The Addition Of Effective Microrganism 4 And Charcoal Husk To Biofilter In Domestic Wastewater Treatment In Makassar

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Abstract: Liquid waste is a potential source of water pollution as it contains a fairly high compound: chemical compounds and pathogenic microorganisms that are harmful to health. Therefore, it is necessary to be processed first before discharged to waterbody. This study aims to determine the effectiveness of the addition of EM4 and charcoal husk to biofilter in reducing BOD, TSS, and NH3 levels in domestic wastewater. This experimental research was conducted by using Pretest-Posttest design in several steps, including literature review, biofilter construction, media setup, and biofilter examination as the main research. The basic principle of the biofilter was using microorganism to disentangle the compound and pollutant in the wastewater. The microorganisms grew to attach to the media surface and formed a biofilm layer. The results revealed that after biofilm growing for 28 days, there was a difference in the level of BOD, TSS, and NH3 before and after the processing. The average of BOD level decreased for 45.01% (258.134 mg/l to 130.96 mg/l), meanwhile, the average of TSS level decrease by 73.15% (116.6 mg/l to 29.8 mg/l) and the NH3 level reached 37.96% (0.162 mg/l to 0.10 mg/l). Biofilter had been able to reduce TSS and NH3 levels by specified quality standards, while for BOD parameter were still above the quality standard.

1. Introduction
A Water Pollution still frequently occurs both in the rivers and the sea. It becomes an environmental issue to be focus on. The results of the analysis showed that the coastal waters of the Gulf coast Youtefa contains organic contaminants that are above the standard quality level, for example, the highest COD levels for all sampling locations is 1806 mg / L [1]. These results exceed the quality standards based on the Ministry of Environment Number 51 2004.

The cause of water pollution is the wastewater derived from domestic, industrial, and office buildings discharged onto the rivers or the sea without preceding process. As found in the research of JICA team (1990) in Said (2011) in the region of Jakarta, the domestic is responsible for the largest contribution of waste in terms of quantity by 75 %, followed by industry for 16 %, and 14 % from office. As a result, It is concluded that domestic wastewater/household affects significant problems of water pollution in DKI Jakarta.
Therefore, it is urgent to find out wastewater treatment to overcome the issues. One of the wastewater treatment methods that is widely used is a biofilter. The biofilter is a method of wastewater processing by utilizing a microorganism that occurs naturally in the wastewater to reduce the content of the physical, chemical and bacteriological compounds in the wastewater. In addition, not only for treating industrial liquid waste, but it was also performed to process domestic wastewater. Research conducted by Romali (2011) resulted that the percentage of removal for parameter SS, COD, BOD were 83.08%, 51.60%, 72.42% (3). Also, research by Garkal (2015) of domestic wastewater treatment using biofilter obtained the preliminary results of BOD, COD, and TDS amounted to 72.05%, 68.52%, and 15.42% [4]. Furthermore, the study by Zahra (2015) using aerobic biofilter with downflow and applying an intermittent system that uses a biofilter media in the form of gravel and rocks to get the preliminary parameters of BOD, COD, and TSS resulted 94.83%, 92.95%, and 95%, respectively [5].

Some of the biofilter media materials commonly used are made of a polymer, gravel, pumice, wood, and pipe. The medium of biofilter function is being a place of attachment of microorganisms (biofilm) which serves to decompose pollutants contained in the wastewater.

A testing conducted in the area of Jakarta in treating industrial wastewater using packing of honeycomb-shaped plastic material under anaerobic-aerobic condition showed a significant decrease in BOD, COD, and TSS. However, packing by plastic materials has a disadvantage in terms of high cost. Therefore it needs a cheap plastic and affordable as alternative for instance the used gallon cap. The unused one is only generally thrown away or sold to scavengers. In fact, it can be useful as a medium for the growing of the biofilter.

Charcoal has been widely used in the water treatment process and wastewater. One of the materials made into charcoal is rice husk. Rice husk is a byproduct in the rice milling process. The use of rice husk in the wastewater treatment process has been carried out for example the research result by Rahayu (2015) using husk charcoal to reduce COD of tofu wastewater conducted on a laboratory scale. The result was a decline of 90% COD by contacting 200 mesh husk where previous COD levels in wastewater was 1,35624 mg / ml (1356,624 mg / l) became 0,135624 mg / ml (135,624 mg / l) [1].

One of the problems in wastewater treatment is long processing time, so it takes an effort to speed up the treatment process. One method implemented to accelerate the process of wastewater treatment is the use of EM-4 (Effective Micro-organisms 4). Munawaroh et al. (2013) gained BOD and COD reduction by 97% and 96% in the fifth day by addition of EM4 1:20 (5%) in the wastewater. The Decrease of TSS MPN Coliform 93.4% and 96.4% occurred in the seventh day [7]. Research conducted by Pitriani et al. (2015) found that there was a decrease in pollutants by the addition of EM4 5%, after 18 days. The decline reached 91.22% BOD, and 90.05% TSS. It met the maximum permissible level as in South Sulawesi Governor Regulation number 69 of 2010 [8].

Due to those findings, the authors are interested in reviewing the effectiveness of biofilter using gallon cap media in the domestic wastewater treatment by the addition of EM-4 (Effective Micro-organisms 4) and rice husk in reduction the parameters BOD, TSS, and Ammonia Free.

2. Method

This research is an experimental study by pretest - Posttest Design. The period time was in September - November 2017. The examination of BOD, TSS, and NH₃ level was carried out in Environmental Health Technology Center Makassar. Besides, the analysis of pH and temperature was conducted by insitu which used pH meter and thermometer mercury. Data were analyzed descriptively illustrated by tables, graphs, and narrative.

Wastewater treatment was conducted by operating the reactor biofilter consisting of a tank, the treatment tank I, treatment tank II, and tank containing husk. Before putting into the reactor, first of all the EM4 was activated by mixing 1 liter EM4 with 20 liters of water and five tablespoons of liquid brown
sugar, then it was fermented 2-4 days in a tightly closed. Furthermore, the process of seeding on the biofilter media was carried out by adding 5% EM4 into the tank. From tanks, waste water was flowed into biofilter with a flow rate of 1 ml/sec and the staying time in the biofilter of wastewater of a biofilm growing was 24 hours. Biofilter volume amounted to 81 liters. Biofilm growing process was conducted for 28 days.

In this experiment, the reactor was operated continuously with the time of staying in the reactor for 4 hours. During the operation process, measurements were made on pH, temperature, BOD, TSS and NH3. These measurements were to determine the effectiveness of biofilter in reducing these parameters in domestic wastewater. Sampling was taken by grab sampling (instantaneous sample) method at 6:00 a.m. to 7:00 p.m., 8:00 to 9:00 p.m. and 10:00 to 11 p.m. It was taken at three points. Point I as the pretest was done at the inlet, Point II was at the reactor outlet I, while point III as the posttest was carried out at the outlet after the wastewater passes through the biofilter with a staying time of 4 hours. Samples were taken 5 times each, after 28 days of biofilm growing.

3. Results

Table 1 shows the results of pH and temperature measurements of the wastewater at the point I, II and III. Tables 2, 3 and 4 show the levels of wastewater parameters before and after processing. The decreased levels of all three parameters are checked are BOD, TSS, and NH3 both at the point of I, II and III.

| Measurement | pH       | Temperature (°C) |
|-------------|----------|-----------------|
|             | The point I | The point II | The point III | Average | The point I | The point II | The point III | Average |
| 1           | 6.26      | 5.8            | 5.3           | 5.8     | 25         | 33           | 35           | 31.0    |
| 2           | 5.45      | 5.6            | 5.75          | 5.6     | 26         | 28           | 28           | 27.3    |
| 3           | 5.45      | 5.52           | 5.93          | 5.6     | 24         | 29           | 29           | 27.3    |
| 4           | 5.2       | 5.3            | 5.5           | 5.3     | 27         | 29           | 30           | 28.7    |
| 5           | 5.6       | 5.7            | 5.9           | 5.7     | 26         | 26           | 28           | 26.7    |

Source: Primary Data 2017

Based on the table above, the temperature of the wastewater during the treatment process are in the range of 25 - 30 °C and pH conditions during the process of biofilm formation in the range of 5, 2 - 6.3
Table 2. Measurement Results of BOD in Point I, II and III

| Measurement | The point I | The point II | The point III | % Efficiency |
|-------------|-------------|--------------|---------------|--------------|
| 1           | 217.46      | 197.32       | 144.97        | 33.33        |
| 2           | 205.38      | 193.30       | 159.47        | 22.35        |
| 3           | 205.38      | 183.63       | 126.85        | 38.24        |
| 4           | 354.38      | 153.03       | 86.58         | 75.57        |
| 5           | 308.07      | 199.34       | 136.92        | 55.56        |
|             | 258 134     | 185 324      | 130 958       | 45.01        |

Source: Primary Data 2017

Based on the table above, the highest efficiency of BOD is 75.57%, and the lowest is 22.35%. The average removal efficiencies of the BOD is 45.01%.

Table 3. Measurement Results of TSS in Point I, II and III

| Number | Date             | TSS | % Efficiency |
|--------|------------------|-----|--------------|
|        |                  | The point I | The point II | The point III |               |
| 1      | 18 September 2017| 116.00 | 35.00       | 28.00        | 75.86        |
| 2      | 19 September 2017| 111.00 | 45.00       | 40.00        | 63.96        |
| 3      | 20 September 2017| 107.00 | 61.00       | 33.00        | 69.16        |
| 4      | 22 September 2017| 125.00 | 45.00       | 25.00        | 80.00        |
| 5      | 25 September 2017| 99.00  | 37.00       | 23.00        | 76.77        |
| Average|                  | 111.6 | 44.6        | 29.8         | 73.15        |

Source: Primary Data 2017

Based on the table above, the highest and the lowest efficiency of TSS are 80% and 63.16%. The average removal efficiencies of the TSS is 73.15%.
Table 4. Measurement Results of NH3 in Point I, II and III

| Number | Date             | The point I | The point II | The point III | % Efficiency |
|--------|------------------|-------------|--------------|---------------|--------------|
| 1      | 18 September 2017| 0.077       | 0.077        | 0.077         | -            |
| 2      | 19 September 2017| 0.077       | 0.077        | 0.077         | -            |
| 3      | 20 September 2017| 0.077       | 0.077        | 0.077         | -            |
| 4      | 22 September 2017| 0.077       | 0.077        | 0.077         | -            |
| 5      | 25 September 2017| 0.16        | 0.15         | 0.10          | 37.96        |

Average: - - -

Source: Primary Data 2017

Based on the table above, the removal efficiency of NH3 is 37.96 %.

4. Discussion

Based on the results measurement, the BOD, TSS, and NH3, experienced a decrease with biofilter by the adding of EM4 and husk after treatment. This decrease is due to the degradation process of microorganisms that become better when the contact between the wastewater and microorganisms in the biofilm layer gets slower. The levels of BOD, TSS and NH3 decreased after 28 days of biofilm growing, although it is not significant.

The temperature of the wastewater during the treatment process was in the range of 25 - 30 °C. Mesophilic microorganisms had a range of temperatures from 20 - 40 °C. High temperatures would prevent the activity of enzyme in the cells. A decrease in processing efficiency can be caused by the increase in temperature.

BOD parameter measurement results of domestic liquid waste by biofilter decreased after processing. The maximum allowable limit for domestic wastewater of BOD parameter based on the regulation of the Minister of Environment and Forestry Number P.68 2016 about Domestic Wastewater Quality Standard is 30 mg / L. Before the wastewater entering a biofilter, the average BOD content of the wastewater was equal to 258.13 mg / L. Meanwhile, an average of BOD content of wastewater was 130.96 mg / L with an efficiency of 45% after processing. It means that the content of BOD after processing does not meet the quality standards required. This study is then not in line with the research by Bahar (2013) who gained a decrease 92.13 mg / L to 16.34 mg / L with a reduction of 85.79 mg / L (82.26% efficiency). However, considering the decline of BOD, this research is successfully to reduce BOD by 127.17 mg BOD / L [9]. Another study using a biofilter in processing wastewater was conducted by Romali (2011), with the percentage of removal for BOD parameter amounted to 72.42% [3]. And also by Garkal (2015) with BOD efficiency of 72.05% [4].

One cause of the ineffectiveness of this biofilter in reducing the levels of BOD is the biofilm formation that is not optimal. The pH conditions during the process of biofilm formation were in the range of 5, 2 - 6, 3. The range is not a required condition in growing of biofilm. The optimum pH of medium environment affect waste treatment process biologically, the general micro-organisms require a pH between 6.5 and 9 [10]. A very high pH (> 9) will inhibit the activity of microorganisms, while a pH below 6.5 will lead to the growth of mold and result the competition with the bacteria in the metabolism of organic material [11].
TSS parameter measurement results of domestic liquid waste decreased after processing by biofilter. The maximum allowable limit for domestic wastewater TSS parameter based on the Regulation of the Minister of Environment and Forestry of Indonesia Number 68 2016 regarding Standard Domestic Wastewater is 30 mg / L. Before the wastewater entering a biofilter, average content of TSS wastewater amounted to 111.6 mg / L, then an average TSS content of the wastewater was 29.8 mg / L with the efficiency of 73.15% after processing. As a result, it met the quality standards required. This research is in line with research by Bahar (2013). It is found that a decrease occurred from 38.8 mg / L to 7.2 mg / L with a reduction of 81.44 mg / L (81.44% efficiency). Another study using a biofilter in processing liquid wastes conducted by Romali (2011), with the percentage of removal for TSS parameter by 83.082% [3]. This research is in accordance with a study by Said (2011) employing a dyed biofilter using honeycomb media. The wastewater treatment of a hospital obtained a fairly high efficiency TSS namely 80.0 – 97.8% [2]. Research conducted by Ainkhaer (2014) also showed a honeycomb biofilter media model resulted TSS reduction efficiency by 62, 51% with 21 days of growing bacteria [12]. In addition, the research conducted by Ning (2011) that added alum to reduce TSS gained the average efficiency of 82% [13]. While research by Mustafa et al., (2012) received the elimination results of TSS in anaerobic and aerobic biofilter starter with the addition of 77% [14].

Furthermore, the results of measurement parameters domestic ammonia from liquid waste after processing by biofilter experienced a decrease. The maximum allowable limit for domestic wastewater ammonia parameter based on the Regulation of the Minister of Environment and Forestry Number P.68 2016 about Domestic Wastewater Quality Standard is 10 mg / L. Before the wastewater entering a biofilter, ammonia content of wastewater was equal to 0.162 mg / L, while the ammonia content was equal to 0.1 mg / L with efficiencies of 38% after treatment. It means that the ammonia content both before and after processing has met the quality standards required. This study is in line with the research conducted by Ainkhaer (2014) applying a model of honeycomb biofilter media without the addition of EM4. It was found that the level of ammonia remains high with the removal efficiency of 49.57% [12]. Meanwhile, the research findings by Said and Ineza (2002) showed liquid waste treatment with dyed biofilter process using honeycomb media resulted a fairly high efficiency of NH3 by 93.75 - 98.2% [2]

The use of rice husk parameters is proven to reduce BOD, TSS, and Ammonia. However, the results have not been significant. After flowed through the tank containing rice husk, it is found that the percentage of reductions were 29, 33% of BOD, 33, 18% of TSS, and 31, 63% of Ammonia. Although BOD level remains above the standard quality after processing, the addition of EM4 and husk into a domestic wastewater treatment with biofilter system could reduce levels of BOD, TSS, and ammonia-free.

5. Conclusion
The addition of Effective Mikroorganism-4 (EM4) and husk after growing biofilm for 28 days is proven to reduce the parameters of BOD, TSS, and ammonia-free. Parameter TSS and ammonia-free meet the quality standard of Ministry of Environment and Forestry of Indonesia Regulation Number 68 2016 regarding Standard Domestic Wastewater, nevertheless, BOD parameters do not either. Liquid waste from the domestic is required to be processed before throwing into the environment, so it does not pollute the sources of clean water.

References
[1] Sander Erari S 2012 Pencemaran Organik di Perairan Pesisir Pantai Teluk Youtefa Kota Jayapura, Papua: Magister Biologi Program Pascasarjana UKSW.
[2] Said NI 2011 Teknologi Pengolahan Air Limbah Rumah Sakit Dengan Sistem Biofilter Anaerob-Aerob. Jakarta: Direktorat Teknologi Lingkungan.
[3] Noor Suraya R, Nadiah M 2011 Application of Biofilter System for Domestic Wastewater Treatment. International Journal of Civil Engineering and Geo-Environmental. 2:13-8.

[4] Garkal DJ, Mapara J, Prabhune M 2015 Domestic Waste Water Treatment By Bio-Filtration: A Case Study. International Journal of Science, Environment and Technology. 4(1).

[5] Zahra LZ, Purwanti IF 2015 Pengolahan Limbah Rumah Makan dengan Proses Biofilter Aerobik. Jurnal Teknik ITS. 4(1):D35-D9.

[6] Rahayu SA, Febriasari A 2016 Efektifitas Arang Sekam Padi Terhadap Penurunan Kadar COD (Chemical Oxygen Demand) Pada Limbah Cair Tahu. Jurnal Chemtech. 1(01).

[7] Munawaroh U 2013 Penyisihan Parameter Pencemar Lingkungan pada Limbah Cair Industri Tahu menggunakan Efektif Mikroorganisme 4 (EM4) serta Pemanfaatannya. Reka Lingkungan. 1(2).

[8] Pritiani, Natsir MF, Daud A 2015 The Effectiveness of EM4 Addition into Anaerob-Aerob Biofilter in the Processing of Wastewater at Hasanuddin University Hospital. International Journal of Sciences: Basic and Applied Research (IJSBAR). Vol 22, No. 1.

[9] Bahar E, Tawali AB, Muin M 2013 Spesifikasi dan Efektivitas Peralatan Pengolahan Limbah Cair Domestik Studi Kasus Rusunawa Blok D Universitas Hasanuddin. Jurnal Sains dan Teknologi Vol. 13.

[10] Flathman PE, Jerger DE, Exner JH 1993 Bioremediation field experience: CRC Press.

[11] Waluyo L 2009 Mikrobiologi lingkungan. Universitas Muhammadiyah Malang.

[12] Ainkhaer 2014 Analisis Efektivitas Biofilter Anaerob-Aerob Media Model Sarang Tawon dalam Mereduksi Parameter Air Limbah Rumah Sakit Unhas. Makassar: Universitas Hasanuddin.

[13] Ningsih R 2011 Pengaruh Pembubuhan Tawas Dalam Menurunkan TSS Pada Air Limbah Rumah Sakit. Jurnal Kesehatan Masyarakat. 6(2).

[14] Mustafa M, Alwathan A, Thahir R 2016 Pemanfaatan Sludge Hasil Pengolahan Limbah Cair Rumah Sakit Sebagai Bahan Baku Pembuatan Biogas: Penelitian Awal. Jurnal Sains dan Terapan Kimia. 6(2):130-8.