An Experience with the Paper Machine Effluent

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SUMMARY

Combined effluent from an integrated Pulp and Paper Mill consists of effluents from Pulp Mill and Soda Recovery Plants, which need an extensive and elaborate treatment due to the presence of high pollutants like lignin and other colouring matters, alkali and many other dissolved as well as suspended solids; and effluents from Paper Machines. The later could be treated in a simple manner by clarification which is sufficient enough to remove most of the pollutants and yield water for reuse in the process resulting in reducing the volume of the mills' combined effluent and its pollution load as well as the requirement of fresh water.

This being a step in the direction of pollution control; a detailed study in this regard was made. An effort has been made to project the useful informations based on the pracitcal experience of the authors in this paper.

INTRODUCTION

In our country, effluent from an integrated Pulp and Paper Mill, on an average comes to 240-360 M^3 per tonne of paper (1), which when compared to the advanced countries is very high, mainly because of low reuse of back waters. When the modern trend is towards "Zero effluent discharge", our water consumption as well as effluent discharge is quite high, which besides polluting the stream to a high degree affects the economics of the paper mills as well as poses a problem for the treatment of high quantity of effluent to make it suitable for discharge to the stream/river.

The paper machine effluent, which forms a sizable quantity of the mills' combined effluent, consists of fibers, fines, fillers, dyes, sizing chemicals and grits etc., can be treated easily and economically to remove the pollutants from it, leaving behind the classified effluent suitable for rouse in the process.

If this effluent could be segregated from the mills' combined effluent and treated, it would reduce the pollution load as well as the volume of the combined effluent and also the requirement of mill water. This would also facilitate and make it economical to treat the remaining effluent, which would be comparatively lesser in quantity, by adopting extensive methods of treatment.

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Keeping the above in mind, a detailed study was undertaken at the Institute. To confirm the observations and results obtained, an integrated Pulp and Paper Mill of repute was requested to try it out on plant scale at their mills.

EXPERIMENTAL

For carrying out various chemical as well as physical tests during the course of our study, standard testing procedures as per Tappi/I.S.I. were followed. Measurement of flow was made with the help of 'v' notch/rectangular weir.

Two hourly samples were collected from various effluent drains along with their flow measurement and composite samples made for the day by mixing quantities proportionate to the flows at the time of respective sample collections. The samples were analysed for total, suspended and total as well as suspended volatile solids, C.O.D., $B.O.D_5$, pH, colour and odour etc. (Table-I).

Settling studies were carried out on Paper Machine effluent in a standard one litre measuring cylinder. 1000 ml. of effluent was taken and the rate of settling was studied without and with the coagulant 'Alum' in varying doses. The classified effluent after settling was analysed for suspended solids (Table-II), alkalinity and total hardness in terms of $CaCO_3$ and compared with normal mill water (Table-III).

Classified effluent during coloured paper runs were bleached with Calcium Hypochlorite.

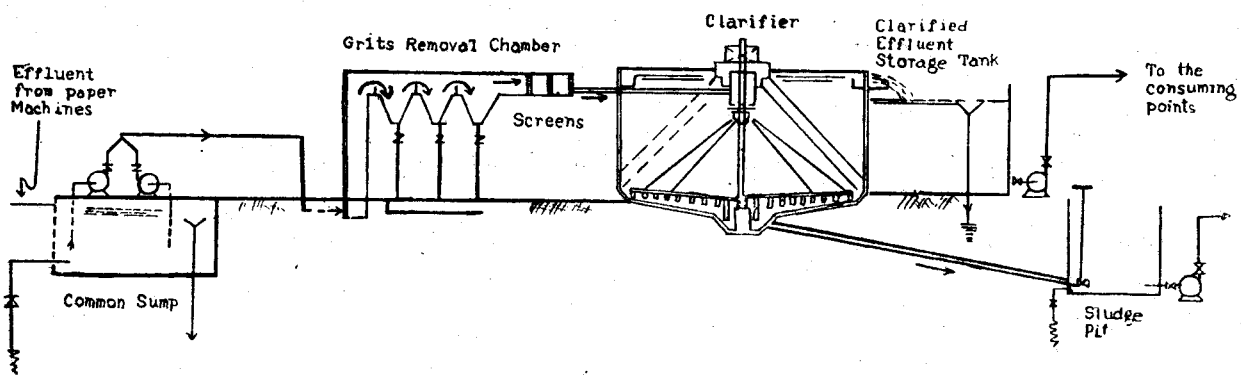

Fig. 1.

TABLE—I. CHARACTERISTICS OF UNTREATED PAPER MACHINE AND COMBINED MILL EFFLUENTS

Particulars	Unit	Paper machine effluent			Mills' combined effluent		
		Max	Min	Average	Max	Min	Average
Flow	M^3/day	8088	5122	6600	30720	23040	26880
Total Solids	ppm	1416	762	1033	1560	910	1188
Suspended Solids	ppm	840	396	608	670	318	494
Volatile total solids	ppm	728	528	628	998	826	912
Volatile Suspended Solids	ppm	693	302	480	442	200	289
C.O.D.	ppm	1034	464	608	960	417	620
$B.O.D_5$	ppm	207	100	153	265	100	131
pH	—	7.3	6.3	6.9	8.8	7.0	7.7
Colour		Depends upon the colour of Paper running on Paper Machines.			Generally yellowish brown. At times tinted.		
Odour		More or less odourless.			Disagreeable.		

TABLE—III. COMPARISON OF CLARIFIED PAPER MACHINE EFFLUENT WITH NORMAL MILL WATER

Particulars	Unit	Clarified Paper Machine effluent			Normal Mill water		
		Max	Min	Average	Max	Min	Average
Alkalinity as $CaCO_3$							
'P' Value	ppm	0.0	0.0	0.0	0.0	0.0	0.0
'M' Value	ppm	150.0	35.0	85.0	105.0	95.0	96.5
Total hardness as $CaCO_3$	ppm	150.0	110.0	133.0	96.0	75.0	87.0
pH	—	7.0	6.4	6.6	7.5	6.0	7.13

TABLE—II. SETTLING CHARACTERISTICS OF PAPER MACHINE EFFLUENT

Particulars	Unit	Without alum			25 ppm alum			50 ppm alum			100 ppm alum		
		Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average
Volume of settled sludge after 0 min. settling	ml	0	0	0	0	0	0	0	0	0	0	0	0
,, 5 ,, ,,	,,	<100	< 50	<100	<100	< 50	<100	100	< 50	<100	150	<100	<100
,, 15 ,, ,,	,,	<100	< 50	< 50	<100	< 50	< 50	<100	< 50	< 50	<100	50	<100
,, 30 ,, ,,	,,	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	<100	50	<100
,, 60 ,, ,,	,,	< 50	< 50	< 50	< 50	< 50	< 50						
Suspended solids in clarified effluent	ppm	68	15	35.5	31	30	30.7	40	22	30.7	49	20	35
Temperature during settling	°C	32	28	30	32	28	30	32	28	30	32	28	30

The figures reported in the tables are based on the average of series of experiments carried out covering a wide period.

DISCUSSIONS

Table-I indicates that paper machine effluent forms approx. 25% of the total volume, 20% of total solids, 30% of suspended solids, 25% of C.O.D. and 30% of $B.O.D_5$ of the mills combined effluent. The pH is generally in the vicinity of 7.0 whereas the combined effluent is always on alkaline side. Colour of the Paper Machine effluent depends upon the colour of papers running on machines and it is more or less odourless. The combined effluent has a yellowish brown colour having an unpleasant odour.

Table-II indicates that paper machine effluent has got good settling characteristics and requires about 15 minutes to settle down about 95% of its total suspended solid content. Any retention beyond, has no appreciable effect on the clarity of the classified effluent. The alum addition does not appear to be effective.

Table-III indicates that though alkalinity of clarified effluent has a wide variation (35-150 ppm) but it is not very different from that of mill water, which too fluctuates in wide range depending upon the season of the year (30-105 ppm). The hardness is on higher side (110-150 ppm) but cannot be considered unacceptable to the process for obvious reasons.

The bleaching results indicate that excepting the yellow coloured effluents, all other can be bleached well with a very small dose of chlorine.

To conclude, the studies indicate that if Paper Machine effluent can be segregated, it can be easily treated separately, resulting in reduction by approx. 25% in the mills' combined effluent volume, which in turn will reduce mills' total pollution load by about 85/30%. The clarified effluent being more or less equivalent to normal mill water in all respects can safely be reused in the process at convenient points.

MODE OF TREATMENT FOR PAPER MACHINE EFFLUENT

Based on the above, a simple primary clarification device was thought sufficient enough to treat the paper machine effluent with three objectives namely; appreciable reduction of volume and pollutants of the combined effluent, less demand of mill water in the mill to conserve the same and allow less draw from the river and finally making it convenient for the remaining mills combined effluent to get extensive and economical treatment.

This thinking is also supported by Hanumanulu and Subrahmanyan [1]. Mohan Das Rao and Chhabria [2], Saxena *et al* [3] and Singhal and Tapadar [4].

Based on the parameters obtained from the laboratory studies, a suitable clarifier for primary clarification of Paper Machine effluent was designed. (Details of designing are not covered in this paper). The process in brief is (Fig. I) collection of each paper machine's effluent in individual sumps—their diversion to a common sump either by gravity flow or pump—where there is a provision for regulation of flow as well as a set of strainers to prevent foreign materials going to the next stage for obvious reasons—Pumping this combined paper machine effluent to a set of hopper type grit removal chambers in series—followed by a set of screens of desired mesh to trap lighter foreign materials—a circular clarifier having a feed device in the centre for horizontal flow and peripherical overflow for the collection of the clarified effluent—a reservoir for clarified effluent collection and then pumping it to the consuming points—a sludge pit for collection of the sludge coming out from the clarifier which can be disposed off in a befitting manner.

RESULTS

The above treatment plant installed at a Paper Mill has given quite satisfactory results based on the working of about two years. The salient observations are as under :

(*a*) The reduction in total suspended solids. C.O.D. and $B.O.D_5$ content of paper machine effluent has been approximately 92, 93 and 82% respectively (Table-IV).

(*b*) The clarified effluent has got the alkalinity similar to that of mill water but it possesses higher hardness. pH is almost the same, (Table-V).

(*c*) There has been a reduction in the volume, suspended solids, C.O.D. and $B.O.D_5$ of the mills' combined effluent by about 26, 32, 25 and 28% respectively (Table-VI).

(*d*) The disposal of sludge coming out from the clarifier, which is in sizable quantity, has been studied in detail. Though the details are beyond the scope of this paper, it could be said that the sludge has a good potential for the use for making cheaper grades of papers or boards.

CONCLUSION

Paper Mills' combined effluent needs extensive methods for its treatment. If the paper machine effluent could be segregated and clarified in a suitable

TABLE-IV. REDUCTION OF POLLUTION LOAD IN PAPER MACHINE EFFLUENT AFTER CLARIFICATION

Particulars	Unit	Before clarification			After clarification			Reduction
		Max	Min	Average	Max	Min	Average	%
Suspended Solids	ppm	900	400	600	66	17	45	92.5
C.O.D.	ppm	897	388	586.6	64	23	42.5	92.8
$B.O.D_5$	ppm	233	92	140.5	43	15	25.0	82.0

TABLE-V. COMPARISON OF CLARIFIED PAPER MACHINE EFFLUENT WITH NORMAL MILL WATER

Particulars	Unit	Clarified Paper Machine Effluent			Normal mill water		
		Max	Min	Average	Max	Min	Average
Alkalinity as $CaCO_3$							
'P' Value	ppm	0.0	0.0	0.0	0.0	0.0	0.0
'M' Value	ppm	130.0	55.0	93.0	105.0	90.0	97.0
Total hardness as $CaCO_3$	ppm	200.0	122.0	155.0	96.0	76.0	81.0
pH	—	7.5	6.6	6.96	7.5	6.0	7.13

TABLE-VI. REDUCTION IN POLLUTION LOAD IN COMBINED EFFLUENT AFTER SEPARATION OF PAPER MACHINE EFFLUENT

Particulars	Unit	Before separation	After separation	Reduction %
Flow	M^3/tonne of paper	244.4	181.0	25.9
Suspended Solids	Kgs/tonne of paper	120.7	82.7	31.5
C.O.D.	Kgs/tonne of paper	151.5	114.4	24.5
$B.O.D_5$	Kgs/tonne of paper	32.0	23.1	27.8

clarifier, it would reduce the total volume of the mills' combined effluent by about 25% and have the way for an easier and economical treatment of the remaining effluent which requires extensive and elaborate treatment. Besides, a good quantity of elarified effluent, almost matching the quantity of the mill water—subject to the seasonal variations—can be used back in the process resulting in a reduction in demand of mill water by about 25%. This brings an overall economics to the mills and also allows a higher flow in the river for better dilution of the treated effluent discharged into it as well as leaving higher quantity of the water for down stream users. The later aspects are of very much importance for streams having low water flows.

The sludge coming out from the clarifier, which is sizable in quantity, can successfully be used for making cheaper grades of papers and boards.

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