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Restaurant Liquid Waste Treatment into Clean Water Using Graded Filter-Ultrafiltration Membrane Polyethersulfone (PES) Method

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ABSTRACT

Restaurant liquid waste contains elevated pollutant levels and is commonly discharged directly into the environment, leading to adverse impacts on ecosystems and aquatic life. The traditional methods for processing such wastewater often involve extensive land usage and complicated operations, posing challenges for effective treatment. Therefore, there is a need for a more practical technology to manage restaurant liquid waste, and one promising approach is the utilization of membrane technology for wastewater treatment. In this study, the researchers employed a combination process of multilevel filters with downflow flow and PES membrane ultrafiltration to treat the restaurant liquid waste. The multilevel filter comprised several layers of filter media, including silica sand, activated carbon, zeolite, and gravel, with specific thicknesses on a PVC pipe. For the PES membrane, two different concentrations were tested: 15% and 20% PES. To evaluate the efficiency of the treatment process, pollutant parameters such as pH, TSS (Total Suspended Solids), COD (Chemical Oxygen Demand), and turbidity were measured. The results indicated significant pollutant reduction: pH levels could reach 6.9, TSS degradation achieved up to 98.37%, COD degradation up to 88.14%, and turbidity degradation up to 97.03%. Based on the outcomes, the most effective treatment for converting restaurant wastewater into clean water involved the combined use of multilevel filters and a 20% PES membrane ultrafiltration system.

***Keywords*:** Dimethylformamide (DMF) solvent, effectiveness, graded filter, Polyethersulfone (PES) membrane, restaurant wastewater, ultrafiltration.

1. INTRODUCTION

Water plays a very important role in the activities and sustainability of human life and other living things. According to the United States Geological Survey, water covers 72% of the earth's surface. However, most of this water is unable to be consumed immediately because 92% of it is in the form of salt water and 70% is in the form of ice. This means that only less than 1% of the world's water can be directly used and consumed [1]. Even though Indonesia is known as a country that has abundant water supplies, several regions in Indonesia are also experiencing a clean water crisis [2]. This problem is caused by sources of pollution such as domestic, industrial and agricultural waste [3].

The definition of home liquid waste includes waste from restaurants, according to Minister of Environment and Forestry Regulation No. 68 of 2016 concerning Domestic Wastewater Quality Standards. Since most restaurants lack their own waste treatment facilities, liquid waste containing these materials is usually dumped directly into the environment, which will eventually harm aquatic biota and ecosystems [4].

Physically, restaurant wastewater tends to be dark in color (dark brown) and smells, because restaurant wastewater consists mostly of water and a little solid/suspended from oil and grease, as well as food scraps. Chemically, restaurant wastewater contains more organic matter from the process of

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washing cooking utensils and cutlery with chemicals used such as detergents, bleaches, solvents and stain removers. These cleaning products can contaminate wastewater when used and discarded.

The biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), turbidity, oil and grease, and the presence of phosphorus and other organic matter can all rise as a result of inadequate wastewater treatment from restaurants. Since disinfectants and antiseptics used to clean floors and wash kitchen equipment are acidic, the pH of waste can be lower (pH 7), which is obviously bad for the environment [5].

A fall in pH signifies a decline in water quality, which has the potential to negatively effect aquatic organisms' lives. As a result, even the most resistant creatures might die as a result of disruptions in the food web in the waters. Changes in dissolved oxygen concentration, in addition to pH, can signal changes in water quality; the lower the dissolved oxygen content, the poorer the water quality [6].

Domestic garbage must first be processed to fulfill quality criteria according to Regulation of the Government of the Republic of Indonesia Number 22 of 2021 concerning Implementation of Environmental Protection and Management before being released into public channels, such as bodies of water. Reusing, recycling, and recapturing the advantages of wastewater are all ways to treat it. However, in general, the treatment of restaurant wastewater necessitates vast tracts of land and challenging operations. As a result, issues with air quality are getting more public attention. Numerous studies have been conducted to address the clarification or reduction of specific substances in water using a variety of techniques, such as the addition of chemicals or natural ingredients to high-tech, environmentally friendly processes. The usage of membrane technology is one strategy that is currently being developed [7].

Based on the size of the particles being filtered, different types of membranes are used in classification, including microfiltration, ultrafiltration, nanofiltration, and reverse osmosis. Because ultrafiltration membranes have smaller pores than microfiltration membranes, they can retain bacteria as well as soluble macromolecules like proteins in addition to large particles and microorganisms [8]. The rejection of COD and surfactants in oily wastewater by ultrafiltration membranes, which are positioned between microfiltration and nanofiltration, ranges from 94.89 to 98.83%. With the potential to reduce COD levels by 97.66% and TSS levels by 98%, the application of PES ultrafiltration membrane technology has been demonstrated to be beneficial in the processing of palm oil industrial wastewater [9,10].

The choice of the proper polymer has a significant impact on the performance of the membrane throughout the filtration process. A number of polymeric materials that can be utilized to manufacture membranes are [11]:

a. Polyacrylonitrile (PAN), this material exhibits exceptional thermal stability, withstanding temperatures of up to 103ºC. It is also highly resistant to various solvents and chlorine solutions, and possesses remarkable hydrophilic properties, earning it a reputation for its resistance to fouling.

b. Poly(eter sulfone) (PES), This thermoplastic compound is characterized by its amorphous structure and exceptional thermal stability, enabling it to withstand high temperatures above 180ºC for extended periods. Even at temperatures above 210ºC, it retains its mechanical and electrical properties admirably. PES exhibits remarkable resistance to various chemical solutions, including hot water, steam, acids, alkalis, oil, grease, gasoline, alcohol, and more.

c. Poly(vinylidene fluoride) (PVDF), This material boasts superior physical and chemical properties, including good thermal stability. However, it exhibits hydrophobic characteristics, which lead to the formation of fouling and the adsorption of macromolecular organic components on the surface of the PVDF membrane.

Consequently, these factors contribute to a decline in permeability when the membrane is utilized in water filtration processes.

d. Celulose Acetate (CA), This material possesses excellent hydrophilic properties, facilitating efficient water transfer characteristics and minimal protein absorption. It also exhibits suitable mechanical properties, allowing for easy membrane formation, and is available at a low cost. However, CA polymers have certain drawbacks, including low chemical resistance and poor thermal stability, which can limit their performance in certain applications.

e. Polysulfone (PSf), Initially developed as a substitute for CA membranes, PSf offers distinct advantages over CA. Its notable strengths include excellent resistance to extreme pH conditions and impressive thermal stability, boasting a glass transition temperature of 195ºC. However, PSf does have its drawbacks. It exhibits hydrophobic properties, making it susceptible to fouling when employed in water treatment processes. Additionally, forming PSf into membranes is relatively straightforward under normal conditions, but it may present challenges in more complex scenarios.

Among various polymers, PES stands out as a highly suitable option for water treatment processes due to its favorable attributes. With its robust mechanical properties, exceptional thermal stability, resistance to oxidative degradation and solvents [12], and remarkable ability to withstand chemical solutions, including oils and fats, PES emerges as the ideal choice for restaurant wastewater treatment when used as membranes. The choice of PES as the polymer was influenced by two significant factors [12]. Firstly, data from 11 prominent international companies revealed the widespread use of PES-dominated ultrafiltration membrane production. Secondly, laboratory studies conducted by emphasized the improvement of membrane performance for wastewater treatment and clean water purification, with PES being the primary choice for manufacturing flat sheet ultrafiltration membranes in these studies. These combined sources of evidence solidified PES as the preferred polymer for the development of ultrafiltration membranes in water treatment applications.

PES membranes exhibit drawbacks, such as inadequate permeability and a propensity for fouling, primarily attributed to their limited hydrophilic properties [13]. Antifouling on the membrane can be improved by adding inorganic chemicals such as TiO_2 (Titanium dioxide) as additives. TiO_2 is a highly useful compound for water usage applications because it is resistant to high temperatures in the 500-1000°C range, is non-toxic, cheap, abundant, and chemically resistant to acidic and alkaline media [14].

However, the membrane also has disadvantages due to fouling which results in low permeation flux. Therefore, to anticipate the rapid occurrence of fouling in membrane filtration, the membrane ultrafiltration method is combined with initial filtration with multilevel filters with a composition consisting of sand, gravel, charcoal and zeolite which can reduce the parameter levels of BOD by 83.18%, TSS by 83, 05%, and fat content of 90%. This system works quite effectively because the inorganic materials used on average have the ability to reduce the levels of contaminants in wastewater, both through the filtration process and the absorption process [15].

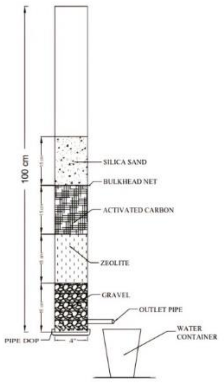
This work intends to characterize PES polymer, TiO_2 additives, and DMF solvent-based ultrafiltration membranes by flux values, morphological analysis, and chemical composition. In order to evaluate the effectiveness of the developed ultrafiltration membrane in enhancing air quality, pH, TSS, COD, and turbidity levels were reduced in the restaurant wastewater treatment process utilizing the multilevel train combination approach.

2. RESEARCH METHODS

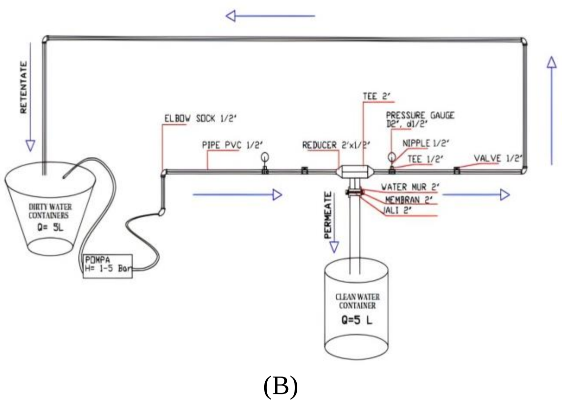
The design of multilevel filter units served as the first treatment in the study, which was followed by the production of PES ultrafiltration flat membranes, the design of membrane ultrafiltration units, which served as the second treatment, and finally tests on the PES membranes' properties and the performance of the membranes in converting restaurant wastewater into clean water.

2.1. EQUIPMENT AND MATERIALS

To make the membrane, polyethersulfone (PES) polymer obtained from BASF Company (USA), TiO_2 as an additive, and N,N-dimethylformamide (DMF) as a solvent (Made in Germany, purity 99.9%) purchased from an internet store (Tokopedia) were utilized, while distilled water is used as a non-solvent. In addition, some of the equipment used included closed glass bottles, hot plate magnetic stirrers, pipettes, spatulas, analytical scales, stopwatches, glass plates, glass rods, and sealtape. The design of the filtration unit used in the study is shown in Figure 1.



(A)



(B)

Figure 1. Unit design of (A) multilevel filter filtration and (B) membrane ultrafiltration.

2.2. MEMBRANE PREPARATION

Phase inversion technique was used to prepare the membrane using immersion precipitation [13,16]. The printing solution was prepared by mixing the main ingredients DMF solvent, TiO_2 additive, and PES polymer, with a composition of 83.5:1.5:15 (PES 15%) and 78.5:1.5:20 (PES 20%) in a bottle closed glass. The first ingredients added were DMF solvent and TiO_2 additive and stirred for 30 minutes at 60ºC. Then PES polymer was added and stirred for 24 hours at the same temperature. After being allowed to stand for ± 2 hours to remove air bubbles, the solution was poured onto a glass plate that had been given a tape on the side as a benchmark for a thickness of 0.03 µm and leveled with a glass stirrer rod. The glass plate is then submerged in distilled water for the coagulation bath while waiting for the membrane layer to organically separate from the glass bath. On the membrane, this procedure is repeated once more.

2.3. MEMBRANE CHARACTERISTICS TESTING

2.3.1. MORPHOLOGICAL ANALYSIS

The morphology and pore statistics were examined using a Scanning Electron Microscope (SEM) (JEOL, Japan) JSM-6360 LA with an electron voltage acceleration of 15 kV on the top surface and membrane cross sections of 15% PES and 20% PES. The results of the analysis with this SEM are Polaroid photos with a magnification of size ranging from 35x to 10000x, but for 15% and 20% PES membrane samples, SEM was performed on the surface with a magnification of 10,000x, while cross-sections were performed by SEM with different magnifications, namely 2000x magnification on 15% membrane and 1,500x magnification on 20% membrane. Finding out how the pores generated on the membrane are shaped is the goal of this investigation.

2.3.2. FUNCTIONAL GROUP ANALYSIS

To analyze the functional groups on PES 15% and PES 20% membranes, tests were carried out using the PerkinElmer Spectrum Two (CT, USA) FTIR (Fourier transform infrared spectroscopy) instrument with a wavenumber range from 400 to 1400 cm^{-1}, and recorded with a resolution of 1 cm^{-1}.

2.3.3. FLUX MEASUREMENTS

The sample is restaurant liquid waste that has been previously purified with a multilayer filter. The created membrane is placed on the tool's bottom, and the sample is inserted in the membrane ultrafiltration unit, which is pressed with a 3 bar pump, so that the sample water flows through the membrane, which is known as permeate. The permeate is collected in a measuring cup for one hour, and the volume is estimated to determine the membrane flux (membrane permeability) using the equation [13]:

$$J = V/(A.t) \quad (1)$$

With :
J = flux (L/m^2. hour)
A = membrane surface area (m^2)
V = permeate volume (L)
t = time (hours)

2.4. TEST OF EFFECTIVENESS

a) pH parameters

As per the guidelines in (Indonesian National Standard 06-6989.11-2004), pH measurements were conducted using a pH meter model (Hanna HI 9813-5). The testing process consists of the following steps: first, the electrode is rinsed with mineral-free water and then dried gently with a soft tissue. Next, the electrode is immersed in the test sample until the pH meter displays a steady reading. Finally, the pH value is recorded from the scale or numerical display of the pH meter.

b) Parameters TSS (Total Suspended Solids)

Based on Indonesian National Standard 06-6989.3-2004, the determination of Total Suspended Solids (TSS) was conducted through a gravimetric method. The process involved filtering a well-mixed test sample using pre-weighed filter paper and a vacuum filtration apparatus (Rocker 300-MS310MF3). Subsequently, the residue on the filter paper was dried at a temperature between 103°C to 105°C. Afterward, the filter paper was weighed again, and the increase in weight on the filter indicated the total suspended solids (TSS) content.

c) COD Parameters (Chemical Oxygen Demand)

As per Indonesian National Standard 6989.2:2019, Chemical Oxygen Demand (COD) measurements were conducted using the closed reflux spectrophotometry method. The testing process involved placing the test sample, $K_2Cr_2O_7$ standard solution, and H_2SO_4 sulfuric acid reagent solution in a tube, which was then heated to 150ºC using the COD reactor Brand Hanna Instrument HI 839800. After the solution cooled to room temperature, the COD value was determined using the Hanna HI 83214 Wastewater Treatment Photometer.

d) Turbidity Parameters

As stated in (Indonesian National Standard 06-6989.25-2005), the procedure for testing the turbidity parameter involves employing a nephelometer (Turbidity Meter Lutron TU-2016). Initially, a turbidity calibration solution, for example, 40 NTU, is introduced into the tube of the nephelometer to obtain a reading. Subsequently, the well-mixed test sample is placed into the tube and positioned on the nephelometer until a steady turbidity value is displayed.

3. RESULTS AND DISCUSSION

3.1. MEMBRANE MORPHOLOGY ANALYSIS

Based on the morphology analysis results of the membrane using SEM, the surface structure of the membrane in Figure 2 (A and C) for both PES 15% and PES 20% membranes. Therefore, both membranes were classified as ultrafiltration membranes with a pore size range of 0.001 - 0.1 µm [17]. After analysis, it was discovered that there was an agglomeration of TiO_2 that formed the structure on the two images of the membrane surface (marked with a red circle). On the 15% PES membrane, however, the titanium granules were more apparent as a result of the formation of more granules in the membrane layer due to the rising TiO_2 concentration [18].

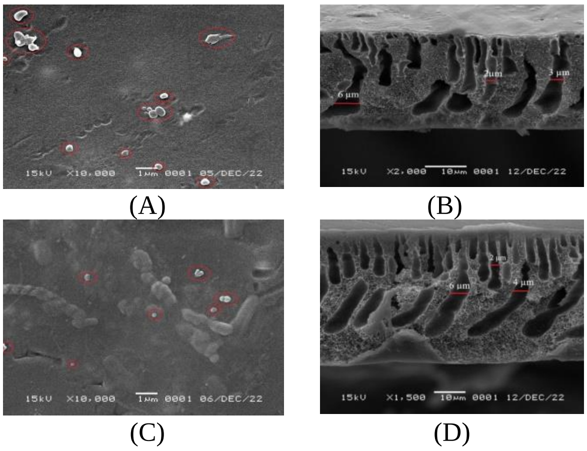


Figure 2. Surface SEM and cross section of flat PES membrane (A-B) 15% PES membrane, (C-D) 20% PES membrane.

The observation for the macropore structure in cross-section was then conducted and shown in Figure 2 (B and D). It revealed that both membranes were asymmetric membranes with two layers, namely the thin and dense upper layer, and the lower layer with finger-shaped pore structures that functioned as support and mechanical strength to the membrane [3]. The PES 20% membrane formed smaller and denser pores than the PES 15% membrane, with a pore size range of 2 µm – 6 µm that was measured using ImageJ software, with an average pore size of 2 µm – 3 µm. This was influenced by the higher concentration of PES polymer, where the denser particle packing led to a smaller pore size, in line with previous research conducted by Fathanah et al. [19].

3.2. MEMBRANE FUNCTIONAL GROUP

The chemical composition of 15% PES and 20% PES membranes which have been analyzed using FTIR is shown in Figure 3. The characteristic of the IR spectrum of the membrane formed is that it indicates pure PES which is characterized by the formation of C-O-C chemical bonds, the formation of asymmetric C=C bonds which indicates the presence of aromatic bonds [17], then there are C=C-C aromatic ring groups and O=S=O [19] sulfone groups, as well as aromatic C-H at wave number 834 cm^{-1}. It can be seen that the IR spectra of the 15% PES membrane and the 20% PES membrane coincide almost exactly where there is only a slightly higher absorption intensity on the 20% PES membrane due to the higher polymer concentration compared to the 15% PES membrane.

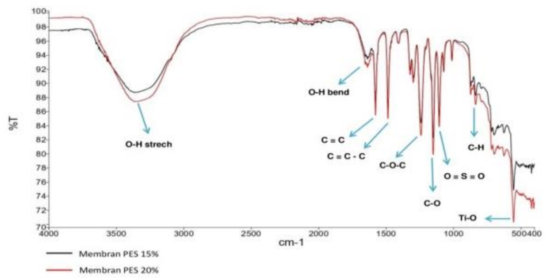


Figure 3. FTIR PES membrane 15% and PES membrane 20%.

Also, it was found that the CO group was the dimethylformamide functional group, which had a relatively higher intensity on the 20% PES membrane, because the 20% PES membrane was created using a greater amount of DMF solvent than the amount of DMF solvent in the 15% PES membrane.

The O-H stretching vibrational peak related to Ti-OH bond was observed, indicating the absorption of water by hydrophilic TiO_2 [18]. Meanwhile, the O-H bending vibrational peak indicated the presence of water content in the sample [20]. The presence of O-H vibration bonds indicated the presence of water molecules in the TiO_2 sample. As stated by Fadli et al. [16], PES polymer does not have O-H bonds in its structure, therefore, the presence of O-H structure could be obtained from the use of aquades as a coagulant during the manufacturing process or due to the sample being analyzed in a wet state using FTIR. Furthermore, the presence of Ti-O vibrational bonds is a characteristic of TiO_2 [20].

3.3. FLUX MEASUREMENTS

a) PES membrane flux value 15%

$$J = V/(A.t) \quad (2)$$
$= 1.125/(39.25 \times 1)$
$= 0.028$ L/m^2.hour

b) PES membrane flux value 20%

$$J = V/(A.t)$$
$= 0.7/(39.25 \times 1)$
$= 0.018$ L/m^2.hour

The results of equation (2) show that the 15% PES membrane has a higher flux compared to the 20% PES membrane because the dense layer on the 15% PES membrane is thinner than the 20% PES membrane, so the flux through the membrane is higher [3].
"Additionally, the high flux value of the 15% PES membrane can also be attributed to its higher TiO_2 concentration. As noted in previous research [18], the addition of TiO_2 can increase the membrane's flux value by promoting the formation of more pores and nanoparticle coverage on the membrane surface, which reduces its mechanical strength and enhances its flux value. The maximum flux value was obtained by the 15% PES membrane, exhibiting a flux of 0.028 L/m^2.hour at 3 bar pressure, whereas the 20% PES membrane showed a lower flux value of 0.018 L/m^2.hour at the same pressure.

3.4. EFFECTIVENESS

a) pH parameters

Based on the experimental results using multilevel filters that have been carried out, it can be seen that the change in pH value from originally acidic with a value of 5.5 has increased to normal with a value of 6.9. According to Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 68 of 2016 about Quality Standards, the pH of Domestic Wastewater that is allowed to be released into the environment is 6-9, this signifies that the pH of restaurant wastewater after processing fulfills quality criteria. This decrease is also influenced by the type of media used in the filtration process, because media such as activated carbon have a fairly good ability to bind metal ions and other fine particles. Apart from zeolite, activated charcoal also played a role in increasing the pH in this experiment because the organic substances contained in domestic wastewater could enter the pores of the activated charcoal and then be adsorbed resulting in the absorption of hydrogen ions (H^+) and an increase in the pH value [5,21]. The use of sand and gravel media also has a role in retaining organic matter and pollutant particles contained in domestic wastewater. Because the smaller the size of the sand used, the more pollutants that can be retained in the pores of the sand.

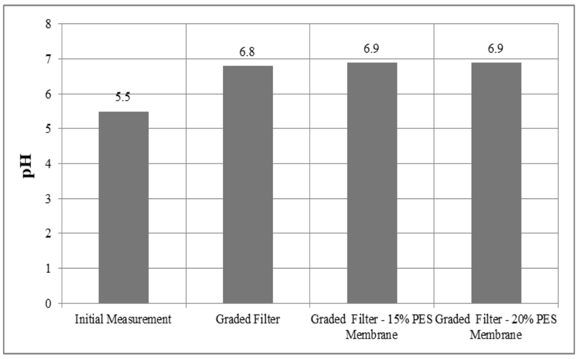


Figure 4. pH change graph.

Figure 4. shows a change in the pH value of the restaurant's liquid waste which was originally acidic with a pH value of 5.5, if it is based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 68 of 2016 Concerning Domestic Wastewater pH Quality Standards that are allowed to be discharged into the environment are 6-9, which means that the pH of restaurant wastewater does not meet quality standards.

b) Parameters TSS (Total Suspended Solids)

The TSS concentration of restaurant wastewater before treatment was 1.044mg/L and there was a decrease in the multilevel filter filtration treatment by 88.89% to 116 mg/L.

These findings are consistent with studies conducted by Hasanah and Sugito [22]. The reduction method uses activated charcoal to absorb colloidal particles and separate suspended materials, and it has a 94.57% reduction efficiency. The use of thicker activated charcoal can boost the absorption of pollutants in waste. supported by zeolite and sand filters, both of which have a strong track record as adsorbents and filtration media.

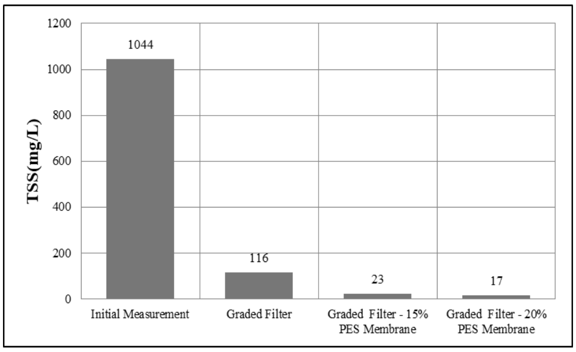


Figure 5. Graph of TSS changes.

The combined multilayer filter-ultrafiltration approach using 15% PES and 20% PES membranes results in a large reduction in TSS, as shown in Figure 5, with successive effectiveness values of 97.80% at a TSS concentration of 23 mg/L and 98.37% at a TSS concentration of 17 mg/L fulfill the quality standards outlined in the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 68 of 2016 Concerning Domestic Wastewater Quality Standards. This is because membrane holes created of 0.001 to 0.1 m will naturally retain suspended solids in liquid waste with a particle size of 2 m.

c) COD Parameters (Chemical Oxygen Demand)

Figure 6 shows a decrease in COD from an initial value of 540 mg/L to 103 mg/L after treatment with a multilevel filter, these findings are consistent with the quality standard values specified in the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 68 of 2016 on COD Quality Standards for Domestic Wastewater. This is due to the type of filtration media used, which is in accordance with research conducted by Asadiya and Karnaningroem [23]. Zeolite and activated charcoal can adsorb organic substances contained in the waste, the lower the organic matter, the COD value also decreases, then the decrease in COD is supported by the absorption capacity of the silica sand used.

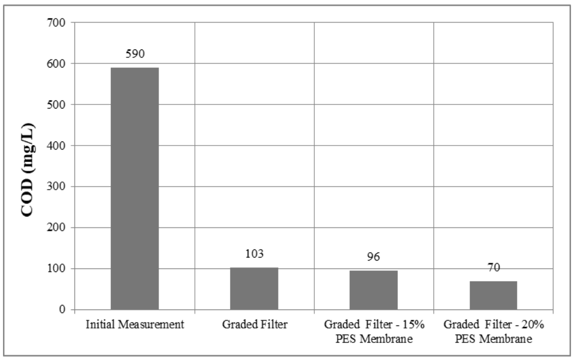


Figure 6. COD change chart.

After treatment using the combined method of multilevel filter-ultrafiltration of PES membranes, there was a significant decrease. In the treatment of the combined filter method with PES 15% membrane ultrafiltration, there was a decrease of 83.73% with an initial value of 540 mg/L to 96 mg/L, whereas in the treatment of the combined filter method with PES 20% membrane ultrafiltration, there was a decrease of 88.14% to 70 mg/L. According to Asadiya and Karnaningroem [23], this was due to zeolite and activated charcoal being able to adsorb organic substances contained in waste. As organic matter decreases, the COD value also decreases, then the decrease in COD is supported by the absorption capacity of the silica sand used and supported by the role of the pore morphology of the membrane formed [24] as shown in Figure 2. The concentration of COD in the waste is also due to the high oil content, so that with the ultrafiltration treatment of the membrane, macromolecules are retained in the membrane against suspended solids and dissolved solids. causes particle deposition on the membrane to form more easily.

d) Turbidity Parameters

The results of the first measurement of the turbidity value in the restaurant's wastewater were 594 NTU; however, following processing with multilevel filters, there was a decrease in the turbidity value, but it was not in compliance with the established quality criteria.

Based on Figure 7, processing restaurant waste using multilevel filters can reduce the turbidity value with effectiveness reaching 78.11%, namely 130 NTU, complies with Regulation No. 32 of 2017 of the Minister of Health of the Republic of Indonesia covering Environmental Health Quality Standards and Environmental Health Requirements, as well as Water Health Requirements for Sanitation Hygiene Purposes, Swimming Pools, Solus Per Aqua, and Public Baths. This decrease can be caused by the type of filtration media used such as gravel which has a role as an interlude so that water can flow through the bottom hole, so can filter coarse impurities and other contaminants [25].

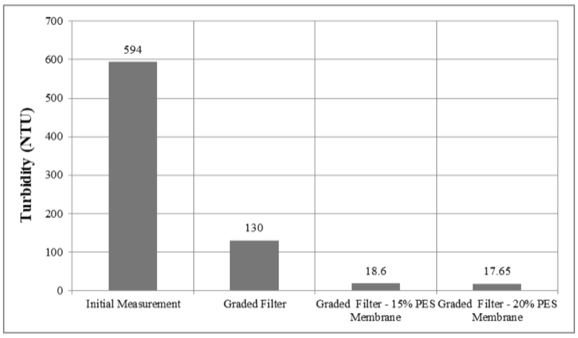


Figure 7. Turbidity change graph.

And also one of the causes of decreasing turbidity in wastewater is the ability of activated carbon filter media to forms a complex bond between cellulose and turbidity, the bond that is formed is so strong that it is difficult to remove and especially in silica sand with high porosity, large surface area will also provide high filtration capacity and can turn dirty water into clean water [26,27].

Then from the results of experiments carried out using the PES membrane multilevel filter combination method, turbidity values of 18.6 NTU and 17.65 were obtained, these results prove that pore size has an important role in the removal or reduction of turbidity.

4. CONCLUSION

PES flat membranes that have been prepared by phase inversion with polymer PES concentrations of 15% and 20% using DMF solvent and TiO_2 additives, obtained membranes that fall into the ultrafiltration (UF) membrane range. The flux value obtained by the 20% PES membrane is 0.018 lower than the 15% PES membrane flux, which is 0.028, because from the SEM results it can be seen that the pores of the 20% PES membrane are smaller and denser. The use of a multilevel filter combined method and PES (polyethersulfone) membrane ultrafiltration for the reduction and degradation of restaurant wastewater. The value of the change in pH became 6.9, the effectiveness of the degradation of the TSS value reached 98.37%, the degradation of the BOD value reached 88.14%, and the degradation of the turbidity value reached 97.03%.

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