THE EFFECTIVENESS OF BIOFILTER AS A TREATMENT FOR DOMESTIC WASTEWATER

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ABSTRACT

Water supports all forms of life and affects our health, lifestyle, and economic well being. Water is also a resource that has many uses, including recreational, transportation, hydroelectric power, domestic, industrial, and commercial uses. Although more than three quarters of the earth's surface is made up of water, only 2.8 percent of the Earth's water is available for human consumption. Water demand in Malaysia has shift to 60% increase from 9543 MLD in 1995 to 15285 MLD in 2010. So, treatment of water is important for human needs and considered as a long term mission for sustainable earth. In the intention to reduce water pollution, treatment for domestic wastewater treatment is done such as biofiltration as one of the alternative. Biofilter is easy to operate, reliable, and a cost-saving system to be implemented. There are many biofilters in studies nowadays but mostly the system fails when been implemented at site although it shows effective results during pilot test. The purpose of this research is to further harness the potential and capability of biofiltration to be used at site to comply with standards of Environmental Quality Act, 1974. Domestic wastewater is produced from kitchens, bathrooms and laundries in residential homes and from various commercial and industrial sources. The location of this study which is cafeteria has effluent discharge that is polluted due to poor wastewater management. This leads to dirty water discharged into Sungai Belat. The biofiltration zone consists of activated carbon, high capacity soils and healthy microbes from mud ball. The parameter that is used is study is based on Environmental Quality Act 1974. The parameters are pH, electric conductivity, turbidity, dissolved oxygen, temperature, salinity, Ammoniacal-Nitrogen, biochemical oxygen demand, chemical oxygen demand, total dissolved solid, total suspended solid, total coliform, E.Coli, and oil & grease.

ABSTRAK

Air merupakan sumber yang amat penting untuk menampung hidupan di bumi ini selain udara, makanan, dan lain-lain. Selain itu, air memberi kesan kepada taraf kesihatan, cara hidup, dan ekonomi. Di anggarkan lebih dari tiga per empat muka bumi ini terdiri daripada air, tetapi hanya 2.8 peratus dari sumber air ini boleh di gunakan oleh manusia untuk kehidupan seharian. Penggunaan air di Malaysia telah meningkat dari 60% dari 9543 MLD pada tahun 1995 kepada 15285 MLD pada tahun 2010. Ini menunjukkan keperluan merawat air yang telah diguna pakai amat penting untuk kelangsungan hidup. Dalam usaha untuk mengurangkan pencemaran air, pelbagai kaedah rawatan air telah di gunakan untuk merawat air kumbahan domestik, termasuklah kaedah biofilter. Biofilter merupakan satu kaedah yang mudah untuk dioperasi, dan menjimatkan kos untuk digunakan. Beberapa kajian dan projek biofilter telah dijalankan tetapi kebanyakan menghadapi masalah di mana biofilter tidak beroperasi dengan efektif di tapak seperti mana di kajian makmal. Kajian biofilter ini di jalankan supaya biofilter boleh di implemen dan beroperasi di tapak dalam usaha untuk meningkatkan kualiti air dengan kos yang lebih murah dan berkesan serta dapat mengikut taraf kebersihan yang telah di tetapkan oleh Standard A dalam Environmental Quality Act 1974. Lokasi tapak untuk kajian adalah di belakang Kolej Kediaman 3 Universiti Malaysia Pahang di mana sumber kumbahan domestik adalah dari cafeteria kolej kediaman itu di mana air kotor dilepaskan ke Sungai Belat. Parameter yang diguna dirujuk dari Environmental Quality Act 1974 yang terdiri daripada pH, daya konduksi elektrik, kekeruhan, oksigen terlarut, suhu, kadar garam terlarut, Ammoniacal-Nitrogen, keperluan oksigen bio-kimia, keperluan oksigen kimia, jumlah pepejal terlarut, jumlah pepejal terapung, jumlah coliform, E.Coli, dan minyak & gris.

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LIST OF ABBREVIATIONS

AN	Ammoniacal-Nitrogen
BOD	Biochemical oxygen demand
BTEX	Benzene,Toluene, Ethylbenzene, and Xylene
CEQ	Council on Environmental Quality
COD	Chemical oxygen demand
CWA	Clean Water Act
DCM	Dichloromethane
DO	Dissolved oxygen
DOE	Department of Environment
EC	Elimination capacity
EEA	European Environment Agency
EFB	Empty Fruit Bunch
EPA	Environmental Protection Agency
EQA	Environmental Quality Act
GEMS	Global Environment Monitoring System
H2SO4	Sulfuric acid
HCL	Hydrochloric acid
HNO3	Nitric acid
IL	Inlet load
IWK	Indah Water Konsortium
KK3	Kolej Kediaman 3
na	Air porosity
NaOH	Sodium hydroxide
MLD	Million liter per day
M	Permissible mass
ppm	Part per million

Q	Flow rate
RDN	Regional District of Nanaimo
RE	Removal efficiency
SS	Suspended solid
STP	Sewerage treatment plant
t	Retention time
TDS	Total dissolved solid
TKN	Total Kjedahl Nitrogen
TN	Total Nitrogen
TPH	Total Petroleum Hydrocarbon
TSS	Total suspended solid
UMP	Universiti Malaysia Pahang
UNEP	United Nations Environment Program
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WMO	World Meteorological Organization

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CHAPTER 1

INTRODUCTION

1.1 General

Water is a resource that has many uses, including recreational, transportation, hydroelectric power, domestic, industrial, and commercial uses. Water also supports all forms of life and affects our health, lifestyle, and economic well being. As individuals, we use water for sanitation, drinking, and many other human needs, and we pay for the public water utilities that provide water. Although more than three quarters of the earth's surface is made up of water, only 2.8 percent of the Earth's water is available for human consumption. (EEA, 1999) Malaysia is facing a major water pollution problem. Water demand is has shift to a whopping 60% increase from 9543 MLD in 1995 to 15285 MLD in 2010. It is estimated water demand will be increasing up to 113% from 20338 MLD by the year 2020. Several parts in Malaysia have faced water shortage due to drought in 1998. So availability of water is reducing day by day. (DOE, 2010)

There are many places where wastewater goes into water body untreated. In some cases, the effluent released come into contact where children downstream might be taking a bath or using the water to drink. The simplest treatment method is boiling. Just bring the water to a boil for at least one minute, and then allow it to cool. But this is not always effective in heavily chemical polluted water supplies. Water borne diseases are any illnesses caused by drinking contaminated water. Diseases can include infection from bacteria (Salmonella), viruses, or by small parasites (Cryptosporida, Giardia, and Toxoplasma). These organisms and viruses cause diseases like cholera, typhoid fever, malaria, botulism, polio, dysentery, giardia, and hepatitis A. One of the first symptoms of these diseases is diarrhea, which cause about three million deaths throughout the world, mainly in India, Africa, and South America, (UNEP/GEMS, 1995).

Because of their size, small communities have traditionally faced the problems of high per capital costs, limited finances and limited operation and maintenance budgets for sewage treatment. Where populations are less dense, the receiving environment is able to cope with lesser level of treatment, often only primary treatment will be provided. However as population increases, these primary treatment systems must be replaced with secondary treatment systems. Simpler systems have been used to service small communities although ever increasing environment standards means that even these areas must eventually install better treatment systems. Biofilter will hopefully overcome the problems of high capital cost and provides better sewage treatment in small communities, (UNEP/GEMS, 1995).

In the intention to reduce water pollution, treatment for domestic wastewater treatment is done such as biofiltration as one of the alternative. Biofilter for wastewater treatment have huge potential for further development as the area of study is studied by only quite a few researchers. Biofilter is easy to operate, reliable, and a cost-saving system to be implemented.

1.2 Problem Statement

Domestic wastewater is produced from kitchens, bathrooms and laundries in residential homes and from various commercial and industrial sources. Storm water is rain that is collected from the roof as well as rainwater that flows over the land. Both wastewater and storm water are predominately discharged into the river or sea, but only wastewater is treated, (EEA, 1999). The location of this study which is cafeteria has effluent discharge that is polluted due to poor wastewater management. This leads to dirty water discharged into Sungai Belat.

Conventional wastewater treatment method maybe used to remove unwanted nutrient and dissolved heavy metal ions from wastewaters. Other method that was available but costly is chemical oxidation and reduction, ion exchange, electrochemical and treatment. However, these high-technology processes have significant disadvantages, including incomplete metal removal, requirements, such as expensive equipment and monitoring systems, high reagent, energy and generation of toxic sludge or other waste products that require disposal, (CWA, 1987). In the other hand, implementing a centralized waste water treatment system would be costly due to construction and maintenance. Considerately, biological method is considered as an economical solution in terms of construction, operation, maintenance, and pollution. Thus, this biofiltration system may be the answer to cleaner and cheaper water source in the near future

There are many biofilters in studies nowadays but mostly the system fails when been implemented at site although it shows effective results during pilot test. The purpose of this research is to further harness the potential and capability of biofiltration to be used at site to comply with standards of Environmental Quality Act, 1974.

The biofiltration zone consists of sponge, activated carbon, high capacity soils, small aggregates, healthy microbes from mud ball, charcoal, and empty fruit bunch. It is hard to get a delicate balance to have the microbes, water, soil and plants working optimally, but when engineered correctly, biofiltration water treatment facilities can naturally and effectively produce clean water.

1.3 Objectives

The objectives of this research are summarized as follows:

1. To evaluate the performance of biofilter system as a treatment system for domestic wastewater.

1.4 Scope of Study

This biofilter consist of a series of filter element which consist of sponge, Empty Fruit Bunch (EFB), mud ball, activated carbon, sand, and charcoal to improve the quality of discharge water from domestic usage at Kolej Kediaman 3 (KK3) of Universiti Malaysia Pahang (UMP).

The scopes of this study are:

1. Evaluation of the capability of biofilter to filter the deposited amount of water produced by the cafeteria.

2. Construction of a biofilter that can filter domestic wastewater and reduce the concentration of its effluent discharge to comply with Standard A and B of the Environmental Quality Act, 1979.

3. Determination of water quality parameters such as turbidity, odor, Suspended Solid (SS), Alkalinity, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), and Dissolved Oxygen (DO).

1.5 Location of Study

Location of study is cafeteria at KK3 and the biofilter is located at a culvert of drainage system behind KK3, Universiti Malaysia Pahang (UMP). The biofilter is designed at a smaller scale to evaluate its effectiveness and durability before it will be constructed at site. Proposed biofilter will be installed at the wastewater output before the effluent meets water body and released to Sungai Belat. Figure 1.1 is UMP from a plan view.

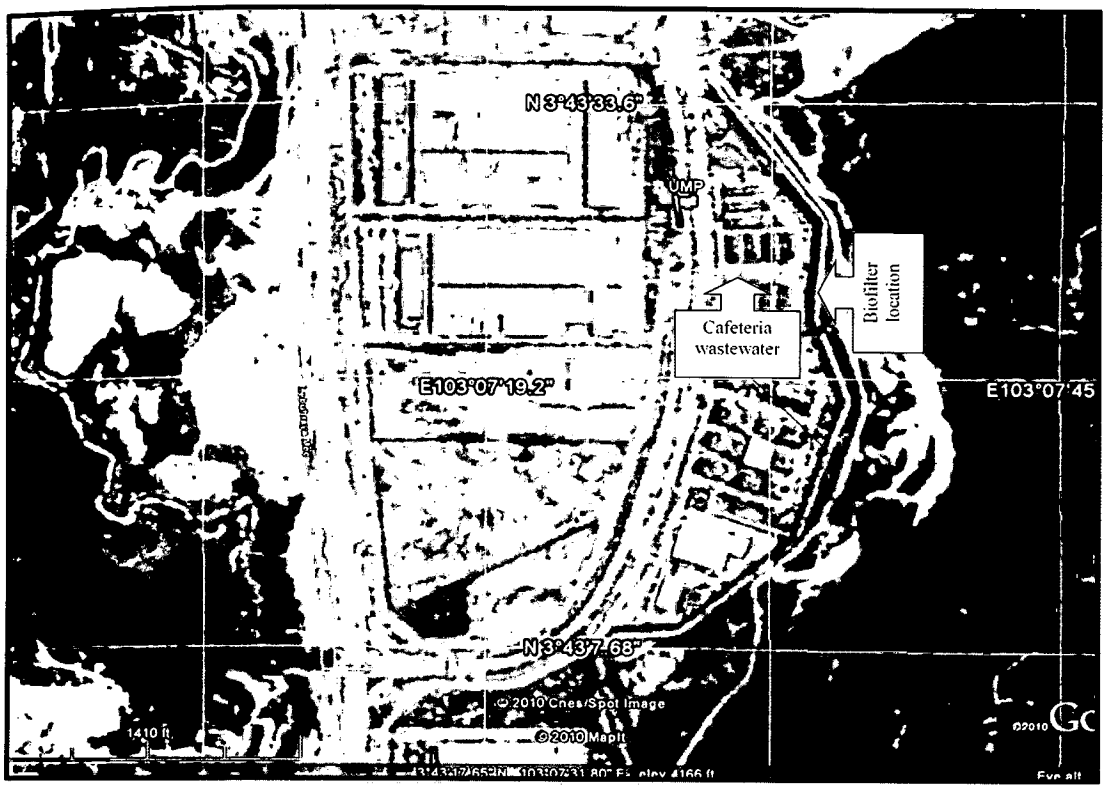

Figure 1.1: Map of UMP and the location of biofilter where the effluent sample is taken.

1.6 Significance of Study

Biofilter studies and research are increasingly popular nowadays as the world is moving environmentally sustainable development technologies. Biofilters has the prospect of an environmental friendly system but most of them lack the capability to be executed at site as the biofilter consist of delicate filtering material that cannot hold up to actual environment force. For this reason, the better design, selection of filtering material, proportion of each material, and ability to tolerate change of flow rate is the design focus of proposed biofilter. A clean end product from the biofilter that complies with the effluent discharge limits of the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 will help reduce the pollution level of rivers in Sungai Belat subsequently Sungai Kuantan.

CHAPTER 2

LITERATURE REVIEW

2.1 General

With two thirds of the earth's surface covered by water and the human body consisting of 75 percent of it, it is evidently clear that water is one of the prime elements responsible for life on earth. Water circulates through the land just as it does through the human body, transporting, dissolving, and replenishing nutrients and organic matter, while carrying away waste material. The population decline of the marine and riparian life, the appearance of green algae in the rivers and the stench and slime that comes as a result of putrefaction in the water, is clear signs of the depth and extent of disruption that has been caused to this intricate ecosystem. Biofilter System will help to reduce these pollutions from entering rivers by filtering wastewater effluent before entering water body, (Mackenzie and David, 2008).

Thus, the study on biofilter is an important step to find alternatives for reducing the pollution of rivers subsequently, the environment. The chapter will review and reveal the important in formations regarding the evaluation of biofilter, water pollution problems, importance of the system, and others.

2.2 Water Pollution

Water pollution refers to harmful substances released into surface or ground water, either directly or indirectly. Hydrologic impacts refer to changes in surface (streams and rivers) and groundwater flows, (Mackenzie and David, 2008).

The sight and smell of grossly polluted waterways provided some of the original impetus to the environmental movement in the 1970s. Nearly a century before that, the dangers of polluted water to human health drove what became known as the "sanitary revolution" in Europeand the United States, emphasizing clean water supplies and sewer systems in cities. Today, despite progress in cleaning up waterways in some areas, water pollution remains a serious global problem, with impacts on the health of freshwater ecosystems and the human communities that rely on them for water supply, (Mark et al., 1998).

Water pollution spans a wide range of chemical, physical, and microbial factors, but over the years the balance of major pollutants has shifted markedly in most industrialized countries the summary of major pollution sources and their effects can be seen from Table 2.1. One hundred years ago, the main water contamination problems were fecal and organic pollution from untreated human waste and the byproducts of early industries. Through improved treatment and disposal, most industrialized countries have greatly reduced the effects of these pollutants, with consequent improvements in water quality. Pollution laws and pollution control technologies have succeeded especially well in cutting emissions from concentrated "point sources" like factories and sewage treatment plants. For example, from 1972 to 1992 the amount of sewage treated at wastewater treatment plants in the United States increased by 30 percent, yet the organic pollution (measured as the Biological Oxygen Demand) from these plants dropped 36 percent, (CEQ, 1995).

Table 2.1: Common Water Pollutants and their Effects, (Sources: Taylor and Smith 1997; Shiklomanov 1997; UNEP/GEMS 1995).

POLLUTANT	PRIMARY SOURCE	EFFECT
Organic matter	Industrial wastewater and domestic sewage.	Depletes oxygen from the water column as it decomposes, stressing or suffocating aquatic life
Excess nutrients (nitrates, phosphorous)	Runoff from agricultural lands and urban areas.	Overstimulates growth of algae (a process called eutrophication), which then decomposes, robbing water of oxygen, and harming aquatic life. High levels of nitrates in drinking water lead to illness in humans.
Heavy metals	Industries and mining sites.	Persists in freshwater environments, for long periods. Accumulates in the tissues of fish and shellfish. Toxic to both acquatic organisms and humans who eat them.
Microbial contaminants (e.g., cryptospori-dium, cholera, and other bacteria, amoebae, etc.)	Domestic sewage, cattle, natural sources.	Spreads infectious diseases through contaminated water supplies, causing millions of cases of diarrheal diseases and intestinal parasites, and providing one of the principal causes of childhood mortality in the developing world.
Toxic organic compounds (oil, pesticides, some plastics, industrial chemicals)	Wide variety of sources, from industrial sites, to automobiles, to farmers, and home gardeners.	Displays a range of toxic effects in aquatic fauna and humans, from mild immune suppression, to acute poisoning, or reproductive failure.
Dissolved salts (salinization)	Leached from alkaline soils by over irrigation, or drawn into coastal aquifers from over drafting of groundwater.	Leads to salt build-up in soils, which kills crops or cuts yields. Renders freshwater supplies undrinkable.
Acid precipitation or acidic runoff	Deposition of sulfate particles, mostly from coal combustion. Acid runoff from mine tailings and sites.	Acidifies lakes and streams, which harms or kills aquatic organisms and leaches heavy metals such as aluminum from soils into water bodies.
Silt and suspended particles	Soil erosion and construction activities in watersheds.	Reduces water quality for drinking and recreation and degrades aquatic habitats by mothering them with silt, disrupting spawning, and interfering with feeding.
Thermal pollution	Fragmentation of rivers by dams and reservoirs, slowing water and allowing it to warm.	Affects oxygen levels and decomposition rate of organic matter in the water column. May shift the species composition of a river or lake.

Unfortunately, a new suite of contaminants from intensive agriculture and development activities in watersheds has kept the cleanup from being complete. In general, national water clean-up programs have not been effective in reducing "nonpoint" pollutants such as nutrients, sediments, and toxics that come in runoff from agriculture, urban and suburban storm water, mining, and oil and gas operations, (NRC 1992; EEA 1999).

Meanwhile, in most developing countries, the problems of traditional pollution sources like sewage and new pollutants like pesticides have combined to heavily degrade water quality, particularly near urban industrial centers and intensive agricultural areas, (Shiklomanov 1997; UNEP/GEMS 1995). An estimated 90 percent of wastewater in developing countries is still discharged directly to rivers and streams without any waste processing treatment, (WMO 1997).

The level of nutrients such as nitrates and phosphorous in freshwater ecosystems is a problem worldwide, (Shiklomanov 1997). In most cases, the major cause of these contaminants is the increased use of manure and manufactured fertilizer in global agriculture. In the United States, for example, agriculture is the single greatest source of pollution degrading the quality of surface waters like rivers and lakes, with croplands alone accounting for nearly 40 percent of the nitrogen pollution and 30 percent of the phosphorous as shown in Table 2.2, (EPA, 2004).