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

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ABSTRACT

The, Multi Soil Layering (MSL) system was evaluated for treatment of Tofu industry waste water. MSL installed using a box acrylic, with dimensions are 50 cm (width) × 15 cm (length) × 50 cm (height), consist from a mixture of volcanic soil, charcoal, iron powder, rice straw was made like a brick pattern and Permeable Layers (PL) of zeolite with diameter 3-5 mm. The treatment process was studied on effect flow rate were 15, 30, 60, 120 and 240 mL/min, aerobic and anaerobic. As the result was found the removal of TSS, BOD, COD and pH in tofu waste water at flow rate 15 mL/min on aerobic system were 99.47%, 94.65%, and 99.41%, respectively and pH was changed from 4.18 to 6.79, while for anaerobic system were 96.69%, 35.70%, 57.97% and pH from 4.18 to 4.62. In generally, MSL system could be used for treatment of tofu industry wastewater.
Keywords: Multi Soil Layering (MSL); Zeolite; Rice Straw; Tofu Industry Wastewater.

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INTRODUCTION

Tofu is one type of protein foods with basic ingredients soybeans as highly favored by Indonesian caused it has containing high nutrition, taste good, affordable and has easy for processing. Wastewater of tofu industry has big problem if discarded directly to environment such as the environment has bad odor, bad colour, low aesthetics. Wastewater in small industry generally does not have a waste treatment facility, where wastewater directly discharged into sewers or rivers without treatment. The tofu industry uses a huge amount of water since producing 540 kg of tofu requires 500 kg of soybeans and 11,000 L of water. This process produces around 9,000 L of wastewater [1, 2]. More than 90% of the water used is wasted [3]. This huge amount of waste could cause serious environmental issues. Some of the issues that could be caused by wastewater from tofu production are ecosystem damage, extinction of certain organisms, decreased quality of water, and many others.

The wastewater contains a large amount of organic substances. Its COD and BOD reach as high as 27,440 and 9800 mg/L, respectively [4]. High COD content causes the wastewater to have the potential to be converted into biogas. Biogas can be produced from various anaerobic process [5]. The biogas produced might be directly used for its heat energy, electricity, and many others [6].

Various methods have been used to process tofu wastewater, such as the up flow anaerobic filter process (UAFP), up flow anaerobic sludge blanket (UASB), anaerobic attached-film expanded-bed reactor (AAFEB), anaerobic fluidized bed reactor (AFBR), anaerobic mixed microflora under thermophilic conditions, activated carbon adsorption, chemical oxidation and biological digestion [6,7]. However, each of these techniques use is limited and less profitable. For example, activated carbon only involved pollutants adsorption without decomposition, chemical oxidation could not mineralization all organic compounds and biological processing has some disadvantages such as the reaction speed is slow, difficult activated sludge disposal; pH and temperature should be controlled. An organic waste treatment technique is more effective, efficient, easy and cost necessary to develop a method Multi Soil Layering (MSL).

A MSL is a method to improving the function of the soil for organic wastewater treatment. Soil is a biological, physical, and chemical system that has been used for the recycling and waste management long time ago. The utilities of land not only as a medium for plant growth but also for disposal of animals, humans and industry waste. MSL method is a system by using soil, zeolite, and charcoal as a source of carbon arranged in a pattern like bricks and use as a source of oxygen aeration pipe [8].

Some studies used MSL as a method in the treatment of wastewater, Sato et al [9] examined the movement of water in the system MSL using zeolite and soil mixtures, which are arranged in acrylic size (50cmx10cmx73cm) with the result of the removal of COD and phosphorous will be decreased, Pattnaik et al [10] used the Leilehua soil as aerobic MSL system first, perlite for MSL system second, while for anaerobic system the composition of the layer was used a mixture of honouliuli soil, charcoal, sawdust and iron powder for each system with removal N inorganic almost the same for each of the system is 22%-93% (honouliuli soil) and 21%-96% (perlite), while for the removal of phosphates 64%-99% (honoliuli soil) and 9%-97% (perlite). From this study showed that the MSL system capable of removing inorganic N and phosphate from dairy waste. Ho C. C., et al [11] has been carried out using the MSL system with material composition comprising a layer of a mixture of sandy clay (Sandy Clay) 75%, carbon 10%, rice bran 5%, iron powder 10%, reported can reduce the content of TSS, BOD, COD, Total nitrogen, Ammonium, Total phosphate from waste water septic tank 70% to 90%. Zein, R et al [12] also used a system of MSL on sewage restaurants treatment at a flow rate of 25 mL/min with removal efficiency of nitrite 86.44%, nitrate 92.53%, phosphate 97.75% on aeration condition and nitrite 64.21%, nitrate 83.98% and phosphate 79.75% on no aeration condition. Zein, R, et al [13] reported processing of peat water into fresh water with MSL using zeolite, volcanic soil mixed with activated charcoal, bagasse, iron powder with a ratio (7.5: 1: 1: 0.5), the results showed on a flow rate of 5 mL/min is very effective in removing color, COD, BOD, organic content respectively 93.57%, 90.48%, 93.65%, 91.07% by aeration and 92.86%, 89.52%, 92.06%, 89.05% are non-aeration condition. Previous research indicated that MSL system has the ability to decrease COD, BOD and TSS in wastewater. In this study designed a MSL system using rice straw as a carbon source for tofu industry wastewater treatment.

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MATERIALS AND METHODS

Instrument: MSL system and pump were used for treating tofu industry wastewater, pH meter (Hanna), BOD Incubator (Hanna), BOD bottles, analytical balance, Winkler bottles, oven, spectrophotometer UV-Vis (Shimadzu double beam UV-170) were used to determined pH, TSS, BOD and COD in sample.

Materials: Tofu industry wastewater used in this study was taken from the tofu industry in Payakumbuh, West Sumatra Province. Zeolite (3-5 cm) was used as permeable layers (PL), volcanic soil, rice straw, iron powder, coconut shell charcoal, sulfuric acid (H_2SO_4) pa, potassium dihydrogen phosphate (KH_2PO_4), NED dihydrochloride, ferrous ammonium sulfate (FAS) {Fe $(NH_4)_2(SO_4)_2.6H_2O$}, potassium permanganate ($KMnO_4$), potassium iodide (KI), indicators ferroin, potassium chromate (K_2CrO_4), sodium thiosulfate ($Na_2S_2O_3.2H_2O$).

Methods

Preparing Soil Mixture Layers (SML).

SML consist of 400 g materials that contained charcoal, rice straw powder, iron powder and volcanic soil with composition ratio (1:1:0.5:7.5), the mixture was packed like a brick pattern as shown at Figure 1., with dimension 9cm (L) x 15cm (W) x 4cm (H).

Figure 1. Soil Mixture Layer (SML) Block

Preparing MSL System:

MSL system was prepared according [12,13,19]. Design of MSL system can be seen in Figure 2.

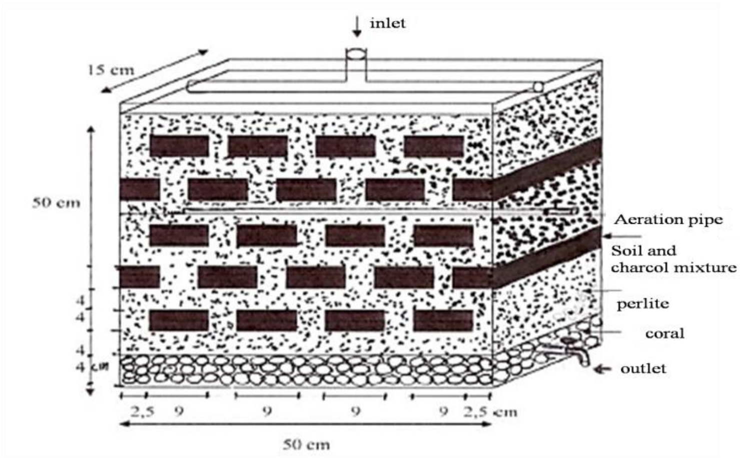


Figure 2: Design of MSL system

Tofu industry wastewater treatment by MSL system

The MSL system was used for treatment of tofu industry wastewater with the drainage system. Streaming samples using some variation of flow rate at 15, 30, 60, 120 and 240 mL/min with aeration and non aeration conditions, flow rate of air for aeration was flowed by pump 1 L/min. Chemical parameters such as pH, TSS, BOD, COD in tofu industry wastewater were analyzed before and after treating by the MSL system.

RESULTS AND DISCUSSION

Characteristic of tofu industry wastewater

Tofu industry wastewater before processing by MSL system was analyzed. The pH value, TSS, BOD and COD is shown in Table 1, it can be seen that the pH value of tofu industrial wastewater before processing by the MSL system was 4.18. The pH value is below the standard quality regulation for water that ranged between pH 6.0–9.0. Tofu industry wastewater condition is known acidic condition; it was caused by acetic acid (CH_3COOH) that used at coagulation process.

Table 1. Characteristic of tofu industry wastewater before treatment with MSL system

Parameters	Unit	Tofu industry wastewater
pH	-	4.18
TSS	mg/L	6442
BOD	mg/L	1720
COD	mg/L	22742

Value of TSS, BOD and COD in tofu wastewater before treatment were shown in Table 1. The value of test results of these parameters higher than standard quality of water regulation, TSS 200 mg/L, BOD 100 mg/L, COD 300 mg/L. The high value of TSS, BOD and COD in tofu industry wastewater was caused by organic compounds. Wastewater from tofu production has a value of COD of around 6,500–8,500 mg/L [14].

Effect flow rate of tofu industry wastewater on pH at MSL system

The pH scale indicates the concentration of hydrogen (H^+) in solution. Tofu industry wastewater pH before contacted with the MSL system was 4.18. Figure 3 showed that the variation of flow rate of tofu industry wastewater in aeration and non aeration condition of MSL system affected the pH value. Tofu industry wastewater before released into the system MSL is acidic; it was caused of the organic compounds in wastewater containing dissolved anions witch reacts with H^+ ions, resulting in a pH of waste water into acid [1]. The optimum condition of tofu industry wastewater treatment was pH 6.79 on the condition of aeration with a flow rate of 15 mL/min. This is due to the administration of oxygen (aeration) to the system MSL, and the contact time is longer, will optimize the work of the aerobic bacteria present in the soil media and zeolite, so that the organic compounds contained in tofu wastewater reduced, resulting in a pH of waste near the pH neutral.

The effect of flow rate on reducing pH in aeration and non aeration conditions of the MSL system was caused of soil as a media layer system has high capability of neutralizing (buffering capacity) on physical and chemical changes conditions, due to the activity of microorganisms and the physical reaction when the wastewater processing mechanisms in the MSL system[15]. In addition, the soil has cations exchange ability, such as bases cations; Ca^{2+}, Mg^{2+}, Na^{2+} and K^+ and acid cation; H^+ and Al^{3+} so that, if the ground under acidic conditions, there will be exchanges acid cation with cation bases and conversely, if the ground under alkaline conditions will occur bases cation exchange with acid cation. The existence of such exchanges can lead to changes in pH, both the pH changes caused by the soil itself, such as the occurrence of weathering, and is caused by the presence of other substances contained in or pass through the soil [16].

From the results, MSL system has the ability to neutralize the pH of tofu industry wastewater, with utilized soil functions and optimized the work of microorganisms found in the soil, according to Zein.R et.al [12] MSL system could raise the pH of the peat water from 4.26 to 6.93 on aeration and 6.91 on non aeration condition.

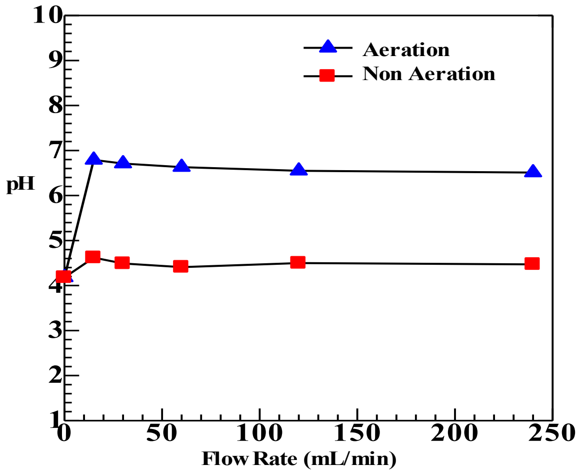


Figure 3. Effect flow rate of tofu industry wastewater on pH at MSL system

Effect flow rate of tofu industry wastewater on Total Suspended Solid at MSL system.

The tofu wastewater has a very high content of TSS, because it contains organic materials including proteins and amino acids, in the form of suspended solids and dissolved. Figure 4 show that the MSL system capable for removal of TSS at flow rate 15, 30, 60, 120, and 240 mL/min were 99.47%; 99.34%; 99.07%;%; 98.17%; and 97.98% on aeration and 99.69%; 96.49%; 95.68%; 95.95%; and 95.59% on nonaeration conditions, respectively, it was caused the MSL system installed with zeolite and soil has variety of pore size, a filter and adsorbent [9, 17]. According to Zein R, et.al [19], TSS was decreased 97.41%.

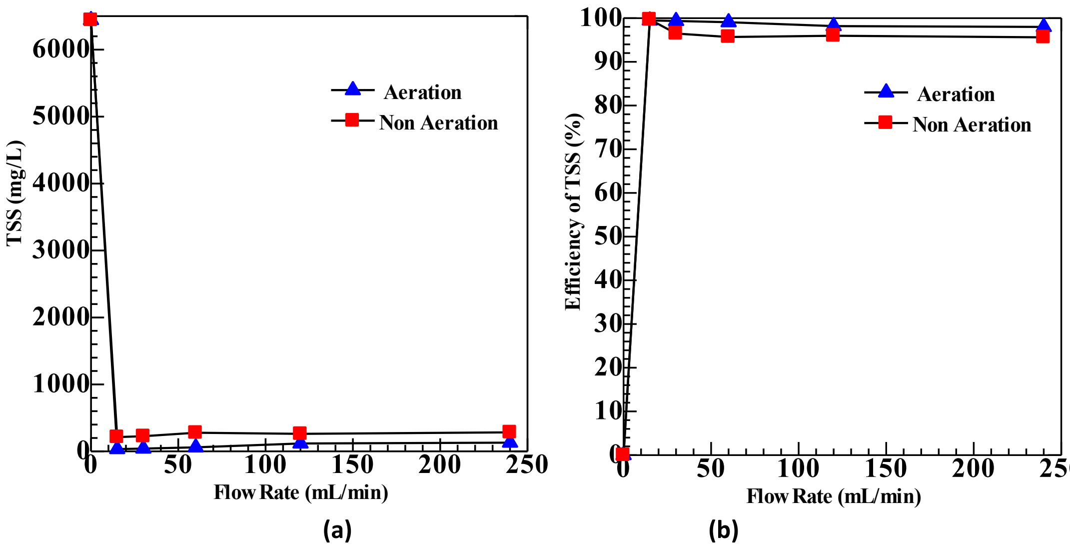
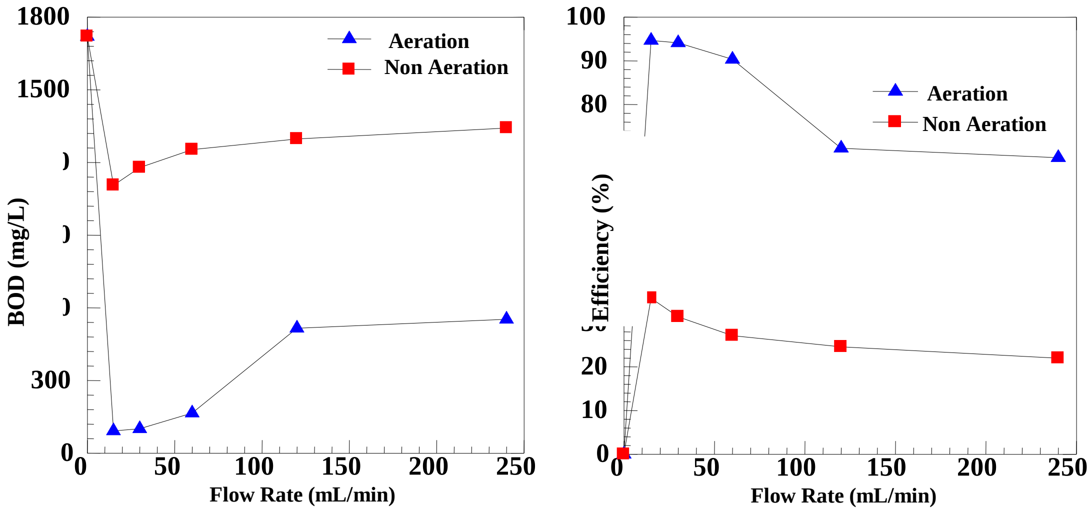


Figure 4. Effect flow rate of tofu industry wastewater on (a) TSS concentration and (b) removal efficiency of TSS at MSL system.

Effect flow rate of tofu industry wastewater on Biochemical Oxygen Demand (BOD) at MSL system

Biochemical oxygen demand (BOD) is a way to characterize the amount of dissolved oxygen required microorganisms for organic matter degradation under aerobic condition. Decomposition of organic material by microorganisms interpreted that, organic matter used microorganisms as food and energy, obtained from the oxidation process. The BOD measures the quantity of oxygen required by bacteria to biologically oxidize organic matter by aerobic conditions [20]. Figure 5. shown the concentration and the efficiency MSL system for tofu wastewater treatment with flow rate variation in the conditions of aeration and non aeration. According to Sato et.al [18], that the MSL system has excellent capabilities in reducing organic compounds and nutrients. The initial BOD of tofu wastewater is 1720 mg/L. The efficiency of MSL system in reducing BOD concentrations of tofu wastewater at flow rate of 15, 30, 60, 120, and 240 mL/min were 94.65%; 94.13%; 90.35%; 70.00% and 67.85% on aeration, and 35.70%; 31.45%; 27.15%; 24.59%; and 21.98%, on non aeration conditions, respectively,. Optimum flow rate is 15 mL/min on aeration and non aeration, it was caused the provision of oxygen and a longer contact time between tofu wastewater with a layer of soil at MSL system.

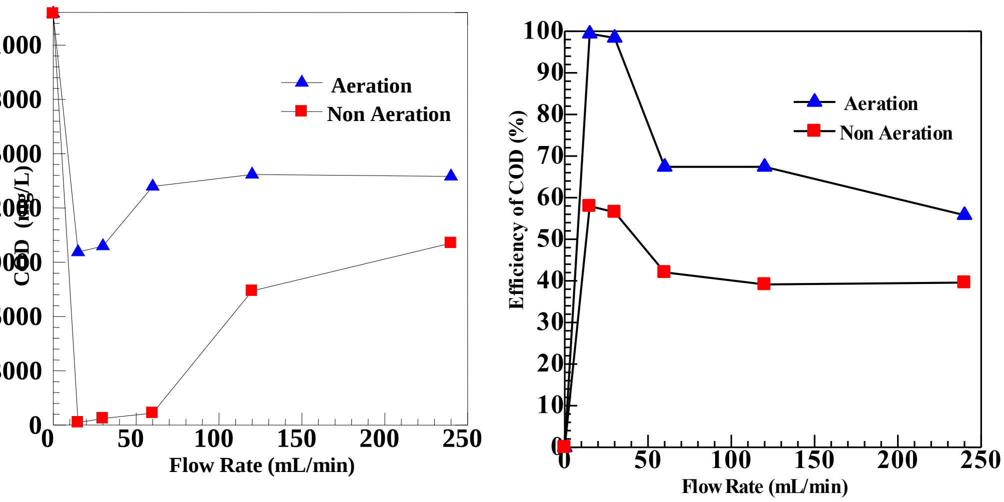


(a) (b)

Figure 5. Effect flow rate of tofu industry wastewater on (a) BOD concentration and (b) removal efficiency of BOD

Effect flow rate of tofu industry wastewater on Chemical Oxygen Demand (COD) at MSL system

COD is the amount of oxygen required to oxidize organic substances present in water samples into CO_2 and H_2O. Whereas the numbers of COD is indication and parameter of water pollution by organic substances that naturally can be oxidized through microbiological processes. Figure 6 show the efficiency of MSL system in reducing COD concentrations of tofu wastewater at flow rate of 15, 30, 60.120, and 240 mL/min were 99..41%; 98.39%; 97.10% 67.39%; and 55.80% on aeration, and 57.97%; 56.52%; 42.03%; 39.13%; and 39.58%, on nonaeration conditions, respectively,. Optimum flow rate is 15 mL/min on aeration and non aeration, it was caused the provision of oxygen and a longer contact time between tofu wastewater with a layer of soil at MSL system. According Wakatsuki et al., [8] that the longer the contact time on the process at MSL as decomposer, will occur much longer anyway, thus decreasing the concentration of COD will be more perfect.



(a) (b)

Figure 6. Effect flow rate of tofu industry wastewater on (a) COD concentration and (b) removal efficiency of COD

Chemical analysis of tofu industry wastewater before and after treatment with MSL system

From Table 2. the concentrations of TSS, COD and BOD in tofu industry wastewater before processing with MSL system were very high. The value of TSS, COD and BOD were 6442; 22742; 1720 mg/L respectively, but after processing with MSL system, the concentration of TSS, COD, and BOD decreased to 34; 135.1; 92 mg/L on aeration and 213; 1106; 9558 mg/L on non aeration condition at a flow rate of 15 mL/min. Because the contact times of tofu wastewater with constituent material of MSL system was long, so the outlet water almost perfectly degraded.

Table 2: Chemical parameter in tofu industry wastewater before and after treatment with MSL system on aeration and non aeration condition with flow rate 15 mL/minutes

Parameter	Unit	Tofu industry wastewater before treatment	Tofu industry wastewater after treatment with MSL system	
			Non aeration	Aeration
pH	-	4.18	4.62	6.79
TSS	mg/L	6442	213	34
BOD	mg/L	1720	1106	92
COD	mg/L	22742	9558	135.1

Table 3: Efficiency of MSL system for tofu industry wastewater treatment on aeration and non aeration condition with floe rate 15 mL/minutes

Parameter	Tofu industry wastewater (mg/L)	Removal efficiency of MSL system for tofu industry wastewater treatment	
		Non aeration	Aeration
		%	%
TSS	6442	96.69	99.47
BOD	1720	35.70	94.65
COD	22742	57.97	99.41

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CONCLUSION

MSL system could used for treatment of tofu wastewater better on aeration condition and flow rate 15 mL/min for increasing the pH and decreasing of TSS,BOD and COD content.

REFERENCES

[1] Faisal M, Machdar I, Mulana F, and Daimon H. *Asian Journal of Chemistry* 2014; 26: 6601-6608.
[2] Faisal M, Gani A, Mulana F, and Daimon H. *Asian Journal of Chemistry* 2016; 28: 501-508.
[3] Lay CH, Sen CH, Huang SC, Chen CC, and Lin CY. *Renewable Energy* 2013; 6: 58-60.
[4] Zhu H, Suzuki T, Tsygankov AA, Asada Y, Miyake J. *Int. J. of Hydrogen Energy* 1999; 24: 305-310.
[5] Faisal M, Gani A, Mulana F, and Daimon H. *Res. J. of Pharm, Biol and Chem. Sci 2015;* 6: 1053-1059.
[6] Starr K, Gabarrell X, Villalba G, Peiro LT, and Lombardi L. *Biomass and Bioenergy* 2014; 62: 2043-2049.
[7] Kim MS, Lee DY, and Kim DH. *Int. J. of Hydrogen energy* 2011; 36: 8712-8719.
[8] Wakatsuki T, Esumi H, Omura S. *Water Sci. Tech* 1993; 27: 31 – 40.
[9] Sato K, Masunaga T, Wakatsuki T. *Soil Sci. Plant Nutrition* 2005; 51: 75-82.
[10] Pattnaik R, Yost RS, Porter G, Masunaga T, Attanandana T. *Ecological Eng* 2007; 51: 342-249.
[11] Ho CC, Wang PH. Int. J of Environ. *Res. and Public Health* 2015; 12: 3362-3380.
[12] Zein R, Suhaili R, Novita L, Mukhlis, Ningsih S, Swesty N, Novrian H. *Res. J of Pharm. Bio and Chem . Sci* 2016; 7: 71-79

[13] Zein R, Mukhlis, Neneng S, Lidia N, Erick N, Syukria N, Syukri. *Der Pharma Chem* 2016; 8: 254-261.
[14] Faisal M, Gani A, Mulana, F, and Daimon H. *Rasayan J. Chem* 2016*;* 9: 133-138.
[15] Masunaga T. *Proceeding First IWA Asia-Pacific Regional Conference, Asian Water Equal 2001:* 52*:* 123-128.
[16] Merry RH. *Environ. and Eco. Chem 2009;* 2: 176-181.
[17] Luanmanee S, Boonsook P, Attanandana T, Saitthiti B, Panichajakul C, and Wakatsuki T. *Eco. Eng* 2002; 18: 415-420.
[18] Sato K, Iwashima N, Matsumoto T, Wakatsuki T, and Masunaga T. *Proceedings of the 19th World Congress of Soil Science: Soil solutions for a changing world* 2010*;* 12: 1-6.
[19] Zein, R, Zilfa, Syukria N, Lidya N, Neneng S, Mukhlis, Novrian H. *Res. J of Pharm. Bio and Chem. Sci 2016;* 7: 88-94.
[20] Faisal, M, Gani A, Mulana F, and Daimon H. *The Proceedings of The 4th Annual International Conference Syiah Kuala University (AIC Unsyiah)* 2014*;* 3: 23-31.