Effective Decolourisation of Pulp & Paper Industries Effluen By Using Chemical Treatment with Ferric Alum, Ferric Chloride & Anionic Polymer

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The dosage of Ferric Alum for the coagulation and sedimentation of suspended solids and color present in effluent varies from 100 to 1000 ppm depends on the color and suspended solids of the mill untreated effluent. Self-generation of the sludge due to the low purity Alum is high. Coagulation and sedimentation studies revealed that Ferric chloride an alternate coagulant economically available as a by-product and suitable in place of Alum. Ferric Alum consumption was 3 - 4 times higher than the consumption of Ferric Chloride. Anionic polymer (0.5 ppm) can be used for better performance of coagulation and sedimentation of suspended solids and color reduction along with the dosage of Ferric alum. By using the anionic polymer along with Ferric alum can reduce not only the consumption of Ferric alum by 50 % but also significant reduction in color and Total suspended solids

INTRODUCTION

Color removal technique from pulp & paper industrial effluent has been a subject of study in the last few decades. Pulp & paper industry is one of the highly polluting industries. The wastewater from this industry has very high proportion of organic pollutant and significant color loads. Presently color reduction in industrial effluents has become a prominent issue due to increasing social awareness, changes in local regulations and aesthetic considerations. The color in a large integrated pulp & paper industrial effluent is mainly due to lignin and its derivatives. Principal colloidal color bodies include tannins, humic acids and humates from the decomposition of lignin. These lignin derivatives are highly colored and quite resistant to biological attack resulting in their long persistence in the environment. Lignin and its derivatives impart an offensive color, which inhibit the natural process of photosynthesis in the stream due to absorbency of sunlight, this affects the whole aquatic ecosystem adversely. The large volume effluents contain both dissolved organic and inorganic solids along with a high chloride content. These properties rule out disposal by evaporation and subsequent incineration in the recovery furnace. Therefore a number of internal and external techniques have been developed to reduce these pollutants (1)

The coloring body present in pulp and paper mills effluent is comprised of wood extractives, lignin and its degradation products formed which is organic in nature, the chromophore groups which generally absorb ultra-violet (UV) light through their functional groups having excess electrons such as the C=C, -C=C-, six carbon atomic rings, nitro, sulfur, and oxygen containing groups hand heterocyclic compounds containing oxygen, nitrogen or sulfur as a member of cyclic ring. Those compounds, which absorb light in a visible range also contain the same high electron density functional groups, but usually arranged in a long chain. The length of the chain and the nature of the electron rich group dictate the shade of the color. Cleavage of one of these groups breaks the molecular chain and generally shifts the color from the visible spectrum to either UV or IR range (9).

Color in pulp & paper mills results from operations of pulping stages, washing stages, bleaching stages, spillovers & leakage. Two different approaches can be followed to eliminate the problem of effluent color. This includes, Process improvement and modification method to control the generation of these highly colored components and end of pipe treatment methods.

END OF PIPE TREATMENT METHODS

Various EOP treatment options, which have been tried, are confined to bleach effluents only. These methods included physico - chemical

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treatment method, physical separation method, UV irradiation methods, biological method etc. Lime treatment, coagulation, adsorption using activated carbon & polymeric adsorbent, membrane separation processes and biological treatment using white rot fungus, etc. have been suggested. Chemical treatment methods include various lime treatment methods, coagulation methods, oxidative treatment, radiation methods, and electro-chemical methods.

Color in pulp & paper effluent generally exists as negatively charged colloidal particles due to which, removal can occur by coagulation with the aid of trivalent or divalent salts such as Ca, Fe, or Al or by addition of cationic-type organic polymers. Treatment of negatively charged particles begins with neutralizing the charge to allow particles to bond onto larger and larger particle structures until removal by sedimentation can be achieved. The first part of the process, the charge neutralization is called 'flocculation'. The disadvantages of these systems are necessity to maintain absolute pH control and problems encountered in sludge handling.

The role of $Al_2(SO_4)_3$ or iron salts $FeCl_3$ or $Fe_2(SO_4)_3$ can be described as that of both flocculating and precipitating agents. Though the use of alum for color removal is relatively cheaper, sludge is difficult to handle and cannot be disposed of directly as landfill. $Al_2(SO_4)_3$ as well as $Fe_2(SO_4)_3$ or $FeCl_3$ are inefficient in removing the color at lower ranges. In case of $Fe_2(SO_4)_3$ or $FeCl_3$ increasing the dosage level in an effort to promote the color removal efficiency may actually increase the color level. This yellow iron compounds will impart a color to water if used in higher concentration levels (9).

Alum and ferric salts have been tried in lignin removal Mittal & Mehrotra 1981 showed that an alum dose of 245 mg/lit. And clay of 500 mg/lit reduced the color by 95%. Thickened sludge is obtained on coagulating color by alum and clay. Optimum alum dose needed to decolorize waste is reduced by lowering the pH of the waste (2). Fuller 1971 has patented a process for alum precipitation of effluent color after secondary treatment in the presence of alum mud (3). Thickened sludge is blended with primary and secondary sludge and dewatered to 30-40% solids in pressure filters before incineration in a multiple hearth furnace. Recovery of alum for reuse is accomplished through acidification with sulphuric acid. Over 90% decolourisation is achieved (4). Work on alum and polymer treatment of individual waste stream has been reported (5). The streams tested were unbleached Kraft effluents, screen room effluent, bleach Kraft effluent and spill overflows consisting largely of pulping liquor. The results of these studies were that alum coagulation and settling removed 81-93% of the color. Sludge dewatering was enhanced considerably by acidification of the sludge to a pH of 2 to 5 and heating to 80°C. Timpe et al 1973 reported color removal from caustic extraction effluent by aluminium chloride, aluminium sulphate and ferric sulphate. Polyelectrolytes and silica were added in some trials. It was found that neither silica nor organic polyelectrolytes had any significant effect on color removal but promoted flocculation and settling.

Christman and Smith 1969 (6) reported that coagulation of Kraft wastes with alum and ferric chloride resulted in a dense rapidly settling coagulum. Optimum pH was found to be 3.9 for ferric chloride and 5.3 for alum where as optimum dose was found to be a linear function of the initial color. At optimum pH and dose 92% and 95% color removal was achieved by alum and ferric chloride respectively. Olthof and Eckenfelder 1975 (7) described the results of the laboratory coagulation studies that the use of Iron salts for color removal from pulp & paper mill waste treatment can be an attractive alternative for lime treatment as the dose of the Iron salts required is only 25-33% of the lime dosage. Polyethylene oxide has been tried and reported to be promising at jar test level (8). From the available information it can be concluded that since the waste volume is large and highly colored, large quantities of coagulants will be required. Adjustment of pH prior to chemical treatment will also be necessary. Further the sludge obtained will offer problems of dewatering and disposal.

Certain organic polymers such as polyamines have been used to precipitate color from effluents. The Mixed Liquor Suspended Solids (MLSS) present in secondary clarifiers do not seem to interfere with the precipitation of color bodies. With a 600-mg/l-polyamine dosage, more than 85% color reduction can be achieved in bleach plant effluent. On the hand, alum dosages of 600 mg/l brought about 54% reduction in color. Precipitation of color bodies using polyamines was more effective than alum but more expensive. Again sludge handling and disposal poses problem in both. (9).

Presently pulp & paper mills are using 13.0 % Ferric Alum for the coagulation and sedimentation of suspended solids and color present ineffluent. The dosage of Ferric Alum varies from 100 to 1000 ppm depends on the color and suspended solids of the mill untreated effluent. The cost of Ferric Alum is getting increased. Self-generation of the sludge due to the low purity Alum is high. Color reduction studies were carried out with Ferric chloride an alternate coagulant economically available as a by-product and suitable in place of Alum. Color reduction studies were also conducted to reduce the existing consumption of Ferric Alum, by using anionic polymer along with Ferric Alum.

EXPERIMENTS

STUDY 1 - FERRIC CHLORIDE & FERRIC ALUM TREATMENT IN MILL UNTREATED EFFLUENT

Coagulation using Ferric chloride and

Ferric alum 5.0-gpl solution of Ferric Chloride and 10.0-gpl solutions of 13.0 % Ferric Alum was prepared. Four different mill untreated effluent samples were collected at different time intervals. The initial colors of the mill untreated effluent samples were 350 ppm, 550 ppm, 650 ppm, and 750 ppm. Due to wide variation in the initial color of the mill untreated effluent Different dosages were given with Ferric Chloride and Ferric Alum separately through Jar test method (1000 ml). 30 minutes settling time was given for each test. After settling the sludge, the sludge volume was measured and the supernatant was filtered through Whatman filter paper No.3. For the filtrate, pH, color, Total Dissolved Solids, Chlorides & Chemical Oxygen Demand were analyzed. The same tests were carried out for the Blank (untreated) also. The results were given in Table- 1, 2, 3 & 4.

STUDY 2 - ANIONIC POLYMER TREATMENTS WITH FERRIC ALUM IN MILL UNTREATED EFFLUENT

10.0 gpl solution of 13.0 % Ferric Alum & 0.1 gpl of Anionic polymer were prepared. The initial color of the effluent was 620 ppm. Polymer optimization study was conducted from the dosage of 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 & 1.0 ppm with the fixed dosage of 300 ppm Ferric Alum and the results were given in Table 1. Four different mill untreated effluent samples were collected at different time intervals. The initial colors of the mill untreated effluent samples were 400 ppm, 460 ppm, 550 ppm, and 750 ppm. Due to wide variation in the initial color of the mill untreated effluent, different dosages were given with Ferric Alum along with the optimized dosage of Anionic polymer at the rate of 0.5 ppm separately through Jar test method (1000 ml). 30 minutes settling time was given for each test. After settling the sludge, the sludge volume was measured and the supernatant was filtered through Whatman filter paper No.3. For the filtrate, pH, color, Total Dissolved Solids, Chlorides &

TABLE - 1

MILL UNTREATED EFFLUENT

FERRIC CHLORIDE TREATMENT WITH 100 ppm DOSAGE

	units	BLANK	FERRIC CHLORIDE					FERRIC ALUM				
	ppm		20	40	60	80	100	100	150	200	250	**300**
Sludge volume(30min)	ml	**Nil**	20	30	50	70	**80**	25	30	80	80	**80**
pH		**7.0**	7.0	7.0	6.9	6.8	**6.8**	7	6.9	6.9	6.8	**6.8**
Colour in Pt.Co units	ppm	**350**	320	290	260	210	**190**	330	300	280	240	**200**
Colour Reduction	%		8.6	17.1	25.7	40.0	**45.7**	5.7	14.3	20.0	31.4	**42.9**
Total dissolved solids	ppm	**2250**	2200	2120	2060	2020	**1980**	2200	2175	2150	2125	**2100**
TDS Reduction	%		2.2	5.8	8.4	10.2	**12.0**	2.2	3.3	4.4	5.6	**6.7**
Chlorides as Cl	ppm	**525**	535	540	547	555	**565**	532	535	540	543	**548**
Chlorides increase	%		1.9	2.9	4.2	3.7	**7.6**	1.3	1.9	2.9	3.4	**4.4**
Chemical Oxygen Demand	ppm	**410**	370	350	320	290	**250**	380	360	330	300	**270**
COD Reduction	%		9.8	14.6	22.0	29.3	**39.0**	7.3	12.2	19.5	26.8	**34.1**

TABLE - 2

MILL UNTREATED EFFLUENT

FERRIC CHLORIDE TREATMENT WITH 150ppm DOSAGE

	Units	BLANK	FERRIC CHLORIDE				FERRIC ALUM			
	ppm		100	125	**150**	175	400	500	**600**	700
Sludge volume(30min)	ml	Nil	40	40	**50**	50	70	80	**80**	80
pH		**7.1**	7.1	7.0	**7.0**	7.0	7.1	7.0	**7.0**	7.0
Colour in Pt.Co units	ppm	**550**	425	290	**200**	160	435	310	**220**	185
Colour Reduction	%		22.7	47.3	**63.6**	70.9	20.9	43.6	**60.0**	66.4
Total dissolved solids	ppm	**2100**	2045	1998	**1925**	1912	2085	2064	**2050**	2042
TDS Reduction	%		2.6	4.9	**8.3**	9.0	0.7	1.7	**2.4**	2.8
Chlorides as Cl	ppm	**580**	588	594	**600**	607	580	580	**580**	580
Chlorides increase	%		1.4	2.4	**3.4**	4.7	0.0	0.0	**0.0**	0.0
Chemical Oxygen Demand	ppm	**450**	400	365	**310**	290	410	375	**315**	300
COD Reduction	%		11.1	18.9	**31.1**	35.6	8.9	16.7	**30.0**	33.3

TABLE - 3

MILL UNTREATED EFFLUENT

FERRIC CHLORIDE TREATMENT WITH 200ppmDOSAGE

	Units	BLANK	FERRIC CHLORIDE				FERRIC ALUM			
	ppm		50	100	150	**200**	400	500	600	**700**
Sludge volume(30min)	ml	**Nil**	20	30	50	**50**	60	70	80	**80**
pH		**7.2**	7.2	7.2	7.1	**7.0**	7.1	7.1	7.1	**6.9**
Colour in Pt.Co units	ppm	**650**	610	425	375	**300**	460	400	380	**320**
Colour Reduction	%		6.2	34.6	42.3	**53.8**	29.2	38.5	41.5	**50.8**
Total dissolved solids	ppm	**2200**	2100	2010	1980	**1780**	2180	2170	2160	**2155**
TDS Reduction	%		4.5	8.6	10.0	**19.1**	0.9	1.4	1.8	**2.0**
Chlorides as Cl	ppm	**600**	603	607	612	**614**	600	600	600	**600**
Chlorides increase	%		0.5	1.2	2.0	**2.3**	0.0	0.0	0.0	**0.0**
Chemical Oxygen Demand	ppm	**525**	475	425	365	**335**	490	450	375	**340**
COD Reduction	%		9.5	19.0	30.5	**36.2**	6.7	14.3	28.6	**35.2**

TABLE - 4

MILL UNTREATED EFFLUENT

FERRIC CHLORIDE TREATMENT WITH 200ppm DOSAGE

	Units	BLANK	FERRIC CHLORIDE					FERRIC ALUM				
	ppm		100	125	150	175	200	300	500	600	700	800
Sludge volume(30min)	ml	**Nil**	70	75	75	80	**80**	60	70	70	80	**80**
pH		**7.4**	7.3	7.2	7.2	7.1	**7.1**	7.2	7.2	7.1	7.1	**7.0**
Colour in Pt.Co units	ppm	**750**	450	425	400	375	**350**	470	450	430	410	**370**
Colour Reduction	%		40.0	43.3	46.7	50.0	**53.3**	37.3	40.0	42.7	45.3	**50.7**
Total dissolved solids	ppm	**2325**	2300	2268	2225	2194	**2175**	2290	2245	2202	2185	**2185**
TDS Reduction	%		1.1	2.5	4.3	5.6	**6.5**	1.5	3.4	5.3	6.0	**6.0**
Chlorides as Cl	ppm	**650**	653	658	661	665	**670**	650	650	650	650	**650**
Chlorides increase	%		0.5	1.2	1.7	2.3	**3.1**	0.0	0.0	0.0	0.0	**0.0**
Chemical Oxygen Demand	ppm	**700**	650	600	525	475	**425**	660	610	550	490	**450**
COD Reduction	%		7.1	14.3	25.0	32.1	**39.3**	5.7	12.9	21.4	30.0	**35.7**

TABLE - 5

POLYMER OPTIMIZATION WITH FERRIC ALUM FOR MILL UNTREATED EFFLUENT

Particulars	units	BLANK	POLYMER DOSAGE OPTIMIZATION										
Ferric Alum	ppm	**0.0**	300	300	300	300	300	**300**	300	300	300	300	300
Anionic Polymer	ppm	**0.0**	0.0	0.1	0.2	0.3	0.4	**0.5**	0.6	0.7	0.8	0.9	1.0
Sludge volume settled in 30 minutes	ml	**Nil**	30	30	35	35	35	**40**	40	40	40	45	45
pH		7.3	7.1	7.1	7.1	7.1	7.1	**7.1**	7.1	7.1	7.1	7.1	7.1
Colour in Pt.Co units	ppm	**620**	330	310	270	230	200	**200**	190	190	180	180	180
Colour Reduction	%		46.8	50.0	56.5	62.9	67.7	**67.7**	69.4	69.4	71.0	71.0	71.0
Total Solids	ppm	**2710**	2560	2502	2420	2380	2290	**2220**	2190	2190	2190	2190	2190
TS reduction	%		5.5	7.7	10.7	12.2	15.5	**18.1**	19.2	19.2	19.2	19.2	19.2
Total Dissolved Solids	ppm	**2200**	2190	2175	2165	2160	2155	**2155**	2150	2150	2150	2150	2150
TDS reduction	%		0.5	1.1	1.6	1.8	2.0	**2.0**	2.3	2.3	2.3	2.3	2.3
Suspended Solids	ppm	**510**	370	327	255	220	135	**65**	40	40	40	40	40
SS reduction	%		27.5	35.9	50.0	56.9	73.5	**87.3**	92.2	92.2	92.2	92.2	92.2
Chlorides as Cl	ppm	**610**	610	610	610	610	610	**610**	610	610	610	610	610
Chlorides decrease	%		0.0	0.0	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0

TABLE - 6

UNTREATED MILL EFFLUENT

SAMPLE - 1 WITH COLOR 400 Pt.Co units

Particulars	units	BLANK	FERRIC ALUM				FERRIC ALUM + 0.5 ppm Anionic polymer			
Ferric Alum	ppm		100	200	300	**400**	100	200	300	**400**
Anionic Polymer	ppm	**0.0**	0.0	0.0	0.0	**0.0**	0.5	0.5	0.5	**0.5**
Sludge volume settled in 30 minutes	ml	Nil	20	30	40	**50**	25	35	50	**60**
pH		**7.5**	7.4	7.3	7.3	**7.2**	7.4	7.3	7.3	7.2
Colour in Pt.Co units	ppm	**400**	265	215	175	**160**	245	200	150	**135**
Colour Reduction	%		33.8	46.3	56.3	**60.0**	38.8	50.0	62.5	**66.3**
Total Solids	ppm	**2690**	2440	2252	2175	**2065**	2230	2160	2060	**1990**
TS reduction	%		9.3	16.3	19.1	**23.2**	17.1	19.7	23.4	**26.0**
Total Dissolved Solids	ppm	**2165**	2080	2050	2025	**1985**	2090	2070	2030	**1975**
TDS reduction	%		3.9	5.3	6.5	**8.3**	3.5	4.4	6.2	**8.8**
Suspended Solids	ppm	**525**	360	202	150	**80**	140	90	30	**15**
SS reduction	%		31.4	61.5	71.4	**84.8**	73.3	82.9	94.3	**97.1**
Chlorides as Cl	ppm	**525**	525	525	525	**525**	525	525	525	**525**
Chlorides increase	%		0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**

Chemical Oxygen Demand were analyzed. The same tests were carried out for the Blank (untreated) also.The results were given in Table- 2, 3, 4 & 5.

Sludge volume was measured from the graduation in the measuring cylinder. pH was measured in the Digital pH meter. Color was measured in the Spectrophotometer. Total dissolved solids were measured by Evaporation method. Chloride was measured by indicative titration method. (Mercuric Nitrate, Diphenyl carbazone & Nickel nitrate buffer). Chemical Oxygen Demand was measured by Oxidative Reduction method. (Potassium Dichromate, Ferrous Ammonium Sulphate and Ferroin indicator)

RESULTS AND DISCUSSION

Study 1 - Ferric Chloride: From the Table 1, it was observed that for the low color effluent (color of 350 Pt. Co units), the optimum dosage of Ferric chloride was 100 ppm and for Ferric Alum 300 ppm. Color reduction of 45.7 % & 42.9 %, TDS Reduction of 12.0 % & 6.7 % COD reduction of 39.0 % & 34.1 % for Ferric Chloride and Ferric Alum respectively and Chloride increase of 7.6 % were observed only for Ferric Chloride.

From the Table 2, it was observed that for the high color effluent (color of 550 Pt. Co units), the optimum dosage of Ferric chloride was 150 ppm and for Ferric Alum 600 ppm. Color reduction of 63.6 % & 60.0 %, TDS Reduction of 8.3 % & 2.4 %, Chloride increase of 3.4 % & 0.00 %, and COD reduction of 31.1 % & 30.0% were observed for Ferric Chloride and Ferric Alum respectively.

From the Table 3, it was observed that for the high color effluent (color of 650 Pt. Co units), the optimum dosage of Ferric chloride was 200 ppm and for Ferric Alum 700 ppm. Color reduction of 53.8 % & 50.8 %, TDS Reduction of 19.1 % & 2.0 %, Chloride increase of 2.0 % & 0.00 % and COD reduction of 30.5 % & 28.6% were observed for Ferric Chloride and Ferric Alum respectively.

TABLE - 7

UNTREATED MILL EFFLUENT

SAMPLE - 2 WITH COLOR 460 Pt.Co units

Particulars	units	Blank	FERRIC ALUM				FERRIC ALUM + 0.5 ppm Anionic polymer			
Ferric Alum	ppm	0.0	100	200	400	500	100	200	400	500
Anionic polymer	ppm	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5
Sludge volume settled in 30 minutes	ml	Nil	5	10	20	25	10	20	30	35
pH		7.6	7.5	7.4	7.0	6.8	7.5	7.4	7.0	6.8
Colour in Pt.Co units	ppm	460	300	275	225	200	250	225	200	175
Colour Reduction	%		34.8	40.2	51.1	56.5	45.7	51.1	56.5	62.0
Total Solids	ppm	2640	2488	2388	2242	2206	2456	2306	2252	2194
TS reduction	%		5.8	9.5	15.1	16.4	7.0	12.7	14.7	16.9
Total dissolved solids	ppm	2200	2124	2188	2164	2136	2194	2200	2208	2154
TDS Reduction	%		3.5	0.5	1.6	2.9	0.3	0.0	-0.4	2.1
Suspended Solids	ppm	440	364	200	78	70	262	106	44	40
SS reduction	%		17.3	54.5	82.3	84.1	40.5	75.9	90.0	90.9
Chlorides as Cl	ppm	564	564	564	564	564	564	564	564	564
Chlorides increase	%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE - 8

UNTREATED MILL EFFLUENT

SAMPLE - 3 WITH COLOR 550 Pt.Co units

Particulars	units	BLANK	FERRIC ALUM				FERRIC ALUM + 0.5 ppm Anionic polymer			
Ferric Alum	ppm		100	200	300	400	100	200	300	400
Anionic Polymer	ppm	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5
Sludge volume settled in 30 minutes	ml	0	5	10	20	30	10	20	30	35
pH		7.5	7.4	7.4	7.3	7.2	7.4	7.3	7.3	7.2
Colour in Pt.Co units	ppm	550	460	350	220	190	440	330	180	160
Colour Reduction	%		16.4	36.4	60.0	65.5	20.0	40.0	67.3	70.9
Total Solids	ppm	2320	2120	2065	1980	1950	2080	1970	1850	1845
TS reduction	%		8.6	11.0	14.7	15.9	10.3	15.1	20.3	20.5
Total Dissolved Solids	ppm	1790	1780	1772	1785	1785	1775	1780	1785	1785
TDS reduction	%		0.6	1.0	0.3	0.3	0.8	0.6	0.3	0.3
Suspended Solids	ppm	530	340	293	195	165	305	190	65	60
SS reduction	%		35.8	44.7	63.2	68.9	42.5	64.2	87.7	88.7
Chlondes as Cl	ppm	575	575	575	575	575	575	575	575	575
Chlorides reduction	%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE - 9

MILL UNTREATED EFFLUENT

SAMPLE - 4 WITH COLOR 750 Pt.Co units

Particulars	units	BLANK	FERRIC ALUM				FERRIC ALUM + 0.5 ppm Anionic polymer			
Ferric Alum	ppm		100	200	300	400	100	200	300	400
Anionic polymer	ppm	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5
Sludge volume settled in 30 minutes	ml	Nil	10	15	20	20	15	25	30	35
pH		7.7	7.4	7.4	7.2	7.2	7.5	7.4	7.4	7.2
Colour in Pt.Co units	ppm	750	640	460	375	350	610	440	340	300
Colour Reduction	%		14.7	38.7	50.0	53.3	18.7	41.3	54.7	60.0
Total Solids	ppm	2544	2410	2340	2260	2206	2260	2080	2040	2020
TS reduction	%		5.3	8.0	11.2	13.3	11.2	18.2	19.8	20.6
Total Dissolved Solids	ppm	2010	2000	2000	2000	2000	2005	2000	2000	2005
TDS reduction	%		0.5	0.5	0.5	0.5	0.2	0.5	0.5	0.2
Suspended Solids	ppm	534	410	340	260	206	255	80	40	15
SS reduction	%		23.2	36.3	51.3	61.4	52.2	85.0	92.5	97.2
Chlorides as Cl	ppm	520	520	520	520	520	520	520	520	520
Chlorides decrease	%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

From the Table 4, it was observed that for the high color effluent (color of 750 Pt. Co units), the optimum dosage of Ferric chloride was 200 ppm and for Ferric Alum 800 ppm. Color reduction of 53.3 % & 50.7 %, TDS Reduction of 6.5 % 6.0 %, Chloride increase of 3.1 % & 0.00 % and COD Reduction of 39.3 % & 35.7 % were observed for Ferric Chloride and Ferric Alum respectively.

Study - 1 indicates that the consumption of Ferric Chloride was between 100 to 200 ppm and Ferric Alum consumption was 300 to 800 ppm. It clearly indicated that the Ferric Alum consumption was 3 - 4 times higher than the consumption of Ferric Chloride.

Study - 2 Anionic Polymer: From the Table 5, it was observed that the optimized dosage of Anionic polymer for the 620 Pt. Co color effluent was 0.5 ppm. Ferric alum dosage was fixed at 300 ppm. There was only slight reduction in color and suspended solids in the increased dosages above 0.5 ppm of anionic polymer. Further studies were carried out with the fixed anionic polymer dosage of 0.5 ppm for different color level effluent samples collected.

From the Table 6, it was observed that for the effluent (color of 400 Pt. Co units), the optimum dosage of Ferric Alum was 400 ppm with 0.5 ppm of anionic polymer, Color reduction of 66.3 % & 60.0 %, TSS Reduction of 97.1 % & 84.8 % were observed for Ferric Alum with and without polymer dosage respectively.

From the Table 7, it was observed that for the effluent (color of 460 Pt. Co units), the optimum dosage of Ferric Alum was 400 ppm with 0.5 ppm of anionic polymer, Color reduction of 56.5 % & 51.1 %, TSS Reduction of 90.0 % & 82.3 % were observed for Ferric Alum with and without polymer dosage respectively.

From the Table 8, it was observed that for the effluent (color of 550 Pt. Co units), the optimum dosage of Ferric Alum was 400 ppm with 0.5ppm of anionic polymer, Color reduction of 70.9 % & 65.5 %, TSS Reduction of 88.7 % & 68.9 % were observed for Ferric Alum with and without polymer dosage respectively.

From the Table 9, it was observed that for the effluent (color of 750 Pt. Co units), the optimum dosage of Ferric Alum was 400 ppm with 0.5ppm of anionic polymer, Color reduction of 60.0 % & 53.3 %, TSS Reduction of 97.2 % & 61.4 % were observed for Ferric Alum with and without polymer dosage respectively.

Study 2 indicates that the Anionic polymer consumption was optimized at 0.5 ppm with the fixed dosage of Ferric alum 300 ppm. Significant improvement in the color reduction and Total suspended solids reduction were observed at the 50 % reduced Ferric Alum dosage of 400 ppm with Anionic polymer in comparison with the dosage of Ferric Alum 800 ppm without any polymer addition.

CONCLUSION

Since Ferric chloride is available economically similar to Ferric Alum & the dosage of Ferric chloride is lower than Ferric alum, Ferric chloride can be used in-place of Ferric alum for coagulation and sedimentation of suspended solids and color present in mill untreated effluent.

The required Anionic polymer consumption for better performance of coagulation and sedimentation of suspended solids and color was 0.5 ppm with the fixed dosage of Ferric alum 300 ppm. By using the anionic polymer along with Ferric alum can reduce not only the consumption of Ferric alum by 50 % but also significant reduction in color and Total suspended solids

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