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Color Removal of Recycled Pulp and Paper Industry Effluent by Coagulation and Flocculation

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Abstract—*Paper and pulp industry has been ranked the twentieth highest environment polluting industry in terms of color in the world. Pulp and paper mill effluents are considered as one of the most polluting streams because of the presence of several persistent and recalcitrant substances. Because of the high water consumption in a pulp and paper mill, the generation of wastewater is also enormous in quantity. Effluent color is also used as an indicator in quantitative terms of pollution strength. The prime objective of present study is to assess the effectiveness various coagulants and flocculants for the treatment of paper and pulp industry effluent color removal. Jar tests of Paper and pulp industry effluent are carried out for effluent from a Bansi paper and pulp industry Sangli. Zeta potential is measured by highly advanced instrument Zeta meter 4.0, absorbance by UV spectrophotometer and turbidity by Hatch Turbidity meter. For treatment of paper and pulp industry effluent commercial coagulant Polyamine Micro plus is found to be most efficient giving efficiency as high as 83.41% at 311nm, at that efficiency zeta potential was -10.57mV(most near to zero amongst all).*

1. INTRODUCTION

Pulp and paper mill effluent are considered as one of the most polluting streams because of the presence of several persistent and recalcitrant substances. Because of the high water consumption in a pulp and paper mill, the generation of wastewater is also enormous in quantity. The paper industry requires large volumes of process water of high purity and generates equally large volumes of waste water from digestion process, which is highly colored .Such colored waste water are unfit for recycling proper treatment.

Coagulation/ Flocculation are widely used for wastewater treatment, as it is efficient and simple for application. Aluminum and iron salts are widely used as coagulants in water and wastewater treatment for removing a broad range of impurities from effluent, including colloidal particles and dissolved organic substances. Many factors affect the process of coagulation and flocculation. They are pH, alkalinity, and zeta potential, dose of coagulant and use of polyelectrolyte. If they are managed to optimum ranges better efficiency can be achieved Therefore the colour removal of paper mill waste in essential for minimizing environmental impacts of it.Further is also necessary to remove colour in order to recycle the treated waste water.

2. COAGULATION AND FLOCCULATION

Coagulation is the process of destabilizing colloidal particles so that particle growth can occur as a result of collisions. A coagulant is the chemical that added to destabilize the colloidal particles in wastewater so that floc formation can result. Flocculation is used to describe the process whereby the size of particle increases as a result of particle collision. A flocculants is a chemical, typically organic in nature added to enhance the flocculation process. The addition of some common coagulants to a wastewater is not only beneficial for colloids removal but also results in precipitation of soluble compounds such as phosphates that can be present in wastewater. Commonly used inorganic coagulants are Aluminum salts (alum), Ferric and ferrous salts, Lime. Prehydrolised metal salts like Polyaluminum chloride (PACl). Organic polymers like cationic polymers, anionic and non-ionic polymers.

3. MATERIALS AND METHODS

2.1 *Colored effluent*: - The colored effluent for experiments was received from ‘Bansi Pulp and Paper Industry’, Sangli. The effluent collected from deinking unit.

2.2 *Coagulants:* - Inorganic coagulants- Alum, Ferrous Sulfate ($FeSO_4$), Magnesium Sulfate ($MgSO_4$), Polyaluminum Chloride (PAC) each of 5% strength and a commercial coagulant Polyamine Microplus (Provided by Micro and Megamoles ltd. Pune) are used for experimentation.

2.3 Commercial cationic polyelectrolyte supplied by Thermax ltd, and commercial anionic polyelectrolyte supplied by Micro and Megamoles ltd. Pune (Animol 152)

2.4 *Measurement of Zeta potential*: - Zeta meter 4.0 is equipment manufactured by Zeta-Meter, Inc. 765 Middlebrooks Avenue, USA is used for zeta potential measurement.

2.5 *Color measurement*: - Absorbance mechanism (Maxima absorbance) is used for color measurement. UV spectrophotometer (DR 5000) manufactured by HACH is used.

2.6 *Jar tests for Paper and Pulp Industry Effluent:* - Jar test apparatus is used for coagulation- flocculation and settling of paper Industry effluent. Presently industry is treating effluent with Lime, $FeSO_4$ and commercial anionic polyelectrolyte at 9 pH. "Theoretically if the Zeta Potential is reduced to near zero (+/- 5mV) the repulsive forces are so reduced that the particles will tend to agglomerate and with continued agitation, will become large enough to settle" jar tests were carried out using above mentioned coagulants along with both cationic and anionic polyelectrolytes. .

Jar test apparatus is used to perform coagulation and flocculation reactions. Initially jar tests were carried out to determine which coagulant is most effective in removing color. The experiments were designed to determine optimum coagulant dose. Then optimum dose was kept constant and coagulants were varied to determine which coagulant offers maximum color removal efficiency at that dose. Each coagulant was tested along with both cationic and anionic polyelectrolyte and at varying pH. Once optimum dose, efficient coagulants and flocculants were determined then further jar tests were carried out to examine effectiveness of coagulant aids.

Fig. 1: Zeta Meter

4. RESULTS AND DISCUSSION

4.1 Jar test with using various coagulants and cationic polyelectrolyte

Sr. No	Coagulants	ZP Initial (mV)	ZP Final (mV)
1.	Alum	-39	-29.04
2.	Ferrous Sulphate	-39	-38.78
3.	Magnesium Sulphate	-39	-38
4.	Polyaluminum Chloride	-39	-28
5.	Polyamine Microplus	-39	-18.09

Absorbance Initial(368 nm)	Absorbance Final(368 nm)	Color removal efficiency %
3.698	1.5	60.5
3.698	3.396	10.74
3.698	3.501	7.820
3.698	1.907	49.79
3.698	0.750	80.25

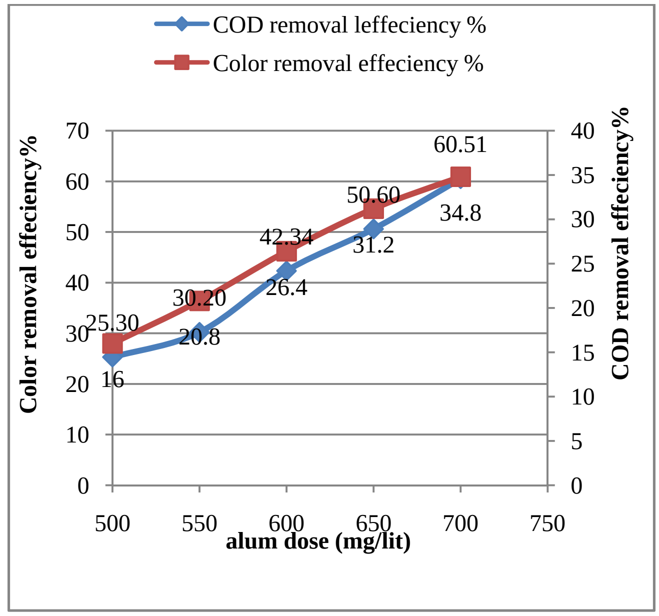

Fig. 4.1: Alum dose with cationic polyelectrolyte (500mg/l to 650mg/l) vs. Color removal efficiency and COD removal efficiency

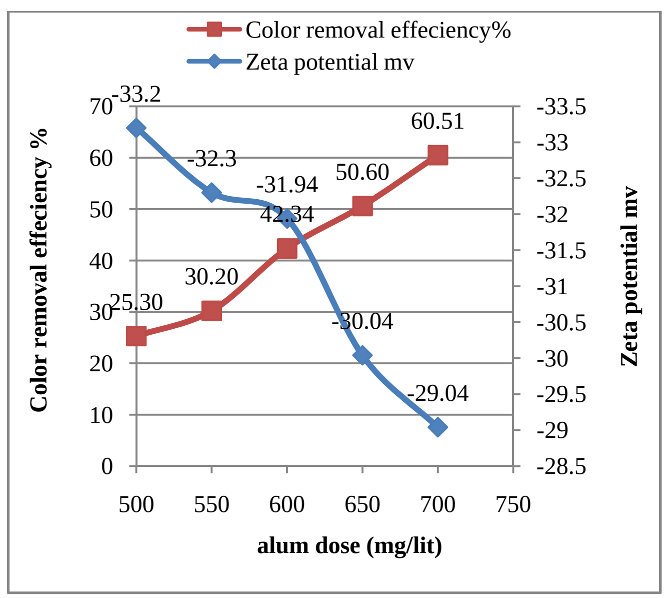

Fig. 4.2: Alum dose with cationic polyelectrolyte (500mg/l to 650mg/l) vs. Color removal efficiency and Zeta Potential

Fig. 4.1 shows results for jar tests, carried out using doses of alum along with cationic polyelectrolyte. With the dose 500 mg/l color removal found 25.30%at 368nm.Further when the dose was increased to 550 mg/l, color removal was increased to 30.20% and finally with the dose 700 mg/l efficiency observed was 61.50 %. Color removal more than 50% was found at higher doses thus COD was measured after coagulation flocculation and settling. Fig 4.1 shows COD removal efficiency for the dose 500mg/l was16 %. Further at the dose 550mg/l COD was reduced by 20.8%. At the dose 700 mg/l COD removal efficiency was 34.8%.

Fig. 4.2 shows results for jar tests, carried out using doses of alum along with cationic polyelectrolyte. With the dose 500 mg/l color removal found 25.30% at 368nm. The dose 700 mg/l efficiency observed was 61.50 %. The Zeta potential is measured at the dose of 500 mg/lit is -33.2 mv and reduced up to the dose of 700 mg/lit is -29.04mv.

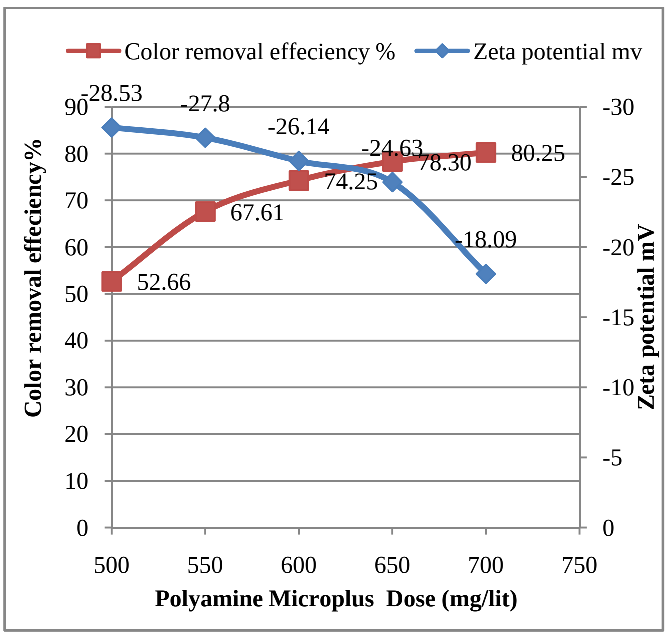

Fig. 4.3: Polyamine microplus with cationic polyelectrolyte dose (500mg/l to 650mg/l) vs. Color removal efficiency and Zeta Potential

Fig. 4.3 shows results for jar tests, carried out using doses of Polyamine microplus along with cationic polyelectrolyte. With the dose 500 mg/l color removal found 49.84%at 368nm. The dose 700 mg/l efficiency observed was 78.94%. The Zeta potential is measured at the dose of 500 mg/lit is -29.mv and reduced up to the dose of 700 mg/lit is -18.20mv

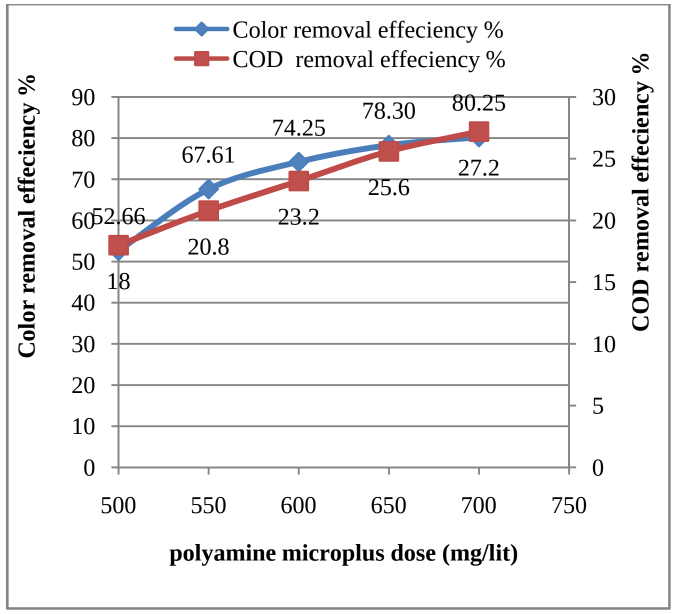

Fig. 4.4: Polyamine microplus with cationic polyelectrolyte dose (500mg/l to 650mg/l) vs. Color removal efficiency and COD removal efficiency

Fig. 4.4 shows results for jar tests, carried out using doses of Polyamine microplus along with cationic polyelectrolyte. With the dose 500 mg/l color removal found 52.66%at 368nm.Further when the dose was increased to 550 mg/l, color removal was increased to 67.61% and finally with the dose 700 mg/l efficiency observed was 80.20 %. Color removal more than 50% was found at higher doses thus COD was measured after coagulation flocculation and settling. Fig 4.4 shows COD removal efficiency for the dose 500mg/l was18 %. Further at the dose 550mg/l COD was reduced by 208 %. At the dose 700 mg/l COD removal efficiency was 27.2%.

4.2 Jar test with using various coagulants and anionic polyelectrolyte

Sr. No	Coagulants	ZP Initial (mV)	ZP Final (mV)
1.	Alum	-39	-29.58
2.	Ferrous Sulphate	-39	-38.8
3.	Magnesium Sulphate	-39	-38
4.	Polyaluminum Chloride	-39	-28.63
5.	Polyamine Microplus	-39	-18.20

Absorbance Initial(368 nm)	Absorbance Final(368 nm)	Color removal efficiency %
3.698	1.591	57.87
3.698	3.456	9
3.698	3.699	7.45
3.698	1.916	49.55
3.698	0.8	78.94

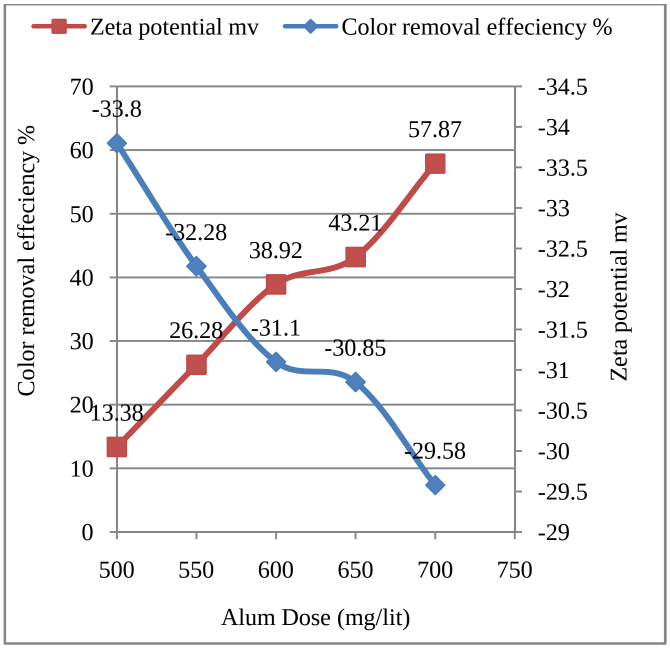

Fig. 4.5: Alum dose (500mg/l to 650mg/l) vs. Color removal efficiency and Zeta Potential

Fig. 4.5 shows results for jar tests, carried out using doses of alum along with anionic polyelectrolyte. With the dose 500 mg/l color removal found 25.30%at 368nm. The dose 700 mg/l efficiency observed was 61.50 %. The Zeta potential is measured at the dose of 500 mg/lit is -33.8mv and reduced up to the dose of 700 mg/lit is -29.58mv.

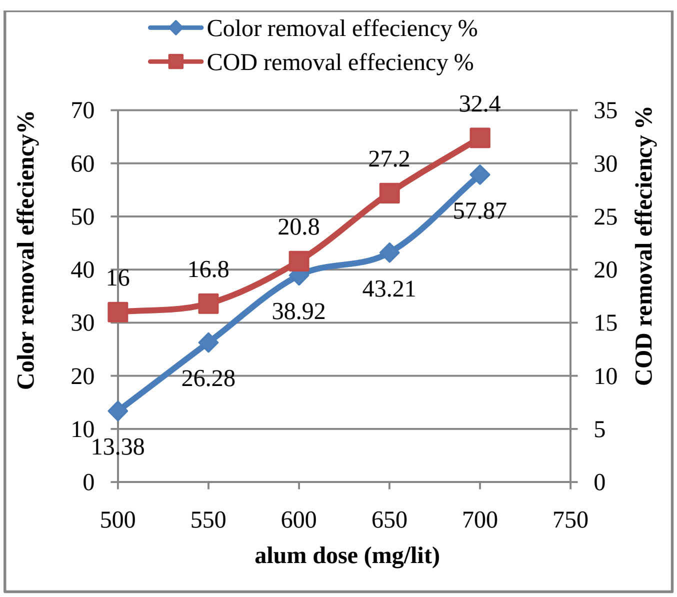

Fig. 4.6: Alum dose with anionic polyelectrolyte (500mg/l to 650mg/l) vs. Color removal efficiency and COD removal efficiency

Fig. 4.6 shows results for jar tests, carried out using doses of alum along with anionic polyelectrolyte. With the dose 500 mg/l color removal found 13.38 %at 368nm.Further when the dose was increased to 550 mg/l, color removal was increased to 26.28 % and finally with the dose 700 mg/l efficiency observed was 57.87%. Color removal more than 50% was found at higher doses thus COD was measured after coagulation flocculation and settling. Fig 3.1 shows COD removal efficiency for the dose 500mg/l was 16%. Further at the dose 550mg/l COD was reduced by 16.8%. At the dose 700 mg/l COD removal efficiency was 32.4%.

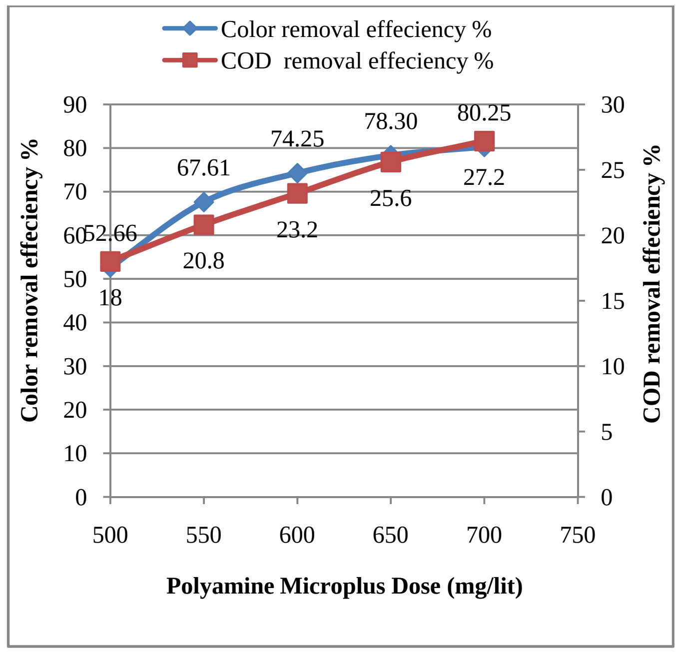

Fig.4.7 Polyamine microplus with anionic polyelectrolyte dose (500mg/l to 650mg/l) vs. Color removal efficiency and COD removal efficiency

Fig. 4.7 shows results for jar tests, carried out using doses of Polyamine microplus along with cationic polyelectrolyte. With the dose 500 mg/l color removal found 52.66%at 368nm.Further when the dose was increased to 550 mg/l, color removal was increased to 67.61% and finally with the dose 700 mg/l efficiency observed was 80.20 %. Color removal more than 50% was found at higher doses thus COD was measured after coagulation flocculation and settling. Fig 4.7 shows COD removal efficiency for the dose 500mg/l was18 %. Further at the dose 550mg/l COD was reduced by 20.8 %. At the dose 700 mg/l COD removal efficiency was 27.2%.

Fig. 4.8 shows results for jar tests, carried out using doses of Polyamine microplus along with cationic polyelectrolyte. With the dose 500 mg/l color removal found 49.84%at 368nm. The dose 700 mg/l efficiency observed was 78.94%. The Zeta potential is measured at the dose of 500 mg/lit is -29.mv and reduced up to the dose of 700 mg/lit is -18.20mv.

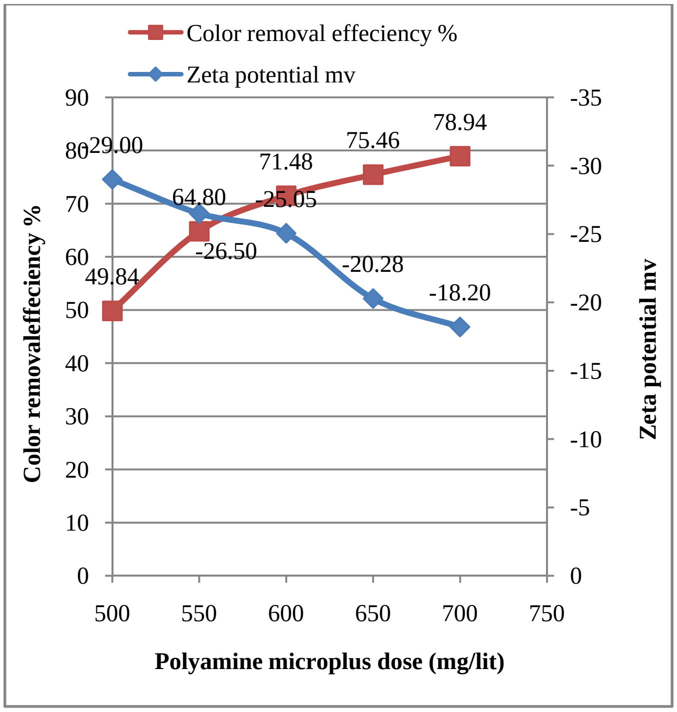

Fig. 4.8: Polyamine micro plus with anionic polyelectrolyte dose (500mg/l to 650mg/l) vs. Color removal efficiency and Zeta Potential.

5. CONCLUSION

Polyamine Microplus is found to be the most effective. Efficiency for color removal with use of Polyamine Microplus is more than 80% at each operating condition

6. ACKNOWLEDGEMENTS

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