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ENVIRONMENTAL ASSESSMENT AND REMEDIAL STRATEGIES FOR TREATMENT OF THE EFFLUENTS OF RECYCLED WASTE PAPER MILLS

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ABSTRACT

Wastewater streams are posing a serious threat to human life, plants, soil, animals and eco-systems of receiving water bodies. One of the main causes of surface water and ground water contamination is industrial discharge from various industries viz. pulp and paper, textile, pharmaceutical and other chemical industries. Compounds released are quite toxic and degrade slowly in the environment. Therefore it becomes imperative to completely degrade these toxics in order to biodegrade the effluents. The incapability of conventional wastewater treatment methods to effectively remove many biorecalcitrant pollutants leads to explore the new efficient and cost effective treatment systems for the complete degradation of these pollutants.

INTRODUCTION

Recycled waste paper industry is a globally growing industry that consumes a significant amount of resources, raw materials and energy. Due to this fact, minimizing the environmental impact of this sector is important. The characteristics of the wastewaters generated from various processes of the recycled pulp and paper industry depends upon the types of processes and raw materials, process technology applied, management practices, internal recirculation of the effluent for recovery and the amount of water being used in a particular process. The majority of pollutants released in pulp and paper industry originate from the pulping and bleaching stages. The high organic content of pulping wastewater, coupled with the presence of chlorine, results in the production of many highly toxic chlorinated organic compounds (Miller *et al*., 1988; Hoigne *et al*., 1983). Of prime concern are chlorinated phenols, guaiacols, catechols, furans, dioxins, aliphatic hydrocarbons. Some members of this family are known to be toxic, mutagenic, persistent, and bio-accumulating and are thought to cause numerous harmful disturbances in biological systems, and pose a human health risk through long-term exposure via drinking water and through bioaccumulation along the food chain (Legrini *et al*., 1993; Carey *et al*., 1990). End-of-pipe treatment of wastewaters can be accomplished by integration of traditional biological treatment processes with chemical/advanced oxi-

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dation applications. Chemical oxidation technologies have revealed that the applied processes are effective and promising applications for the treatment of pulp and paper industry wastewaters (Beltrán *et al*., 1997; Galge *et al*., 1987). Ozonation is efficient in removing COD, TOC and color as well as increasing the biodegradability of the wastewater in many cases (Li *et al*., 1991; Andreozzi *et al.*, 1999). However, it is rather an expensive process. Electrochemical methods have proved to be an efficient treatment option for the treatment of pulp and paper industry wastewaters. Combinations of two or more physicochemical processes can be used for the enhancement of removal efficiencies and design of the setup (Benitez *et al.*, 1995). Currently no relevant data is available on the states/parameters of the effluents released from recycled paper mills; the most important task seems to be the assessment of the effluents of recycled paper mills so as to design the specific treatment systems for the recycled mills.

The demand for paper and paperboard by the year 2006– 2007 in India was 3.8 million tons/annum and 4.9 million tons/annum at the end of the year 2010. The Indian paper industry will be constrained by extremely high investment costs and raw materials shortfalls, when pitted against foreign competition. India was also the first country in the world to use bamboo as a basic raw material for making paper. Due to limited forest resources, other raw materials like bagasse, straw, jute, etc. were identified and are now extensively used in the paper product. Waste paper is also being widely used for paper making.

At the same time pulp and paper industry is one of the largest and most polluting industries in the world. At present, there are 666 pulp and paper mills in India, of which 632 units are agro-residue and recycled fiber based units (CPPRI, 2005). Being a fiber deficient country, two-third of the raw material comes from non-wood sources. These include agro-residues like rice straw, wheat straw, sarkanda grass, bagasse, jute rags as well as wastepaper.

To assess the pollution load of recycled paper mills on the environment, the present paper reports the investigation of the characteristics of effluents released from recycled paper mills of Punjab state.

EXPERIMENTAL

SAMPLING

Effluents Samples

The effluents samples were collected from the wastewater treatment plants of recycled paper mills of Punjab. There were seven treated samples of effluents collected from various recycled paper mills of Malwa region of Punjab. The effluents samples were 24-hour composite samples collected in plastic bottles and containers. All samples were refrigerated at 4°C.Prior to treatment; the samples were warmed to room temperature (24°C –27°C). For UV Spectrophotometer analysis, the samples were centrifuge by centrifuge equipment and again filtered through 0.45 micrometer glass-fiber filters to remove suspended solids. Effluents samples from recycled paper mills were collected and analyzed for the required parameters in order to evaluate the pollution load of water streams. The effluents were characterized by analyzing the physico chemical characteristics.

Soil Samples

As the effluents from recycled mills enter the water streams and also with time, the organic and inorganic components enter into soil and underground water and thus affecting the land and water streams. In order to assess the impact of wastes on the environment, the study has also been carried out for analysis the soil profile near to the recycled paper mill. Various soil samples collected at variable distances (1, 2 and 5 km) area from the recycled paper mills.

Instruments used in these experiments include UV-Spectrophotometer (HACH: DR/4000U), Water and Soil Analyzer kit: (Model: GMK- 731), COD Analyzer kit (Thermo Orion COD-125 Meter), Centrifuge, Ultraviolet Lamp Unit, BOD_5days Incubator(HACH BOD Trak Incubator), Hot oven and Electric furnace.

RESULTS AND DISCUSSION

Analysis of Effluents Samples

The effluents generated by the mills contain high concentration of used chemicals in the receiving water bodies results in reduced penetration of light, thereby affecting benthic growth and habitat. The high concentration of organic matter in the effluents contributes to the Biochemcial oxygen demand and depletion of dissolved oxygen in the receiving ecosystems. The organic compounds may be persistent, bio-accumulative and toxic pollutants and thereby their removal for the effluents is desirable. Paper and pulp mill effluents are also major contributor to absorbable organic halide (AOX) loads in the receiving ecosystems. Table 1 reflects that the treated effluent discharged from recycled paper mills contains high TDS

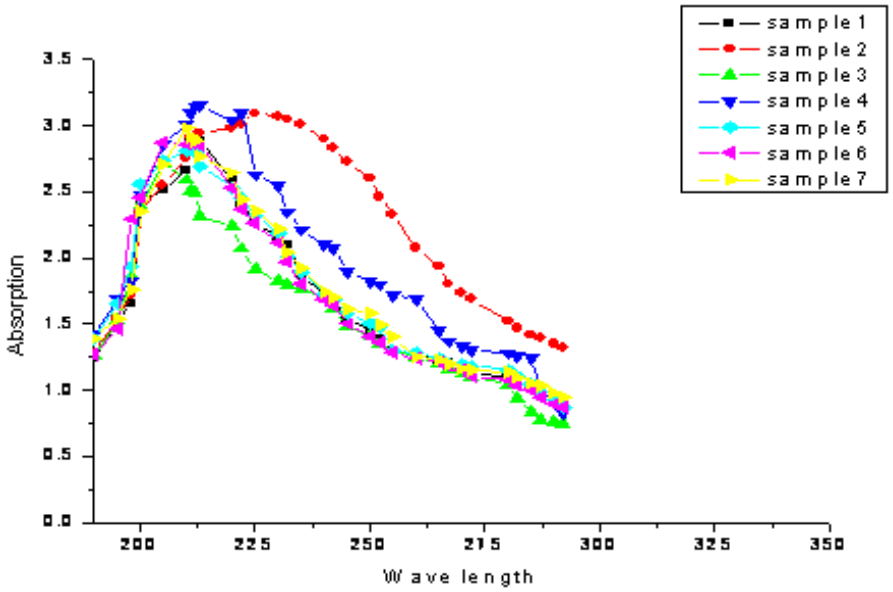

Fig. 1 Absorption Spectra of effluents of paper mills.

and TSS. The high COD value reflects the presence of organic and inorganic matter which may be persistent and not degraded by the treatment process established at the industries. The physico chemical characteristics of effluents are given in Table 1.

UV-VIS SPECTRA OF THE EFFLUENTS OF RECYCLED PAPER MILLS

The UV-Vis spectra of the effluents samples of recycled paper mills were recorded and are given in Fig. 1. The UV-Vis spectra of the effluents show absorbance around 210nm, which indicates the presence of aliphatic compounds with different functionalities as well aromatic constituents. The most probable compounds presents in the effluents steam may be phenol and its derivatives, liquor chlorophenols, chlorocatechols etc. The maximum absorbance values (λ_{max}) for all the samples have been recorded in Table 3.

The very high absorbance in the region 200-300nm value suggests the effluents are not fit to be disposed to the water stream as these effluents will results in increase of organic load in the water steams. The UV-Vis spectra show the absence of any colored constitu-

Table 1. Physico Chemical characteristics of effluents from recycled paper mills

S.No.	Parameters	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Indian standard (BIS)
1.	TDS (ppm)	2300	2800	2700	3800	3100	3260	1760	2100
2.	DO (ppm)	0.4	0.6	1.5	0.6	0.7	0.9	2.0	5
3.	TVS (ppm)	1000	1500	400	1200	900	600	1000	-
4.	TSS (ppm)	700	1500	1200	1400	1000	940	820	100
5.	TFS (ppm)	3000	2800	3700	4000	3200	3600	2000	-
6.	Total Residual Chlorine (ppm)	3	4	3.5	5.8	6.2	5.3	4.6	1.00
7.	Total Solids (ppm)	4000	4300	4100	5200	4100	4200	3000	-
8.	BOD5Day (ppm)	192	188	126	152	132	168	124	30
9.	COD (ppm)	1168	1120	518	1270	881	1276	961	250
10.	pH	6.79	7.05	7.37	6.94	7.25	7.38	7.62	5-9
11.	Chloride (ppm)	505	448	349	647	363	508	576	600

ents present in the effluents. The absorbance intensity for the sample is quite high and the λ_{max} of absorbance was in the range of 200-300nm for effluents.

Table 2. λ_{max} for the effluents of recycled paper mills

Sample No.	Peak Value (λ_{max})	
	Wavelengthλ	Absorbance
1.	211	2.893
2.	207	2.915
3.	205	2.717
4.	216	3.150
5.	208	2.898
6.	212	2.867
7.	208	2.982

Analysis of Soil Samples

As the effluents from recycled mills enter the water streams and also with time, the organic and inorganic components enter into soil and underground water and thus affecting the land and water streams. In order to assess the impact of wastes on the environment, the study has also been carried out for analysis the soil profile near to the recycled paper mill. Various soil samples collected at variable distances (1, 2 and 5 km) area from the recycled paper mills.

The soil has high COD values which indicate the input of non biodegradable components in the soil, which decrease with increase in distance. The high COD values decrease the fertility of soil and cause soil pollution and also have detrimental in the environment after long period.

The pH of soil decreases very near to the site i.e., 1km from paper mill, which show that the effluents are some acidic in nature and hence affect the fertility of soil and cause soil pollution. pH varies from 6.72 to 8.14 with variation of distance from 1km to 5km. which is shown in the Table 3. The decrease in pH near the mills was due to the acidic nature of effluents, which affect the pH of soil.

The DO in soil increases with increase in distance which show that the effluents contains chemical load which affect the DO value of soil and hence decreases the fertility of soil and also affect the production and cause soil pollution. The DO value varies from 2.0ppm to 4.1ppm as the distance varies from 1km to 5km, which is shown in the Table 3.

The TDS value in soil decreases with increase with distance, which indicates that effluents contains big load of organic and inorganic components and non biodegradable components in the soil. The high TDS value of soil affects the fertility of soil and cause the soil pollution. The TDS values vary from 0.304ppt to 0.136ppt with the distance varies from 1km to 5km, which is shown in the Table 3.

CONCLUSION

The results of the present study are summarized as:

Treated industrial effluents released from recycled paper mills have high COD (1270ppm) and BOD (192ppm) contents.

The UV/VIS spectra show the presence of organic compounds i.e. may be the chloro/methoxy derivatives of phenol.

The soil samples from various distances from paper mills are collected and analysed, which shows that COD and TDS of effluents reduced with distance and pH and DO increase with increase in distance as we move away from paper mills.

The present study suggests incapability of waste water treatment plant to effectively remove many biorecalcitrant pollutants. Thus there is need to explore the new efficient and cost effective treatment systems and to explore the coupled technologies to be incorporated for complete degradation of these pollutants.

Table 3. Parameters of Soil Samples At Different Distances

S.No.	Parameters	Soil (1km)	Soil (2km)	Soil (5km)
1.	Temperature	14.6^{0}C	14.6^{0}C	14.6^{0}C
2.	pH	6.72	8.02	8.14
3.	ORP	670mV	530mV	630mV
4.	DO	2.0ppm	3.4ppm	4.1ppm
5.	Conductivity	0.602mS	0.286mS	0.268mS
6.	TDS	0.304ppt	0.142ppt	0.136ppt
7.	Salinity	000.3ppt	000.2ppt	000.2ppt
8.	COD	133ppm	113ppm	90ppm

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