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INTEGRATED SYSTEM OF BIOFILTER AND CONSTRUCTED WETLAND FOR SUSTAINABLE BATIK INDUSTRY

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Abstract: Wastewater produced during the batik production process contains toxic and difficult to decompose chemicals which can cause an increase in power of hydrogen (pH), biological oxygen demand (BOD), chemical oxygen demands (COD), total suspended solids (TSS), and heavy metals. Wastewater produced from batik or the textile industry is generally an organic compound that is difficult to decompose, which can cause environmental pollution, especially from the aquatic environment. The effluent from the batik industry in the boiling process does not meet the quality standards set by Regulation of the Minister of Environment of the Republic of Indonesia No. 5/2014 on wastewater quality standards. Natural wastewater treatment systems such as constructed wetlands (CWs) and biological sand filter be a relevant alternative in treating wastewater because of its efficiency, cost and operation. This research aims to treat batik industry wastewater using biofilter-horizontal sub surface flow constructed wetlands (HSSFCWs) integration. The results showed a decrease in efficiency for each COD, TSS, and oil and fat parameters 72.67-86.67%; 95.85-98.18%; dan 79.47-90.04%. The results of statistical analysis showed that there was a significant influence between biofilter performance and biofilter-HSSFCWs integration in a period of 3 days, 5 days and 7 days with the dependent variable. The water from batik industry waste processing still exceeds the established quality standards so that the treated water is not allowed to be discharged into water bodies. The treated water also cannot be designated by the community because it does not meet the water quality criteria in the specified water class.

Keywords: Batik Wastewater, Boiling, Biofilter, Constructed Wetlands

1. INTRODUCTION

Nowdays, water scarcity is becoming a global issue in most countries [1][2]. There are at least 3.6 billion people (almost half the world's population) experiencing water scarcity. The amount is predicted to increase to reach 4.8-5.7 billion in 2050 [3]. Most of them are experienced by developing countries, where small industries are the main backbone of the economy. As is known the characteristics of small industries in developing countries generally have limited knowledge, capital and technology and are not aware that in carrying out their activities it has polluted the environment [4]. Pollution occurs because small industries dispose of the remaining production activities, including liquid waste into the environment without undergoing treatment first.

One wastewater that polluted the environment among all sectors such as pharmaceuticals, paper mills and paints is textile wastewater [5]. The largest textile industry in Southeast Asia is the batik industry [6]. In Indonesia, the batik industry is developing very rapidly along with the stipulation of batik as a world cultural heritage by United Nations Educational, Scientific, and Cultural Organization (UNESCO) in 2009 [7][8]. Based on data from the Ministry of Industry in 2015, the production of the batik industry and the average export value reached US$ 178 million, an increase of 25.7% from the previous year [9]. However, this industrial growth has alarming environmental consequences through its wastewater.

Batik industry liquid waste is produced from the process of soaking, boiling and rinsing [10]. The wastewater contains toxic chemicals such as waxes, coloring agents, reinforcing substances [8] and synthetic materials that are difficult to degrade [5][7][11]. These chemicals cause an increase in pH, BOD, COD, TSS, and heavy metals [6][10]. The increase in various pollutants along with the increase in production capacity and the number of batik industry in Indonesia can cause aquatic environmental pollution which results in the death of aquatic organisms and triggers waterborne disease for humans [12]. Based on these conditions, starting today developed a variety of natural dyes that are more environmentally friendly but not all batik industries want to do it. Therefore, we need a technology to support the sustainable batik industry. The technology implemented must be economically affordable, socially acceptable and environmentally effective [13]. Based on these conditions, from now on developing a variety of natural dyes that are more environmentally friendly but not all batik industries want to do it. Therefore, we need a simple technology to support the sustainable batik industry.

The use of macrophyte or known as the wetland system has been known for decades because it has high capability in pollutant removal, does not require energy in its operation, and low maintenance costs [1][14][15]. Therefore, constructed wetland has a high potential to be applied in developing countries. Constructed wetland is an engineering system or artificial system in the form of ponds or shallow channels (less than 1 meter) utilizing natural processes that occur in wetland vegetation, media (rocks, gravel, sand) and microbial assemblages to treat wastewater [16].

Constructed wetland is known to be able to process various types of waste such as urban, agricultural, animal, industrial, mine wastewater [17][18] as well as petroleum wastewater [19][20][21] and also municipal wastewaters [18][22][23]. However, constructed wetland can be combined with other technologies to treat more complex types of wastewater and obtain higher processing efficiency [24]. The weakness of constructed wetland is that it experiences a decrease in performance at low temperatures because the activity of plants and microorganisms is also low [25]. This condition can be improved by providing a larger area and longer retention time [26] for example combining it with the filtration method. Filtration is one of the most important processes in wastewater treatment to produce high quality waste so that it can be reused for various purposes. All types of filters with biomass attached to the filter media (gravel, sand, plastic, and activated carbon particles) can be defined as biofilter. The basic principle of biofilter is biodegradation of pollutants by microorganisms attached to the filter media through a combination of biological oxidation, adsorption and filtration processes [27].

Biofilter is able to eliminate various organic and inorganic pollutants, even for substances that are classified as compounds that are relatively dangerous, toxic, and difficult to biodegrade. The characteristics of the media used in biofilter have an important role in achieving the desired level of efficiency to remove pollutants. The effectiveness of filter media is influenced by the type of material, shape, size, surface area, porosity, and surface roughness [28]. One of the potential biofilter media for water treatment is sand and gravel because of its abundant availability. Sand and gravel grains provide a wider contact surface for attaching biofilms so that they are expected to improve processing efficiency. Some previous studies mention the success of the combination of biofilter as a pretreatment and constructed wetland as subsequent treatment in domestic wastewater treatment [25]. Integrated system *constructed wetlands* (CWs) and biofilter be a relevant alternative in treating wastewater because it is efficient in terms of installation, operational and maintenance aspects [31]. This study aims to determine the performance of a combination of biofilter and constructed wetland treatment systems in treating batik wastewater.

2. METHODOLOGY

2.1 The Raw Batik Wastewater

The raw wastewater used in this study came from a small batik industry in Jetis, Sidoarjo Regency, East Java Province, Indonesia. Raw wastewater is obtained from the boiling process. The sample from this process was chosen because it has the highest contaminants compared to very high when compared with the other two processes namely soaking and rinsing [10]. Samples were taken directly after the boiling process using 1,000 mL glass bottles as shown in Figure 1 for further characterization.

Fig 1. Wastewater sampling in batik industry

2.2 Characterization of Raw Batik Wastewater

The parameters analyzed were physical chemical parameters including TSS, COD, and oils and grease. The laboratory analysis was carried out according to the standard methods of APHA [10]. Measurements for TSS parameters and oils & grease used gravimetric analysis methods while COD parameters used reflux methods. Measurements were made on the influent before being treated to determine the initial characteristics of the batik wastewater and after treatment. The measurement results are then compared with the quality standards set by the Republic of Indonesia's Minister of Environment Regulation No. 5/2014 concerning wastewater quality standards. The results of the analysis can be seen in Table 1.

Table 1. Characteristics of raw batik wastewater

Parameter	Unit	Value	Effluent standard (*)	Analytical method
TSS	mg/L	3,180	50	Gravimetric
COD	mg/L	12,000	150	Reflux
Oil & Grease	mg/L	9,740	3	Gravimetric

* Regulation of the Minister of Environment of the Republic of Indonesia No. 5/2014 on wastewater quality standards.

2.3 Pilot System

2.3.1 Biofilter

The biofilter used is made of glass with dimensions of 20 x 20 x 80 cm. The filter material is very important for biofilter and constructed wetland. Suitable material can improve pollutants removal in biofilter [32]. The filter media used are 1-2 mm sand and 19-25 mm gravel. These two media were chosen because of their local availability. Gravel is placed at the bottom with a height of 100 mm, while sand with a height of 500 mm. Free space from sand to the top surface of the glass is 200 mm. Gauze cloth is placed between sand and gravel as insulation to prevent mixing of media. The schematic diagram of biofilter can be seen in Figure 2.

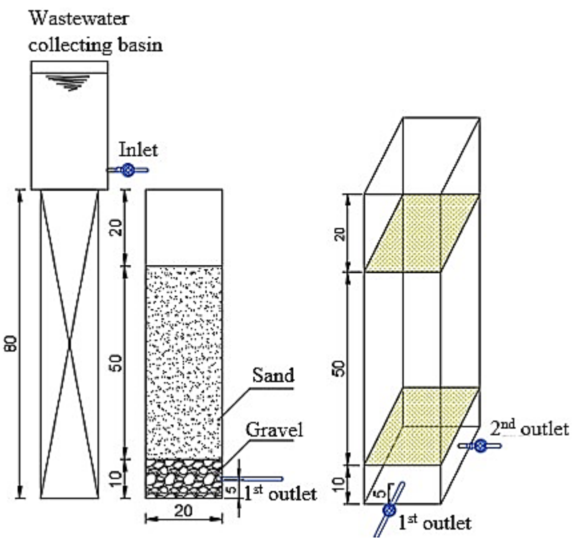

Fig 2. Schematic diagram of biofilter

The acclimatization process is carried out after the biofilter pilot system has been completed by flowing raw batik wastewater continuously and sufficient rate of aeration into the biofilter for 4 weeks at 27-29 ° C to grow the biofilm layer on the surface of the media. The layer serves to help reduce levels of wastewater pollutants in the biofilter [33][34][35]. The acclimation process aims to obtain a stable growth rate of microorganisms characterized by removal efficiency of physical parameters and organic matter [33]. Biofilter system performance is shown by the efficiency of TSS, COD, and oil and grease removal. Samples are taken and tested for each hydraulic retention time and then analyzed in the laboratory using the standard procedure of APHA.

2.3.2 Constructed Wetlands

Pilot system of is made of glass with dimensions of 100 x 50 x 60 cm. The type of CWs used in this study is horizontal subsurface flow (HSSF). The CWs planning design can be seen in Figure 3. The media used in CWs are gravel and sand. The first medium used was of 150 mm gravel with a size of 19–25 mm and a porosity of 0.6% [36]. The second layer above the first was of 700 mm coarse sand (filter media size was 1–2 mm) into which the macrophyte was planted [37]. Between the two media lay a gauze cloth that serves as a barrier so that the two media are not mixed and the roots of the plant are not disturbed but still allows raw batik wastewater to pass through. Free space from sand to the top surface of the glass is 30 cm.

In HSSFCW, macrophyte used must pay attention to several things, namely (1) have a high tolerance for high organic and nutrient loadings; (2) has many roots and rhizomes in order to provide substrate for attached bacteria and oxygenation (even very limited); and (3) has high aboveground biomass for winter isolation in cold climates. The plant used in this study was *Hymenocallis littoralis*. *Hymenocallis littoralis* or tiger lily is a plant species of the genus *Hymenocallis* which is widely available in various tropical countries including Indonesia [17].

Hymenocallis littoralis is a plant that has been used to observe the efficiency of reducing nutrients (total phosphorus: TP and total nitrogen: TN) in surface flow constructed wetlands (SFCW) [38]. Use of *Hymenocallis littoralis* together with *Canna siamensis* and *Heliconia* spp. has been used in constructed wetlands with seafood waste flowing and is capable of reducing BOD, SS, TN and TP each by 91-99%; 52-90%; 72-92%; 72-77% [39]. *Hymenocallis littoralis* also shows high absorption of phosphorus (P) [38]. A data show that higher removal rates correlate with faster growth and greater biomass.

Hymenocallis littoralis has high biomass when compared to other rhizomatic root plants so that the average nutrient removal is also high [32].

Plant density is needed to ensure optimal processing performance on CWs. Plant density in general 6 – 8 clumps/m^2 [40]. Based on the area of the pilot system HSSCWs is 0.5 m^2 (0.5 m x 1.0 m) 4 plant units are used *Hymenocallis littoralis*. Acclimatization of plants is carried out for 56 days until the plants have good growth [41]. Plants are watered using PDAM water in the first two weeks while the next is using raw batik wastewater with concentration 25%, 50% and 75%.

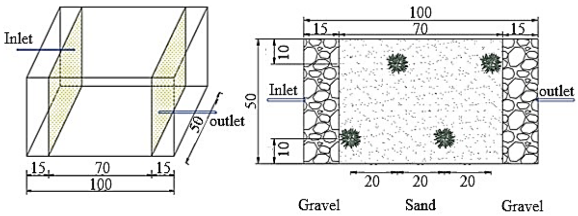

Fig 3. Schematic diagram of HSSFCW

2.4 Experimental Set Up and Operations

The combination of biofilter and HSSFCW technology is used to treat batik industry wastewater with better performance. The Batik wastewater is pumped to the elevated water tank over the biofilter and trickled down to the naturally aerated upper layer. Furthermore, the batik industry liquid waste flows towards the upper layer and then entered submerged lower layer. During the spatial alternations of aerobics and anoxic conditions in the biofilter, organics, nitrogen and suspended solids were removed simultaneously. After biofiltration, batik wastewater was introduced into the HSSFCW to remove other residual pollutants. The schematic diagram of the combination of the two methods is shown in Figure 4.

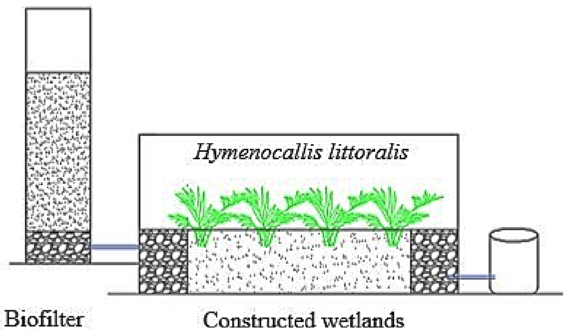

Fig 4. Schematic diagram of combined biofilter dan HSSFCW

Both of these methods are operated in batches which are believed to provide better results than continuous feeding because they provide more oxygen in the processing system [42]. The statement confirmed by Zhang et al. (2012), which compares the performance of subsurface flow treatment wetlands operated in batch and continuous feed. The results show that ammonia-nitrogen was removed with an efficiency of 95.2% in the batch mode system, which was significantly ($p < 0.05$) higher than continuous mode of 80.4% removal efficiency. In this study, the batik industry's liquid waste is flowed in batches by discharge 5.2 mL/second with hydraulic retention time for 3 days, 5 days and 7 days. The parameters observed consisted of TSS, COD, and oil & grease [43].

2.5 Data Analysis

The data analysis technique used in this study is inferential analysis. Inferential analysis includes testing the research hypothesis using test multivariat analysis of variance (manova). Testing the hypothesis in this study using SPSS version 22.0 for windows. Manova test can be used in a data if it meets 2 test prerequisites, namely normality and homogeneity. Data is considered normal and homogeneous if it has a significance value of more than 0.05. The normality test uses the Kolmogorov Smirnov one sample test while the homogeneity test uses the Lavene's Test.

3. RESULT AND DISSCUSION

3.1 The Characteristics of Raw Batik Wastewater

The characteristics of raw wastewater batik taken from the boiling process for later use as influents in the study are all above the effluent standard determined by the Minister of Environment Regulation of the Republic of Indonesia No. 5/2014. The analysis results as shown in Table 1 show the TSS value of 3.180 mg / L, COD of 12,000 mg / L and oil and grease of 9,740 mg / L. These results are consistent with previous research which states that the COD of batik wastewater value shows the highest value This value is close to the results of previous studies which stated that the characteristics of batik wastewater after the boiling process amounted to 13.600 mg/L [10].

3.2 Removal Efficiency on Various Parameters of Batik Wastewater

Parameter measurements were performed on biofilter-HSSFCWs with hydraulic retention time (HRT) for 3 days, 5 days and 7 days. It aims to determine the effectiveness of each pilot system. The measurement results are in Table 2.

Table 2. Measurement results effluent biofilter and HSSF CWs

No.	Method	Parameter	Sample	Hydraulic retention time (days)		
				3	5	7
1	Biofilter	COD	BIO1	4,127	2,770	5,030
			BIO2	4,144	2,806	5,035
			BIO3	4,149	2,824	5,055
		TSS	BIO1	241	183	270
			BIO2	.253	199	278
			BIO3	262	206	298
		FO	BIO1	2,509	1,697	3,061
			BIO2	2,516	1,709	3,072
			BIO3	2,535	1,718	3,077
2	Biofilter-HSSFCWs	COD	HSSF1	1,583	2,547	3,261
			HSSF2	1,605	2,564	3,276
			HSSF3	1,612	2,569	3,303
			HSSF1	82	123	49
		TSS	HSSF2	91	133	60
			HSSF3	102	140	65
			HSSF1	959	1551	1990
		FO	HSSF2	966	1558	1998
			HSSF3	985	1571	2012

Manova test was conducted to determine differences in performance between single methods and combination methods. Based on Table 3 on the value of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root showed a significance value <0.05. This means that there is a significant difference between the performance of biofilter and biofilter-HSSFCWs combination on HRT for 3 days, 5 days and 7 days. This proves that the two methods have different capabilities in processing COD, TSS, and oil & grease parameters.

Table 3. Manova test results

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1.000	1231599.20[b]	3.000	10.000	.000
	Wilks' Lambda	.000	1231599.20[b]	3.000	10.000	.000
	Hotelling's	369479.760	1231599.20[b]	3.000	10.000	.000
	Roy's Largest	369479.760	1231599.20[b]	3.000	10.000	.000
Technology	Pillai's Trace	1.000	57606.711[b]	3.000	10.000	.000
	Wilks' Lambda	.000	57606.711[b]	3.000	10.000	.000
	Hotelling's	17282.013	57606.711[b]	3.000	10.000	.000
	Roy's Largest	17282.013	57606.711[b]	3.000	10.000	.000
HRT	Pillai's Trace	1.242	6.011	6.000	22.000	.001
	Wilks' Lambda	.000	508.711[b]	6.000	20.000	.000
	Hotelling's	17878.596	26817.895	6.000	18.000	.000
	Roy's Largest	17878.277	65553.681[c]	3.000	11.000	.000
Technology* HRT	Pillai's Trace	1.885	60.190	6.000	22.000	.000
	Wilks' Lambda	.000	884.232[b]	6.000	20.000	.000
	Hotelling's	8140.110	12210.164	6.000	18.000	.000
	Roy's Largest	8132.393	29818.773[c]	3.000	11.000	.000

3.2.1 Efficiency Removal of COD

The combination of biofilter-HSSFCW processing methods showed a decrease in COD value in HRT for 3 days, 5 days and 7 days as shown in Figure 5. The results of the combination of processing methods showed an efficiency of 86.67% in HRT 3 days, then decreased to 78.67% in HRT 5 days and again decreased in HRT 7 days to 72.67%. These results are different from previous studies which state that the processing of polluted river water using biofilter results obtained by 30% on HRT 3 days. After 7 days, the removal efficiency of organic matter increases to 80-90%. After 18 days of operation, organic removal efficiency is relatively stable at around 90%. At this point, steady state conditions have been reached which are characterized by the formation and development of biofilms by bacterial layers that can be observed visually. Longer HRT allows raw water to have a long contact time with the media and adequate oxygen supply, and thus accelerates the formation of biofilms in the media [33].

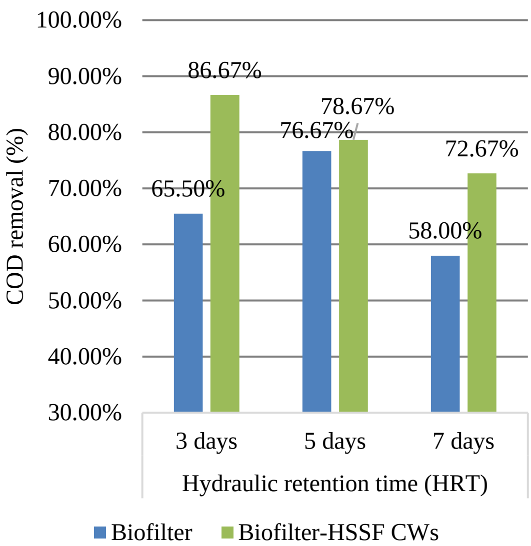

Fig 5. Efficiency of COD removal

The difference in results is due to differences in the type of raw water treated and the media used. In this study the efficiency of COD reduction by biofilter-HSSFCW combination was obtained at 3 days HRT. This means that steady state biofilter conditions were obtained in HRT before 3 days and in the HSSFCW in the HRT *Hymenocallis littoralis* had experienced saturation in deciphering various types of toxic pollutants in the batik industry liquid waste. It can be said that the most optimum HRT in treating batik wastewater is 3 days with a COD reduction efficiency value of 86.67%.

Other studies suggest that a combination of biofilter-HSSFCWs systems can eliminate COD contaminants with an efficiency of 95% [25][44]. The higher performance was obtained by using a combination of two types of plants namely *Syzygium campanulatum* and *Ficus microcarpa* and pretreatment before the combination of the biofilter-HSSFCW method. Pretreatment is done to separate oil and grease [44]. Other studies suggest that COD reduction efficiency ranges from 82.4 to 91.4% in summer. The study used double-layer biofilter with a combination of plants in CWs, namely *C. alternifolius* and *Canna* CWs that use several types of plants will be more effective in reducing organic compounds when compared to using one type of plant [25].

In biofilter, the decrease in COD occurs physically through the process of adsorption. The adsorption process is the concentration of pollutants on the surface of the filter media caused by the attraction between the filter media and pollutants. Filter media such as gravel can also help reduce COD by precipitating particulate material [39]. Organic contaminants absorbed by the filter media will be broken down by microorganisms [27][35][44]. Molecular breakdown is carried out through the process of fermentation, aerobic and anaerobic respiration to use energy and carbon sources to support the growth of microorganisms. The COD in HSSFCW removal process occurs through the process of suspended solids filtration or sedimentation and the activity of microorganisms from aerobic and an aerobic bacteria. The macrophyte, Hymenocallis littoralis, provides aerobic conditions in the root zones of planted cells so that microorganisms are able to carry out microbiological degradation [45]. The aerobic condition occurs because the oxygen produced from the photosynthesis process in the leaves is transferred to the roots to support the growth of microbial degrading organic matter [46].

3.2.2 Efficiency Removal of TSS

The combination of the biofilter-HSSFCW method in reducing TSS has proven to be very effective. This is evident from the results of a decrease in TSS that is able to reach above 90%, where in HRT 3 days is obtained by 97.12%; on HRT 5 days at 95.85%; and in 7 days HRT was 98.18% as shown in Figure 6. These results are in line with previous studies, but there are slight differences. Previous research has suggested that the combination of biofilter and HSSFCWs systems can eliminate TSS contaminants by 84,38% [44]. The difference lies in the use of filter media, which uses sand and limestone while in this study using sand and gravel as filter media.

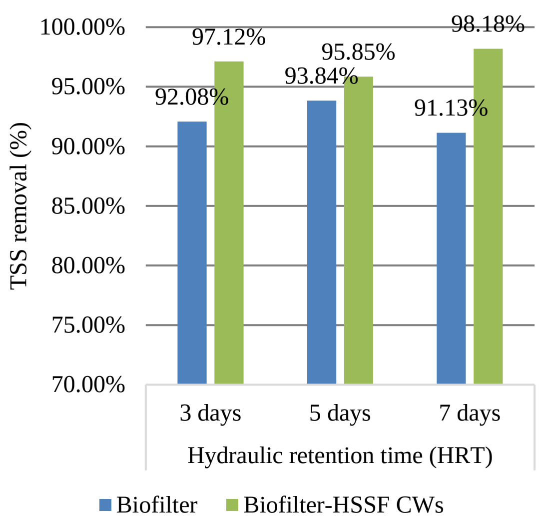

Fig 6. Removal efficiency of TSS

The TSS pollutant removal process is caused by the physical filtration effect of sand and gravel. However, it is also possible for organic particles to be captured by gravel sand media and degraded by microbes contained in the biofilm layer [33]. In the combination of these two methods which have a more important role in the TSS elimination is HSSFCW. In a previous study it was mentioned that HSSFCWs were able to increase TSS removal to 43% when combined with biofilter which was only able to reduce TSS by 39% [44]. When batik wastewater was flown to HSSFCW, further entrapment and sedimentation of the solids due to media that reduces the hydraulic surface loading rates was happen [47].

In this process, the media play the most important role because it acts as a filtering media for contaminants in batik wastewater [48]. The sedimentation process causes the waste water to retain in the pores of the substrate due to the low water velocity and retention time. Waste water will directly replace the air cavities contained in the substrate. The presence of plants in HSSFCWs increases sedimentation by slowing down the water velocity thereby allowing suspended material to settle [31].

3.2.3 Efficiency Removal of Oil and Grease

The presence of oils and fats in water bodies causes the formation of oil layers which triggers various impacts including the following: 1) decreased light penetration which can cause disruption of photosynthesis of aquatic plants and other organism activities; 2) cause blockages in various pipelines and pumps thereby increasing maintenance costs; 3) excess oil and grease content in wastewater causes difficulty in sludge generated from the treatment plant unit will be difficult to compact; 4) disrupt the biological aerobic wastewater treatment process by reducing the rate of oxygen transfer; 5) causes underarm optimization in the anaerobic treatment process by reducing the transport of soluble substrate to bacterial biomass; and 6) cause turbidity, aesthetic disorders and unpleasant odors [49]. Therefore, oil and grease must be treated so that it does not cause water pollution.

In the process of decreasing oil and grease content using a biofilter-HSSFCW combination method with various HRT results obtained by 90.04% in HRT 3 days, then in HRT 5 days efficiency decreased to 83.98% and in HRT 7 days efficiency reached 79.47% as shown in Figure 7. This shows that for the decrease in oil and grease parameters, an optimal HRT is obtained on day 3. The decrease is due to oil and grease being hydrocarbon compounds, which are organic materials and have long and complex carbon chains [50][51]. The complex and long carbon chains in oil and grease cause slow degradation of microorganisms. Lack of penetration of sunlight and dissolved oxygen that occurs due to the presence of oils & fats also affects the slow performance of microorganisms. The slower performance of microorganisms causes a decrease in the efficiency of oil and grease has decreased from HRT 3 days to HRT 7 days.

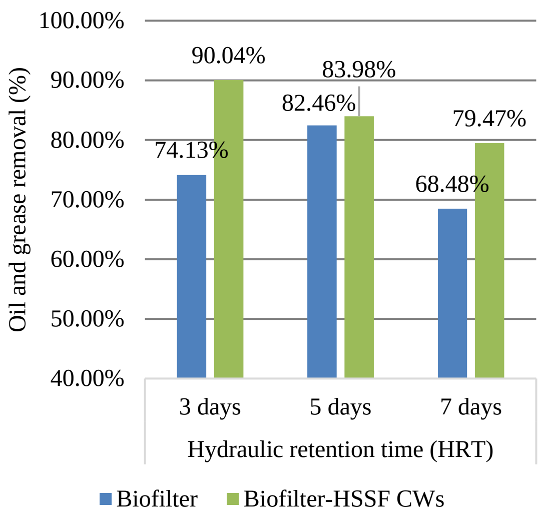

Fig 7. Efficiency removal of oil and grease

High oil and grease removal efficiency (up to 90%) is due to the main role of biofilter. This efficiency depends on the contact time (HRT), column length, and thickness of the media. Previous research in which industrial waste treatment using adsorption was obtained results of 67% at slow flow rates but maximum efficiency can reach 80% at higher flow rates for 200 cm for column length. The length of this column is very influential on decreasing oil and grease because it will increase the efficiency of oil transfer as well as the concentration of oil and grease due to longer contact between wastewater and filter media [52].

3.3 Effluents from Combinations Biofilter-HSSFCWs

The results of the batik wastewater treatment using the integration of biofilter and HSSFCWs have not been able to reduce batik liquid waste pollutants to meet effluent standards stipulated in the Regulation of the Minister of Environment of the Republic of Indonesia No. 5/2014. This means that effluents generated through a combination of HSSFCWs biofilter treatment methods cannot be discharged directly into water bodies. In addition, this effluent also does not meet the standards for various designations referring to Government Regulation No. 82/2001 concerning management of water quality and water pollution, which can be seen in Table 4.

Table 4. Comparison of biofilter-HSSFCW processing results

Parameter	Combined biofilter-HSSFCW HRT (days)			Class*			
	3	5	7	I	II	III	IV
TSS (mg/L)	64	132	58	50	50	400	400
COD (mg/L)	1.600	2.560	3.280	10	25	50	100
Oil and grease (mg/L)	970	1.560	2.000	1.000	1.000	1.000	(-)

* Government Regulation (PP) No. 82 of 2001 (Government Regulation Number 82 of 2001 concerning Management of Water Quality and Water Pollution Control)

Table 4 shows that treated water still exceeds the predetermined class limits, both class I, class II, class III, and class IV. The three parameters, namely TSS, COD, and oil & fat exceed all class limits, except for the oil & fat parameter on HRT 3 days. Oil & fat parameters on HRT 3 days at 970 mg / L do not exceed the specified class limit, which is 1,000 mg / L. However, other parameters indicate values that exceed the water class limit so it can be concluded that treated water should not be intended for the community, whether class I, class II, class III, or class IV.

The results showed that the treated water still exceeded the specified quality standards, especially for the COD parameters and oil & fat. This causes the need for pretreatment before it flows into the integration of biofilter and CWs. Some studies also use pretreatment to help reduce levels of pollutants. The pretreatment includes using oil & grease separator [44], membrane filtration [53] or flotation [54]. Dissolved Air Flotation (DAF) is the most widely used floatation type because it is flexible and can reduce oil and grease significantly [55].

4. CONCLUSIONS

Batik wastewater which generated from the boiling process has COD, TSS, and oil and grease values respectively 12,000 mg/L, 3,180 mg/L, and 9,740 mg/L. This value exceeds the quality standards set by the Regulation of the Minister of Environment of the Republic of Indonesia No. 5/2014 on wastewater quality standards so that they are not allowed to be discharged into water bodies because they have the potential to cause environmental pollution. The combination of the biofilter-HSSFCWs method resulted in a COD reduction efficiency of 72.67-86.67%; TSS of 95.85-98.18%; and oils & grease at 79.47-90.04%. There was a significant difference in p <0.05 between the biofilter method and the combination of the biofilter-HSCCFCWs method. The highest reduction efficiency was obtained in the TSS removal, while the optimum HRT value was achieved on the 3rd day for all observation parameters. However, although the performance of the biofilter-HSSFCWs combination method is quite high in reducing various parameters in wastewater, it has not been able to meet the effluent standards set by the government for various purposes. Therefore, pretreatment is needed in advance to reduce COD pollutants and oil and grease before the batik industry wastewater enters the biofilter-HSSFCWs unit combination.

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