Jurnal Serambi Engineering JSE
Volume IX, No.1, Januari 2024 Hal 8366 - 8372
p-ISSN : 2528-3561
e-ISSN : 2541-1934

Biocoagulant Utilization from Java Tamarind Seed and Sweet Orange Peel for Turbidity, COD and BOD reduction in Domestic Wastewater

Aulia Nur Febrianti[1*], Rhenny Ratnawati[2], Muhammad Indra Ramadhan[3]

[1,2,3]Environmental Engineering Department, Faculty Of Engineering, Universitas PGRI Adi Buana
***Corresponding email**: aulianur@unipasby.ac.id

Received: February 3, 2024 Approved : February 19, 2024

Abstract
Domestic liquid waste typically originates from home trash and requires treatment to decrease quantities of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), and mixed particles. Additionally, treatment is necessary to eliminate nutrients and harmful components. The objective of this study is to determine the optimal dosage of biocoagulant needed for the process of coagulation and flocculation in a laboratory setting using the jar test method, specifically for treating domestic wastewater. Tamarind seed shell waste contains tannin, which can act as a natural coagulant. It functions as a positively charged natural polyelectrolyte that efficiently binds to negatively charged colloidal particles. The study included independent variables consisting of different doses of a mixture between tamarind seed shell and sweet orange peel bio coagulants, with ratios of 1:0, 1:0.5, and 1:1. An optimal dosage of 1.5 grams of tamarind seed shell effectively reduced turbidity by 51%, BOD levels by 80%, and COD levels by 77%.
Keywords: *biocoagulant, domestic wastewater, turbidity, COD, BOD*

Abstrak
Limbah cair domestik biasanya berasal dari limbah rumah tangga dan memerlukan pengolahan untuk menurunkan jumlah Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), dan partikel campuran. Selain itu, perlakuan tertentu diperlukan untuk menghilangkan nutrisi dan komponen berbahaya yang terdapat di dalamnya. Tujuan dari penelitian ini adalah untuk mengetahui dosis biokoagulan optimal yang diperlukan untuk proses koagulasi dan flokulasi di laboratorium dengan menggunakan metode jar test, khususnya untuk pengolahan air limbah domestik. Limbah cangkang biji asam jawa mengandung tanin yang dapat berperan sebagai koagulan alami. Tanin berfungsi sebagai polielektrolit alami bermuatan positif yang secara efisien mengikat partikel koloid bermuatan negatif. Penelitian ini melibatkan variabel bebas yang terdiri dari perbedaan dosis campuran antara cangkang biji asam jawa dan biokoagulan kulit jeruk manis, dengan perbandingan 1:0, 1:0,5, dan 1:1. Dosis optimal 1,5 gram cangkang biji asam jawa efektif menurunkan kekeruhan sebesar 51%, kadar BOD sebesar 80%, dan kadar COD sebesar 77%.
Kata kunci : *biokoagulan, air limbah domestik, kekeruhan, COD, BOD*

1. Introduction

Domestic wastewater in Indonesia has become a severe problem. Most Indonesians dispose of their domestic wastewater directly into the environment or the drainage network and then into the river. In several big cities, only some people communally manage domestic wastewater. In Jakarta, only about 20% of domestic waste is treated in a communal wastewater treatment plant (IPAL). Whereas in other big cities, WWTP may treat less than 20% or even no domestic waste[1]. Domestic liquid waste or household wastewater is a severe threat because it is inevitable that this waste will pollute the environment, especially groundwater, which can also be a carrier for disease germs. The household rubbish typically consists of residual waste from bathrooms, human waste, and kitchens. Waste is waste or something to be eliminated and is dangerous. These chemicals can give life to germs that cause diseases like dysentery, typhus, and other diseases.

The objective of residential sewage treatment is to diminish the levels of pollution caused by Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), and mixed particles. Additionally, it aims to eliminate nutritious elements and hazardous components that cannot be broken down to low concentrations [2]. In research by Khaq & Slamet, the characteristics of

domestic wastewater in Sidoarjo District (Magersari Village, Jati Village, Pagerwojo Village) include the parameters Biological Oxygen Demand (BOD) = 162 mg/L and Chemical Oxygen Demand = 268 mg/L[3]. The Minister of Environment Regulation No. 68/2016 regulates the Domestic Wastewater Quality Standard. The appendix states that the maximum level allowed for the parameters Biological Oxygen Demand (BOD) is 30 mg/L and Chemical Oxygen Demand (COD) is 100 mg/L.

Coagulation-flocculation is a wastewater treatment technology that can be employed in this investigation. Coagulation is the process of adding coagulants or chemicals additive to a solution with the aim of conditioning suspensions, colloids, and suspended matter in preparation for the advanced flocculation process. Flocculation refers to the aggregation of particles that possess unstable charges, resulting in the formation of bigger particles known as flocculant particles or flocs by collision[4]. The objective of this review is to examine the utilization of pectin and starch derived from fruit waste as eco-friendly coagulants in the treatment of water and wastewater. Pectin is a constituent of the cell wall structure in fruit peels, whereas starch serves as a source of food reserves in fruit seeds. In order to be employed as a natural coagulant, pectin or starch must undergo an initial extraction process, with starch requiring both physical and chemical modifications[5].

Biocoagulants offer a viable option for reducing environmental pollution and health hazards associated with chemical coagulants/flocculants. Biocoagulants and flocculants are derived from living organisms or biodegradable organic materials that are environmentally friendly and have minimal impact on human health. Several bio coagulants and flocculants obtained from various sources have been analyzed and proven efficient for application in the processing process as a substitute for chemical coagulants and flocculants currently widely used [6].

In light of the escalating apprehensions regarding using chemical coagulants for wastewater treatment, which has adverse effects on the environment and human well-being, alternative methods have been investigated to address this problem. The plant-based source is being actively researched and explored to determine its capacity for substituting chemical coagulants. Plant-based biocoagulants are more prevalent than animal-based and microorganism-based biocoagulants because of their abundance and accessibility[7].

Tamarind seed waste can be a biocoagulant to reduce COD and BOD levels in liquid waste. Tamarind seeds contain tannins, which can serve as a natural coagulant. Tannins are positively charged natural polyelectrolytes that are effective in binding negatively charged colloidal particles. Tamarind seed powder with a dose of two grams can reduce COD and BOD levels with a removal percentage of 80.86% and 62.07% in 1 liter of liquid waste from the fish processing industry[8].

Using sweet orange peel waste can potentially reduce turbidity levels in liquid waste. In a study conducted [9], orange peel extract at a dose of 6 ppm reduced turbidity levels to 99.6% in bentonite synthetic waste. According to [10], the nature of the pectin content in the orange peel can form a gel in the presence of bivalent ions such as Ca2+ until, finally, a gel structure resembles a net that can bind colloidal particles in the wastewater. Referring to the background that has been described, this study has the aim of obtaining a decrease in turbidity, COD and BOD levels in Pesona Sekar Gedangan Housing domestic wastewater after the addition of tamarind seed shell and sweet orange peel biocoagulants using the Jar Test method.

2. Material and Methods

This research's method consists of the preparation of biocoagulants for the coagulation-flocculation process in domestic wastewater.

The Biocoagulants Preparation

First, gather the sweet orange peel and tamarind seeds. Clean the sweet orange peel by washing it with water. Cleansing is typically the primary stage preceding subsequent treatment for biocoagulants. Washing is conducted to eliminate impurities, such as grain impurities and sand or soil, to avoid the growth of fungi and yeast and improve the initial stage of extracting biocoagulants[11].

Spread the orange peel evenly in a baking dish to enhance the evaporation of water. Heat the sweet orange peel in the oven at 105 ℃ for one hour. The drying process significantly impacts the properties of biocoagulants. Prior to carrying out this stage, it is necessary to study the optimal drying temperature and duration in order to ensure that no active substances, such as proteins, are compromised throughout the process[12]. Excessive temperatures during the drying process can lead to the destruction of active compounds. Additionally, it can cause a phenomenon called "case hardening" where the outer layer of the materials dries too quickly and becomes hardened. This prevents moisture from escaping the inner part of the materials, resulting in reduced efficiency in removing moisture[13].

Grind the sweet orange peel finely using a pestle and mortar. Then, filter the resulting mixture using a 100 mesh sieve to ensure the bio coagulant powder has uniform particle size. Grinding and screening are two integral processes for achieving a consistent particle size of the biocoagulant powder[14]. The powdered bio coagulant is more advantageous for sale and storage than its liquid version. Furthermore, the reduced particle size of the biocoagulant facilitates increased interaction between the materials and the carrier solution during subsequent utilization [15]. Finally, store the biocoagulant powder in a dry, airtight container in a cold location.

The Experimental Research

The research was conducted in batches with two experiments (duplo) on each tamarind seed powder dose variation with sweet orange peel as a biocoagulant. There are five variations of dose combinations: D1 = 1.5 g tamarind seed shell powder without sweet orange peel powder combination, D2 = 1 g tamarind seed shell powder with 0.5 g sweet orange peel powder, D3 = 0.75 g tamarind seed shell powder with 0.75 g sweet orange peel powder. The coagulation-flocculation process was carried out using the Jar Test method using a flocculator. The fast-stirring speed was set at 200 rpm for 1 minute, the slow stirring speed at 80 rpm for 12 minutes, and the settling time for 30 minutes.

Initial domestic wastewater characteristics testing includes turbidity, BOD, and COD parameters intended to determine turbidity, BOD, and COD levels before Jar Test treatment and adding biocoagulants. The data from testing the initial domestic wastewater characteristics are presented in **Table 1**.

Table 1. Test results of initial domestic wastewater characteristics

Parameter	Unit	Result
Turbidity*	NTU	137
BOD**	mg/l	1099
COD**	mg/l	1642

Based on **Table 1**, it is known that the condition of domestic wastewater in the Pesona Sekar Gedangan Sidoarjo Household settlement for the turbidity parameter has exceeded the range of turbidity levels of wastewater originating from kitchen household activities (gray water), namely 92.5 - 168.5 NTU. It is known that BOD and COD levels also exceed the predetermined quality standard limits; this is due to the high-water pollution load originating from household activities such as bathing, cooking, and washing clothes. Biochemical Oxygen Demand (BOD) shows the amount of dissolved oxygen organisms need to carry out the degradation process of polluting materials in the water. A high BOD value indicates high water pollution. Chemical Oxygen Demand (COD) is the amount of oxygen needed for polluting materials to be chemically decomposed [10].

3. Results and Discussion

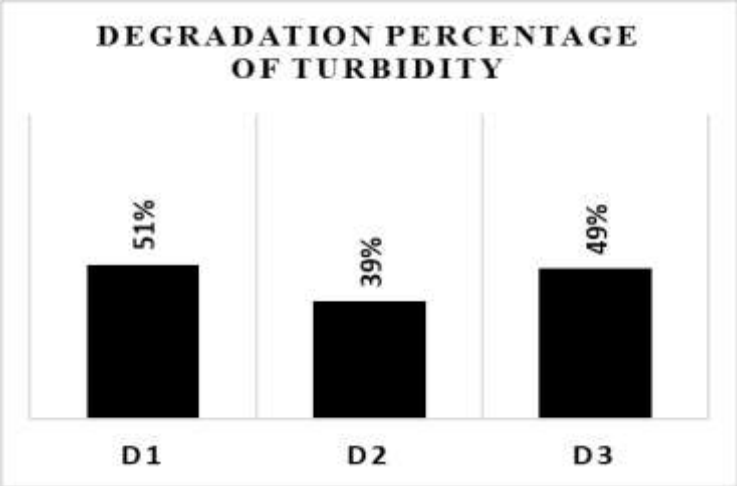
3.1 Effect of Combination Dosage of Tamarind Seed Shell and Sweet Orange Peel on Turbidity

Turbidity is a measure that uses the effect of light as a basis for measuring the state of raw water on a scale of NTU (Nephelometrix Turbidity Unit) or JTU (Jackson Turbidity Unit) or FTU (Formazin Turbidity Unit)[16]. To reduce turbidity levels, a coagulation-flocculation process is needed with the addition of biocoagulants to bind colloidal particles contained in domestic wastewater, so that they can form a floc. Then a sedimentation process is carried out to settle the floc formed. The effect of the combined dose of tamarind seed skin biocoagulant and sweet orange peel on domestic wastewater turbidity levels is presented in **Fig.1.**

Based on **Fig.1**., there are differences in the use of various doses of biocoagulants in reducing turbidity levels in domestic wastewater. The highest turbidity reduction efficiency (51.13%) occurred when domestic wastewater was treated in dose D1 (1.5 g tamarind seed shell powder without sweet orange peel powder combination) from 137 NTU to 66.95 NTU. This is because the skin of tamarind seeds (*Tamarindus indica L.*) contains an active substance called tannin. According to[17], tamarind seeds are a substitute for synthetic coagulants that have the ability to treat clean water and wastewater by uniting and shortening the settling time.

The high protein contained in tamarind seeds acts as a polyelectrolyte that has the ability as a biocoagulant. The NH^{3+} group is an electrolyte protein contained in tamarind seeds that is able to absorb negatively charged colloidal particles and undergo destabilization which produces large particles which at the end of the process will settle. In addition, there is pectin content found in sweet orange peel. The study showed that galacturonic acid (the main constituent of pectin substances) acts as a coagulant substance and

the coagulation mechanism is adsorption. In this case in line with research[18]. which in his research at a dose of 1 gr of orange peel was able to reduce turbidity levels from 260 NTU to 8 NTU in dairy industry wastewater with a percentage efficiency of 96.92%.

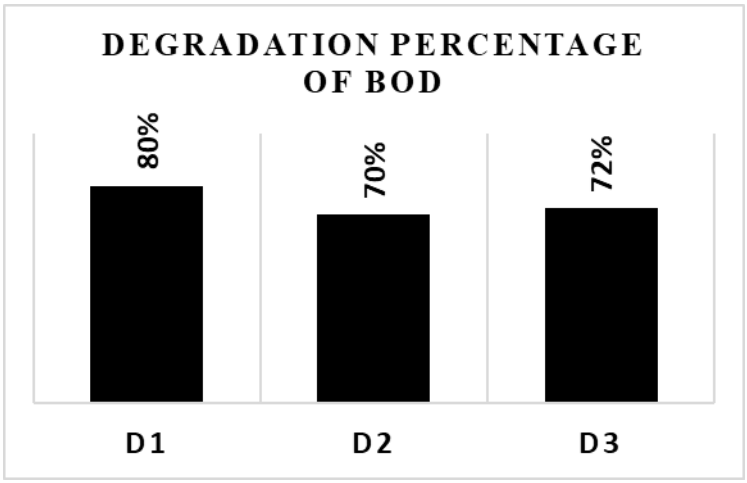


D1 = 1.5 g tamarind seed shell powder without sweet orange peel powder combination
D2 = 1 g tamarind seed shell powder with 0.5 g sweet orange peel powder
D3 = 0.75 g tamarind seed shell powder with 0.75 g sweet orange peel powder

Fig. 1. Effect of combination dosage of tamarind seed shell and sweet orange peel biocoagulant on turbidity level of domestic wastewater
Source: Environmental Laboratory Test Results of PGRI Adi Buana University Surabaya

3.2 Effect of Combination Dosage of Tamarind Seed Shell and Sweet Orange Peel Biocoagulant on BOD

Biological Oxygen Demand (BOD), is the amount of dissolved oxygen required by bacteria to decompose (oxidize) almost all dissolved organic substances and some suspended organic substances in water[19]. The effect of the combined dose of tamarind seed shell biocoagulant and sweet orange peel on domestic wastewater BOD levels is presented in **Fig.2**. as follows.



D1 = 1.5 g tamarind seed shell powder without sweet orange peel powder combination
D2 = 1 g tamarind seed shell powder with 0.5 g sweet orange peel powder
D3 = 0.75 g tamarind seed shell powder with 0.75 g sweet orange peel powder

Fig. 2. Effect of combination dosage of tamarind seed shell and sweet orange peel biocoagulant on BOD level of domestic wastewater
Source: DLH Sidoarjo Laboratory Testing Results

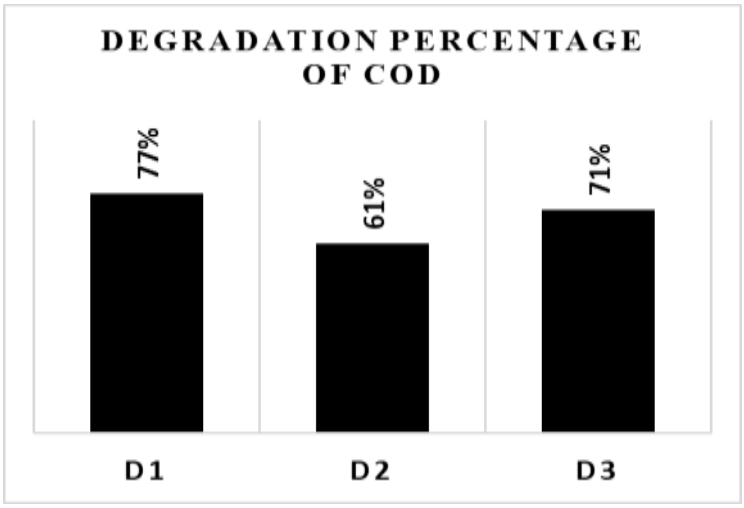
Based on **Fig.2**., there are differences in the use of various doses of biocoagulants in reducing BOD levels in domestic wastewater. The highest BOD reduction efficiency (80%) occurred when domestic

wastewater was treated with dose D1 (1.5 g tamarind seed shell powder without sweet orange peel powder combination) from 1099 mg/L to 300 mg/L. According to Badri, the decrease in BOD levels is due to the presence of tannin content, in tannins there are water-soluble compounds that can precipitate proteins from the solution, a decrease in BOD levels can occur because very fine particles and colloids are stable in water, with the addition of coagulants so that the forces of attraction occur and will form flocs[20], [21].

Variations in the dose of biocoagulant combinations affect the percentage reduction in BOD levels in domestic wastewater samples. In this case, it is in line with research by Badri which in his research at a dose of 2 grams of tamarind seeds was able to reduce BOD levels from 1055.33 mg/L to 400.25 mg/L in fish processing industry liquid waste with a percentage efficiency of 62.07% [8].

3.3 Effect of Combination Dose of Tamarind Seed Shell and Sweet Orange Peels Biocoagulant on COD

Chemical Oxygen Demand (COD), is the need for chemical oxygen to break down all organic matter contained in water[19]. The effect of the combined dose of tamarind seed shell and sweet orange peel biocoagulants on domestic wastewater turbidity levels is presented in **Fig.3**. as follows.



D1 = 1.5 g tamarind seed shell powder without sweet orange peel powder combination
D2 = 1 g tamarind seed shell powder with 0.5 g sweet orange peel powder
D3 = 0.75 g tamarind seed shell powder with 0.75 g sweet orange peel powder

Fig. 3. Effect of combined doses of tamarind seed shell and sweet orange peel biocoagulant on domestic wastewater COD levels
Source: DLH Sidoarjo Laboratory Testing Results

Based on **Fig.3**., there are differences in the use of various doses of biocoagulants in reducing COD levels in domestic wastewater. The highest efficiency of reducing COD levels (77%) occurred when domestic wastewater was treated with a dose of D1 (1.5 g of tamarind seed shell powder without a combination of sweet orange peel powder) from a level of 1642 mg/L to 385 mg/L.) This is because the tamarind seed skin (Tamarindus indica L.) contains an active substance called tannin. In research by Badri, the ability of biocoagulants from tamarind seeds to reduce COD levels is due to the tannin content which has the ability to bind organic materials in liquid waste [8].

In another study, the content of tannin compounds in papaya seeds can complex and accelerate protein precipitation and can bind macromolecules. In her research, Krisdiana also mentioned that in addition to tannins, there are other contents such as high protein (polyelectrolytes) which act as coagulants [17].

4. Conclusion

This study showed that degradation in turbidity levels with the highest efficiency occurred without a combination of biocoagulant, which at D1 (1.5 g tamarind seed shell without sweet orange peel) was able to reduce turbidity levels up to 51%, reduce BOD levels up to 80% and reduce COD levels up to 77%. Biocoagulants serve as a substitute for conventional chemical coagulants that are frequently employed in the treatment of water and wastewater. Biocoagulants derived from the seed shell of Java Tamarind

(Tamarindus Indica) and the peel of Sweet Orange (Citrus Sinensis) show promise due to their abundant availability and similar efficacy especially for the seed shell of Java Tamarind (Tamarindus Indica).

5. References

[1] M. Al Kholif, *Pengelolaan Air Limbah Domestik*. Scopindo Media Pustaka, 2020.

[2] M. Al Kholif, J. Sutrisno, And I. D. Prasetyo, "Penurunan Beban Pencemar Pada Limbah Domestik Dengan Mengunakan Moving Bed Biofilter Rekator (Mbbr)," *Al-Ard Jurnal Teknik Lingkungan*, Vol. 14, Pp. 1–8, 2018.

[3] F. A. Khaq And A. Slamet, "Perencanaan Sistem Pengolahan Air Limbah Domestik Di Kecamatan Sidoarjo, Kabupaten Sidoarjo," *Jurnal Teknik Its*, Vol. 6, No. 2, Pp. D129–D134, 2017.

[4] A. F. Rusydi, D. Suherman, And N. Sumawijaya, "Pengolahan Air Limbah Tekstil Melalui Proses Koagulasi–Flokulasi Dengan Menggunakan Lempung Sebagai Penyumbang Partikel Tersuspensi (Studi Kasus: Banaran, Sukoharjo Dan Lawean, Kerto Suro, Jawa Tengah)," *Arena Tekstil*, Vol. 31, No. 2, 2017.

[5] H. Kristianto, A. Jennifer, A. K. Sugih, And S. Prasetyo, "Potensi Polisakarida Dari Limbah Buah-Buahan Sebagai Koagulan Alami Dalam Pengolahan Air Dan Limbah Cair," *Jurnal Rekayasa Proses*, Vol. 14, No. 2, Pp. 108–127, 2020.

[6] S. B. Kurniawan *Et Al.*, "Challenges And Opportunities Of Biocoagulant/Bioflocculant Application For Drinking Water And Wastewater Treatment And Its Potential For Sludge Recovery," *Int J Environ Res Public Health*, Vol. 17, No. 24, P. 9312, 2020.

[7] S. B. Kurniawan, A. Ahmad, N. S. M. Said, K. Gustinasari, S. R. S. Abdullah, And M. F. Imron, "The Influence of Preparation And Pretreatment On The Physicochemical Properties And Performance Of Plant-Based Biocoagulants In Treating Wastewater," *Environmental Advances*, Vol. 14. Elsevier Ltd, Dec. 01, 2023. Doi: 10.1016/J.Envadv.2023.100441.

[8] "Hilal Badri, 160702056, Fst, Tl, 085359233615".

[9] M. Kebaili, S. Djellali, M. Radjai, N. Drouiche, And H. Lounici, "Valorization Of Orange Industry Residues To Form A Natural Coagulant And Adsorbent," *Journal Of Industrial And Engineering Chemistry*, Vol. 64, Pp. 292–299, 2018.

[10] S. N. Khotimah, N. A. Mardhotillah, And N. Arifaini, "Karakterisasi Limbah Cair Greywater Pada Level Rumah Tangga Berdasarkan Sumber Emisi," *Jurnal Saintis*, Vol. 21, No. 02, Pp. 71–78, 2021.

[11] W. L. Ang And A. W. Mohammad, "State Of The Art And Sustainability Of Natural Coagulants In Water And Wastewater Treatment," *J Clean Prod*, Vol. 262, P. 121267, 2020, Doi: Https://Doi.Org/10.1016/J.Jclepro.2020.121267.

[12] S. B. Kurniawan, A. Ahmad, M. F. Imron, S. R. S. Abdullah, A. R. Othman, And H. A. Hasan, "Potential Of Microalgae Cultivation Using Nutrient-Rich Wastewater And Harvesting Performance By Biocoagulants/Bioflocculants: Mechanism, Multi-Conversion Of Biomass Into Valuable Products, And Future Challenges," *J Clean Prod*, Vol. 365, P. 132806, 2022, Doi: Https://Doi.Org/10.1016/J.Jclepro.2022.132806.

[13] M. Ibrahim, N. Ismail, B. L. Chua, And A. S. M. Adnan, "Drying And Extraction Of Moringa Oleifera And Its Application In Wastewater Treatment," *J Phys Conf Ser*, Vol. 2120, No. 1, P. 012002, 2021, Doi: 10.1088/1742-6596/2120/1/012002.

[14] A. Ahmad, S. B. Kurniawan, S. R. S. Abdullah, A. R. Othman, And H. A. Hasan, "Exploring The Extraction Methods For Plant-Based Coagulants And Their Future Approaches," *Science Of The Total Environment*, Vol. 818, P. 151668, 2022, Doi: Https://Doi.Org/10.1016/J.Scitotenv.2021.151668.

[15] R. S. Putra And N. H. Airun, "The Effect Of Particle Size And Dosage On The Performance Of Papaya Seeds (Carica Papaya) As Biocoagulant On Wastewater Treatment Of Batik Industry," *Iop Conf Ser Mater Sci Eng*, Vol. 1087, No. 1, P. 012045, 2021, Doi: 10.1088/1757-899x/1087/1/012045.

[16] R. N. Hidayat, "Perancangan Sistem Deteksi Kekeruhan Air Pada Akuarium Ikan Arwana Berbasis Iot," *Konstelasi: Konvergensi Teknologi Dan Sistem Informasi*, Vol. 1, No. 2, Pp. 391–401, 2021.

[17] Yusnita Dwi Krisdiana, "Asam Jawa (Tamarindus Indica L.) Dan Biji Pepaya (Carica Papaya L.) Dalam Proses Koagulasi Limbah Cair Industri Batik," 2018, Accessed: Feb. 02, 2024. [Online]. Available: Http://E-Journal.Uajy.Ac.Id/Id/Eprint/16155

[18] S. Anju and K. Mophin-Kani, "Exploring The Use Of Orange Peel And Neem Leaf Powder As Alternative Coagulant In Treatment Of Dairy Wastewater," *Ijser*, Vol. 7, No. 4, Pp. 238–244, 2016.

[19] S. Royani, A. S. Fitriana, A. B. P. Enarga, And H. Z. Bagaskara, "Kajian Cod Dan Bod Dalam Air Di Lingkungan Tempat Pemrosesan Akhir (Tpa) Sampah Kaliori Kabupaten Banyumas," *Jurnal Sains & Teknologi Lingkungan*, Vol. 13, No. 1, Pp. 40–49, 2021.

[20] D. Y. Lestari, D. Darjati, And M. Marlik, "Penurunan Kadar Bod, Cod, Dan Total Coliform Dengan Penambahan Biokoagulan Biji Pepaya (Carica Papaya L)(Studi Pada Limbah Cair Domestik Industri Baja Di Surabaya Tahun 2020)," *Jurnal Kesehatan Lingkungan: Jurnal Dan Aplikasi Teknik Kesehatan Lingkungan*, Vol. 18, No. 1, Pp. 49–54, 2021.

[21] A. Yusuf, R. Ruhiyat, And R. Hadisoebroto, "Pemanfaatan Koagulan Biji Asam Jawa Guna Memperbaiki Parameter Bod, Cod, Dan Tss Limbah Cair Industri Tahu," *Jurnal Ekologi, Masyarakat Dan Sains*, Vol. 3, Aug. 2022, Doi: 10.55448/Ems.V3i2.66.