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Selective Characterization and Impact Analysis of Liquid Paper Industry Effluent

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ABSTRACT

The treated effluent water from paper industry has an alkaline pH, dissolved oxygen (DO) and biochemical oxygen demand (BOD) and the observed values indicate that, it affects the aerobic respiration of organisms and hence not suitable for aqua-culture application. Residual sodium carbonate (RSC) values observed for the treated liquid effluent sample suggest its suitability for irrigation purposes.

INTRODUCTION

The common sources of water pollution can range from purely natural to man-made sources like discharge of domestic and industrial wastewaters. The industrial wastes have the greatest potential for polluting the receiving waters. The nature and composition of industrial wastes widely vary from industry to industry and even within the industry depending on the raw materials, processes and operational factors. The industrial wastes may have pollutants of almost all types ranging from simple nutrients and organic matter to complex toxic substances. The wastes from industries like sugar, paper and pulp, distilleries, dairies and tanneries are rich sources of organic matter.

Focusing our attention to paper industry, the chemicals employed in this industry include alum, talc, rosin, chlorine, caustic soda, soda ash, dyes, magnesium sulphite, sulphurous acid and clay. The characteristics of combined effluents from sulphite, and pulp and paper industry located on the banks of River Hoogly were reported (Kudesia 1998). A multiple regression analysis and mathematical models were described to define specific relations between cynobacteria and physico-chemical factors with respect to the effluent from paper mills discharged into the River Godavari (Sudhakar 1991).

Influence of treated paper mill effluent on hepatic morphology in male bullhead (*Cottius gobio* L.) revealed a marked depletion of glycogen, necrosis of single hepatocytes and higher degree of liver parasitization (Bucher et al. 1992). A study on the influence of paper mill effluent on the fish fauna of stoney shores of Lake Paijanne revealed the inhibiting effect of the reproduction activity of different species of fish (Bagge & Hakkari 1992). A comprehensive study (Lavella et al. 1993) on Quebec's pulp and paper mill effluent showed that the effluent is toxic to trout and other organisms. The effects of pulp mill effluent on two freshwater species, *Oreochromis niloticus* (Tilapia) and *Geophagus brasciliensis* (Acara) were investigated (Wilhelm et al. 1997). The impact of pulp and paper mill effluent on the composition of the humic fraction of aquatic organic matter was studied (Santosh et al. 1998).

The survival of mayflies which grew on pulp mill effluents were not affected; instead it had a significant stimulatory effect on its growth and development, which is a matter of concern (Lowell et al. 1995). A study on the effect of paper mill effluent on the water quality of receiving wetland (Ellenga Beel) before and after confluence with effluents was reported (Baruah et al. 1996). Before confluence with effluent water, Beel water quality showed its suitability for sustenance of life processes, but after confluence, the water quality degraded in several parameters making it not suitable for the survival of life processes.

Stress of pulp and paper manufacturing plant (located at Faizabad) wastewater on the yield of components of wheat were reported (Agarwal et al. 1994). According to this study, the number of spikes per ear, number of grains per ear, grain weight per ear, ear weight per plant, grain yield per plant, biological yield, test weight and percentage harvest index were reduced significantly with the increasing concentration of the effluent treatment in comparison to the healthy and controlled plants.

The present work has been carried out to understand the nature of the liquid effluent discharged from paper industry in the East Godavari region of Andhra Pradesh and to assess its suitability for land application.

MATERIALS AND METHODS

The effluent samples generated from a paper industry located in East Godavari district of Andhra Pradesh, India before and after treatment, and the process water from the River Godavari were collected for characterization. The analysis was made as per standard procedures and recommendations (Ramteke & Moghe 1998). The measured parameters included pH, electrical conductivity, total solids, chloride, sulphate, phosphate, fluoride, carbonate, bicarbonate, total hardness, calcium and magnesium hardness, metallic calcium and magnesium, residual sodium carbonate (RSC), dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand (COD).

RESULTS AND DISCUSSION

The quality of water of River Godavari employed for the manufacturing process of paper has been characterized and the details are presented in Table 1. Based on different constituents present, water is classified into three grades for irrigation purposes (Goel 2001) (Table 2).

Residual sodium carbonate (RSC) is an important parameter to assess the suitability of water for irrigation purposes. It can be calculated as per the following relation expressed in me/L (Gupta 2004) and the results are given in Table 3.

$RSC = (CO_3^{-2} + HCO_3^{-}) - (Ca^{+2} + Mg^{+2})$

RSC Value < 1.25: Water can be safely used for irrigation.

RSC Value 1.25-2.50: Water to be used with due caution.

RSC Value > 2.50: Water suitable for irrigation.

Based on RSC values (0.58) the treated effluent can be considered for irrigation purposes. However, this needs to be examined further taking into account the other analytical parameters studied.

The characteristics of untreated and treated liquid effluents from paper industry are presented in Table 4.

- Various parameters characterized as per standards (CPCB 1995) and IS: 3025-1964 except for BOD indicate that the other parameters are well within the permissible limits.

Table 1: Analysis of intake water employed in the paper industry.

Sl. No.	Parameter	Units	Values
1	pH	-	8.26
2	Electrical Conductivity	µmohs/cm	264
3	Total Solids (TS)	mg/L	111
4	Total Dissolved Solids (TDS)	mg/L	105
5	Total Suspended Solids (TSS)	mg/L	6
6	Carbonate as (CO_3^{-2})	mg/L	3.0
7	Carbonate as Bicarbonate (HCO_3^-)	mg/L	BDL*
8	Residual Sodium Carbonate (RSC)	me/L	BDL*
9	Hardness	mg/L	72
10	Calcium Hardness	mg/L	35
11	Magnesium Hardness	mg/L	37
12	Ca^{2+} ion concentration	mg/L	14
13	Mg^{2+} ion concentration	mg/L	9
14	F^- ion concentration	ppm	0.17
15	Cl^- ion concentration	ppm	22.5
16	SO_4^{-2} ion concentration	ppm	1.30
17	PO_4^{-3} ion concentration	ppm	0.12
18	Dissolved Oxygen (DO)	mg/L (Max.)	6.5
19	Biochemical Oxygen Demand (BOD)	mg/L (Max.)	1.2
20	Chemical Oxygen Demand (COD)	mg/L (Max.)	6.6

*BDL = Below Detectable Limit

Table 2: Water classification for irrigation purposes.

Class of Water	TDS (ppm)	Chlorides (ppm)	Sulphates (ppm)	Electrical Conductivity (µmohs)	Suitability for irrigation
I	0 – 700	0 – 142	0 – 192	0 – 750	Excellent to good for irrigation.
II	700 – 2000	142 – 355	192 – 480	750 – 2250	Good to injurious. Suitable only with permeable soil and moderate leaching. Harmful to sensitive crops.
III	> 2000	> 355	> 480	> 2250	Unfit for irrigation.

Table 3: RSC content of liquid effluent before and after treatment.

S.No.	Parameter	Units	Paper Industry Effluent	
			Before Treatment	After Treatment
1	CO_3 content	mg/L	72	24
2	HCO_3 content	mg/L	585	536
3	Ca^{2+} ion concentration	mg/L	204	128
4	Mg^{2+} ion concentration	mg/L	9.76	26.8
5	Residual Sodium Carbonate (RSC)	me/L	BDL*	0.58

Table 4: Characterization of untreated and treated liquid effluent from paper and pulp industry.

Sl. No.	Parameter	Standards		Effluent	
		Irrigation	Aquaculture	Before Treatment	After Treatment
1	pH	5.5-9.0	5.5-9.0	7.4	7.9
2	Electrical Conductivity, μmohs/cm	Class-I: 0-750 Class-II: 750-2250 Class-III: > 2250	-	2550	2040
3	Total Solids (TS), mg/L	100	200	2360	1360
4	Total Dissolved Solids (TDS), mg/L	Class-I: 0-700 Class-II: 700-2000 Class-III: > 2000	2100	1840	1320
5	Total Suspended Solids (TSS), mg/L (Max.)	200	100	520	40
6	F^- ion concentration, mg/L (Max.)	-	2.0	0.929	0.841
7	Cl^- ion concentration, (mg/L)	Class-I: 0-142 Class-II: 142-355 Class-III: > 355	-	774.7	390
8	SO_4^{-2} ion concentration, mg/L	Class-I: 0-192 Class-II: 192-480 Class-III: > 480	-	57.96	36.1
9	PO_4^{-3} ion concentration, mg/L (Max.)	-	5.0	0.82	0.48
10	Dissolved Oxygen, mg/L (IS: 3025-1964)	-	50	BDL	1.2
11	Biochemical Oxygen Demand (BOD), mg/L (Max.)	100	30	156	39
12	Chemical Oxygen Demand (COD), mg/L (Max.)	-	250	505.6	160

- The lower value of 1.2 mg/ L of dissolved oxygen (DO) of the treated effluent indicates that it affects the aerobic respiration of organisms and hence is not suitable for aquaculture (Poole et al. 1978).
- The biochemical oxygen demand (BOD) value of 100 for liquid effluent after treatment is more suitable for irrigation purpose. It is marginally higher (39mg/L) for aquaculture application.
- Dissolved solids may impart colour and toxicity to mill effluents (Wilhelm et al. 1997). From the analytical observations made with respect to dissolved solids and its impact on BOD value is significant.
- The suitability of water with different constituents for irrigation purpose and its classification is given in Table 2. Considering the sulphate content, the treated effluent water can be graded under Class-I, which is good for irrigation. However, from the values of electrical conductivity and total dissolved solids, this can be graded as Class-II, which is harmful to sensitive crops.
- The Total dissolved solids (TDS) value is significant and hence the electrical conductivity is also considerably high.
- Considering the chloride content and electrical conductivity of the treated effluent, it can be treated as Class-III, which indicates that this treated effluent is not suitable for irrigation purposes.

CONCLUSION

Taking into consideration the physical parameters, treated liquid effluent from paper industry is not suitable for irrigation and aquaculture, even though the RSC values are within the permissible limits.

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