STUDY ON DOMESTIC WASTEWATER TREATED USING MODIFIED RICE HUSK SEQUENCES SLOW SAND FILTER (MRHSSSF)

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ABSTRACT

Malaysia is facing river pollution which mainly cause by domestic wastewater. On the other hand, rice husk as the by-product from rice mill created disposal and air pollution problem. Rice husk are believed can remove the water pollutants. The aim of this study is to design a compacted slow sand filter which called Modified Rice Husk Sequence Slow Sand Filter (MRHSSSF) as well as to determine the effectiveness of MRHSSSF in wastewater treatment. The optimum retention time of the system also was determined in this study. MRHSSSF is a system that comprised of 3 aerators, sand and rice husk integrated filter bed (0.15-0.3mm sand size - 0.075-0.15mm activated rice husk size- 0.6-1.18mm sand size) where rice husk was soaked in 0.5 mole acid sulphuric for 20 minutes. In this study, MRHSSSF was used to treat the domestic wastewater in 8 days duration. Based on the result and analysis, the highest percentages of removal achieved by MRHSSSF in this study for turbidity, TSS, BOD, COD, E.coli, oil and grease, Iron (Fe), Lead (Pb), Zinc (Zn), TDS, Total coliform, are 98.08%, 100%, 100%, 96.12%, 100%, 97.59%, 100%, 100%, 61.19%, 50.17% and 22.79% respectively. The optimum retention time for the system is 3 hours since most parameters show good mean result. In the conclusion, MRHSSSF is a very cost effective compacted wastewater treatment system.

ABSTRAK

Malaysia menghadapi pencemaran sungai yang kebanyakannya disebabkan oleh air sisa domestik. Sebaliknya, sekam padi sebagai sisa produk dari kilang beras menyebabkan masalah pelupusan dan pencemaran udara. Sekam padi dipercayai boleh mengurangkan pencemar air. Tujuan kajian ini adalah untuk mereka bentuk sebuah penapis pasir perlahan yang dipadatkan iaitu "Modified Rice Husk Sequence Slow Sand Filter" (MRHSSSF) serta untuk menentukan keberkesanan MRHSSSF dalam rawatan air sisa. Masa tahanan optimum sistem tersebut juga ditentukan dalam kajian ini. MRHSSSF adalah satu sistem yang terdiri daripada 3 biji alat pengudara, lapisan penapis pasir yang bersepadu dengan sekam (0.15-0.3 mm saiz pasir- 0.075-0.15mm saizsekam padi yang diaktifkan- 0.6-1.18mm saiz pasir) di mana sekam padi telah direndam dalam 0.5 molar sulfurik asid selama 20 minit. Dalam kajian ini, MRHSSSF telah digunakan untuk merawat air sisa domestik dalam tempoh 8 hari. Berdasarkan keputusan analisis, peratusan penyingkiran tertinggi yang dicapai oleh MRHSSSF dalam kajian ini untuk kekeruhan, TSS, BOD, COD, E.coli, minyak dan gris, Besi (Fe), Plumbum (Pb), Zink (Zn), TDS, Total koliform masing-masing adalah 98.08%, 100%, 100%, 96.12%, 100%, 97,59%, 100%, 100%, 61.19%, 50.17% dan 22.79%. Masa tahanan optimum bagi sistem ini adalah 3 jam memandangkan keseluruhan parameter menunjukkan keputusan yang baik. Kesimpulannya, MRHSSSF merupakan sebuah sistem rawatan air sisa domestic yang kos efektif.

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Al	Aluminium
Ca	Cadmiun
CO_2	Carbon dioxide
Cu	Copper
Fe	Iron
H_2S	Hydrogen sulphide
Mn	Manganese
O_2	Oxygen
Pb	Lead
Zn	Zinc

LIST OF ABBREVIATIONS

AAS	Atomic absorption spectrometer
BOD	Biological oxygen demand
COD	Chemical oxygen demand
DOE	Department of environment
E.coli	Escherichia.coli
EPA	Environmental protection agency
KK3	Kolej Kediaman 3
MRHSSSF	Modified rice husk sequences slow sand filter
MPN	Most probable number
TDS	Total dissolved solids
TSS	Total suspended solids
UV	Ultra violet

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Environment is the combination of the life-being and nonlife-being. The examples of life-being are plant, animal, man, microorganism and etc while the nonlife-being are sun, wind, water, soil and etc. Therefore, water is one of the important elements in the environment. Water is the source of the life. This is because all the life-being in this earth needs water to survive.

Nowadays, the world is facing water crisis. The percentages of the clean water in the earth are decreasing year by year. One of the factors of water crisis is water pollution. There are many factors that contribute to the water pollution and one of the factors is domestic wastewater. There are many microorganism contain in the domestic wastewater. Some microorganisms are pathogen which can cause disease to human. Besides that, high concentration of microorganism in the water make the water unsafe to use for daily purpose (Davis and Cornwell,1998) So, in order to reduce the effect of domestic wastewater to the water resources there is a need to do wastewater treatment.

There are many types of wastewater treatment. In Malaysia, the wastewater treatment method that normal practiced in Malaysia is conventional wastewater treatment. Basically, it involve three levels: removing of large object and adding the chemical substances to remove suspended and dissolved solids, removing organic and inorganic substances by chemical and biological process, remove the balance substances form second level by filtration or microscreens (Metcalf and Eddy, 2003). Conventional

treatment plant is not environmental friendly because there is adding of chemical substances into the treatment process.

There are many alternative methods to remove the contaminants from the domestic wastewater such as ion-exchanger, active carbon, rapid sand filter and etc. Many researchers agree that adsorption method by using activated carbon in the wastewater treatment is the most effective method to remove the contaminants (Gupta et al.,2006). However, the process and material of activated carbon is expensive. Therefore, many studies are done to search for the alternative material for the absorbent which is natural, cheap and abundant in the market. Agricultural waste is one type of the potential materials that can be use as the absorbent. Coconut shell, peanut shells, maize comb are the examples of the agricultural waste. Rice husk which is also one type of the agricultural waste has high potential to use as absorbent in the water treatment. It is proven in many studies that rice husk use to remove the dye and heavy metal in polluted water (Malik, 2003; Feng et al.,2004).

Aeration is a process that can improve the dissolved oxygen rate in the water and remove the undesirable gases in the water. It is important in water treatment. On the other hand, slow sand filter is a filtration process in conventional water treatment system. It is simple and effective. Either absorbent, aeration or slow sand filter is independent process, integration and innovation for that particular process into one sequence bath treatment are possible with the aim to reduce the consumption of cost and space. Slow sand filter as a kind water treatment system that carry many treatment process such as physical, chemical, biological in one single unit is the ideal treatment system that can be modified and integrated become a new system which is low cost and effective in the wastewater treatment which the treated effluent meet the standard wastewater quality.

1.2 PROBLEM STATEMENT

Nowadays, river pollution is the serious issue happened in Malaysia. The factors that cause the river pollution are the discharge of untreated domestic and industrial wastewater to the river, solid waste dumping activities, construction, mining activities

and etc. The river polluted by domestic wastewater normally containing high suspended organic materials and it make the polluted river become the breeding site for the pathogen such as E.coli and this make water borne diseases become a public health issue in Malaysia. Consumption of unsafe water and poor sanitary system is the main factor of waterborne diseases, this problem normally happen in the rural area in Malaysia. According to the statistic showed from the Ministry of Health Malaysia in 2006 (Ministry of Health Malaysia, 2010), there is a decrease of waterborne diseases from 1998-2006 due to clean water consumption. It showed that drinking safe water is the best way to avoid from waterborne disease. In house water treatment is choice to ensure the rural area resident to have a safe water to drink. However, due to the complex operation and the financial problem, rural area resident unable to install in house water treatment.

On the other hand, rice husk which is one type of the agricultural waste will bring a lot of environmental problem due to the improper disposal of the rice husk. According to Tarley and Arruda (2004), it is estimated that 12 million tons of rice husk are produced in Brazil local mill per year. Rice husk can be use as a low class of fuel but it cause a air pollution (Bishnoi,2003).

Slow sand filter is a simple and effective water treatment system. It is widely been used in the world. However, slow sand filter need to use up a large area of land for its installation. Besides that, the effectiveness of slow sand filter affected by high turbidity of raw water, low oxygen rate and climate change. Nowadays, the installation cost of slow sand filter is higher due to the increase price of the sand.

1.3 OBJECTIVES

The objectives of the study are:

i) to design a compacted slow sand filter which is Modified Rice Husk Sequences Slow Sand Filter (MRHSSSF).

ii) to determine the effectiveness of Modified Rice Husk Sequences Slow Sand Filter in domestic wastewater treatment.

iii) to determine the optimum retention time of Modified Rice Husk Sequences Slow Sand Filter

1.4 SCOPE OF STUDY

In this study, the source of the wastewater was the domestic wastewater took from the drain outlet near the Kolej Kediaman 3 (kk3) and café of University of Malaysia Pahang, Gambang campus. Modified rice husk sequences slow sand filter is a slow sand filter with activated rice husk as carbon source and sand for the filter bed. Besides that, aeration system have been provided in the Modified rice husk sequence slow sand filter. In this research, the effectiveness of modified rice husk sequences slow sand filter in the domestic wastewater treatment was determined by examined the domestic wastewater quality based on the Sewerage and Industrial Effluents Standard Malaysia and Interim National Water Quality Standard For Malaysia. The suitability of activated rice husk as the filter bed of the system also was investigated based on the effectiveness of the system. The tested parameter are pH, temperature, turbidity, BOD, COD, TSS, Total coliform, E.coli, oil and grease, Iron (Fe), Lead (Pb), Zinc (Zn).

1.5 SIGNIFICANCE OF STUDY

The success of modified rice husk sequences slow sand filter (MRHSSSF) can bring a lot of benefit to the society and environment. The installation of MRHSSSF at the point of discharge for sewerage or domestic wastewater can reduce the effect of contaminants to the river and water sources. This is because most of the contaminants such as organic materials, heavy metals and pathogens can be remove through MRHSSSF. Therefore, river are clean from pollutant and the chance of river become

breeding site of pathogen is reduce hence it can reduce the risk for the rural residents expose to water borne diseases. Besides that, when the river are clean from heavy metals and other toxic materials, the life of the aquatic organism and plant can be ensured. It also can avoid the transfer of toxic materials and heavy metal which accumulated on the aquatic life such as fishes to human beings through food chain. This can reduce the risk of public who consume the seafood get serious health problem which related to heavy metal poisoning.

MRHSSSF is a type of system which is more economical compare to conventional slow sand filter. This is because some depth of the sand layer in the conventional slow sand filter was replaced with rice husk which is abundant in local rice mill. Due to the price increasing of the sand, the materials cost for conventional slow sand filter are increased, the use of the agricultural waste which is rice husk as the filter bed in MRHSSSF make the system cheaper than the conventional slow sand filter. This system not only can reduce the agricultural waste in the market but also creating the value for the rice husk. Moreover, the efficiency improvement of the MRHSSSF caused it less land consumption compare to the installation of conventional slow sand filter. This is because MRHSSSF can have the same performance with conventional slow sand filter although the size of MRHSSSF is less than conventional slow sand filter.

MRHSSSF also can be modified as compacted domestic wastewater treatment system. The low cost, simple operation and less maintenance of MRHSSSF can be a good choice of domestic wastewater system for the residents in rural area who have financial limitation to install an expensive wastewater treatment system. In the future, if the MRHSSSF system are successfully developed, it can become an intellectual properties which can bring monetary profit.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the discussed elements were domestic wastewater which include the definition, characteristic and the effect of the domestic wastewater. The morphology, absorption and organics removal ability, disinfection properties of rice husk also been discussed. Besides that, the process and mechanism involved in the slow sand filter to remove the contaminants of the domestic wastewater and the effect of aeration in water treatment plant also were discussed in this chapter.

2.2 DOMESTIC WASTEWATER

2.2.1 Definition

Domestic wastewater is the water that produced after the use by human for their daily purpose. Basically it can be concluded that domestic wastewater is the composition of sanitary waste and sewer (Kling,2007).Sanitary wastewater is the wastewater created from laundry and kitchen cleaning purpose while the sewer is the wastewater resulting from the flushing of toilet or from bath activities. Therefore, untreated domestic wastewater contain a lot of pollutant which can cause environmental problem (Mara, 2004).The characteristic of domestic wastewater can be categories to three which is physical, chemical and biological. The typical characteristic untreated domestic wastewater are shown in table 2.1

Table 2.1: Typical characteristic of untreated domestic wastewater

Contaminants	Unit	Concentration		
		Weak	Medium	Strong
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(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 carbon	mg/L	80	140	260
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	mg/L	30	50	90
Sulphate	mg/L	20	30	50
Oil and Grease	mg/L	50	90	100
Volatile organic compound	mg/L	<100	100-400	>400
Total Coliform	Per 100mL	10^6-10^8	10^7-10^9	10^7-10^{10}
Fecal Coliform	Per 100mL	10^3-10^5	10^4-10^6	10^5-10^8

Source: Kling (2007)

2.2.2 Characteristic of Domestic Wastewater

2.2.2.1 Physical Characteristic

The first physical characteristic of the domestic wastewater that has to be concern is turbidity. Turbidity is the measurement of the clearness of the water. According to Sincero and Sincero (2003), turbidity is the measurement of the suspended solid in the water which 'absorb or scatter the light energy'. Therefore, it can conclude that total suspended solids are related to turbidity. The higher the total suspended solids

in the water, the higher the turbidity. Therefore, it is important to determine the total suspended solids in the water. According to EPA method (Keith,1996), the total suspended solids can be determined by filter the mixture sample with a weighed filter paper, drying the filter paper in a oven with 103-105 Celsius, the increase of the weight for the filter paper after drying process is the total suspended solids.

Colour also considered as physical properties of the domestic wastewater. The colour of the wastewater can be determined by the naked eyes. Primary evaluation for the wastewater can de done based on the colour of the wastewater. Clean water is colourless. There is a similarity of the domestic wastewater in term of colour which is grey or brownish in colour.

Another property of domestic wastewater is the odour or it also can be described as smell. Odour can be determined by the nose. Clean water should be odourless just like the drinking water. Nowadays, odour is getting concern by the public because the unpleasant odour release from the domestic wastewater can make people in uncomfortable condition. One of the common smells that can obtain form domestic wastewater is the rotten-egg smell due to the presence of hydrogen sulphide (H_2S) gas. Hydrogen sulphide is a gas resulting from the decaying process of organic matter by the microorganism. There are a lot of organic matters present in domestic wastewater, therefore hydrogen sulphide gases will always presence in the untreated domestic wastewater.

Besides that, temperature also is the physical parameter of domestic wastewater. According to Davis and Cornwell (2008), temperature of the domestic wastewater was always higher compared to the supply clean water with the range of 10-20 Celsius. This is because domestic wastewater formed by the sanitary and sewer wastewater which is warmer. The higher temperature of domestic wastewater may due to the high rate of microorganism activities in the domestic wastewater.

2.2.2.2 Chemical Characteristic

Organic matters are the chemical substances that always can be found in the domestic wastewater. The examples of the organic matter are oils, greases, mineral acids, organic acids and etc. Some of the organic matter can be the nutrient for the plant such as nitrate and phosphorus. Some of the organic matters are biodegradable such as oil. This is because that particular organic matter can be digested by the microorganism through biological process. On the other hand, environmental problem occurs when the untreated domestic wastewater that contain with high concentration of organic matter discharge to the river or lakes. The example of the problem is the formation of the blue-green algae bloom due to the high concentration of the nitrate and phosphorus in the domestic wastewater. Besides that, oil and grease produce by the petroleum factory also can cause water pollution.

Besides organic matter, the inorganic matters also are the substances that always presence in the domestic wastewater. Normally the inorganic matters are toxic substances. The examples of the inorganic matter are pesticides, heavy metal (mercury, copper, zinc, lead, etc) and etc. The inorganic matters are non-degradable substances which mean that it cannot consumed by the microorganism through biological process such as aerobic and anaerobic process. Inorganic matter such as Iron is the nutrient for the animal. For example human being needs iron in the body for the formation of haemoglobin. In the contrast, high concentration of inorganic matter or when the accumulation of the inorganic matter is high, its toxicity will increase and may cause a health problem to the mankind. According to Parihar (2008), the local residents who drank the water from the mercury polluted river were exposed to a serious health problem.

2.2.2.3 Biological Characteristic

Biological characteristic of domestic wastewater here refer to the existing of microorganism in the domestic wastewater. Domestic wastewater contains a lot of microorganism such as bacteria, algae, virus, fungi and etc. Most of the bacteria are faecal bacteria (Mara, 2004).This is because the main sources of the domestic

wastewater are human body waste or faeces. Besides that, microorganism in the domestic wastewater might be pathogen which is one kind of microorganism can bring disease to human.

2.2.3 Effect

2.2.3.1 Effect on Human Being

Domestic wastewater might contain heavy metals with the concentration not as high as wastewater discharged from industry. The heavy metals contain in the domestic wastewater may bring serious health problems to human being. Some heavy metal such as iron, zinc, copper are nutrient for human, but when these heavy metal accumulate in the human body with high concentration, it will become a toxic and will bring a hazardous health problem or even may cause death due to heavy metal poisoning. Arsenic for example, is related to the lung cancer (Sarkar, 2002).

Besides that, the polluted water also cause the waterbones disease to human who drink or use that polluted water. Waterborne disease is the disease that caused by the pathogen such as bacteria E. coli. This is proven in the research done by Butt et al. (2005). Butt et al.(2005) found that population that highly exposed to the domestic wastewater have the higher chance to get the diarrheal disease and hookworm infection compare to the control population. Besides that, pathogen also can cause gastrointestinal disease such as typhoid fever and cholera which can cause a death (Metcalf & Eddy,2003). According to Metcalf and Eddy (2003), it was estimated that about 4.5 billion people had suffered from parasite infection due to consume of domestic wastewater polluted drinking water .

2.2.3.2 Effect on Environment

One of the serious problems caused by the domestic wastewater to the environment is eutrophication. Eutrophication is the process of aggressive growth of algae due to the excess supply of nutrient (Parihar, 2008). The untreated domestic wastewater contains high concentration of phosphorus, nitrate and organic matter which

are the nutrient for the microorganism. The over growth of algae in the aquatic ecosystem due to the excess supply of nutrient are called algae bloom. It may affect to the particular ecosystem. For example, when the surface of the lake water fully covered with algae, it will decrease the penetration of sunlight into the lake. Submerge plant unable to carry out the photosynthesis to produce their food without solar energy. This will cause the death of the submerged plant. Due to the decaying process of the death plant and the algae by the bacterial, the quantity of the dissolved oxygen will decrease while the quantity of the carbon dioxide will increase due to the decaying process and the omnipresence of the aquatic submerged plant (Parihar, 2008). Therefore, the organism that need oxygen for survive such as fish will die and the whole ecosystem will be destroy.

2.3 RICE HUSK

2.3.1 Introduction

Rice husk is one kind of agricultural waste. It is a by product form rice mill during rice production. In India, few million tons of rice husk are produced in a year. Risk husk is a waste and may cause environment pollution. However, rice husk are not been handle well by the rice industry. Normally, the rice husk dumped as a solid waste, as animal feed , and some might used as cementing material where the rice husk are burnt and as fly ash but the burning process may need many energy and cost (Shao et al., 2009). Recently, many researchers conducted research to utilise the use of rice husk. Rice husk was proposed to be used water treatment. The ratio of rice husk to whole rice is just 20% and The composition of silica contain in the whole rice is 20% (Chuah et al.,2005). Moreover, Risk husk is granular in structure and insoluble in water. The typical composition of rice husk is show in table 2.2