The use of subsurface constructed wetland for the treatment of tofu industrial wastewater in Semanan, Jakarta Barat

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Abstract. The tofu preparing industry, typically done by the little businesses, can be found in almost every city in Indonesia and is dominated by industrial house stairways. The largest industry does not have a unit of processing wastewater. The wastewater focus is as yet over the edge quality norm, which messed contamination up. Constructed wetlands are affordable and reliable green technologies to diminish water contamination by utilizing plants. This study aims to know the quality of tofu industrial wastewater in Semanan, Jakarta Barat and analyze the removal of pollutants. The performance of the horizontal flow type Sub-Surface Flow constructed wetland with Typha latifolia plant. The media used were soil, sand, and gravel with a Typha latifolia plant. Testing the quality of tofu wastewater in Constructed wetland every 7 days at inlet and outlet, the sample was taken for TSS, BOD, and COD concentration. This research showed that the reactor could decrease TSS by 91.17% on day 36, a decrease of BOD 89.30% on day 15, and COD 87.86% on day 36. Those plants can produce growth fertile. These results fulfil the requirement of the quality standards of the Decree of the Minister of Environment No. 05 of 2014.

1. Introduction

The rapid growth of the population and the industrial sector in Indonesia, especially in urban areas, has a severe impact on the environment's carrying capacity. These impacts must be addressed and handled appropriately, especially in managing clean water and industrial and household waste. The increase in population and growth in the industrial sector increases the consumption of clean water that can cause an increasing amount of wastewater. Disposal of wastewater without undergoing a treatment process can cause environmental pollution, such as pollution in water bodies, incredibly raw water sources for drinking water that cause both surface water and groundwater.

Tofu is one of the favourite food that many people can consume, from low to high class. Tofu itself is known as healthy food with a low price. Almost every town in Indonesia has a tofu industry. Generally, the tofu industry is a small industry managed by the people, and some of them are included in the Tofu Entrepreneurs Cooperative (KOPTI), such as the one in Semanan, West Jakarta.

Tofu industrial wastewater that is disposed of without further processing can cause several problems for the environment. Usually, the problems that arise are in the form of deposition and decomposition of organic matter in water bodies receiving waste which ultimately worsens water quality [1]. In general, water pollution by wastewater from the tofu industry can diminish the dissolved oxygen content in the water (due to the decomposition of organic matter) and create an anaerobic atmosphere that...
disrupts ecosystems and life in the waters. According to the Regulation of the Minister of the Environment No. 5 of 2014 concerning Quality Standards for Tofu Industrial Wastewater, it is a form of regulation as a guide to the quality of tofu wastewater ef fluent standards which have a value of BOD (150 mg/L), COD (300 mg/L), TSS (200 mg/L) and pH (6-9) [2].

Efforts with simple, cheap, easy, efficient, and economical technology include operations and maintenance that do not require a particular person to be applied by the community, such as an artificial wetland system (Constructed Wetland). The use of aquatic plants in the Constructed Wetland system as an alternative means of treating wastewater has been widely used in several countries. However, in Indonesia, its development has not been so popular because studies and publications on the ability of these aquatic plants are still lacking. Based on the morphology of the Cattail plant (*Typha latifolia*), it is very suitable for processing with the Constructed Wetland system. Cattail plants have a root system that can absorb organic substances in the water chart. Meanwhile, Cattail plants are very numerous and thrive in Indonesia [3].

Constructed wetland is a planned or controlled processing system designed and constructed using natural processes. The Advantages of Constructed wetland that compared to sewage treatment facilities conventional investment, operation and maintenance costs is cheaper. [4]. Constructed wetlands can adequately dispense with suspended solids, natural poisons, and supplements from wastewater [5]. The constructed wetland framework has two sorts, in particular the kind of stream above Free Water Surface Flow (surface) and Sub-Surface Flow (subsurface flow) [6]. Notwithstanding, because the Constructed wetland framework in a traditional manner requires huge land, successive blockages, slow mass exchange, and helpless root entrance into layered soil sections, innovation is expected to defeat this issue.

Another methodology in constructed wetland frameworks expands proficiency in wastewater treatment by consolidating the advantages of phytoremediation and connected development frameworks based on bio-rack technique (engineering procedures) [7]. This bio-rack technique can make preferable conditions to plant growth, the influence of microorganisms in plants, better oxygen diffusion, and detect changes in the environment for the object of study.

Because tofu industrial wastewater can cause environmental pollution, a cheap and efficient treatment effort can reduce the negative impact of the wastewater with constructed wetlands. The objective of this study was to know the quality of tofu industrial wastewater in Semanan, West Jakarta and analyze the removal of pollutants. The performance of the horizontal flow type Sub-Surface Flow constructed wetland with *Typha latifolia* plant.

2. Methodology

2.1. Location

The study was conducted in Tofu Industry Semanan Village, Kalideres Sub-district, West Jakarta. The area of Semanan Village is 598 Ha with a population of more or less 79,306 people spread in 12 hamlets with a population density of 13,262 people/ km².
2.2. Tofu industrial wastewater
The wastewater used is tofu industrial waste Semanan Urban Village, West Jakarta, from the sewer. The tofu wastewater is directly disposed of through the sewer before being channelled into a ditch or drainage channel.

2.3. The constructed wetland
This research was implemented in Semanan Village, West Jakarta, and for the constructed wetland at the researcher's own house, which is located in Tangerang. This Wetland Construction measures 400cm x 100cm x 100cm. This wetland system uses a type of sub-surface flow (Sub-Surface Flow). The Constructed Wetland system was constructed for the tofu industry. It requires a large area, and primary wastewater treatment is needed because the wetland system is constructed as secondary wastewater treatment. New technology is expected to beat this issue.

2.4. Media and plant
Media containing gravel, sand, topsoil mixed with 10% compost. The plant used Typha latifolia, which can retention pollutants as nutrients required [8].

2.5. Data analysis
Utilizing + formulas to the calculation of the effectiveness of pollutant removal in constructed wetlands.

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\text{Efficiency (\%)} = \left( \frac{C_i - C_0}{C_i} \right) \times 100\%
\]

where:
- \(C_i\): Value of tofu wastewater parameters before treatment.
- \(C_0\): Value of parameters for tofu wastewater after treatment.

2.6. Quality standard
Tofu industrial wastewater is the wastewater used from this research that quality is not following the quality standard necessities to release into the environment. Through table 1, the quality of tofu industrial wastewater before processing can be shown.
Table 1. Quality of tofu industrial wastewater in Semanan.

| Parameter | Unit | Quality of wastewater | Quality Standard* |
|-----------|------|------------------------|-------------------|
| pH        | -    | 4.6 – 4.87             | 6-9               |
| TSS       | mg/l | 442 – 840              | 200               |
| BOD       | mg/l | 3,072 – 3,649          | 150               |
| COD       | mg/l | 5,190 – 6,192          | 300               |
| T-N       | mg/l | 21.5 – 52.7            | -                 |
| T-P       | mg/l | 51.9 – 80.2            | -                 |

*Quality Standards: Ministry of Environment and Forestry Indonesia No.05/2014.

3. Results and discussion
The highest TSS concentration from figure 2 shows that after passing through the constructed wetland is 396 mg/L, and the lowest is 17.3 mg/L. On day 36, the highest efficiency occurred with 91.17%, while the lowest concentration occurred on day 8 with a removal efficiency of 78.16%. After the 15th day, because the ability to reduce TSS content increases, the efficiency of removing wastewater content depends on the concentration and length of detention time in a constructed wetland. Moreover, this result has been fulfilled compare to the quality standard by the Minister of Environment Regulation No. 04 of 2014, where the TSS concentration value is 200 mg/L.

The absorption process by plants, the decomposition of dissolved organic matter and the deposition of the decomposition products of organic matter causes a decrease in TSS levels after processing using plants and a significant decrease from TSS focus because of calm water conditions making particles or colloids effectively enter and settle at the lower part of the compartment. [9]. The system, through filtration and sedimentation in the Constructed Wetland, TSS were reduced [10].

In Figure 3, it can be seen that the COD concentration at the outlet has a COD highest value was 2,592 mg/L and had a COD concentration lowest value was 102 mg/L. This result fulfils the quality standard by the Minister of Environment Regulation No. 04 of 2014, where the COD concentration value is 300 mg/L. The high amount of ingredients organic matter contained in tofu industrial wastewater causes an increase or decrease in concentration. Here is a graph of COD parameter removal efficiency in a constructed wetland that can be seen in Figure 3.
Figure 3. COD concentration.

Figure 3 shows that the removal of COD concentration in constructed wetland has the highest removal that is 87.86%, on the 36th day, and the lowest removal of COD concentration was 73.29% on the 8th day. It shows that the high and low are caused by the performance of microorganisms and pollutant concentrations in a constructed wetland.

The increase in COD concentration was caused by the water hyacinth plants having passed the immersion point. The ability of plants to assimilate natural materials was reduced, and even the convergence of natural materials in wastewater expanded because plants were considered to provide natural ingredients that had been preserved once again. [8]. The process of reducing COD in wastewater can occur due to the role of aquatic plants, carbon adsorption, and organic materials and microorganisms present in artificial wetlands. The cycle that happens because of natural substances contained in wastewater is used by plants as nutrients and for the course of photosynthesis [11].

In Figure 4, it can be seen that the removal of BOD concentration in constructed wetland has the lowest removal that is 74.37%, on the 8th day and the highest removal was 89.30% on the 15th day. There are many organic substances in the tofu industrial wastewater, which is shown from the highest BOD₅ value so that microorganisms require a great deal of oxygen to break down natural substances. Here is a graph of BOD parameter removal efficiency in a constructed wetland that can be seen in Figure 4.

Figure 4. BOD₅ concentration.
The highest BOD$_3$ showed from Figure 4 the value at the outlet occurred on the 22$^{nd}$ day as for the 36th day, the lowest concentration occurred. The impact of maintenance time additionally assumed a part during the time spent decreasing waste content. The decrease in wastewater treatment is due to bacteria and microbes found in soil and plant roots working on setting aside BOD parameters. The decrease in BOD levels which is getting higher with lower water levels is brought about by a large portion of the natural matter is as wastewater that enters the Constructed wetland framework through adsorption cycles. Disintegration measures on the substrate and the lower the water level, the contact time, and the decay interaction between the wastewater and the substrate contained in the Constructed wetlands are more viable. Hence, the decrease in proficiency is higher [12]. The high concentration of BOD in liquid tofu waste is caused by Tofu wastewater that contains high organic matter, so BOD and COD levels are also relatively high. If directly discharged into water bodies, it will reduce the environmental carrying capacity [13].

Plants help bacteria debase natural mixtures through their underlying foundations delivering exudate into the rhizosphere zone, and the exudate triggers the corruption interaction by bacteria [14]. The availability of oxygen for biological processes is one of the factors. Wherefrom, the course of digestion of microorganisms, created CO$_2$ which is then utilized by plants to do photosynthesis, from the photosynthesis interaction delivered glucose/carbs which will become supplements for plant notwithstanding oxygen delivered which will be reused by vigorous microorganisms to decay the natural substance in tofu wastewater [8]. The opportunity to deposit solid particles will be given when the wastewater passes through the soil particles at a specific detention time. Through this deposition process, the need for oxygen will be reduced for further biological treatment.

The BOD value is additionally influenced by the presence of plants that cover wastewater surfaces. The presence of these plants can assimilate natural substances contained in wastewater—the more plants, the more adsorbed natural matter and natural matter that fewer microorganisms should corrupt. The less natural matter we need to debase by microorganisms, the oxygen content in the wastewater increments. The lessening in wastewater treatment is because of microorganisms and organisms found in soil and plant attaches attempting to save BOD parameters [15]. Mainly living bodies in profoundly high-impact soil need oxygen to help the action of outlining organic matter. Generally, an effective wastewater treatment system equipped artificial wetlands with proven plant growth high enough.

4. Conclusion
Sourced on the outcome analysis of tofu industrial wastewater parameters of TSS ranged from 442–840 mg/L, COD ranged from 5,190–6,192 mg/L, and BOD$_3$ ranged from 3,072–3,649 mg/L while Tofu wastewater quality standards according to Minister of Environment Regulation No. 5 of 2014 for BOD 300 mg/L, COD 150 mg/L and TSS 100 mg/L. The treatment with constructed wetlands by Typha latifolia plant has a good performance in tofu industrial wastewater treatment in a constructed wetland system. The planting pattern is made in a zig-zag way to adjust the flow pattern, and while testing the quality of tofu industrial wastewater in effluent constructed wetlands every 7 days, the average TSS removal is 85.71%, the average COD removal is 81.57%, and the average BOD$_3$ removal is 81.52%.

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