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Multi Soil Layering (MSL) System for Treatment of Noodle Industry Wastewater

Refilda, Syukrya Ningsih, Matlal Fajri Alif, Zilfa and Rahmiana Zein*

Abstract— Multi-soil-layering (MSL) systems consist of soil mixture layers (SML) such as charcoal, sawdust, iron scraps, volcanic soil with composition (10:10:5:75) and permeable zeolite layers (PL) were constructed in 50 cm (width) × 15 cm (depth) × 50 cm (height) an acrylic box like the brick pattern for removal of phosphate, nitrite, nitrate, oil and grease from noodle industry wastewater. The variations of the wastewater flow rate in the system were 10, 20, 40, and 80 mL min⁻¹ with two processes aeration and non-aeration conditions were evaluated. The results revealed that the aeration assists the removal efficiency of phosphate, nitrite, nitrate, oil and grease on MSL system at flow rate 10 mLmin⁻¹ were 99.43%, 83.65%, 79.43% and 100%, respectively.

Keywords— multi-soil-layering (MSL) system, phosphate, nitrite, nitrate, oil and grease removal.

I. Introduction

Multi Soil Layering (MSL) is a method that can be used for wastewater treatment system designed for enhances the inherent ability of the soil to purify wastewater. The MSL system has high treatment efficiency for municipal wastewater, livestock wastewater and polluted river water treatment that has been reported [1,2,3], these authors reported the characteristics of the MSL system and its applicability to various types of wastewater or polluted water treatments. The MSL system is known to minimize of cost treatment, requiring only a small land, is ideal for urban areas in developing countries [2] it is simple in terms of operation and control, as well as environmentally friendly, because it can be developed mainly from locally available resources, such as soil, sawdust, iron particles, coconut charcoal, and gravel or other rocks of homogeneous sizes that allow a high hydraulic loading rate [4]. The MSL system is effective for the prevention of clogging which are the main constraints in the conventional soil-based wastewater treatment systems [5].

The MSL system has several advantages, among others, were able to reduce the value of BOD, COD, TSS and color, has a high ability to receive and absorb water that flowed into the system, 1000-4000 Lm⁻²d⁻¹ whereas conventional soil 10-40 Lm⁻²d⁻¹, can prevent clogging and does not need -

large area such as a pool treatment [2]. The MSL system constructed in Kasetsart University, Thailand, for food service wastewater treatment showed high removal rates of BOD 90%, TN 70% and TP 90% for wastewater at a loading rate of 250 L/m²/day [6].

From previous studies restaurant wastewater treatment with combination method of Grease Trap and Multi Soil Layering (MSL) has been studied. The highest efficiency for removal grease, nitrite, phosphate, nitrate on grease trap at flow rate of 25 mL/min were equal to 95.40%, 12.91%, 8.65%, 8.02% respectively and MSL could decreased of grease 100% both with aeration and non aeration for all flow rate. At a flow rate of 25 mL/min with aeration, removal efficiency 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 [7]. The efficiency of MSL system with composition volcanic soil, active carcoal, bagasse, iron powder (7.5:1:1:0.5) and zeolite in peat water treatment at flow rate of 5 mLmin⁻¹ is better, it could 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%; 89.005% on non aeration, while for pH could changed from 4.26 to 6.93 for aeration and 4.26 to 6.91 for non aeration [8]. The MSL system capable to remove the tartrazine dye of noodles wastewater with an efficiency were 76.86% and 82.14% in the conditions of aeration and non aeration at a loading rate of 10 mL min⁻¹ [9].

The noodles wastewater consist of liquid organic waste based of raw materials processed from agriculture, such as wheat flour (contains carbohydrates, protein, vitamins, and minerals), palm oil (contains fatty acids include lauric, palmitic, oleic) and tartrazin dyes, dissolved in wastewater [9]. Tartrazine is also reputed to catalyze hyperactivity and other behavioral problems, asthma, migraine, thyroid cancer, etc. Because of its hazardous health effects, foods and drinks containing tartrazine are avoided [10]. In dealing with the waste generated in industrial, waste treatment noodles that have been used in some noodles industrial are using landfill system which needs large area and high operational cost.

In this study wastewater treatment of noodles industrial by using a MSL system with a composition of zeolite, volcanic soil from Mount Merapi of West Sumatera, Indonesian, coconut shell charcoal, sawdust, and the iron powder was investigated. The variations of the wastewater flow rate in the system were 10, 20, 40, and 80 mL min⁻¹ with two processes aeration and non-aeration conditions, the removal efficiency of phosphate, nitrite, nitrate, oil and grease were evaluated.

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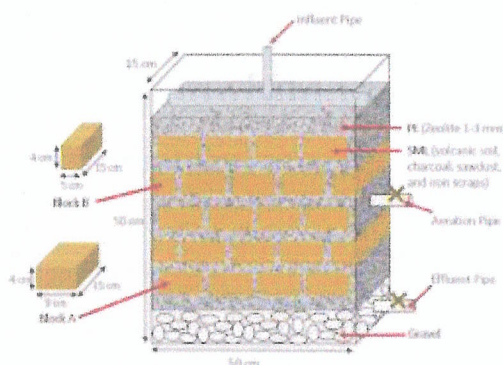


Figure 1. Design of MSL system [9].

II. Materials and Methods

A. Materials of the MSL System

The soil mixture layers of MSL system consist of materials, such as charcoal, sawdust, and iron scraps, were added to the volcanic soil (10:10:5:75) by dry weight, respectively, and the mixture is packed into gunnysacks. The permeable layers used zeolite (1-3 cm).

B. Preparing the MSL System

Fig. 1 shows the structure of the laboratory-scale MSL system used in the present study, these soil mixture blocks are placed into the MSL units in the form of an alternating brick layer-like pattern. Manner within the 50 cm (L) × 15 cm (W) × 50 cm (H) box made with acrylic, the SML blocks were prepared in two sizes. The blocks in the Block A group were 9 cm (L) × 15 cm (W) × 4 cm (H) in size, and those in the Block B group were 5 cm (L) × 15 cm (W) × 4 cm (H) in size.

An SML followed by a PL was repeatedly stacked in the acrylic box to form the MSL system. First, a 5-cm-thick gravel arranged at the base of the box and then covered with plastic net then 5-cm-thick PL layer was paved followed by a 4-cm-thick SML layer. The horizontal intervals between the SML blocks were 2.5 cm, and this interval was filled with the PL material. Next, a 4-cm-thick PL followed by a 4-cm-thick SML was repeatedly packed onto the base layer. Finally, a 5-cm-thick PL was packed at the top of the box to complete assembling the MSL system [9].

C. Treatment of the Sample

The wastewater of noodle industry was used to analysis

of the quality wastewater parameters of pH, phosphate, nitrite, nitrate, oil and grease. In order to predict the ability of the MSL system with performed analysis after treatment of noodle industry wastewater, loading rates were observed, 10, 20, 40, and 80 mLmin⁻¹ at aeration and non-aeration condition

D. Monitoring Water Quality

The Noodle Industry wastewater accumulated in the wastewater box and flowed through into the MSL system,. Some parameters such as pH, phosphate, nitrate, nitrite, oil and grease were evaluated in the effluent to know the water quality [9].

III. Results and Discussion

A. Characteristic of Noodle Wastewater

The characteristics of noodle industry wastewater are shown as (INFLUENT) in Tab. 1. It seems that all parameter analysis is above the quality standard parameters of USEPA wastewater. Based on the characteristics of noodle industry wastewater, it is required for treatment. In this research variation of flow rate on aeration and non-aeration conditions in MSL system were evaluated. The effect of flow rate on concentration is shown in Tab.1. The smaller of flow rate will decrease the concentration parameter, contact between the wastewater and material in the MSL will be longer so that the purification process will be more optimal. Aeration system will be improved the reduction effluent concentration in each parameter analysis. Oxygen will increase the microorganism's activity present in the soil in degradation organic compounds contained in noodle wastewater.

TABEL.1. FLOW RATE EFFECT ON EFFLUENT CONCENTRATION THROUGHT MSL AERATION AND NON AERATION CONDITION

PARAMETER	INFLUENT (mg/L)	Concentration (mg/L)							
		AERATION				NON AERATION			
		10 mL.min ⁻¹	20 mL.min ⁻¹	40 mL.min ⁻¹	80 mL.min ⁻¹	10 mL.min ⁻¹	20 mL.min ⁻¹	40 mL.min ⁻¹	80 mL.min ⁻¹
Tartrazine ^a	252	58.3	64.1	76.4	82.7	45	52.3	58.7	61.5
T-P	125	0.72	0.80	0.83	1.07	0.99	1.09	1.28	1.36
Nitrate	8.03	1.625	2.375	3.063	3.667	2.333	2.833	3.271	3.979
Nitrite	0.48	0.078	0.085	0.098	0.125	0.081	0.099	0.129	0.143
Oil and grease	4	0	0	0	0	0	0	0	0

a. R. Zein. et al. [9]

TABLE II. FLOW RATE EFFECT ON MSL SYSTEM EFFICIENCY OF NOODLE WASTEWATER TREATMENT BY AERATION AND NON AERATION CONDITION

PARAMETER	MSL System Efficiency (%)							
	AERATION				NON AERATION			
	10 mL.min ⁻¹	20 mL.min ⁻¹	40 mL.min ⁻¹	80 mL.min ⁻¹	10 mL.min ⁻¹	20 mL.min ⁻¹	40 mL.min ⁻¹	80 mL.min ⁻¹
Tartrazine ^a	76.86	74.56	69.68	67.18	82.18	79.25	76.98	75.59
T-P	99.43	99.36	99.33	99.14	99.21	99.13	98.98	98.91
Nitrate	79.43	70.42	61.86	54.34	70.95	64.72	59.27	50.45
Nitrite	83.65	82.18	79.45	73.79	83.02	79.25	72.96	70.02
Oil and grease	100	100	100	100	100	100	100	100

a. R. Zein et al [9]

B. The MSL System Efficiency of Noodle Wastewater Treatment

The flow rate variations effect is very significant, because the impact of the contact time between the materials in the system MSL with noodle wastewater treated. The increase the contact time will increase the efficiency of the MSL and decrease contaminants in noodle wastewater. While giving aeration on MSL system did not affect too much, this is about 1-2% for each analysis parameter. This indicates that the amount of aerobic and anaerobic microorganisms in the system is not much different. The MSL efficiency to all parameters analysis conducted in the noodle wastewater treatment influenced by flow rate variations and aeration-non aeration condition can be shown in Tab. 2.

C. pH Analysis

Noodle industrial wastewater is containing organic compounds so that the organic acids in waste can make the pH became lower (pH 4.23). Noodle wastewater has been processed using MSL system obtained pH 8.25 at a loading rate of 10 mL min⁻¹ [9].

In Fig. 2, shows that the loading rate play an important role in changing the pH value of noodles industrial wastewater, where the slower of loading rate, the pH of the wastewater to be much improved from 4.23 to 8.25.

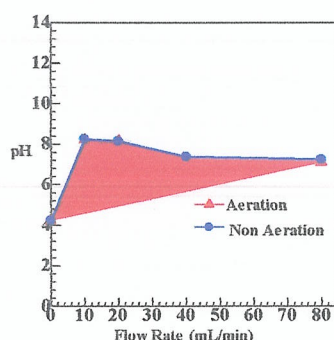


Figure 2. Effect of flow rate on pH of noodle wastewater

If the loading rate slower the contact times of wastewater will longer on the process denitrification by *Nitrobacteria* released hydroxyl ions which will raise the pH value [2]. According to Zein R. et al, The pH of the effluent combination system of grease trap and MSL on the aeration slightly lower than non-aeration process due to nitrification possibility is greater than denitrification [7].

Nitrification is the process of oxidation organic compounds containing N (org-N) into NH₃-N, NH₃-N is then oxidized into NO₂-N and NO₃-N by aerobic bacteria. This process release H⁺ ions that caused the pH of the effluent being lower than non-aeration process. While in the non-aeration process, pH of the effluent becomes greater than the effluent aeration, due to in the denitrification process NO₂-N and NO₃-N were reduced into N₂ gas by releasing OH⁻ ions [13].

D. Removal Efficiency of Total Phosphorus (T-P)

Total phosphorus is one of the important chemical parameter that determines, the T-P value in initial liquid influent data was obtained 125 mg.L⁻¹. Fig. 3. shows the values obtained in the optimum of total phosphorus removal efficiency of aeration and non aeration system were 99.43% and 99.21% at a flow rate of 10 mL.min⁻¹. Soil mixture block contain iron particles which mix in soil to enhance the phosphate adsorption and denitrification functions act as reducing agents [2]. The value of the efficiency of T-P due to in the MSL system adsorption phosphorus layer of soil containing compounds of aluminum hydroxide occurs and also by the iron hydroxide formed from the addition of ferrous metals in the soil mix and this occurs in anaerobic conditions [12]. Phosphorus can be absorbed by the hydroxide of Al and Fe in the soil. Iron is added to the soil layer is converted to the ferrous ion Fe²⁺, which will move into the sieve and oxidized to the ferric ion Fe³⁺ which aims to decomposition PO₄³⁻ in wastewater [13].

Based on research by Masunaga [1], percentage of T-P decreased 63-89% by using the MSL system. MSL system is very effective in allowance due to the ability of the soil phosphate and iron powder as an absorbent or phosphate precipitation. With the aeration of the total phosphorus removed with the help of iron hydroxide in phosphate binding [13].

E. Removal Efficiency of Nitrate

Based on Fig. 4, the removal efficiency of nitrate (NO₃-N) in the noodle wastewater using MSL system were 70.95% for aeration and 79.43 % for non aeration at a flow rate 10mLmin⁻¹. Nitrification is the aerobic oxidation process ammonium compounds into nitrate and nitrite catalyzed by microbial nitrification. Nitrification bacteria, among others: *Nitrosomonas europae* and *Nitrobacter spp* [15].

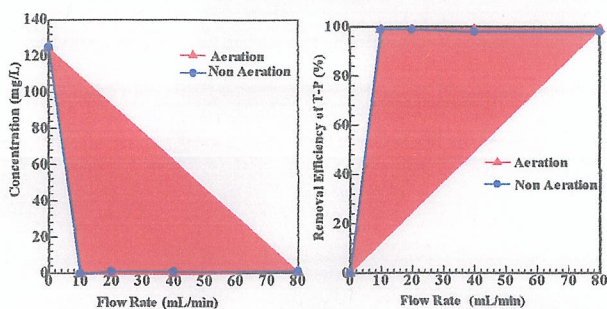


Figure 3. T-P removal concentration and efficiency of noodles wastewater after treated with aeration and non aeration MSL system

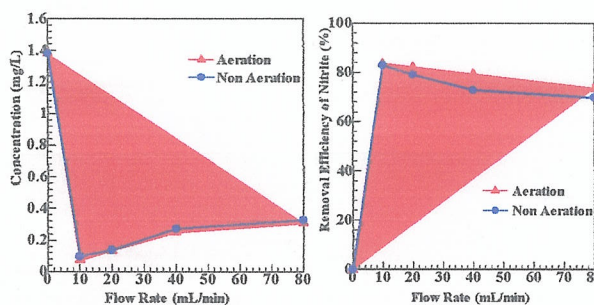


Figure 4. NO₂-N removal concentration and efficiency of noodles wastewater after treated with aeration and non aeration MSL system

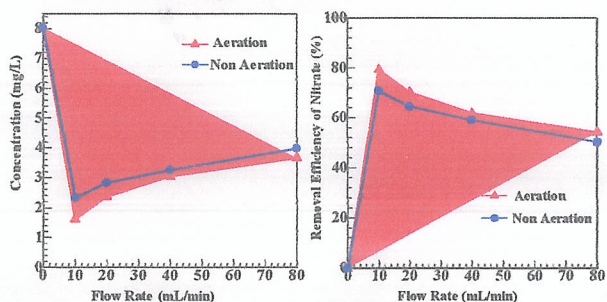


Figure 5. NO₃-N removal concentration and efficiency of noodles wastewater after treated with aeration and non aeration MSL system

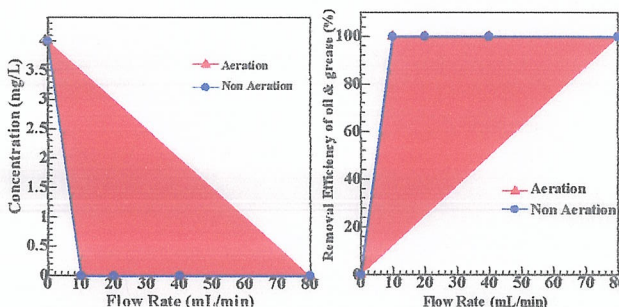


Figure 6. Oils and grease removal concentration and efficiency of noodles wastewater after treated with aeration and non aeration MSL system

F. Removal Efficiency of Nitrite

Based on the Fig. 5, the removal efficiency Nitrite (N-NO₂) on the condition of aeration and non aeration were 83.65 and 83.02%. Sato [11] conducted a water and purification wastewater to see a decrease Nitrite, where a reduction in the concentration of nitrite after processing with MSL system with varying sizes. This may be due to the system denitrification process occurs under anaerobic conditions where bacteria denitrification utilizing nitric compounds in the process of respiration which is then converted into nitrogen gas.

Aeration condition at the right level and the optimal duration significantly increases the elimination of Total Nitrogen (TN). However, excessive aeration has an adverse effect on the removal of TN by inhibiting the process of denitrification [4, 13].

In the MSL system, a block of soil mix with a bunch of sawdust and charcoal as a source of nutrition of the bacteria, so these bacteria work well in the process of denitrification in the MSL system. The nature of nitrite unstable, it is easy to turn into nitrates in the wastewater and it is also possible that the total ammonia is decomposed into nitrite in the nitrification few in number, so that nitrite produced become slightly [3,14].

G. Removal Efficiency of Oil and Grease

Filtration and adsorption process plays a role in the allowance for oils and greases, especially the mixture of soil and zeolite. Edwin [16] in his research said that the removal efficiency of oil and fat in the MSL system 1 (layer of soil mix Andisols and charcoal) ranged from 27.778 to 89.474% and the MSL system 2 (layer of soil mix Andisols with

sawdust) ranged from 23.810 to 62.500%, it can be concluded that the removal efficiency of oil and greases shown to be affected mixture of soil and organic material on a layer of anaerobic system.

iv. Conclusion

The MSL system that was constructed has contributed in decreasing levels of phosphate, nitrite, nitrate, oil and grease at flow rate 10mL.min⁻¹ and raising the pH of the Noodle Industry wastewater with aeration and non aeration condition.

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