A STUDY ON EFFECT OF 4% TOTAL SOLID FOR BIOGAS PRODUCTION FROM WASTEWATER IN ANAEROBIC DIGESTION AT INDAH WATER KONSORTIUM (IWK) TREATMENT PLANT

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ABSTRACT

Nowadays, the population in Malaysia is increased and as a result, the production of waste also increased. Through the industry awareness and the experimental effort, this sewage water has a huge potential to produce byproduct and it is biogas. Biogas is used to generate heat and electricity and as a result, it can save energy and save the environment. In this study, anaerobic digestion process was involved in the production of biogas. This process can occur with some appropriate conditions. This study is involves the comparison between pH 5 and pH 7 conditions. Besides that, this study is also involves the comparison between 5ml and 15ml inoculums recirculation and it is to make sure the most suitable conditions between both recirculation that can produce higher biogas in anaerobic digestion process. Based from the results of this study, the production of biogas in pH 7 is higher than pH 5, while in 15 ml of inoculums recirculation, the production of biogas is higher than in the 5ml inoculums recirculation. So, as a conclusion, the anaerobic digestion process can occur well and can increase the production of biogas at pH 7 and 15 ml inoculums recirculation.

ABSTRAK

Pada masa kini, pertambahan populasi masyarakat di Malaysia semakin bertambah dan kesannya, sisa pengeluaran menjadi semakin meningkat. Melalui kesedaran industri dan usaha ujikaji, sisa kumbahan ini mempunyai potensi yang besar untuk menghasilkan produk sampingan iaitu biogas. Biogas digunakan untuk menjana haba dan elektrik dan hasilnya, ia dapat menjimatkan tenaga dan menyelamatkan alam sekitar. Dalam kajian ini, penghasilan pengeluaran biogas dari sisa air kumbahan adalah melibatkan proses pencernaan anaerobik. Beberapa keadaan yang sesuai diperlukan bagi membolehkan proses ini berlaku. Kajian ini melibatkan perbandingan hasil keadaan sisa air kumbahan pada ujikaji antara pH 5 dan pH 7. Di samping itu, perbandingan antara 5ml dan 15ml edaran semula inokulum juga dikaji bagi memastikan keadaan edaran semula inokulum yang paling sesuai yang dapat menghasilkan pengeluaran biogas yang lebih tinggi dalam proses pencernaan anaerobik. Daripada hasil kajian ini, keputusan mendapati, pengeluaran biogas dalam keadaan pH 7 adalah lebih tinggi berbanding pada keadaan pH 5 manakala dalam keadaan 15ml edaran semula inokulum menghasilkan pengeluaran biogas yang lebih tinggi berbanding pada keadaan 5ml edaran semula inokulum. Maka, sebagai kesimpulannya, keadaan dimana proses pencernaan anaerobik dapat berlaku dengan baik dan dapat meningkatkan pengeluaran biogas adalah pada keadaan pH 7 dan juga 15ml edaran semula inokulum.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	x
	LIST OF FIGURES	xi
	LIST OF ABBREVIATION S	
1	**INTRODUCTION**	1
	1.1 Introduction	1
	1.2 Problems Statement	2
	1.3 Objectives	3
	1.4 Scope of Study	4
	1.5 Significant of Study	4
	1.6 Expected Outcome	5

2	**LITERATURE REVIEW**		6
	2.1	Domestic Wastewater	6
	2.2	Wastewater Treatment	10
	2.3	Anaerobic Digestion process	15
	2.4	Effect of pH in Anaerobic Digestion Process	21
	2.5	Biogas Production	22
	2.6	Design of Experiment by Using Design Expert Software	26
3	**METHODOLOGY**		27
	3.1	Introduction	27
	3.2	Location of Study	29
	3.3	Preservation Sample	30
	3.4	Method of Analysis	31
		3.4.1 pH	32
		3.4.2 Total Suspended Solid (TSS)	32
		3.4.3 Volatile Suspended Solid (VSS)	33
		3.4.4 Total Nitrogen (TN)	34
		3.4.5 Ammonia Nitrate (AN)	35
		3.4.6 Total Phosphorus (TP)	36
		3.4.7 Alkalinity	37
		3.4.8 Chemical Oxygen Demand (COD)	37
	3.5	Medium Preparation	38
		3.5.1 Sterilization of Apparatus	38
		3.5.2 Purging the Substrate	39
		3.5.3 Inoculums	41
	3.6	Reagent Preparation	41
	3.7	Set up Experiment	41

4	**RESULT & DISCUSSION**		48
	4.1	General	48
	4.2	Screening of Main Factor Affecting Biogas Production by Using Full Factorial Design	49
	4.3	Optimization for Biogas Production of Sewage Water	53
		4.3.1 Optimization for Biogas Production of Sewage Water for pH 5	54
		4.3.2 Optimization for Biogas Production of Sewage Water for pH 7	56
		4.3.3 Optimization for Biogas Production of Sewage Water for 5ml Inoculums Recirculation	58
		4.3.4 Optimization for Biogas Production of Sewage Water for 15ml Inoculums Recirculation	59
5	**CONCLUSION AND RECOMMENDATION**		62
	5.1	Introduction	62
	5.2	Conclusion	63
	5.3	Recommendation	64
REFERENCES			65
APPENDICES			68

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Typical Influent Characteristics of Domestic Wastewater	7
2.2	Energy from Biosolids Pathways, Processes and Products	23
4.1	List of Journals	50

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
2.1	Summary of Parameters Comparing Anaerobic Food Waste Digestion to Anaerobic Municipal Wastewater Solids Digestion	9
2.2	A Flowchart Showing Various Types of Biological Wastewater Treatment Plants which are Classified into Aerobic and Anaerobic Process	11
2.3	Flowchart Showing Stages Involved in Sewage Treatment Process	13
2.4	Simplified Schematic Representation of the Anaerobic Degradation Process	17
2.5	Schematic Representation of the Course of Anaerobic Methane Generation from Complex Organic Substances Showing Scanning Electron Micrographs of Individual Microorganisms Involve	18
2.6	Carbon Flow in Anaerobic Environments with Active Methanogens	19
2.7	Principal Methanogenic Reactions	20
2.8	Daily and Cumulative Biogas Production during Start-up	25
3.1	Research Methodology	28
3.2	Location of Sewage Treatment Plant Pantai Dalam	29
3.3	Anaerobic Digestion Point	30
3.4	Sample Stored in the Refrigerator	31
3.5	pH meter	32
3.6	Filter Disc was washed with Distilled Water	33
3.7	Muffle Furnace	34

3.8	Total Nitrogen Testing	35
3.9	Ammonia Nitrate Testing	36
3.10	Chemical Oxygen Demand (COD) Testing	38
3.11	Autoclave	39
3.12	Set up the Apparatus for Purging the Substrate	40
3.13	Circumstances where Air was removed and Nitrogen Gas was Inserted	40
3.14	Defining Factors	42
3.15	Defining Levels of pH	43
3.16	Defining Levels of Revolutions per Minute (rpm)	43
3.17	Defining Levels of Recirculation	44
3.18	Defining Levels of Total Solid (TS)	44
3.19	Defining Replications	45
3.20	Defining Responses	46
3.21	Design Layouts	46
3.22	Set up Experiment for Optimization Stage	47
4.1	Screening Factor Value Calculated by Designed Expert DX6	53
4.2	Comparison of Biogas Production for 5ml and 15ml Inoculums Recirculation for pH 5	54
4.3	Comparison of Cumulative Biogas Production for 5ml and 15ml Inoculums Recirculation for pH 5	55
4.4	Comparison of Biogas Production for 5ml and 15ml Inoculums Recirculation for pH 7	56
4.5	Comparison of Cumulative Biogas Production for 5ml and 15ml Inoculums Recirculation for pH 7	57
4.6	Comparison of Biogas Production for pH 5 and pH 7 for 5ml Inoculums Recirculation	58
4.7	Comparison of Cumulative Biogas Production for pH 5 and pH 7 for 5ml Inoculums Recirculation	59
4.8	Comparison of Biogas Production for pH 5 and pH 7 for 15ml Inoculums Recirculation	60
4.9	Comparison of Cumulative Biogas Production for pH 5 and pH 7 for 15ml Inoculums Recirculation	61

LIST OF ABBREVIATIONS

NO.	LIST	
1	IWK	: Indah Water Konsortium Sdn. Bhd.
2	VFAs	: Volatile Fatty Acids
3	TVS	: Total Content of Volatile Solids
4	TP	: Total Phosphorus
5	COD	: Chemical Oxygen Demand
6	TN	: Total Nitrogen
7	AN	: Ammonia Nitrate
8	TS	: Total Solid
9	TSS	: Total Suspended Solid
10	VSS	: Volatile Suspended Solid
11	rpm	: revolutions per minute
12	H_2SO_4	: Sulphuric Acid
13	NaOH	: Natrium Hydroxide

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, many developed towns and cities around the world adopting the Zero Waste management concept. Participation from communities to manage wastes also increases. The concept of waste management is based on nature, which is everything has its purpose. Waste can also produce by-products that can boost the economy of this country and no waste problem will occur. The same concept is also used to treat domestic wastewater.

Domestic wastewater means water used by household and discharged as sewage. In domestic sewage treatment, once wastewater reaches the sewage treatment plant (STP), sewage undergoes various physical and biochemical processes that convert the sewage into environmentally acceptable end products. Wastes handled by sewage treatment plant are converted to three different forms of treated effluent, bio-solids and bio-gas.

A public survey conducted in tandem with the research indicated that the industrial sector is highly receptive to the idea of using processed wastewater to produce biogas. Anaerobic treatment of domestic wastewater is a selective way for production of biogas (B. Lew, 2008). The production of biogas is made up of around sixty percent (60%) methane and forty percent (40%) carbon dioxide can be to generate heat and electricity.

The anaerobic treatment is used for production of biogas because the lower handling costs as no oxygen is needed compared with handling cost in aerobic sewage treatment. Besides that, greenhouse gas emissions during anaerobic treatment are lower relative to aerobic technologies if methane is used as an energy source (M. Green, 2008).

The purpose of this study is to increase the production of biogas from domestic wastewater in anaerobic digestion process and the factors that were considered in this study are pH, revolutions per minute (rpm), total solid (ts) and recirculation.

1.2 Problem Statement

Nowadays, Malaysia is rapidly transforming into a developed nation with densely populated urban development nationwide. This transformation is incomplete without proper sewerage collection and treatment systems to provide a clean and healthy environment.

Recently, the potential of anaerobic digestion has been discovered as having a central role in delivering higher outputs from finite biomass resources. As the one of entity who is responsible in providing sewerage services, operating and maintaining 5780 public sewage treatment plants, Indah Water Konsortium (IWK) has endeavoured to create marketable green products from the byproducts of its core services. The

treatment processes will result in products which can be reused for the benefit of the environment biosolids such as compost fertiliser, bioeffluent (treated water) and also biogas (The Star, 2012).

One of the branches of the Indah Water Konsortium (IWK) that take part in the biogas production project is a sewage treatment plant at Pantai Dalam, Kuala Lumpur. However, there is lower gas production from existing set up by sewage treatment plant Pantai Dalam, Indah Water Konsortium (IWK) Sdn Bhd. The production of biogas is less than 900 m^3 from the total gas volume in the collecting gas tank. This sewage treatment plant provides an opportunity for many researchers to design a solution to enable increased production of biogas at the treatment plant.

So, the findings indicates the importance of this research to determine the screening factor value of wastewater parameters chosen that calculated by Design Expert (DX6) Software and also to identify the effect of different pH and recirculation for production of biogas in wastewater. This research was conducted to optimize the production of biogas from wastewater in anaerobic digestion process.

1.3 Objectives

The main objectives of this study are:

1) To determine the screening factor value of wastewater parameters selected that analyzed by Design Expert (DX6) Software.
2) To identify the effect of pH 5 and pH 7 for production of biogas in wastewater.
3) To identify the effect of 5ml and 15ml inoculums recirculation for production of biogas in wastewater.

1.4 Scope of Study

This study was focused on optimization of biogas production at Indah Water Konsortium (IWK) sewage treatment plant at Pantai Dalam, Kuala Lumpur. The experiment to optimization of biogas production was conducted at Environmental Laboratory, Faculty of Civil Engineering University Malaysia Pahang (UMP). The sample of sewage water was taken from anaerobic digestion point.

Design Expert (DX6) Software was used to achieve the first objective. Full factored designs (FFD), was applied in this software to screen the main value factor based from the wastewater parameters chosen. Parameters that were chosen are pH, revolutions per minute (rpm), recirculation and total solid (TS). The range of the parameters that were selected was obtained from the journal.

The optimization of biogas production of sewage water was determined from the comparison between pH 5 and pH 7. Besides that, the effect of 5ml and 15ml inoculums recirculation also was identified to optimize biogas production in wastewater (Binod, 2008).

1.5 Significant of Study

The results and analysis of study are important to optimize the biogas production of wastewater in anaerobic digestion process. From the analysis, the effect of different pH and recirculation was identified to optimize the biogas production of sewage water.

1.6 Expected Outcome

This research was focused on the effect of different pH and recirculation. From the analysis of the effect of different pH and recirculation, the optimization of biogas production was detected.

CHAPTER 2

LITERATURE REVIEW

2.1 Domestic Wastewater

Wastewater is water that has been used and comes from variety of sources. Everything that flushes down or rinse down the drain is domestic wastewater and wastewater also can comes from agricultural and industrial sources. Domestic wastewater means the sewage water that discharge from domestic residences, commercial or industrial premises into public sewer, originated from all aspects of human sanitary water usage. It is the sewage water that flows from bathroom, toilets, floor traps, kitchen sinks, dishwashers and washing machines. Domestic wastewater generations in Malaysia do not combine the domestic sewage water with storm water or industrial process wastewater. Wastewater must be treated before it is discharged to water body.

Differences in food consumed, water use and personal hygiene practices are difficult to adopt the design parameter for biological process design. Domestic wastewater concentrations vary greatly from one place dependent on the sosio-economic status of the community that live at that place.

The accurate method to establish the characteristic and quantity of domestic wastewater is measure the existing sewage water flow over sufficient length of time to determine its variability in terms of composition, concentration and load (Kling, 2007). Different with new development case, a prescribed wastewater flow and typical characteristic of the domestic wastewater need to be adopted for the design stage of a new treatment system in meeting with the stipulated discharge standard. Table 2.1 shows the typical influent characteristics of domestic wastewater studied elsewhere.

Table 2.1: Typical Influent Characteristics of Domestic Wastewater (Matcalf, 2004)

Contaminants	**Unit**	**Concentration**		
		Weak	**Medium**	**Strong**
Total Solid (TS)	mg/l	390	720	1230
Total Dissolved Solid (TDS)	mg/l	270	500	860
Fixed	mg/l	160	300	520
Volatile	mg/l	110	200	340
Suspended solid (SS)	mg/l	120	210	400
Fixed	mg/l	25	50	85
Volatile	mg/l	95	160	315
Settable solids	mg/l	5	10	20
BOD_5 20°C	mg/l	110	190	350
Total organic	mg/l	80	140	260

carbon				
COD	mg/l	250	430	800
Total nitrogen (TN)	mg/l	20	40	70
Organic	mg/l	8	15	25
Free ammonia	mg/l	12	25	45
Nitrites	mg/l	0	0	0
Nitrates	mg/l	0	0	0
Total phosphorus (TP)	mg/l	4	7	12
Organic	mg/l	1	2	4
Inorganic	mg/l	3	5	10
Chlorides	mg/l	30	50	90
Sulfate	mg/l	20	30	50
Oil and Grease	mg/l	50	90	100
Volatile organic compound	mg/l	< 100	100 – 400	> 400
Total Coliform	#/100mL	10^6~10^8	10^7~10^9	10^7~10^{10}
Fecal Coliform	#/100mL	10^3~10^5	10^4~10^6	10^5~10^8

Source: Wastewater Engineering, Treatment and Reuse. 4th Edition, Table 3-15

The industry research has found, the sewage water can carry out anaerobic digestion process to produce biogas. Figure 2.1 shows the comparison of parameter between food waste digestion and municipal wastewater solids digestion.

Parameter	Units	Food Waste Digestion				Municipal Wastewater Solids Digestion
		15-day MCRT		10-day MCRT		15-day MCRT
		Meso	Thermo	Meso	Thermo	Meso[1]
VS (as percent of TS), Feed	%	86.3	87	89.9	90.6	77
VS Loading, Feed	lb/ft³-day	0.28	0.29	0.53	0.54	0.2[2]
COD Loading, Feed	lb/ft³-day	0.55	0.57	1.09	1.11	0.06-0.3[3]
VSD	%	73.8	80.8	76.4	82.4	38-57%[4]
Methane (CH_4) Content	%	64	67	59	60	63
Methane Production Rate, Avg (Range)	ft³/lb TS applied	13,300 (9,800–17,000)[5]		9,500 (6,600–14,400)[5]		10,000 (7,500–12,600)
	ft³ per day/ 1,000 ft³ digester volume	2,300 (1,100–3,200)		2,600 (1,800–3,800)		750 (550–930)
Residuals (Mass of Biosolids Produced) as a Percent of Feed Applied.	%	36	30	31	26	56-70

Notes:
1. Based on data from previous EBMUD bench-scale pilot study. Digesters were fed thickened waste activated sludge and screened primary sludge.
2. Maximum recommended loading rate. WEF MOP 8.
3. Maximum recommended loading rate. M&E, 4th Edition.
4. EPA 503 Regulations minimum is 38%. Typical average is 57% from EBMUD bench-scale pilot study.
5. Data combined for mesophilic and thermophilic digesters.

Source: Environmental Protection Agency US

Figure 2.1: Summary of Parameters Comparing Anaerobic Food Waste Digestion to Anaerobic Municipal Wastewater Solids Digestion (East, 2007)

2.2 Wastewater Treatment

As societies moved from nomadic cultures to building more permanent sites, the concern over wastewater disposal became an important concern. This issue has been dealt with many different ways. When groups were living as hunters and gathers, the sewage water decomposition dealt with naturally. Different with developed cities other mechanisms were necessary to address waste issues. Recently, wastewater sanitation focused on minimizing health risks, primarily infectious diseases and the scope of wastewater management issues has broadened to include chronic health risks and environmental concerns (Burks and Minnis, 1994).

Wastewater treatment is the process of taking sewage water and making it suitable for discharge back into the environment. Sewage water can be formed by a variety of activities, including washing, bathing, and using the toilet. Bacteria, chemicals, and other contaminants can be found in this water. These contaminants can be reducing to acceptable levels so as to be safe for discharge into the environment by wastewater treatment.

In Malaysia, company that is responsible for the sewerage system for domestic use is Indah Water Konsortium Sdn Bhd (IWK). As this research is involve with Indah Water Konsortium Sdn Bhd (IWK), it would be beneficial to know more about the wastewater treatment system IWK use. Indah Water Konsortium Sdn Bhd (IWK) wastewater treatment plants mostly used biological treatment plants which cater for aerobic process that occur such as in aerated lagoons and oxidation ponds. Aerobic process is a treatment that occurs in the presence of oxygen.

Some of the biological treatment plants operated and maintained by Indah Water Konsortium (IWK) also caters anaerobic processes which occur in the absence of oxygen with the use of Imhoff tanks and Sequencing Batch Reactors (SBR). Figure 2.2 shows various types of treatment plants that being used worldwide.

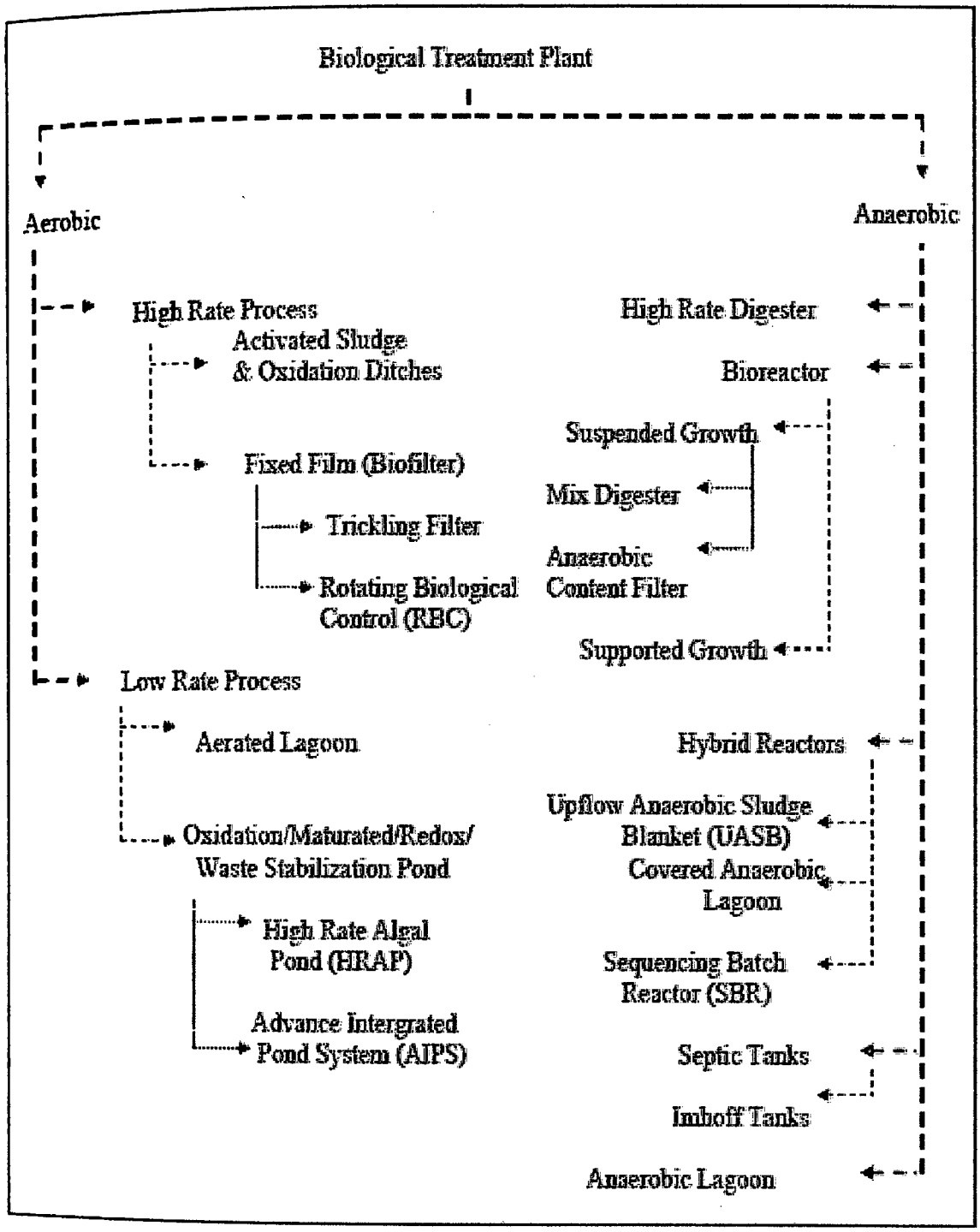


Figure 2.2: A flowchart showing various types of biological wastewater treatment plants which are classified into aerobic and anaerobic process (Qasim, 1999)

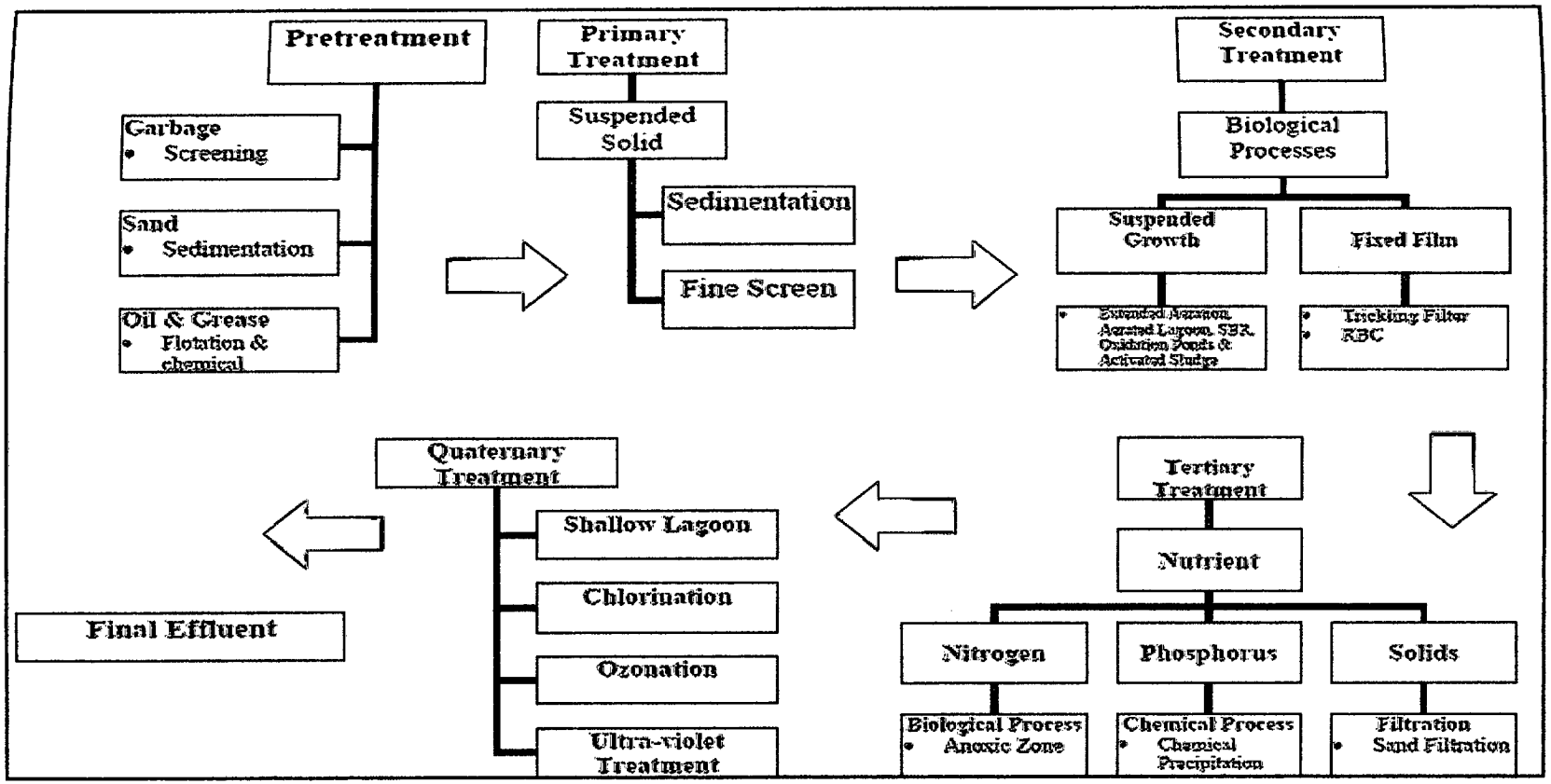
Sewage water treatment process has several steps before the final effluent is discharged into the rivers or other receiving water bodies. Sewage water treatment process consists of pretreatment, primary, secondary, and tertiary and some extent to quaternary treatment. Figure 2.3 illustrate the regular processes that are being carried out by Indah Water Konsortium (IWK) in order to treat the sewage as required by the regulations.

All garbage, sands, seeds, and other things that are heavier than organic matter were removed using pretreatment step. Causes of functions failure of the mechanical devices like blockage in pipelines and channels can occur from things that are heavier than organic matter. Besides that, all these things could lead to cementing effects due to the hardened sedimentation at the bottom of the tanks and reducing the water volume that is to be treated as they could accumulate together.

Before entering the next treatment process, screening process was required to screen big objects like logs, plastics and cloth. Biological and chemical compound was used in flocculation process of fats, oil and grease while sedimentation process was used for sand and suspended solids.

Sewage was treated in primary pond after grit removal process in the pretreatment. About 40 to 60% of the suspended solids and more than 90% settleable solids and organic solids are removed in sedimentation process. Biological oxygen demand (BOD) also decrease to 20% because of suspended solids were removed and in this process there is no biological activity that occurs.

The sewage velocity was controlled in primary treatment ponds to prevent the water from mixed and allows the sedimentation process to occur. The detention period is about one to two hours to make sure the water meet the quality before it is released into the next stage. Scum board is used to isolate the scum from the wastewater and sludge that produced from sedimentation process will sinks at the bottom of the tanks.



Source: Indah Water Konsortium Sdn Bhd (IWK) Training Module

Figure 2.3: Flowchart Showing Stages Involved in Sewage Treatment Process (Indah Water Konsortium Sdn Bhd)

By using pump to suck out the sludge from ponds or tanks, the desludging process can be done because after a period, the sludge needs to be taken out from the tanks.

Wastewater is allowed to enter the secondary treatment after the sedimentation process in primary treatment and at this treatment; soluble and colloidal organics are removed by utilizing bacteria to perform biological process. Purpose of the biological process is to simulate aquatic nature like rivers and lakes in treating waste.

Suspended growth and fixed film are two types of treatment that involved biological treatment. Type of suspended growth consists of extended aeration, aerated lagoon, oxidation ponds, Sequencing Batch Reactor (SBR) and activated sludge. Suspended growth is a biological process where all the organisms will be suspended with the organics.

Meanwhile, there are two types of fixed film, trickling filter and Rotating Biological Control (RBC). In this biological process, the organics attach to substances contained with bacteria that function as a media in the stabilization process.

Suspended solids and biological oxygen demand (BOD) were inclined after sewage gone through this stage but nutrients in the wastewater such as nitrogen and phosphorus are remained.

The next treatment is tertiary treatment. In this treatment, nutrients were removed from wastewater. Not all treatment plants possess this treatment and if the water is not go through this treatment especially to treat nitrogen and phosphorus; it will give impact to environment especially to the receiving water bodies.

The environmental impact due to nitrogen and phosphorus content in water bodies is algae bloom. This phenomenon is a consequence of nutrient enrichment in water or eutrophication. Besides that, it is one condition where there is abundance of algae exists and covers the water surface.