

Improving quality of textile wastewater with organic materials as multi soil layering

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Abstract. On agricultural land, fresh water is needed especially for irrigation. Alternative ways to fulfill needs of fresh water is by utilizing wastewater from industry. Wastewater that produced in the industry in Surakarta is over flowing especially textile wastewater. Wastewater that produced from industry has many pollutants that affected decreasing fresh water quality for irrigation. Multi Soil Layering (MSL) is one of method that utilize the soil ability as main media by increasing its function of soil structure to purify wastewater, so it does not contaminate the environment and reusable. This research was purposed to know affectivity of organic materials (such as rice straw, baggase, sawdust, coconut fibre, and corn cob) and dosage (5%, 10% and 25%) in MSL, also get alternative purification ways with easy and cheaper price as natural adsorbent. This study using field and laboratory experiment. The result shows that MSL can be an alternative method of purification of wastewater. The appropriate composition of organic materials that can be used as adsorbent is MSL with wood sawdust 10% dosage because it can increase pH, decrease the number of Cr, ammonia, and phosphate but less effective to decrease BOD and COD.

1. Introduction

Needs for fresh water is increasing every year, it also gives an impact on the agricultural sector. Wastewater utilization is alternative ways to appropriately irrigation needs. According to Supriyadi (2013) waste is the usually outcome of the production process, both industrial and domestic, can also be produced by nature or classified as having no economic value [1].

Wastewater generated from the industry in the region of Surakarta is large in amount, especially the textile waste. Industrial wastewater usually contains many contaminants including heavy metals that can pollute main waterways receiver. The pollution gives impact on the quality of water, especially for irrigation.

Wastewater treatment systems in various countries around the world have been using physical, chemical, and biological properties of soil. Multi Soil Layering (MSL) applied might do purification of waste from natural materials. MSL is a kind of method that utilizes the ability of the soil as the main medium to enhance its function through the structure of soil to fresh wastewater so can decrease pollutant in the environment. MSL method is formed in a coating construction ground with rocks, organic minerals and other materials as bricks compiled with zeolite for treating wastewater by flow through the wastewater into the structure of the layer. A layer of soil mixture act as part of



anaerobic and rock layers act as part of aerobic [2-4].

Andisols in Indonesia still rarely used as water purification, actually it has a very good ability to adsorb pollutant. Andisols is expected to help the purification of wastewater if used in the MSL, so that wastewater can be fully utilized. Andisols is the kind of soil that has many short-range order minerals such as allophane, imogolite, ferrihydrite, or Al-humus complexes [5]. Allophanes are aluminosilicate minerals such as clay contained in the soil has a high adsorption for heavy metals [6].

According to Pranoto et al. (2013), Andisols in some volcanic mountains in Indonesia such as Papandayan, Arjuna, and Willis contain allophane [7]. Allophane has great ability to adsorb heavy metals. Activation of allophanes by NaOH is needed to increase heavy metals adsorption. Heavy metal level such as Fe, Mn, Cr, Cd, Cu, and Pb proved to be lowered percentages. Utilization of allophane in Andisols soil can be expanded on Multi Soil Layering. Based on these problems then conducted an experiment to determine effectiveness and efficiency of the organic materials that used in the MSL and compose the appropriate dosage for application in liquid industrial waste treatment.

2. Materials and Methods

2.1. Materials and Tools

Andisols used for MSL was taken from Lawu Mountain, which had altitude about 900 meters above the sea. Organic materials used include: rice straw, corncob, sawdust, coconut fibre and baggase. Other materials, which support this MSL, are zeolite, iron sands, and adhesives. Textile industry waste water sample obtained from batik industry factory in Sukoharjo, with sampling in the waste outlet reservoirs tub that circulated.

2.2 Research Method

This research through several phases including: soil sampling, experimental in greenhouse and laboratory analysis. This study uses the basic design of completely randomized design (CRD) with type 2 factorial experiment. The first factor is the type of organic material used and the second factor is the dosage of organic materials. The first factor: the type of organic materials, including: B1 (rice straw), B2 (baggase), B3 (sawdust), B4 (coconut fibre), B5 (corn cob). The second factor is dosage of organic materials, with 3 levels: P1 (5% dosage), P2 (10% dosage), P3 (25% dosage).

Research data were analyzed with SPSS 16.0 software applications and Excel 2007. Research data were analyzed using an ANOVA F test with a 5% level to determine differences between the treatments of the data calculation. If there is a significant difference in treatment then followed by Duncan's Multiple Range Test (DMRT) at the level of 95%. Another test that related to this research maybe applied, such as correlation test used to determine the relationship between variables, and Principal Component Analysis (PCA) used to determine the variables that influence.

2.3 Soil Sampling

Soil samples used in this study came from the area around an altitude of 900 m above sea level, from Lawu, sampling is done by using a drill ground at some point in a different location by first separating about 60 cm layer of soil over the top of the darkened colour.

2.4 Making Multi-Soil Layering

Early stages of MSL are to prepare bricks made from a mixture of organic materials according to treatment, with a brick size 15 cm x 10 cm x 3 cm. Furthermore, container / jar that is used for the manufacture of MSL. The size of container/plastic jars used were 22 cm x 22 cm x 22 cm. The containers then fitted with a hole on one side near the base of it, then it fitted with a hose to the outlet of the wastewater.

MSL is formed by arranging the bricks that were produced alternately with zeolite. Given base layer of zeolite ± 2 cm, then placed the bricks that have been previously prepared. The next layer is a zeolite with a thickness of ± 1 cm and continued laying a second layer of bricks. Provision is also

made for the zeolite third layer with a thickness of ± 1 cm and then topped with a hose to aerator. Giving hose laying bricks followed by a third layer and the top layer was closed using a zeolite with a thickness of ± 2 cm. MSL layout can be viewed in Figure 1.

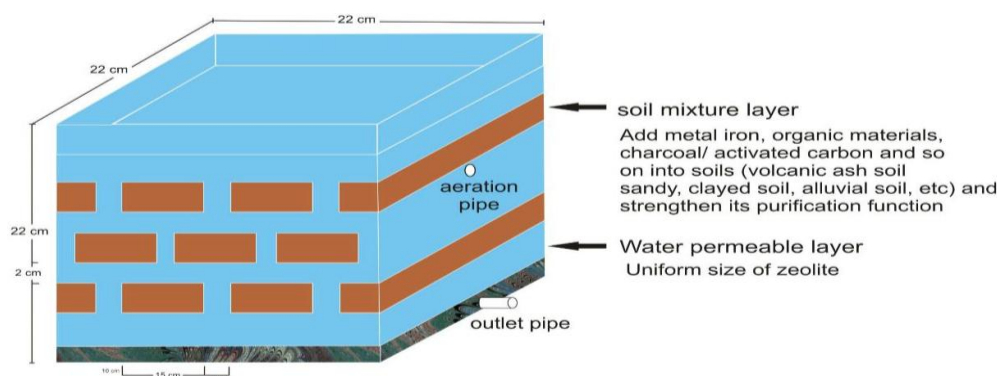


Figure 1. Multi Soil Layering Layout.

Application of wastewater to the MSL, first, wastewater is fed to the MSL ± 2 L in each container. Second, put 2.5 L of wastewater derived from the pre-experiment conducted in order to produce the amount of output ± 600 ml of waste water which will be used in the analysis. Then, output of wastewater put in bottle to make easier when saving the samples.

2.5 Testing the performance of Multi Soil Layering

The results of the analysis of each application variables in the MSL as compared with that previously contained in the wastewater. The performance of the MSL can also be seen from the comparison between the control treatments with a variety of other treatments in MSL testing.

3. Result and Discussion

The presence of the waste usually came from the production process, both industrial and domestic (household, for example: garbage), it can also have a negative impact on the environment and human health. Textile industry such as “Batik” is also generating the waste from the washing. The process raises a large wastewater and containing the rest of the colours, high BOD, high oil and toxic content. Required treatment of the wastewater is by recycling.

The recycling process can be divided into three phases: physics, chemistry, and biology. One method that can be used decrease toxicity content in wastewater is used Multi-Soil Layering (MSL). The performance of the MSL can be known through the results of the analysis of pH, ammonia content, content of dissolved phosphate, chromium content, BOD and COD level, and physical testing (colour and odour).

3.1 pH effluent on the MSL

Preliminary analysis of the wastewater samples showed that the pH value of the sample is 10.7 pH of laboratory test results presented in Figure 2 shows the average of pH value on the three replicates on each treatment.

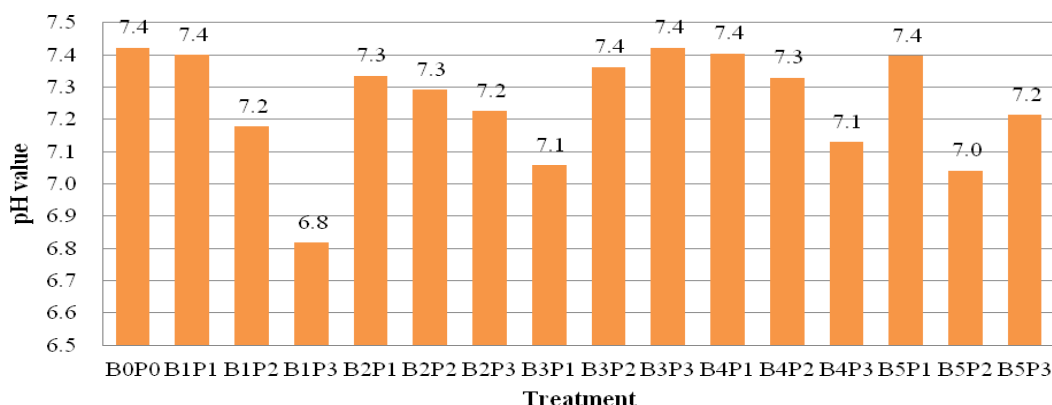


Figure 2. Average of pH value in MSL.

The lowest pH value was 6.8 contained in the MSL with 25% dosage of rice straw organic material (B1P3), while B0P0 and B3P3 have the highest pH value (7.4). B0P0 is a control and B3P3 is a combination of residual sawdust with 25% dosage. B0P0 (controls) have a tendency to high pH because although it does not use a mixture of organic materials but are in MSL zeolite. According to Yulianto et al. (2009) the addition of rice straw can reduce the pH value [8]. The pH value can also affect the process of removal of chromium (Cr) in wastewater. The pH value was effective in lowering serum Cr levels was 6.0 to 9.5 [9].

3.2 Chromium (Cr) value on the MSL

Based on Cr laboratory test result, which presented in Figure 3 shows average value of the three replicates of Cr on each treatment. The highest value of 1.58 ppm Cr contained in B0P0 (control), while the lowest value of 0.09 ppm found in the MSL with corncob organic materials at 10% dosage (B5P2). Maximum allowable levels of chromium for the textile industry waste is 2.0 mg/l based on Badan Pengendalian Dampak Lingkungan (BAPEDAL) [10]. Although it appropriates quality standards, Cr has an accumulative character in nature, so it should be removed from the water. Chromium is a dangerous element found in the earth's surface and the condition of the oxide between Cr (II) to Cr (VI) [11]. Chromium is one example of heavy metals that are carcinogenic.

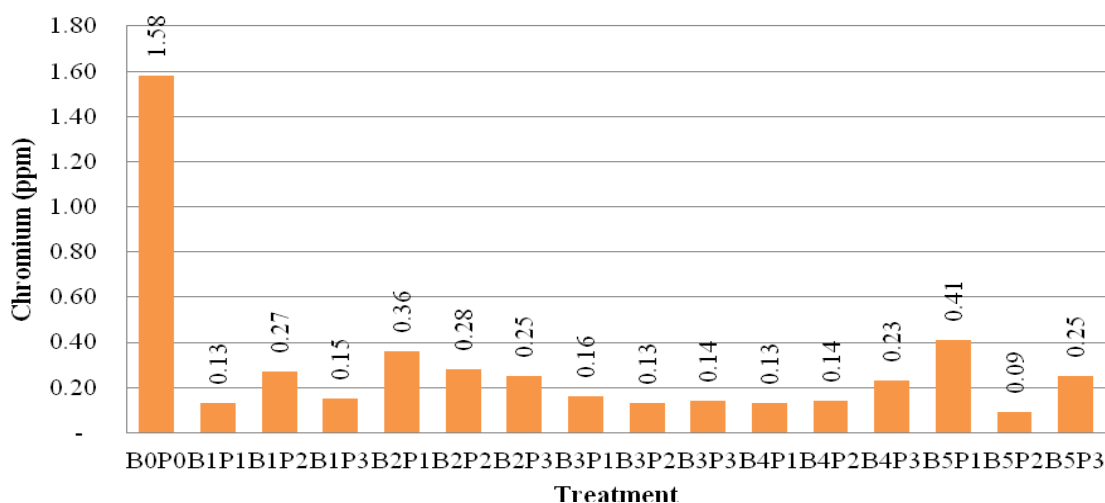


Figure 3. Average of Chromium value on MSL.

Adsorption capacity for Cr (VI) ion removal is depend on temperature, pH effluent, effect of concentration variation, and contact time. The most appropriate pH condition for chromium removal on ranges 6.0-8.0. Application of adsorption with patented hybrid surfaces, organofunctionalization with alkylamines necessary for separation of solid/liquid for chromium removal in industrial and environmental [12].

3.3 Ammonia value on the MSL

Based on ammonia laboratory test results that presented in Figure 4 shows the average value of the three replicates of ammonia on each treatment.

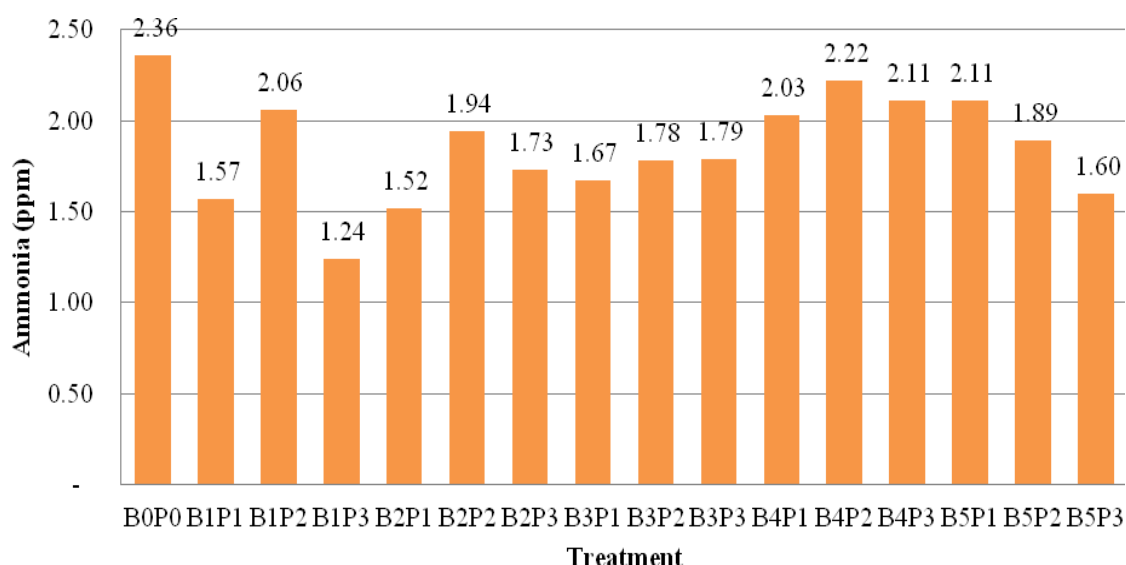


Figure 4. Average of Ammonia value on MSL.

The average of ammonia content in test showed that the lowest value of 1.24 ppm found in the MSL with rice straw organic materials at a 25% dosage (B1P3). The highest value (2.36 ppm) produced in controls (B0P0). A maximum allowable level of ammonia in the textile industry waste is 8.0 ppm based on [10]. All over the treatments has an average value of ammonia <8.0 ppm which indicate that ammonia levels after treatment MSL still at the threshold of the permissible standard. Research from Sato et al. (2010) suggest that aeration is needed in upper parts of MSL for nitrification, and extra organic materials in the lower part of MSL for denitrification [13]. It was because ammonia adsorption and nitrification were almost completed up to 3rd layer and denitrification not much proceeds after 4th layer.

3.4 Dissolved phosphate value in MSL

Dissolved phosphate in laboratory test results presented in Figure 5 shows the average value of the three replicates phosphate on each treatment.

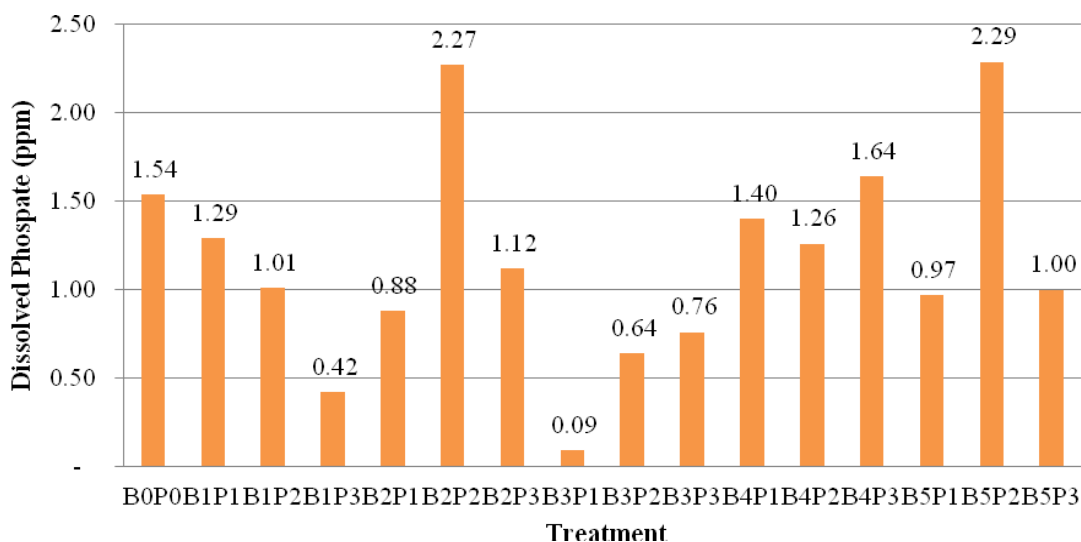


Figure 5. Average of Dissolved Phosphate value on MSL.

The average of dissolved phosphate based on histogram shows that the highest value of phosphate is 2.29 ppm contained in the MSL with corncob organic materials at 10% dosage (B5P2). Phosphate lowest value (0.09 ppm) contained in the MSL with sawdust organic materials of 5% dosage (B3P1) by 0.09 pm. Based on the regional regulation of Central Java No. 10 years 2004, total of phosphate for raw threshold is 5.0 ppm. The average of each treatment showed ppm phosphate 5.0 ppm, which indicates that, the ppm phosphate in wastewater after the application MSL still on the threshold allowed. Permeability of MSL was also very important for phosphorus removal in MSL system. Phosphorus can be removed by ferric hydroxides on soil mixture. The adsorption of phosphorus on decreased or the adsorbed phosphorus leached from the MSL due to establish an anaerobic condition [13]. Andisols basically have amorphous materials such as mineral allophane, imogolite and Al or Fe oxide minerals that have a high phosphate adsorption capacity [14]. According to Yunarsi (2013) reduced levels of dissolved phosphate can be through adsorption by chitosan or materials containing high lignin [15]. Research of Wikanta et al. (2013) shows that wood sawdust has cellulose (48.89%), lignin (28.90%), ash (2.09%), water content (6.02%) and pentose (14.10 %) [16].

3.5 Biological Oxygen Demand (BOD) in wastewater

Based on BOD test results are presented in Figure 6 shows the average of the BOD value of the three replicates on each treatment. Based on the available data in the histogram, it is known that the average lowest value (149.53) contained in the MSL with bagasse organic material at 5% dosage (B2P1). The highest average value (393.83 ppm) contained in the MSL with organic material in the rice straw at a 25% dosage (B1P3). Maximum of allowable levels of BOD for the textile industry waste is 85 mg/l based on BAPEDAL [10].

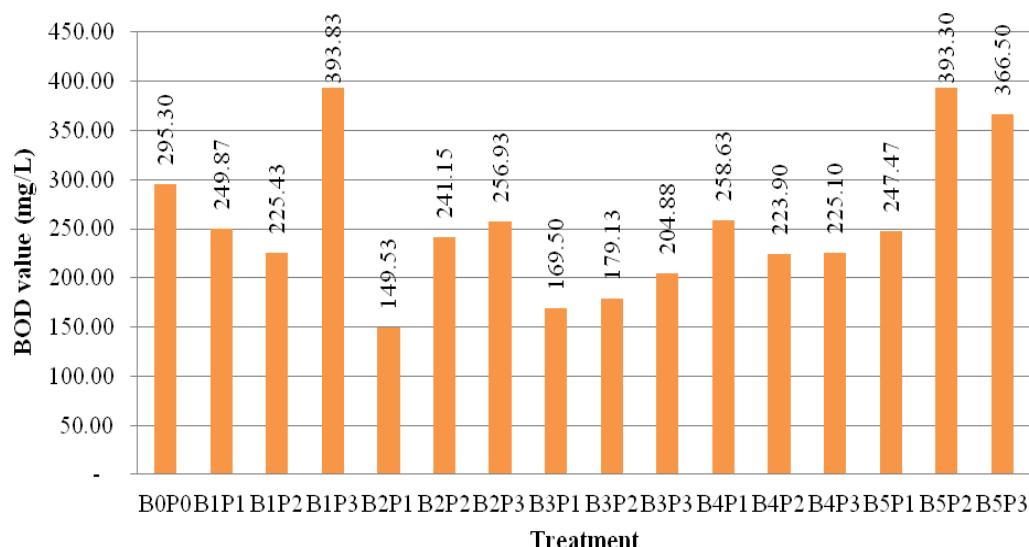


Figure 6. Average of BOD value on MSL.

Although BOD value after application of MSL still above threshold standard but has decreased from the initial BOD value (780 ppm). BOD indicates the amount of biological oxygen dissolved. The average value of BOD of MSL treatment outcomes when compared with standard threshold is 85 ppm, all of the treatment does not appropriate the threshold standard. The average BOD value of each treatment showed a high value is >100 ppm, which indicates that the MSL still not effective in lowering the levels of BOD.

According Sato et al. [13] the water flow rate in MSL was an essential factor for removal of organic materials, phosphorus and ammonia. There are some factors that can keep the proper flow rate in MSL, that selection of soil with proper particle size, mixing of high permeable materials with MSL and the setting of aeration regime. Proper aeration is effective in the prevention of clogging.

3.6 Chemical Oxygen Demand (COD) in wastewater

COD laboratory test results are presented in Figure 7 shows the average of the COD value of the three replicates on each treatment. Average value of COD on MSL treatment outcomes when compared with standard threshold of 150 ppm, all of the treatment does not appropriate the threshold standard. The average of the COD value of each treatment showed a high value is >300 ppm, which indicates that the MSL still not effective in lowering the levels of COD.

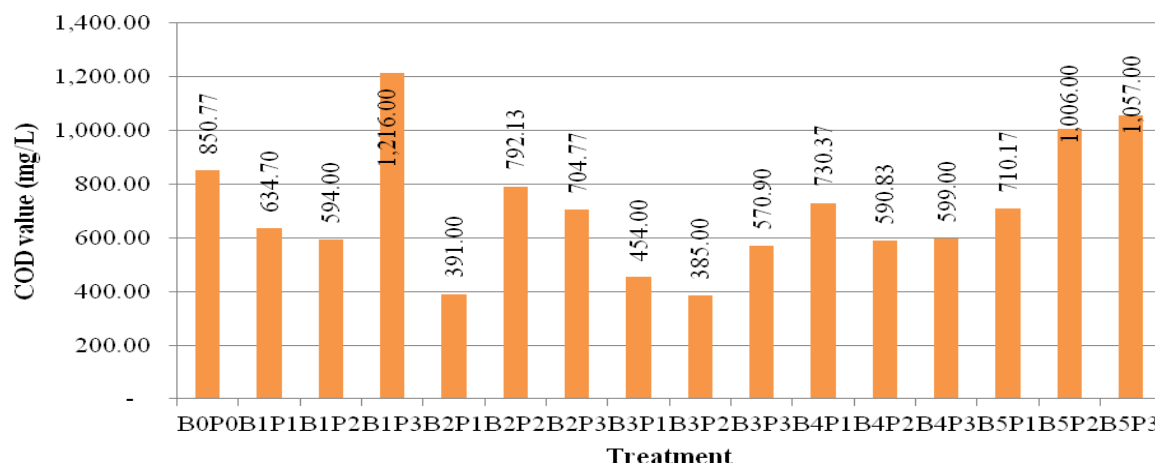


Figure 7. Average of COD value on MSL.

The highest average of COD value (1216 ppm) based on the histogram shown by MSL rice straw organic materials at 25% dosage (B1P3), while the lowest average COD value (385 ppm) contained in the MSL with organic material sawdust at 10% dosage (B3P2). Maximum allowable levels of COD for the textile industry waste is 250 mg/l based on BAPEDAL (1995). The COD value at the beginning of the sample is equal to 1520 ppm, after MSL applications tend to decrease even though its value is not significant.

Impairment of COD based on the research of Georgiou et al. (2003) was also influenced by the pH value of the environment. Higher pH values can inhibit a decrease in COD values, whereas low pH can help reduce the COD by 60%. In COD and BOD removal, COD needed number of layers than BOD. It was because COD includes easily and slowly decomposable organic materials, while BOD represents easily decomposable organic materials [13].

3.7 Testing Odor and Colour Changes

Based on Table 1 known that any samples taken have dark colour and pungent odour. The first, second and third samples show that wastewater plant output produces a pungent odour (detergents and dyes) of various treatment processes. It shows that the wastewater does not appropriate to threshold of fresh water ready to be disposed of into the water reservoir canal.

Table 1. The results of physical observation (colour and odor) in the sample of wastewater

Sample	Odor	Colour
1	Detergents and dyes pungent	Dark blue, slightly cloudy
2	Detergents and dyes pungent	Livid, slightly cloudy
3	Detergents and dyes pungent	Dark blue, slightly cloudy

The results of physical observation (colour and odour) in the sample after application of MSL on each repetition are also not different from the initial waste samples. Some samples also showed changes in colour though not completely - can completely eliminate the existing colour in the liquid waste. MSL has not been effective in removing odours and colours might be due to the application of MSL has not used the system on a regular circulation causes the incubation time in MSL less waste, and environmental conditions (pH) which does not support the purification so that the absorption of odours and colours at less than the maximum waste. pH value can affect the change of colour in textile wastewater. Low pH conditions can improve discolouration than when the pH is likely to be

high. The reason is alkaline environment can make H_2O_2 is unstable and tends to decompose the formation of oxygen and water than hydroxyl radicals [18].

3.8 MSL Performance Effectiveness

MSL proven effective to raise the pH, lowering ppm Cr, lowering dissolved ammonia and phosphate. Application of MSL is less effective to reduce the BOD and COD. The correlation test shows the correlation of the factors used. The results of the correlation test showed that the correlation found between BOD to COD, pH dissolved phosphate and ammonia with Cr levels. Additional testing is also done to determine the factors that really affect the performance of MSL.

Based on PCA test, known that the factors that influence them are COD, soluble phosphate, and Cr levels. Treatment is best seen from the factors that most influence in the PCA test is B3P2 that MSL with sawdust organic material with 10% dosage. Treatment B3P2 COD value a low of 385.00 ppm, 0.64 ppm of dissolved phosphate levels, and Cr content is 0.13 ppm. Sudarja & Novi (2012) research shows that sawdust can be used as activated charcoal, which has the capability of adsorbing heavy metals in high level such as Cd, Pb, and Cr [19]. However, in high saturation of sawdust uses will impact to decreasing of adsorption. Smell and colour test of the waste showed textile wastewater quality still does not appropriate for threshold of safety standard for distributed into a major waterways receiver.

4. Conclusion

The results showed the organic material can be used to raise the pH, Cr lower level, ammonia and phosphate lower level less effective to reduce the BOD and COD. Multi Layering Soil composition is suitable as a natural adsorbent is MSL with organic material sawdust with a dosage of 10%. Multi-Soil Layering can be used as effective and efficient alternative method to dissolve Cr metal.

Acknowledgement

The experiment was supported by Indonesia Higher Ministry of Education of Sebelas Maret University Surakarta.

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