DESIGN CRITERIA OF BIOFILTER SYSTEM AS TREATMENT FOR DOMESTIC WASTEWATER

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ABSTRACT

Nowadays, the effluent from domestic wastewater is highly untreated. So when the effluents flow to the river it will cause water pollution and will affect water quality of the river. If the water polluted, the aquatic life and environment surrounding will be in deep trouble. A device known as biofilter can help this problem solve. To make this biofilter effective, it will depend on the design. The optimum design criteria will make this biofilter become more effective although in the market nowadays have many biofilter but the available biofilter now is doesn't have proper design criteria. This study aims to determine the design criteria of biofilter as treatment for domestic wastewater and to evaluate the effectiveness of biofilter as treatment for domestic wastewater. This study involves two main methods which are field measurement and laboratory experiments. Field measurement includes test for Dissolved Oxygen (DO), Total Dissolved Solid (TDS), pH, temperature, salinity, turbidity and electric conductivity while laboratory experiments involve test for Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Ammonia Nitrogen (AN), Total Coliform, E-Coli and Oil and Grease. All the results were compare with Standard A and Standard B, Environment Quality Act, 1974 and analyzed in terms of percentages of removal. The study indicates that the design criteria adopted not shows an excellent performance where most of the water quality parameters not complying Standard A and Standard B, Environment Quality Act, 1974, however it do shows improvement in terms of percentage of removal for parameters turbidity, total suspended solid and ammonia nitrogen The percentage removal of turbidity as high as 98.99%, while TSS and AN range from 31.25% to 58.55%.

ABSTRAK

Dewasa ini, efluen dari air sisa domestik sangat tercemar. Apabila efluen sisa domestik dilepaskan dan mengalir ke sungai, ia akan menyebabkan pencemaran air dan akan menjejaskan kualiti air sungai. Jika pencemaran air berlaku, ia akan mengancam hidupan akuatik dan persekitaran sekililing juga akan mengalami masalah yang besar. Justeru itu, satu alat yang dikenali sebagai 'Biofilter' boleh menyelesaikan masalah ini dan ia bergantung pada reka bentuk 'Biofilter'. Reka bentuk 'Biofilter' yang optimum akan membuatkan ia menjadi lebih efektif walaupun pada hari ini terdapat banyak 'Biofilter' dijual dipasaran tetapi 'Biofilter' yang sedia ada di pasaran tiada reka bentuk yang tetap. Oleh itu, tujuan kajian ini dijalankan ialah untuk menentukan satu reka bentuk 'Biofilter'sebagai alat utuk merawat air sisa domestik dan untuk menilai keberkesanan 'Biofilter' sebagai alat untuk merawat air sisa domestik. Terdapat dua kaedah yang dilakukan di dalam kajian ini iaitu ujian di tapak dan ujian di makmal. Ujian di tapak meliputi penganalisaan Oksigen Terlarut (DO), Bahan Pepejal (TDS), pH, suhu, kekeruhan, kemasinan dan konduktiviti elektrik manakala ujikaji di makmal ialah Permintaan Oksigen Biokimia (BOD), Permintaan Oksigen Kimia (COD), Pepejal Terampai (TSS), Ammonia Nitrogen (AN), Total Koliform, E-Coli dan Minyak dan lemak. Selepas ditapis oleh 'Biofilter' dan ujikaji makmal, hasilnya akan dibandingkan dengan Standard A dan Standard B, Akta Kualiti Persekitaran, 1974. Peratus penyingkiran kekeruhan ialah setinggi 98.99% manakala pepejal terampai dan ammonia nitrogen ialah dari 31.25% sehingga 58.5%.

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LIST OF SYMBOLS AND ABBREVIATIONS

AN	-	Ammonia Nitrogen
BOD	-	*Biochemical Oxygen Demand*
CM	-	*Centimetre*
COD	-	Chemical Oxygen Demand
DO	-	*Dissolved Oxygen*
EFB	-	*Empty Fruit Bunch*
EM	-	*Effective Microorganism*
FKASA	-	Fakulti Kejuruteraan Awam dan Alam Sekitar
KK3	-	Kolej Kediaman 3
M	-	*Metre*
Mcm	-	*Million cubic meter*
Mcm/year	-	*Million cubic meter per year*
Cm/day	-	*Centimetre per day*
NRE	-	Natural Resources and Environment
NTU	-	Nephelometric Turbidity Units
P	-	*Dilution Factor*
pH	-	*Hydrogen-ion Concentration*
PPT	-	*Parts per Thousand*
TDS	-	Total Dissolved Solid
TSS	-	Total Suspended Solid
TOD	-	Total Oxygen Demand
UMP	-	Universiti Malaysia Pahang
VOC	-	Volatile Organic Compound
WQI	-	Water Quality Index
Ag_2SO_4	-	Argentums sulphate
°C	-	Degree of Celsius

Ca	-	Calcium
H_2SO_4	-	Sulphuric acid
$HgSO_4$	-	Mercuric sulphate
K	-	Potassium
$K_2Cr_2O_7$	-	Potassium dichromate
gal/ft^2/day	-	Gallon per feet square per day
Mg	-	Magnesium
Mg/L	-	Miligram per liter
Ms/cm	-	MiliSiemen per centimetre
Na	-	Sodium
NaCl	-	Sodium Chloride
V_s	-	Volume of sample
V_{dw}	-	Volume of dilution water

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CHAPTER 1

INTRODUCTION

1.1 General

Water is an important element for all human beings in the world. Our body consists mostly of the water. We need water for drinking, cooking, washing, agriculture and to run our industries. We usually take it for granted because of its availability; but when in scarcity it becomes our most precious resource (Che-Ani et al., 2009).

Water pollution is a major problem in the global context. It has been suggested that it is the leading worldwide cause of deaths and diseases and that it accounts for the deaths of more than 14,000 people daily (West, 2006). Water pollution may be analyzed through several broad categories of methods: physical, chemical and biological. Most involve collection of samples, followed by specialized analytical tests. Some methods may be conducted *in situ,* without sampling, such as temperature. Government agencies and research organizations have published standardized, validated analytical test methods to facilitate the comparability of results from disparate testing events (Clescerl et al., 2007).

Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources.

A biological filter technology is used to control water pollution by applying the use of microorganisms as agents to treat contaminated water. This method introduced by Shimanto Gawa has been successfully applied in Japan. The biofilter reliance on microorganisms requires an appreciation of ecological concepts which must be considered in biofilter design (Nur, 2007).

1.2 Problem Statement

Nowadays, the effluent from domestic wastewater is highly untreated. So when the effluents flow to the river it will cause water pollution and will affect water quality of the river. If the water polluted, the aquatic life and environment surrounding will be in deep trouble. A device known as biofilter can help this problem solve. To make this biofilter effective, it will depend on the design. The optimum design criteria will make this biofilter become more effective although in the market nowadays have many biofilter but the available biofilter now is doesn't have proper design criteria.

Sewage water pollution is a type of water pollution and one of the major problems in cities. The sewage water is drained off into rivers without treatment. The careless disposal of sewage water leads to a chain of problems, such as spreading of diseases, eutrophication, increase in Biological Oxygen Demand (BOD) and many more. The waste water that flows after being used for domestic, industrial and other purposes is termed as sewage water. In ideal situations, the sewage water is channelled or piped out of cities for treatment. Bulk of the sewage contains water as the main component, while other constituents include organic wastes and chemicals.

After the biological treatment, the partially pure effluent is treated with chemical disinfectants. The water treated in the treatment plants can be used in golf courses for watering the lawns and in agriculture for irrigation. Some sewage treatment plants are very efficient and produce clear and clean water at the end of the process. Sewage water treatment is a must, when environmental issues are an increasing concern. An effort needs to be taken to purify the effluents. It will not only benefit human beings but also the varied flora and fauna on our planet. Let's pledge to keep our environment beautiful and free from any kind of pollution (Shashank, 2009).

1.3 Study Objectives

The objectives of this study are:

I. To determine the design criteria of biofilter criteria as treatment for domestic wastewater.

II. To evaluate the effectiveness of bioflter as treatment for domestic wastewater.

1.4 Scope of Studies

I. Proposed new modification system design and new of biological filter medium for waste water treatment.

II. Setup the model of this system at drainage near with KK3 hostel and conduct water quality testing at Environmental Laboratory, Fakulti Kejuruteraan Awam dan Alam Sekitar (FKASA), Universiti Malaysia Pahang (UMP).

III. Collection of waste water samples effluent from drainage system located near student residential area (KK3), UMP.

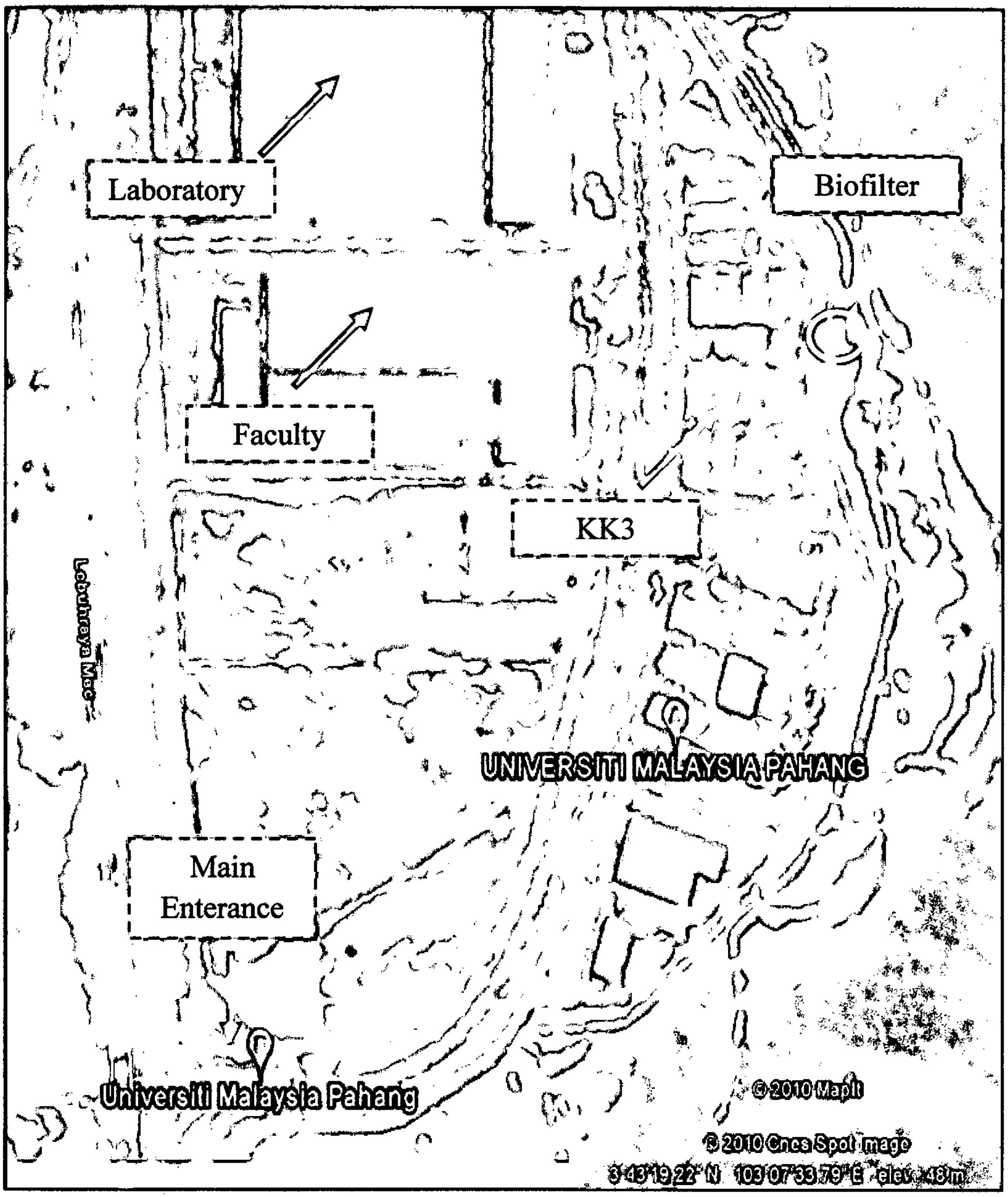
IV. Laboratory water quality testing for water quality parameters which are BOD, COD, Oil and Grease, Ammonia Nitrogen, TSS, E-Coli, Total Coliform and compare with standard A and standard B of Environmental Quality Act (1974).

V. In-situ water quality testing for parameters which are DO, pH, electric conductivity, salinity, turbidity, TDS, temperature and compare with standard A and standard B of Environmental Quality Act (1974).

1.5 Location of study

The biofilter is located at the point sources of wastewater treatment. Figure 1.1 shows the location of biofilter at Universiti Malaysia Pahang (UMP), while Figure 1.2 shows the waste water's discharge point at KK3.

Figure 1.1: Location of study area



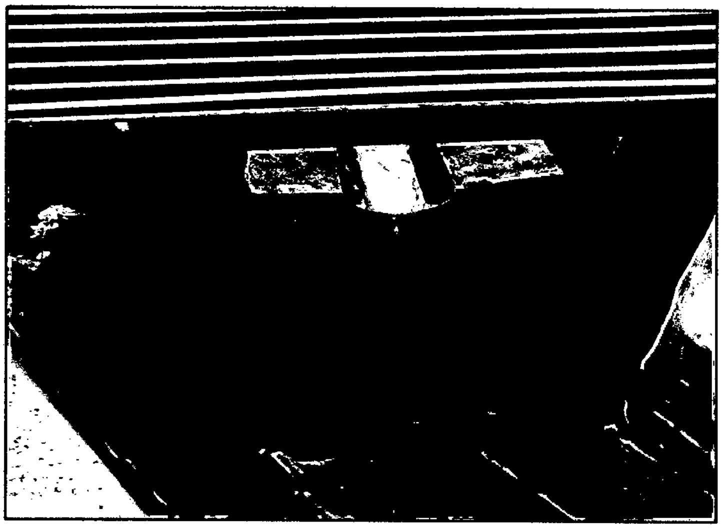


Figure 1.2: Waste water's discharge point at KK3.

1.6 Significance of Study

Biofiltration is a pollution control technique using living material to capture and biologically degrade process pollutants. Common uses include processing waste water, capturing harmful chemicals or silt from surface runoff, and microbiotic oxidation of contaminants in air. The use of indigenous microorganism enables this system to operate this minimal maintenance due to its biological regeneration, thus this system serve as sustainable, effective and economic filtration method in various waters and discharges for the improvement of water quality. The biofilter can be very useful in various waste water due to the efficiency for biological purification, good integration in environment and low sludge production.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Water pollution in Malaysia is an environmental problem that facing serious problem from a day to another day and until now there is no effective ways to reduce the water pollution level. Pollution occurs when there are impurities in the water such as sediment (suspended solid), nitrate, heavy metal and others. The presence of impurities can affect all living things that rely on river water resources.

Wastewater quality can be defined by physical, chemical, and biological characteristics. Physical parameters include color, odour, temperature, solids (residues), turbidity, oil, and grease. Solids can be further classified into suspended and dissolved solids (size and settle ability) as well as organic (volatile) and inorganic (fixed) fractions. Chemical parameters associated with the organic content of wastewater include the biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), and total oxygen demand (TOD). BOD is a measure of the organics present in the water, determined by measuring the oxygen necessary to biostabilize the organics (the oxygen equivalent of the biodegradable organics present). Inorganic chemical parameters include salinity, hardness, pH, acidity, alkalinity, iron, manganese, chlorides, sulfates, sulfides, heavy metals (mercury, lead, chromium, copper, and zinc), nitrogen (organic, ammonia, nitrite, and nitrate), and phosphorus. Bacteriological parameters include coliforms, fecal coliforms, specific pathogens, and viruses.

A biological filter technology is used to control water pollution by applying the use of microorganisms as agents to treat contaminated water. This method introduced by Shimanto Gawa has been successfully applied in Japan. The biofilter reliance on microorganisms requires an appreciation of ecological concepts which must be considered in biofilter design (Nur Eezani, 2007).

2.2 Water Pollution

There are strategies to propel country's growth trends towards sustainable development which embodies the three pillars which are economic development, social development and environment protection. Realizing the importance to facilitate a coordinated and comprehensive approach in managing natural resources and environment, the Ministry of Natural Resources and Environment (NRE) was formed in 2004. With regards to the water pollution, generally in Malaysia it is caused by point and non-point sources. Point sources comprise sewage treatment plants, manufacturing and agro-based industries as well as animal farms. Non-point sources are made up of diffused sources such as agricultural activities and surface runoffs (National Policy on the Environment, 2002).

According to the study commissioned by ASEAN Secretariat and AusAID presented in the Report on State of Water Resources Management in ASEAN 2005, the total available internal water resources for Malaysia are 630,000 mcm/year. It is estimated for the year 2025, the total demand for sector such as industry, agriculture, irrigation and domestic is 14,504 mcm compared to 1,622 mcm for the current demand.

Rapid development has created gaps in the prevention of pollution and the highly dense population in urban centres has converted rivers into open sewers. Cities are well known for being polluters of aquatic environment with sewage and municipal wastewater, industrial effluent and polluted urban runoff. Similarly, the farming communities pollute the aquatic environment with irrigation returns that contain fertilisers and pesticides, and animal wastes. River water quality is also degraded by sediments from land clearance and solid wastes. Water pollution disrupts water supply services, affects human health and destroys aquatic lives and habitat. The 'Love Our Rivers' campaign was launched in 1993 with the aim of improving awareness among the general public including school children, and the relevant authorities on the need to preserve rivers. The campaign is a joint effort by government agencies, NGOs, private sector and general public. It is carried out through river adoption and river watch programmes, river expeditions, educational talks, river beautification, seminars and the promotion of water conservation through the mass media (Raja Zaharaton, 2004).

2.3 Domestic Wastewater

As the country grows so does the problem of providing sufficient clean water to the population and until about five decades ago, Malaysia's waste disposal system was no different from what is still found in many developing countries. Malaysia's 27 million people generate about six million tons of sewage every year, most of which is treated and released into the rivers. Proper treatment of sewerage is paramount as about 98% of Malaysia's fresh water supply comes from surface water. Raw surface water becomes contaminated as a result of excessive and indiscriminate discharge of wastewater directly from households or factories to drains and into rivers with minimal or no treatment. This impairment of water quality greatly reduces the usability of the water for ordinary purposes or in a worst case scenario creates a hazard to public health through poisoning or the spread of diseases. To combat this, around 8,000 public sewage treatment plants, 500 network pumping stations, 17,000 kilometres of underground sewerage pipes and half a million household septic tanks connected to the sewers. In response to the increasing demand for a better and effective sanitation services, private companies were encouraged by the government to build wastewater management systems (APEC, 2009).

Municipal wastewater is comprised of domestic (or sanitary) wastewater, industrial wastewater, infiltration and inflow into sewer lines, and storm water runoff. Domestic wastewater refers to wastewater discharged from residences and from commercial and institutional facilities (Metcalf and Eddy, Inc. 1991). Domestic water usage, and the resultant wastewater, is affected by climate, community size, density of development, community affluence, dependability and quality of water supply, water conservation requirements or practices, and the extent of metered services. Metcalf and Eddy, Inc. (1991) provide details on the influence of these factors. Additional factors influencing water use include the degree of industrialization, cost of water, and supply pressure (Qasim, 1985). One result of the combined influence of these factors is water use fluctuations. About 60 to 85% of water usage becomes wastewater, with the lower percentages applicable to the semiarid region of the south western United States (Metcalf and Eddy, Inc. 1991).

2.4 Wastewater Characteristic

Municipal wastewater is mainly comprised of water (99.9%) together with relatively small concentrations of suspended and dissolved organic and inorganic solids. Among the organic substances present in sewage are carbohydrates, lignin, fats, soaps, synthetic detergents, proteins and their decomposition products, as well as various natural and synthetic organic chemicals from the process industries. Figure 2.1 shows the typical concentration range of various constituents in untreated domestic wastewater. Depending on the concentrations, wastewater is classified as strong, medium or weak (Clescerl et al., 2007)

		Concentration[a]		
Contaminants	**Unit**	**Low strength**	**Medium strength**	**High strength**
Solids, total (TS)	mg/L	390	720	1230
Dissolved, total (TDS)	mg/L	270	500	860
Fixed	mg/L	160	300	520
Volatile	mg/L	110	200	340
Suspended solids, total (TSS)	mg/L	120	210	400
Fixed	mg/L	25	50	85
Volatile	mg/L	95	160	315
Settleable solids	mL/L	5	10	20
Biochemical oxygen demand, 5-d, 20°C (BOD_5, 20°C)	mg/L	110	190	350
Total organic carbon (TOC)	mg/L	80	140	260
Chemical oxygen demand (COD)	mg/L	250	430	800
Nitrogen (total as N)	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
Phosphorus (total as P)	mg/L	4	7	12
Organic	mg/L	1	2	4
Inorganic	mg/L	3	5	10
Chlorides[b]	mg/L	30	50	90
Sulfate[b]	mg/L	20	30	50
Oil and grease	mg/L	50	90	100
Volatile organic compounds (VOCs)	mg/L	<100	100–400	>400
Total coliform	No./100 mL	10^6–10^8	10^7–10^9	10^7–10^{10}
Fecal coliform	No./100 mL	10^3–10^5	10^4–10^6	10^5–10^8
Cryptosporidum oocysts	No./100 mL	10^{-1}–10^0	10^{-1}–10^1	10^{-1}–10^2
Giardia lamblia cysts	No./100 mL	10^{-1}–10^1	10^{-1}–10^2	10^{-1}–10^3

[a] Low strength is based on an approximate wastewater flowrate of 750 L/capita·d (200 gal/capita·d).
Medium strength is based on an approximate wastewater flowrate of 460 L/capita·d (120 gal/capita·d).
High strength is based on an approximate wastewater flowrate of 240 L/capita·d (60 gal/capita·d).
[b] Values should be increased by amount of constituent present in domestic water supply.
Note: mg/L = g/m^3.

Figure 2.1: Typical composition of untreated domestic wastewater (Source:https://dspace.ist.utl.pt/bitstream/2295/163262/1/IT_Caracterizacao_qualitativa_aguas_residuais_2_.pdf)