Simple Prototype on Fixed Bed Reactor (FBR) Based on Used Plastic with Active Suspension Solution Starter in Domestic Wastewater Treatment

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Abstract— Biofiltration was commonly performed in a complex bioreactor. Yet by adjusting the biofiltration according to the field conditions and application purposes, the efficiency factor need to be considered. This study aims to determine the treatment performance of biobags on the fixed bed reactor (FBR) in treating domestic wastewater. Biobag in FBR was supported by used plastic of Low-Density Polyethylene (LDPE). The plastic waste was cleaned and arranged in such a way into a bag. The bag unit was activated by immersing it in media containing nutrients and active suspension. The growth of biofilm in biobags was carried out at various active suspension content (10%, 20% and 30%) and variations in the treatment time of 12, 24, 36 hours. The results showed that the soil samples obtained from Badung River 2 Denpasar City was found to yield the best active suspension. The active suspension contained microbial colonies as much as 3.66 x 10^4 CFU/mL after incubation of 42 days. During the HRT of 24 hours, the sample with 20% active suspension content resulted to the most optimal biofilm growth with COD removal up to 74.35%. With this treatment, efficiency was achieved against COD, BOD, and ammonia.

Keyword— active suspension, used plastics, biofilm, domestic wastewater

I. INTRODUCTION

There are several factors that influence the treatment process of biofiltration. These factors consist of the source of microorganisms, processing time, pH and dissolved oxygen levels. The biofiltration process of wastewater treatment requires suitable microorganisms to decompose various compounds from the content of organic matter [1]. Interaction between pollutants and microorganisms in solution requires optimal time in the removal of pollutants concentration. Aerobic microorganisms can live and thrive in a certain pH range, for that pollutant removal efficiency will occur at a pH of 6.5 to 7.5[2]. Dissolved oxygen content is also very important in the removal of pollutants in aerobic microbiological systems. The efficiency of pollutant removal also depends on the adequacy of dissolved oxygen levels. The minimum dissolved oxygen level of 2 ppm can still support the nitrification process and the life of aquatic organisms [3]

Biofiltration generally uses a bioreactor with materials and arrangements that are complicated and unreliable. This research was triggered by intention to simplify the workflow and compartments of biofiltration reactor with cheaper materials but with sufficient treatment efficiency. Efficiency considerations are needed for ease of application with the adjustment of conditions and cheaper materials [4]. Ease of maintenance is an integrated part for the sustainability of the system's work. The development of bioactive in the form of biofilm were conducted in a media with small modular forms such as bags for easy installation and maintenance. Utilization of biofilm as part of the technical efforts of downstream processing in order to overcome water pollution as the final discharge media. The application of wastewater treatment plants is a management approach from the source. This is integrated with a management system that should be applied to control pollution of an area such as a tourist area that demands high quality.

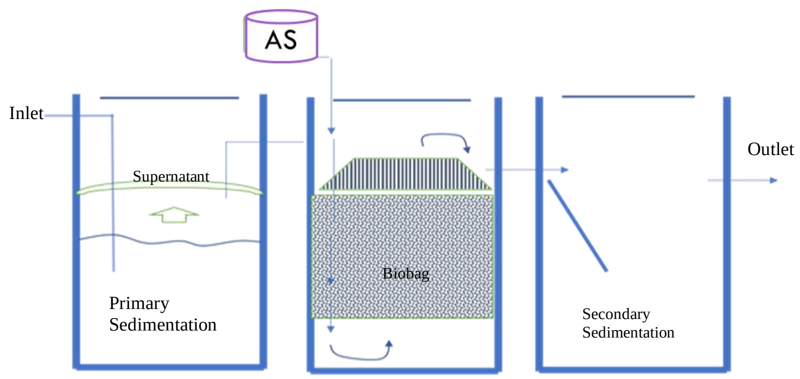
The use of supporting media in the formation of biofilms on the FBR system can be developed with the characteristics and advantages of each material [5]. The use of used plastic supporting media in the FBR system is an effort to utilize waste and efficiency. Utilization of used plastics as biobag was activated by growing a biofilm on its surface. The use of used plastic is an effort to reuse the remaining plastic which is generally disposed of into the environment.

This study aims to determine the efficiency and effectiveness of biofilters from biofilms supported by used plastic in reducing pollutant levels of domestic liquid waste and meeting the quality standards determined by the government. The application of a supporting installation of a biofilter system is illustrated by a prototype of a wastewater treatment unit with an aerobic-biobag system.

II. MATERIALS AND METHODS

Biobags were made from processed LDPE type plastic which was put into a plastic bag/net. The average biobag weight was 0.40 kg. The bag was activated by immersing it in a medium containing nutrients and active suspension.

The aerobic-biobag tub with an effective volume of 90 litres was made of plastic/PVC with a height of 110 cm and a diameter of 30 cm. The installation unit was also equipped with an initial sedimentation tank and a final sedimentation tank. The research design is shown in Figure 2.1. Biofilter is the main treatment using Biobag.



Note: AS = active suspension

Figure 2.1 FBR prototype treatment scheme using biobag

Nutrients to support the growth of the consortium of microorganisms used the composition of sucrose, $(NH_4)_2SO_4$, K_2HPO_4, KH_2PO_4 and $MgSO_4.7H_2O$ with a ratio of C:N:P = 100:5:1[6]. Microbial consortia were cultivated by placing the sediment samples obtained from polluted river in an aeration tank. A total of 5 grams of soil was mixed with nutrients with 10%, 20% and 40% treatment variables. The mixture was then stirred until homogeneous and then aerated for each sample, the mixed liquor of volatile suspended solid (MLVSS) was observed from initial time until the steady phase of the consortia biomass growth.

In order to examine the growth of biofilm in the biobags during the treatment in FBR reactor, the biobags were immersed into three different solutions with the ratio of 10% nutrients - 90% wastewater, 20% nutrients - 80% wastewater, and 30% nutrients – 70% wastewater respectively. Observation of biofilm growth was carried out with MLVSS parameters from 0 hours to steady phase. Determination of the performance of the aerobic-biobag basin was carried out by treating domestic wastewater based on the addition of active suspension (SA) in volume percentages of 10% and 20%, respectively, and hydraulic retention time (HRT) of 8, 12, and 24 hours, respectively. Treatment efficiency and effectiveness of the treatment were observed by examining the changes in water quality parameters of BOD, COD, TSS and Ammonia as well as pH.

III. RESULT AND DISCUSSION

3.1 Domestic wastewater character

The physical and chemical characteristics of domestic wastewater discharged into water bodies in the North Kuta Badung Bali Tourism Area are presented in the following table 3.1.

Table 3.1 Characteristics of Wastewater from various activities in the North Kuta area of Badung Region

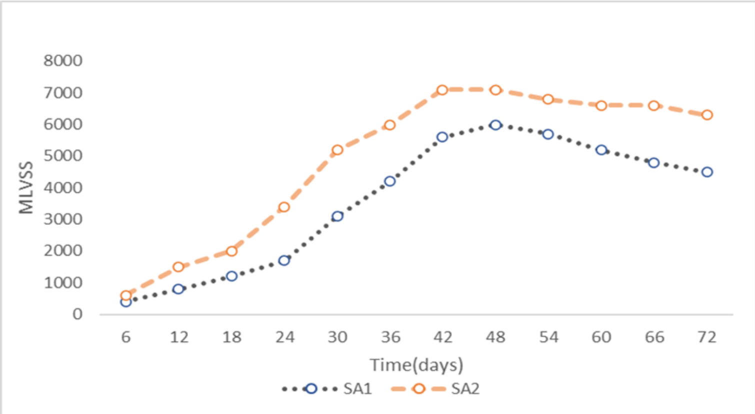
No	Unit	Parameter	Content	Standard*
1	mg/l	COD	146	50
2	mg/l	BOD	87	28
3	mg/l	TSS	102	30
4	mg/l	Ammonia	8.3	10
5	mg/l	Oil & Grease	6.5	5
6	pH unit	pH	6.75	6.0 - 9.0

*Standard of domestic wastewater of Bali Governor Role No.16 (2016)

From the data in table 3.1, it can be seen that the wastewater tested exceeded the specified quality standard [7]. Parameters that exceed these quality standards are COD, BOD, TSS and Oil/fat. Direct observation of the wastewater showed the characteristics of cloudy, light brown colour, slightly foamy and smelled quite pungent.

3.2 Active suspensions

Active suspensions are suspended particles resulting from the cultivation process. This solution was made by cultivating isolates or microbial seeds present in soil samples, with certain media and given sufficient oxygen. The following are the results of seeding of two soil samples as a source of microbes. Microbial growth indicators were measured by Mixed Liquor Volatile Suspended Solid (MLVSS) which showed the growth of biomass. The growth pattern of the active suspension is shown in Figure 3.1



Note:
SA1 = sediment samples of Badung River 1 Denpasar City
SA2 = sediment samples of Badung River 2 Denpasar City

Figure 3.1 The growth pattern of active suspension

The active suspension (SA2) contained a colony count of 3.66 x 104 CFU/mL (there were 3.66 x 104 colony-forming units in 1 mL of the active suspension). The content of the number of colonies is sufficient to be applied to the wastewater treatment process [5]. From microscopic observations, the dominant species in the active suspension obtained was Bacillus sp. The genus Bacillus is a rod-shaped bacterium that can be found in soil and water, including seawater [3]. Some species produce extracellular enzymes that can hydrolyse complex proteins and polysaccharides. Bacillus sp. form endospores, are gram positive, move in the presence of peritrichous flagella, can be aerobic or facultative anaerobic and positive catalase. Figure 3.2 exhibits a microscopic image of active suspension which signifies the existence of Bacillus sp. The colony image also shows of presence of yeast, the fungus group microorganism in the form of unicellular which has high resistance to the presence of antibiotics, has antimicrobial properties, and has resistance to salt, acid and sugar.

Figure 3.2 A microscopic image of active suspension

3.3 Biofilms

Biofilms are the most essential part of FBR treatment in pollutant removal. The acceleration of biofilm formation on the plastic surface was supported mainly by variations in the content of the active suspension in the growth medium. The growth patterns of biofilms on several active suspensions are shown in Table 3.3

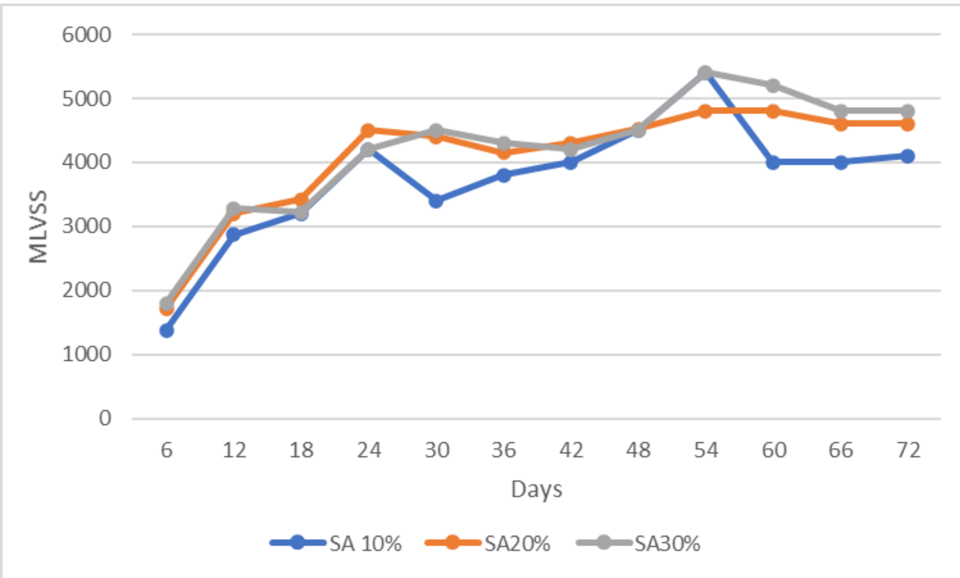


Figure 3.3 The growth patterns of biofilms on 10%, 20% and 30% of active suspensions

According to the result, the most optimum biofilm growth profile was obtained from the cultivation with an active suspension (SA) content of 20%. The SA 20% showed a stable and even growth in MLVSS compared to the other SA content. The treatment character data is shown in Table 3.2.

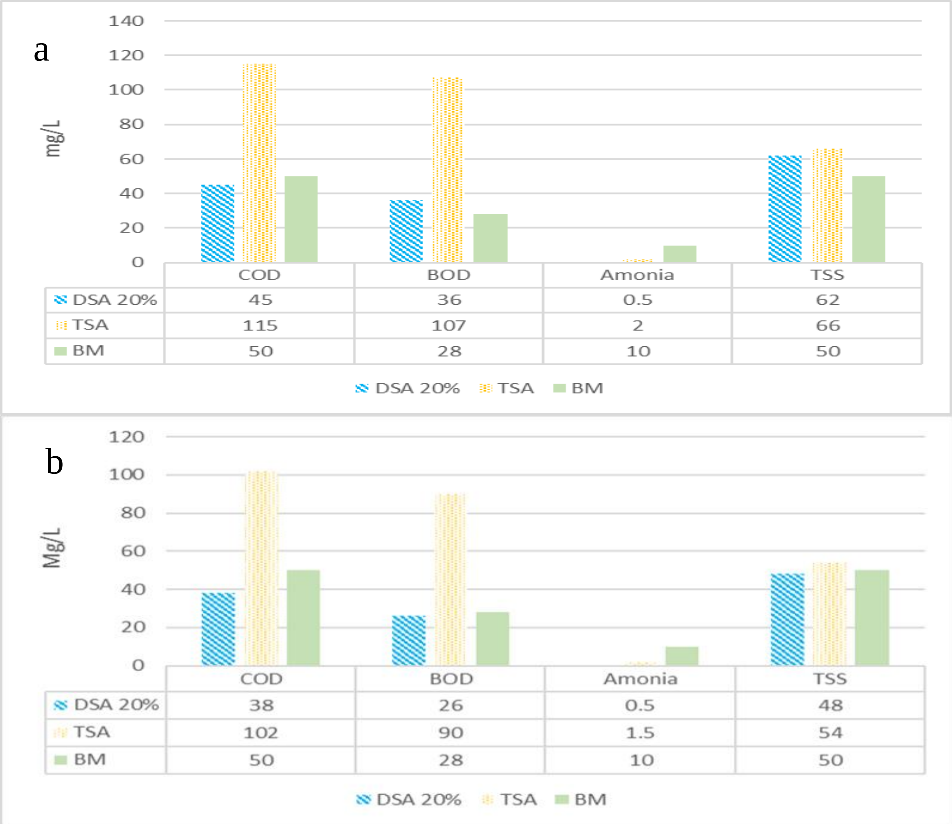
Table 3.2 Biofilm growth profile supported by liquid media with 20% active suspension

Days	Control	SA20%	pH C	pH SA	T C	T pH
6	1320	1720	5.6	6.2	27	27
12	2200	3200	5.8	6.4	27	27
18	2400	3420	5.8	6.6	28	27
24	3500	4500	6.0	6.6	27	27
30	3600	4400	6.0	6.7	27	28
36	3800	4150	6.3	6.7	27	28
42	3900	4300	6.4	6.7	28	27
48	3700	4520	6.5	6.8	27	28
54	3600	4800	6.5	6.8	27	27
60	3800	4800	6.5	6.8	28	27
66	2800	4600	6.5	6.8	27	27
72	3100	4600	6.6	6.9	27	28

Note: SA= Suspended Active, T = Temperature, C = Control

3.4 Effect of Hydraulic Retention Time (HRT) in FBR treatment

One of the important factors that affect the performance of biobags is the interaction time between the microorganisms in biobags and domestic wastewater as the carbon source for the microbial growth. The results of measuring several parameters with HRT at 12 and 24 hours are shown in Figures 3.4 (a) and (b). On the HRT of 12 hours, biobags with 20% active suspension (DSA) were able to reduce COD, BOD and Ammonia to meet the standard quality, except for TSS which only decreased to 62 mg/l while the TSS standard was 50 mg/l. On the other side, the treatment without active suspension (TSA) was not showing any significant removal for COD, BOD, TSS, and ammonia. This result emphasizes the key role of the active suspension in removing pollutant. With HRT of 24 hours, the treatment performance even getting better and more effective than the 12 hours HRT. The 24 hours HRT the COD, BOD, ammonia and TSS removal were up to 74.32%, 67.05%, 93.9%, and 47.06% respectively. Table 3.3 compares the treatment efficiency and effectivity between 20% active suspension treatment (DSA) with no active suspension (TSA) at HRT 12 and 24 hours.



Note:
DSA = with active suspension
TSA = without active suspension
BM = water quality standard

Figure 3.4 (a) Biofilter performance with 20% active suspension on HRT 12 hours and (b) on HRT 24 hours

Table 3.3 Efficiency and Effectivity of HRT 12 hours and s 24 hours

	COD	BOD	Ammonia	TSS
Removel efficiency (%) HRT 12 hours				
DSA 20%	70.20	60.44	93.98	39.22
TSA	23.84	38.46	75.90	35.29
Removal efficiency (%) HRT 24 hours				
DSA 20%	74.32	67.05	93.90	47.06
TSA	31.08	53.41	81.71	52.94
Standard effectivity HRT 12 hours				
DSA 20%	S	TS	S	TS
TSA	TS	TS	S	TS
Standard effectivity HRT 24 hours				
DSA 20%	S	S	S	S
TSA	TS	TS	S	TS

Note:
S = meet the water quality standard
TS = above the water quality standard

The domestic wastewater treatment model with the development of an aerobic-biobag system produces a prototype that was supported by the previous research [8]. This prototype consists of an initial reservoir with stabilization and equalization functions with the ability to reduce the BOD load up to 20%. The main part of the processing is an aerobic tank with biofilm growth supported by used plastic which was conditioned with an up-flow system to act as biofiltration. With a final inundation time of at least 6 hours, it is proven to be effective to reduce concentration of COD, BOD, Ammonia and TSS parameters.

IV. CONCLUSION

1. Active suspension from samples sediment of Badung River 2(SA2) has stable MLVSS growth to support the biomass grow in 42 days with bacteria colonies as much as 3.66×10^4 CFU/1 mL
2. The best biofilm growth period on the plastic surface was obtained on the 55^{th} day.
3. Biofilm on used plastics that grown in 20% of active suspension in FBR system was effective for domestic wastewater pollutants removal on 24 hours HRT. With this treatment the COD, BOD, ammonia and TSS removal were up to 74.32%, 67.05%, 93.9%, and 47.06% respectively. The effluent of the FBR unit met the water quality standard requirements.
4. The prototype of domestic wastewater treatment with an aerobic-biobag system consists of an initial reservoir that functions to stabilize and equalize, the core of an aerobic tub with biofilm growth supported by used plastic which is conditioned with an up-flow system as a biofilter. With a final inundation time of at least 6 hours, it is proven to be effective against COD, BOD, Ammonia and TSS parameters

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