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Study on Treatment of Pulp and Paper Wastewater using Coagulation-flocculation

Hnin Yu Khaing[a], Khaing Zin Win[b], Tint Tint Kywe[*]

[a]Chemical Engineering Department, Yangon Technological University,
Room (C/403), Hninsi Street, Tamwe Township, Yangon, Myanmar
hninyukhaing2007@gmail.com

[b] Chemical Engineering Department, Yangon Technological University,
B-block, YTU Campus, Yangon Technological University, Yangon, Myanmar
khaing.zin@gmail.com

[*] Chemical Engineering Department, Yangon Technological University,
YTU Campus, Yangon Technological University, Yangon, Myanmar
ttkywe@gmail.com

Abstract

In this study, treatment of pulp and paper wastewater was investigated. Wastewater from pulp and paper industry was treated by coagulation-flocculation method using alum ($Al_2(SO_4)_3$) and polyaluminium amide (PAM). The various chemical dosage were tested such as 1000 ppm, 2000 ppm, 3000 ppm, 4000 ppm, 5000 ppm, 6000 ppm and the maximum removal efficiency percent of Total Suspended Solid (TSS), Total Dissolved Solid (TDS), Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) were found to be 69%, 28%, 62%, and 80%, respectively. According to the results, the removal of turbidity to a maximum level of 98% at dosage of 5000 ppm. This technology can prove to be eco-friendly processes.

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Keywards: Alum; Coagulation-flocculation, COD; Pulp and Paper Wastewater; Turbidity

1. Introduction

The pulp and paper industry uses large quantity of freshwater and lignocellulosic materials in the process of production of paper and it generates large quantity of effluent. The generated effluent is characterized by dark color, foul odour, high organic content and extreme quantities of chemical oxygen demand (COD), biochemical oxygen demand (BOD) and pH. The dark color in untreated effluent is a major environment concern as its discharge to water bodies inhibits the photosynthetic activity of aquatic biota by reducing sunlight, besides exhibiting the toxic effects on biota. The present aim is to determine the optimum conditions for the treatment of pulp and paper wastewater effluent. The objectives of this research were to study the physico-chemical characteristics of the effluent wastewater and to investigate the COD, TSS, and turbidity removal capabilities of coagulation-flocculation process.

2. Literature Review

2.1 Pulp and Paper

The pulp and paper industry comprises of companies that use wood as a raw material and produce pulp, paper, paperboard and other cellulose-based products. Pulp is a lignocellulosic fibrous material prepared by chemically or mechanically separating cellulose fibres from wood, fiber crops, waste paper, or rags. Many kinds of paper are made from wood with nothing else mixed into them. This includes newspaper, magazines and even toilet paper. Pulp is one of the most abundant raw materials worldwide [1]. The basic structure of pulp and paper sheets is a felted mat of cellulose fibres held together by hydrogen bonds. Cellulose is a polysaccharide with 600 to 1,500 repeated sugar units.

The fibres have high tensile strength, will absorb the additives used to modify pulp into paper and board products, and are supple, chemically stable and white. The purpose of pulping is to separate cellulose fibres from the other components of the fibre source. In the case of wood, these include hemicelluloses (with 15 to 90 repeated sugar units), lignins (highly polymerized and complex, mainly phenyl propane units; they act as the “glue” that cements the fibres together), extractives (fats, waxes, alcohols, phenols, aromatic acids, essential oils, oleoresins, stearols, alkaloids and pigments), and minerals and other inorganics. As shown in Table 1 , the relative proportions of these components vary according to the fibre source [2].

Table 1. Chemical constituents of pulp and paper fibre sources (%) [2]

	Softwoods	Hardwoods	Straw	Bamboo	Cotton
Carbohydrates					
α-cellulose	38–46	38–49	28–42	26–43	80–85
Hemicellulose	23–31	20–40	23–38	15–26	nd
Lignin	22–34	16–30	12–21	20–32	nd
Extractives	1–5	2–8	1–2	0.2–5	nd
Minerals and other inorganics	0.1–7	0.1–11	3–20	1–10	0.8–2

nd = no data available

Coniferous and deciduous trees are the major fibre sources for pulp and paper. Secondary sources include straws from wheat, rye and rice; canes, such as bagasse; woody stalks from bamboo, flax and hemp; and seed, leaf or bastfibres, such as cotton, abaca and sisal. The majority of pulp is made from virgin fibre, but recycled paper accounts for an increasing proportion of production, up from 20% in 1970 to 33% in 1991. Wood-based production accounted for 88% of worldwide pulp capacity in 1994 [2].

2.2 Pulp and Paper Wastewater

The paper industry uses very high volumes of process water for pulp preparation and bleaching among other processes. Water is needed to make paper pulp out of fibers such as cellulose, wood or recovered paper. If recycled paper is used a further stage is involved to remove the ink from the recycled paper. These processes collectively produce a significant amount of contaminated wastewater and sludge. On average for every ton of pulp produced in the production of paper approximately 17,000 gallons of industrial process water is required. The environmental problems of pulp and paper industry are not limited by the high water consumption. Wastewater generation, solid wastes including sludge generating from wastewater treatment plants and air emissions are other problems and effective disposal and treatment approaches are essential. The significant solid wastes such as lime mud, lime slaker grits, green liquor dregs, boiler and furnace ash, scrubber sludges, wood processing residuals and wastewater treatment sludges are generated from different mills.

Disposal of these solid wastes cause environmental problems because of high organic content, partitioning of chlorinated organics, pathogens, ash and trace amount of heavy metal content.The wastewater produced by the paper production process contains sediments, effluent solids, absorbable organic halides (AOX), chlorinated organic compounds, chemical oxygen demand (COD), and biological oxygen demand (BOD) contaminants. The treatment of this wastewater requires onsite primary and secondary treatment systems. The conventional wastewater treatment processes was shown in Fig.1 [3].

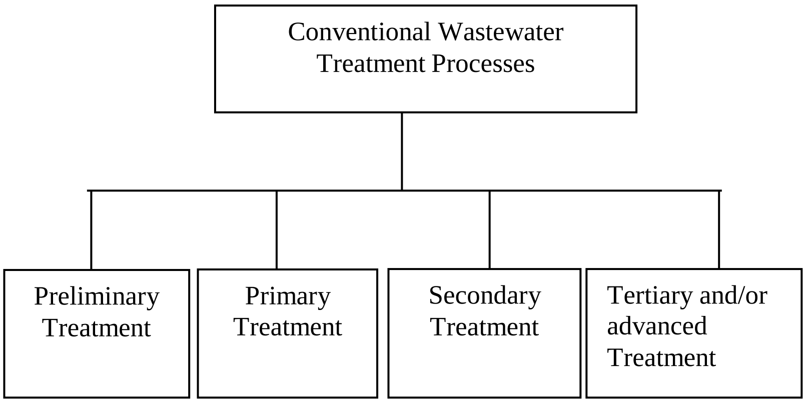

Fig. 1 Conventional Wastewater Treatment Processes

Primary treatment removes material that will either float or readily settle out by gravity. It includes the physical processes of screening, comminution, grit removal, and sedimentation. Screens are made of long, closely spaced, narrow metal bars. They block floating debris such as wood, rags, and other bulky objects that could clog pipes or pumps. In modern plants the screens are cleaned mechanically, and the material is promptly disposed of by burial on the plant grounds [4].

Secondary treatment of wastewater makes use of oxidation to further purify wastewater. This can be done in one of three ways:

- Biofiltration

This method of secondary treatment of wastewater employs sand filters, contact filters, or trickling filters to ensure that additional sediment is removed from wastewater. Of the three filters, trickling filters are typically the most effective for small-batch wastewater treatment.

- Aeration

Aeration is a long, but effective process that entails mixing wastewater with a solution of microorganisms. The resulting mixture is then aerated for up to 30 hours at a time to ensure results.

- Oxidation Ponds

Oxidation ponds are typically used in warmer places. In addition, this method utilizes natural bodies of water like lagoons. Wastewater is allowed to pass through this body for a period of time and is then retained for two to three weeks [5].

Tertiary treatment is a term applied to polishing methods used following a traditional sewage treatment sequence. Tertiary treatment is being increasingly applied in industrialized countries and most common technologies are micro filtration or synthetic membranes. After membrane filtration, the treated wastewater is nearly indistinguishable from waters of natural origin of drinking quality (without its minerals). Nitrates can be removed from wastewater by natural processes in wetlands but also via microbial denitrification. Ozone wastewater treatment is also growing in popularity, and requires the use of an ozone generator, which decontaminates the water as ozone bubbles percolate through the tank, but this treatment is energy intensive. The latest, and very promising treatment technology is the use aerobic granulation [5].

3. Materials and Method

3.1 Raw Material

Pulp and paper wastewater was collected from pulp and paper factory in Yangon.

3.2 Analysis of Sample

Wastewater samples were analysed at Laboratory of Green Myanmar Environmental Services Co. Ltd and Chemical Engineering Department, YTU.

3.3 Expermental Method

Raw wastewater was placed in a 1000 ml beaker and added with 4N H_2SO_4 solution to get the pH 4. Then, 15% $Al_2(SO_4)_3$ solution was added into the beaker on the magnetic stirrer and these sample was stirred for 15min. After that, 0.01% PAM solution was mixed into the beaker and was stirred for 1 min. After the flocculation process, the sample was settled for overnight and was filtered. After filtering the process, the treated sample was analyzed for parameters. Coagulation-flocculation process was carried out with different dosage: 1000 ppm, 2000 ppm, 3000 ppm, 4000 ppm, and 5000 ppm. The flowchart of treatment of pulp and paper wastewater was shown in Fig. 2.

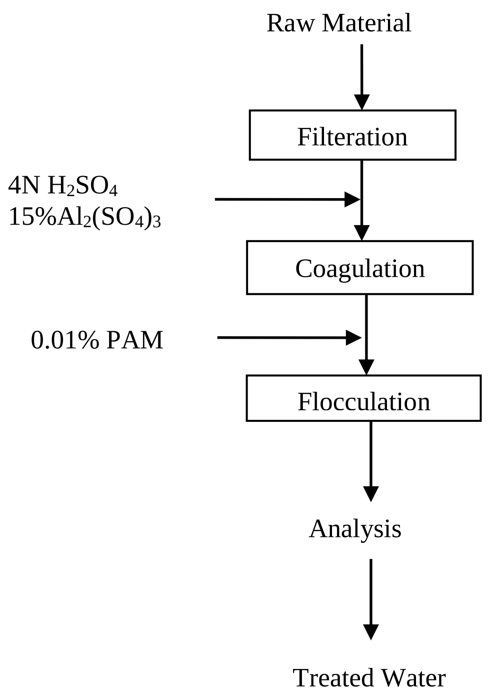

Fig. 2. Flowchart of Treatment of Pulp and Paper Wastewater

4. Results and Discussion

The paper mill effluent used in study had a dark brown color and a turbid colloidal appearance with a large amount of solid particulate matter present in it. The raw and treated wastewater was shown in Fig.3. The characteristics of raw pulp and paper wastewater and treated pulp and paper wastewater were shown in Tables 2 and 3. Percent removal of COD, BOD, TSS, Turbidity and TDS was shown Fig 4.

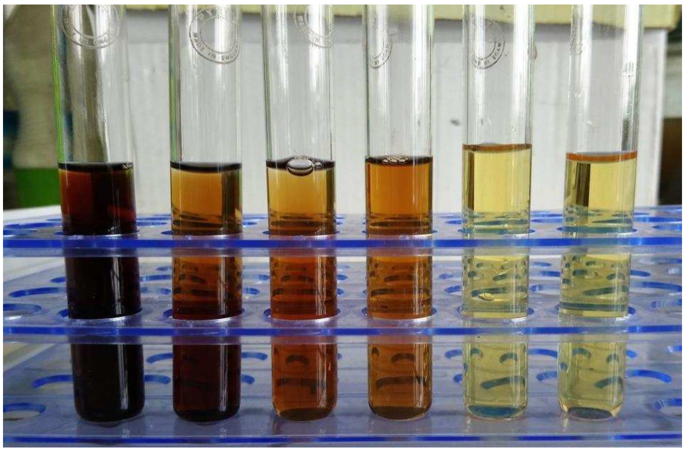

Fig.3. Raw Wastewater and Treated Wastewater

Table 2. Characteristics of Raw Pulp and Paper Wastewater

Parameter	Unit	Values
pH	-	9.56
Turbidity	NTU	56.7
TSS	mg/L	440
TDS	g/L	6.68
COD	mg/L	8550
BOD	mg/L	4110

Table 3. Characteristics of Treated Pulp and Paper Wastewater

Parameter	Unit	Values				
		S 1	S 2	S 3	S 4	S 5
pH	-	4	4	4	4	4
Turbidity	NTU	23.8	10.8	2.64	1.17	1.12
TSS	mg/L	410	210	180	175	135
TDS	mg/L	6.59	6.32	6.13	5.8	4.82
COD	mg/L	5130	5130	3420	2570	1710
BOD	mg/L	2630	2300	2050	2030	1570

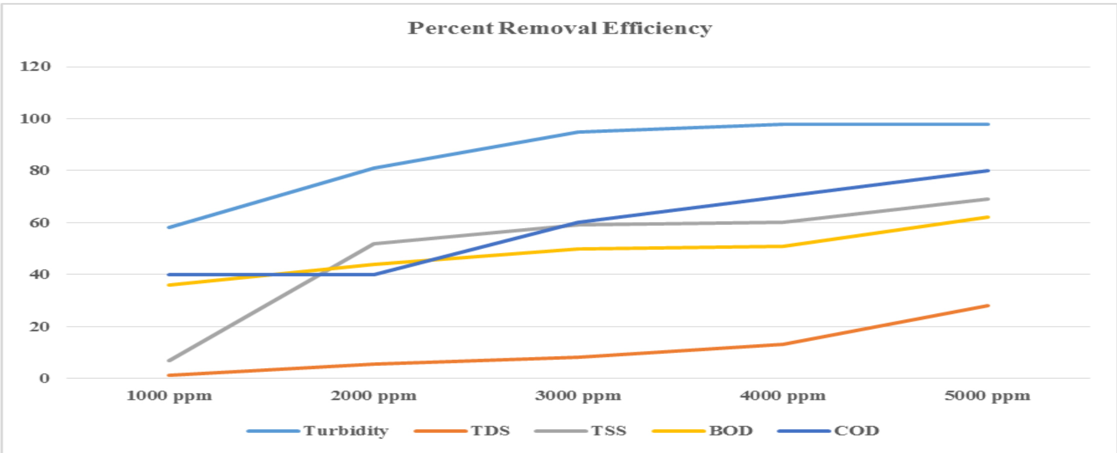

Fig.4. Precent Removal Efficiency of Treated Wastewater

On viewing from this Fig. 3, the color was reddish brown color to pale yellow color. The highest turbidity removal of 98% was achieved at pH 4 for the dose rate of 5000 mg/L of aluminium sulfate but the observed COD, BOD, TSS, TDS removals under these conditions were 80%, 62%, 69%, 27.84% respectively. It was also observed that the coagulation-flocculation treatment partially remove COD and BOD. The experiments showed the TDS reduction from 4.82mg/L to a dischargeable level ≦2000mg/L after treatment with aluminium sulfate at pH 4. According to this study, the aluminium sulfate can be used effectively to remove turbidity from pulp and paper wastewater. It is needed to carry out the other types of the coagulant such as poly aluminium chloride, lime, and aeration process.

5. Conclusion

In this research, pulp and paper wastewater treatment was study using coagulation-flocculation process. From the results, it may be concluded that the optimum conditions of process parameters, a coagulant dose of 5000 mg/L was efficient to remove 80% COD and 98% turbidity. Accordingly, coagulation-flocculation process has proved an efficient process to remove turbidity from pulp and paper wastewater effluent. The treated water quality does not meet the national emission guidelines. Therefore, it is need to do more experiments.

Acknowledgements

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