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Peat Water Treatment by Using Multi Soil Layering (MSL) Method

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ABSTRACT

Multi Soil Layering (MSL) is a method of wastewater treatment (contaminated water) organic by utilizing soil as a main medium and organic material formed in the form of beams bricks and arranged in layers among zeolite layer. MSL reactor made of acrylic box 50 cm (L) x15 cm (H) x 50 cm (W) cm contains the beam brick 4 cm (H) x9 cm (L) x15 cm (W) cm with mixture as volcanic soil, actif charcoal, bagasse and iron powder (7,5: 1: 1: 0,5) and a permiable layer used zeolite (2-3 mm). The sample is peat water located in the Perawang area, Siak District, Riau Province of Indonesia.The Research was done by flowrate variation of 5, 10, 20 and 40 mL. min^{-1}in aeration and nonaerasi conditions. From the research that the efficiency MSLmethod in peat water treatment at a flow rate of 5 mL. min^{-1} is better,itcould remove of Color, COD, BOD, Organic content are 93,57%; 90,48%; 93,65%; 91,07% on aeration condition and 92,86%; 89,52%; 92,06%; 89,05% on nonaerasi, while for pH could changed from 4,26 to 6,93 for aeration condition and from 4,26 to 6,91 for nonaeration. This results showed that the MSL method is an efficient way of peat water treatment to be fresh water. The flow rate and aeration-nonaeration conditions are key factors in increasingthe effectiveness of the MSL method.

Keywords *:* MSL, peat water, bagasse.

INTRODUCTION

Fresh water is one of the basic human needs are obtained from various sources, depending on local conditions. The water resources condition in each region is varies, depending on the nature state and human activity were found in the area. Residents living in the low areas and marshy like all almost areas in province of Riau, Indonesian difficulty obtaining fresh water for household purposes, especially drinking water. This is caused the water source in the area is peat water wich based water quality parameter does not meet the requirements of the fresh waterquality to WHO standard, because peat water has low pH (3-5), color is maroon, and high organic content. Acidic pH of the peat water was predicted due to the composition of the surrounding peat soil itself which had been formed by decaying material possessing humic substances [1]. Organic content including as humic substances are comprised of fractions (humic acid, fulvic acids and humin) with different molecular weights which mean high concentration of turbidity and coloured water and composition of peat soil may also have an impact on the iron ion concentration of peat water [2]. Peat water in Indonesian is one of the water resources are still abundant. Then, the peat water quantitatively is very potential to be treat as a water resource can be processed into fresh water or drinking water. However on the qualitative using peat water are still a problem.

This research will designed a model for peat water treatment to produce fresh water by the Multi-Soil-Layering (MSL) method with organic materials mixtureis bagasse. Multi Soil Layering (MSL) method is a method for treatment of wastewater by utilizing the soil as the main medium and the organic matter formed in blocks of brick and arranged in layers with a layer of perlite or other particles that are homogeneous[9,13]. This method is known have many benefit likeuse small land, the correct in developing countries, aesyoperation and control, as well as environmentally friendly, because it uses natural materials and easily obtained, among which the topsoil from the mountains (Andisols), bagasse, coconut charcoal, and others as unaerobic layers, as well as zeolit or other geomaterials as aerobic layers[10,11]. The MSL system of wastewater restaurant at a flow rate of 25 mL. min^{-1} with aeration, ability a removal efficiency result of nitrite 86.44%, nitrate 92.53%, phosphate 97.75%, whereas in the non-aeration 64.21% nitrite, 83.98% nitrate and 79,75% phosphate [3].

Bagasse is the fibrous matter that remains sugarcane. The bagasse in MSL system is corbon sources for microorganisms soil. The bagasse ash is a good adsorbent for dye effluent treatment[4]. The composition of bagasse is 40-50% cellulose, 25-30% hemicelluloses, and 20-25%lignin [5].The bagasse used adsorbent for heavy metal ion are Zn, Cd, Cu and Pb, where have benefit, than sintetic adsorbent in the more. The bagasse without ashes can using as heavy metal ion adsorbent like zinc, cadmiun, cupper, and lead with efficiency of 90%, 70%, 55%, 80% [6]. The activated carbon is an effective adsorbent for treating water with high concentrations of organic compounds [7].

The zeolite nowadays has been explored for its ability in many fields especially in water treatment.The used combination of Cationic Surfactant Modified Zeolite, Granular Activated Carbon, and Limestone of pwat water treatment were very efficient in removing colour, COD, turbidity at pH range 2-4 and Fe at pH range 6-8 [8]. The used Combination of Cationic SurfactantModified Zeolite, Granular Activated Carbon, and Limestone of peat water treatment were very efficient in removing colour, COD, turbidity at pH range 2-4 and Feat pH range 6-8 [8].

MATERIALS AND METHODS

All chemical used in this experiment namely H_2SO_4 98%, K_2PtCl_6, $CoCl_2.6H_2O$, Indicators Ferroin, Fero Ammonium Sulfat, alkali azide, $MnSO_4$ 10%, $K_2Cr_2O_7$, $HgSO_4$, $Na_2S_2O_3$. $5H_2O$, $KMnO_4$, asam oksalat, $KHC_8H_4O_4$, KH_2PO_4, Na_2CO_3, $NaHCO_3$, are analytical grade and obtained from E-Merck (Germany) unless other wise noted. Distilated water areobtained from laboratory. A pH meter (Hanna), Aerator (Amara, AA-350), Incubator BOD (FTC 90, Merk Velp Scientifica), Oven (Memmert, Germany), filter paper (Whatman 42 milipore), analyticalbalance (AA-200, Denver Instrument Company), Dirigent, Nessler tube, Nefalometer, Winkler bottles, heating, reflux, desiccators and other laboratory glassware was used in this experiment. The peat water were collected from region Perawang Siak districk, Riau Province, Indonesia.

Preparation and Set Up MSL System : The primary materials of the MML system includes soil mixture layers (SML) and permeable layers (PL). For the soil mixture layers others materials, such as charcoal, bagasse, and iron powder, are added to the volcanic soil (0,5:10:5:75), and the mixture is packed into sampler cloth. The permeable layers used zeolite (1-3 cm).

The research begins with the assembly of equipment MSL system in the form acrylic box with dimensions in 50 cm(L) × 15 cm(W) × 50 cm(H). The base box with a height 4 cm filled with gravel (diameter 4 cm), then the all surface gravel is covered with plastic net. The next second layer with a height 4 cm filled with zeolite (diameter 2-3 mm). The third layer is made of four SML wrapped in sampler cloth with dimensions in 9 cm(L) × 15 cm(W) × 4 cm(H) mounted in parallel at distance of 3 cm. Then the next layer is filled with zeolite 4 cm. Other layers loaded in the same way to form five layers SMB, then the top layer covered with zeolite 4 cm. Between the third and fourth layer installed aeration pipes (diameter 1.5 cm) to the distance between holes aeration 5 cm, hole aeration size 0.5 cm [6].The MSLsystem setting is shown in fig.1.

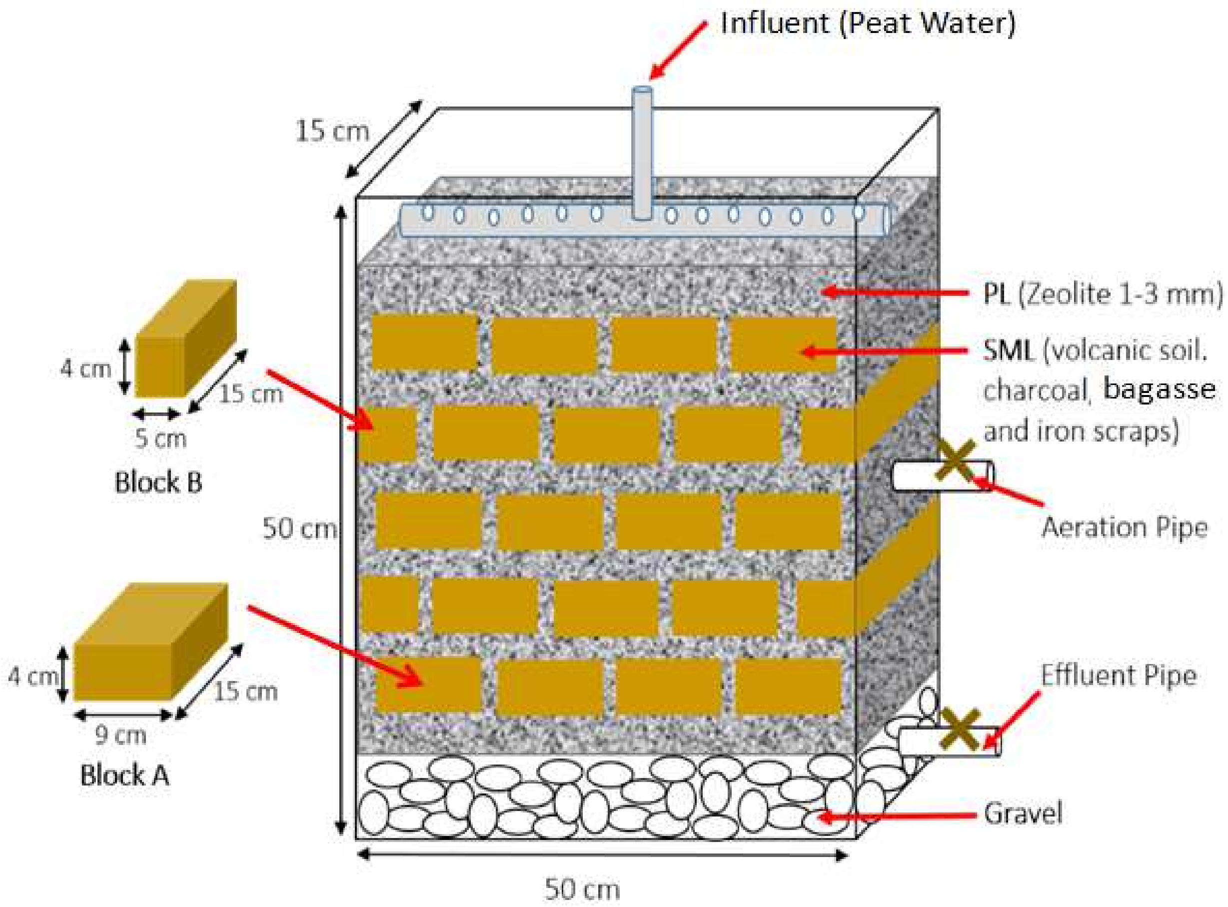

Fig. 1.Design of MSL system

Treatment process peat water of MSL method : The peat water accumulated in the tank then flowing through into the MSL system has been constructed and furthermore accumulated in drip cup as effluent. The effluent wereanalysed for water quality. In order to predict the ability of the MSL system is then performed analysis before and after peat water treatment. Treatment process of the MSL system with set-up four loading rates of 5, 10, 20, and 40 mL. min^{-1} and two conditions, Aeration and nonaeration.

Analytical methods : The peat water samples were analysed to determine of pH according to Standard Methods (ASTM D1293 – 95), Color was measured to APHA (The American Public

Health Association) Method, BOD was measured to Winkler Method, CODwas measured toreflux Method, Organic content was measured to titrimetric Method.

Efficiency MSL determined with be calculated using the formula:

MSL Efficiency = {(A)-(B) / (A)} x 100%

where A is the concentration before treatment (mg. L^{-1}), B, concentrations after treatment

RESULTS AND DISCUSSION

Characterisation of Peat Water
The characteristics of the peat water supply from region Perawang Siak districk, Riau Province, Indonesia is shown in Table 1. It can seem that the all parameters analysis are above the quality standard parameters of water. Based on the characteristics of peat water, it has required for treatmented, and this research were used MSL (Multi Soil Layering) method with a flow rate variation in aeration and non-aeration conditions.

The color and high organic matter shows that the peat water contains high organic polymer compound, where in the organic content is 265.44 mg. L^{-1}. This caused the color and acidity of peat water is high.Peat water has color brown with high color level 350 PtCo. Which color of dark brown peat water caused by the substance humus (organic compounds) contained in peat soils, which are polymers that contain carboxyl acid and phenol group. This color is also caused by iron bound with humic acids present in water to form humic iro colored dark brown [21]. Where the degree acidity degree of the peat water reached 4.26.While the content of BOD and COD (50.40 and 165.44 mg. L^{-1}) is high in peat water indicates the amount of dissolved oxygen needed by microorganisms to degrade and oxidize organic compounds that are high in peat water. It indicates the amount of organic content to be degradation by microorganisms[13], thus requiring a high amount of dissolved oxygen.

Table 2. Characteristics of peat water in Perawang area

Parameter	Unit	Inlet
pH	-	4,26
Color	PtCo	350
COD	mg/L	168
BOD	mg/L	50,6
Organic Content	mg/L	265,44

Peat water analysis after treatment of MSL system

Flow rate variations is performed on the system to give effecZ of peat water analysis.the smaller flow rate it is meancaused contact time between peat water with the material on MSL system isslowly. By giving the aeration system will be improve the reduction effluent concentration in each parameter analysis. Due to given oxygen will increase the microorganisms activity present in the soil in degradation organic compounds contained in peat water [9].

Table 2. Flow rate effect of the analysis parameters in aeration and nonaeration condition

PARAMETER	INLET	UNIT	AERATION (mL/min)				NONAERATION (mL/min)			
			5	10	20	40	5	10	20	40
pH	4,26	-	6,93	6,86	6,76	6,61	6,91	6,84	6,75	6,61
Color	350	PtCo	22,5	30,0	45,0	75,0	25,0	32,5	47,5	75,0
COD	168,0	mg/L	16,00	20,00	27,20	48,80	17,60	22,40	28,80	49,60
BOD	50,40	mg/L	3,20	6,00	8,40	14,40	4,00	7,20	9,60	15,20
Organic content	265,44	mg/L	23,70	31,60	43,82	77,63	29,07	37,13	50,40	83,42

MSL system effeciency of peat water treatment

Where to flow rate variations effect is very significant, because the impact of the contact time between the material in the system MSL with peat water treated. The greater the contact time ,so the greater the efficiency of the MSL in decrease contaminants in the peat water. While to giving aeration on MSL system did not affect too much, which is about 1-2% for each analysis parameter. This indicates that aerobic and anaerobic microorganisms in the system the amount is not much different.MSL efficiency to the all parameters analysis conducted in the peat water treatment influenced by flow rate variations and aeration-nonaeration condition can be show in table 3.

Table 3. MSL system efficiency of peat water treatment by flow rate variations and aeration-nonaeration condition

PARAMETER	MSL System Efficiency (%)							
	AERATION				NONAERATION			
	20 mL. min^{-1}	40 mL. min^{-1}	20 mL. min^{-1}	40 mL. min^{-1}	20 mL. min^{-1}	40 mL. min^{-1}	20 mL. min^{-1}	40 mL. min^{-1}
pH	-	-	-	-	-	-	-	-
Color	93,57%	91,43%	87,14%	78,57%	92,86%	90,71%	86,43%	78,57%
COD	90,48%	88,10%	83,81%	70,95%	89,52%	86,67%	82,86%	70,48%
BOD	93,65%	88,10%	83,33%	71,43%	92,06%	85,71%	80,95%	69,84%
Organic Content	91,07%	88,10%	83,49%	70,75%	89,05%	86,01%	81,01%	68,57%

Naturalized pH peat water : pH peat water is acidic peat before treatment, which is 4.26. Peat water is water that contains organic compounds high so that organic acids in peat water can cause the pH to become acidic. After done peat water treatment using MSL system, obtained pH 6.93 (aeration) and 6.91 (nonaerasi) at a flow rate of 5 mL. min^{-1}. With increasing pH peat water with MSL system indicates that media layers in the system that exist as volcanic soil containing many microbes capable of degrading organic seyawa present in peat water and exhibits at soil which has a capacity for neutralizing the pH [12]. And when seen from MSL system working shows that organic compounds is major cause of water is food for microbes and improve the ability of (development) of the microbes in the MSL system [13].

In Fig.2 can be seen that treatment flow rate variation on the system greatly affect the MSL efficiency in neutralizing the peat water, because the effect of contact time. The greater the contact time is getting smaller flow rates given in the system so that the MSL sytem efficiency of the resulting also high. And by providing aeration treatment to system does not have a significant impact in the neutralizing pH.

Effect flow rate of Neutralization degree of acidity (pH)

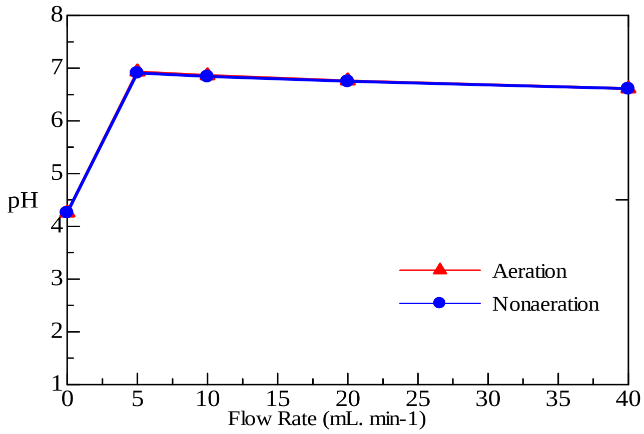

Fig. 2. Effect of flow rate on pH of peat water

The color removal efficiency : Color analysis on the water is one of the physical parameters in determining the water quality. Peat water has a brownish yellow or brownish red color that can not be directly used by the public. The colors on the peat water can also be caused by the presence of Fe contamination which combine with humic acid, will be forming humic metal [2].

Effect flow rate to removal effeciency of color

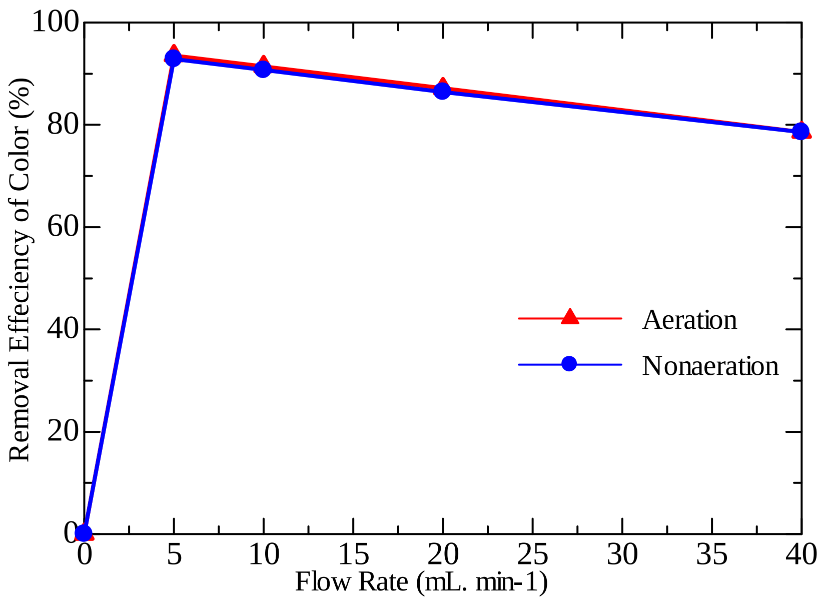

Fig. 3. Removal effeciency of colorof peat water

Color peat water coming from the Perawang, Siak colored yellow brownish color with level 350 PtCo. In Fig.3 shows the MSL system efficiency in lowering peat water color unit is influenced by the flow rate and aeration-nonaerasi conditions. Where MSL efficiency for each flow rate of 5 mL/min, 10 mL/min, 20 mL/min, 40 mL/min was 93.57%; 91.43%; 87.14%; and 78.57% for and 92.86% aeration conditions; 90.71%; 86.43%; and 78.57% in nonaerasi. The flow rate provides a very significant influence on the MSL efficiency in lowering the peat water color. Where the smaller flow rate will be higher MSL efficiency in reducing peat water color, because of the contact time influence between the MSL system with peat water is large. And the aeration and nonaerasi treatment the MSL system also gives a difference. Where the data difference color unit effluent with variations in flow rate ranged from 78.57 to 93.57% for aeration and from 78.57 to 92.86% for nonaerasi, so that aeration effect of about 1-2%. Giving aeration will increase oxygen levels in MSL system, so the conditions become more aerobic and the organic compounds decomposition occurs more frequently [16].

Removal efficiencyCOD of peat water :COD is an important chemical parameters in water as an indication of water pollution by organic substances that naturally can be oxidized through microbiological processes and can be a lack of oxygen dissolved in the water. COD value on the peat water inlet is 168 mg/L. Fig.4 showed that theCOD reduction peat water with flow rate variation of 5 mg/L, 10 mg/L, 20 mg/L, 40 mg/L with an efficiency respectively of 90.48%; 88.10%; 83.81%; 70.95% for aeration and 89.52%; 86.67%; 82.86%, 70.48% for nonaerasi.MSL efficiency in COD decrease on the peat water affected by the contact time between the peat water with MSL system. which of great contacts time will reduce effluent COD or MSL efficiency in reducing the COD peat water. The removal of COD might need amore effective contact between the wastewater and theSMB because it represents slowly decomposable organicmatter [11]. Mbuligwe also reported that in anengineered wetland system, effective contact between thesystem and wastewater was necessary to achieve a hightreatment for COD [21]. By giving aerated will be reduce COD peat water or increase the MSL efficiency.

A high percentage of decrease COD velue by MSL system a large possibility caused by the effects on soil microorganisms to degrade organic substances, besides that it is also useful as a filter and absorbent organic compounds. According to Chen, which MSL uses sawdust in a soil mixture and perlite can be in COD reduction because it can be used as adsorbents, absorption caused by the cellulose content in sawdust. In this MSL system, mixture soil material used is bagasse can also serve as an adsorbent in addition to charcoal [15]. COD reduction may be also influenced by the zeolite, wherein the zeolite useful is filter organic compound and the ion exchange process. According to Chen, which uses sawdust in a soil mixture can be in the COD removal because it can be used as adsorbents, absorption caused by the cellulose content in sawdust [15]. In this MSL, material used is bagasse can also function as an adsorbent caused the bagasse also cellulose about 22.27% [5]. The study by Sato et al, obtained decrease COD percentage of 80.6% aeration system and 74.3% nonaerasi system [16]. It that caused differences the materials mixture and akrelik sizes.

Effect flow rate to removal effeciency of COD

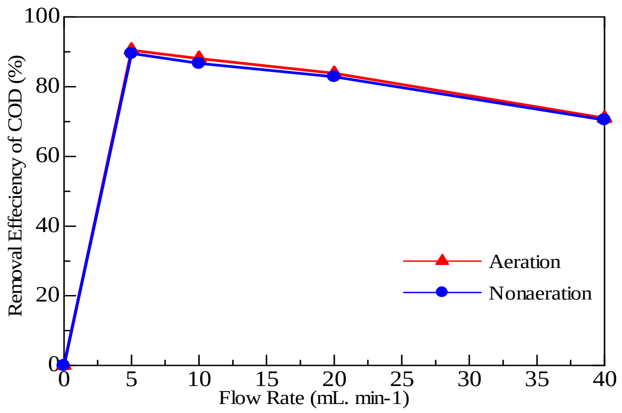

Fig. 4. Removal efficiency of CODofpeat water

Removal efficiency BOD of peat water :BOD peat water before treatment using MSL systems is 50.60 mg/L. Fig.5showed thehigh MSL efficiency at a flow rate of 5 mL/min is 93.09% for aeration and 92.06% for nonaerasi. The higher the flow rate is given, so lower the efficiency of MSL system because the smaller contact time peat water with a material in the MSL system, so that organic compounds decomposition in the peat water by microorganisms is low. And also by making the aeration conditions can be improve MSL efficiency in decomposing organic compounds.

Based on research by Masunaga, using reactor size D10 x W50 x H139 cm with a mixture of soil material Andisol, sawdust and iron with aeration system obtained percentage decreased by 91-98%[17]. Aeration process on research by Masunaga last long so it can be stated that the aeration system can also increase the microbiology activity in decomposing organic compounds in polluted water that goes to the lining of the Land. The BOD efficiency after processing with MSL system is 87.5 to 92.6%, the reactor used is made of akrelit with size (9W50 x H60 x D10) cm and a humus soil material mixture, charcoal, sawdust and iron powder[11]. Penurunaan BOD in the MSL system occurs because of absorption and decomposition process in nature soil. Land has large pores and large surface area. Fungtion soil as microorganisms provider and pore space for the microorganisms accumulation on MSL system. The organic material is a carbon source for microorganisms, the high concentration of BOD in the wastewater can improve the microbes work so that microorganisms can easily form biofilms both in the soil layer as well as zeolit. With the microbes biofilm can help absorption, thus easier the organic material decomposition in the waste [18].

Effect flow rate to removal effeciency of BOD

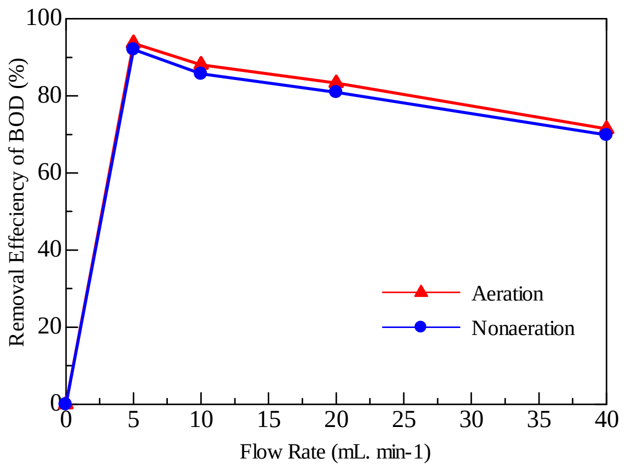

Fig. 5. removal efficiency of BOD of peat water

removal efficiency Organic Content of peat water : Organic matter value peat water in Perawang before treatment by the MSL system 265.44 mg/L. The decrease organic content in the peat water can be done with the MSL system. In Fig.6 can be seen decrease efficiency of organic content with flow rate variations of 5 ml. min^{-1}, 10 ml. min^{-1}, 20 ml. min^{-1}, 40 ml. min^{-1}, respectively of (91.07%); (83.49%); (88.10%); (70.75%) for aeration and (90.12%); (87.20%); (82.72%); (70.05%) anaerasi.

With increasing flow rate will lower the removal efficiency of organic substances by the system, because contact time the peat water with microorganisms in the system will that decompose the organic compounds contained in the raw water peat is decreased with increasing flow rate. By giving the aeration system will increase MSL efficiency. Because it will increase the microorganisms activity of soil in decomposisi organic compounds. The giving of aeration is done after efficiency level decrease and can improve the efficiency of 48.2% to 90.3% [18].

Effect flow rate to removal effeciency of organic content

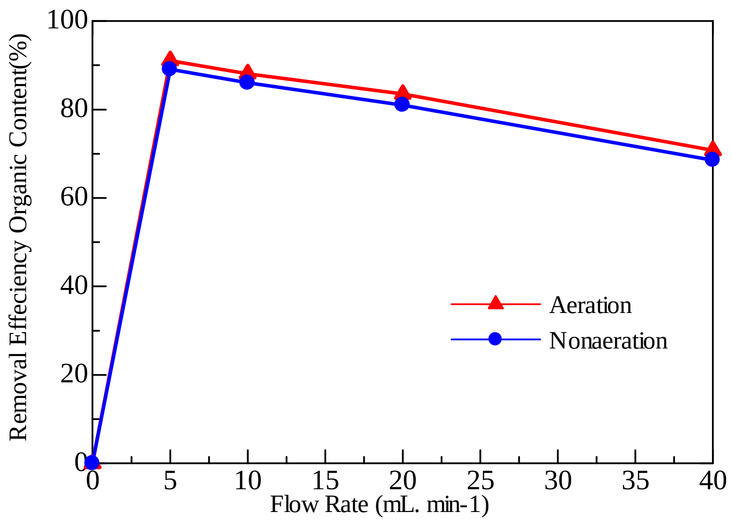

Fig. 6. Removal efficiency of organic content ofpeat water

CONCLUSION

The MSL system is a method for treatment of peat waterconsist from severalmaterials arevolcanic soil, bagasse, charcoal, iron powder and zeolite could improvedof peat water quality on flow rate of 5 mL. $min^{-1}$with removal efficiency of color 93.57%; Turbidity 92.21%; COD 90.48%; BOD 93.65%; organic content 91.07%; with aeration condition, while nonaeration condition of color 92.86%; COD 89.52% BOD 92.06%; organic matter 89.05% respectively.The quality of peat water after treatment with MSL method could used for public consumption but not for drinking water.

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