Standardisation of Pulp Mill Effluent for Irrigation Purposes

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SUMMARY

The purpose of this study was to standardise water of irrigation quality by mixing grade III effluent from pulp mill and chlorination and hypochlorite stage bleach plant effluent.

Total dissolved inorganic solids, chlorides, sulphates, boron and percent sodium are important parameters which have to be taken into consideration in deciding the usefulness or otherwise of waste water for agricultural purposes.

It was observed that when 2 volume of grade III effluent and one volume of chlorination and hypochlorite effluent from bleach plant were mixed, all the above mentioned parameters come within the limits prescribed in IS : 3307–1965 (Tolerance limits for discharge of industrial effluent on land for irrigation).

INTRODUCTION

Industries are the backbone of economical development of any country. But one of the common drawback of industrialisation is the production of wastes from all most all industries which pollute the environment. Waste treatment and disposal is a big challange before the industries. The best solution of this problem is the utilization of waste materials from the industries.

Pulp and paper industry is one of the largest industry in India today, which consumes huge quantity of water (40,000 to 100,000 gallons of water per ton of paper). As the product does not carry any water, most of the water used in the process reappears as wastewater. Usually this water is discharged into the stream, which pollute the natural water resources. Hence to save our water resources and to permit the industry to expand the discharge of wastewaters into streams should be controlled. If this wastewater can be used for crop irrigation this will serve the nation in two ways. First it will solve the wastewater disposal problem of the industry and second it will give much needed irrigation water for agricultural purposes.

Sewage effluents and domestic wastewaters have been in use in many places and have proved quite satisfactory for crop irrigation. But regarding the utilization of industrial effluents for land irrigation not much information is available. Since the industrial wastewaters may present more of a hazard to plant life due to their higher concentration of soluble salts, much attention has not been paid towards their utilization for crop irrigation. But looking to the limited water resources and increasing industrial pollution, serious attention will have to be paid towards re-utilization of industrial wastewater either for land irrigation or for the industry itself.

Efforts have been done by some paper industries in India to utilize their wastewater for irrigation purpose. Seshasayee Paper and Boards Ltd., Madras is using part of the combined effluent for paddy irrigation, Pudumjee Pulp and Paper Mills Ltd., Maharashtra is supplying their wastewater (after treatment) to farmers for crop irrigation and some other paper mills tried their effluent for Eucalyptus irrigation.

Present investigation have aimed to standardise a mixture of different type of wastewaters coming out from the pulp mill for irrigation purpose. In this study efforts have been made to standardise irrigation water as per IS : 3307-1965 (Tolerance limits for discharge of industrial effluents on land for irrigation).

MATERIAL AND METHOD

Orient Paper Mills, Amlai is an integrated pulp

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and paper mill producing 200 tons of paper per day, using sulphate process. The mill requires about 14 million gallons of fresh water and discharges about 11.5 million gallons of wastewater per day. Wastewater discharged from different sections of the mill have been segregated into three grades:

Grade I— is cooling water which is practically uncontaminated and is reused in the process.

Grade II— this waste is a mixture of wastewater from paper machine, chlorination and hypochlorite stage bleach plant effluent and wastewater from Chipper house. Total volume of this waste is about 7.0 million gallons per day. Out of which 3 to 3.5 million gallons of wastewater is from chlorination and hypochlorite stage from bleach plant.

Grade III— is a mixture of wastewater from pulp washing, digester and recovery sections floor washes, and caustic extraction effluent from bleach plant. The volume of this effluent is 3.5 to 4.0 million gallons per day. This effluent is dark brown in colour with high pH and rich in sodium.

Wastewater from paper machine section is less contaminated and it can be reused in the process itself after some treatment. Hence the present study is concentrated on the acidic effluent of bleach plant (chlorination and hypochlorite stage) and Grade III effluent.

Composite samples of untreated Grade III effluent and chlorination and hypochlorite stage bleach plant effluent were collected on various dates and analysed in the laboratory as per "Standard method for water and wastewater analysis" 12th edition published by APHA and "Text book of Quantitative Analysis" by A.I. Vogal. The parameters studied were—pH, EC (electrical conductivity), BOD, COD, dissolved solids, chloride, sulphate, carbonate, bicarbonate, calcium, magnesium, sodium and potasium. Results are presented in Table-I.

After characterising both the wastewater, Grade III effluent was mixed with chlorination and hypochlorite stage bleach plant effluent in the ratio of 3:1, 2:1 and 1:1, and analysed for the above mentioned parameters. Analysis results are given in Table–III A, B, C and D.

RESULTS AND DISCUSSIONS

Quality of the irrigation water is evaluated on the basis of quantity of dissolved salts and its composition. Salinity or alkali hazards that are likely to develop, depends upon the quality of irrigation water used. The generally accepted criteria for irrigation water and their potential hazards to crop growth are:

1. SALINITY

It comprises due to the high concentration of total soluble salts mostly inorganic in nature. High salinity retards Plant growth, producing smaller plants with fewer and smaller leaves. It is generally expressed in terms of electrical conductivity (E.C.) water with the E.C. of 750-2250 micromohs/cm are widely used for irrigation to get satisfactory crop growth. But water having E.C. above 2250 micromohs/cm are seldom used for crop irrigation.

2. SODICITY (PROPORTION OF SODIUM TO THE OTHER CATIONS)

High sodium percent in irrigation water is harmful to the soil as well as to the Plants. High sodium percent reduces permeability of soil and deteriorate soil structure. Sodium rich water also effect the Plants, such as leaf burning and defaliation have been observed. The sodium percent in irrigation water should be below 60.

3. BORON

For the normal growth of the plant Boron is found to be an essential plant nutrient. But it is required in traces. Boron is found to be very toxic to certain plant species. Boron should be less than 2 mg/l in irrigation water.

4. CARBONATE AND BI-CARBONATE

Presence of appreciable quantity of carbonate and bi-carbonate in irrigation water causes the precipitation of Calcium (Ca) and Magnesium (Mg) as their carbonates and thereby increases the Sodium (Na) percent of the soil water.

Looking to the analysis results presented in Table–I it becomes clear that chlorination and hypochlorite stage bleach plant effluent alone can not be used for irrigation purpose, since it is acidic in nature with pH less than 3.0 and chlorides more than 1000 mg/l. Whereas permissible limits as per I.S: 3307-1965 is pH 5.5 to 9.0 and chlorides less than 600 mg/l. Work on the utilization of Grade III effluent for agriculture purposes has been done by NEERI-Nagpur at Amlai. Although their findings has not been published. But the characteristics of the effluent shows that it can not safely be used for crop irrigation, as it is highly alkaline having pH upto 10.0 and percent sodium is as high as 84, where as permissible limit is only 60 percent.

Results presented in Table–III A, B, C and D

TABLE—1. CHARACTERISTICS OF GRADE III EFFLUENT AND CHLORINATION AND HYPOCHLORITE EFFLUENT FROM BLEACH PLANT

Parameters		Grade III effluent	Chlorination and hypochlorite effluent
pH		8.6–10.0	1.6–3.5
E.C.	milimohs/c.m.	1.5–2.2	3.0–5.8
BOD_5 at 20 °C	mg/l	180–360	80–160
COD	,,	1000–2000	500–800
Dissolved solids	,,	1200–2800	1700–3000
Chlorides (as Cl)	,,	100–300	800–1500
Sulphates (as SO_4)	,,	45–150	35–60
Alkalinity (as $CaCO_3$)	,,	200–600	200–450*
Calcium (Ca)	,,	50–200	600–1100
Magnesium (Mg)	,,	12–60	100–250
Sodium (Na)	,,	300–600	110–180
Potassium (K)	,,	20–40	10–20
Percent Sodium		55–85	16–21.5
S.A.R.		8–18	1.5–2.0

* Refers for acidity.

TABLE—II. TOLERANCE LIMITS FOR DISCHARGE OF INDUSTRIAL EFFLUENTS ON LAND FOR IRRIGATION (IS : 3307-1965)

Characteristics			Tolerance limits
1. pH			5.5–9.0
2. Dissolved solids (inorganic)	mg/l	Max.	2100
3. Sulphates (as SO_4)	,,	,,	1000
4. Chlorides (as Cl)	,,	,,	600
5. Percent sodium		,,	60
6. BOD_5 at 20 °C	mg/l	,,	500
7. Oil & Grease	,,	,,	30
8. Boron (as B)	,,	,,	2

reveals that when Grade III effluent and bleach plant effluent are mixed in the ratio of 2:1 all the required parameters comes within the limits prescribed for irrigation water. pH of the water lie in between 5.6 to 8.0, E.C. 2220 to 2290 micromohs/cm., dissolved solids 1800 to 2100 mg/l, chlorides 532.5 to 610 mg/l, sulphates 60 to 70 mg/l and sodium 43.8 to 55.6 percent. Comparing these results with the specifications presented in Table-II (As per IS : 3307-1965) it becomes clear that all the parameters are within the tolerance limits for discharge of industrial effluents on land for irrigation.

Boron has not been determined since neither the raw-material used nor the chemicals employed in the process contain Boron.

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TABLE—III A. CHARACTERISTICS OF WASTEWATERS AFTER MIXING GRADE III EFFLUENT WITH CHLORINATION & HYPOCHLORITE STAGE BLEACH PLANT EFFLUENT IN DIFFERENT PROPORTIONS

Grade III Effluent + Chlorinations & hypochlorite effluent	pH	Electrical conductivity E.C.	BOD_5	COD	Dissolved solids	Chlorides (as Cl)	Sulphates (as SO_4)	Carbonate (as CaCo3)	Bi-Carbonate (as CaCo3)	Calcium (as Ca)	Magnesium (as Mg)	Sodium (as Na)	Potasium (as K)	Percent Sodium	S.A.R.
		Milimohs/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 : 0	9.4	1.59	220	1232	1600	276.9	65	5	250	56	33.6	440	32	84.0	16.19
3 : 1	7.6	2.13	190	1072	1750	454.4	75	Nil	180	200	57.6	400	26	68.3	9.06
2 : 1	7.0	2.22	190	1000	1800	532.5	60	Nil	10	320	91.2	360	25	55.6	6.42
1 : 1	6.0	2.49	180	1000	1800	646.1	50	Nil	Nil	520	96.0	300	22	42.5	4.45
0 : 1	2.8	4.20	130	572	2000	1065	35	Nil	Nil	832	144.0	130	18	17.0	1.53

TABLE—III B

1 : 0	8.6	1.65	200	1248	2000	300.0	75	Trace	180	200	57.6	360	30	65.6	8.13
3 : 1	6.3	2.13	180	1128	2100	600.6	70	Nil	50	360	81.6	300	26	50.0	5.22
2 : 1	5.6	2.22	170	968	2100	610.0	65	Nil	30	460	86.4	280	23	43.8	4.44
1 : 1	3.7	2.76	153	820	2200	842.0	50	Nil	Nil	626	100.8	240	18	33.9	3.30
0 : 1	2.4	5.8	110	700	2300	1120	35	Nil	Nil	940	124.8	140	14	17.3	1.61

$$\text{Percent Na} = \frac{\text{Na} \times 100}{\text{Na} + \text{K} + \text{Ca} + \text{Mg}}$$

All cations expressed in terms of meq/l.

$$\text{S.A.R.} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca} + \text{Mg}}{2}}}$$

All cations expressed in terms of meq/l.

TABLE—III C

Grade III Effluent + Chlorination Hypochlorite effluent	pH	E.C.	BOD_5	COD	Dissolved solids	Chlorides (as Cl)	Sulphate (as SO_4)	Carbonate (as CaCO3)	Bicarbonate (as CaCO3)	Calcium (as Ca)	Magnesium (as Mg)	Sodium (as Na)	Potasium (as K)	Na	S.A.R.
	mg/l	milimohs/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	%	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 : 0	8.8	1.56	250	1552	1860	269.8	110	7.0	305	104	14.4	460	28	83.6	15.87
3 : 1	7.1	2.19	210	1208	1900	525.4	70	Nil	200	320	24.0	400	26	64.2	8.21
2 : 1	6.95	2.29	190	1144	1900	603.5	65	Nil	160	400	33.6	350	22	54.7	6.36
1 : 1	5.3	2.64	180	1008	1900	781	60	Nil	40	560	48.0	310	20.6	45.0	4.77
1 : 0	2.55	5.60	125	744	2000	1313.5	45	Nil	Nil	1040	110.4	160	16	18.4	1.79

TABLE—III D

1 : 0	9.0	2.07	360	2163	2000	440.2	95	10	400	112	38.4	530	35	81.2	15.54
3 : 1	8.2	2.10	310	1450	1900	568.0	85	Nil	330	288	130	466	30	60.2	8.05
2 : 1	8.0	2.25	290	1348	1800	582.2	70	Nil	290	360	153	353	26	48.7	5.52
1 : 1	7.2	2.43	260	1167	1800	681.6	60	Nil	210	440	211	300	25	38.89	4.13
0 : 1	3.5	3.30	130	528	1700	1022.4	38	Nil	Nil	584	288	160	20	20.5	1.92