STUDY ON DOMESTIC WASTEWATER TREATED USING MODIFIED RICE HUSK SLOW SAND FILTER

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ABSTRACT

Domestic wastewater discharges from domestic residences, commercial, industrial or institutional and other similar facilities premises into the public sewer. This wastewater was originated from all aspects of human sanitary water usage. It is a potential wastewater source to be treated in future. It is because it contributes the most to water pollution problem. Adsorption, chemical reaction, filtration, ion-exchange, coagulation, flocculation reverse osmosis and so on are the technologies used to treat water and wastewater. Those technologies are costly and involved a lot of chemical usage and create a lot of chemical sludge. In addition, rice husk causes disposal problem because it is a hardly biodegraded materials and contains highly in silica when it is in ash form which will reduce the quality of soil. The aims of this study was to design a low cost and effective filter by adding agriculture waste to purify domestic wastewater, evaluate the potential of modified rice husk slow sand filter, MRHSSF in treating domestic wastewater to achieve the standard A and Class 1 of wastewater standard and investigate the optimum retention time for the optimum effectiveness of MRHSSF in removal of the impurities in domestic wastewater. The MRHSSF consist of four components which are sand bed with 0.15mm to 0.30mm and 0.625mm to 1.18mm diameter in size, 0.5 mol sulphate acid modified rice husk (0.075mm – 0.015mm diameter), 10mm diameter river gravels and under drainage. The selected domestic wastewater was filtrate using MRHSSF and all the raw and treated water samples were tested to know its contaminants. This study successfully shows that modified rice husk slow sand filter, MRHSSF was effectively removed up to 100% in BOD5, COD, TSS, Fe, Pb and E.coli, 98.6% in turbidity and 97% in oil and grease respectively. Besides that, MRHSSF was also treated domestic wastewater to achieve Standard A for pH, temperature, BOD5, COD, TSS, Fe, Pb and Zn, Standard B for oil and grease or Class1 for turbidity, total coliforms, E.coli and TDS according to Environment Quality (Sewerage and Industrial Effluences) Regulations, 1979 and Interim National Water Quality Standard (INWQS). The retention time for MRHSSF to achieve its equilibrium was on the third hours where there was 98.8% removal of BOD_5, 99.1% of COD, 98.5% of turbidity, 98.8% of TSS and 100% of E.coli, Fe and Pb respectively. This study showed that MRHSSF is a cheap and effective in treating domestic wastewater. Thus, it can be continued with some improvements in future research or commercial usage to reduce the environmental problems especially water pollution.

ABSTRACK

Pelepasan air sisa domestik dari kediaman domestik, komersil, industri atau institusi dan lain-lain kemudahan yang serupa premis ke dalam pembetung awam. Air sisa ini berasal dari semua aspek penggunaan air kebersihan manusia. Ia adalah sumber air sisa yang berpotensi untuk dirawat pada masa depan. Ini adalah kerana ia menyumbang paling banyak kepada masalah pencemaran air. Penjerapan, tindak balas kimia, penapisan, pertukaran ion, pembekuan, pemberbukuan, osmosis songsang dan sebagainya adalah teknologi yang digunakan untuk merawat air dan air sisa. Teknologi-teknologi ini mahal dan melibatkan banyak penggunaan bahan kimia dan menghasilkan banyak lumpur kimia. Di samping itu, sekam padi menyebabkan masalah pelupusan kerana ia adalah bahan-bahan yang susah direputkan dan mengandungi banyak silika apabila ia adalah dalam bentuk abu yang akan menjatuhkan kualiti tanah. Matlamat kajian ini adalah untuk mereka bentuk penapis air yang berkesan dan kos rendah dengan menambah sisa pertanian untuk membersihkan air sisa domestik, menilai potensi penapis pasir perlahan dengan ubahsuaian sekam padi, MRHSSF dalam rawatan air sisa domestik untuk mencapai Standard A dan Kelas 1 dalam air sisa standard dan menyiasat masa tahanan optimum untuk keberkesanan optimum MRHSSF pembuangan kekotoran dalam air sisa domestik. MRHSSF terdiri daripada empat komponen iaitu katil pasir dengan 0.15mm ke 0.30mm dan 0.625mm ke 1.18mm diameter dalam saiz, 0.5 mol asid sulfat ubahsuaian sekam padi (0.075mm - diameter 0.015mm), 10mm diameter kerikil sungai dan perparitan di bawah. Air sisa domestik terpilih telah dituraskan dengan menggunakan MRHSSF dan semua sampel air mentah dan air dirawat telah diuji untuk mengetahui kandungannya. Kajian ini berjaya menunjukkan bahawa penapis pasir perlahan dengan ubahsuaian sekam padi, MRHSSF telah berkesan dikeluarkan sehingga 100% BOD_5, COD, TSS, Fe, Pb dan E.koli, 98.6% dalam kekeruhan dan 97% dalam minyak dan gris masing-masing. Selain itu, MRHSSF juga dapat merawatkan air sisa domestik sehingga mencapai Standard A untuk pH, suhu, BOD_5, COD, TSS, Fe, Pb dan Zn, Standard B bagi minyak dan gris atau Kelas 1 untuk kekeruhan, jumlah koliform, E.koli dan TDS mengikut Peraturan-Peraturan Kualiti Alam Sekitar (Kumbahan dan Effluences Perindustrian), 1979 dan Interim National Water Quality Standard (INWQS). Masa tahanan untuk MRHSSF untuk mencapai keseimbangan adalah pada jam ketiga di mana terdapat 98.8% daripada penyingkiran BOD5, 99.1% daripada COD, 98.5% daripada kekeruhan, 98.8% daripada TSS dan 100% daripada E.coli, Fe dan Pb masing-masing. Kajian ini menunjukkan bahawa MRHSSF adalah murah dan berkesan dalam merawat air sisa domestik. Oleh itu, ia boleh berterusan dengan beberapa penambahbaikan dalam penyelidikan masa depan atau penggunaan komersial untuk mengurangkan masalah alam sekitar terutamanya pencemaran air.

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mg/l	Milligrams per liter
ml	milliliter
MPN/100ml	Most probable number per 100 milliliter
Ntu	Nephelometric Turbidity Units
°C	Degree Celsius

LIST OF ABBREVITIONS

BOD_5	Biochemical Oxygen Demand
Cd	Cadmium
COD	Chemical Oxygen Demand
Cu	Copper
Fe	Ferum/Iron
MRHSSF	Modified rice husk slow sand filter
Pb	Lead
RHA	Rice husk ash
SSF	Slow sand filter
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Background of Study

There is 2 million tons of sewage, industrial and agricultural waste is discharged into water resources every day all around the world. The wastewater produced annually is more than clean water (WHO, 2003). Basically, according to Tjandraatmadja and Diaper, 2006 the major input stream are:

- Domestic wastewater resulted from the daily activities in residential area.
- Commercial activities discharged from small medium enterprise such as health clinics, restaurants ,laundry shop and others
- Industrial waste resulted from the production, manufacture and trading activities which are categorized based on effluent volume, type of process and quality of wastewater.
- Groundwater infiltration caused by the penetration of rainwater into the ground and storm water inflow into the water resources during dry and rainfall session.

However, domestic wastewater is the main contributor to the water pollution. There are 2.5 billion people in this world live in poor sanitation condition (UNICEF, 2008). 70% of these people or 1.8 billion people who lack sanitation live in Asia. This unimproved sanitary system produces much of the untreated waste water discharges into the stream and cause serious water pollution. Domestic waste water is the wastewater generated from human daily activities including kitchen works, bathroom, floor or clothes washing, toilet and so on. It contains of high organic, heavy matter and total coliform. It will directly or indirectly cause the problem towards human in health issue, aquatic ecosystem problem, and also economy effect to government in water purification. While, the status of the rivers quality in Malaysia can be shown in table in the report of Jabatan Alam Sekitar which shows the substances in water from the year of 1998 until 2010.

Table 1.1: Status of river water quality based on BOD5, NH3-N and SS, 1998 – 2010, Malaysia

Year	Total River Basin Monitored	Biochemical Oxygen Demand			Ammoniacal Nitrogen (NH3-N)			Suspended Solids		
		P	SP	C	P	SP	C	P	SP	C
1998	120	25	36	59	52	53	15	41	28	51
1999	120	31	75	14	33	70	17	45	22	53
2000	120	18	63	39	22	48	50	53	25	42
2001	120	21	41	58	24	43	53	38	25	57
2002	120	22	29	69	29	40	51	28	14	78
2003	120	15	29	76	29	37	54	28	17	75
2004	120	18	37	65	30	47	43	31	11	78
2005	146	28	41	77	43	54	49	34	22	90
2006	146	22	28	96	41	56	49	42	20	84
2007	143	12	37	94	36	56	48	42	39	62
2008	143	18	46	79	33	38	72	53	33	57
2009	143	42	73	28	40	47	56	57	32	54
2010	143	52	79	12	42	66	35	48	27	68

Note: P – Polluted SP – Slightly Polluted C – Clean

Source: DOE (2011)

To reduce the rate of pollution, the Environmental Quality (Sewerage and Industrial Effluences) Regulation, 1979 and Interim National Water Quality Standard (INWQS) had been set the rules, limits and standard of wastewater that should be achieved before it is discharged into the natural water bodies. Generally, the contributors of wastewater to the rivers or streams are from suburban areas. They are less of instrument, cost, and technical knowledge about water treatment and the seriousness of water pollution. In addition, if there is agriculture area, the problem will become complicated with the additional of the waste of the plants and pesticide. On the opposite, there is a lot of researchers had proved that there are loads of agriculture waste have the ability in purifying the water. Apart from reducing the polluted contaminants in wastewater, the agriculture waste like rice husk, groundnut cells and so on also can be reduced by applying them as a treatment medium in filter. Lastly, a simple, low cost, effective and environmental friendly water filter is produced. It can be applied both in urban and suburban area.

1.2 Problem Statement

Water pollution is a serious problem recently and being a concern of this world. It causes depletion of the clean water resources. Besides treating the rivers, reservoirs and groundwater, the industrial and domestic waste water treatment is also being look important to solve the water crisis problem. Various treatment technologies were utilized for organics and toxic inorganic metal removal from wastewater. These techniques include adsorption, chemical reaction, filtration, ion-exchange, coagulation, flocculation, reverse osmosis, electrodialysis and so on (Sahu, et al., 2009) However, those technologies are costly and involved a lot of chemical usage. Hence, many researchers nowadays have tried to determine a functional effectiveness and economic method for removal of the impurities in wastewater.

Slow sand filter and rice husk are simple and economical equipment and material that using in water treatment. Their functions and effectiveness are well proven in practices over long period and been written in many articles, journals and also books. Another highlight, it is also proved that modified rice husk such as activated rice husk, pretreatment of rice husk by using acid and other has higher efficiency in treating water. However, there is no researcher combine them being modified rice husk and size specified sand in a filter. In addition, the target of waste water that will be used for treatment testing is domestic wastewater which will become an interesting issue for a review for general for future used. Furthermore, the stage of effectiveness of the combination of modified rice husk and slow sand filter in removal of contaminants in water is the main purpose in this invention. It is because domestic waste water is a potential water source for the coming years. For example, a normal slow sand filter which its detention time of water in filter is about 12 – 24 hours for the complete process or mechanism between and waste and sand which mean the time period is the best time for achieving the highest stage of waste removal. Similarity, after adding rice husk into slow sand filter, the optimum effective functioning time in removal of the parameters or chemical is the issue to be investigate. The retention time to achieve optimum effectiveness means that the optimum operation time needed for the modified rice husk slow sand filter to achieve their most affect in purifying of wastewater process.

1.3 Research Objectives

The objectives of this study are:

1.3.1 To design a low cost and effective water filter by adding agriculture waste to purify domestic wastewater,

1.3.2 To evaluate the potential of modified rice husk slow sand filter, MRHSSF in treating domestic waste water to achieve the standard A and Class 1 of wastewater quality, and

1.3.3 To investigate the optimum detention time for the optimum effectiveness of rice husk slow sand filter in removal of domestic waste.

1.4 Scope of Study

In this study, there were three components that were concerned on. There were the characteristic and function of instrument (slow sand filter) and materials (modified rice husk, sand and gravels) and the contaminants of wastewater source (domestic wastewater from the effluent of café and hostel Kolej Kediaman 3 (KK3) in University Malaysia Pahang, Gambang Campus. The modified rice husk slow sand filter, MRHSSF was used to filter the sample of domestic wastewater. Variety of tests were applied to the raw and filtered water sample to know their contaminants or characteristics such as pH, temperature, BOD_5, COD, TSS, TDS, turbidity, oil and grease, total coliform, E. coli and heavy metals like Cadmium, Iron, Lead, Copper and Zinc.

The scopes of this study were:

1.5.1 The evaluation of the capacity of modified slow sand filter to dispose the parameters as stated in the Environmental Quality Regulation, 1979 and INWQS.

1.5.2 Reduction of the influence discharge of domestic waste water to comply with Standard A or Class 1 as referred to Environmental Quality (Sewerage and Industrial Effluences) Regulation, 1979 or INWQS.

1.5.3 Determination of the retention time for the optimum operation effectiveness of waste removal by MRHSSF.

1.5 Significance of Study

The results and data from this study will be very useful for review for further research. It is because this is a new invention with a sequent combination of modified rice husk and slow sand filter for domestic wastewater treatment. For the industrial and public, this invention can be used to apply in the future STP wastewater treatment to purify the water to meets the Standard A or B as mentioned in Environmental Quality Regulation, 1979 before the water is exposed to the river or stream. The purpose is to reduce the pollution of the source of clean or drinking water. Then, the public will have more clean and safe water to drink and use. In addition, when the pollutants in water sources are reduced, then the cost to treat water for drinking water will also be reduced and then, the healthy level of communities will also be improved.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Water covers 71% of the Earth's surface and 39% is land. However, there are 96.5% of the Earth's water is found in oceans, 1.7% in groundwater, 1.7% in glaciers and the ice caps of Antarctica and Greenland, a small fraction in other large water bodies, and 0.001% in the air as vapor, clouds, and precipitation. While, only 2.5% of the Earth's water is fresh water, and 98.8% of that water is in ice and groundwater (Gleick, et al., 1993). There is only little clean and consumed water can be safely use, but there is still a lots of water pollution. Pollutants from industrial and residential caused the sources of clean water being in unsafe mode. Moreover, lack of improve sanitation system and waste water treatment is directly contribute the domestic waste into our water source (UNICEF, 2008). Turbidity and odour of water can be observed physically. While, the other content of pollutants which can only be known through tests such as pH, BOD, COD, heavy metal and so on. All these are harmful to human healthy especially the fecal pollution and consequently cause waterborne diseases which cause death.

Another highlight is the discharge of the husk accruing in the numerous rice mills causes a serious environmental problem. Rice husks makes up about 20% of the rice or paddy weight. The rice mills spread a world's wide therefore should generate more than 100 million tons of rice husks from 500 million tons of the production of paddy (Zemke and Woods, 2009). However, nowadays almost 70% of the rice husks are not commercially used. This agricultural waste has a significant calorific value and a high percentage of amorphous silica. In addition, rice husk has a very low nutritional value and as they take very long to decompose are not appropriate for composting or manure. The world production of rice paddy and rice husk as shown in Table 2.1.

Table 2.1: World Production Rate for Rice Paddy and Rice Husk (Million Metric Tons)

Country	Rice Paddy	Rice Husk
Bangladesh	27	5.4
Brazil	9	1.8
Burma	13	2.6
China	180	36.0
India	110	22.0
Indonesia	45	9.0
Japan	13	2.6
Korea	9	1.8
Philippines	9	1.8
Taiwan	14	2.8
Thailand	20	4.0
US	7	1.4
Vietnam	18	3.6
Other	26	5.2
Total	500	100

Source: Zemke and Woods (2009)

Disposal of rice husk ash is an important issue to those countries that produce huge amount of rice yearly. Rice husk is hard to be decomposed or biodegraded as it has a low dietary value. Therefore, improper of disposal of rice husk can create many environmental problems which can bring adverse effect to environment. One of the useful methods applied today to reduce the rice husk waste is to use it to fuel kilns where the function of the kilns is to help in the production of bricks and other clay products. Incineration of rice husk is an efficient method which can remove the rice husk resulted from rice production while create another added value to burned rice husk by transform it as a useful by-product. After the kilns have been fired using rice husk, the ash still remains. As the production rate of rice husk ash is about 20% of the dried rice husk, the amount of rice husk ash generated yearly is about 20 million tons worldwide (Zemke and Woods, 2009). So, it is encouraged to use in purifying water or wastewater so that the extremely extra rice hush ash has another way to reduce.

Another highlight is about slow sand filter, it named as slow sand filter which mean it need a longer time than other filter. Basically, it required one day time for the water to detent in the filter (Khosrowpanah and Heitz, 2003). As a result, as the development of treatment equipments or plants, it becomes oblivion. It is because other filters are fast operating than slow sand filter such as rapid sand filter, biofilm filter, and membrane filter and so on although it is very effective in purifying water.

Lastly, in this chapter, the criteria and functions of slow sand filter, rice husk and domestic waste will be reviewed as follow.

2.2 Slow Sand Filter

2.2.1 History

Slow sand filtration has been in large-scale use for 100years. It is simple, cheap and reliable. It is still used as water supplies purifying for some of the major cities of the world. However, it is less applied in wastewater treatment (Adeniran and Akanmu, 2010). According to Doekhie (2008), the traditional slow sand filter is an open rectangular basin with 2.5 to 4 m deep and finished ground level. It may in a few hundred to a few thousand m^2 of area and sometimes will even larger. This filter is filled with a layer of sand with 0.7 to 1.3 m thick, the water to be treated is present to a depth of about 1.5 m on top of sand and a drainage system is at bottom to support the sand and at the same time allows the passage of the filtered water.

The reason to choose slow sand filter as water treatment equipment is because it has high quality of treated water which would not support after growth in distribution system and no chemicals are added, thus obviating taste and odour problems. The design of slow sand filter is simple and easy to construct by using the local materials and skills so the cost of construction should be low. On the other hand, it is also easy to operate while the cost is deal with the cleaning of sand bed manually or mechanically. It means the removal of the top sand which contains sediments and will disturb the effectiveness of slow sand filter as well as for a certain period. In addition, slow sand filter has the advantage to sludge disposal where the sludge is handling in dry state and will not pollute nearby water sources as stated in Huisman, et.al. (1974)'s research. As a result, from the advantages of slow sand filter, it is applicable in domestic wastewater treatment where the domestic wastewater can be found at every places there has human-being.

2.2.2 The Characteristics of Slow Sand Filter

A slow sand filter basically consists of 3 components which are sand bed, gravels and under drainage (Khosrowpanah and Heitz, 2003). It is a bed of graded sand at top which is supported by a layer of gravel. Wastewater is flow into the filter at top and pass through the fine sand bed for few processes and mechanisms for water purification. At drainage layer, bigger size of gravel allows the filtered water to flow to bottom of the filter under gravitational force (Doekhie, 2008). Filter control like valve may included for adjusting the water flow rate so that the detention of water in slow sand filter can be controlled.

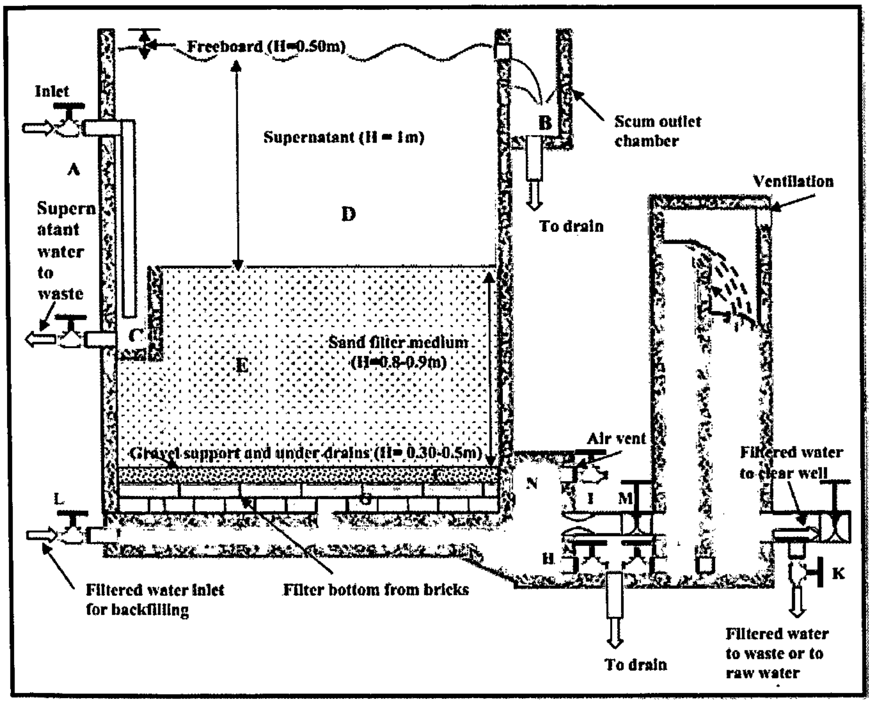

Figure 2.1: Section of a typical rectangular slow sand filtration unit

Source: UNICEF (2009)

Table 2.2: Design criteria and recommendations for slow sand filters

Design criteria	Recommended level
Design period	10-15 years
Period of operation	24 h/d
Filtration rates in the filters	0.1-0.2 m/h
Filter bed area	5-200 m2 per filter, minimum of 2 units
Height of filter bed: ~ Initial ~ Minimum Specification of sand: ~ Effective size ~ Uniformity coefficient	 0.8 -0.9 m 0.5-0.6 m 0.15-0.30 mm <5, preferably below 3
Height of under-drains including gravel layer	0.3-0.5 m
Height of supernatant water	1 m

Source: Khosrowpanah and Heitz (2003) and UNICEF (2009)

The slow sand filter is not only used sand as the main content in the constructed filter. However, there are also some countries use crushed coral and burnt rice husk as the material for filter UNICEF, 2009. Without consider any kind of materials used to treat the water, the chosen size of the sand or filter medium is very important to be concerned on. It is because the sufficient oxygen in the raw water (at least 3 mg/l) is required to induce biological activity. From the guideline of UNICEF (2009), the composite sand for slow sand filter is expressed with its effective size (Es or D10) and uniformity coefficient (UC). The effective size of the composite sand defines that the sieve opening in millimeter that permits passage of 10% by weight of the sand.

Thus, the uniformity coefficient of sand will be the ratio between the sieve size that permits passage of 60% of sand and effective size D10 of the composite sand. However, effective size and the uniformity coefficient can be determined by sieve analysis. So, can be concluded that the effective sand size operated slow sand filters is in the range of 0.15 to 0.30mm. Table 2.3 shows the performance of slow sand filter in contaminants removal by using effective sand size. The filter with 0.2mm sand size performs very effectively in feacal coliforms, total coliforms, turbidity and colour removal.

Table 2.3: Effect of effective size (D10) on filter performance

Impact of Effective Size (D10) on Filter Performance at Filtration Rate of 0.1 m/h				
D10 (mm)	**Average % removal**			
	Feacal coliforms	Total coliforms	Turbidity	Colour
0.2	99.6	99.7	96.5	95.1
0.35	99.3	99.3	96.5	95.1
0.45	99	98.6	96.2	92

Source: UNICEF (2009)

After the slow sand filter is operated for a period, a cake layer is formed by the sediments and microorganism on top of sand called schmutzdecke (UNICEF, 2009). Schmutzdecke is one of the characteristics of slow sand filter. So, time, oxygen and temperature should at the suitable level are needed for the microbes to growth and cause the occurrence of biological treatment process. As a result, this helps to improve or maintain the effectiveness of slow sand filter.

2.2.3 Function and Effectiveness

Slow sand filter are commonly used to remove turbidity and microorganism or total coliform like E. coli in water according to UNICEF (2009) and Adeniran and Akanmu (2010)'s researches. It is also proved as a filter that has high effectiveness in reduce turbidity and eliminate the bacteria as shown in Table 2.3. Turbidity is generally reduced to less than 1 NTU and microorganism is almost completely removed in the study of UNICEF (2009). On the hand, slow sand filter also shows good performance in removing the other impurities in water such as suspended solids, colour, BOD, organic matter, heavy metal and so on.

In the filter box, as the water flow down the sand bed, some process or mechanism occur to trap the contaminants in water in the filter. The processes are sedimentation, adsorption, straining and the most important is biochemical and microbial actions (Doekhie, 2008). However, Zheng et al., 2007 describe that from time to time, the upper 5 cm sand layer was removed manually and new sand was added to reduce the head loss in the filter to ensure that effectiveness of slow sand filter.

2.2.3.1 Sedimentation

Sedimentation is a physical process which is used to remove particles and colloids from both water and waste water. As like is slow sand filter, water is left and detent in the filter is to let the sedimentation process to occur. In filter, the water flow rate is at very minimum level where it is recommended as 0.1-0.2 m/h as shown in Table 2.2. The average time of water retains on the sand bed is in range of 3 to 12 hours where it is also depend on the water flow rate (Huisman et al., 1974). Hence, the turbulence is minimizing and encouraging the particles to suspend or settle naturally due to gravitational.

2.2.3.2 Straining

Straining will happen as passing the water through a filter in which the pore are smaller than the particles to be removed. It is a physical process that will occur for every filtration. From figure below, the size of floc particles are bigger than the gap between sand particles. So, there are trapped while water is able to pass through the sand and leave the floc particles behind. In slow sand filter fine sand is used as well as the gap between sand is small enough to capture the pollutants in water.

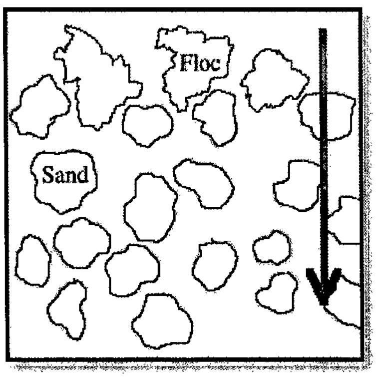

Figure 2.2: Straining Process

Source: http://water.me.vccs.edu/courses/env110/lesson6.htm retrieved (13/10/2012)

2.2.3.3 Adsorption

Adsorption is the gathering of gas, liquid, or dissolved solid onto the surface of another material. Adsorption is a physical separation process in which the adsorbed material is not chemically altered. It is a preferable process used in the treatment of industrial wastewaters containing organic compounds which are not easily biodegraded. For example, the substances are difficult to remove via conventionally during secondary (biological) treatment, toxic, volatile and cannot be transferred to the atmosphere and have the potential for creating noxious vapors or odors, or for imparting color to the wastewater. Some factors may affect effectiveness of adsorption like the surface area of adsorbent where larger sizes imply a greater adsorption capacity. Besides that, the longer the time the more complete the adsorption will be. However, the equipment will be larger. In addition, the degree of ionization of a species is affected by the pH such as a weak acid or a weak basis. Huisman et al., (1974)'s report states that the sand bed take 40% of the total volume of filter here it is the adsorption process taking place as the water comes in contact with the sand.

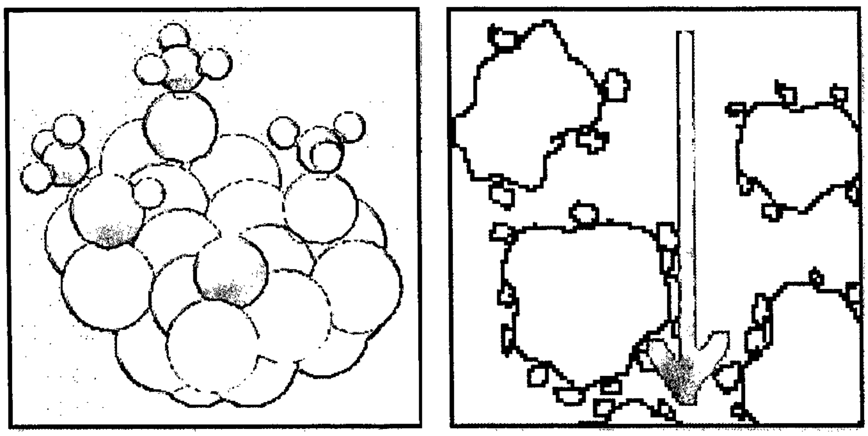

Figure 2.3: Adsorption Mechanism
Source: (http://www.esrf.eu/UsersAndScience/Publications/Highlights/2000/surfaces/SU3.html, retrieved on 13/10/2012)

2.2.3.4 Biochemical and Microbial Actions

Biochemical and microbial actions can be observed at the top layer of the filter bed. It is occurred as the day passes with the effect of sunlight, algae grows at the sediments on the sand bed which also contains plankton, diatom, protozoa and also other bacteria (Huisman et al., 1974). They forms a thin layer called 'schmutzdecke' and will envelope which will act as filth cover. The bacteria that develops in the schmutzdecke which will not interrupt the flow in filter as stated in UNICEF (2009) and Huisman et al., (1974)'s report. The algae are absorbing carbon dioxide, nitrates, phosphate and also other nutrients in water and produce oxygen which will help to improve the quality of water. While the variety of biologically very active micro-organisms will work to entrap, digest and break down organic matter, then a great deal of suspended inorganic matter is retained by straining (Doekhie, 2008).

Table 2.4: Performance slow sand filters

Parameter	Purification effect
Organic matter	Clear effluent, virtually free from organic matter
Bacteria	Between 90% and 99% of pathogenic bacteria may be removed; cercariae of schitstosoma, cyst and are removed to an even higher degree; E. coliare reduced by 99-99.9 %
Phages	In a mature slow sand filter viruses are virtually completely removed
Colour	Significantly reduction
Turbidity	Raw water turbidities of 100-200 NTU can be tolerated for a few days only; turbidity more than 50 NTU is acceptable only for a few weeks; preferably the raw water turbidity should be less than 10 NTU; for a properly designed and operated filter the effluent turbidity will be less than 1 NTU.

Source: Doekhie (2008)

On the other hand, from Adeniran and Akanmu (2010)'s study shows that 88% removal of suspended solids, 76% removal of BOD, and 97% removal of coliform organisms. His reported that most of the removal occurred at or about the surface sand layer, schmutzdecke. In the further study of Adeniran and Akanmu (2010), at the end of the 28 days study, the removal efficiency of colour, turbidity, BOD, TDS, Nitrate and e-