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Conference Paper

Electrocoagulation Process to Reduce Microplastic in Wonokromo Surface Water

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ABSTRACT

The abundance of microplastics in Surabaya's surface water can disrupt the sustainability of river ecosystems and harm humans because most of the raw water used by the people of Surabaya comes from surface water. Microplastics less than 5μm in size contain harmful chemicals such as Polychlorinated Biphenyls (PCBs) and are toxic. One alternative treatment is to reduce the levels of microplastics in the electrocoagulation process. Electrocoagulation is the process of clotting and deposition of fine particles in water using electrical energy. Microplastics contained in the water are removed through flocculation and deposition processes. This study aims to determine the effectiveness of the electrocoagulation process on reducing microplastic levels. The variables of this experiment are the distance of the electrodes (1.5 cm, 2 cm; 3 cm, and 5 cm), and the detention time (15 minutes, 25 minutes, 30 minutes, 45 minutes). This research was set up by using a reactor with a volume of 5 liters and a settling time of 30 minutes.

Keywords: Microplastic, electrocoagulation, detention time

Introduction

Microplastics are tiny plastic particles with a diameter of less than 5 m (Shen et al., 2020). The microplastics found are quite diverse in type and size. Microplastics on the surface water of the Surabaya river were 13.33 particles/m^3 (Wijaya et al., 2019). The presence of microplastics in waters can disrupt the sustainability of river ecosystem life. Microplastics contain harmful chemicals such as Polychlorinated Biphenyls (PCBs), which cause poisoning (Nugroho, 2018). Microplastics can carry heavy metals and also some pathogenic microorganisms that attach to microplastic, it is possible to enter the bloodstream and infect the body.

One alternative to reduce microplastics in water, using electrocoagulation technology. Electrocoagulation technology is proven to reduce microplastic by around 90-98% in artificial wastewater (Rajala et al., 2020). In previous studies, it was explained that microplastics in artificial wastewater could decrease influenced by detention time and current strength in the electrocoagulation process (Perren et al., 2018). The reduction of microplastic in raw water by electrocoagulation process on variations of the distance between the electrodes has not been tried yet. This study was conducted to determine the effectiveness of electrocoagulation in reducing microplastic in raw water and the effect of electrode distance on reducing microplastic. This study aims to determine the effectiveness of reducing microplastic in Wonokromo's surface water by electrocoagulation technology and determine the effect of electrode distance and detention time to remove microplastics.

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Characteristics of microplastics are insoluble in water or commonly referred to as hydrophobic molecules. Hydrophobic molecules are non-polar molecules so they cannot form hydrogen bonds with water molecules. The hydrophobic nature of microplastics causes microplastics to be susceptible to the impact of contaminants that are absorbed on their surface so that microplastics become toxic in the environment (Tri Aji, 2017).

Based on previous studies, the reduction of microplastic has been widely studied using coagulation and ultrafiltration membranes. There was a development of research using electrocoagulation technology conducted by Perren et al. (2018). Electrocoagulation technology has been proven to be able to reduce the microplastics in artificial wastewater by 90% by using an Aluminum plate as an electrode (Perren et al., 2018).

In simple terms, electrocoagulation is a process of clumping and deposition of fine particles in water using electrical energy (Rachmanto, 2020). The removal of organic and inorganic waste in the electrocoagulation process occurs due to adsorption on the particle surface by the coagulant produced from the electrocoagulation process. This causes the formation of a hydrophobic surface, and the hydrophobic particles will coalesce, causing the particles in the wastewater to rise to the surface because of gas bubbles formed (Apriyani, 2017). In the electrocoagulation process, the detention time affects the effluent results from the process because the longer detention time, the metal ions will attach to the electrodes (Rachmanto, 2020). According to Saputra & Hanum (2016), the distance between the electrodes affects the electrocoagulation process, it causes the electron transfer that occurs. The optimal distance between electrodes for electrocoagulation is 1.5 cm and 3 cm (Saputra & Hanum, 2016).

In the electrocoagulation process, flocculation and neutralization can happen simultaneously. Microplastics are removed because they are adsorbed on the floc formed during the process. The coagulant absorbs the microplastic so that it becomes floc. The process of flocculation and deposition in electrocoagulation is the dominant mechanism for reducing microplastic during high floc production (Perren et al., 2018). The size of the floc formed by the Al3+ coagulant is 150-1000 m (Nur & Effendi, 2014). Meanwhile, the size of the microplastic itself is <5μm, so that the microplastic is easily trapped in the floc formed in electrocoagulation using Aluminium electrodes. The specific gravity of microplastics is 0.85-0.90 g/cm3 (Mujiarto, 2005).

Material and Methods

Material

Material for this research was Surface water of Kali Surabaya, Electrocoagulation Reactor; pH meter; *Power supply* 5 A.

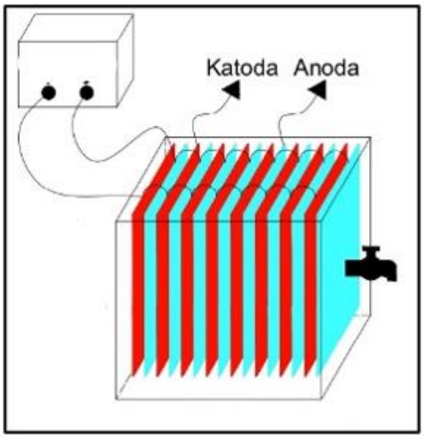

Figure 1. Electrocoagulation Reactor

Methods

The batch process was used in this research to choose the best variable for the removal of microplastic. There was much analysis before the process ran. The first analysis was the identification of microplastic and pH. Process of research did for any variables distance between Aluminium plat as cathode and anode for 5 A of current and 30 minutes of settling. The sample was analyzed by Physical Identification and FTIR. Physical Identification of microplastic used *Guide to Microplastic Identification, Marine and Environmental Research Institute* (2015). Independent variables were detention time for 15, 25, 30, and 45 minutes, and distance of electrode for 1.5, 2, 3, and 5 cm. The sampling method used SNI 6989.57:2018. Water and Wastewater-Section 57: Surface Water Sampling Methods.

Results and Discussion

Result of microplastic analysis by FTIR Methode

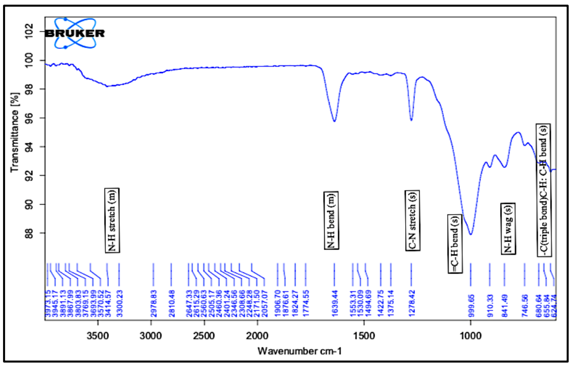

Figure 2. FTIR analysis of microplastic before electrocoagulation process

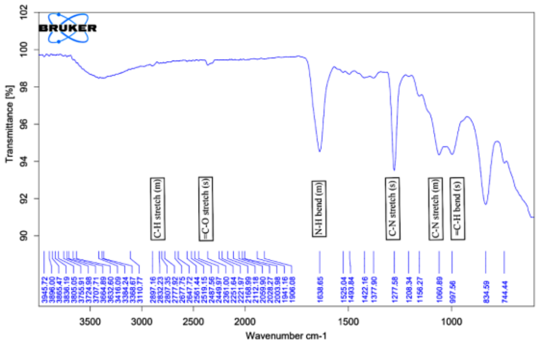

Figure 3. FTIR analysis of microplastic after electrocoagulation process

Table 1. Pure spectrum microplastic

First spectrum (cm^{-1})	Last spectrum (cm^{-1})	*Nylon (all polyamides)*	*Polypropylene (PP)*	*Functional*
3414,57-3300,23	3416,09-2897,16	3298		N-H *stretch*
1639,44	1638,65	1538		N-H *bend*
1278,42	1277,58	1538		C-N *stretch*
999,65	1060,89-997,56		1455	=C-H *bend*
841,4	834.,59			N-H *wag*
680,64-624,74	744,44		997	-C(*triple bond*)C-H: C-H *bend*

(Source: Jung et al., 2018)

Overall, the insignificant shift in the wavenumber may indicate no change in the chemical elements present in the microplastic. Still, there has been a physical process in the reduction of microplastics in electrocoagulation (Padervand et al., 2020).

The removal of microplastic was influenced by detention time

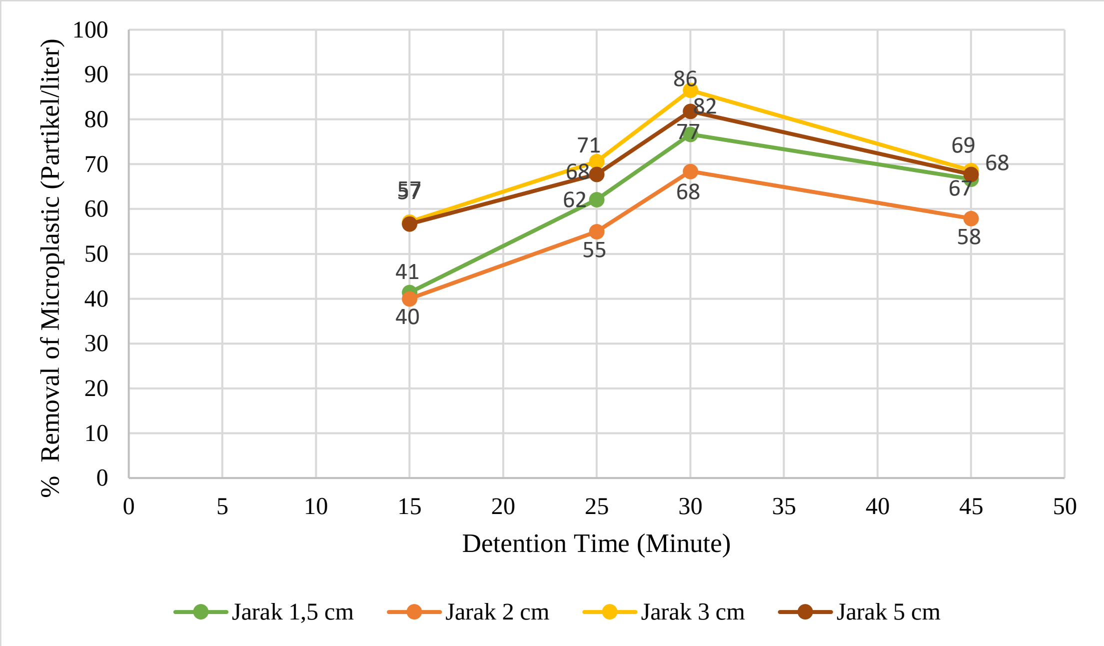

Figure 4. Relation between detention time and removal of microplastic on varian distance of the electrode

Figure – 4, shows that detention time affects reducing microplastic levels. Along with the increase in detention time, there was an increase in the percentage decrease in microplastic content. The longer the detention time, the more metal ions will attach to the electrodes and increase the production of coagulants and hydrogen gas. It increased the production of coagulants and hydrogen gas. The lowest percentage of decrease in microplastic occurred within 15 minutes, which was 40%, this was due to insufficient coagulant production to bind microplastics. Meanwhile, the maximum coagulant production in this study occurred at 30 minutes which could reduce microplastic up to 86%. The decrease in microplastic content occurred because it was adsorbed on the floc formed during the process. The resulting floc comes from $Al^{3+,}$ which functions as a coagulant. The coagulant absorbs the microplastic so that it becomes floc. Microplastics have properties that are insoluble in water or are commonly referred to as hydrophobic molecules. Hydrophobic molecules are non-polar molecules, so they cannot form hydrogen bonds with water molecules (Perren et al., 2018).

In addition to coagulant production, the percentage decrease in microplastic levels at each detention time is influenced by pH. At 15 minutes, the pH value shows the number 7.2, which is the lowest pH value, so that little hydroxide ion production is produced. According to Perren et al. (2018), the best pH in reducing microplastic levels by electrocoagulation is 7.5. The largest percentage decrease in microplastic levels in this study occurred within 30 minutes. This is influenced by pH conditions, where the pH at 30 minutes shows the number 7.5, which is the highest pH value in the sample. The increase in pH will facilitate the formation of hydroxide ions and increase the conductivity of the solution so that the production of coagulants increases and the interaction of coagulants and microplastics increases. Coagulant serves to bind microplastics to form flocs which are then assisted by hydrogen gas to float. The more coagulant production, the more microplastics are absorbed.

Removal of microplastic was influenced by electrode distance

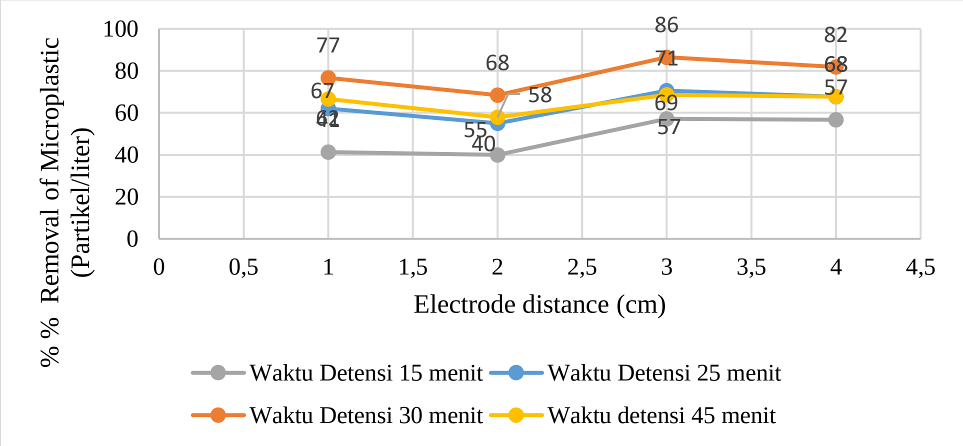

Figure 5. Relation between electrode distance and % removal of microplastic on varian of detention time

The electrocoagulation process used Al electrodes arranged in parallel. The distance between the electrodes affects the speed of electron transfer between the anode that receives electrons and the cathode as the site of the reduction process. At the anode, the oxidation and reduction process can change Aluminium to produce Al3+, then react with hydroxide ions OH- generated from reduction at the cathode. The reaction between hydroxide ions and Aluminium cations will produce a coagulant that functions as a microplastic binder in water. At a distance between the electrodes of 2 cm, the lowest percent effectiveness of reducing microplastic was 40%. This is because the distance of 2 cm is the closest in this study. If the distance between the electrodes is getting closer, more amount of coagulant is produced, but the system will experience disturbances due to a short circuit that occurs between the electrodes (Reusyella Saulina & Rosariawari, 2021).

There was a decreased removal of microplastic at a distance between the electrodes of 2 cm, seen from the control variable that the pH value in the sample with a distance between the electrodes of 2 cm was smaller pH than the others. pH is one of the factors that affect the electrocoagulation process. If the pH of the solution is higher, it means that the production of hydroxide ions and coagulants will also increase so that the percentage of the decrease in microplastic will also be higher. At a distance between the electrodes of 2 cm, the pH of the solution has the smallest value, which is 7.2-7.3. This causes the production of hydroxide ions and coagulants to decrease so that the percent decrease in microplastic also tends to below. The decrease of electrocoagulation efficiency occurs when the distance between the electrodes is enlarged, due to the large current resistance so that the conductivity decreases. The highest percentage of reduction in microplastic levels occurred at a distance between electrodes of 3 cm, which was 86%, this indicates that the optimum distance in reducing microplastic levels in surface water samples using an electrocoagulation reactor with a reactor volume of 5 liters is 3 cm.

Conclusion

Based on the research, it can be concluded that:

1. Microplastic in surface water of Wonokromo could be reduced using electrocoagulation and the percentage of reduction up to 86%. This proves that using batch electrocoagulation is quite efficient in reducing microplastic content;
2. The results showed that the distance between the electrodes and the detention time affected the decrease in microplastic. The distance between the electrodes affects the speed of electron transfer between the anodes. The reaction between hydroxide ions and Al cations will produce a coagulant that functions as a microplastic binder in water. The most effective distance between electrodes to reduce microplastic content is 3 cm. The

longer the detention time, the more metal ions will attach to the electrodes and increase the production of coagulants and hydrogen gas. Thus, it causes the production of coagulants and hydrogen gas to increase, and the microplastics that are absorbed by the coagulant increase. The most effective time to reduce microplastic levels is 30 minutes.

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References

Apriyani, N. (2017). Penurunan kadar surfaktan dan sulfat dalam limbah laundry. *Media Ilmiah Teknik Lingkungan, 2*(1), 1689–1699. https://doi.org/10.33084/mitl.v2i1.132

Mujiarto, I. (2005). Sifat dan karakteristik material plastik dan bahan aditif. *Traksi, 3*(2), 65–74.

Nugroho, A. A. K. (2018). *Study of potential microplastics on surabaya river fishes*. Education Program Manager ecoton-ecological observation and wetlands conservation

Nur, A., & Effendi, A. J. (2014). Aplikasi elektrokoagulasi pasangan elektroda aluminium pada proses daur ulang grey water hotel. *Jurnal Tehnik Lingkungan, 20*(1), 58–67. Https://Doi.Org/10.5614/Jtl.2014.20.1.7

Padervand, M., Lichtfouse, E., Robert, D., & Wang, C. (2020). Removal of microplastics from the environment. *A Review. Environmental Chemistry Letters, 18*(3), 807–828. Https://Doi.Org/10.1007/S10311-020-00983-1

Perren, W., Wojtasik, A., & Cai, Q. (2018). Removal of microbeads from wastewater using electrocoagulation. *Acs Omega, 3*(3), 3357–3364. Https://Doi.Org/10.1021/Acsomega.7b02037

Rachmanto, T. A. (2020). *Pembuatan unit pengolahan berbasis tenaga surya.*

Rajala, K., Grönfors, O., Hesampour, M., & Mikola, A. (2020). Removal of microplastics from secondary wastewater treatment plant effluent by coagulation/flocculation with iron, aluminum and polyamine-based chemicals. *Water Research, 183,* 116045. Https://Doi.Org/10.1016/J.Watres.2020.116045

Reusyella Saulina, D., & Rosariawari, F. (2021). Kombinasi elektrokoagulasi dan oksidasi lanjut berbasis O3/Gac dalam mengolah limbah industri batik. *Jurnal Teknik Lingkungan UPN Veteran Jawa Timur, 1*(2), 1-5. Doi: https://doi.org/10.33005/envirous.v1i2.29

Saputra, E., & Hanum, F. (2016). Pengaruh jarak antara elektroda pada reaktor elektrokoagulasi terhadap pengolahan effluent limbah cair pabrik kelapa sawit. *Jurnal Teknik Kimia USU, 5*(4), 33-38. https://doi.org/10.32734/jtk.v5i4.1552

Shen, M., Song, B., Zhu, Y., Zeng, G., Zhang, Y., Yang, Y., Wen, X., Chen, M., & Yi, H. (2020). Removal of microplastics via drinking water treatment: current knowledge and future directions. *Chemosphere, 251,* 126612. Https://Doi.Org/10.1016/J.Chemosphere.2020.126612

Tri Aji, N. A. (2017). Identifikasi mikroplastik di perairan Bangsring Jawa Timur. Thesis. http://repository.ub.ac.id/8332/

Wijaya, B. A., Trihadiningrum, Y., Distribusi, K. K., & Sampling, A. M. (2019). Pencemaran meso- dan mikroplastik di Kali Surabaya pada segmen driyorejo hingga karang pilang. *Jurnal Teknik Its, 8*(2), 2–7.