

**Textile Wastewater Decolorization by *Pleurotus ostreatus* in Organic Material Board Media****Citra Mawada Entristiana, Ratna Stia Dewi\* and Aris Mumpuni***Faculty of Biology, Jenderal Soedirman University, Jl. Dr. Suparno, Purwokerto 53123, Indonesia**\*Corresponding author: [ratna.dewi0509@unsoed.ac.id](mailto:ratna.dewi0509@unsoed.ac.id)**Received 9 November 2021; Accepted 24 February 2022; Available online 18 April 2022***ABSTRACT**

The textile industry in one of the fastest industries that grow today. However, the increased activity makes the production of liquid wastewater also increased because the use of water reaches 80% in production. The wastewater can endanger the aquatic ecosystems because it contains toxic dyes. *Pleurotus ostreatus* has ligninolytic enzymes that are capable of degrading synthetic dyes into non-toxic forms to the environment. This study aims to determine the optimum contact time of *P. ostreatus* in organic material board media for the best result in textile wastewater decolorization. This research used an experimental method. The research consisted preparation of *P. ostreatus* isolate, making of seed media, inoculation into seed media, making of log media, inoculation into log media, making of board media, and decolorization process. The parameters tested were different contact time (24, 48, 72, 96, 120, 144, and 168 hours), Total Dissolved Solid (TDS), pH, and temperature. The result of this research was that the treatment of *P. ostreatus* in organic material board media can decolorize textile wastewater. The value of highest decolorization percentage was 35,69% at 24 hours contact time. There are change of TDS, pH, and temperature on before and after namely 835 to 566, 8.7 to 7.62, 28.3 to 31. This board system is promising for wastewater treatment.

**Keywords:** decolorization, textile wastewater, *P. Ostreatus*, board media**ABSTRAK**

Industri tekstil merupakan salah satu industri yang paling cepat berkembang saat ini. Namun peningkatan aktivitas tersebut membuat produksi limbah cair juga meningkat karena penggunaan air mencapai 80% dalam produksinya. Air limbah tersebut dapat membahayakan ekosistem perairan karena mengandung zat pewarna yang bersifat racun. Jamur *Pleurotus ostreatus* memiliki enzim ligninolitik yang mampu mendegradasi zat warna sintetis menjadi bentuk yang tidak beracun bagi lingkungan. Penelitian ini bertujuan untuk mengetahui waktu kontak optimum *P. ostreatus* pada media board dari bahan organik untuk memperoleh hasil dekolonisasi limbah tekstil terbaik. Penelitian ini menggunakan metode eksperimen. Penelitian meliputi preparasi isolat *P. ostreatus*, pembuatan media bibit, inokulasi ke dalam media bibit, pembuatan media log, inokulasi ke dalam media log, pembuatan media board, dan proses dekolonisasi. Parameter yang diuji adalah waktu kontak yang berbeda (24, 48, 72, 96, 120, 144, dan 168 jam), Total Dissolved Solid (TDS), pH, dan suhu. Hasil penelitian ini adalah bahwa perlakuan *P. ostreatus* pada media board bahan organik dapat menghilangkan warna air limbah tekstil. Nilai persentase dekolonisasi tertinggi adalah 35,69% pada waktu kontak 24 jam. Terjadi perubahan TDS, pH, dan suhu pada sebelum dan sesudah yaitu 835 menjadi 566, 8,7 menjadi 7,62, 28,3 menjadi 31. Sistem board ini menjanjikan untuk pengolahan air limbah.

**Kata kunci:** penghilangan warna, air limbah tekstil, *P. ostreatus*, media papan**1. Introduction**

The textile industry in one of the fastest industries that grow today. The increased activity of the textile industry makes the liquid wastewater produced also increases. The liquid wastewater still contains 10-15% of dye when discharged into the waters. The dye contains

pollutant compounds consisting of organic and inorganic materials. These pollutant compounds can harm aquatic ecosystems and cause great health risks (Christian et al., 2007). Textile wastewater will be channeled into reservoirs then discharged into rivers and will cause pollution. Pollution that occurs in river bodies will

have a negative impact on the fish that live in the river. Polluted waters will experience a decrease in, thus causing a decrease in the carrying capacity of the waters for the life of aquatic organisms. Another impact that can occur is the mass death of fish or in the form of structural and functional abnormalities in the direction of abnormality (Wikiandy, 2013).

Textile wastewater treatment can be done by physical, chemical, and biological methods. This physical and chemical method is effective for textile wastewater treatment, but still has some drawbacks. According to Awaluddin et al. (2001), physical and chemical methods require high costs and still produce hazardous compounds, besides that these two methods also result in more concentrated sludge accumulation and produce by-products such as toxic aromatic amines (Yesilada et al., 2018). Chemical compounds are only able to absorb pollutants that have non-polar properties with low molecular weights. Therefore, an alternative textile wastewater treatment using biological methods is needed because it is considered cheaper and environmentally friendly. This method can take advantage of the activity of organisms such as fungi.

One group of fungi that can be used for the degradation of textile wastewater is the white rot fungi (WRF) group. The WRF group is an organism that has a high decolorization ability, which one is *Pleurotus ostreatus* (Wulandari et al., 2014). The research of Wulandari et al. (2014) reported that *P. ostreatus* was able to decolorize indigosol yellow dye. Research Sorta et al. (2012) also reported that *P. ostreatus* was able to decolorize naphthol and indigosol dyes.

The decolorization mechanism can occur through enzymatic and nonenzymatic mechanisms. The nonenzymatic mechanism occurs through adsorption by fungal mycelium. The color change in the fungal mycelium indicates a decolorization process. The mechanism of enzymatic decolorization occurs with the involvement of extracellular enzymes, namely Lignin peroxidase (LiP), Manganese dependent peroxidase (MnP), and laccase. This enzyme has a role in the breakdown of aromatic bonds containing benzene rings in complex colored compounds (Wikolazka et al., 2002).

The process of decolorization of synthetic dyes is influenced by several factors. According to Gita et al. (2020) decolorization of synthetic dyes using fungi is influenced by environmental conditions such as contact time, pH, and temperature. Contact time affects the dye absorbed. The longer the contact time, the greater the dye absorbed (Purnama & Setiati,

2004). However, if it has reached the saturation point, the absorption of the mycelium will decrease. Changes in pH that are too low or too high will cause denaturation of the enzyme so that the decolorization activity decreases (Kaushik & Malik, 2009). The temperature during the decolorization process will increase due to fungal activity.

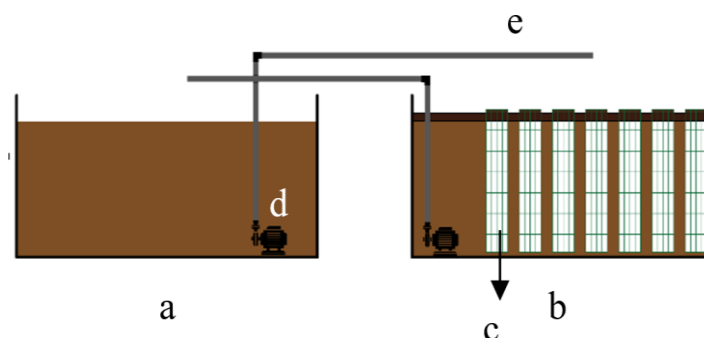
Decolorization studies have mostly used free cells, but still need to develop efficient decolorization processes. The solution to this is decolorization using immobilization techniques, namely growing mycelia or enzymes in a matrix that can maintain their activity. Several studies of immobilization techniques were carried out using Light Expanded Clay Aggregate (LECA), zeolite, and Ca-alginate (Nurhayat et al., 2020). The innovation in this research is to growing mycelium in a media board that is used for decolorization. Media board decolorization is media created in a square shape with a size of 30 cm x 30 cm and a thickness of 2 cm is made from organic materials such as rice bran, corn flour, and sawdust as a medium for the growth of fungal mycelium which will be used for decolorization of textile wastewater that applied in a bioreactor (Dewi 2021, pers. comm., 20 January). Therefore, it is necessary to study the decolorization of textile wastewater using *P. ostreatus* which was colonized on board media with variations in contact time.

The aims of this research is to determine the effective contact time of *P. ostreatus* in organic material board media for best results in textile wastewater decolorization.

## 2. Materials and Methods

### 2.1. Preparation of Inoculum

*P. ostreatus* was rejuvenated on PDA media and then incubated for 3 x 24 hours at room temperature. After that making the inoculum media use the ingredients namely 700 g of sawdust, 250 g of rice bran, and 50 g of calcium were mixed and then 700 mL of water was added. Then after all the ingredients are mixed well, they are put into clear bottles with a diameter of 6 cm and a weight of each bottle weighing 250 g. The bottle is then covered with cotton and plastic. The inoculum media was sterilized using an autoclave at 121 °C for 40 minutes. Then *P. ostreatus* on PDA were taken aseptically with an ose needle and inoculated to inoculum media. Incubate at room temperature until the mycelium fills the bottle for 3 weeks.



**Figure 2.** Side view of the board's bioreactor system (a = waste container (in let), b = container for medium board for the decolorization process (out let), c = medium board in bracket, d = water pump and e = pipe)

## 2.2. Making of Organic Material Media

The ingredients for making the media of organic matter are mixed, namely 650 g of wood powder, 150 g of rice bran, 100 g of milled corn, 50 g of gypsum, and 50 g of lime then given enough water or until the mixture feels moist. Then the mixture of materials is put into Polypropylene (PP) plastic measuring 20 cm x 30 cm x 0.6 mm. The organic material media that has been prepared is arranged in a drum, then steamed or evaporated for 6 hours. Fungal cultures were inoculated into the organic material media aseptically with a spatula and then incubated at room temperature until the mycelium growth reached  $\frac{3}{4}$  media.

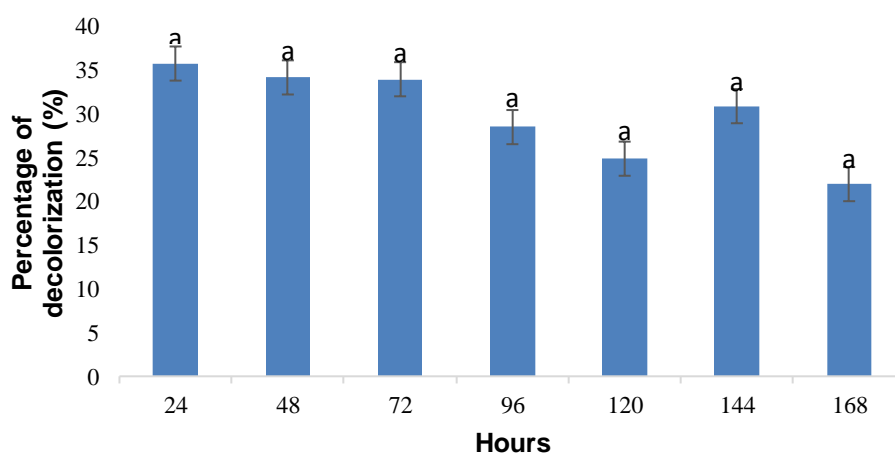
## 2.3. Making of Board Media

The organic material media that has been overgrown with mycelium reached  $\frac{3}{4}$  media and then transferred to a media board mold 30 x 30 x 2 cm that has been coated with sterile plastic sheet then covered with plastic wrap and

incubated at room temperature for 3 days and made 100 holes perforation using a needle then continued incubation for 2 weeks so that all of the media board was colonized by *P. ostreatus* mycelia.

## 2.4. Textile Wastewater Decolorization Process

Waste decolorization was carried out using a bioreactor board. The bioreactor consists of a textile wastewater container and a medium board placement tank. Seven medium boards with a volume of 12.6 liters are arranged vertically. A total of 50 liters of textile liquid waste is put into both containers, so the total volume of textile wastewater is 100 liters. The textile wastewater collection tank is pumped to drain the waste into the medium board container and the medium board container is also pumped to remove the waste which is returned to the waste collection container. The average flow rate of the two pipes is  $52.08 \text{ mL} \cdot \text{s}^{-1}$ . Observations at 24 hours, 48 hours, 72 hours, 96 hours, 120 hours, 144 hours, 168 hours,



**Figure 2.** Percentage of textile wastewater decolorization.

144 hours, and 168 hours. The percentage of decolorization is calculated using the formula:

$$\text{Decolorization (\%)} = \frac{\text{Initial absorbance} - \text{final absorbance}}{\text{Initial absorbance}} \times 100\%$$

### 3. Result and Discussion

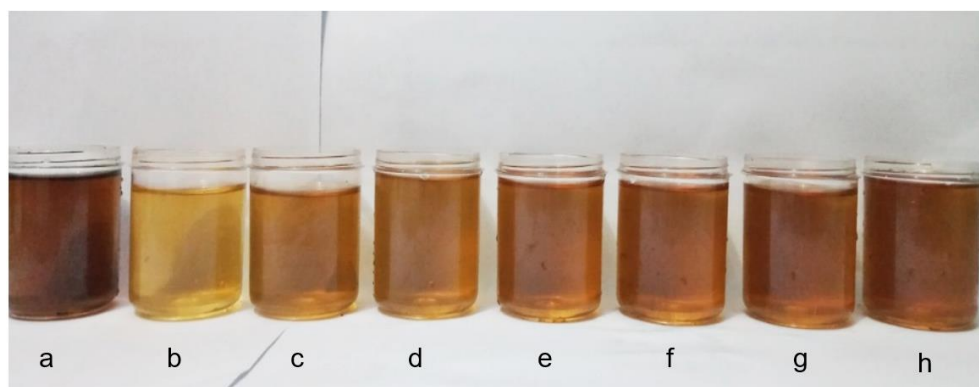
Based on the research, the highest decolorization activity was at a contact time of 24 hours, which was 35.69 %, and the lowest decolorization activity was at contact 168 hours, which was 21.93 %. Figure 2 showed a decrease in decolorization activity with increasing contact time of the media board with textile water. Based on these results *P. ostreatus* in medium board with different contact time treatments gave the same ability to decolorize textile wastewater. This can assume that the effective contact time for textile wastewater decolorization using *P. ostreatus* in board media is 24 hours.

The results also showed that *P. ostreatus* in board media with different contact times also could reduce dyes present in textile wastewater. This can be seen in Figure 3, which offers a decrease in color intensity compared to the initial textile wastewater.

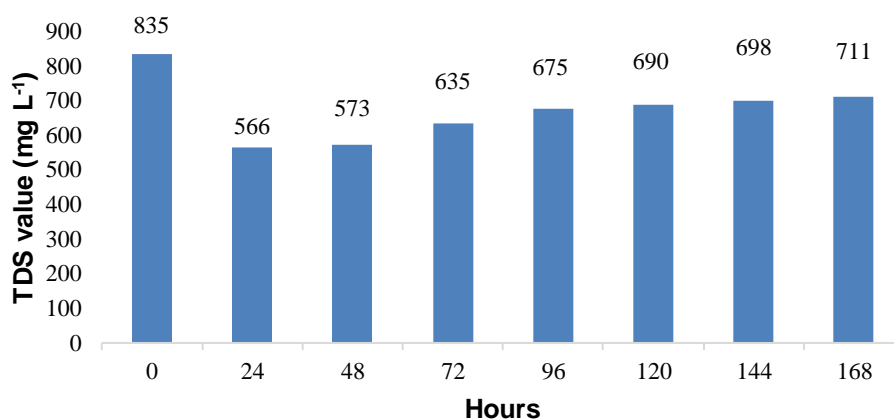
Based on Figure 3, the color comparison of textile wastewater before and after decolorization using *P. ostreatus* with different contact time treatments can be seen. Textile wastewater, which was originally dark brown, turned brownish-yellow. The color change occurred due to the absorption of dyes by the *P. ostreatus* mycelium on the media board. The decrease in color intensity is also in line with the reduction of the absorbance value of textile wastewater. This decrease in absorbance value indicates that each treatment occurs in a decolorization process.

The decolorization process occurs through two mechanisms, namely non-enzymatically and enzymatically. The initial process of decolorization occurs non-enzymatically through adsorption carried out by fungal mycelium. This is evidenced by the changing color of the mycelium of *P. ostreatus* from white to brownish. The mechanism of enzymatic decolorization occurs through the secretion of ligninolytic extracellular enzymes such as Lignin Peroxidase (LiP), Manganese Peroxidase (MnP), and Laccase. Ligninolytic enzymes are enzymes that have the ability to oxidize phenolic compounds and contain a lot of copper oxidase (Dimawarnita & Panji, 2019). These enzymes function to break the aromatic bonds and the saturation of the cyclic carbon chain in the dyes. The bond supports the formation of color, so that if the bond is broken, the dyes can be removed (Coulibaly et al., 2003). It was proven in the research of Dewi et al. (2019b), that *P. ostreatus* colonized on sawdust base secreted LiP, MnP, Lac, with an activity of 12938.60, 200.43, 9.714, U/l, respectively.

In addition, to non-enzymatic and enzymatic mechanisms, the cellulose components in the board media can also absorb the dyes in textile wastewater. According to Mulyatna et al. (2013), every material containing cellulose can absorb the dyes. The hydroxyl group or OH group in the cellulose molecule binds to the chloride group composed of textile dyes. In addition, hydrogen bonds are also formed between the H atoms of the OH groups in cellulose and N atoms of textile dyes; these bonds make the dyes bound to the cellulose fibers of wood powder, so that textile dyes color the cellulose fibers. According to this result, it



**Figure 3.** Comparison of textile wastewater before and after decolorization using *P. ostreatus* in board media with contact times of 0 hours (a) 24 hours (b), 48 hours (c), 72 hours (d), 96 hours (e), 120 hours (f), 144 hours (g), and 168 hours (h).



**Figure 4.** Changes in TDS levels on textile waste decolorization using *P. ostreatus* in medium board with different contact time

means that if the waste is disposed of into the waters, it will be safer for the life of the fish in those waters.

The TDS level in textile wastewater before the decolorization process was 835 mg. L<sup>-1</sup>. High TDS levels are caused by high solids in minerals, salts, metals, and cations in the water (Ilyas et al., 2013). High TDS levels can endanger waters because it can cause changes in salinity that can disrupt the balance of aquatic biota and cause toxicity to an organism (Hidayat et al., 2016). The process of decolorizing textile wastewater using *P. ostreatus* in the media board able to reduce the TDS levels in the wastewater. The process of decolorizing textile wastewater using *P. ostreatus* in the media board able to reduce the TDS levels in the wastewater. The decrease in TDS levels in textile wastewater is caused by the organic matter dissolved in the wastewater being degraded into gas. In the methanogenic phase,

the organic acids are converted into carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>). TDS levels in textile wastewater after decolorization at contact times of 24, 48, 72, 96, 120, 144, and 168 hours were 439, 573, 635, 675, 690, 698, and 711 mg. L<sup>-1</sup>, respectively. Data on the decrease in TDS levels are shown in Figure 4. Based on KEP-51/MENLH/10/1955, the quality standard of dissolved solids in liquid waste of group I industrial activities is 2000 mg. L<sup>-1</sup>. This means that the TDS level of textile wastewater used is below the maximum limit.

Decolorization activity is also supported by changes in the degree of acidity (pH) from textile wastewater. Data on changes in pH values can be seen in Table 2. The initial textile wastewater pH is around 8.77-8.71 and after decolorization it rises to 8.07-7.05. The enzymatic activity of *P. ostreatus* caused changes in pH. The more acidic the pH value, the smaller the absorbance value, which means that the percentage of

**Table 1.** Changes the pH value of textile wastewater before and after decolorization using *P. ostreatus* in a medium board with different contact times

Hours	pH					
	1		2		3	
	Before decolorization	After decolorization	Before decolorization	After decolorization	Before decolorization	After decolorization
24	8.71	7.34	8.62	7.16	8.77	8.36
48	8.71	7.26	8.62	7.10	8.77	7.26
72	8.71	7.43	8.62	7.47	8.77	8.06
96	8.71	7.10	8.62	7.54	8.77	7.68
120	8.71	7.66	8.62	7.73	8.77	7.75
144	8.71	7.57	8.62	7.70	8.77	8.09
168	8.71	7.05	8.62	7.53	8.77	8.07

decolorization will be higher (Hadianto, 2000). The ideal pH value for waters is 7 – 8.5. Water conditions that are very alkaline or very acidic will endanger the survival of organisms because it will interfere with metabolic and respiratory processes (Hamuna et al., 2018).

An increase in temperature also occurred during the textile wastewater decolorization process using *P. ostreatus* in the media board. Changes in the temperature value of textile waste can be seen in Table 2. The initial textile wastewater temperature is around 28-30 °C and after decolorization it rises to 30-35 °C. The research conducted by Sorta et al. (2012) also showed that the initial temperature value of batik liquid wastewater was 28 °C and increased to 30 °C at the end of the treatment. According to Abedin (2008), an increase in temperature indicates that the mycelium's metabolic activity can affect the decolorization process.

Fungi that can decolorize dye effluents can be integrated into the sewage treatment system which can later reduce heavy metal levels and their toxicity to fish. Fungal contamination in spent mushroom (which is colonized on sawdust) can decolorize, reduce heavy metals and can reduce the toxicity of batik effluent in preliminary tests on fish (Dewi & Hana, 2021). Especially the isolate fungi *Aspergillus* sp. 3, has been shown to reduce the initial toxicity of batik effluents in Goldfish (*Cyprinus carpio*) (Dewi et al., 2019b). This occurs because the decolorization of the effluent by fungi produces harmless compounds such as benzene compounds that have been decomposed into simple compounds (Dewi et al., 2021).

The condition of Padelegan coastal waters is utilized by various human activities including marine tourism on Padelegan Beach, access to fishing boat traffic, seaweed cultivation and

along the coast there are salt ponds whose water sources come from Jumiang coastal waters. The distribution of turbidity values from observation points close to the coast to high seas observation points can be seen in Table 1.

Table 1 shows the highest turbidity value at point 1 near the coast, which is 29.8 NTU, while the lowest value is 4.1 NTU at point 8 in the high seas. The distribution of turbidity values at points 1, 2, 3 which is a coastal area dominates the highest turbidity value. Coastal areas are dynamic areas where they interact directly with activities on land and sea. Turbidity is influenced by the entry of land waste from both residential and agricultural or aquaculture ponds which contributes to the amount of sludge and suspended solids in the water. Turbidity can affect the penetration of sunlight into the water column. In many coastal areas, suspended solids are found which affect the penetration of sunlight, thus affecting the productivity of coastal waters (Yingying, et al, 2014). The highest value is obtained in the area of point 1 where the area is directly adjacent to the marine tourism activities of Padelegan Beach and is a fishing boat traffic lane. The stirring of suspended material and mud that affects the turbidity value will result in inhibiting the penetration of sunlight into the waters so that the photosynthesis process of organisms will be disrupted (Makmur, 2003). The turbidity value in coastal areas is close to the maximum turbidity threshold value, which is 30 NTU seawater quality standard for aquaculture (Peraturan Gubernur DIY, 2010). The level of turbidity in coastal areas tends to be higher than the high seas (Framinan, et al, 1993). Seaweed cultivation activities and sources of salt ponds should not be carried out in locations close to the coast with a distance of 500 m from the shoreline. Lloyd (1985) in Effendi

**Table 2.** Changes the temperature values of textile waste before and after decolorization using *P. ostreatus* in medium board with different contact times

Hours	Temperature (°C)					
	1		2		3	
	Before decolorization	After decolorization	Before decolorization	After decolorization	Before decolorization	After decolorization
24	28	30	27	31	30	32
48	28	30	27	30	30	30
72	28	30	27	31	30	35
96	28	30	27	31	30	32
120	28	31	27	33	30	33
144	28	31	27	31	30	32
168	28	31	27	32	30	32

(2003), stated that an increase in the turbidity value of 25 NTU can reduce 13-50% of the primary productivity of waters so that it interferes with seaweed cultivation activities and salt pond production.

The value of turbidity at points 4, 5, and 6 which is the beach has a value on the turbidity threshold of sea water quality standards for cultivation so that seaweed cultivation activities using floating rafts can be carried out at a distance of  $\pm$  1500 m from the shoreline. The source of salt pond water can also be taken at this location because the turbidity value that affects the production and quality of salt is still far from the threshold. On the high seas (points 7, 8, 9) it has the lowest turbidity value of 4.1 NTU where this value is far below the threshold for sea water quality standards for aquaculture (Peraturan Gubernur DIY, 2010). The value of turbidity in the high seas is influenced by the location far from the entry of land waste and the influence of marine hydrodynamics which results in stirring and dilution of turbidity.

#### 4. Conclusion

Based on the results the effective contact time for *P. ostreatus* in organic material board to decolorize textile wastewater is 24 hours with decolorization percentage 35.69 %.

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