Remediation of Oriented Strand Board (OSB) Process Water

Dowlatabadi, L.; Borazjani, H.

The process of manufacturing OSB involves a pressing process that releases water and extractives from wood. This type of water is known as process water and contains wood extractives, phenol/urea formaldehyde resins, terpenes, and other organic compounds which increase the biological oxygen demand (BOD) and total suspended solids (TSS). In order to discharge this water, it must be treated to reach a regulated discharge levels for BOD and TSS. A 30 day laboratory study with bioreactors filled with OSB process water and treated with air only, air plus fertilizer and air with fertilizer and duckweed were conducted to evaluate the removal of BOD and TSS from this type process water. Three untreated controls were used in this experiment. Significant reduction of BOD occurred for all treated replicates after 30 days. No significant differences observed among treated samples. For TSS, again all treated treatments showed significant reduction but reactors treated with only air showed the highest reduction of TSS. Bacterial population remained sufficient throughout this experiment.

Introduction

Treating wastewater is an important aspect for wood processing plants. In recent years, the production of OSB (Oriented Strand Board) and other materials such as Wafer board (WB) worldwide has grown dramatically (over 50%) [Steinwender et al., 2009]. These two are referred to as flake boards because of their composition of being reconstituted wood panel products. OSB is manufactured by obtaining strands and wood wafers taken from logs at the plant and aligning each of the 3-5 layers, blended with resin, in a perpendicular fashion to give OSB a far superior flexible property unmatched in regular wafer boards [Steinwender et al., 2009]. These types of engineered boards are commonly used for sheathing, single layer flooring, and underlayment in light frame construction [EPA, 2003].

Trees have high water content, so the process of making OSB and other boards which involve pressing, results in the water being released [Mangum, 2001]. The wastes generated from the production of OSB type products includes wood, water, resins, waxes and organic compounds such as terpenes, resin acids, phenol formaldehyde resins, and other wood leachates [Diehl et al., 2003]. These are all commonly combined with water to create a wastewater that must then be treated for proper discharge. The amount of these wastes that remains in the water affects the biological oxygen demand (BOD). The BOD will determine whether the wastewater can be properly discharged [Diehl et al., 2003]. BOD will determine the degree of water pollution and is the most important measurement taken for treatment plants [Hach et al., 1997]. Because bacteria within bodies of water will oxidize organic matter and will consume oxygen faster than it is dissolved back in from the air causing significant depletion of oxygen and it will negatively affect the ecosystem of the river leading to a high mortality rate of fish and other living organisms[Hach et al., 1997]. This makes it an important factor to monitor prior to release.

Current wastewater strategies to decrease BOD include aerated ponds and bioreactors. These two techniques incorporate air to help stimulate microbial breakdown. Filtration can also be used after coagulation and flocculation treatment [Ali and Skreerishnan, 2001; Huang et al., 2004; Pokhrel and Viraraghavan, 2004]. Although these processes do work, they tend to be costly as well as create a need for disposal of the filter cakes and spent filtrate produced from the process of coagulation and flocculation [Mangum, 2001]. The use of aquatic plants is another process that has been considered and experimented with as a way to alleviate cost and disposal. There have been many positive results using aquatic plants to remove heavy metals in addition to filtering the process water [Koner et al., 2003; White, 2008; Masbaugh et al. 2005; Keith et al. 2006, Ran et al. 2004]. One such positive treatment facility is in Columbus, MS at a local paper manufacturing facility that uses three steps to successfully to treat wastewater. These steps include a cooling pond which is fed into an aerated pond that suspends solids, which is then fed to a cattail artificial wetland that reduces BOD level before being discharged [White, 2008]. In this study, the use of Common Duckweed (Lemma gibba) will be explored to potentially help decrease BOD.

Objectives

Air sparging is a technique used to remediate wastewater, and can be defined as introducing air beneath the surface of water to begin volatilization and biodegradation [Hinchee, 1994]. The main objective with air sparging is to provide oxygen which will trigger biological breakdown processes [Hinchee, 1994]. In this experiment, air sparging was used in order to provide oxygen for microbial breakdown of organic compounds and to determine that if it is a reliable treatment technique to decrease BOD and TSS. The use of fertilizer and Common Duckweed will also be used to find their correlating effects on decreasing BOD and total suspended solids (TSS).

Materials and Methods

Wastewater Characterization

The wastewater used in this study was obtained from an engineered wood manufacturing plant in northeast Mississippi. The wastewater was untreated and contained resin, a small amount of fertilizer and other organic compounds present in wood extractives. The wastewater was plated on day zero on nutrient agar to find a bacterial count. The total counts can be found in table 1.

Table 1. Bacterial counts, BOD, TSS and pH for samples.

Treatments	Bacterial Counts (colonies/ml)	BOD (PPM)	Total Suspended Solids (PPM)	pH
C	3,633	240	847	6.78
A	3,800	240	847	6.78
AF	3,867	240	847	6.78
AFD	3,700	240	847	6.78

Note: Treatment ID refers to the treatment. C=Control, A=Air, F=Fertilizer, D=Duckweed

Treatment Conditions

Twelve 4L bioreactors (tanks) were placed under a chemical ventilation hood where 1.5L of OSB wastewater was randomly and evenly distributed among all of them. Tanks were kept at room temperature. Environmental conditions such as temperature, light, and aeration were controlled to ensure proper homogeneity in the experiment. Samples were taken from each tank for bacterial counts as well as biological oxygen demand (BOD) and total suspended solids (TSS) for day zero. Three tanks were just air sparged (A). Three had the addition of air sparging and fertilizer (AF), and the last three had air sparging, fertilizer, and the addition of Common Duckweed (AFD). Three containers were set aside as a control with no treatment(C). Final samples were taken after thirty days. Deionized water (DI) was added to each tank daily for water loss (due to evaporation) to keep the initial water level.

Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) is the amount of oxygen present for utilization of bacteria to use when they oxidize organic matter, measured in mg/L or parts per million (ppm) [Hach, 1997]. This organic matter consists of carbohydrates (cellulose, starch, sugars), proteins, resins, petroleum hydrocarbons, etc. [Hach, 1997]. These accumulate in water during manufacturing processes and will either dissolve or become suspended particulate matter. BOD samples were run by an outside analytical laboratory according to EPA Standard method 5210B [Clerceri et al., 1998]. Two samples of the wastewater were taken on day zero and sent to a lab to determine the amount of oxygen required for the microbial decomposition of the organic matter in the wastewater. This procedure was incredibly helpful for the monitoring of water quality and was useful in the comparison to day thirty, in which it showed how much oxygen was consumed by microorganisms and was performed using the procedure as [Walker, 1992] describes.

Total Suspended Solids

Total suspended solids are an analytical method used to determine concentrations of suspended solid-phase material [Gray et al., 2000]. It is important with water quality because it indicates negative effects the water may have on the ecosystem when discharged [Zhang et al., 2013]. Suspended solids are organic and inorganic materials such as sediment, algae, metals, nutrients etc., with a grain size larger than 2 μm suspended in water [Zhang et al., 2013]. These suspended materials can change turbidity, reduce dissolved oxygen, and harm wildlife [Zhang et al., 2013]. Some of the suspended solids are natural from the environment while others are the result of effluent water from industrial activities such as making OSB wood. In this experiment, samples of each treatment were taken and filtered through filter paper using a funnel and vacuum. The initial weights of the filter papers were taken and once dry at 100C for eight hours, were reweighed again. The difference between the weights indicated the TSS found in the treatment water.

pH Analysis

The pH of each sample was determined using an expandable Orion research ion analyzer. The initial pH of the wastewater was tested and found to be 6.78 and reduced slightly to 6.67 at day thirty. The procedure was followed as Walker (1992) reported.

Bacterial Counts

As seen in Figure 1, bacterial counts were taken for each treatment. All samples were plated on nutrient agar petri dishes and incubated for 48 at 27C hours and then counted. Bacterial counts are important because they help to understand the processes occurring in the water. Higher levels of bacteria indicate higher rates of microbial decomposition. Increased bacteria is healthy and good up to a point with water and after that, it can become harmful which is why bacteria counts are another important indication for the health of water. These comparative numbers show which treatment is best when compared to day thirty bacterial counts.

Statistical Analysis

A completely random design statistical analysis was performed using SAS where the means was separated and used to compare treatments.

Results and Discussion

The initial identical samples revealed a BOD average of 240 mg/l. Final BOD for the control was an average of 138.33 mg/l while air was found to be 45 mg/l. Air plus fertilizer was 49 mg/l and the air/fertilizer/duckweed was 75 mg/l. All treatment including controls showed a surprisingly significant decrease in the BOD (table 2 and figure 1). All treated samples had significantly lower BOD levels than controls but no significant differences were observed among treated samples. Initial pH was measured at 6.78 and final pH was found to be an average of 6.68 at the conclusion of the experiment showing no significant changes for pH levels of any samples. Bacteria counts were also taken at the beginning of the experiment as well as at the conclusion of 30 days. Initial and final bacteria counts for the control, were 3,633 colonies/ml and 6,833 col/ml, for the air was 3,800 col/ml and 29,000 col/ml. For air and fertilizer were 11,600 col/ml and 79,666 col/ml. Last, air/fertilizer/duckweed was 3,700 col/ml and 127,166 col/ml (table 3 and figure 2). This shows that there was significant bacteria available for all treatments. BOD showed to have the largest change from the initial tests with a substantial decrease which could be due to the large release of VOC's present in the water (table 3, 4 and figure 2). A high increase in bacteria count shows that there was a natural microbial activity going on within the water and that the air/fertilizer/duckweed had the highest increase in bacterial counts.

Total suspended solids were also taken after the 30 days to get an understanding of the initial and final status of the treated water. Day 0 results found the water to be at 847 mg/l. After 30 days, the control was 871 mg/l while the air treatments were slightly lower at 696 mg/l. The air/fertilizer treatments were 716 mg/l and the air/fertilizer/duckweed was 740 mg/l. Although the results show that there wasn't a large difference in suspended solids throughout the course of this study for treatments but sparging of air into processwater showed most significant change (table 4 and figure 7).

Table 2. Shows table of BOD averages of all treatments measured in mg/l and percent reduction. C=Control, A=Air, AF= Air/Fertilizer, AFD=Air/Fertilizer/Duckweed

Treatments	Day 0	Day 30	% Reduction
Initial	240	-	-
C	240	138	42.5%
A	240	45	81.3%
AF	240	49	79.5%
AFD	240	75	68.8%

Table 3. Shows summarized bacterial counts (col/ml). C=Control, A=Air, AF= Air/Fertilizer, AFD=Air/Fertilizer/Duckweed

Treatment	Day 0	Day 30
C	3,633	6,833
A	3,800	29,000
AF	3,867	79,667
AFD	3,700	127,167

Table 4. Total suspended solids in ppm. Initial= Day 0 control, C=Day 30 Control, A=Day 30 Air, AF=Day 30 Air/Fertilizer, AFD=Day 30 Air/Fertilizer/Duckweed.

Treatments	Day 0	Day 30	% Reduction
Initial	847	-	-
C	847	874	-3.1%
A	847	696	17.82%
AF	847	716	15.46%
AFD	847	740	12.63%

Conclusion

This study was designed to test the uses of air, fertilizer, and duckweed and to examine their effects on the reduction of OSB process water. This study found that the process water with low initial bacteria counts and high BOD can be treated to much lower levels. The process water was reduced from about 240 mg/l to the lowest (air) 45 mg/l which shows a significant change.

It was also determined that all treatments resulted in a decrease in suspended solids and an increase in bacterial activity. Air proved to be the most effective at treating the water with the lowest BOD and suspended solids. The duckweed treatment was not as effective as the other two showing higher BOD and TSS levels but surprisingly higher number of colonies resulted. A higher suspended solids and BOD levels for duckweed treatment was possibly due to the increase in organic matter from dead plant tissues and root exudates. Highest bacterial counts for duckweed, far surpassing the other treatments was possibly due to duckweed's exudates providing extra nutrients for the microbes. The addition of fertilizer showed an intermediate range of values when compared to the duckweed and air. Overall, it was determined that the use of air by itself is enough to reduce BOD significantly and should be considered a major part of any remediation on this type of process water.

Acknowledgment

The article is approved for publication as Journal Article SB - 856 of Forest & Wildlife Research Center, Mississippi State University, Mississippi State, MS.

References

1. Ali, M. and T.R. Sreekrishnan. 2001. Aquatic toxicity of pulp and paper mill effluents: A Review. Adv. Environ. Res. 5: 175-196.
2. AP 42, Fifth Edition, Volume 1. Chapter 10: Wood Products Industry. (2003). U.S. Environmental Protection Agency.
3. Blum, R.A., Taras, M.J. 1968. Determination of emulsifying oil in industrial wastewater. JWPCF Res. Suppl. 40: R404.
4. Clesceri, L.S., Greeenberg, A.E., Trussel, R.R. 1989. Standard methods for the examination of water and wastewater. ed. 17.
5. Diehl, S., Borazjani, H., Strombock, Baldwin, Prewitt. (2006). Biological remediation of oriented strand board (OSB) Waste Water. Mississippi water resources 36th conference. April 25-26. Jackson MS p.22. Abstract
6. Gray, J.R., Glysson, G.D., Turcois, L.M, Schwarz, G.E. 2000. Comparability of suspended sediment concentration and total suspended solids data.U.S. Geological Survey.
7. Hach, C.C., Klein R.L., Gibbs, C.R. (1997). Introduction to biochemical oxygen demand. Hach Company.

8. Hinchee, R.E. 1994. Air sparging for site remediation. Boca Raton, Florida:CRC Press Inc.
9. Horvath, R.S., Alexander, M. 1970. Co-metabolism of m-chlorobenzoate by an arthrobacter. Appl. Microbiol. 20: 254-258.
10. Huang, W. H., C. Y Poynton,., L. V Kochian and M. P Elless. 2004. Phytofiltration of arsenic from drinking water using arsenic-hyperaccumulating ferns. Environ. Sci. Technol. 38: 3412-3417.
11. Keith, K.C., H.Borazjani, S.V.Diehl, M.L.Prewitt, Y.Su, F.Han, and B.S.Baldwin 2006 Aquatic phytoremediation of CCA and copper contaminated water.37th Ann. Miss. Water Resources Research Conf. April 24-25. Jackson, MS. Pp 23-28.
12. Korner, S., J.E. Vermatt, and S. Veenstra. 2003. The capacity of duckweed to treat wastewater: the ecological considerations of sound design. J. Environ. Qual.32:1583-1590.
13. Mangum, L. (2010). Use of duckweed for reduction of BOD in timtek process water. Environmental Science and Technology.
14. Masbough, A., K. Frankowski, K.J. Hall and S.J.B. Duff. 2005. The effectiveness of constructed wetland for treatment of woodwaste leachate. Ecol. Eng. 25:552-566.
15. Pokhrel D., and T. Viraraghavan. 2004. Treatment of pulp and paper mill effluent – A Review. Sci Total Environ. 333: 37-58.
16. Ran, N., M. Agami and G Oron. 2004. A pilot study of constructed wetlands using duckweed (Lemna gibba L.) for treatment of domestic primary effluent in Israel. Water Res. 38:2241-2248.
17. Steinwender, M.; Barbu, M.C. (2009): Environment impact of the wood based panels industry. Proceeding of ICWSE, 4-5 June, Brasov.
18. Walker, K.W. 1992. Biodegradation of selected polycyclic aromatic hydrocarbons and pentachlorophenol in highly contaminated wastewater. Mississippi State University. Mississippi.
19. White, M. 2008. Personal Communication.
20. Zhang, T., Stansbury, J., Branigan, J. 2013. Development of a field test method for total suspended solids analysis. Mid-America Transportation Center. University of Nebraska.

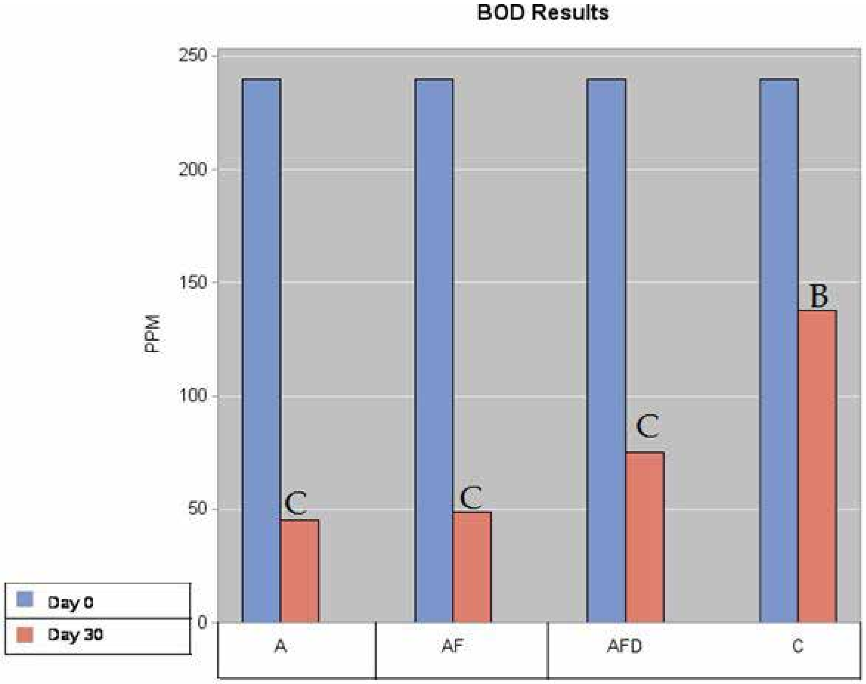

Figure 1. Shows distribution of BOD results. C=Control, A=Air, AF= Air/Fertilizer, AFD=Air/Fertilizer/ Duckweed.

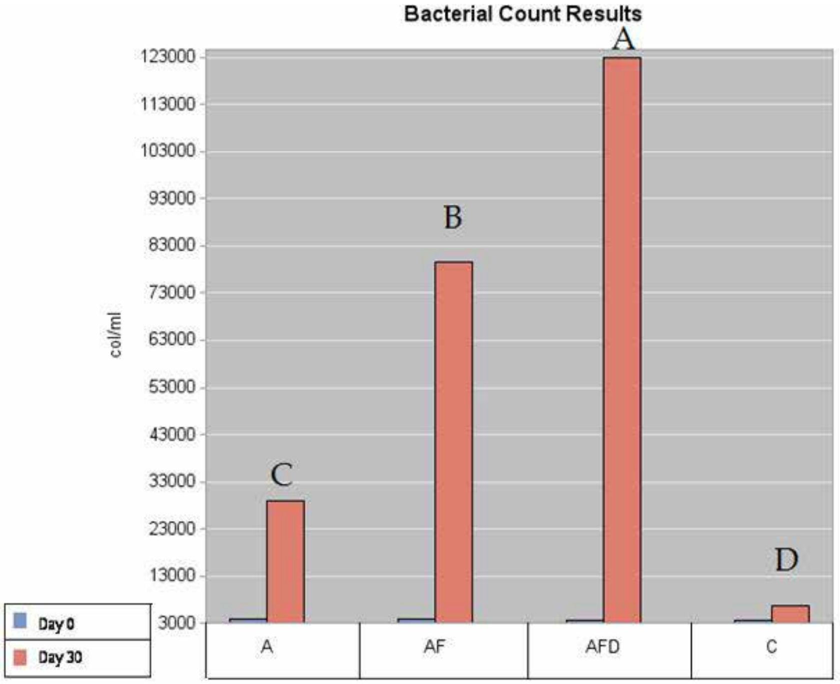

Figure 2. Distribution of bacterial counts. C=Control, A=Air, AF= Air/Fertilizer, AFD=Air/Fertilizer/Duckweed.

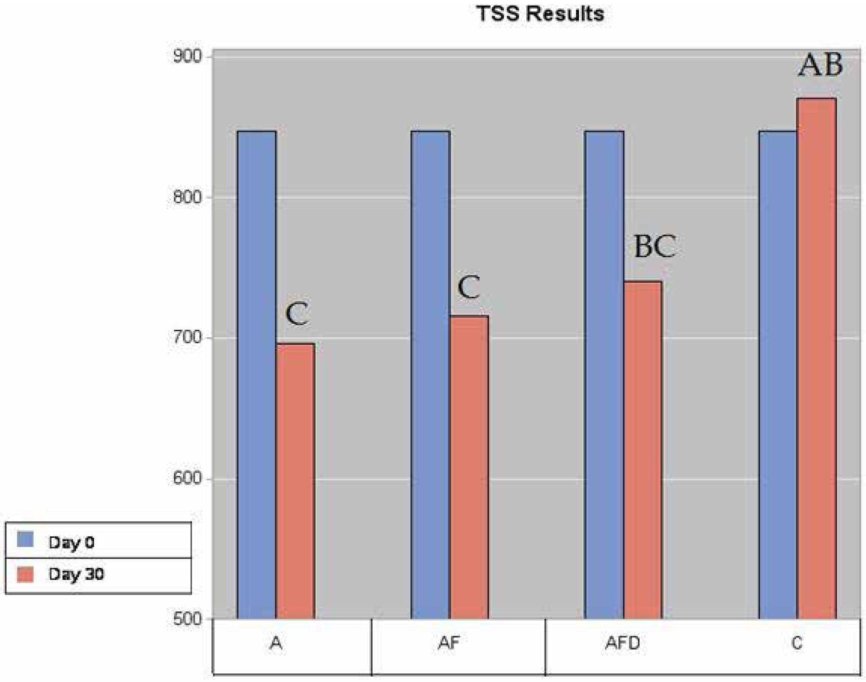

Figure 3. Distribution of total suspended solids. C=Control, A=Air, AF= Air/Fertilizer, AFD=Air/Fertilizer/Duckweed.