

Addition of EM-4 (effective microorganisms-4) to reduce BOD (biological oxygen demand) of batik cap waste in Pekalongan City

Kiswanto^{1,2,*}, *Wintah*^{3,*}

¹Public Health Study Programme, Faculty of Public Health, Teuku Umar University Indonesia

²Master's Degree Programme, Faculty of Engineering, Teuku Umar University Indonesia

³Master of Fisheries Science Study Programme, Faculty of Fisheries and Marine Sciences, Teuku Umar University Indonesia

Abstract. The **Biological Oxygen Demand (BOD)** level of batik cap liquid waste in Pekalongan City exceeds the quality standard, which is 3549.67.53 mg/l. The purpose of this study was to determine the effect of the addition of EM-4 on the decrease in BOD of batik cap liquid waste. The method used in this research was pretest-posttest with control group. The population of this study was a stamped batik making home industry that does not yet have an IPAL. Samples were taken from liquid batik cap waste from the production process. The study used 3 variations of EM-4 doses, namely 0 ml / l, 5 ml / l, 10 ml / l and 15 ml / l with incubation time for 1, 2, 3 days and replication 3 times. From the results of the study obtained a decrease in BOD with the addition of EM-4 (5 ml/l, 10 ml/l, and 15 ml/l) of 61.24%, 90.71% and 92.42%. BOD levels after treatment decreased to quality standards, namely; 300 mg/l. The results of statistical tests using two-way anova show that there is an effect of the addition of EM-4 on the decrease in BOD of stamped batik liquid waste.

1 Introduction

The batik industry in Pekalongan City is one of the producers of liquid waste derived from the dyeing process with a high dye content, batik industrial waste contains synthetic materials that are difficult to dissolve or difficult to decompose [1;2]. Positive impacts such as increasing the economic level and opening up employment opportunities. This is expected by humans in order to improve the quality and comfort of life. The negative impact is that batik waste can pollute river water which can reduce water quality, so it must be handled properly[3;4]. Especially in Pekalongan Regency, where public awareness about batik waste management is still low. These compounds when contained in wastewater will increase the content of BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), TSS (Total Suspended Solid), TDS (Total Dissolved Solid), pH, nitrite, odour, and other elements which are the main parameters in wastewater pollution [5;6].

*Corresponding author: kiswanto@utu.ac.id, wintah@utu.ac.id

The batik industry is an industrial sector that produces relatively large volumes of liquid waste. About 80% of the amount of water used to make batik is discharged as wastewater [7;8]. The waste comes from various batik making processes, such as dyeing, washing and wax removal. The chemicals used in batik making have a diverse composition, consisting of organic and inorganic substances [9;10]. The residues of these materials are wasted in liquid waste, so that liquid waste from the batik industry is considered one of the most hazardous industrial wastes compared to other industrial sectors such as pharmaceuticals, pulp and paper and paint [11;12]

In Indonesia, batik is generally produced by small and medium-sized industries (SMIs). Many batik industries are found outside industrial areas that do not have liquid waste treatment facilities. Batik liquid waste is usually discharged into rivers or sewers with minimal or no treatment [9;12;5]. Batik wastewater contains dyes, waxes and heavy metals. Batik wastewater contains dyes, waxes and heavy metals [13;14] and has high concentrations of total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) [15;3;].

Wastewater treatment technology in the batik industry usually uses a series of physical, chemical, and biological treatments [15;16;17]. Various kinds of wastewater treatment have been carried out, but these treatment systems do not always succeed in significantly reducing pollutant content. In addition, conventional WWTPs also produce sludge that requires further treatment [18;19]. To build a conventional WWTP requires relatively high costs and is not affordable by SMEs. Financial problems are one of the main factors that hamper environmental pollution control efforts in developing countries including Indonesia[20;21]. Oleh karena itu, diperlukan alternatif pengolahan limbah cair industri batik yang lebih terjangkau namun tetap efektif.

Various types of stamped batik waste treatment have been carried out, starting from chemical, physical processing to using the biofilter method and precipitation using a Waste water treatment plant [21;22]. The provision of EM4 is expected to further degrade organic compounds contained in wastewater and faster than using only natural microorganisms contained in the wastewater.

The purpose of this study is to determine the effectiveness of EM-4 addition in reducing BOD in Batik liquid waste. Some studies explain that EM4 can be used to degrade liquid waste for the provision of EM4 in restaurant liquid waste is able to reduce organic materials (BOD₅ and COD) giving a real effect with a shorter time of 6 days [23;3;24]. in stamped batik liquid waste. Batik liquid waste was taken with several concentrations and incubated for one day, two days and three days. According to the Minister of Environment Regulation Number 5 of 2014, waste parameters discharged into waters such as BOD must be below the quality standard so as not to pollute the aquatic environment. The quality standard value of BOD in batik cap liquid waste is 150 mg/L. This study aims to determine the effect of giving EM4 to batik cap liquid waste to reduce BOD levels in batik cap liquid waste to comply with quality standards [25].

2 Research methods

The method used in this research is an experimental method using a Completely Randomised Design (CRD) on the cap batik liquid waste reservoir [3;26]. The experimental design in this study used a complete randomised design (CRD) factorial pattern, namely the dose of EM-4 (ml/l) and the length of incubation using the treatment:

P0.1 = control at 1 day incubation.

P0.2 = control at 2 days incubation.

P0.3 = control at 3 days incubation.

- P1.1 = EM-4 5 ml/l at 1 day incubation.
- P1.2 = EM-4 5 ml/l at 2 days incubation.
- P1.3 = EM-4 5 ml/l at 3 days incubation.
- P2.1 = EM-4 10 ml/l at 1 day incubation.
- P2.2 = EM-4 10 ml/l at 2 days incubation.
- P2.3 = EM-4 10 ml/l at 3 days incubation.
- P3.1 = EM-4 15 ml/l at 1 day incubation.
- P3.2 = EM-4 15 ml/l at 2 days incubation.
- P3.3 = EM-4 15 ml/l at 3 days incubation.

2.2 Tools and materials

2.2.1 .Tools

Winkler incubation bottles (made of glass) 250 ml, jerry can, 200 ml measuring cup, 50 ml volumetric flask, 25 ml Erlenmeyer, 10 ml pipette, burette or titration meter, thermometer, electric pH meter, reflux heater, reflux tube.

2.2.2 Materials

Stamped batik liquid waste, distilled water, 250 ml FAS solution {FAS (Ferro Ammonium Sulfate) 9.75 g + 10 ml distilled water + 5 ml H₂SO₄ (sulfuric acid), diluted to 250 ml and stirred}, K₂Cr₂O₇ solution (kallium dichromate) 0,6125 g, diluted with distilled water to 50 ml, 90 ml H₂SO₄ (sulfuric acid) solution + 0.9 g Ag₂SO₄ (silfersulfate) stirred, HgSO₄ (mercury duasulfate) Feroin indicator, EM-4 (Effective Microorgandsms-4).

2.3 Data analysis

Data obtained from the results of the study were analysed using a completely randomised design (CRD) and compared with quality standards based on the Minister of Environment Regulation No. 5 of 2014 concerning wastewater quality standards. Data Analysis

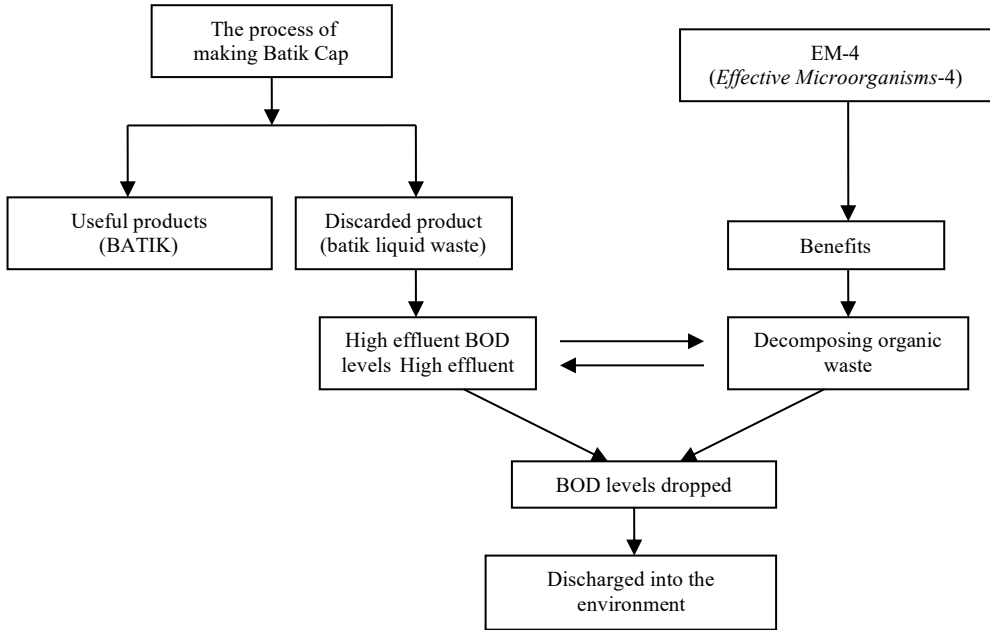


Fig. 1. Research design

3 Results And Discussion

Measurement of printed batik liquid waste levels carried out during the study by measuring BOD, temperature, and pH parameters. The following are the results of the analysis of printed batik liquid waste levels using EM4: Decrease in Biochemical Oxygen Demand (BOD) Levels. The results of the calculation of the decrease in BOD levels of stamped batik liquid waste in various treatments can be seen in table 1.

Table 1. Average BOD Level (mg/l) Batik Cap Liquid Waste percentage decrease

Treatment	Ulangan			Average (mg/l)	Percentage decrease %
	1	2	3		
P0.1	3739	3730	3716	3728	0.00
P0.2	3471	3407	3375	3417	0.00
P0.3	3588	3492	3429	3549	0.00
P1.1	1486	1367	1303	1352	62.84
P1.2	1418	1399	1303	1358	59.82
P1.3	1452	1359	1295	1275	66.24
P2.1	355	323	291	312	90.90
P2.2	387	315	323	326	90.30
P2.3	321	315	270	301	91.17
P3.1	287	276	255	277	92.42
P3.2	243	263	301	265	92.30

P3.3	266	252	278		92.53
------	-----	-----	-----	--	-------

Based on the table above, it can be seen that the BOD level in the control is greater than the treatment, while in each treatment the more the addition of EM-4 the smaller the BOD level. The average decrease in BOD levels after the addition of EM-4 is as follows; at a dose of 5 mg/l, on the first day of incubation there was a decrease in BOD of 3549.67 mg/l, or 62.84%. On the second day of incubation there was a decrease in BOD of 1358 mg/l, or 59.82%. On the third day of incubation there was a decrease in BOD 1277 mg/l or 66.24%. At a dose of 10 mg/l showed a decrease in BOD on the first day incubation of 312 mg/l, or 90.90%. On the second day of incubation there was a decrease in BOD of 326 mg/l, or 90.30%. On the third day of incubation there was a decrease in BOD of 301 mg/l, or 91.17%. At a dose of 15 mg/l, on the first day of incubation there was a decrease in BOD 267 mg/l, or 267 mg/l. On the second day of incubation there was a decrease in BOD of 277 mg/l, or 92.30 mg/l. On the second day of incubation there was a decrease in BOD of 265 mg/l, or 92.53 mg/l.

Table 1 shows that as incubation time and EM-4 addition levels increase, BOD levels decrease. BOD levels with the addition of 5 ml, 10 ml, and 15 ml dropped much faster than the control (without the addition of EM-4) even with the same observation time. Based on the table, there is a process of decomposition of organic compounds in the waste so that there is a decrease in BOD levels during the study. In addition, there is cooperation between lactic acid bacteria contained in EM4 with fermentation fungi (*Saccharomyces* sp.) which are also contained to ferment organic matter into simpler organic compounds that tend to be faster than natural organic compounds [27;28;3].

The ability of EM-4 is very effective in reducing batik liquid waste, the longer the incubation and the greater the dose of EM-4 in stamped batik liquid waste, the greater the decrease in BOD, but the decrease in BOD concentration at P3 tends to be stationary which will continue in the microorganism death phase. The graph for measuring the BOD value can be seen in Figure 2.

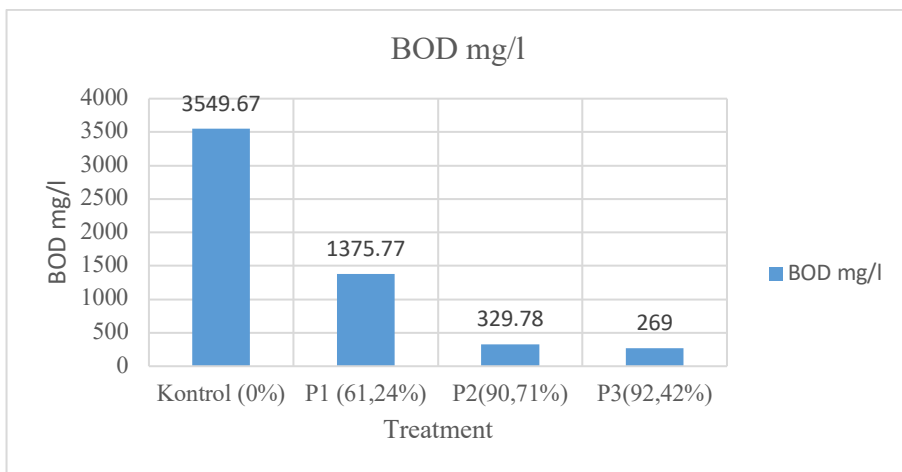


Fig. 2. Graph of BOD Measurement During the Study

Based on the histogram of treatments that are quite good at reducing BOD parameters, namely P2 and P3. The final concentration of BOD is already below the quality standards of Permen LH No. 5 of 2014 concerning Industrial Liquid Waste Quality Standards. This is because the oxygen supply is very good in connection with the research, the oxygen needed

by bacteria in degrading organic compounds utilises oxygen from the aerator in the aerobic process used during the study. So that the restaurant liquid waste discharged into the waters will not interfere with the life of aquatic organisms.

To see if there is an effect of EM4 concentration on batik cap liquid waste in reducing BOD levels of liquid waste, an ANOVA further test will be carried out. To see if there is an effect of EM4 concentration to reduce BOD5 levels of batik liquid waste, an ANOVA further test was carried out. Based on the ANOVA test for the BOD5 parameter, it was found that $F_{count} > F_{table}$ 1%, which means H_1 is accepted and H_0 is rejected.

Table 2. ANOVA Analysis of Variance on Liquid Waste Batik Cap

SK	DB	JK	KT	Fcount	Ftable		Information
					0,05	0,01	
Treatment	3	1999.5	666.5	124	3.490295	5,952545	**
error/remainder	12	64.5	5.375				
Total	15	2064					

** significantly different

Based on the ANOVA test of BOD parameters, $F_{count} > F_{table}$ 1%, which means H_1 is accepted and H_0 is rejected. The results of the Smallest Real Difference (BNT) further test show that the control with P1, P2, and P3 are significantly different. The significant difference in effect between the control and P1, P2 and P3 further explains that the application of EM-4 to batik cap liquid waste can affect the magnitude of the decrease in BOD levels. The decrease in BOD and COD levels in liquid batik waste and home industry is proven to be reduced using EM-4 as an effective liquid waste degrader [3;29].

3.1 Temperature and pH of Batik Cap Wastewater

Before calculating BOD levels, the temperature and pH of the batik cap wastewater in the control and various treatments can be seen in table 3.

Table 3. Results of pH and temperature measurements of stamped batik wastewater in control and various treatments

Parameters	Incubation time (days)	Control	Dose of 5 ml/l EM-4	Dose 10 ml/l EM-4	Dose 15 ml/l EM-4
Temperatur (°C)	1	29	27	27	27
	2	29	27.5	27	27
	3	30	28	28	28
pH	1	7.05	7.00	6.70	6.55
	2	8.80	7.70	7.20	7.00
	3	9.00	8.50	8.50	8.10

Based on the table above, it can be seen that the pH level in the control is greater than the pH in the various treatments. Likewise with temperature, the control is greater than the various treatments. The temperature is optimal on the first and second day of incubation, because the temperature on the first and second day of incubation is the same the same [3;21;30].

3.1.1 Temperature

Based on (Table 3), it can be seen that the temperature of stamped batik wastewater on the first day and second day of incubation, in the control, the average is 29 °C. While the temperature in the treatment averaged 27 °C, the temperature on the third day of incubation, in the control was 30 °C and in the treatment averaged 28 °C. The optimal temperature on the first and second day of incubation, because the temperature on the first and second day of incubation is the same. As for the third day treatment, there was an increase of 1 °C to 28 °C. This is confirmed in accordance with group one of the wastewater quality standards.

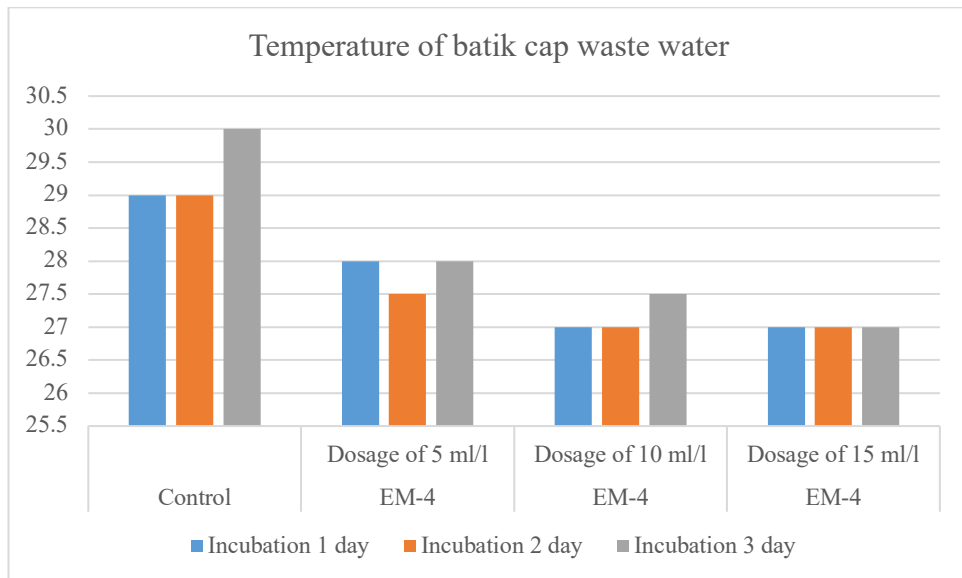


Fig. 3. Temperature of batik cap liquid waste against various variations of EM-4 doses and incubation duration

Hot wastewater is directly discharged into the river, so the river water will become hot. Oxygen dissolved in water comes from the air which is slowly diffused into nature. The higher the increase in water temperature, the less oxygen content dissolved in it [29;23;10].

3.1.2 pH of Stamped Batik Wastewater

Based on (Table 3), it can be seen that the pH of stamped batik wastewater for control on the first day of incubation is 7.05, the second day is 8.80, while the third day is 9.00 which is alkaline. After giving EM-4 5 ml/l, the pH on the first day of incubation was 7.00 (a decrease in pH of 0.05). On the second day of incubation the pH was 7.70, (a decrease in pH of 1.10), and on the third day of incubation was 8.50 which means it is still alkaline (a decrease in pH of 0.50). After giving EM-4 10ml/l the pH on the first day of incubation was 6.70 (a decrease in pH of 0.35). On the second day of incubation the pH was 7.20, (a decrease in pH of 1.0), and on the third day of incubation was 8.50 which means it is still alkaline (a decrease in pH of 0.50). On the provision of EM-4 15 ml/l the pH on the first day of incubation was 6.55 (a decrease in pH of 0.5), on the second day of incubation was 7.00 (a decrease in pH of 1.8), on the third day of incubation was 8.10 (a decrease in pH of 0.9) which means it is still alkaline, but there is a decrease in pH which is close to the pH according to the decision of the minister of state of the MOE, No. KEP-03/MENKLH/11/1991.

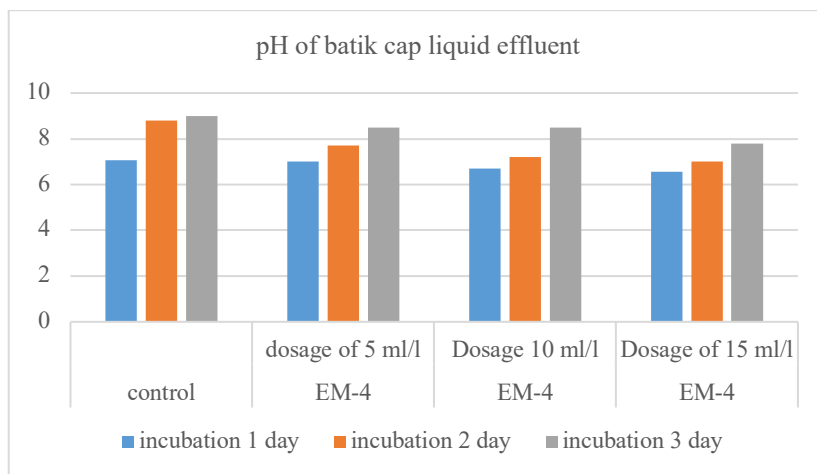


Fig. 4. Relationship Graph of BOD Levels (mg/l) with Various Additions of EM-4 and Incubation Duration

In Figure 4, the relationship of BOD with various additions of EM-4 and the length of incubation there is a change in hydrogen potential (pH). The optimal hydrogen potential (pH) in the treatment is EM-4 at a dose of 15 ml/l and at one day incubation, because in this treatment the lowest pH is calculated at 6.55. It is possible that one of the components of EM-4, namely *Lactobacillus*, is an acid-producing microorganism so that the basicity of the waste decreases. When compared with the decree of the minister of state of the MOE, No. KEP-03/MENKLH/11/1991, pH 6-9 for wastewater after the addition of EM-4 has met the predetermined standards. Potential hydrogen (pH) 6.5–8.5 is the limit allowed in wastewater discharges [31;26;28;32].

4 Conclusion

The results obtained from the parameters that have been carried out in this study can be concluded that EM4 is able to reduce BOD concentrations, a real effect with a shorter time of 4 days. The best treatment to reduce BOD is the addition of EM4 15 ml/liter able to reduce BOD levels by 92.53%. The addition of EM-4 in batik cap liquid waste with doses of 5 ml/l, 10 ml/l, 15 ml/l has a significant effect on reducing BOD levels. Incubation time of 1 day, 2 days and 3 days has a significant effect on reducing BOD levels in printed batik liquid waste. The most effective dose of EM-4 to reduce BOD levels in batik cap liquid waste is 15 ml/l, which is able to reduce BOD levels by 92.53% and the effective incubation time is one day.

Acknowledgements : The authors would like to thank to University of Teuku Umar for providing the research sites and various other facilities. The author also thanks the people of the batik home industry in Pekalongan city who have provided a place for research.

References

1. K. Kiswanto, L.N. Rahayu, W. Wintah. *J Litbang Kota Pekalongan*, **17**, 72–82 (2019)
2. E.B. Agustina, A.H.P. Yuniarto. *JKPK (Jurnal Kim dan Pendidik Kim)*, **7**(2), 150 (2022)
3. Wintah, Kiswanto. *Efektivitas Em-4 Dalam Menurunkan Kadar COD Limbah Cair Batik Cap Di Kelurahan Simbang Wetan*. **18**, 27–35 (2020)

4. Kiswanto, N. Hamada, Sudarno, H.Purnaweni. *Removing Content of Color and Heavy Metals (Pb) in The Waste Liquid Using Batik Industries Membrane Technology NF 270*. 2nd Int Conf Public Heal. (October):209–15 (2021)
5. A.N. Priambodo, A.A. Wijayanto, K. Udyani. *Pengolahan Limbah Industri Batik Tulis Dengan Metode Gabungan Adsorpsi Dan Elektrokoagulasi Variabel Penelitian*. In: Seminar Nasional Sains dan Teknologi Terapan VII 2019 Institut Teknologi Adhi Tama Surabaya. p. 519–24 (2019)
6. Kiswanto, Wintah, J. Maulana. *Ristek J Riset, Inov dan Teknol Kabupaten Batang*. **4**(1), 7–17 (2019)
7. B. Suharto, R. Wirosodarmo, R.H. Sulanda. *Jurnal Sumberdaya Alam dan Lingkungan*. *J Sumberd Alam dan Lingkungan*. 14–9 (2013)
8. 8M. Triwiswara. *Pros Semin Nas Ind Kerajinan dan Batik*. **1**(1), 1–11 (2019)
9. N.S. Subki and Rohasliney H. *Abstract — Batik industries generate a huge contribution to A Preliminary Study on Batik Effluent in Kelantan State: A Water Quality Perspective*. *Ccebs*:2011. 274–6 (2011)
10. B.S.D. Dewanti, T.F. Prastiwi ATSH. *Pengolahan Limbah Cair Batik Menggunakan Kombinasi*. **7**(3), 358–69 (2019)
11. W.F. Khalik, Li-Ngee Ho, Soon-An Ong, Yee-Shian Wong, N.A Yusoff, F. Ridwan. *Decolorization and Mineralization of Batik Wastewater through Solar Photocatalytic Process*. **44**(4), 607–12 (2015)
12. N. Syuhadah, N.Z. Muslim, H. Rohasliney. *Int J Chem Environ Biol Sci*, **3**(1), 7–9 (2015)
13. M.M.F. Ardiyanto, M. Rahmayanti. *Performance of Ceramic Membrane Modified with Corncob Activated Carbon for Efficient Remazol Red Removal in Batik Wastewater*. *Berk Sainstek*. **10**(4):202 (2022)
14. Kiswanto, Wintah, Feti Fatimatuzzahroh N laila R. *Reduction of Color and Heavy Metals (Pb, Cu) in Hand-drawn Batik Liquid Waste Using Electrolysis*. 2022;(October 2021):16–7.
15. L. Indrayani, M. Triwiswara. *Din Kerajinan Dan Batik*. **35**(1), 53–6 (2018)
16. I. Amri, P. Destinefa. *Pengolahan limbah cair tahu menjadi air bersih dengan metode elektrokoagulasi secara kontinyu*. **5**(1), 57–67 (2020)
17. J. Tourir, S. Kitanou, M. Zait, S. Belhamidi, M. Belfaquir, M. Tahaikt, et al. *Indonesian Journal of Science & Technology*. (1), 17–30 (2021)
18. S. Manjunath, H. Kousar. *Int J Environ Sci*. **5**(2), 75–81 (2016)
19. F. Razansyah, M. Syafila. *J Tek Lingkungan*. **28**(2), 28–54 (2022)
20. H.R. Rashidi, N.M.N. Sulaiman, N.A. Hashim. *Batik Industry Synthetic Wastewater Treatment Using Nanofiltration Membrane*. *Procedia Eng*. **44**, 2010–2012 (2012)
21. L. Simarmata, S. Harahap, E. Purwanto. *P. J Sumberd dan Lingkungan Akuatik*. **1**(2), 114–23 (2020)
22. E. Wiyanto, B. Harsono, A. Makmur, R. Pangputra, M.S. Kurniawan, Elektro JT, Et Al. *Penerapan Elektrokoagulasi Dalam Proses Penjernihan Limbah Cair*. **12**, 19–36 (2014)
23. N.R. Qurrotu’aini, M. Mawarni, Y. Beay, N. Nurrochman. *J Pengendali Pencemaran Lingkungan*. **4**(1), 7–12 (2022)
24. Ahmad Nazria MA Bin, Ghazali NLB. *The Effectiveness em Mudball and Banana Peels for Textile Wastewater Treatment*. *MATEC Web Conf*. 2016;87:1–5.
25. Kementerian Lingkungan Hidup Republik Indonesia. *Peraturan Menteri Lingkungan Hidup Republik Indonesia*. *Angew Chemie Int Ed* **6**(11), 951–952. 2014;**13**(April):15–38.
26. S.A. Avia, B. Kamulyan, A.T. Yuliansyah. *Bioremediation of Tofu Industry Liquid Waste Using Effective Microorganism-4 (Em4) Solution (Case Study of Tofu Sentosa Industry, Yogyakarta)*. *ASEAN J Syst Eng*. **6**(1), 21–6 (2022)

27. S.A. Sari, D. Biyatmoko, E. Indrayatie, R.P. Mahyudin. *The dosage variant combinations of EM-4 and fermentation time based on physics and chemicals parameters of tofu's wastewater*. J Biodivers environmental sciences. **12**(4), 117–26 (2018)
28. B. Jassey, Syafrudin, B. Zaman, K. Ceesay, I. Touray, J. Ngum, et al. *The effectiveness of EM4 and Local Micro-organisms (LOM) Activators in Organic Waste Processing in Brikama Market West Coast Region, the Gambia*. IOP Conf Ser Earth Environ Sci. **1098**(1). (2022)
29. A. Maysabila, R. Heryanti, R. Permana, Z. Hasan. *Bioremediation of shrimp pond wastewater using effective microorganism-4 (EM4)*. Aceh J Anim Sci. **8**(3), 72–7 (2023)
30. Y. Harwiyanti. *Pengaruh Penambahan EM4 (Effective Mikroorganisme) Terhadap Pengomposan Blotong*. Skripsi. (2016);48–54
31. N.N. Aini, R.D. Lisminingsih, A. Syauqi. J Ilm Mhs Sains UNISMA Malang. **1**(2), 66–73 (2023)
32. I.W, Budiharto, H.B. Pratama, A.C. Salmanisa. J Sains Terap. **13**(1), 48–59 (2023)