The Analysis of Plywood Industrial Wastewater Treatment in South Kalimantan

H Soedarmanto1 and E Setiawati2
1 State Polytechnic of Banjarmasin, Jl. Brigjen H. Hasan Bary, Banjarmasin, South Kalimantan, Indonesia
2 Department of Mechanical Engineering, Brawijaya University, East Java, Indonesia

Email: evy.kemenperin@gmail.com

Abstract. Plywood industrial wastewater can cause heavy pollution to the environment. The wastewater treatment system will be determined by the parameters of the liquid waste produced. This study was aimed to reduce the wastewater contamination level in the plywood industry. The method consisted of sedimentation, coagulation, flocculation, aeration, sand filtration, activated carbon adsorption, and ion exchange. The wastewater was pumped into the reservoir and conditioned to a pH of 6 – 7 and allowed to stand for 2 (two) hours for sedimentation. The blower with a speed of 50 rpm was turned for aeration. Then the wastewater was sand filtrated and absorbed by activated carbon. The wastewater flowed into the anion-cation resin tank for ion exchange. The treated effluent filtrate was analyzed for Biological Oxygen Demand (BOD5), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Phenol, and total ammonia (NH3). The results showed that the decrease of BOD5; COD; TSS; phenol; and NH3 was from 1,426 ppm to 30,5 ppm (97.9%); 2,545.7 to 34.7 ppm (98.6%); 865 ppm to 9.65 ppm (98.9%); 56.98 ppm to 1.45 ppm (97.5%); and 1,652 ppm to 4.56 ppm (99.7%).

1. Introduction
The plywood industry in South Kalimantan is generally spread along the Barito and Martapura riverbanks with an installed capacity of between 26,000 m3 per year to 180,000 m3 per year. The equipment used in general is relatively the same in principle and how it works. This machine and equipment have been adapted to its development, which can increase the yield by 64%. Products that are generally produced are polyester plywood, ordinary plywood, blockboard, phenolic film-faced plywood, fancy plywood [1].

The plywood industrial wastewater is generated from processing activities such as the washing of dryer machines, wood, adhesive machine, and others. Based on the results of previous studies, wastewater from the plywood processing industry had a pH of 7.81-10.51, TSS 104-241 mg/L, BOD 4.56-17.34 mg/L, COD 9.89-36.82 mg/L, NH3 5.10-46.9 mg/L and total phenol 6.17-46.46 mg/L [2]. The washing water contains soluble chemicals can cause environmental pollution if disposed of without treatment first. This is evidenced by the presence of pollutants in rivers along with the plywood processing industry which has an average pH of 7.74-7.53, TSS 54-58 mg/L, BOD 7.2-14.4 mg/L, and COD 14.31-31.53 mg/L [2]. If the water has been polluted by the plywood industry, the water is no
longer suitable for use. Plywood industrial wastewater can also contain contaminants derived from wood preservatives. This preservative has an active ingredient which, if the level exceeds the threshold, can be dangerous for aquatic biota as well as for humans who consume it because it contains very hazardous parameters.

The wastewater that is formed from the plywood industry comes from washing used glue spreaders and wastewater from cooling machines and other equipment. Glue spreader washing water generally contains ammonia and formaldehyde; even if the industry uses phenol-formaldehyde adhesive, it will also find phenol residues.

The parameter value of the existing wastewater determines the next wastewater treatment system. The wastewater treatment and the equipment needed can be determined based on the types of parameters in the wastewater [2]. The use of chemicals in the plywood processing industry as raw material for adhesives has had many negative impacts. The chemical raw materials consist of resins, hardeners, and industrial flour. The type of adhesive used in plywood processing is formaldehyde resin. The primary pollutants contained in the plywood industry are phenolic compounds (benzene derivatives) which are difficult to decompose in water in a short time so that they can change the physical and chemical properties of water. The compounds are toxic to aquatic life and damage the flavor or taste of fishery products [3]. The main characteristics of wastewater from the plywood industry are pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), phenol, and total ammonia (NH₃). This study was aimed to reduce the wastewater contamination level in the plywood industry.

2. Materials and methods

2.1. Materials
Materials used in this study were a liquid waste of plywood industry in South Kalimantan, alum, polyacrylamide (PAM), PAC, granular activated carbon, silica sand, and anion-cation resin, potassium hydrogen phthalate (KHP) standard solution, ferroin indicator solution, manganese sulfate (MnSO₄) solution, starch indicator, potassium standard solution, sulfuric acid solution (H₂SO₄), sodium hydroxide (NaOH), distilled water.

2.2. Methods
The method consisted of primary treatment (sedimentation, coagulation, flocculation) and secondary treatment (aeration, sand filtration, activated carbon adsorption, and ion exchange). The first step was sedimentation. The wastewater was being allowed to stand for 2 (two) hours of sedimentation. The second step was coagulation. In this step, the valve was opened until the coagulation tub was filled with wastewater, while the sludge from the sedimentation was removed. This coagulation tank was given alum with an optimum dose of 22.5 ppm for the flocculation (the third step). At this time, the 300 rpm blower-speed was turned on for 30 minutes after and 1-hour settling. The sludge that remains in the bottom of the coagulation bath was removed. After that, the flocculation tub flowed with wastewater. In this tub was given the 27.5 ppm PAC and 0.5 ppm PAM [4]. At this time the blower with a speed of 50 rpm was turned on for 30 minutes and an hour settling. The sludge would remain at the bottom of the flocculation bath and be discharged. Then the wastewater flowed into the aeration bath for aeration. During aeration, the blower was turned on. Afterward, the wastewater was sand filtrated. The aerated wastewater flowed to the sand filter tank. The sand filter tank contained three sizes of sand, consisting of gravel at the bottom, coarse sand in the middle, and fine sand/silica sand at the top. After that, the wastewater flowed directly to the activated carbon tank for absorption, then flowed into the anion-cation resin tank for ion exchange. The treated effluent filtrate was analyzed for BOD₅, COD, NH₃, phenol, and TSS.
3. Results and discussion

3.1. The inlet characterization
The characteristics of the inlet was shown in Table 1. It was observed that the average value for BOD5, COD, NH3, Phenol, and TSS was above the standard limits, except for pH. The wastewater was hazardous, toxic, and also often had an intense color and a nasty odor. The wastewater contained high levels of organic matter because, during the production process, the materials used were types of organic materials, such as urea and melamine. The high content of organic materials in wastewater will cause the oxygen content that dissolves in water to decrease [5]. Plywood industrial wastewater has a very strong odor such as the smell of formaldehyde and ammonia. The odor of formaldehyde was caused by the use of formaldehyde as an adhesive. Meanwhile, the smell of ammonia was caused by the production process using ammonia. On the other hand, the high COD and BOD5 values indicated that the wastewater contained high levels of recalcitrant (phenol) compounds. The recalcitrant molecule was survived through wastewater treatment and eventually discharged into the surroundings [6].

| Table 1. Main characteristics of inlet |
|---------------------------------------|
| Parameters   | Unit | Value   | Maximum standard* |
| BOD5         | ppm  | 1,430.00 | 75               |
| COD          | ppm  | 2,545.70 | 125              |
| TSS          | ppm  | 865.00   | 50               |
| Phenol       | ppm  | 56.98    | 0.25             |
| pH           | -    | 7.93     | 6.0-9.0          |
| Total ammonia| ppm  | 1,652.00 | 4                |

* Based on Kep-51/MenLH/10/1995

3.2. Wastewater treatment
The wastewater treatment consisted of 2 (two) treatments, namely primary treatment (sedimentation, coagulation, flocculation) and secondary treatment (aeration, sand filtration, activated carbon adsorption, and ion exchange).

3.2.1. Sedimentation. Sedimentation was a unit operation for the removal of suspended matter or chemical floc by gravity. Process sedimentation in wastewater treatment was generally for removing suspended solids before further processing. The solid clumps formed during the coagulation process were still small. These little lumps would continue to coalesce into larger lumps in the flocculation process. With the formation of large lumps, their weight will increase, so that due to their gravity, the lumps would move downwards and settle at the bottom of the sedimentation tank. The sedimentation played a role in lowering TSS levels [7]. The wastewater was being allowed to stand for 2 (two) hours of sedimentation. This study used sedimentation for 2 hours to increase about 14% of the solids settling at the lowest fraction [8].

3.2.2. Coagulation. This study used alum as the coagulant. The jar test was performed in the study before [4] to determine the optimum dose of coagulant. The coagulation tank was given alum with an optimum dose of 22.5 ppm. At this time the 300 rpm blower-speed was turned on for 30 minutes after and 1 hour left to floc formation in the waste. TSS removal decreasing was optimal at 250 to 300 rpm [9]. The coagulation was used to reduce TSS, as well as sedimentation.

3.2.3. Flocculation. Flocculation was used to remove suspended solids and colloidal. In flocculation was given the 27.5 ppm PAC and 0.5 ppm PAM. According to García-Fayos et al. [10], PAM dosages must be in the range of 0.2 to 0.5 ppm. In the case of the PAC-PAM combination, 20 ppm of PAC and 0.3 ppm of PAM had been selected, because they resulted in a higher percentage of coagulant activity
and a larger floc size. At this time the blower with a speed of 50 rpm was turned on for 30 minutes and an hour undisturbed settling. The speed was used for slow mixing (50 rpm for 30 minutes) because the growth of floc particles was much slower near the end of 30 minutes in slow flocculation [11].

3.2.4. **Aeration.** The Aeration is direct exposure to water and air. This is how to thoroughly mix air and water so that various reactions can occur between air and water components. Aeration releases water composer through oxidation and scrubbing action. Oxidation is the removal of electrons and hydrogen, and the addition of oxygen. The suspended material can then be removed through filtration. The scrubbing movement is caused by turbulence that occurs when air and water mix. The scrubbing removes gas solution in the water [12].

3.2.5. **Sand filtration.** This study was used three sizes of sand, consisting of gravel at the bottom, coarse sand in the middle, and fine sand/silica sand at the top. The smaller size sand was demonstrated to be more efficient in a slow sand filtration system [13]. Generally, the slow sand filter was removed organic matter, suspended solids, turbidity, and pathogens from wastewater.

3.2.6. **Activated carbon absorption.** The activated carbon was used in this study because activated carbon was suitable for processed water containing phenols and this material had a high molecular weight. In this study, granular activated carbon was used. Each gram of activated carbon can absorb 0.4-0.9 g of phenol.

3.3. **Outlet characterization**
In the initial stage, the pH of wastewater was neutralized at pH 6-7, because at this pH the coagulant would work effectively. Furthermore, concentrated wastewater was chemically treated with the addition of alum so that it was separated between the sediment and the filtrate. The mixing of alum as a coagulant could reduce suspended organic and inorganic materials which were negative and positive chemicals so that the formation of a crystalline nucleus could occur. This tub was equipped with a stirring so that the alum could be mixed evenly and in a short time so that the chemical process runs faster and evenly. After going through the coagulation and flocculation stages, the filtrate was then tested for parameters including BOD5, COD, and NH3. There was a decrease in BOD5, COD, and NH3 by 42.5%, 19.5%, and 39.3% for coagulation, 72.5%, 58.6%, 68.9% for flocculation as shown in Table 2. Based on previous research, the flocculation stage was able to reduce pollutants by 65.77% - 85.35% [14]. The percentage reduction in BOD5, COD, and NH3 have not been maximized, therefore further treatment was needed.

| Parameters | Coagulation | Percentage of decreasing | Flocculation | Percentage of decreasing |
|------------|-------------|--------------------------|--------------|-------------------------|
| BOD5       | 735         | 42.5                     | 468          | 72.5                    |
| COD        | 2,879       | 19.5                     | 1,213        | 58.6                    |
| NH3        | 665         | 39.3                     | 372          | 68.9                    |

The characteristics of the outlet was shown in Table 3. It was observed that the wastewater treatment, which consisted of sedimentation, coagulation, flocculation, aeration, sand filtration, activated carbon adsorption, and ion exchange, could decrease the value for BOD5, COD, NH3, Phenol, and TSS.
Table 3. Outlet characteristics of industrial plywood wastewater

| Parameters     | Unit | Value | Percentage of decrease |
|----------------|------|-------|------------------------|
| BOD5           | ppm  | 30.5  | 97.9                   |
| COD            | ppm  | 34.7  | 98.6                   |
| TSS            | ppm  | 9.65  | 98.9                   |
| Phenol         | ppm  | 1.45  | 97.5                   |
| Total ammonia  | ppm  | 4.56  | 99.7                   |

Based on Table 3, it appeared that the results of the wastewater treatment had fulfilled the Liquid Waste Quality Standard for industrial activities according to Kep-51/MenLH/10/1995. Another study stated that the activated carbon and quartz sand filtration media could reduce TSS and COD by 84.4% and 80.7%, with a filter media thickness of 80 cm [7]. Meanwhile, this study proved that the use of activated carbon as an absorbent could reduce TSS and COD levels by 98.9% and 98.6%. Activated carbon had adsorptive properties so that the media filtration functions as a solution purifier and color absorption. Activated carbon had combining force with organic matter, hence it could be used to recover the material organic contaminants from wastewater, especially COD levels.

4. Conclusion

The main characteristics of wastewater from the plywood industry were pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), phenol, and total ammonia (NH3). The percentage decreasing of coagulation was BOD5, COD, and NH3 42.5%, 19.5%, and 39.3% respectively, while 72.5%, 58.6%, 68.9%, respectively for flocculation. Overall, the treatment of sedimentation, coagulation, flocculation, aeration, sand filtration, activated carbon adsorption, and ion exchange was proven effective to be used as industrial plywood wastewater treatment. The results showed that the treatment could decrease BOD5; COD; TSS; phenol; and NH3 from 1,426 ppm to 30.5 ppm (97.9%); 2,545.7 to 34.7 ppm (98.6%); 865 ppm to 9.65 ppm (98.9%); 56.98 ppm to 1.45 ppm (97.5%); and 1,652 ppm to 4.56 ppm (99.7%).

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