Some Aspects of Water Pollution by the Indian Pulp & Paper Industry

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This paper reviews the water pollution problem of the Indian Pulp and Paper Industry as regulatory requirements demand that the waste water must conform to some quality as measured by permissible limits for major pollutants before discharging into the receiving stream. Since pulp and Paper Industry uses a variety of fibrous raw materials, adopt different processes and treatment conditions, manufactures a wide variety of products, have varyins efficiencies for the various inputs that make the pulp and paper, discharges their waste water at varying locations and under different conditions, a more realistic and rational approach is necessary to tackle the water pollution problem. For this undoubtedly the spirit of understanding and co-operation between the Industry and regulatory enforcement agencies is a must. Emphasis is laid in this paper that permissible limits for major pollutants such as BoD, CoD, suspended solids etc. in the waste water of the Pulp and Paper mills may also be defined on load basis. In other words pollution control on load basis rather than on concentration basis is also to be considered, if the conditions warrant it, since each situation constitutes a different problem. The paper also briefly mentions of the inplant approaches of reducing the quantity of pollutants and external treatment methods normally followed.

The Paper Industry in India has a record of achievement. In 1951 the installed capacity stood at only 0.137 million tonnes and this rose to 1.103 million tonnes of paper and paper board, 75,000 tonnes of newsprint and 25,000 tonnes of market pulp in 1976. The Indian Paper Industry is peculiar by the fact that there are a number of small mills as will be seen from Table-1.

Of the total production of paper & paper board in 1975, 55 small paper mill accounted for 16 percent and the balance 84 percent by the 20 mills of capacity over 50 TPD. More than 16 percent of the total production of paper board which is accomplished in small mills is based on the utilisation of straws, grasses, bagasse, cotton rages, Kenaf, hemp and waste paper etc. Other mills are using bamboo, eucalyptus and mixed hardwoods for their paper production. Because of the chemical & physical differences in the fibrous raw materials, treatment conditions employed, the problem of water pollution from small mills is little different from those of big mills. Most of the mills running in the country on forest based raw materials recover the cooking chemicals mainly caustic soda and sodium sulphide. The two high polymers viz. cellulose (hemicelluloses) and lignin which are dissolved to varying extent during the digestion are burnt in the process of recovery of chemicals and serve as a source of fuel for producing steam. For Techno-economic reasons chemicals mainly caustic soda are not recovered in small mills and both the hemicelluloses and lignin and its degradation products present in the spent liquor exert BoD, CoD and colour load, if discharged without treatment into

TABLE 1

Capacity wise distribution of the mills as on April 1, 1976

Capacity Class (MTPA)		*No. of mills*	*Percentage of total mills*
Small Mills:	Upto 3,000	31	41
	3,001 to 10,000	20	27
10,001 to 20,000		8	10
20,001 to 40,000		5	7
40,001 and above		11	15
	TOTAL :	75	100

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the receiving stream. BoD, CoD and colour load in small mills is mainly confined to the cooking section-in the spent liquor and dilute wash waters.

For a straw based pulp mill producing full chemical pulp BoD load of 150 Kg/tonne of unbleached pulp may be obtained compared to 10 Kg/tonne of unbleached pulp as prevalent in bamboo based mills obviously because in the later case spent liquor is burnt for the recovery of chemicals and heat. Where good quality cotton linters are used, the BoD, CoD and colour load as obtained in the laboratory is given in Table II. (1)

Suspended matter usually present in the form of fibres and filler is also high in small mills compared to large mills as the pulps from straw, bagasse etc. contain a high proportion of fines (Table III) which are conveniently lost due to the use of simple, cheap equipments. The fact that the small mills have the following advantages over large mills:

(i) Low investment per tonne of paper.
(ii) Mills can be located very near to the market for their products.
(iii) Reduced infrastructure requirements
(iv) Water requirement can be met from sub-soil water.
(v) Contribute to the agrarian economy by giving a value to agricultural wastes.

TABLE II

Mechanical Cleaning, Kier Boiling of Cotton Linters

Mechanical Cleaning :		
Accepts %	95.1	
Rejects %	4.9	
Kier Boiling (100 g. accepts were cooked in bomb digester)		
NaoH %	5	
Time Hrs	1+2	
Temp. °C	150	
Material to liquid ratio	1 : 7	
Soap %	0.1	
Results:		
NaOH consumed %	4.9	
Yield %	79.1	
Rejects %	2.3	
Spent Liquor Analysis:		
pH	9.0	
Total solids g/1	30.1	
Total solids %	3.0	
Colour Pt Co units	47,500	420 Kg/Tonne of pulp
CoD mg/1	40,930	362 ,,
BoD mg/L	6,070	53.7 ,,

These mills could decisively play a complementary role to the large units in meeting the country's requirement of paper. However, these mills will be seized with the problem of disposal of spent liquor and dilute wash waters. If an elaborate treatment is included the investment on effluent treatment alone may be 6-8% of the total cost of the project besides the running cost of Rs. 100-150 per tonne of paper. The additional demand on capital, land, power etc. for providing effluent treatment facilities is a big challenge for small mills and in order to negate its effect so that the growth of small mills continues uninterrupted a simple economical solution has to be found. This is important so that the expenditure on effluent treatment does not become a significant cost factor in the economic viability of small mills. Among the various approaches, to economically solve the water pollution problem of small mills emphasis should be placed on:

(i) Irrigation disposal of pulp and Paper mill effluent. This is being practiced in the Letjes Paper Mill in Indonesia for the last 30 years. The mill employs soda pulping of wet cleaned paddy straw and presently produces about 30 tonnes bleached paper per day. The waste water from the pulp mill is mixed with the white water from the paper machine and afterwards mixing takes place with irrigation water. This mixed water is used by the farmers to irrigate their rice fields. The use of waste water from the Pulp and Paper mill after sufficiently diluted has been of great advantage to the farmers and the general conclusion is that it has fertilised rather than endanger the rice fields.

(ii) Many fibrous raw materials such as wheat straw, rice straw, kenaf, bagasse etc. contain a high proportion of water soluble sugars, starches, pectins, gums etc. which can exert a very high BoD and in such cases wet cleaning of the material would help in reducing the BoD in the spent liquor. The effluent from the wet cleaning step can be safely used for irrigation. In some cases as in the case of Kenaf this could be beneficial to the soil as the organic matter, nutrients and trace minerals washed out of the kenaf are returned to the soil.

(iii) To devise a simple and economical method of burning of waste liquor with or without recovery of chemicals and heat. Wet air oxidation system have the merits and deserve consideration. Also new solvent pulping process using ammonium hydroxide (2) is described to be pollution free. Ammonia is recovered by distillation and the residual black liquor is dried and used as fuel with the surplus available for agricultural or industrial uses.

(iv) To convert the waste water spent alkaline liquor into revenue producing chemicals such as lignin, organic acids etc. A paper mill the Kushiro Works of the Juli Paper Manufacturing Co. Japan experimented with fibrous Pulp waste as fertiliser (3).

(v) Till such time, a suitable economical method for treatment of black liquor is developed adopt a more flexible approach in prescribing tolerance limits. Since in small mills the quantity of paper produced is low, the total pollutants discharged on load basis are also low. As such the limits for major pollutants can depend more on the receiving stream condition such as the dillution factor in the water course, gradient, depth, rate of flow the character of the bed etc. This approach will be consistent with the financial consideration and technical developments. An advantage of pollution control on lead basis is that, it is free from the defect whether a mill employs more or less water which has a direct effect on the quantitative analysis of the various pollutants present in the effluent. With increasing emphasis on reuse of water, the practical result of which is to reduce consumption and to minimize the quantity to be treated for the removal of suspended solids, is an increase in the BoD of the effluent. The total quantum of polluting matter going to a river is reduced by the reuse of water and such circumstances it will not be fair to judge an effluent by its quantitative analysis instead of by the quantum of polluting matter going to the stream.

TABLE III

Bauer—Mc Nett Fibre Classification of Bleached Rice Straw, Wheat Straw & Bamboo Pulps

% of fraction retained on Mesh	*Wheat straw Soda Pulp*	*Rice Straw Soda Pulp*	*Bamboo Sulphate Pulp*
35	1.7	6.6	36.4
50	5.8	10.8	9.1
100	8.0	19.3	16.5
150	20.8	7.9	5.1
Passing through 150	63.7	55.4	32.9

Coming to the water pollution problem of the large Indian Pulp and Paper mill it would be better if first a mention is made that the Indian Standards viz. IS: 2490—1974, IS: 3306—1974 and IS: 3307—1965 have prescribed tolerance limits for Industrial effluents and these limits are invariably applied by the State Pollution Boards for all kinds of Pulp & Paper Mills. For discharging waste water into inland surface water, the limits for BoD 5, CoD and suspended solids are 30,250 and 100 mgl respectively. Assuming that a large number of Pulp & Paper Mills in the country are using on average 350 M^3 water/Tonne of pulp & paper, the quantity of permissible pollutants on load basis works out 10.5, 87.5 and 35 Kg/tonne of Pulp & Paper respectively. For comparison are given in table IV(4) the proposed standards for the suspended solids and BoD5 in some other countries. Without going into the merits and demerits of applying the Indian Standard for pollution control in the Pulp & Paper Industry, it would not be out of place to mention here that many countries apply limits based on the process followed such as sulphate, sulphite (with and without recovery etc. and the product manufactured. Probably in our case also a more penetrating approach in understanding and solving the pollution problem is necessary. There is also need for developing regulatory standards specifically for the Pulp & Paper Industry.

2. Groups V and VI refer to waste paper processing plants.

The integrated sulphate pulp & paper mills in the country are making all efforts to reduce the quantity of pollutants discharge from the cooking, washing and screening section and so also from the paper making section. The major pollutants are produced in the bleaching sec-

TABLE IV

Pollution Control Standards in some Countries

Canada BOD requirements in lbs BOD/ADT.	*Existing mill*	*New, altered & expanded mill*
Sulphite 55% or less yield	255	170
55-56%	170	115
More than 65%	150	75
Sulphite bleaching (market pulp)	35	35
Kraft Pulping	64	33
Kraft bleaching	27	27
MSSC	80	60

— SS allowances calculated using component process, categories method.

— BoD values for kraft mills are those permitted prior to toxicity reduction. Such systems usually result in BoD reduction of 75% to 90%.

Finland :

SS & BoD requirement in Kg/tonne

	SS	*BOD*
Semi Chemical Pulp	3-12	—
Sulphite Pulp	15-25	60-80
Sulphate Pulp	10-18	26-35
Newsprint	5-10	8-10
Other Paper & Board	3-12	4-10
Fibre building board	9-10	—

France :

SS & BoD requirement in Kg/tonne

	Primary treatment	*Secondary Treatment*	
	Suspended Solids,	*BoD5*	*Suspended solids*
Kraft unbleached	2.5	5	10
Kraft bleached	10	9	20
Sulphite :			
With liquor recovery	12.5	45	50
Without liquor recovery	15	80	85
Semi-chemical :			
More than 150 t/day	5	8	5
Less than 150 t/day	13	60	60

* Biological treatment by aerated lagoon.

tion and in the condensates. The condensates originate in the cooking department, pulp blowing and evaporation of the black liquor. Among the bleachery effluents the heaviest pollution load is imparted by those from the first chlorination and alkali states. The data for pollution load as obtained in the laboratory for an unbleached bamboo sulphate pulp of KMno4 No. 23.2 when bleached by CEHH sequence is given in Table V.

The use of medium to heavy mixed hardwoods in the mill could create problem of additional colour load in the bleach plant. A study of the sulphate pulps made from different fibrous raw materials have demonstrated this and can be seen from the results given in Table VI (5).

Though presently no standard exist for colour in Industrial effluent but the conclusion of COD of 250 mg l as a tolerance for discharge of industrial effluents into inland surface water will require additional control on the colour of the pulp mill effluent.

Among the approaches which could be followed to reduce the quantity of pollutants in the bleach plant, is to delignify the pulps more in the digester if this is consistent with the quality of pulp as well as economical considerations. Antipollution/Anti colour bleaching sequences (APS) also helps in reducing the quantity of pollutants. An anti colour bleaching sequence was earlier described, in one of the publications (6)

Japan :

Standard for 1976 dead line (expressed in ppm)

	BOD	*COD*	*SS*
Semi-chemical	600	600	150
Sulphite (Paper grades)	300	600	150
Sulphite (Dissolving grades)	600	800	150
Sulphate (Paper grades)	120	200	150
Sulphate (Dissolving grade)	120	300	150
Paper & Board	120	120	150

Sweden :

No precise standards, each case examined separately on the basis of "Specified Values" (In Kg/tonne) as follows :

BOD5 from	A	B	C	D	E
—Barking	0-6	0-6	0-6	0-6	0-6
—Washing	1-18	1-10	3-7	5-30	—
—Grinding	—	—	—	—	10-30
—Condensate	—	1-12	15-20	10-30	—
—Bleaching	2.5	10-20	10-13	2-5	—
SS	2-5	2-5	2-5	2-5	2-5

A = Mechanical Pulp
B = Sulphate
C = Sulphate
D = Semi-chemical
E = Fibre board

United States :

Interim Guidelines

	SS *lb/Short ton*	*BoD5* *lb/short ton*
(I) Kraft Pulping & Manufacture of Coarse Paper & Liner Board	5	6
Newsprint	6	8
Bleached and unbleached grades	10	10
Bleached grades	10	12
(II) *Sulphite Pulping & Manufacturing of :*		
Paper	20	40
Dissolving Pulp	20	80
(III) *MSSC :*	15	25

Evaporation and digester room condensate which contain hydrogen sulphide, methyl mercaptan, dimethyl mono sulphide, dimethyl-disulphide, acetone, methanol and ethanol, the last two mainly determining the BOD of the condensate can be used as make up water in the causticising section and as an hot water source in the wash room.

On the paper making side a knowledge of the BOD contribution of additives could be very beneficial. Starches, gums, proteins, all exert BOD and their maximum retention on cellulose fibre during the process of paper making is therefore desirable. Use of certain chemicals is helpful in reducing the white water solids (suspended & dissolved) and thus reducing the quantity of pollutants. The above are just very few inplant approaches to reduce the quantity of pollutants discharged in the waste water and it is rarely possible to meet the requirements of regulatory agencies by this limited approach. Some sort of external treatment is always necessary both for suspended solids and BOD reduction. For the removal of suspended solids clarifier/clarifloculators are used and for BOD reduction low and high rate biological treatment systems are adopted. Low rate biological treatment systems with or without machanically aerated devices are used if sufficient land and space are available and state standards permit. High rate biological treatment systems of which conventional activated sludge process is the forerunner is best suited where high BOD removal

(IV) *Groundwood :*		
Unbleached	9	5
Bleached	10	6
(V) Deinking	—	25
(VI) Paper Board (No de-inking)	5	5
(VII) Paper manufacture (from purchased pulp)		
Coarse	5	5
Fine (<8% filled)	8	6
Book(>8% filled	15	6
Tissue	6	8

Note : Groups I, II, III, & IV apply to integrated mills (combined pulping and paper making operations)

TABLE V

BoD, CoD Load in Kgs/Tonne of Unbleached Bamboo Pulp During CEHH Bleaching

		COD	*BOD5*
Chlorination	C	19.7	7.9
Extraction	E	36.4	3.3
Calcium Hypochlorite	H_1	13.5	3.0
Calcium Hypochlorite	H_2	4.9	0.0
TOTAL :		74.5	14.2

TABLE VI

Colour Load (Kg/Tonne of Pulp) for Sulphate Pulps Prepared from Different Fibrous Raw Materials During CEHEH Bleaching

	Bamboo	*E. Hybrid.*	*Mixed* H. Woods*	*Mixed+ H. Woods*
Kappa No. of UB Pulp.	32.4	34.2	36.8	36.1
KMNo4 No (40 ml)	24.0	26.2	26.1	25.7
Chlorination C	7.4	19.4	12.5	45.2
Extraction E	108.2	72.2	108.0	114.0
Hypochlorite H	7.8	5.9	3.9	4.9
Extraction E	5.5	2.2	8.2	10.4
Hypochlorite H	0.6	0.7	0.5	0.5
TOTAL :	129.5	100.4	133.1	175.0

* Mixture of following hardwood species : Lagerstroemia Lanceolata, Kydia Calycina, Grewia tilliaefolia, Anogeissus Latifolia, Adina Cordifolia, Terminalia balerica, Tectona Grandis, Dipterocarpus Indicus, Calophyhlum Tomentosum, Mitragyna Parviflora.

+ Xylio Xylocarpa, Terminalia Tomentosa, Terminalia Paniculata.

efficiencies are desired, land availability is limited and the systems has to work efficiently unrelated to climatic conditions. Recently a two high rate activated sludge process (7) (Zurn-Attis Holz system) is described which makes use of the following principles :

(i) Large quantities of organics can be efficiently removed by biological degradation at very high volumetric loading rates, as compared with conventional activated sludge.

(ii) Two distinct groups of microorganisms are necessary in biological treatment, Bacteria and Protozoa. Each performs different functions and each operate best under different environmental conditions. In conventional system these two groups coexist where as in this process they are kept separated.

Rotating biological surface system (RBS) is also investigated as a means of BOD reduction of waste water. A series of closely spaced flat surface discs are slowly rotated in the waste water to provide a biological support media. These half submerged discs alternately exposed to the waste water and to the air create an oxygen enriched environment. Because, of this environment large microbial populations readily assimilate the waste water. The result accelerated bio-degradation.

All the treatment methods involve considerable investment, and in situations wherever possible this effect of cost can be reduced if the waste water treatment is considered as a potential productive process. In other words the disposal of waste water by utilisation such as the water used for irrigation could contribute to form soil humus, the nutrients and organics in an stabilished waste water used as water supply for fish culture ponds could contribute to the fertilization of ponds. In such situations a cost benefit analysis would be very useful. Feasibility of irrigation of softwood and hardwood for disposal of paper mill effluent to reduce stream pollution during the low flow period of the summer months, the possible increase in tree growth as a result of irrigation, the possible adverse effect on the soil were studied by Wildon(8) and this method of disposal of paper mill effluent by irrigation was reported to be promising.

Concluding the above discussion it may be impressed that the pollution control programme for the Pulp and Paper Industry needs in addition to what is mentioned earlier certain additional considerations such as,

(iii) Intensify R & D work to develop methods in relation to local conditions for reduction of pollutants at less cost.

(ii) Have a look at the availability of capital and means of financing the investment on pollution control, for existing and new Pulp and Paper Mills.

(iii) Increase in production cost due to adoption of pollution control measures may have to be suitably compensated for by adopting a favourable policy on product price etc.

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