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The Effectiveness of Zeolite and Activated Charcoal Media in Reducing Pollutants in Tofu Industrial Waste

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ABSTRACT

Liquid waste treatment is very important because the untreated liquid waste may pollutes water bodies. To understand the effectiveness of the use of zeolit and active charcoal media to reduce the pollution in the tofu liquid waste, a study has been conducted. There were 5 treatments aplied, namely the 5, 10 and 15 days *retention time.* Results shown that the wastewater quality parameters of the treated waste were TSS (102.0 mg / L), pH (6.0 mg / L), DO (3.6 mg / L) BOD_5 (88.0 mg / L), COD (141.0 mg / L), ammonia (1.4 mg / L), orthophosphate (1.2 mg / L) and nitrate (17.2 mg / L). The most effective treatment is the 10 days retention time and it reduced 73.3% of BOD_5, 79.3% of COD and 80.9% of ammonia.

Keywords: *tofu liquid waste, zeolite, activated charcoal, pollutants*

INTRODUCTION

Tofu industries are classified as small and medium industries and are mainly owned by the public. As the growth of Indonesian polulation reach 3% per year, the demand of food is also rise. Harahap et al (2010) stated that the need of soybeans is arround 3 million tons / year. While national soybean production only reached 6 million tons / year, it means that half of the soybean production is used for industrial purposes. Unfortunately, the waste water originated from the soybean processing industries was discharged into aquatic environment, arround 135,000,000 tons / year. According to Dhahiyat (1990), 1 ton soybean may produced 30,000 to 40,000 liters liquid waste. As the presence of the soybean industries liquid waste pollute the water, it is necessary to find out a solusion to solve this problem.

Materials that can be used to reduce the pollutant level are zeolit and activated charcoal. Combining zeolit and activated charcoal for processing the waste may increase the ability of the media to assimilate the organic and inorganic compounds present in the waste. The floating, suspended and dissolved organic and inorganic materials in the waste water might be absorbed. To understand the effectiveness of the zeolit and activated charcoal media in reducing the pollutant level of tofu industry liquid waste, a study is need to be conducted.

MATERIAL AND METHODS

This research was conducted in February 2014 to October 2014, in the field and in the laboratory. Field study waslocated in the Cisalada Cikuda village , RT - 04 / RW - 07, Jatinanor, Sumedang District. Samples wete analyzed in the Chemical Laboratory of the Faculty of Mathematics and Natural Sciences (MIPA), Padjadjaran University, The materials used in this study is the liquid waste, zeolite (40 cm thickness/ tank), activated charcoal (15 cm tickness/ tank). The wastewater processing unit was consisted of a tank to keep the liquid waste (1 tank), and tanks for processing the waste (3 tanks) (Figure 1).

Figure 1. Design of the biofilter reactor

Methods applied in this study is as follows:

1. Physical-chemical parameters was analyzed by standard methods and it was conducted in the Chemical Laboratory of the Faculty of Mathematics and Natural Sciences (MIPA), the Padjadjaran University Bandung.
2. Results of physical-chemical analysis was compared with the wastewater quality standard (Kep-51 / MENLH / 10/1995, dated October 23, 1995).
3. The effectiveness of the zeolites and activated charcoal media was calculated using the formula of Saeni (1989):

$$EP = \frac{(C\text{-in} - C\text{-out})}{C\text{-in}} \times 100\ \%$$

   EF = The effectiveness of the treatment of wastewater out of media
   Cin = Levels of waste water parameters know early.
   C out = Levels of waste water parameters know who came out after processing
4. The ability of zeolites and activated charcoal to decrease wastewater contaminants was analyzed descriptively.

RESULTS AND DISCUSSIONS

The effectiveness of zeolite and activated charcoal media in reducing the pollutant. TSS. The TSS in the water tank filled with zeolit and activated charcoal media, with 5, 10, 15 days retention time, showing various results (Table 1).

No	WT (days)	Before the treatment (mg/L)	After the treatment (mg/L)	Decrement (mg/L)	Effectiveness (%)
1	5	460,00	260,67*	199,33	43,33
2	10	305,00	120,17*	184,83	60,60
3	15	291,00	112,43*	180,57	62,21

Description: WTO = residence time, * = standard (200-400 mg / L)

Table 1 shown that the decrement of TSS in the 5 days retention time was 260.67 mg / L, in the 10 days retention time was 120.17 mg / L and in the 15 days retention time was 112.43 mg / L. This result has satisfy the quality standard (200-400 mg / L). At a residence time of 5 days, the early levels was 460.00 mg / L andit does not meet the quality standards. This decline may be related to the ability of zeolite-activated charcoal in adsorbing the organic and inorganic materials due to the presence of pores present in the media and its ability to exchange anions and cations that are present in the zeolite. Said and Erlambang (1999) stated the effectiveness of aerobic and anaerobic processor in proccessing the wastewater is able to reduce pollutant by of 60%.

Koswara (1990), stating that the ability of zeolite in absorbing of TSS (Total Suspended Solid) in the liquid waste resulting zeolites can absorbing the molecule is based on molecular size and configuration of the shape of the cavities of the zeolite. Due to the absorbsion, the TSS particles in the liquid waste can be reduced. Adamson in Priyanto and Prayitno (2005) stated that the decrement of TSS level in wastewater that is treated with zeolite and activated charcoal is affected by the time , the longer time, the more pollutant reduced, as the organic and inorganic materials contained in wastewater were absorbed by the zeolites and activated charcoal. with a zeolite-activated charcoal treatment residence time (retention time) different can reduce levels of TSS.

According to Syafrani (2006), zeolite is able to reduce the TSS levels in the wastewater of palm oil industry, with the effectiveness ranged from 60 to 80%. The TSS is decreased because the zeolites consisted of alumino - silicate hydrated and also composed by alkali cations and alkaline mineral. These compounds are three-dimensional structure that have pores or spaces that can be filled by other cations or water molecules present in the liquid waste and they are able to absorb high amount of TSS. The zeolite function, however, is generally based on its chemical and physical properties. The zeolite has the ability to exchange cations with other cations such as potassium and calcium needed by plants. Zeolite is also able to absorb ammonium, and it as a selective absorbent or cation exchanger. In a solution media, cations can be exchanged with other cations and it can be exchanged by anions (Goto, 1990).

Zeolite is widely used as a medium to improve the quality of effluent, as the zeolite is able to alter the cation in waste in large quantities selectively. The chemical composition of zeolites is as follow Fe2O2, = 0.5%, CaO, = 2%, MgO, = 2%, TiO2 = 0.03%, Na2O, = 0.05%, K2O, = 7%, SiO2, and Al2O3 = 55%, = 30%. Arifin (1991) stated that zeolite has been used to control radioactive waste, household waste, livestock waste and sulfuric acid waste. Purwadi (1997) states that the zeolite has ion exchange capacity as well as the selective adsorption of the cations NH4 +, Pb 2+, Zn 2+, Cu 2+, Fe 2+ and Mn 2+. The phosphate anion, sulfate anion and nitrate anions can be worn changed into organic waste. The levels of phosphate, nitrate, sulphate and ammonia contained in the liquid waste can be dropped into 35%. Furthermore, the size of zeolite used also affects the ability of lowering the the pollution materials in the water. The proper sizeis of 8-11 mm length.

Riyanto (1991) states that the zeolite is widely used in water treatment, because the zeolite has a hollow framework structure and porous that containing cations and water molecules that can be freely moved in the reversible ion exchange and reversible dehydration. The zeolite as a natural mineral has several functions such as absorbent, ion exchangers, molecular filters and as a catalyst. Harahap et al (2010), stated that in anaerobic condition, the zeolite is able to degrade the pollutant in wastewater , 7 mg zeolite/ liter of is able to reduce ammonia levels by 70%. According to Said and Herlambang (1999) the use of activated charcoal absorbs micro pollutants in the wastewater and also is able to absorb the dye and eliminate the stench. Research on liquid waste indicates that 25 cm thick of activated charcoal is able to lower the TSS levels, from 60-80%. Furthermore, Hammer (1986) states that the surface-active porous charcoal can absorb, TSS, organic substances, detergents, odor, phenol compounds and heavy metals. The effectiveness of activated charcoal ability to reduce the TSS level in the wastewater of palm oil was 69.35% (Syafrani, 2006). In this study, the effectiveness of zeolite-activated charcoal with 15 days retention time in lowering the TSS levels of was.36% TSS.

BOD5. Results shown that the combination of zeolit and activated charcoal is able to reduce the BOD_5 (Table 2). Based on the table above shows the use of zeolite-activated charcoal (5, 10, 15 days), have been able to reduce BOD5 . However, the BOD levelin the treated waste is higher than that of the government standard. After being treated for 15 days the BOD decrement reached 90.53% (into 236.67 mg / L), but it is categorized as "high" and it is not safe to discharge the waste to the river or to other aquatic resources. The organic and inorganic materials content is is predicted by measuring the BOD5 (Biochemical Oxigen Demand).

No	WT (days)	Before the treatment (mg/L)	After the treatment (mg/L)	Decrement (mg/L)	Effectiveness (%)
1	5	4000,12	2820,43	1179,69	29,49
2	10	3000,67	539,33	2461,34	82,03
3	15	2500,33	236,67	2263,66	90,53

Description: WTO = residence time, quality standard (50-150)

The BOD5 is the demand of Oxygen used by decomposers to decompose organic matter or break down the complex into the simpler compounds. The amount of oxygen required by that microorganisms is known as BOD5. The more organic material goes into the water, the higher the oxygen it needs, even the oxygen in the water can be discharged and the levels reached zero (Abel, 1989). If the oxygen levels in the water is high enough and more than the oxygen required by aerobic bacteria , it does not cause negative impacts on aquatic organisms (Alaerts and Santika, 1987). However, if there is high amount of organic material present in the wastewater, the oxygen may not enough to fill the anaerobic bacteria need, and the decomposition process may results on high levels of ammonia, nitrite and highly toxic H2S that causes problems in the waters (Komarawijaya, 1995).

COD. The COD reduction at each treatment are listed in Table 3.

No	WT (days)	Before the treatment (mg/L)	After the treatment (mg/L)	Decrement (mg/L)	Effectiveness (%)
1	5	6500.33	4000.17	2500.16	38.45
2	10	5500.67	1253.00	4265.67	85.30
3	15	5235.33	1242.67	3992.66	86.26

Description: WTO = residence time, quality standards (200-300)

By the end of the experiment (15 days residence time), the COD reduced into 1242.67 mg / L (effectiveness 86.26%). This COD level, however, has not satisfy the quality standards (Kep-51 / MENLH / 10 / 1995, which is 200-300 mg / L).

Ammonia. The levels of ammonia each residence time treatment are shown in the following table. The decrement of ammonia in the 5, 10, 15 days of treatment residence time are different. The highest decrement was present in the 15 days of residence time (4.00 mg / L). Data on the table above indicates that the decreased levels of ammonia increase , from of 32.33 to 28.97 mg / L (down by 3.36 mg / L, effectiveness 10.39 on a 5 day treatment period). In the 10 days treatment, from 25.12 mg / L decrease into 14.37 mg / L, (down by 10.80 mg / L, the effectiveness 49.99%).

No	WT (days)	Before the treatment (mg/L)	After the treatment (mg/L)	Decrement (mg/L)	Effectiveness (%)
1	5	32.33	28.97	3.36	10.39
2	10	25.12	14.37	10.80	49.99
3	15	10.11	4.00*	6.11	60.44

Description: WTO = residence time, * = appropriate quality standards (1-5)

By the end of the experiment (15 days of treatment) the ammonia reduced, from 10.11 mg / L down into 4.00 mg / L (decreased by 6.11 mg / L , effectiveness of 60.44%). Ammonia in the waters derived from the breakdown of organic nitrogen and inorganic nitrogen contained in natural wastewater which comes from the decomposition of organic matter by bacteria and fungi. The process of denitrification by bacterial activity in aerobic conditions produces ammonia gas (Nurhasanah et al, 1987). In this study the zeolite -activated charcoal media was able to gradually decreased the ammonia content in the waste water.

Orthophosphate. The ability of zeolite-active charcoal in reducing the levels of orthophosphate in wastewater are listed in the following table.

No	WT (days)	Before the treatment (mg/L)	After the treatment (mg/L)	Decrement (mg/L)	Effectiveness (%)
1	5	3,61	3,20	0,41	3,10
2	10	2,93	1,40*	1,53	52,22
3	15	2,60	1,00*	1,60	62,00

Description: WTO = residence time, * = appropriate quality standards (1-3)

The zeolite-activated charcoal media was very effective in decreasing the orthophosphate content. In the 5 days treatment, the orthophosphate decrement was relatively low and the waste was not safe to be discharge to the river. In 10 and 15 days treatment, the orthophosphate level was reduced and satisfy the quality standards.

Nitrate. Nitrate levels found in wastewater is relatively high and the ability of zeolite and activated charcoal in lowering the nitrate levels during the 5, 10, 15 residence time are presented in the table below. Data in the table above indicate that the zeolites and activated charcoal media is able to reduce the nitrate level into the standard value, in the 5 to 15 days treatments. In means that the waste with these nitrate levels were reletively safe to be thrown to the river. The zeolit-activated charcoal combination is effective in reducing the nitrate content in the waste water. In the 5 days treatment, the initial nitrate was 13.21 mg / L and it reduced into 12.00 mg / L (reduced by 1.21 mg / L, the effectiveness 9.16%). In the 10 days treatment, the nitrate reduced, from 8.23 mg / L to 5.11 mg / L (decreased by 3.12 mg / L, the effectiveness 37.91%). In the 15 days treatment, the effectiveness was 42.03%. The nitrate was derived from the decomposition of organic materials, industrial waste, agricultural waste, manure and domestic waste. The effectiveness of zeolite-activated charcoal media to decrease the orthophosphate levelwas 84.17%. According to Syafrani (2006) the zeolite is able to absorb orthophosphate by 50% in the palm oil industry waste.

No	WT (days)	Before the treatment (mg/L)	After the treatment (mg/L)	Decrement (mg/L)	Effectiveness (%)
1	5	13,21	12,00*	1,21	9,16
2	10	8,23	5,11*	3,12	37,91
3	15	6,90	4,00 *	2,90	42,03

Description: WTO = residence time, * = accordance with the standard (20-30 mg / L))

pH. Acidity determines the balance between acids and bases in water where the pH <7 = acidic, pH = 7 is neutral and a pH> 7 is alkaline. PH values ranging between 6-9. When the pH value is less than 5 or more than 9, it indicates that the water is heavily polluted (Setiaji et al, 2003), and it can not be used for household and fishing activities. The pH measurement is needed to determine changes in the acidity of the water, either the acidic or alkaline condition. The more organic material present in the water, the pH became low (acidic condition). pH in the treated wastewater in this study tends to increase, in the 5-day observation, the pH value was 3.25, it increased into 3. 30 (10 days) and into 3.35 (15 days). The rise of the pH in this study is lower than the standard value (6-9).

The use of zeolites and activated charcoal with different residence times shows that the longer the residence time, the greater the pH increase occur (Sudibyo, 1998). In the 5 days observations , the pH value was 4 (the effectiveness 14.2%), in the 10 days observation, the pH value is 5.6 (effectiveness 40%) and the 15 days observation the pH value was 6 (the effectiveness 42.8%).

The increase of pH value is due to decrement of organic matter in the effluent, as the zeolite absorb this matter (Nurhasanah and Pramudiyanto, 1987). Moreover, the aerobic and anaerobic bacteria may decompose the organic materials such as protein, fat, carbohydrates and other compounds contained in wastewater (Craving et al, 1999). While the increase of the DO in the wastewater might be caused by the presence of aerator.

The availability of dissolved oxygen in the water is very important, especially for the needs of biota in the oxidation process, ie breathing. In aquaculture dissolved oxygen should not be less than 2.0 mg / L, the waters that lack of oxygen can cause death in cultured organisms (Alaerts and Santika, 1987). DO range in tha treated wastewater is between 0 (not detected) mg / L - 3.82 mg / L.

The DO measurement in the treatment tanks that is completed with zeolites and activated charcoal were carried out in 3 stages (5 days, 10 days and 15 days retention time). The results are as follows; the DO concentration in the initial measurement (5 days) was 0.5 mg / L, while in the10 and 15 days retention time the DO was not detected. The lack of dissolved oxygen might be due to high content of pollutants in the wastewater. According to Mahida (1986) low dissolved oxygen content in the waste water is might be due to the degradation process that require oxygen, and as a consequence, the oxygen became depleted.

To increase the oxygen content in the wastewater during the decomposition process, the zeolites and activated charcoal media was completed with aerator. According to Heru (1999) the availability of oxygen in the water support the succed of decomposition process. The DO measurements was conducted at 3 stages (5, 10 and 15 retention days). The results are 1.25 mg / L; 2.55 mg / l and 3.00 mg / L respectively. The longer retention time, the higher DO content obtained.

Temperature. During the study, the wastewater temperature naturally reduced and remained steady during the treatment, it was arround 30^o C. This wastewater temperature was satisfied the standard quality (Kep-51 / MENLH / 10/1995) as the temperature of industrial liquid waste that is allowed to be discharged to the environment ranges between 30-40^{o}C.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion. The effectiveness of zeolites and activated charcoal media in absorbing organic materials in tofu wastewater is 80.90% (ammonia), 79.30% (COD) and 73.30% (BOD_5).

Recommendation. As the use of zeolit-activated charcoal media to reduce the organic materials in the tofu wastewater is not completely succed, it is needed to such research in the use of zeolit-activated charcoal –aquatic plants combination for reducing organic materials in the tofu wastewater.

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