# THE EFFECT OF DIFFERENT QUANTITY OF FILTERING MATERIALS TO THE PERFORMANCE OF BIOFILTER SYSTEM FOR WASTEWATER TREATMENT

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## ABSTRACT

Nowadays, clean water resources are reduced due to water pollution problems. Pollution carried by the wastewater is considered as one of the contributors to the water pollution problems. One of the ways to reduce water pollution is to treat wastewater at the source points. This can be accomplished by constructing a biofilter system at the point sources of polluted water before being discharged into rivers. Biofilter system consists of several compartments of filtration media, which is located at Kolej Kediaman 3, UMP Gambang. This research focused on the performance of biofilter for water quality improvement before and after passing through the filtration system and the effect of increasing the quantity of filtration materials. This system utilizes sponge, sand and granite, EM mudball, activated carbon, charcoal and empty palm oil fruit bunch as its filtration media for the removal of constituents in water. Results of these experiments were analyzed by evaluating the water quality parameters such as Turbidity, SS, AN, BOD and COD in comparison to Standard A and Standard B Environmental Quality Standards Act (1974) and in terms of their percentages of removal. The results indicated that all effluent discharge of parameters pH, temperature, COD, BOD, and TSS are complying Standard B only. However, the performance of biofilter in terms of BOD, COD, and TSS removal is excellent where the removal efficiency range from 0.97% to 4.90%, 2.63% to 51.63% and 17.05% to 67.31% respectively. The study also found out that the concentration of pollutants after the treatment is decrease as the quantity of filtering materials increased and the percentages of removal increase as the quantity of filtering materials increased.

# ABSTRAK

Pada masa ini, sumber air bersih berkurang kerana masalah pencemaran air. Pencemaran yang dibawa oleh air sisa dianggap sebagai salah satu penyumbang terhadap masalah pencemaran air. Salah satu cara untuk mengurangkan pencemaran air adalah untuk memproses air sisa pada titik-titik sumber. Hal ini dapat dicapai dengan membina suatu sistem biofilter pada titik sumber air tercemar sebelum dibuang ke sungai. Sistem Biofilter terdiri daripada beberapa petak media filtrasi, yang terletak di Kolej Kediaman 3, UMP Gambang. Penelitian ini difokuskan pada prestasi biofilter untuk peningkatan kualiti air sebelum dan selepas melepasi sistem filtrasi dan kesan meningkatkan kuantiti bahan filtrasi. Sistem ini menggunakan spans, pasir dan batu kelikir, EM Mudball, karbon aktif, arang dan tandan buah buah sawit kosong sebagai media penapisan untuk menghilangkan kotoran dalam air. Hasil dari percubaan ini dianalisis dengan menilai parameter kualiti air seperti Kekeruhan, SS, AN, BOD dan COD dibanding dengan Standard A dan Standard B Akta Kualiti Alam Sekitar (1974) dan dalam hal peratusan pengurangan. Keputusan kajian menunjukkan bahawa pembuangan sisa cair bagi semua parameter seperti pH, suhu, COD, BOD, dan SS memenuhi Standard B sahaja. Namun, prestasi biofilter dalam hal pengurangan kandungan BOD, COD, dan SS yang sangat baik di mana julat kecekapan penyisihan masing-masing dari 0.97% kepada 4.90%, 2.63% kepada 51.63% dan 17.05% kepada 67.31%. Penyelidikan ini juga mendapati bahawa kepekatan polutan selepas rawatan berkurang dengan jumlah penapisan bahan meningkat dan peratusan pengurangan meningkat dengan jumlah kuantiti bahan penapisan meningkat.

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# CHAPTER 1

# INTRODUCTION

## 1.1 General

Water is much more than just a basic human need. It is an essential, irreplaceable element to ensuring the continuance of life. The demand of clean water increases as population grows. Human have a right to obtain safe water but the quality of water become worse since runoff water from streets, buildings and sidewalks carries many pollutants including: oil, metal, sediment, road salt, bacteria, chemicals, pet droppings and litter. Cars, refineries, power plants and other contaminant emitting sources send pollutants into the air that eventually settle in water.

Some businesses and industries do not dispose of waste properly and dump pollutants directly into waterways. Also, when cities are built, the natural watershed is changed. Wetlands are often filled in with dirt and concrete and natural streams are redirected by man-made channels. This takes away nature's ability to filter out contaminants before they end up in larger bodies of water.

To preserve the good quality of water resources, it is essential to control the water pollution in river by treating the waste water. Investigate the feasibility of the

biofilter system as pollutant removal before contaminants end up in river is important to identification of filtering materials and flow used. This is because both provide the basic data required for the design of biofilter system based on MASMA. An effective biofilter system is important to cater the various types and size of pollutants. (Norhan *et al.*, 2008a).

## 1.2 Problem Statement

Almost all the activities in our life require water. In other words, water is a basic need that is very important. At one time, sources of clean water available from rivers and lake. Water was derived from two main sources; the water can be obtained from spring water, or most commonly known as earth water. But unfortunate water source at present is very difficult to be obtained because of contamination. If contamination continuously occurs, more difficult to us continue to use water directly as before, contrarily now the water should be treated first before safe to drink.

Development and industrial activity, coupled by the increase in the world population has greatly affected our river system. The changing of human lifestyle has introduced many chemicals in basic human requirement like foods, water and air. Besides, industrial processes coupled by various domestic activities often produce discharges that are harmful and toxic to the environment. Water that has been contaminated will change its physical, chemical and biological properties. The water does not become clearer as the original due to the presence of waste such as waste from cafeteria, the presence of organic materials that result from the decay of plants.

Contaminated water is very dangerous not only to humans but also to ecosystems. This contaminated water if want to be used, should be treated first to ensure the water is safe to use. However, while these chemicals purify water, they also produce a lot of adverse impacts upon the water system. In a typical wastewater treatment

process, optimum dosing of the appropriate chemicals is added into the water. When there is an insufficient dosing of chemicals this may result in wastewater being untreated and at the same time, enhance pollution in water thus contribute to the poor surface water quality.

One of the ways to reduce pollution in surface waters is to treat wastewater at the source point. This can be accomplished by constructing a biofilter system at the source point to treat water prior to discharge into the river. Biofilter system is suitable method by filtering waste water to make sure the water is suitable to dispose into the river. Biofilter is one of the most important separation processes that can be employed to remove organic pollutants from air, water, and wastewater.

## 1.3 Study Objectives

The objectives of the research are:

1. To evaluate the performances of biofilter system for water quality improvement.

2. To investigate the effect of quantity variables on filtering materials to the performance of biofilter system.

## 1.4 Scope of Study

This biofilter system consists of several filtering media such as sponge, sand & granite, Effective Microorganism (EM) mudball, activated carbon, empty fruit bunch (EFB) from palm oil, and charcoal. This study is concern on different quantities of

filtering materials use to improve water quality discharge from cafeteria and to evaluate the performance of biofilter system.

The scopes of this study are;

i. Conducted laboratory test to determine the effectiveness of biofilter system for improving the quality of water.
ii. Water quality testing for parameters tested at Enviromental Laboratory, FKASA, Universiti Malaysia Pahang, Gambang.
iii. To design biofilter tank specification in order to provide effective treatment for wastewater.
iv. Determination of filtering materials quantity for each increment.
v. Determination of water quality parameters at influent and effluent point of the biofilter system.
vi. The effect of different quantity materials to the performance of biofilter.
vii. The maintenance of biofilter system to ensure smooth filtering water flow.

## 1.5 Location of study

The location of study is at Kolej Kediaman 3 (KK3), Universiti Malaysia Pahang (UMP), Gambang, Pahang Darul Makmur. Biofilter system installed at an open drainage system at KK3 for the treatment of wastewater flowing from the nearby drainage system of cafeteria, hostel and office building. The wastewater is expected to be treated through a biofiltration system as it flows into the biofilter tanks before it is being discharged into the river. The river in this study is the tributaries of the Sungai Belat, as shown in Figure 1.1.

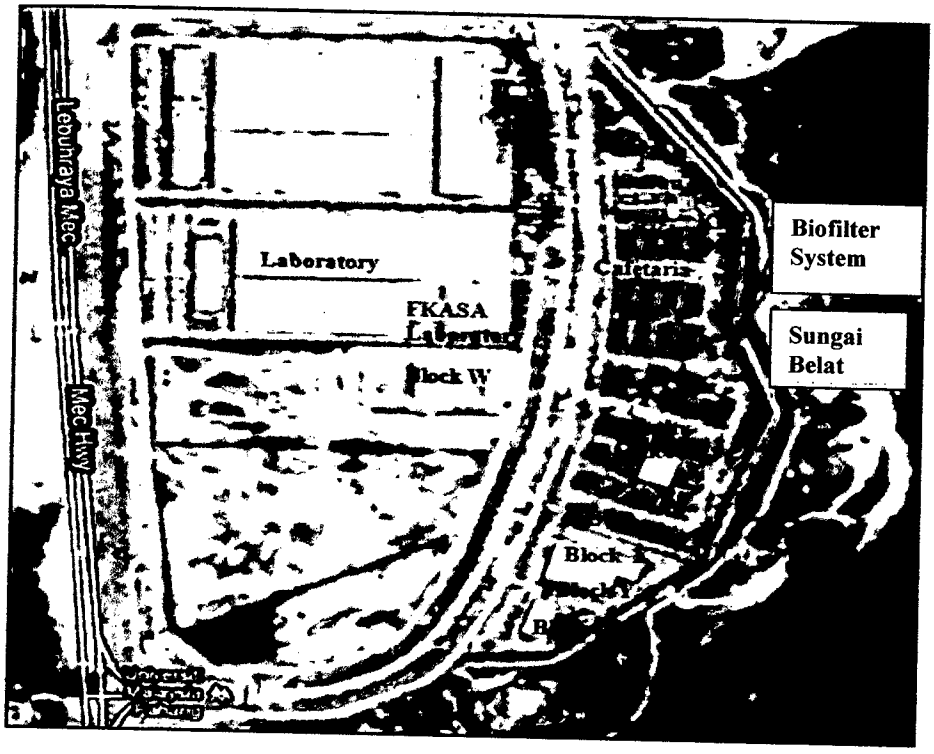


**Figure 1.1**: Location of Study Area

## 1.6 Significance of Study

Biofilter system has a good potential in removing water pollutants. A single pass aerobic biofilter, it is designed for efficient treatment of domestic and municipal sewage wastewater. This filtration technology utilizes a medium with optimum physical properties for microbial attachment, water retention time and ease of ventilation. This system operates independent of terrain or soil and drainage conditions, and has a small space requirement. It can be retrofit to repair failed systems. The filter material can be removed and replaced if needed. Nowadays, there are certain types of biofilter product in market. However, there is only certain biofilter system that is taking into account the exact number of quantities of filtering materials to evaluate the effectiveness of biofilter system. Recently, the number this kind of technology is still less and most of it are only concentrated in removing pollutants from storm water event or rainfall. There are still

lacks of biofilter systems that include the function of removing small size pollutants and most of it does not consider variables of filtering material quantity. Hence, a development of biofilter system that consists of different quantity filtering material that will function in removing pollutants either it small or large and it is essential in order to produce an effective water pollution treatment system. Moreover, there only a few available products in Malaysia compared to overseas. The study on Biofilter system in Malaysia is significant in order to improve water quality before it entering the larger bodies of water such as river or sea.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 General

Water is a fundamental for all known form of life. It is composed of hydrogen and oxygen which is important chemical substance for people and the environment. It is a liquid at ambient conditions, but it often co-exists on Earth with its solid state, ice, and gaseous state, water vapor or steam. Water is one of the most important commodities which have been exploited than other resource and most of the water on this planet is stored in oceans and ice caps which is difficult to be recovered for our diverse needs. Water on Earth moves continually through a cycle of evapotranspiration (evaporation and transpiration), precipitation and runoff, commonly the water will flow into the river and then goes to sea. Water is continuously purified by this cycle, yet pollution of water has emerged as one of the most significant environmental problems of the recent times. Pollution in this source of water will give a huge impact to the world where it would harms natural environment and human health.

Rain water helpful to fulfilled this resource needs where it gets deposited in surface and ground water resources. The quantity of this utilizable water is very much limited on the earth despite of water is continuously purified by evaporation and

precipitation, yet pollution of water has become as one of the most significant environmental problems of the recent times. The properties of water which is called unique make it universal solvent and a renewable resource. It is also make it a substance which by virtue of these properties has got a much greater tendency to get polluted. Water can be regarded polluted when it gets changed in its quality or composition either naturally or as a result of human activities so as to become less suitable for drinking, domestic, agricultural, industrial, wildlife, recreational and other uses for which it would have been otherwise suitable in its natural or unmodified state (Goel, 2006).

Biofilter system is a water treatment device that can be used to improve water quality and at the same time reduce the water pollution by treating the water after the filtration system. It will reduce the water pollution before entering a river or the larger water bodies. In this filtration system, the types of filtering material and the quantity is an important criterion that should be taken into account to obtain an effective result of water treatment.

The aims of this study are, thus, to evaluate the performances of biofilter system for water quality improvement and investigate the effect of quantity variables on filtering materials to the performance of biofilter system. In the following articles the related literature are briefly presented. This chapter is mainly divided into several parts. The first part contains the information about water pollution problems and the others will discuss about biofilter system in terms of its types, design criteria and literature of previous studies on the role of biofilter system in reducing water pollutions.

## 2.2 Water Pollution

Water is one of the most essential resources for everything on our planet to grow and prosper. Over 70% of Earth surface comprising water and most of the water is stored in oceans and ice caps. Our demand for water is diverse and difficult to be

recovered since the utilizable water or rain water is very much limited on the earth. Water is continuously purified following evaporation, transpiration and precipitation process but human disregard the facts of water pollution effects by polluting rivers, lakes, and oceans.

Water sustains life for humans, animals and plants. People need water for basic everyday activities for instance drinking and cooking. Yet water is also play an important role in human life for the fuelling of industry, agriculture, and the nature of national economies. Nevertheless, the supply of freshwater available to humanity is decrease. Many causes of this problem, one of the main is the polluting of many freshwater resources. In some countries lakes and rivers have become polluted with an assortment of waste, including untreated or partially treated municipal sewage, toxic industrial effluents, harmful chemicals, and ground waters from agricultural activities. Polluted water supplies not only limit water availability but also put millions at risk of water-related diseases. Peter Gleick estimated in 1996 that about 25 liters per day (L/d) are needed for basic human consumption, cooking, washing, bathing and an additional 25 L/d are needed for sanitation. This means that about 50 liters per capita daily (Lpcd) are required to maintain minimum domestic needs for human health and well-being, excluding water for food production of energy. At that time, hundreds of millions of the poorest people on Earth lacked even this minimum (Gleick, 1996).

Water pollution can come from two different sources either point source pollution or non-point source pollution. Point source pollution comes from a single source, where contaminants enter waterway through a discrete conveyance such as pipe. Domestic waste water is one of the sources instead of a factory or city storm drain. While, nonpoint-source pollution comes from many pollution and contaminants gathered from a large area. The contaminant does not originate from a single discrete source. Nutrient runoff in storm water from sheet flow over an agricultural field or a forest is also cited as examples of nonpoint-source pollution.

Many causes of pollution including sewage and fertilizers contain nutrients such as nitrates and phosphates. In excess levels, nutrients over stimulate the growth of aquatic plants and algae. Excessive growth of these types of organisms consequently clogs our waterways, make pumping of water facilities difficult, and use up dissolved oxygen as they decompose, and block light to deeper waters. The growing need to preserve and restore the physical, chemical and biological integrity of rivers and other water bodies is implicit in several ongoing studies (Merwe *et al.,* 1993).

The development of irrigation in intensive agricultural areas can have important implications for water quality because of the changes in physical and chemical properties and aquatic life. Application of water for crop production in semi-arid areas has been attributed to increased evapotranspiration, with a potential for accumulation of soluble salts within the soil. Where rivers draining irrigated land receive water highly charged in soluble salt, marked changes in water quality may result. Nitrogenous fertilizers are generally associated with the NO3 ion, either directly or as a result of mineralization and nitrification, and this ion is readily leached through the catchment system to watercourses.

Sewage and other effluents are rich in decomposable organic material, cause primary organic pollution. As stated by Marshall (1997), organic wastes mineralize in the receiving water bodies and the resulting nutritive elements stimulate plant production, leading to eutrophication, an aging process that slowly fills in the water body with sediment and organic matter. In this situation, the biomass increases considerably and goes beyond the assimilation limit by herbivores. The excessive production of organic matters leads to the build up of sludge and the mineralization process consumes all dissolved oxygen from the water column, which causes fish kills.

When these sediments enter various bodies of water, fish respiration becomes impaired, plant productivity and water depth become reduced, and aquatic organisms and their environments become suffocated. Pollution in the form of organic material enters waterways in many different forms as sewage, as leaves and grass clippings, or as

runoff from livestock feedlots and pastures. When natural bacteria and protozoan in the water break down this organic material, they begin to use up the oxygen dissolved in the water. Many types of fish and bottom-dwelling animals cannot survive when levels of dissolved oxygen drop below two to five parts per million. When this occurs, it kills aquatic organisms in large numbers which leads to disruptions in the food chain. The relatively high temperatures in tropical countries accelerate this process.

Gowers (1980) suggest that drainage water passing under grassland contains less $NO_3N$ than from under arable soil. Drainage water from a grassland section analyzed separately showed average concentrations of 22 and 4 mg/l $NO_3$-N, respectively. Therefore, the composition of the water entering a watercourse from the drains will depend on the proportions of arable and grassland soils or buffer zones with natural vegetation.

### 2.2.1 Stormwater Pollutants

Stormwater is a term used to describe water that originates during precipitation events. It may also be used to apply to water that originates with snowmelt or runoff water from overwatering that enters the stormwater system. When, stormwater does not soak into the ground it will becomes surface runoff, which either flows into surface waterways or is channeled into storm sewers. Stormwater pollution is the untreated contaminated water that drains into natural waterways from land uses within an urban catchment. The stormwater runoff can cause hydrological changes in the catchment as well as environmental, social and economic losses (Joliffe, 1995).

Stormwater is of concern for two main issues one related to the volume and timing of runoff water like flood control and water supplies and the other related to potential contaminants that the water is carrying water pollution. Polluted runoff occurred during precipitation events, where pollutants' entering surface waters and it is known as nonpoint source pollution. Water runoff makes it way to a larger water bodies

like river, lake or ocean when it is raining. Human activities affect the large quantities of pollutants and harm these receiving waters. Urban stormwater runoff has been cited as the largest non-point source of pollution to receiving waters, leading to increased degradation of downstream coastal and stream environments (Parker *et al.*, 2000).

Paved and impervious surfaces in urban development are to rural catchments increases surface runoff that is discharged more quickly to the receiving water. Many of the water pollution problems in urban areas are due, in large part, to pollutants that are washed off from land by storms. The stormwater runoff from urbanized lands can change the health of water bodies, recreation and aesthetics, uncontrollably algae growth and impact on aquatic habitats. Contributions to water quality impairment from point sources such as industrial effluent, domestic effluent and sewage treatment plants (STP) effluent can be equal to or even greater than that of stormwater. Pollutant loads discharged through point sources are relatively simple to quantify because the point of entry into the waterways is fixed, and the flow rates and concentrations are generally known. Releases are licensed and pollution must remain within license restrictions. On the other hand, stormwater pollution generally has no fixed point of origin, and the flow rates are not as well documented. In addition, diffuse source loads are more temporally and spatially variable than are point source loads because they occur only as a catchment responds to rainfall events. Furthermore, pollution from diffuse sources such as stormwater runoff is more difficult to monitor and control (Bakri *et al.*, 2008).

## 2.3 Wastewater

Wastewater can be defined as the flow of used water discharged from homes, businesses, industries, commercial activities and institutions which is directed to treatment plants by a carefully designed and engineered network of pipes. This wastewater is further categorized and defined according to its sources of origin. The term domestic wastewater refers to flows discharged principally from residential