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Biosystem Treatment Approach of Textile Dyeing Industry Wastewater

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Abstract— *Biosystem is composed of plants and microorganisms ecosystem. Biosystem is basin with the dimension of 200 long, 90 cm wide, and 60 cm deep. The basin is filled with 15 cm thick of gravel, 165 cm thick of coarse sand and 20 cm thick of gravel. Ipomeacrassialis is grown with its roots planted in the coarse sand layer. The highest Mixed Liquor Volatile Suspended Solid (MLVSS) concentration was 2010 mg/L, measured in 60 hours growth. Active suspension inoculatedinto biosystem improves the biosystem ability to decrease color intensity, COD, and BOD of the wastewater. Decrease in the color intensity begins to occur within 24 hours of treatment and reach levels below maximum allowed level after 60 hours treatment with the effectivity of 80.07%, meets the quality standard of textile was 5 mg/L. Decrease in COD was identified in 60 hours but still above the quality standard of textile was 70 mg/L and remained unchanged to 90 hours. Decrease in BOD levels began to look significant in 16 hours. However, up to 90 hours treatment time the BOD still above the quality standard of textile waste that was 50 mg/L. Microbe presents predominantly in biosystem was identified as Pseudomonas Pseudomonadanceae.*

Keywords—active suspension, Bio system, MLVSS, Pseudomonas Pseudomonadanceae.

I. INTRODUCTION

Textile industries generate an excessive amount of wastewater containing extremely high concentration of organic materials and high color intensity. Those conditions can inflict the declining of environmental condition and affect human health [1]. In developing countries, business licensing issues and breaches of provisions were generally prevalent resulting in environmental problems. Denpasar city is one of the developing cities in Indonesia which has 208 operating dyeing business activities. The presence of this industry has given the impact of pollution, especially the surrounding river. The wastewater of dyeing activity contains high BOD and COD as well as other contaminants that were very dangerous for environmental sustainability. Thewaste contents were known as hazardous chemicals and very dangerous to the environment and may create problems especially healthand environmental issues. Treating the waste prior to discharge into the environment is therefore a crucial issue.

In this research we use a bio system method to degrade contaminants in the textile dyeing wastewater. Bio system using isolated microorganisms coated on media in trickling filters have been used to treat liquid waste from fish processing industry [2]. In the current study, the bio system utilize plant and microorganisms ecosystem to treat the wastewater. Wastewater of dye activities contains organic and inorganic compounds that were difficult to degrade. Therefore, only several specific microorganisms were able to degrade dyeing chemicals, as the result, only some kind of bacteria and fungi that can be potentially observed as the treatment precursor. The advantage of using bacteria as main role in this treatment is its ability to grow in specific substrate so that it literally works in specific spectrum [3].

This study used bio system consisting of media where microorganisms seeded from Badung river sediments collected from three locations were inoculated. The mediais composed of sand and gravel, and plant roots. The purpose of this research is to find the best suspension of microorganism from different soil samples and determine the effectivity and capacity of bio systems in lowering BOD, COD, Color intensity, TSS and changes the pH of dyeing wastes.

II. MATERIALS AND METHODS

2.1 Soil Sampling and Seeding of Active Suspended

Soil samples were collected by grab method from Badung Riverse diments of Denpasar City, Indonesia. The sampling sites were near by the catchment of dye activities wastewater effluent. Sediment samples (about 100 grams) were collected from the river bed ± 05-15 cm depth and preserve properly. The sample was seeded into a nutrient-rich solution then gently shaken and observed for their biomass growth. The composition of nutrient-rich solution consist of 2,0 gram glucose (KH) ; 0,1 gram K_2HPO_4 ; 0,1 gram KH_2PO_4 ; 0,1 gram $(NH_4)_2[Fe(SO_4)_2].6H_2O$; 0,02 gram $MgSO_4$; 0,02 gram $FeSO_4$; 0,02 gram yeast extract [4]Determination of the time of exponential growth of microorganisms was achieved through Mixed Liquor Volatile Suspended Solid (MLVSS) measurement. The exponential growth time was used as indicator in the inoculation of microbial

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suspensions into the bio system.

$$VSS = \frac{a-b}{c} \times 10^6 \text{ mg/L}$$

Where:

a = mass of porcelain dish and residue (gram) before combustion/heating at 600ºC

b = mass of porcelain dish and residue (gram) after combustion/heating at 600ºC

c = sample volume (mL)

2.2 Treatment of Dye Wastewater on Horizontal Bio system

Horizontal biosystemis constructed from glass block with a dimension of 120 cm long, 90 cm wide and 70 cm deep(figure 1).Horizontal biosystem consists of gravel layer along the 15 cm, coarse sand layer along 90 cm and gravel layer along 20 cm. The plants of *Ipomeacrassialis* was grown with its roots planted in the coarse sand layer[2]. Active suspension was inoculated to the system and acclimatized for 3 days.

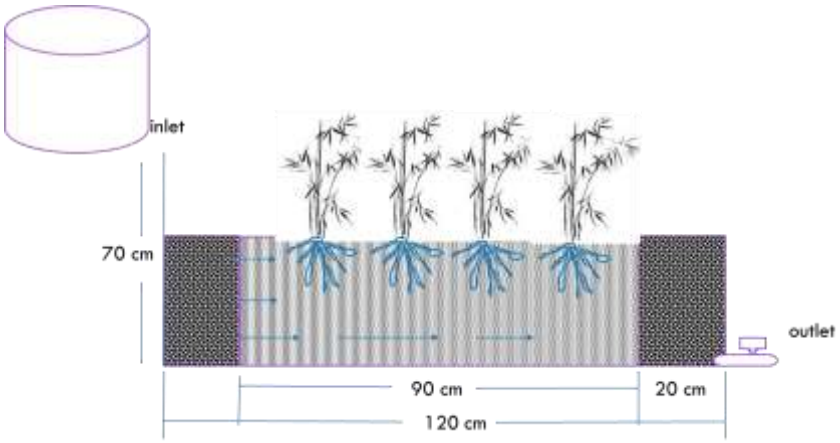

Fig.1: Horizontal Biosystem Schema

The wastewater to be treated wasallowed to swamp the bio system for 90 hours.Observations were made by analysingthe TSS, BOD, COD, color (methylene blue) intensity and pH of the waste sampled at of 0, 8, 16, 24, 32, 40, 48 and 90 hours treatment. The color and smell of the treatment effluent were also observed.

The colonies of the microorganism and its characteristics were determined according to the National Standard Procedure. Capacityand effectivity of the Bio system in removing pollutant were determined by measuring the parameters until they remain unchanged. The Effectivity of bio systemis calculated following the equation as follows :

$$\% \text{ effectivity} = \frac{(A-B)}{A} \times 100\ \%$$

Where:

A = Initial concentration of pollutant/parameters(mg/L)

B = Final concentration of pollutant/parameter (mg/L)

III. RESULT AND DISCUSSION

3.1 The growth of microorganism in Active Suspension

The result of MLVSS calculation (Figure 3.1) from the three sediments showed that the maximum microbial growth in the sediments occurred after60-hours seeding. The seed collected from the middle stream, which is closest to the textile industry waste catchment point, showed the maximum microorganism growth at 2010 mg/L, while that from upstream gave the minimum growthwhich was 900 mg/L. The differences was caused by different seed density, behavior and adaption abilities of the microorganisms to survive in selective media, and also the ability to replicate and create consortium[2].As a result, the biomass production in the three sediments were completely different.

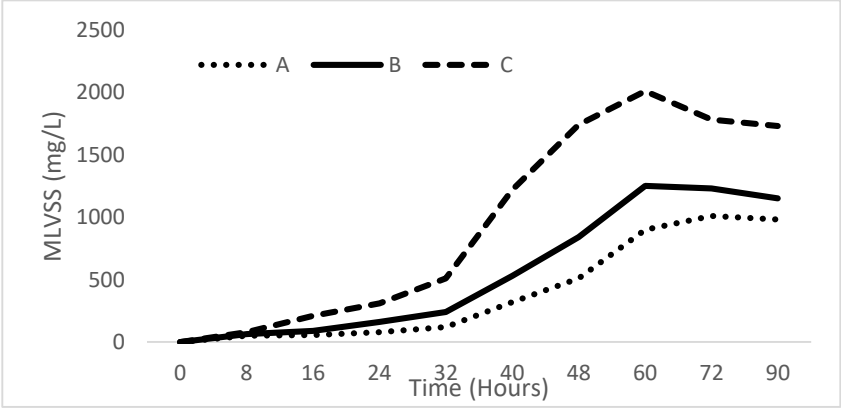

Fig.2: Biomass growth in contaminated-nutrient suspension (A = upstream, B = downstream, C = Middle)

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3.2 Reduction in dye concentration, COD, BOD, TSS, and TDS

The maximum wavelength was foundat660 nm with absorbance of 0.3608. Reduction of Methylene Blue concentration in the treated waste is shown in Figure 3. The active suspension inoculation into bio system enhanced the decolorisation of the waste significantly. As seen in Figure 3, bio system enriched with microorganism ("bioH"), the methylene blue concentration drops steeply from 24 hour treatment and continue to decrease to fulfill the quality standard (QS) after 60 hours. On the other hand, the system without microorganism enrichment ("nonBioH") does not show significant decrease.

The effectivity of the decrease in the dye content is 80.07% with residual dye of 4.0155 mg/L (below the quality standard of textile waste that is 5 mg/L).

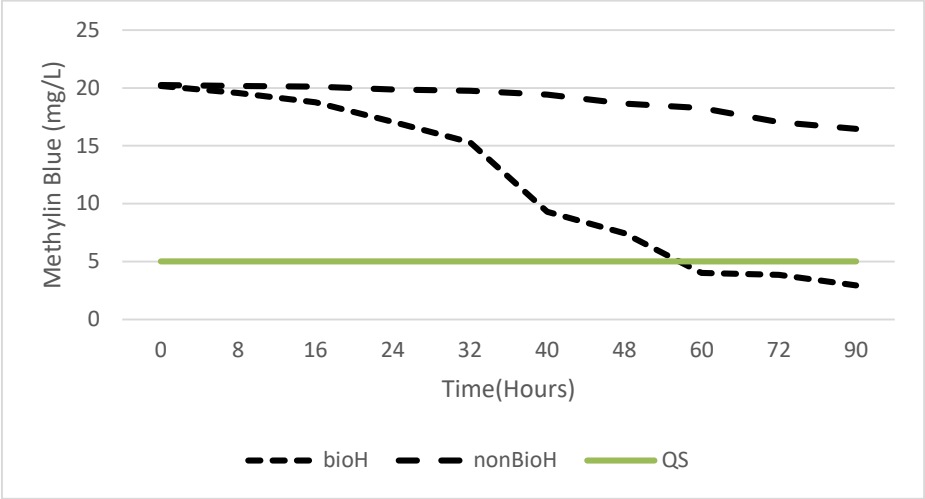

Fig.3: The decrease indye concentration

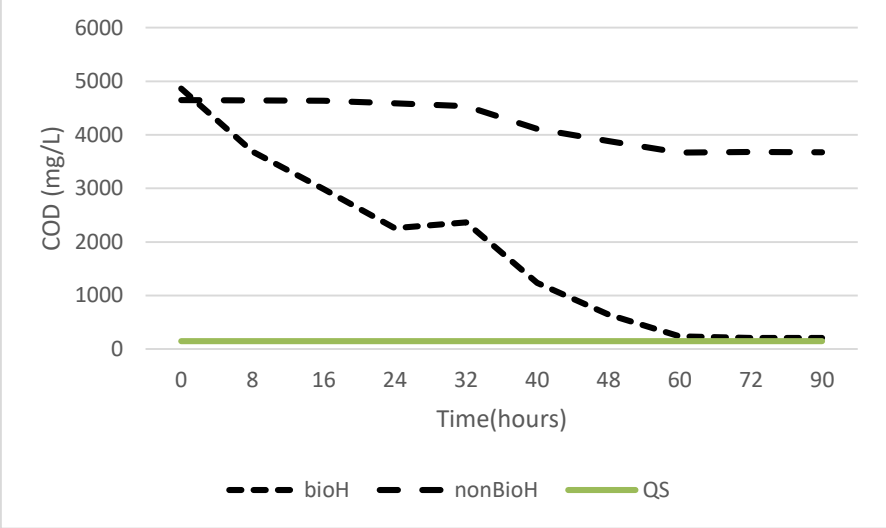

Fig.4: Decreased levels of COD in bio system treatment

Figure 4. shows that active suspension inoculation into the bio system (bioH) affects the ability of bio systems (nonBioH) in lowering the COD. Decreasein COD is seen significantly since the beginning of the treatment.However, after60 hour treatment it has reached the lowest point and up to 90 hours it does not show significant changes in COD levels. Removalof dye content of 95.78% has occurred since 60 hours, but until 90 hours the COD level is still as high as 205 mg/L, which is above the quality standard of textile waste that was≤50mg/L).

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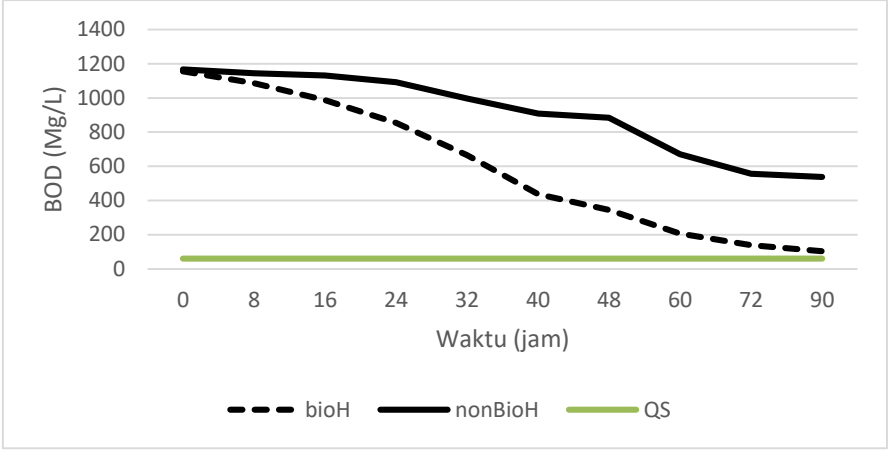

Fig.5: Decrease in BOD

Figure 5. shows that active suspension inoculation into the bio system (bioH)increases the ability of the bio system (nonBioH) in lowering BOD.Decrease in BOD levels began to look significant in 16 hourtreatment. However, up to 90 hourtreatment the BOD remains 103 mg/L(still above the quality standard of textile waste that is≤50mg/L).

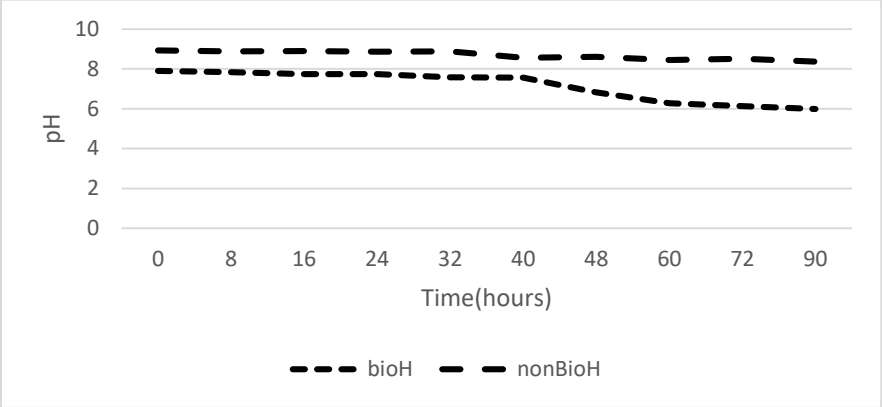

Fig.6: Changes in pH during the treatment

Figure 6 shows a significant decrease in pH after treatment for 40 hours. This condition was in accordance with the degradation of contaminants that occur during the growth of microorganisms.

Based on the results shown above, it is found that the treatment using bio system inoculated with active suspension, has successfully decreased the dye concentration, COD and BOD up to 91.09%, 80%, and 95.7% respectively, in 60 hours. These results are much better than those achieved by Agustina *et al* [1] on the fish processing waste treatment using trickling filter. This suggests that microorganism consortiums on the bio system accomplished the peak of growing rate in 48-hours. Microorganism, in the presence of co-substrate as electron donor on organic molecule of dyeing agents, catalyzed by reductase enzymes,breaks of chemicals bonds. This mechanism results in the improving performance of the bio system[5]. The degradation occurring during the treatment by the bio system is accomplished by at least three processes: physical interaction between the contaminant particles and the media in the bio system (adsorption and filtration), biodegradation by microorganism, and absorption by plant roots. Breakdown of the dye molecules causes decoloration of the wastewater. On oxygen presence, the Azo chemicals and oxygen will compete to take electrons from NADH. Hydrogen Ion on the NADH prefers to exchange with oxygen than Azo compounds, through electron transfer. Therefore, under aerobic condition, Azo dyes will be more difficult to degrade [6].

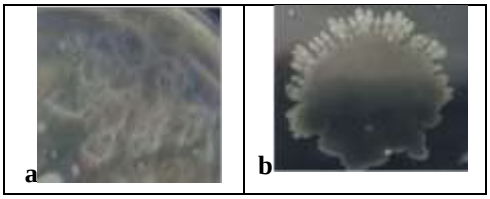

Fig.7: Characteristics of bacterial colonies

The bacteria was isolated from samples collected from one point in the outlet area of the bio system after 90 hour treatment. Isolation performed on 10 to 2 dilution found 2 (two) isolates as shown in Figure 7, *i.e*. transparent form (a) and flower shape (b).

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Table.1: Genus Identified onIsolate

Parameter	Characterize		
	Isolate 1*	Isolate 2*	Reference**
a. Morphology			
- Cell form	Rod	Rod	Rod
- Gram	Negative	Negative	Negative
- Motility	positive	positive	positive
b. Growth			
- Aerobe/anaerobe	Obligateanaerobe	Obligateanaerobe	Aerobe
- pH optimal	5- 9	5- 9	7 – 8.5
- temperature(^oC)	20 - 40	20 - 40	4 - 43
c. Biokimia			
- Catalase	Positive	Positive	Positive
Carbohydrate fermented (glucose)			
- O/F	Negative	Negative	Negative
	Negative/negative	positive/negative	oxidation
Identified:*familyPseudomonadanceaegenus Pseudomonas*			

**) Laboratory of Microbiology, Biology Department of Udayana University, 2017*

***) Bergey'sManualDeterminativeBacteriologyeightedition,part7,1975*

The microbe presents predominating the bio system is identified as *Pseudomonas Pseudomonadanceae*. The number of the microbe obtained in 48 hour treatment is 7.4 x 10^4CFU/g and in 90 hour treatment is 3.6 x 10^3CFU/g.

IV. CONCLUSION

The research found that:

1. The bio systemsinoculated with active suspension can decrease the dye concentration, COD, and BODof dye liquid waste up to 91.09%, 80%, and 95.7% respectively, within 60 hours.
2. The systems decrease the dye concentration from liquid waste to up to 85.4%, within 90 hours, leaving residual concentrationto meetthe quality standard for textile waste which is≤5 mg/L.
3. **Genus Identified on Isolate as *Pseudomonas Pseudomonadanceae***

V. ACKNOWLEDGMENT

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