J. Pijar MIPA, Vol. 18 No. 6, November 2023: 1034-1039 ISSN 1907-1744 (Print)
DOI: 10.29303/jpm.v18i6.5989 ISSN 2460-1500 (Online)

USING PUMICE AS AN ALTERNATIVE TO REDUCE BIOLOGICAL OXYGEN DEMAND AND CHEMICAL OXYGEN DEMAND IN TOUGH WASTE

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Received: October 28, 2023. Accepted: November 28, 2023. Published: November 30, 2023

Abstract: The tofu industry is a type of industry that operates in the field of food processing from soybean raw materials. The tofu industry is dominated by small-scale businesses, most integrated into residential areas. The tofu industry has yet to process the liquid waste it produces. High environmental pollution can result in the death of aquatic biota due to lack of oxygen. This research aims to reduce BOD and COD levels that do not meet quality standards. Based on this, research was conducted to reduce the organic content in tofu liquid waste using pumice stone as a filtration medium. The research used a 2.5-inch PVC pipe with a height of 70 cm and a media size of 8 mesh, which was heated at temperatures of 50°C and 100°C. The research results after treatment showed that the initial concentration of BOD levels was 160 mg/L. After going through the filtration process with media heating treatment at 50°C and 100°C, the BOD levels were reduced to 116.8, 76.8, and 40 mg/L, respectively, with 52% and 75% reduction effectiveness. While the initial concentration of COD levels was 326 mg/L, after going through the filtration process with media heating treatment at 50°C and 100°C, the COD levels were reduced to 252 and 198 mg/L, respectively, and the effectiveness of the reduction was 23% and 39%.

Keywords: *Tofu Wastewater, Pumice Stone, BOD, COD.*

INTRODUCTION

Kekalik Jaya Village is an area in the city of Mataram where many home industries produce soybeans in the form of tofu. Based on data from the Kekalik sub-district, the number of tofu entrepreneurs is 97 producers [1]. Based on the results of a survey conducted by researchers, tofu processing is still done manually with human power. The waste produced from the tofu process is thrown directly into the river.

The tofu industry is widely spread throughout Indonesia and is one of the household industries integrated with residential areas. Liquid waste from the tofu industry is the most significant part and has the potential to pollute the environment because the organic substance content is relatively high [2]. The tofu industry produces liquid waste, and if it is not processed and discharged into river bodies, it will affect the physical, chemical, and biological properties of water, thereby affecting the survival of aquatic organisms. Business actors need to be made aware and have minimal insight into managing tofu liquid waste, which will impact the environment [3].

Liquid waste produced by tofu industrial waste has the potential for quite high environmental pollution. The content of organic and inorganic substances in liquid waste from the tofu industry will undergo a decomposition process. Composing organic materials by aerobic microorganisms requires large amounts of oxygen to obtain energy. It causes a decrease in the concentration of dissolved oxygen in the water. A decline that exceeds the threshold will result in the death of aquatic biota due to a lack of oxygen [4].

Biological Oxygen Demand (BOD) is the amount of dissolved oxygen microorganisms need to decompose organic matter under aerobic conditions [5]. In other words, it can be interpreted as describing the amount of organic material easily decomposed in waters [6].

Chemical Oxygen Demand (COD) is the amount of oxygen (mgO2) needed to oxidize organic substances in 1 liter of water sample, where the K2Cr2O7 oxidizer is used as an oxygen source (oxidizing specialist). The COD figure is a measure of water pollution by organic substances, which can naturally be oxidized through microbiological processes and reduce dissolved oxygen in the water [7].

The research results show that liquid waste from the tofu industry has a high BOD concentration, namely around 160 mg/l, and a COD concentration of around 326 mg/l. These results exceed wastewater quality standards for industrial activities based on Minister of Environment Regulation No. 5 of 2014. Considering the high potential for environmental pollution due to tofu industry wastewater, simple, cheap, and efficient processing is needed. It is easy for the public to use to improve the quality of liquid waste before it is discharged into the environment. One of the treatments for tofu liquid waste is using pumice as an adsorbent to reduce BOD and COD parameters.

Pumice stone is an adsorbent that has the property of binding molecules on its surface. Pumice has a large surface, is porous, active, and pure, and does not react with adsorbates (substances that are absorbed). Adsorbents are generally in the form of porous solids with the property of binding substances. The adsorbent in the adsorption process greatly influences the adsorption capacity. What influences the adsorption process is size, particles, surface area, and pore volume [8].

In preventive efforts to reduce liquid waste pollution from the tofu industry, pumice breccia is used in PVC pipes measuring 2.5 inches in diameter as an

adsorption/filtration medium. With easy and simple processing, this medium is very suitable for application in the tofu industry, which is simple and has limited capital. Therefore, the author is interested in studying the use of pumice breccia as an alternative medium in reducing BOD and COD parameters.

The independent variables in this research are: The effect of heating pumice stone at a temperature of 50oC and heating pumice stone at 100oC. The dependent variables in this research are BOD and COD in tofu wastewater.

This research aims to analyze the effectiveness of reducing BOD and COD in tofu wastewater using pumice filtration media with pumice heating treatment at temperatures of 50^{o}C and 100^{o}C

RESEARCH METHODS

This type of research is an experimental study. Sampling used a purposive sampling technique, namely a sampling technique with certain considerations from the researcher.

Filter Media Manufacturing Process

Prepare pumice stones as chunks, wash them with clean water, and drain them. Pumice chunks are crushed into granules and sieved to obtain eight mesh sizes. The pumice stone will be heated in the Furnace to a certain temperature, namely 50oC and 100oC for 2 hours. After that, prepare a container made of gallons and four tubes made of PVC pipe filled with pumice with a width of 2.5 inches (6.5 cm) and a height of 70 cm [9].

The filtration process wastewater:

1. Fill the holding tank with 5 L of tofu wastewater
2. Flow the wastewater from the storage tank to the filter device
3. After the water has passed the filter process, the water will be allowed to flow for 1 minute to obtain clean water using the sample bottle that has been prepared. Then, in the final stage, the wastewater will be tested in the laboratory.

The data analysis technique was carried out using a quantitative descriptive approach to determine the effectiveness of reducing the concentration of BOD and COD levels obtained in experiments with filtration media using pumice as an adsorbent. The effectiveness of this reduction is calculated by comparing the initial and final results after using the filtration media.

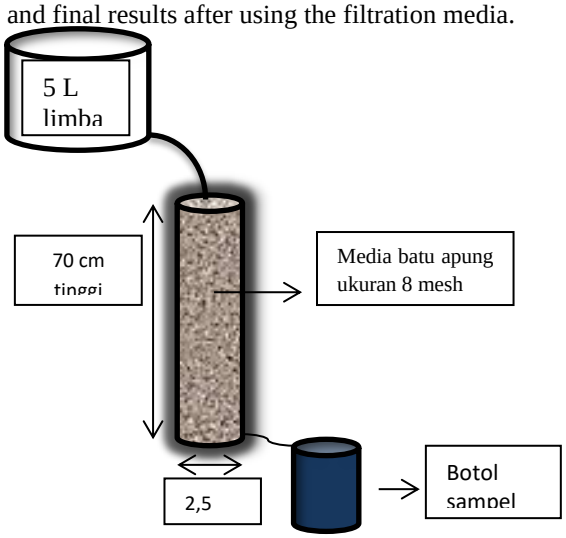

Figure 1. Filtration Process Scheme

Effectiveness of BOD Value:

The equation for determining BOD effectiveness value:

Effectiveness of BOD Value =

$$\frac{\text{Initial BOD Level} - \text{Final BOD Level}}{\text{Initial BOD Levels}} \times 100\% \text{.....[10]}$$

The equation for determining COD effectiveness value:

Effectiveness of COD Value =

$$\frac{\text{Initial COD Level} - \text{Final COD Level}}{\text{Initial COD Levels}} \times 100\% \text{.....[10]}$$

RESULTS AND DISCUSSION

The researchers pounded pumice stone with a mesh size of 8 for three weeks. In the fourth week, the researchers heated the pumice stone and continued by arranging the filtration media in the pipe. The research was conducted at the STTL Mataram Laboratory. The wastewater samples tested came from one of the tofu industries in Kekalek Jaya.

Table 1. Test Results Tofu Waste Water

No	Parameter	Metode uji	Satuan	Hasil Uji	Baku Mutu
1	BOD	SNI. 6889.72-2009	mg/L	160	150
2	COD	SNI. 6889.72-2009	mg/L	326	300

Based on Table 1, the initial quality of tofu industrial wastewater, before processing, BOD, and COD levels, needed to meet the quality standards following Minister of the Environment Regulation No. 5 of 2014.

Waste Water Quality Standards for the Tofu Industry. It is known that the tofu industry has never processed any waste daily, so the tofu wastewater discharged into the environment does not meet the quality standards for the wastewater obtained.

This research has obtained data from BOD and COD levels before and after processing tofu wastewater. The following is a table of the quality of tofu wastewater after processing it using filtration. Data on BOD and COD content values for the quality

of tofu wastewater after processing can be seen in Table 2.

Table 2. Results of Tofu Wastewater Treatment Using Filtration

Parameter	Kontrol	Media tidak	Pemanasan Media	
	Tanpa media	dipanasakan	50oC	100OC
COD	326	270	252	198
BOD	160	116,5	76,8	40

Based on Table 2, the results of processing tofu wastewater using pumice as a filtration media can reduce COD and BOD parameters in tofu waste. During filtration, the wastewater has a pH of 5 and a temperature of 36°C. The contact time for wastewater and filter media, namely during the adsorption process, is 10 minutes, with a flow rate of 9 minutes/L. This research has used pumice as a filtration medium. The pumice stone taken is a lump, which will later be crushed into granules with a media size of 8 mesh and heated in a furnace for 2 hours. The size of the pumice media is made the same so that the density of the pumice in the tube is the same so that the adsorption process throughout the part will be the same.

COD (Chemical Oxygen Demand) levels

COD is a measure of water pollution by organic substances, which naturally can be oxidized through microbiological processes, resulting in reduced dissolved oxygen in the water [11].COD is the amount of oxygen in ppm or milligrams per liter (mg/L) needed under special conditions to decompose organic matter chemically [12].

The results of COD parameter testing carried out at the Mataram STTL Laboratory obtained the following results:

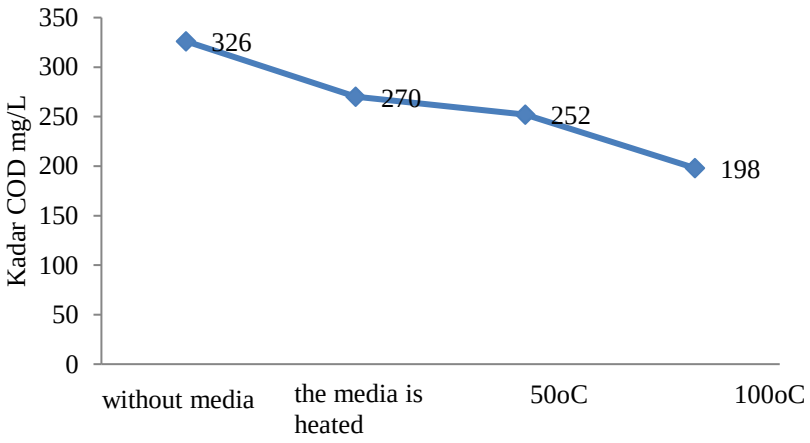

Figure 2. COD graph
(Source: Research Data 2023)

Based on Figure 2, the effectiveness of reducing COD in media that is not heated is 17%, followed by media heated at a temperature of 50°C, the effectiveness of the reduction is 23%, and the effectiveness of media heated at a temperature of 100°C is 39%. The reduction percentage in this study was influenced by the thickness of the media and contact time because the constituent materials contained in the media for adsorption can take place optimally. The thicker the pile of adsorbent material, the longer the contact time and the more adsorption processes in the pores. It allows the diffusion process of solute molecules attached to the adsorbent walls to be adsorbed properly. Molecules with low polarity and solubility tend to be more easily adsorbed. The contact time for wastewater and filter media during the adsorption process is 10 minutes/L. Contact time is one thing that influences the adsorption process. The longer the contact time, the more substances are adsorbed [21].

According to Humaedi, it has been observed that the adsorption media from pumice after activation can absorb metal ions of (66-99.5)%, while that which is not activated is (55-89)% [14]. Figure graph 4.1 shows that the higher the heating of the pumice adsorbent material, the higher the reduction in tofu wastewater.

BOD (Biological Oxygen Demand) levels

BOD, called biological oxygen demand, is the amount of dissolved oxygen microorganisms needed to decompose organic matter under aerobic conditions [15]. The results of the BOD parameter analysis carried out at the Mataram STTL Laboratory obtained the following results:

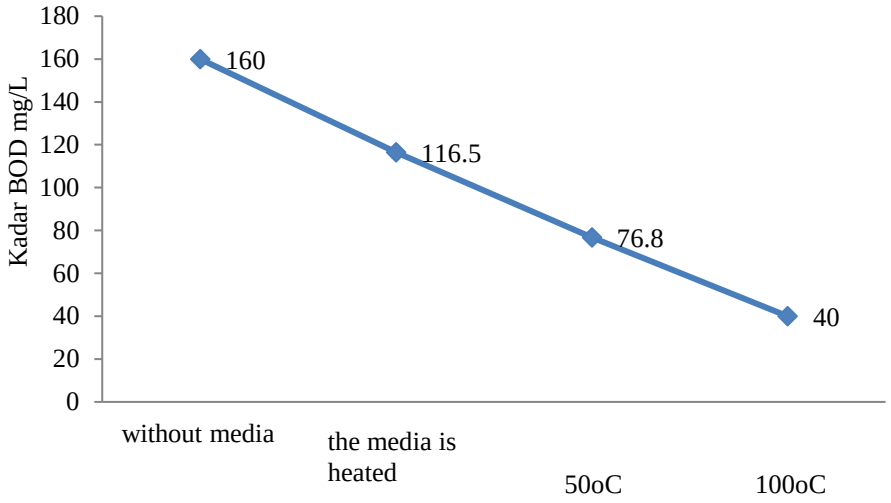

Figure 3. BOD graph
(Source: Research Data 2023)

Based on Figure 3, the results of the analysis after undergoing treatment with various variations in heating temperature of the pumice media through the filtration process show that heating at a temperature of 100°C provides absorption capacity until the efficiency decreases by 75%, namely from the initial concentration of 160 mg/L to 40 mg/L so it is safe to use. Dispose of or discharge into water bodies. Meanwhile, heating the media at a temperature of 50°C was smaller, with a reduction efficiency of 52%, and for the control treatment, namely media that was not heated, the reduction efficiency was 28%. It shows that pumice can absorb pollutants from both organic and inorganic substances.

The tofu industry is dominated by small-scale businesses, most integrated into residential areas. Limited capital and a lack of environmental awareness result in the waste produced being directly dumped in ditches or water bodies without prior processing. The tofu industry produces solid waste and liquid waste. Solid waste is sold and used as food for livestock, such as cattle and pigs. In contrast, liquid waste generated from the production process comes from washing soybeans, filtering, pressing, squeezing tofu, and washing tools used, collected, and immediately disposed of in the Ancar River, Kekalik Jaya sub-district.

An adsorbent is a solid substance that can absorb certain components from a fluid phase[16]. Most adsorbents are very porous materials and adsorb, especially on pore walls or at certain locations in the particle [17]. Adsorbent pores are usually very small, so the inner surface area is larger than the outer surface. This research uses pumice stone as an adsorbent as a filtration medium. The filtration media initially takes the form of chunks, which are then crushed and sieved with an 8-mesh size. The media is then heated in a furnace and then used for filtration.

Pumice stone is a local material widely available in the Lombok region, West Nusa Tenggara[18]. Pumice stone is a type of rock that contains foam made from glass-walled bubbles. It is usually called silicate volcanic glass rock and has light-colored properties. A porous structure characterizes pumice and contains many fine capillaries, so the adsorbate will be adsorbed[19]. Pumice stone is an effective adsorbent for removing organic materials and heavy metals [20]. The high porosity and rich content of alumina and silica make pumice potential for use as an adsorbent, filter bed, and supporting material in water and wastewater treatment[21]. Media with a size of 8 mesh can reduce high BOD and COD levels so that they are following quality standards. The smaller the size of the adsorbent, the greater the adsorbed substance [22].

Adsorption is the adsorption of a substance (molecule or ion) on the surface of an adsorbent. The adsorption mechanism can be divided into two, namely, physical adsorption (physisorption) and chemical adsorption (chemisorption). In the physiosorption process, the forces that bind the adsorbate to the adsorbent are van der Waals forces. The molecules are very weakly bound, and the energy released during physical adsorption is relatively low, around 20 kJ/mol. Physical adsorption occurs due to the influence of weak attractive forces between molecules. It causes the adsorbate to move freely on the surface of the adsorbent. Intermolecular forces are the forces of attraction between fluid molecules and a solid surface, while intermolecular forces are between fluid molecules [23]. Adsorption, in general, is a process where molecules leave the solution and stick to the surface of the adsorbent or adsorbent object, where a chemical and physical bond occurs between the substance and the adsorbent. Adsorption can also be influenced by surface area, particle size or diameter, adsorbent structure, pH, temperature, concentration of adsorbed solute, and contact time. Pumice is an adsorbent that has the property of binding molecules on its surface, and pumice is a porous solid [24].

Pumice has adsorption properties so that it can absorb organic and inorganic pollutants. The mechanism for the adsorption of pumice on the COD and BOD parameters contained in domestic waste is that a pipe containing adsorbent media is fed by sample water by gravity (vertical flow), so that the molecules contained in domestic wastewater stick to the surface of the adsorbent due to chemical processes and physics towards the film layer surrounding the pumice adsorbent, a process of diffuse adsorbent occurs through the film layer and capillaries or pores of the adsorbent. Pollutant molecules are adsorbed on the outside of the adsorbent and then move towards the pores and then to the inner wall, and adsorption of the pollutant molecules occurs in the pores of the adsorbent medium, in this case, pumice breccia[25].
This phenomenon causes a decrease in BOD and COD levels because the less organic material is dissolved in the water, the more oxygen is dissolved or contained. Apart from that, there is also a process of bacteria found in domestic wastewater sticking to the surface walls of the adsorbent and degrading organic materials, resulting in a decrease in BOD and COD levels.

Tofu liquid waste tends to be acidic with a pH of 3-4. This is because making tofu uses acetic acid (CH3COOH), which also dissolves in the tofu waste[26]. Meanwhile, pumice itself tends to be alkaline, so during the adsorption process, the water is in a neutral atmosphere, namely at a pH of 6.5-7.5, which is a supporting parameter so that it does not hinder the absorption process between the adsorbate and the adsorbent[27].

The filtration process is a combination of several different processes. These processes include adsorption. The principle of this process is due to the difference in charge between the surface of the grain and the suspended particles around it, resulting in an attractive force. Biological activity is a process caused by the activity of microorganisms that live in the filter. This process can affect water quality and cause a decrease in BOD and COD parameters[28].

COD is the oxygen needed to oxidize organic substances in a water sample. COD is a measure of water pollution by organic substances, which can naturally be oxidized through microbiological processes and result in reduced dissolved oxygen in the water. If the COD concentration is high, it can cause the dissolved oxygen content in the water to become low or even run out. The oxygen used as a source of life for aquatic creatures decreases, resulting in the water creatures' needs not being met and causing death[29]. Therefore, researchers used pumice stone as a filtration medium to treat tofu wastewater to reduce high COD levels.

BOD shows the amount of organic material in water that can be degraded biologically. BOD is the amount of biological oxygen in ppm or mg/L needed to decompose organic matter by bacteria so that the waste water becomes clear again. Bacteria will use oxygen to oxidize organic objects. BOD units are needed to measure the need for oxygen, and with this BOD, the pollution load is determined. The higher the BOD level, the lower the water quality will be and cause fish to die due to lack of oxygen. Therefore, researchers used pumice stone as a filtration medium to treat tofu wastewater to reduce high BOD levels.

CONCLUSION

The initial concentration of BOD levels was 160 mg/L. After filtration with media heating treatment at 50oC and 100oC, the BOD levels were reduced to 76.8; 40 mg/L. While the initial concentration of COD levels was 326 mg/L, after filtration with media heating treatment at 50^{o}C and 100oC, COD levels were reduced to 252 and 198 mg/L, respectively.
The effectiveness of reducing BOD and COD levels using pumice stone media with media heating treatment of 50^{o}C and 100^{o}C, respectively, is 52% and 75%. Meanwhile, effective COD levels decreased by 23% and 39%.

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