Comparation Treatment Method for Industrial Tempeh Waste by Constructed Wetland and Activated Sludge

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***Abstract*—**Ever since industrial revolution began, our ecosystem has changed. And indeed, the negatives outweigh the positives. Industrial waste usually released into all kinds of body of water, such as river or sea. Tempeh waste is one example of waste that carries many hazardous and unwanted substances that will affect the surrounding environment. Tempeh is a popular fermented food in Asia which is rich in nutrients and active substances. Tempeh liquid waste- in particular- can cause an air pollution, and if penetrates through the soil, it will contaminates ground-water, making it unavailable for the water to be consumed. Moreover, bacteria will thrive within the polluted water, which often responsible for causing many kinds of diseases. The treatment used for this chemical waste is biological treatment such as constructed wetland and activated sludge. These kinds of treatment are able to reduce both physical and chemical parameters altogether such as temperature, TSS, pH, BOD, COD, NH_3-N, NO_3-N, and PO_4-P. These treatments are implemented before the waste is released into the water. The result is a comparation between constructed wetland and activated sludge, along with determining which method is better suited to reduce the physical and chemical subtances of the waste.

***Keywords*—**activated sludge, constructed wetland, waste, water treatment

I. Introduction

TMPEH is a fermented soybean product which is consumed as a staple food in Indonesia, Southeast Asia [1]. It is made by fermenting *Rhizopus*, a species of soybean. Today it has emerged as one of vegetarian's favorite food and becoming more popular worldwide.Tempeh waste is a kind of waste generated in the process of soybean washing. This waste generated in the form of solid and liquid waste. The impact of solid waste on the environment is not yet felt, because it can be utilized as livestock food, but the liquid waste is capable of emitting an odor and when discharged directly into the river will result in pollution. 100 kilos of soybeans can produce up to 2 m^3 of waste [2].

The type of waste tempeh produced is in the form of liquid waste. The remaining waste water does not clot, destroyed tempeh pieces occasionally can be found because clotting process was not perfect. Whereas the waste is yellowish in color and if left unprocessed, it can turn blackish in color and rot which produces bad odor [2].

The resulting liquid wastes -which contain suspended and dissolved solids-, will go through physical, chemical, and biological changes to produce toxic substances and also create a medium for bacterial growth whereas bacteria can be either germs that causes diseases or other type of germs that can potentially harm human or tempeh itself. If the toxic stays in the waste, it will change color into black and produces an odor. This odor can cause respiratory disease, and if the waste penetrates through the soil close to water wells, it is certain the wells could not be used again. The waste discharged into rivers will pollute the river and if the water is used, it can cause diarrhea and other diseases [2].

In this study, we will try two different methods of wastewater treatment (constructed wetlands and activated sludge) and assess which method is the most effective in reducing levels of waste produced by tempeh.

II. Materials And Methods

A. Constructed Wetland

According to reference [3], swamp is an area inundated by surface water or ground water within a specified period which allows the occurrence of saturated water conditions on the same area. Constructed wetlands usually have a depth of about 0.6 meters shaped like elongated narrow channel.

It consists of water, a substrate, and, most commonly, vascular plants. These components can be manipulated in constructing a wetland. Other important components of wetlands are communities of microbes and aquatic invertebrates which developed naturally [10].

Contaminants are removed from wastewater through several mechanisms. Processes of sedimentation, microbial degradation, precipitation and plant uptake remove most contaminants. Heavy metals in a wetland system may be absorbed to wetland soil or sediment, or may be complexes with organic matter. Metals can precipitate out as sulfides and carbonates, or get taken up by plants. Compounds in sediment, such as iron oxides, however, show preference for certain metals [11].

Compared to sediments, plants do not take up much metal, but they are involved in oxygenation and microbiological processes that contribute to the ability of the wetland to remove metals. Organic compounds can be broken down for consumption by microorganisms in a wetland system. This

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biodegradation removes the organic compounds from water as they provide energy for the organisms. Organics can also be degraded when taken up by plants. They can also sorb to surfaces in the wetland, usually to plant debris. Organic compounds containing nitrogen sorb to surfaces in the wetland, and organic nitrogen is converted to ammonia. Ammonia can volatilize, be exchanged with other cations in the sediment, or be nitrified if oxygen is present. Nitrate is the form of N taken up by plants, so emergent plants use it during the growing season. Excess nitrate in an anaerobic system is reduced to N_2 and N_2O gases as a result of denitrification, the main mechanism of nitrate removal [11].

Unlike natural wetlands, constructed wetlands for wastewater treatment can be done almost anywhere, albeit limited land. constructed wetlands also have the capacity and capability of processing waste better than natural wetlands because the bottom structure of this man-made wetlands is usually made with special construction so the hydraulic load can be adjusted [3].

In this study, constructed wetlands treatment is done by filling as much as 1 liter of soybean waste water into the tank, then added diluent until the volume reached 15 liters. Then place aquatics plants in the water samples.

B. Activated Sludge

One way of waste processing is the use of rich biological activated sludge microorganisms. Microorganisms in aerobic conditions are capable of converting organic material into biomass. Organic nitrogen compounds can be converted into ammonium or nitrate. Organic phosphate compounds may be converted into orthophosphate [5]. Activated sludge also contain a variety of heterotrophic microorganisms such as bacteria, protozoa and some higher level of organisms. The growth of microorganisms can form lumps of mass that can be maintained when the mud is stirred [6].

Waste of tempeh can be processed in a sludge that contains a number of microorganisms commonly used in wastewater treatment processes. Waste prokaryotic microorganisms which play a role such as fungi protozoa, rotifers, and algae which each have their own role [7]. Microorganisms can also take advantage of the compounds contained in the waste to meet the nutritional needed such as carbon, nitrogen, phosphorus, sulphur and other micro elements [6].

The first of this procedure is by putting chicken droppings into 30 ml of water. Then wait several days for bacterial decomposition to be grown, this used as a seedling. And then tempeh waste (+ / - 100 g) is filled into the Aquarium that has been provided, and then diluted until its volume reached 10 liters. For this waste treatment, 1 liter of waste is inserted into the aquarium, and add the seedling and then diluted until the volume reached 15 liters. Then give aeration system to the aquarium.

C. Data Analysis

During a week of observation, all parameters will be measured such as temperature, TDS, turbidity, pH, Ammonia, Nitrate, Orthopospat, dissolved oxygen, COD, and the density of aquatic plants.

DO analysis by Winkler method is to fill as many as 25 ml of sample into a BOD bottle, then add 10% of $K_2SO_4Al_2(SO_4)_3$ and 35% of NaOH, stir and wait until deposit is created. Then add 1 ml of Sulfanic Acid, mixed by shaking the bottle. Then add 2 ml of manganese sulfate and 2 ml of NaOH and a solution of KI (Shake the bottle roughly 20 times) and wait until precipitate is formed. A total of 10 ml of supernatant were taken and aerated then titrated with 0.0244 N Na-Thiosulfat so the color can change from dark yellow to light yellow. After that, add 2-3 drops of starch indicator until it change its color to blue, then titrated with Na-Thiosulfat again until the sample is colorless.

The working principle of BOD (Biochemical Oxygen Demand) is to dilute the sample 300 times, depending on the clarity of water samples. Then aerate (in order to increase the oxygen levels of samples) for roughly 5 minutes. Then move the water into light and dark BOD bottles. Immediately analyze the sample's dissolved oxygen for light BOD bottle. For dark BOD bottles, incubated the sample at a temperature of 20^oC for 5 days, then analyze the oxygen level.

The working principle of COD (Chemical Oxygen Demand) is to dilute the sample 100 times, depending on the clarity of the samples, water from the sample then taken in 25 ml erlenmeyer, add 2.5 ml of 0025 N K_2CrO_7 then add 7.5 ml of concentrated H_2SO_4 and left for 30 minutes in the acid room. Then, add 5 ml of distilled water and 2-3 drops of Ferroin then titrate with FAS.

The working principle of nitrate is to filter the sample as much as 25-50 ml by using specific filter paper. Then take a 5 ml of filtered sample, put it in a beaker glass. Then add 10 ml of Brucine and 5 ml of concentrated H_2SO_4 and then stirred. Then, create a 5 ml of standard and blanco solution as the previous step above shown. Then measure with spectrophotometer with 410 nm λ.

The working principle of Ammonia is to filter the sample as much as 25-50 ml using specific filter paper. Then take 10 ml of filtered sample, put it in a beaker glass. Then add 1 drop of 0.5 ml Chiorox $MnSO_4$ and 0.6 ml of phenol. Then let it still for roughly 15 minutes. Then, create a blanco and standard solution as the previous step above shown. Then measure with spectrophotometer with 640 nm λ.

The working principle of orthopospate is to filter the sample as much as 25-50 ml using specific filter paper. Then take as much as 25 ml of filtered sample and add 1 ml of ammonium molybdate, then stirred. Add 5 drops of $SnCl_2$, stir and let it still for roughly 10 minutes. Then measure with spectrophotometer with 690 nm **λ.**

III. Results

A. Constructed Wetland and Activated Sludge Effectiveness

Characteristics of tempeh waste can be seen in Tab. 1. Characteristics of initial stock of waste before treatment showed the waste is high in alkalinity, so it has the potential to form foam during aeration. Waste water which is brown in color and high in turbidity were shown with the increased value of TDS. Judging from the high content of organic compounds of COD and BOD indicate that the waste contains

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dominantly by complex organic compounds with high pollution levels, thus the need for biological treatment system is necessary.

The very high ratio value of COD / BOD in the beginning of study indicates that the waste water is dominated by a soluble organic complex and thus requires biological treatment with a high load of organic systems. Decreasing values of dissolved oxygen showed an increase in demand of oxygen. Because activated sludge microorganisms are aerobic microorganisms, the consumption of dissolved oxygen is needed for higher metabolism process.

Tempeh waste treatment using activated sludge contains lower values of BOD and COD and higher value of dissolved oxygen, so it can be inferred that using activated sludge is a better method than the processing done by using an constructed wetlands. Harmful substances will be greatly reduced due to microbial metabolism, aquatic plant metabolism, adsorption by plants and natural mortality by bacteria and viruses. The higher value of ammonia content in activated sludge is generated from biological processes of pollutants.

TABLE I
OUTPUT PARAMETERS OF TEMPEH WASTE PROCESSING

Parameters	Observations	Activated Sludge			Constructed Wetlands		
		Number of Sampling			Number of Sampling		
		1st	**2nd**	**3rd**	**1st**	**2nd**	**3rd**
Physical	Temperatures	28.2	27.5667	26.6000	28.2000	27.7667	26.7667
	TDS	120	216.6667	306.6667	130.0000	210.3333	260.0000
	Turbidity	22	58.3333	91.6667	23.0000	22.5000	26.6667
Chemical	pH	7.8467	6.9900	6.3800	6.6633	6.3600	5.8733
	DO	4.9000	0.3000	0.2500	5.0000	0.3333	0.0000
	COD	22475.	25686	30101	30101	30301	139378
	BOD	189.6503	634.3616	701.7421	189.6503	769.1226	791.5828
	Ammonia	30.4817	-	64.9369	30.9404	-	64.9656
	Nitrate	0.1950	-	0.1451	0.1950	-	0.0743
	Orthophosphate	4.2574	-	4.0429	3.9274	-	3.6634

IV. Discussion

Wastewater treatment using activated sludge has shown as a suitable method for processing organic waste with high concentrations, such as industrial waste. The number of microorganisms is kept constant, and perfectly mixed waste water around the reactor is necessary in order to increase the processing performance. Organic substances contained in waste water are decomposed in aerobic condition with the constant supply of oxygen into the water. Activated sludge is widely used in wastewater treatment because of its simplicity in construction, operation and maintenance, with high pollutant removal efficiency.

Constructed wetlands are also an effective “passive treatment”, not only because of their low cost and minimal maintenance, but because they may also provide critical wildlife habitat, an advantage if compared to the other method (Activated sludge). It only require periodic, rather than continuous, on-site labor operation, and also provide aesthetic enhancement of open space. But this method has its own limitations, such as the sensitivity of biological components to toxic chemicals, such as ammonia and pesticides, and further studies are necessary due to lack of information regarding this method in the long-term performance [10]. Reference [8] shows that constructed wetlands can reduce the concentration of the metal content of cadmium, copper and zinc respectively up to 99%, 99% and 97%. However, plants in the constructed wetlands only absorb metals in very low concentrations of less than 1% [9].

Absorption of metals in water, especially Fe and Mn, will be effective if there is a biological interaction between oxidation and reduction. Constructed wetlands are the only ecosystem that provides the process of oxidation and reduction.

The effectiveness of constructed wetlands in the removal of contaminants depends on the type of contaminants, above or below ground level water drainage system, type of substrate on which the plants grow, plant species, and others. Although the constructed wetlands cannot completely eliminate the pollutant, but at least it is effective on reducing the concentration of pollutants exists in the water.

Removal of pollutants by physical mechanisms will occur through sedimentation, filtration and adsorption. Chemical mechanisms will occur through precipitation, adsorption and decomposition of less stable compounds. Biologically, pollutants will be reduced due to microbial metabolism, plant metabolism, adsorption by plants and a natural death by bacteria and viruses.

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