Environmental Engineering and the Indian Paper Industry

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Environmental aspects of three main types of pollution, i.e. of water, air and solid wastes are discussed in the present paper. Special emphasis is laid on in-plant controls to reduce pollution load to the sewer. Water pollution considerations, particularly with respect to Central Pulp Mills, are discussed in greater detail.

The need to protect environment from pollution hazards is well recognised today. For instance, the Government of India enacted "Water Pollution Control Act" in March 1974 and will soon be legislating on air pollution.

The conventional effluent treatment plants, although effective in solving the pollution problem, call for high installation and operations costs. Hence the need to pay greater attention on in-plant controls to reduce pollution load to the sewer or to the treatment plants, should the latter become essential. It is worth noting that water consumption could be brought down from 28,000 gallons to 8,000 gallons per AD ton of bleached kraft pulp in some North American and Swedish pulp mills. Also, BOD load was reduced from 180 to 30 lbs/ton of pulp with effective in-plant controls[1].

As guidlines to protect environment from pollution, certain standards on water and air pollution have been laid down by various countries, some of these standards are given in Table 1,2 and 3.

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Effluent Disposal at Central Pulp Mills

Central Pulp Mills started production operations in 1968. The mills manufacture 100 TPD flash-dried paper grade pulp. Conventional kraft cooking and CEHH bleaching are adopted. The source of water for the mills is river Tapti. The mills discharge 4.5 MGD effluent into a nearby nala, which after passing through a distance of 8 Km. joins river Tapti.

Table 4 shows the characteristics of mill effluent for different grades of pulp. As could be expected, bleached pulp generates higher BOD and TSS than does semi-bleached or unbleached pulp.

Table 5 shows the characteristics of effluent of each section. This study has revealed that bleach plant and screening section are the major sources of pollution load. Several in-plant measures adopted in reducing water consumption, as well as pollution load, are listed below :

a) Uncontaminated bearing cooling water from different places, that is, ID fan and compressor (3200 gal/ton), lime klin (800 gal/ton) and feed water pump (1000 gal/ton of pulp) is collected in a sump and taken to mills clear water storage tank.

b) Pulp dryer white water, which is comparatively clean, is used in the following operations : i) make up water in screening (1800 gal/ton), ii) for diluting bleached pulp from 13% to 10% in both hypo stages (800 gal/ton) and final stage dilution of bleached pulp from 10% to 4% consistency (3300 gal/ton) at conveyor to low density storage tank.

c) Alkali extraction seal tank filterate is used in chlorine washer shower for pulp wsshing (1700 gal/ton).

Table 1 Industrial Waste Pollution Standards For Suspended Solids And BOD_5 In Different Countries

Particulars	India	Japan	Australia	England	Sweden	Canada
Suspended solids PPM	100	150	200	30	5 (Kg/ton of pulp)	35 (lb/ton of pulp)
BOD_5 PPM	30	120	25	20	5 (Kg/ton of pulp)	64 (lb/ton of pulp)

Table 2: Indian Standards For Effluent (IS 3307-1965) For Irrigation

Particulars		Tolerance Limits
pH		5.5–9.0
Total dissolved solids	mg/L	2100
Sulphates (as SO_4)	mg/L	1000
Chlorides (Cl)	mg/L	600
BOD_5 at 20°C	mg/L	500
Boron	mg/L	2
Percent Sodium	Max.	60

Table 3: Air Pollution Standards

Particulars	Swedish	California (USA)	
Particulate Matter mg/M^3 (dry gas)	250	60 Mg/M^3	(24 Hr. sampling)
Sulphur Dioxide Kg/ton	5	0.5	PPM (1 hour
Hydrogen Sulphide mg/M^3	10	0.03	PPM Test)
CO	—	10	PPM (12 hour)
		40	PPM (1 hour)
NO_2	—	0.25	PPM (1 hour)

Table 4: Characteristics of Mill Composite Effluent For Different Grades of Pulp Manufactured At Central Pulp Mills (100 TPD Pulp)

Particulars		Quality UBKP	SBKP	BKP
Colour (Pt–Co units)		400	800	1250
Conductivity (Micro-Mhos)/Cm.		627	1504	1900
pH		8.3	8.7	8.5
P-Alkalinity as $CaCO_3$	PPM	4	12	6
M-Alkalinity as $CaCO_3$	PPM	118	214	200
Total suspended solids	PPM	600	470	450
Total dissolved solids	PPM	680	1350	2300
Chlorides as Cl	PPM	28	490	653
Oxygen absorbed (4 Hrs.)	PPM	200	260	280
COD	PPM	604	967	1000
BOD (5 days at 20°C)	PPM	115	135	170

UBKP : Unbleached Kraft Pulp SKP : Semi-bleached Kraft Pulp BKP : Bleached Kraft Pulp

Table 5: Characteristics of Sectional Effluents During BKP Bamboo Pulp Production (100 TPD)

Particulars		Pulp Dryer	Washing & Screening	Cyclone rejects	Chlorination	Alkali Extraction.	Combined Recovery	Chipper House.	Mill Composite
Flow	MGD	0.2	0.9	0.1	2.1	0.4	0.5	0.3	4.5
Temperature	°C	35	38	31	26	42	40	31	31
Colour (Pt-Co units)		20	2000	800	280	20,000	10	300	1,500
Conductivity (Micro-Mhos)/Cm.		300	1775	990	3340	8,360	350	410	2,000
pH		7.4	9.2	8.6	2.4	10.2	9.1	7.6	8.4
P-Alkalinity as $CaCO_3$	PPM	Nil	90	7	Nil	124	20	Nil	2
M-Alkalinity as $CaCO_3$	PPM	156	520	184	Nil	1980	130	160	190
Total suspended solids	PPM	100	400	900	100	165	700	3,200	200
Total dissolved solids	PPM	240	1740	920	1300	5,300	730	520	2,200
Chlorides as Cl	PPM	46	56	10.6	700	700	17.7	28.4	540
Oxygen Absorbed (4 Hrs.)	PPM	56.8	578	192	140	1,268	16	280	80
COD	PPM	380	1560	1300	475	3,246	40	900	1,100
BOD_5 at 20°C	PPM	45	410	200	80	460	15	70	170
Total suspended solids	Kg/ton	0.90	16.20	4.05	9.45	3.05	15.75	14.4	40.5
BOD_5 at 20°C	Kg/ton	0.4	16.6	0.9	8.5	8.28	0.337	0.95	34 5

d) 1st and 2nd Hypo stage excess white water is used in chlorinated pulp dilution (4300 gal/ton).

e) Fresh water in hypo shower is completely eliminated; pulp dryer white water is used in its place (2600 gal/ton).

f) Fresh water used in chiller for bleach liquor preparation, being uncontaminated, is sent to mills' clear water reservoir (3600 gal/ton). All these measures reduced water consumption by about 20,000 gal/ton to the present level of 45,000 gal/ADT of pulp.

A further reduction in water consumption can be achieved by adopting the following in-plant measures (which also help in reducing BOD load).

i) Bamboo chips washing consumes large quantity of water. Wash is mostly recirculated and fresh water (3000 gal/ton) is added as make up. Evaporator effluent (Non-condensible gas scrubbing water 1500 gal/ton), screening effluent (9000 gal/ton) or paper machine effluent can be used for make-up. Excess white water from paper machine can be used in screening. It is advisable to go in for closed screening for reducing water consumption and avoiding foam problem.

Average alkali loss in Indian pulp and paper industry is around 15–25 Kg/ton as Na_2SO_4. It may be noted that one of the Finish mills achieved alkali loss of 7–8 Kg/ton by installing an extra washer.

Evaporator secondary condensate which is contaminated (BOD load 5–10 kg/ton), could be used in brown stock washing. Cenpulp presently utilises this condensate without adversely affecting pulp quality.

ii) Proper preventive maintenance to check leakages or spills of pulp or black liquor.

iii) Bleach plant offers maximum opportunity for reducing water consumption, as about 50% of total water is consumed here.

Complete counter—current washing is usually practised abroad. For instance, Kimberly Clark in one of its mills has reduced water consumption to 10,600 gal/ton of pulp without any drop in pulp quality.

Some of the in-plant measures to reduce effluent volume from bleach plant are given below :

a) Seal tank dilution water should be completely stopped.

b) Fresh water usage in showers should be minimised. Only in chlorination and last stage Hypo washer, fresh water showers should be used.

c) Increasing the number of bleaching stages reduces water requirement as well as pollution load.

d) Oxygen-alkali pulping, oxygen bleaching, chlorine dioxide substitution in chlorination, high consistency chlorination and dynamic bleaching greatly help to cut down pollution load.

e) Chlorination stage effluent could be recycled to decker pulp as well as chlorinated pulp, if suitable materials of construction such as 317 SS are available.

An attempt was made at Central Pulp Mills to see the effect of chlorination effluent on pulp quality. Decker pulp at 6% consistency was diluted to 3% consistency with chlorination effluent and then chlorinated with 8% chlorine on OD pulp, using 3.0 gpl chlorine water. Finally, the chlorinated pulp was diluted with the chlorination effluent to 1% consistency. Tables 6 and 7 show the characteristics of the pulps and effluents. It could be seen that pulp quality remained practically the same on reusing 48% chlorination effluent. However, the chloride content in the pulp went up. Further laboratory and pilot plant investigations are needed before recycling chlorination effluent on the plant scale.

Air Pollution Controls

In the pulp and paper industry, malodour in air is chieffly due to sulfur dioxide, hydrogen sulphide, methyl mercaptan, dimethyl sulphide and dimethyl di-sulphide. Recovery furnace and lime kiln flue gases contribute particulate matter to air pollution.

Odour thresholds and gaseous sulphur compound emission data in pulp and paper mills are listed in Tables 8 and 9. Direct contact evaporator, recovery furnace and multiple effect evaporator are the major sources of gaseous air pollution.

Various in–plant controls to help in reducing air pollution are listed below:

a) Recovery boiler should not be overloaded by more than 20-30% of its capacity.

b) Oxygen in flue gas from furnace should be maintained at 2.5–4% to ensure minimum TRS emission.

c) Secondary air should be 30-40% of total air supply to the furnace.

d) Droplets of black liquor to furnace should be as large as possible to help in obtaining less carry over of combustible matter to oxidising zone. (3)

e) Sulphur dioxide emission from furnace will be almost negligible, if smelt sulphidity is maintained below 28%.

f) pH and sodium sulphide concentration in black liquor play an important role in gaseous emission. Black liquor should be oxidised to convert Na_2S to $Na_2S_2O_3$ to reduce H_2S emission in multiple and direct contact evaporators.

g) Lower sulphidity and higher pH (> 12) in white liquor as well as low cooking temperatures minimise gaseous emission from digester relief.

h) Electro–static precipitator with or without Venturi scubber will help to reduce particulate matter going to atmosphere.

Solid Pollution Control

The main solid wastes in the Indian pulp and paper industry are lime sludge, bamboo chipper dust and pulp mill tertiary cycleans rejects. Table 10 shows the effect of lime sludge and bamboo dust on the suspended solids of mill composite effluent. Table 11 shows the characteristics of mill effluent sludge without lime sludge and with/without bamboo dust. A 100 TPD kraft pulp mill handles 60 tons/day lime sludge, 3-4 tons/day bamboo dust and approximately 1 ton/day pulp mill rejects. Hence the need of in-plant control measures to reduce solid pollutants entering the sewer.

Suspended solids of mill effluent at 3000 PPM have been brought down to 200-300 PPM by adopting the measures given below :

a) Lime sludge is dumped in company's low lying areas.

b) Causticising lime kiln effluent containing lime particles from scubber is passed through settling tanks (27'X52'X5'). 90–95% solids in TSS reduction is achieved this way.

c) Chipper effluent containing washed dirt and other foreign material is also passed through two separate settling tanks (25'X50'X5'). Settled dust is periodically removed 70–80% reduction in TSS of effluent is achieved here.

d) In order to remove suspended from tertiary cyclean and screen rejects effluent, a DSM screen has been installed. This way one ton/day of rejects going to drain was prevented. This is mostly fibrous material (97% organics) and has a high percentage (42% on +20 mesh) of long fibres. A suitable outlet for using the recovered fiber at 2% consistency is yet to be found.

e) Regarding lime sludge, successful attempts were made to disilicate it, then causticize and reburn in Cenpulp research laboratory. However, the present cost of fuel oil may prohibit lime sludge burning in rotary kiln for economic lime recovery on plant scale.

f) Bamboo dust could be used as fuel in multi–fuel boilers or pulped in M & D type digesters or could be converted to humus for use as fertilisers in gardens, etc.

Mini Paper Mills:

Pollution control might be a very serious, if not suicidal, matter for small paper mills, since the cost required for effluent treatment is high, perhaps as much as the cost of pulp and paper plant equipment. Diluting mill effluent with water, if available, should be given due consideration. Also, the possibility of treating the small mill effluent with municipal sewage or in combination with other industrial effluents of the locality should be studied. Lastly, it is worth examining the scope of using the small mill effluent for irrigation. Land for irrigation should be made available by the local Government authorities.

Site Selection:

Selection of site plays an important role in pollution control. As seen from Tables 12 and 13, Cenpulp effluent undergoes considerable improvement by way of natural aeration, and dilution on its way to river Tapti. Mill effluent at mixing point of the river is well within ISI standard for discharge into inland surface water (IS: 2490–1974). In this particular case, it might be mentioned that a minimum of 5000 cusecs of water discharge from Ukai Hydro–electric project flows throughout the year into the downstream of river Tapti.

Tables 14 and 15 relate BOD_5 (20°C) to COD and BOD_5 (20°C) to BOD_1 (37°C) for Cenpulp mill effluent. The information will be useful in the sense it gives a quick BOD check for control purposes.

Government Assistance:

Since pollution treatment is an expensive affair, Government authorities should help the industry in financing treatment plants, if the latter are absolutely necessary. In such a case, concessions such as interest free and long term loans should be made available to the industry. As the loan is going to be used in unproductive investment, the industry should be helped with direct and indireet tax benefits as well as other fiscal incentives. Again, if water pollution abatement is a must for any particular industry, the same should be implemented in a time–bound programme rather than on crash basis. Also, prior training should be given to operation personnel to run the treatment plant efficiently. Finally, it should be emphasized that Government regulations should be realistic and consider the extent of pollution caused by each mill. For example, when the receiving stream is not polluted nndue importance should not be laid on the characteristics of the effluent leaving the mill site.

Table 6 : Effect of Chlorination Stage Effluent For Brown Stock Dilution During Kraft Pulp Chlorination

Particulars		Decker Pulp (Unbleached)	Chlorinated Pulp: Washed in Plant with fresh water (100%)	Chlorinated Pulp: Washed in laboratory with chlorination effluent (48%)
pH		10.0	2.2	1.7
Consistency	%	6.0	1.0	1.0
Brightness	PV	2.7	43	42
K.No.		23	10	9.4
Chlorides as Cl	PPM	133	600	1000

Table 7 : Characteristics of Chlorination Effluent

Characteristics		Chlorination stage filtrate from bleach plant	Filtrate (Lab.) from the chlorination effluent
Colour (Pt–Co units)		280	250
Conductivity (Micro–Mhos/cm)		3340	8388
pH		2.3	1.6
Total dissolved solids	PPM	1300	1800
Chlorides as Cl	PPM	774	1221
Oxygen absorbed (4 Hrs.)	PPM	139	208
COD	PPM	465	561
BOD_5 at 20°C	PPM	125	127

Table 8 : Odour Thresholds of Kraft Mill Gaseous Compounds in Air

Particulars		PPM by volume
Sulphur dioxide	(S_2)	1.0 to 5.0
Hydrogen sulphide	(H_2S)	0.0009—0.0085
Methyl Mercaptan	$(CH_3\ SH)$	0.0006—0.040
Di Methyl Sulphide	$(CH_3)_2S$	0.0001—0.0036

Table 9 : Summary of Emission Data—Kraft Process (LB/ADT)

Particulars	SO_2	H_2S	MeSH	MeSMe	MeSSMe	Particulate
Digestor Relief & Blow	Traces–0.01	0.01–0.12	0.02–0.40	0.40–2.5	0.20–1.50	—
Brown Stock washers	0.01–0.02	0.01–0 12	0.10–0.25	0.01–0.02	0.01–0.02	—
Multiple Effect Evaporator OX	0.01	0.01–0.02	0.10–0.30	0.05–0.15	0.05–0.15	—
UNOX	0–0.01	0.10–3.0	0.10–1.50	0.05–0.08	0.01–0.02	75–125 (Cascade)
Direct Contact Evaporators OX	2.0–8.0	0.10–2.0	0.05–0.25	0.01–0.1	0.01–0.20	20–40 (Venturi)
UNOX	2.0–8.0	5.0–30.0	0.50–2.50	0.10–0.30	0.10–0.40	75–125 (Cascade) 20–40 (Venturi)
Recovery Furnace	10–15	1.0 –5.0	0.01–0.01	0.01–0.02	0.01–0.02	—
Smelt tank	0.0–0.01	0.02–0.05	0.02–0.05	0.01–0.02	0–0.01	1.0–4.0
Lime kiln	—	—	—	TRS-0.01 to 0.83		20–65

Table 10 Effect of Lime Sludge And Chips Dust on Suspended solids of Mill Composite Effluent

Particulars		With lime sludge and chipper dust	With Chipper dust but without lime sludge.	Without lime sludge and chipper dust
Colour (Pt–Co units)		500	1600	1400
Conductivity (Micro/CM)		1964	1540	1672
pH		10.8	8.6	8.5
P–Alkalinity as $CaCO_3$	PPM	740	15	14
M–Alkalinity as $CaCO_3$	PPM	1020	260	220
Total suspended solids	PPM	2750	700	250
Total dissolved solids	PPM	2100	1824	1400
Oxvgen Absorbed (4 Hrs.)	PPM	204	270	289
COD	PPM	1077	1100	1224
BOD_5 at 20°C	PPM	160	190	180

Table 11 : Analysis and Fiber Classification of Mill Composite Sludge

Particulars			Without lime sludge	Without lime Sludge and chipper dust
Inorganics		%	22.42	24
Silica as SiO_2 (on Inorganics)		%	15.42	12
Fiber classification	+ 20 mesh	%	31.10	22.72
	+ 50 mesh	%	19.20	11.92
	+ 65 mesh	%	6.2	5.36
	+ 125 mesh	%	5.0	8.15
	— 125 mesh	%	38.5	55.85
Calorific value		Cal/gm	3400	—
Packing density at 90% solids		kg/Cu. ft.	5	4.25

TABLE 12 : Analysis of Mill Composite Effluent at Different Places on the Way to Ghoda Nala

Particulars		SAMPLING POINTS FROM MILL SITE					
		Cenpulp Mill site	Vagada Village (1½ KM)	Ghoda Village (4 KM)	Patharda Village (6 KM)	Mixing Point of River Tapti (8 KM)	ISI limits (IS 2490–1974)
Colour (Pt–Co units)		1150	160	200	85	80	—
Conductivity (Micro–Mhos/CM)		1337.8	961.4	668.8	459.8	443.0	
pH		8.5	9.0	8.4	8.2	7.9	5.5 to 9.0
P-Alkalinity as $CaCO_3$	PPM	4	12	5	1	Nill	—
M-Alkalinity as $CaCO_3$	PPM	190	185	176	165	155	—
Total suspended solids	PPM	172	115	72	8	8	100
Total dissolved solids	PPM	1220	680	420	260	200	—
Chlorides as Cl	PPM	365	221	92	83	48	—
Oxygen absorbed (4 Hrs)	PPM	336	107	88	16	14	—
COD	PPM	1161.6	670	451	104	90	250
BOD (5 days at 20°C)	PPM	180	80	57	13.5	10	30
BOD_5 reduction	%	—	50	75	92	94	—

TABLE 13 : RIVER WATER ANALYSIS

PARTICULARS		UP STREAM OF RIVER	DOWN STREAM OF RIVER
pH		8.2	8.2
M-Alkalinity as $CaCO_3$	PPM	136	137
Total hardness as $CaCO_3$	PPM	105	104
Total suspended solids	PPM	Traces	Traces
Total dissolved solids	PPM	180	182
Oxygen absorbed (4 Hrs.)	PPM	1.1	1.1
COD	PPM	48	56
BOD (5 days at 20°C)	PPM	1.2	1.2

Table 14 : Relationship Between COD BOD_5 (at 20°C) For Mill Composite Effluent.

	COD	BOD_5 at 20°C	COD/BOD
	896	190	4.7
	736	136	5.3
	1018	157	6.4
	1117	180	6.2
	896	190	4.5
	1018	165	6.1
	643	120	5.3
	942	180	5.2
	572	105	5.4
	1081	175	6.1
	1206	215	5.6
Avg:	920	165	5.6

Table 15 : Relationship Between BOD_5 (at 20°C) and BOD_1 (at 37°C for Mill Composite Effluent

	BOD_5 at 20°C	BOD_1 at 37°C	BOD_5/BOD_1
	190	95	2.0
	136	80	1.7
	157	100	1.57
	180	100	1.8
	190	115	1.65
	165	100	1.65
	120	60	2.0
	180	85	2.1
	105	65	1.61
	175	105	1.7
	215	115	1.87
Avg.	165	93	1.8

Conclusions:

1. In-plant control measures are stressed to reduce pollution load to the environment.
2. A thorough discussion is given on how Central Pulp Mills reduced their water consumption and pollution load with effective in-plant conrols.
3. Preliminary laboratory research work was done on recycling chlorination effluent. The study reveals that upto 50% of the chlorination effluent could be recycled without affecting pulp quality.
4. In-plant controls to reduce air and solids waste disposal were also briefly discussed.
5. It is suggested that environmental protection should be the joint responsibility of the industry and Government agencies.

Acknowledgements :

To Shri J. L. Patel for conducting laboratory work on analysis of effluents.

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