Chemical Oxygen Demand (COD)	400 mg/L
Total Solid	1000 mg/L
Suspended Solids	150 mg/L
Ammonia Cal nitrogen	300 mg/L
Total nitrogen	300 mg/L
pH	6-9
Zn	1.0 mg/L

Biological removal of COD and nitrogen is usually conducted in a series of tanks namely, aeration, anoxic and sedimentation. This requires large space for installation and results in high operation and maintenance cost. Therefore, it was necessary to design a reactor that combines these tanks in one unit (i.e. the integrated sequential anoxic-aerobic (ISA) reactor.

1.3 Objectives & Scope of Study

1.3.1 Objectives

- To develop a novel integrated sequential anoxic-aerobic (ISA) reactor for COD and Nitrogen removal.
- To evaluate the treatment of rubber factory wastewater by using THE (ISA) reactor.

1.3.2 Scope of Study

The study is related to the principle of environmental engineering and environmental management system with following the standards and regulations. Suitable and adequate wastewater treatment can protect environment and human life. Also, to avoid the negative impacts that may happen after discharge of the wastewater to the river. Therefore, the studying of the rubber factory wastewater characteristics completed first in term of measuring the pH, COD, BOD, total suspended solids (TSS), and volatile suspended solids (VSS). Then, conducted the process of development for the aerobic-anoxic reactor with synthetic wastewater. After that, by using the same reactor to treat rubber wastewater.

1.4 Relevancy and Feasibility

1.4.1 Relevancy of the Project

The study is related to wastewater engineering, environmental engineering, and environmental management system in following the standards and regulations.

1.4.2 Feasibility of the Project

By using the tools, equipment, and chemicals from wastewater lab that will make the project possible to achieve the expected results.

CHAPTER 2

LITERATURE REVIEW

2.1 Organic Matter and Nitrogen Removal

The excessive nitrogen inflows from domestic and industrial effluents cause the eutrophication that affect the ecological system. Therefore, the removal of nutrient is very important for water environment conservation. Normally, in the ammonia- nitrogen removal there are two convention processes, aerobic nitrification and denitrification. Wastewater with high ammonia-nitrogen value is treated by aerobic system to remove the COD load. Several studies have been used to combine both nitrification and denitrification process in a single bioreactor.

Normally, the types of nitrogen present in wastewater are ammonia-nitrogen, nitrite, nitrate and organic nitrogen. Nitrifying organisms are present in almost all aerobic biological treatment process, but their numbers are depending on the mean cell residence time and on the BOD_5/N ratio. (Tchobanoglou et al., 2003). Nitrate contamination of water resources is becoming a serious environment problem worldwide. (Carrera et al., 2004; Hu et al., 1999; Prosnascy et al, 2002; Sakakibara et al., 1994; Yu and Fang, 2003).

Advanced wastewater treatment processes for nitrogen removal are usually separated into biological denitrification and chemical denitrification. (An et al., 1996; Fanning,2000; Hasegawa et al., 2000; Itokawa et al., 2001; Liang et al., 2006; Zhang et al., 1998). The nitrogen removal by means of biological process is the most preferable treatment method in urban and industrial wastewater; because it is less in the cost. Accordingly, biological processes are more attractive because they are inexpensive and cause no environmental pollution, (Elias et al., 2002; Kim et al., 2002; Oyarzun et al., 2003; (Sercu et al., 2005) The studies shows that, the biological nitrogen removal process is the most common method for removing low quantities of ammonium from wastewater, but Lee et al. had exclude wastewater rich with ammonium. The influent C/N ratio is one of the most critical parameters of the biological nitrogen removal process due to its direct influent on the growth competition between autotrophic and heterophic bacteria (Carrera et al., 2004; Niel et al., 1993). Previously, the ammonium was extensively treated with physicochemical methods or conventional biological methods. (EL-Gohary et al., 1995; Jenicek et al. 1996, Wang et al., 2005; Challiapan et al., 2006)

In conventional nitrification-denitrification process done by Chung et al. (2007), they concluded that ammonia is oxidized to nitrate by two different groups of bacteria, ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB). AOB converts ammonia to nitrite, while NOB transforms nitrite to nitrate. Recently, Gu et al.(2001) introduced a novel real time control strategy based on pH and lower frequency to achieve short-cut nitrification at low temperature in an 8800 liter SBR. In studies for Terada et al., (2003), the research found that when applying a membrane-aerated biofilm reactor (MABR) to wastewater containing organic carbon and ammonia, the aerobic zone to support nitrification, the anoxic zone to allow denitrification. MABR can be used for simultaneous nitrification and denitrification in a single reactor vessel without pH adjustment and a compact reactor system. Also, in the MABR system there is no need for pH adjustment because nitrification and denitrification occurring in a single reactor vessel.

Kassab et al.(2010), the anaerobic-aerobic system achieved total kjeldah nitrogen (TKN) removal efficiencies ranging from 80% to 89%, phosphate removal with efficiency amount to 72%, and ammonia removal limited to 69%. Therefore, it was better to use anoxic-aerobic reactor in this study.

In anoxic-aerobic treatment of wastewater by suing integrated sequential anoxic-aerobic (ISA) reactor nitrification and denitrification are required through nitrification organisms (Nitrosomonas and Nitrobacter) which oxidize ammonia to nitrite and then to nitrate. This organisms growth in the media balls in the upper part of the (ISA) reactor which the wastewater flow pass throw this porous media. Aerobic granular sludge in the aerobic-anoxic treatment can contribute to simultaneous nitrification and dinitrification (SND) process. The nitrified aerobic effluent is recycled to the anoxic reactor for denitrification. The recirculation process is to control the nitrogen level in the system.

According to nitrogen budgets calculated in some studies, the amount of nitrogen recycled was 23-35% of that missing from the medium, because of the loss of ammonia to the atmosphere. (Voltolina et al., 1998; Nunez et al., 2001).

In the nitrification process the ammonia converted to nitrate by using the aeration process (aerobic treatment). Denitrification is happened in the case of anaerobic or anoxic treatment where the nitrate is converting to nitrogen gas. The representative reactions are as follow:

Nitrification:

- First step: ammonia is oxidized to nitrite by nitrosamines bacteria.
  $$2NH_4 + 3O_2 \xrightarrow{\text{nitrosomonas}} 4H^+ + 2H_2 + 2NO_{2^-} + E$$

- Second step: nitrite is oxidized to nitrate by nitrobacter bacteria.
  $$2NO_{2^-} + O_2 \xrightarrow{\text{nitrobacter}} 2\,NO_{3^-} + E$$

- Total oxidation reaction
  $$NH_4 + 2O_2 \rightarrow NO_{3^-} + 2H^+ + H_2O$$

Denitrification:

- First step: nitrate is converted to nitrite by using a carbon source

$$6NO_{3^-} + 2CH_3OH \rightarrow 6NO_{2^-} + 2CO_2 + 4H_2O$$

Carbon source

- Second step: nitrite is converted to nitrogen gas

$$6NO_{2^-} + 3CH_3OH \rightarrow 3N_2 + 3CO_2 + 3H_2O + 6OH^-$$

Carbon source

Conventional aerobic technologies based on activated sludge processes are dominantly applied for the treatment of domestic wastewater due to the high efficiency achieved, the possibility for nutrient removal and the high operational flexibility (Gavrilascu and Macoveanu, 1999). Chan et al.(2009) found through his study that anaerobic-aerobic SBR has proved to be a suitable technology for organic removal from textile wastewater as high COD removal. Also this method shows great potential in the treatment of high strength industry and municipal wastewater due to their simplicity in operation.

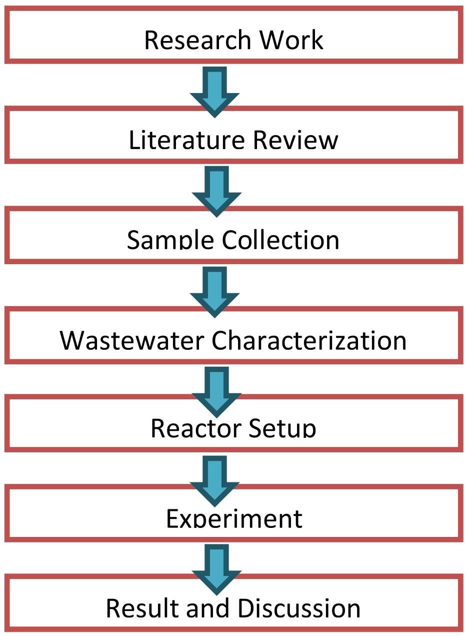
Demuynck et al. have determined that a sequence of short aerobic-anoxic phases was better than the usual sequence of aerobic phase followed by anoxic phase.

Economically, the use of anoxic- aerobic treatment is better than aerobic or anoxic treatment alone; because it reduce the operation cost. Not only the cost but also it can reduce the area needed for the treatment plant.

CHAPTER 3

METHODOLOGY

3.1 Research Stages



3.2 Wastewater Sample Collection

The wastewater sample was obtained from a glove factory, which process. produce the household and industrial rubber gloves. All the activities in the factory use water in the production

3.3 Sludge Preparation

The sludge used in this study was obtained from the sewage treatment plant (STP) of University Technology PETRONAS (UTP), Perak.

3.4 Wastewater Characterization

The sample characteristics include pH, COD, DOD_5, and TSS, alkalinity, zinc, and other characteristics like nitrate and Ammonia-Nitrogen. The study was in two phases:

Phase I: Synthetic wastewater

Table 3.1: Characteristics of synthetic wastewater (Isa & Anderson, 2005)

Compound	Concentration (mg/L)
Glucose ($C_6H_{12}O_6$) COD	8000
Ammonium hydrogen carbonate (NH_4HCO_3)	2500
Potassium di-hydrogen carbonate (KH_2PO_4)	400
Sodium hydrogen carbonate ($NaHCO_3$)	400
Magnesium sulphate ($MgSO_4.7H_2O$)	5
Ferric chloride ($FeCl_3$)	5
Calcium chloride	5
Potassium chloride (KCl)	5
Cobaltous chloride ($CoCl_2$)	1
Nickel chloride ($NiCl_2$)	1

Phase II: Rubber industry wastewater

Table 3.2: Characteristics of the rubber wastewater

Parameter	Value
pH	6.6
BOD	160.8 mg/L
COD	235 mg/L
TSS	55 mg/L
VSS	10.65 mg/L
Ammonia-Nitrogen	12.07 mg/L
Nitrate	58.5 mg/L
Alkalinity	228mg/L
Zinc	1.17 mg/L
Phosphorus	7.15 mg/L
TKN	124.7 mg/L

3.5 The ISA Reactor

3.5.1 The ISA Reactor Set-up

The ISA reactor was set-up in the wastewater laboratory. It consists of a cylindrical tube with 160 cm height and 6.5cm diameter. The upper part is used as aerobic zone (fixed film) where organic removal and nitrification take place. During nitrification process ammonia (NH_4-N) is oxidized to nitrate (NO_2-N) and then to nitrate (NO_3-N). Nitrate produced in the upper part of the reactor is recycled to the bottom of the reactor where the anoxic regime causes denitrification which converts nitrate to nitric oxide, nitrous oxide, and nitrogen gas. The experimental setup of the ISA reactor is shown in Figure 3.1 and 3.2

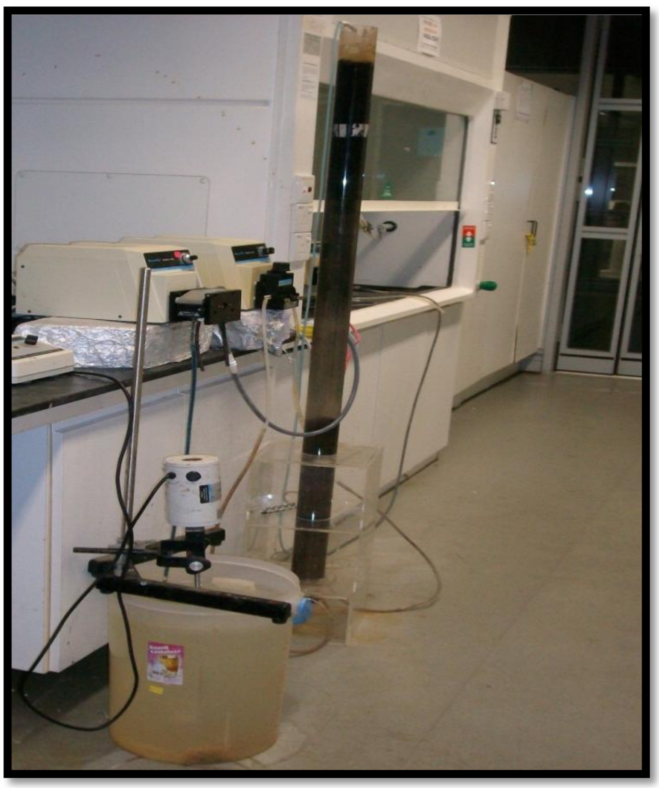


Figure 3-1: The experimental setup of the ISA reactor

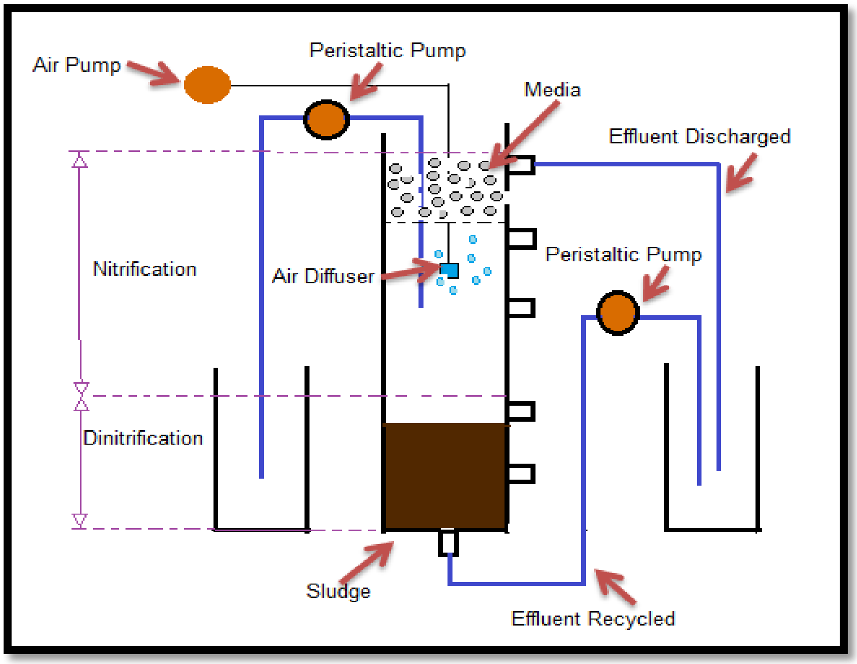


Figure 3-2: Schematic diagram of the experimental setup of the ISA reactor

3.5.2 Flow Rate for the Feed and Recycle Process

Flow rate per day, Q Feed:

Q_{Feed} = Volume/ Time

Q_{Feed} = 3.5 mL/ 5 min

= 0.694 mL/ min

= 1 liter/ day

Flow rate per day, Q Recycle:

$Q_{Recycle}$ = 2.5 litres per day

Recycle flow rate must be at least two times the feed flow rate in other to pump the effluent after nitrification back to the bottom part of the reactor.

3.5.3 ISA Monitoring Parameters

1- pH:

pH reflects the hydrogen-ion concentration. It is a measurement method for acidic or alkaline conditions of the wastewater sample. If the pH is less than 7.0 that means it is acidic. If the number between 7.0-14.0 that means it is alkaline or basic. The pH value of 7.0 is generally considered as neutral. pH of the wastewater sample determined using pH meter.

2- Alkalinity:

Alkalinity in wastewater results mainly from the presence of the hydroxide [OH^-] carbonates [CO_3^{2-}], and bicarbonates [HCO_3^-] ions. The alkalinity is important because it will help in buffering the treatment process and nutrient removal (like ammonia). The alkalinity test can be conducted by taking 25ml of the sample. Then adding 3 drops of mineral stabilizer and 3 drops of Polyvinyl Alcohol Dispersing Agent. Then, adding 1mL of Nessler Reagent. After 1 minute, the ammonia-nitrogen was determined using HACH spectrophotometer.

3- Chemical Oxygen Demand (COD):

The COD determination measures the oxygen equivalent of that portion of organic matter in wastewater sample that can be oxidized by a strong chemical oxidizing agent. The block digester was preheated to 150°C and will reflux for 2 hours. Then have to cool to room temperature and then place vessels in test tube track. After cooling, the COD of the wastewater sample was determined using HACH spectrophotometer.

4- Biochemical Oxygen Demand (BOD_5)

The biochemical oxygen demand is the measurement of the dissolved oxygen used by microorganisms. In the test the sample and seed was poured into the BOD bottle. The dilution water used to fill the bottle completely. Then measure the value of the initial oxygen concentration in the bottle. After 5 days the oxygen concentration was measured again at 20 °C.

5- Total suspended solid (TSS):

Total suspended solid are the portion of the TS retained on a filter (Whatman Glass Fiber Filter) with special pore size, measured after will be dried at a specified temperature (105°C). TSS will determine after by filtering 50 mL of the wastewater samples using a 45 mm filter disc. Then the filter paper will be dried in a drying oven in (105°C) for 1 hour. After that the filter paper will be cooled off in desiccator. Then the weight of the filter paper will be measured by using the following formula:

$$TSS = \frac{(W1 - W2)}{Volume\ of\ the\ sample, L}$$

Where:

W1=mas of residue + filter paper + glass fiber desk (mg)

W2= W1 after ignition (mg)

6- Ammonium-nitrogen (NH3-N):

Ammonium-nitrogen was determined using Nessler Method by adding drops of Mineral stabilizer and Polyvinyl Alcohol Dispersing Agent and Nessler Reagent, then measuring the sample by spectrophotometer.

7- Nitrate (NO_3^-):

Nitrate was determined using Cadmium Reduction Method by adding Nitra Ver5 Nitrate Reagent Powder Pillow, then measuring the sample by spectrophotometer.

8- Total Kjeldahl Nitrogen (TKN):

The test was held by adding 10 tablets of catalyst to the certain volume of sample (15ml), then adding H2SO4 (98%). Then, digest the sample for 30 minutes. After that it was kept for 30 minutes for cooling before distillation. TKN value calculated by using the following formula:

$$TKN= \frac{V1-V2}{Vo} * C * 14.01 * 1000$$

TKN= TKN in mg/L

V_1= Volume in ml of the acid used for titration of the sample.

V_2= Volume in ml of the acid used for titration of the blank.

V_O= Volume in ml of the sample.

C= Molarity of the acid.

14.01= Relative atomic mass of nitrogen.

9- Zinc:

Zinc is measured using USEPA Zincon method. The Zinco Ver5 Reagent Powder Pillow and Cyclohexanone was added to the sample. The Zinc in the sample was measured again by spectrophotometer.

3.6 Tools and Equipment

Table 3.3: List of tools and equipment

Test	Tools and Equipment
COD	- Heating block - COD Vials HR/LR
BOD	- BOD bottle - BOD cap - DO equipment
pH and Alkalinity	- pH meter
Ammonium- nitrogen, Nitrate, Phosphorus and COD	- spectrophotometer - sample cells
TSS test and VSS	- Filter paper Whatman - Drying Oven (105°C) and (550°C) - Desiccator unit - Filter holder - Filter flask - Tweezers
TKN	- Distillation machine
pH	- PH meter
Anoxic-Aerobic treatment	- Integration Sequential Anoxic-Aerobic (ISA) reactor

3.7 Chemicals and Reagents

Table 3.4: Chemicals and reagent

Test	Chemicals and Reagents
Solution preparation	- Distilled water
COD	- Chromic acid - Mercuric sulfate - Ferroin indicator - Potassium dichromate solution
Alkalinity, COD, and pH adjustment	- Sulfuric acid solution
pH adjustment, Total phosphorus test	- Sodium hydroxide solution
Zinc test	- Zinco Ver5 Reagent Powder Pillow - Cyclohexanone
Ammonium-nitrogen test	- Mineral stabilizer - Polyvinyl Alcohol Dispersing Agents - Nessler reagent
Nitrate test	- NitraVer 5 Nitrate Reagent Powder Pillow
Phosphorus	- Acid Hydrolyzable Test Vial - Potassium Persulfate Power Pillow - 1.54N Sodium Hydroxide Standard Solution - PhosVer3 Powder Pillow

3.8 Gantt Chart for FYP I

Items	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection of the project topic	■	■												
Research work		■	■	■	■									
External proposal						■								
Starting experiments and analysis							■	■	■	■	■	■		
Draft report													■	
Final report														■

3.9 Gantt Chart for FYP II

Items	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Data collection through experiment	■	■	■	■	■	■	■								
Results gathering and Analysis							■	■	■	■					
Submission progress report								■							
Pre - EDX											■				
Break(Eid-ul-Fitri)															
Submission of draft report													■		
Submission of final report														■	
Submission of Technical Paper														■	
Oral presentation (Viva)															■

CHAPTER 4

RESULT AND DISCUSSION

The experiment was conducted by using Integrated Sequential Aerobic-Anoxic (ISA) reactor to treat a wastewater sample. The pH range of 6-9 was recommended during the treatment. The pH value for the rubber wastewater was around 6.6-7, that means the pH value was suitable for the treatment process. The parameters tested are COD, NH3, NO3, Alkalinity and Phosphorus. This parameters show the results as follow:

4.1 Phase I: Synthetic Wastewater

Table 4.1: Influent test result values

DAY	INF COD Mg/L	INF NH_3-N Mg/L	INF NO_3^- -N Mg/L	Phosphorus Mg/L
0	520	55	0.6	40
1	518	54	0.6	38
2	518	54	0.6	38
3	517	53	0.6	37
4	517	53	0.6	37
5	517	52	0.6	36
6	519	54	0.5	39
7	518	53	0.5	38
8	518	52	0.5	38

Table 4.2: Effluent test result values

DAY	COD Mg/L	NH_3-N Mg/L	NO_3-N Mg/L	Phosphorus Mg/L
0	520	55	0.6	40
1	230	30	1.6	18.8
2	162	22	0.3	15.2
3	121	17	0.2	20.1
4	99	19	0.5	17.4
5	67	14	0.2	14.3
6	43	11	0.1	12.6
7	26	9.6	0.1	13.1
8	17	7.2	0.1	11.4

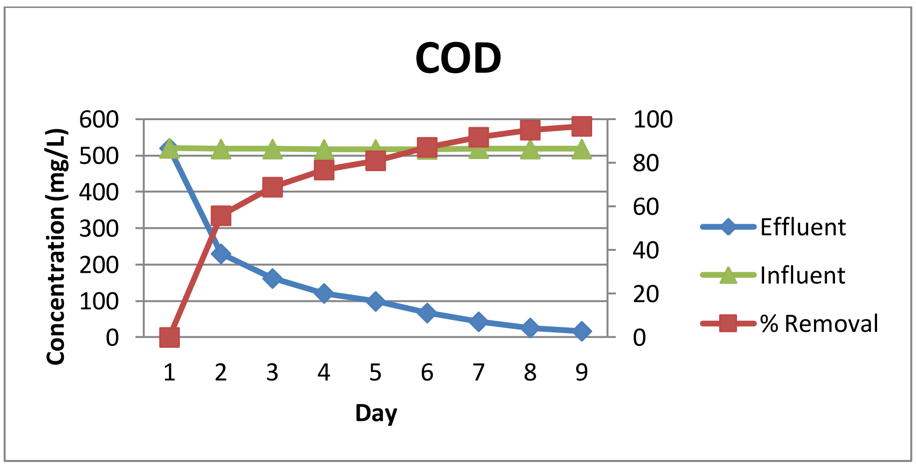


Figure 4-1: COD value in the ISA reactor

The COD removal rate was high in the ISA reactor. As shown in Figure 4.1, it starts with high decrease in COD value, and then it continues increasing slowly. The reactor was able to meet standard A COD discharge limit of below 20 mg/L.

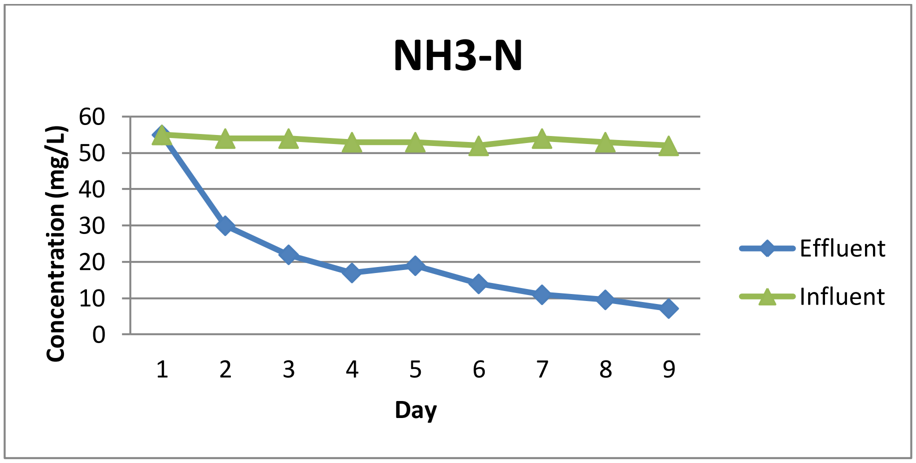


Figure 4-2: Ammonia-Nitrogen value in the ISA reactor

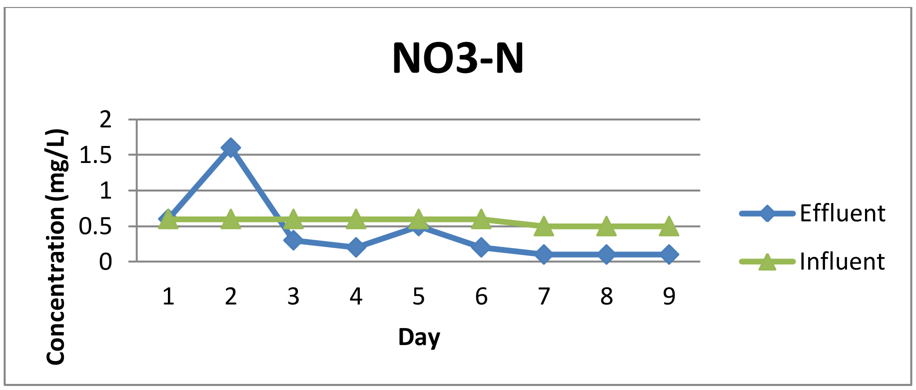


Figure 4-3: Nitrate value in the ISA reactor

The biological method for removing nitrogen from wastewater is applied in this project. Normally, solid removal can remove some nutrients, but it cannot remove the soluble nitrogen (Van Horn et al., 1994). The main biological nitrogen removal process happen in the reactor was nitrification and denitrification. For the Ammonia-Nitrogen as shown in figure 4.2, the removal was high. Ammonia- nitrogen value is decreased from 55mg/L to 7.2mg/L, which means the treatment method gives an effective removal process. That means the ammonia discharge limit is below 10 mg/L was achieved.

The nitrate in figure 4.3 shows that there was a little increase at the first two days. Then, it gives a high continues percentage reach to 80% removal.

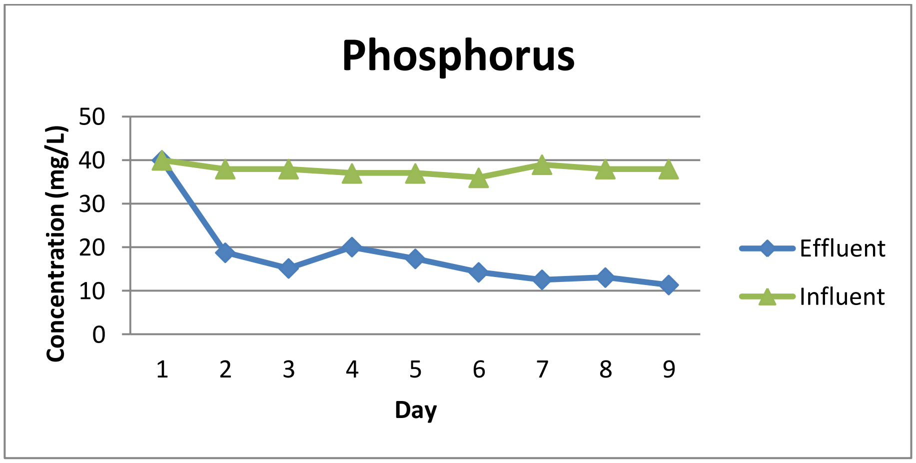


Figure 4-4: Phosphorus value in the ISA reactor

The phosphorus was start with high decrease in the first two days. The average phosphorus removal was 92 %. (Figure 4-5)

4.2 Phase I: Rubber Wastewater

Table 4.3: Influent test result values

DAY	INF COD	INF NO3-N Mg/L	INF NH3-N Mg/L	INF Phosphorus Mg/L
1	230	6.25	13.5	5.85
2	150	6.17	10.12	4.28
3	150	7.3	12.95	5.7
4	149	9.3	12.27	7
5	149	10.17	9.02	6
6	149	10.17	14.03	7.15
7	149	11.67	7.43	5.2
8	100	11.3	14.78	7.7
9	100	9.5	17.23	6.8
10	102	13	10.1	6.5

Table 4.4: Effluent test result values

DAY	COD Mg/L	NO3-N Mg/L	NH3-N Mg/L	Phosphorus Mg/L
1	60	2.83	0.517	2.28
2	27	3.17	0.18	3.1
3	44	4.5	0.7	3.45
4	63.5	5.67	0.6	2.75
5	43.5	6.5	0.55	1.8
6	9	4.8	0.1	1.9
7	20	4	0.1	0.88
8	30	4.83	0.1	1.3
9	23	3.3	0.15	0.93
10	23	2.7	0.18	0.58

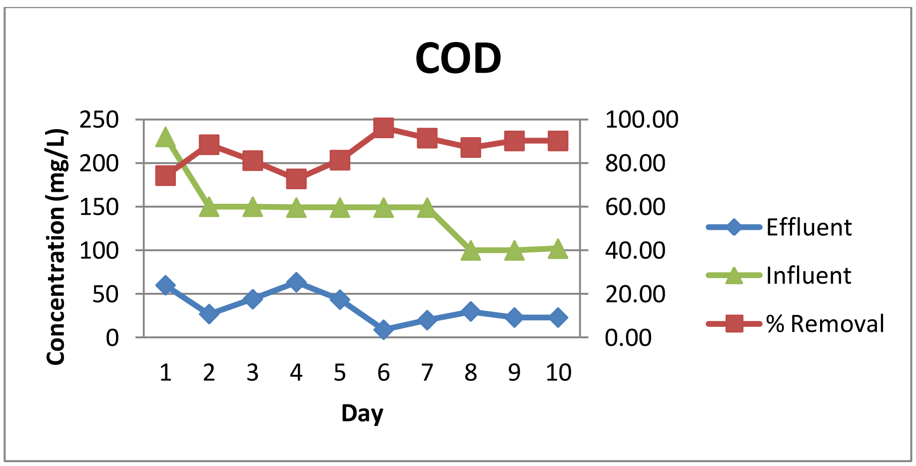


Figure 4-5: COD value in the ISA reactor

The COD removal rate was high in the ISA reactor. As shown in the figure 4.5, it starts with 235 mg/L COD till decrease to 23 mg/L COD which can meet the standards.

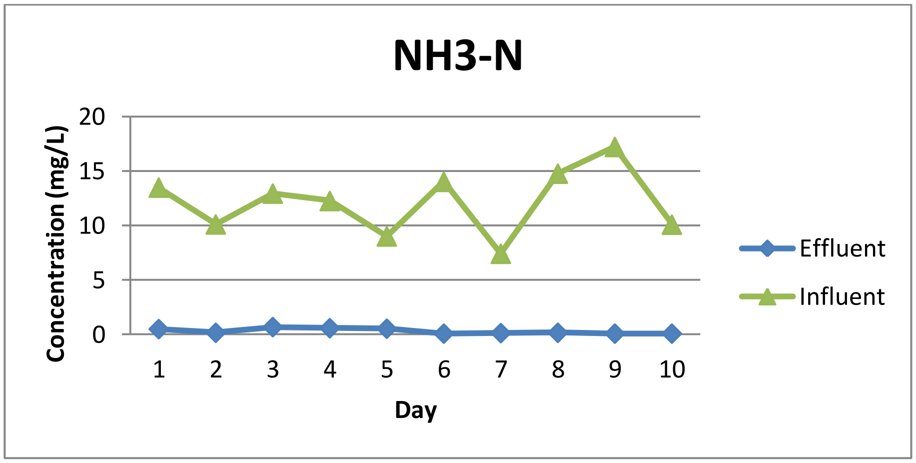


Figure 4-6: Ammonia-Nitrogen value in the ISA reactor

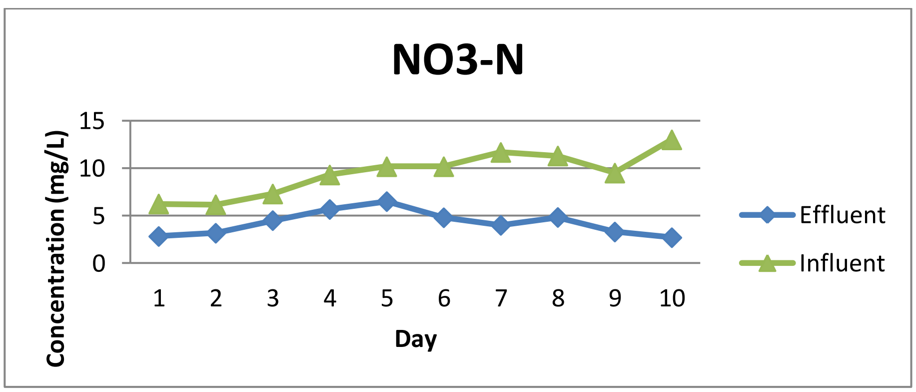


Figure 4-7: Nitrate value in the ISA reactor

According to Cui et al,(2011) study to remove organic and nutrients from food wastewater, the removal efficiency of COD was 71% with average removal efficiency of total nitrogen (TN) reach to 74%.

In this case, the nitrification and denitrification process was happen in the reactor during rubber wastewater treatment. For the Ammonia-Nitrogen values as shown in figure 4.6, the removal was high and in short period of time; because the faster growth of the organisms (nitrobacter) in the nitrification part at the bottom . Then, it was continue with slow improvement and continuous values. The removal efficiency of ammonia-nitrogen reaches to 99% and TN removal 80%. The initial total nitrogen kjeldahl (TKN) is equil to 124mg/L. While the final effluent result gives 24.27mg/L.

The nitrate in figure 4.7 shows that the removal was in continues increasing form the beginning stage of the treatment.

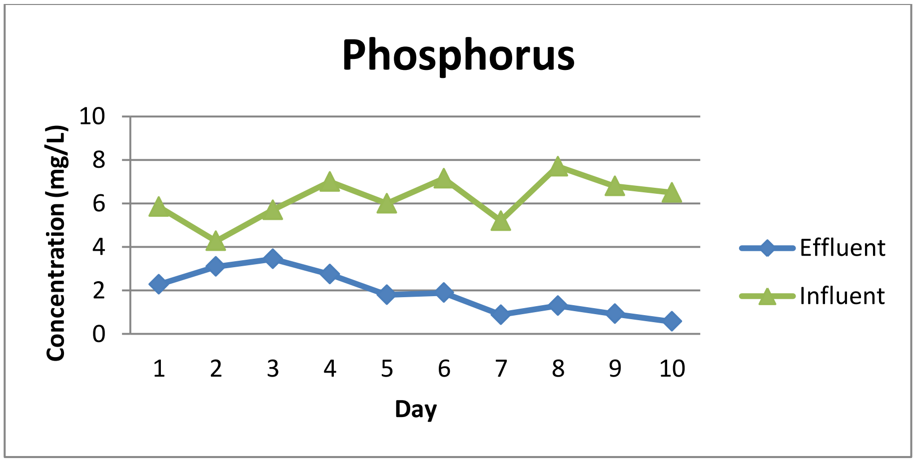


Figure 4-8: Phosphorus value in the ISA reactor

The phosphorus removal gives high percentage of removal reach to 92%. This is shown in Figure 4.8.

The characteristics of synthetic and rubber industry wastewater were highly biodegradable organic contents, they contain high concentrations of ammonium-nitrogen. The biological treatment process using (ISA) reactor was suitable to remove COD, high strength ammonia, nitrogen and phosphorus. Furthermore, the study of rubber industry wastewater shows 96% of COD was removed and total nitrogen (TN) removal efficiency was about 80%.

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The biological degradation in this study gives 96% percentage COD removal with synthetic wastewater and 90% with rubber industry wastewater. With this values the wastewater discharge can meet the standards that mentioned by the Environmental Quality Act. Also, the reactor present high efficiency in the removal of nitrogen, it can control the values for each of ammonium, nitrite, and nitrate.

The project has great benefit to society and the environment. The integrated sequential anoxic-aerobic (ISA) reactor is an effective reactor that can combine two treatment methods, i.e. aerobic and anoxic treatment. It also suitable for the nitrification and denitrification process. The reactor is economical in terms of cost and space required.

The removal of organic matters and nutrients (nitrogen and phosphorus) from rubber industry wastewater by integrated sequential anoxic-aerobic (ISA) reactor was achieved in the study.

5.2 Recommendations

During the nitrification process was there some difficulty because of the slow growing of the nitrification organisms (Nitrosomonas and Nitrobacter). Rather than the use of the aeration process (by using the air pump) cause a disturbance for this organisms and washed some of them from the reactor with the effluent treated wastewater discharge. This problem may be able to be fixed by using special type of media that can catch high amount of Nitrosomonas and Nitrobacter bacteria.

CHAPTER 6

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CHAPTER7

APPENDIX

Appendix A: Influent Characteristics

Appendix B: characteristics of rubber industry wastewater

Appendix C: Effluent analysis for synthetic wastewater

Appendix D: Effluent analysis for rubber industry wastewater

Appendix E: COD reactor

Appendix F: COD vials

Appendix A: Influent Characteristics

Parameter	Value
pH	6.6
BOD	160.8 mg/L
COD	235 mg/L
TSS	55 mg/L
VSS	10.65 mg/L
Ammonia-Nitrogen	12.07 mg/L
Nitrate	58.5 mg/L
Zinc	1.17 mg/L
Phosphorus	7.15 mg/L
TKN	124.7 mg/L

Appendix B: characteristics of rubber industry wastewater

Table 2. Characteristics of process effluents from rubber processing (Chua and Garces, 1992; Guha, 1995; Bacon, 1995; Hutagalung, 2003; Choo et al., 2003; Tekasakul and Tekasakul, 2006; Chaiprapat and Sdoodee, 2007; Rungruang and Babel, 2008; Vijayaraghavan et al., 2008a).

Parameter	Typical range
pH	3.7 - 5.5
Biological oxygen demand	1500 - 7000
Chemical oxygen demand	3500 - 14000
Suspended solids	200 - 700
Total nitrogen	200 - 1800
Sulphate	500 - 2000

All units are mg/l, except pH.

Appendix C: Effluent analysis for synthetic wastewater

DAY	COD	% Removal	NH3	% Removal	NO3	% Removal	Phosphorus	% Removal
0	520	0	55	0.00	0.6	0.00	40	0
1	230	55.77	30	45.45	1.6	0.00	18.8	53.00
2	162	68.85	22	60.00	0.3	50.00	15.2	62.00
3	121	76.73	17	69.09	0.2	66.67	20.1	49.75
4	99	80.96	19	65.45	0.5	16.67	17.4	56.50
5	67	87.12	14	74.55	0.2	66.67	14.3	64.25
6	43	91.73	11	80.00	0.1	83.33	12.6	68.50
7	26	95.00	9.6	82.55	0.1	83.33	13.1	67.25
8	17	96.73	7.2	86.91	0.1	83.33	11.4	71.50

Appendix D: Effluent analysis for rubber industry wastewater

DAY	COD	% Removal	NO3-N	% Removal	NH3-N	% Removal	Phosphorus	% Removal
1	60	74.25	2.83	78.64	0.517	96.47	2.28	68.11
2	27	88.41	3.17	76.08	0.18	98.77	3.1	56.64
3	44	81.12	4.5	66.04	0.7	95.22	3.45	51.75
4	63.5	72.75	5.67	57.21	0.6	95.90	2.75	61.54
5	43.5	81.33	6.5	50.94	0.55	96.25	1.8	74.83
6	9	96.14	4.8	63.77	0.1	99.32	1.9	73.43
7	20	91.42	4	69.81	0.15	98.98	0.88	87.69
8	30	87.12	4.83	63.55	0.18	98.77	1.3	81.82
9	23	90.13	3.3	75.09	0.1	99.32	0.93	86.99
10	23	90.13	2.7	79.62	0.1	99.32	0.58	91.89

Appendix E: COD reactor

Appendix F: COD vials