Environmental Issues in Small Pulp and Paper Mills-Problems & Possible Solutions

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ABSTRACT:-- The capacity of small mills which has already been existing and the additional capacity which is likely to come in this category of mills will have to survive looking in to the domestic demand of paper & board. The survival of these mills to a large extent will be dictated by two forces, which are-Regulatory and the Economic forces.

Regulatory forces will be essentially the environmental issues & norms the industry will have to comply with.

Economic forces will be mostly the cost effective production dictated by market forces.

Considering these two forces and survival of the capacity in these mills, it is essential to evolve the strategies for addressing the environmental issues. The environmental issues in these mills are the serious threat & a collective efforts is required by all those facing the pollution problems. The paper highlights the various approaches & possible solutions before the industry. These are only a short terms measures which the industry can explore to contain the pollution problems.

INTRODUCTION

For sustained growth of Indian Paper Industry, the continuing existence of small agrobased mills can not be over looked. Today there are about 380 number of pulp and paper mills in our country with an actual production 2.51 million tonnes of paper and board as against installed capacity of 3.96 million tonnes. Of the total installed capacity, the agrobased accounts for about 36%, which is almost at par with forest based mills accounting to 38%. The countries demand of paper & board is projected to grow from the present level of 2.51 million tonnes to about 4.2 million tonnes by the turn of century 2000-01AD. For meeting this additional demand of about 1.69 million tonnes, closed capacity which at present is about 1.02 million tonnes has to be revived and further additional 0.69 million tonnes capacity has to be built. Due to the constraint regarding availability of forest based raw material this capacity increase certainly has to be built up from agro based raw material or the imported waste paper. Inspite of Government's efforts to encourage agro based mills the performance of these mills fell short of expectations despite various facilities extended to them. Various factors contributing to their poor performance mainly concerns to energy and environmental issues which has arisen due to;

- Adoption of out dated technology.
- Lack of appropriate technology particularly for chemical recovery and waste management.
- Poor operation and maintenance practice.

The category of small agro based mills below 40 tpd may not be able to afford for any chemical recovery system due to economic reasons. As a result the black liquor generated is discharged as

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effluent contributing to major pollution loads and at the same time loosing valuable energy in the form of both organic biomass and inorganic chemicals. These mills without a chemical recovery thus have a significant impact on environment from view point of consumption of raw material as well as disposal of waste products leading to pollution. In an agrobased mills nearly 60% of raw material consumption end up as waste as against 12% in an integrated paper mills with chemical recovery.

Central Pulp & Paper Research Institute, (CPPRI) has been actively involved for last 10 years in developing appropriate technology for recovery of chemicals. The Institute has generated exhaustive data on discharge characteristics of effluent from such mills which should help equipment manufacturer for design and development of right types of equipments and effective pollution control for the agro based mills. With fast changing scenario of Indian Paper Industry & tremendous rise in input cost for chemical recovery installations, the concept of chemical recovery for these small mills which at one time appeared feasible, today seems to be a difficult task.

The present paper discusses various problems & possible solutions relating to environmental issues in Indian agro based mills which are aimed towards effective waste minimisation and pollution control.

DISCUSSIONS

Pollution: The major problem for small agro based paper mills - With the pollution control law becoming more and more stringent today, the growth and survival of small agro based mills have become entirely contingent upon finding a viable solution to handle the black liquor. CPPRI has developed technology to overcome the technical problems of high silica, poor combustibility and high viscosities. Although most of the technical problems have been tackled through extensive R&D efforts by developing technologies like desilication of silica rich black liquor and thermal treatment of black liquor for viscosity reduction and sustained combustibility but these mills with capacity less than 40 tpd. may not be in a position to afford any chemical recovery system due to high investment costs. Further these mills, for the cost effective pulp production, still are depending on the pulp production in their own pulping units. Therefore, the pulping section in these mills discharges the black liquor which becomes a major source of pollution. The pollution loads generated in these small pulp mills is much higher than large integrated paper mills. Depending upon the seasonal availability, variety of agro-residues raw materials are used under different conditions of pulping, it is rather difficult to predict or generalise the characteristics of different waste water streams because segregation of different streams is not practiced. Whereas in large paper mills, waste water are generally segregated in to two streams namely coloured stream (due to lignin of pulp washing, caustic extraction & chemical recovery section) & the less coloured stream from chipper house, chlorination, hypochlorite and paper machine section. Lignin and its derivatives which are responsible for the brown color of waste water are found to be non-biodegradable. Although lignin does not exert BOD, it exerts about 1.8 mg. of COD per mg and hence it becomes difficult for the mills to achieve desired COD tolerance limits for discharge into inland surface waters.

Table-1 shows characteristics of effluent generated in small mills and its comparison with large integrated paper mills equipped with chemical recovery.

Data shown in Table-1 clearly indicate that pollution loads in agro based small mills having no chemical recovery is almost three times to that of pollution load in large integrated paper mills with chemical recovery.

Table-1

Characteristics of effluent generated from small agro based and large paper mills.

Parameter	Large integrated paper mill with Chemical recovery	Agrobased paper mill without Chemical recovery
Flow, m^3/t paper	220	250
pH	6.6-10	6-8.5
S.S., mg/l	765	615
BOD_5 at 20°C mg/l	295	700
COD, mg/l	1120	3000
COD/BOD	3.8	4.2
Colour, PCU	600	20,000
Pollution loads kg/t paper		
S.S.	168	155
BOD	65	175
COD	245	740

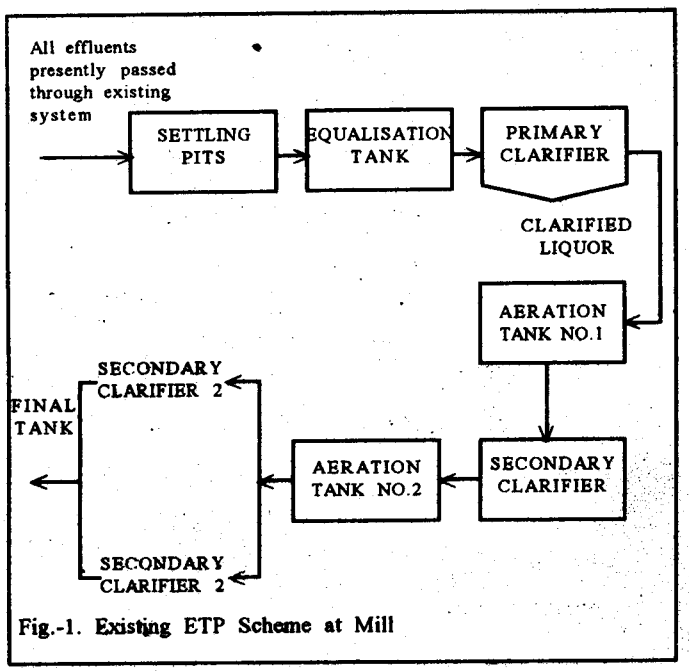

Fig.-1. Existing ETP Scheme at Mill

Prevailing Effluent Treatment Practices in Agrobased Mills

In agrobased mills with no chemical recovery, the lignin contributes to about 215-225 kg/t paper in discharged water which is the largest contributor to pollution and at the same time is bio inhibitory in nature. Prevailing practices of effluent treatment in these mills by aerobic process suffers major disadvantages of higher operational costs due to higher energy and chemical requirement and results in high bio solids causing further waste disposal problems. Above all the desired discharged Standards are not being attained. Existing effluent treatment plant in a typical 40 tpd agrobased pulp mill is shown in Fig.-1, wherein the entire effluent generated in the mill is being treated by aerobic process. Inspite of higher operational costs, the targets laid down by the pollution control authorities seems difficult to achieve.

Strategies and possible Solutions for Pollution Control in Small Agro based Mills

Due to the constraints and problems associated with these mills, the mills were forced to look into alternative economically viable technologies in order to achieve the discharge standards laid down by the concerned authorities and simultaneously preventing the valuable resource drainage. Based on CPPRI's extensive work in the area of black liquor research since last 15 years, some of the alternative options for the small mills have been identified. These are-

1. Increased use of Recycled Waste Paper

Utilization of waste paper for paper making is ecologically desirable in countries with shortage of other fibrous raw materials. Over the past few years, the environmental factors have become increasingly important and the paper industry has responded to the development by offering waste recycled fibre based, so called environmentally friendly product. Replacing virgin pulp with recycled waste paper decreases the overall pollution load in the mill and at the same time energy demand in terms of raw material, input chemicals and waste treatments also gets reduced tremendously. Although there is a great variation in literature references to what extent energy can be saved by the use of waste paper, which varies from 10-80% of virgin paper. Table-2 shows pollution load in agrobased paper mills which uses virgin pulp & recycled waste paper pulp in different proportions. From the data, it is clearly indicated that at 50% use of waste paper, the pollution loads in terms of S.S., BOD, COD can be reduced by about 30-50%. It further reduces the problems of handling & disposal of solid waste generated from the pulp mill.

Table-2

Reduction in pollution load with increased use of waste paper (Agro residues : Waste Paper)

Basis	Pollution load, Kg/t						
Parameters	100:0	75:25	67:33	50:50	33:67	25:75	0:100
COD	740	575	520	415	300	240	70
BOD	175	140	120	100	70	50	20
Suspended solids	160	135	120	110	90	70	58

2. Segregation of Spent Liquor Streams

The prevailing system practiced in small agro based mill is batch pulping followed by washing. Because of lack of chemical recovery systems, these mills normally do not bother much for

effective washings. Normally the mills employ poacher washers followed by one or two drum washers. Often the drum washers do not work at desired efficiency levels due to lack of required pulp mat formation & thereby the desired vacuum is not achieved. This results in use of high quantities of water for black liquor extraction. Introduction of belt washer after the blow tank before existing washing system may help in extracting the black liquor in concentrated form. The segregation of this concentrated black liquor stream coming out of belt washer from other streams may help in proper management of pollution problems. The segregated concentrated stream can have the options for its further processing in following different ways.

Incineration of Segregated Stream

One promising option before these mills with capacity ranging 15-40 tpd is to evaporate the segregated stream to solids concentration up to 30-35% at the mill site itself using a single/two stage evaporation system. This spent liquor in the semi concentrated form at solids concentration of 30-35% w/w may be transported to a nearby integrated paper mill equipped with chemical recovery where this semi concentrated black liquor, which will constitute about 5-10% of the total black liquor generated in wood based mill may be processed for recovery of chemicals along with wood black liquor. Adoption of this practice may help the small mills to get rid of its more than 50% of pollution load in terms of BOD & COD and at the same time it may help in achieving the discharge standards which otherwise is very difficult under prevailing conditions. The integrated paper mill on the other hand will be benefitted by recovery of about 100-125 kg/tp of caustic in addition to thermal energy which may be compensated during evaporation of semi concentrated spent liquor from 30-35% solids level to be achieved at firing stage. Integrated paper mill even after meeting the cost paid for transportation will be benefitted by way of cost of recovered caustic.

The preliminary financial indicator per tonne of pulp produced in small paper mills are shown in Table-3.

Table-3

Preliminary financial indicators for processing concentrated streams for chemical recovery

Total BOD load, kg/tp	300
Reduction of pollution load in terms of BOD through segregated stream, kg/tp	180
Treatment cost by conventional methods	Rs. 360+500=860
Total discharge, m^3/tp	8.0
Solids, % W/W	8.0
Solids to be achieved at mill site	30%
Steam required (steam economy 2.0)	2.9 tonnes
Cost of evaporation at mill site @ Rs. 500/t Steam	Rs. 1450
Chemical recovery at integrated paper mill	
Recovery of caustic kg/tp	100
*Cost of recovered caustic @ Rs. 12/kg	Rs. 1200
Semi concentrate B.L. transportation cost Rs/tp	Rs. 150
Savings	Rs. 1050

* The cost includes cost of processing of caustic recovery. The savings on account of caustic recovery at large paper mill may be shared on mutually acceptable terms which may partially compensate the cost of evaporation at small mill.

Partial Lignin Removal followed by Anaerobic Treatment of Combined Effluent

An alternate approach could be pretreatment of black liquor in which lignin can be recovered partially from segregated concentrated weak black liquor stream. This may result in more than 50% reduction of COD load & color load. Extensive studies have been carried out at CPPRI in the area of lignin removal from the black liquor in agro based pulp mills. Studies indicated that removal of lignin from the concentrated stream segregated in the mill, under optimised conditions of acidification and temperature could result in overall reduction of COD to the extent of about 50%. The data are shown in Table-4. The results are quite promising on laboratory scale. Pilot scale studies are underway to find out actual economics of the process. The resultant liquor now rich in carbohydrates & low molecular weight lignin becomes more prone for biomethanation.

Table-4

Pollution loads in spent liquors before and after lignin removal (Basis 40tpd).

Parameters	Original spent liquor	Spent liquor after partial lignin removal
Flow, m^3/d	4500	4500
COD, mg/l	12000	5500
BOD, mg/l	3900	3600
Lignin, mg/l	4100	1950
% COD removal	--	54
% BOD removal	--	8
% Lignin removal	--	52
Recovered Lignin, kg/d	--	8150
Equivalent coal, kg/d	--	8000

Biomethanation of Effluent Resulting after Lignin Removal

In the last decade, the anaerobic treatment system has become popular primarily due to its ability to handle effluents with high concentration of COD & generation of biogas as source of bio energy. The effluents generated in small pulp & paper mills such as waste paper, chemi-mechanical, thermomechanical & the one after removal of lignin can be successfully treated by anaerobic means which could further be treated by conventional aerobic process to get desired discharge limits specified by pollution control authorities : The pilot trials have been completed successfully. Comparative performance indicators and financial indicators of Biomethanation and conventional activated process are shown in Table-5.

Table-5

Comparative performance indicators and financial indicators of biomethanation and activated sludge process. (Basis - 40 tpd mill)

Performance Indicators	Original Effluent	Conventional Treatment Process	Anaerobic +conventional Process
Flow, m^3/d	4500	4500	4500
COD, mg/l (Combined effluent)	12,000	5400	2400
BOD, mg/l (Combined effluent)	3900	1170	190
Color, mg/l (PCU)	14000	6000	2600
% BOD removal	--	70	$\leq$ 90
% COD removal	--	55	$\approx$ 80
% Color removal	--	57	$\leq$ 82
Biogas production, m^3/day	--	--	10000
(equivalent rice husk, mt/d)	--	--	17

Financial indicators of biomethanation plant:

Investment cost in million Rs.	25	
Operational costs, million Rs.	9.5	
Interest @ 19%, million Rs.	4.7	
Depreciation @ 18%, million Rs.	4.5	
Total running expenditure/ yr. million Rs.	18.5	
Total savings/ yr., million Rs.	12.5	
Payback period, years	3.5	(approx.)

From the data shown in Table-5, it is clearly evident that inspite of high operation cost in conventional aerobic effluent treatment process, it is still not possible to achieve the desired discharge standards, whereas adoption of anaerobic followed by conventional aerobic process with further incorporation of CPPRI's developed lignin removal process may help not only in achieving and or approaching nearer to desired discharge standards but also results in savings by way of reduced operational cost and recovery of bioenergy through biogas generation. The process is at stage of demonstration in one of the agro based mills.

Corporate Chemical Recovery System for Mills with a Capacity 30 TPD and Above

Pulp mills having capacity around 30 tpd can not afford to have chemical recovery units and find it difficult economically, due to high investment & operational cost, to recover chemicals from spent liquors in conventional chemical recovery system. In such cases, it may be feasible to have common chemical recovery system for cluster of mills located in close proximity. To have such corporate recovery systems, certain modalities have to be worked out for the participating mills, such as:

a) Cooking conditions has to be optimised so that the resulting spent liquor in each mill has minimum solids concentration of around 8% with minimum required active alkali.
b) The spent liquor from the mills may be transported to common site by means of pipe lines.
c) Proper facilities of storage of different types of liquor at common site choosen.

With such an arrangement, received chemical can be shared by the participating mills although not the steam as it will be utilized in evaporation of WBL. Schematic of corporate chemical recovery

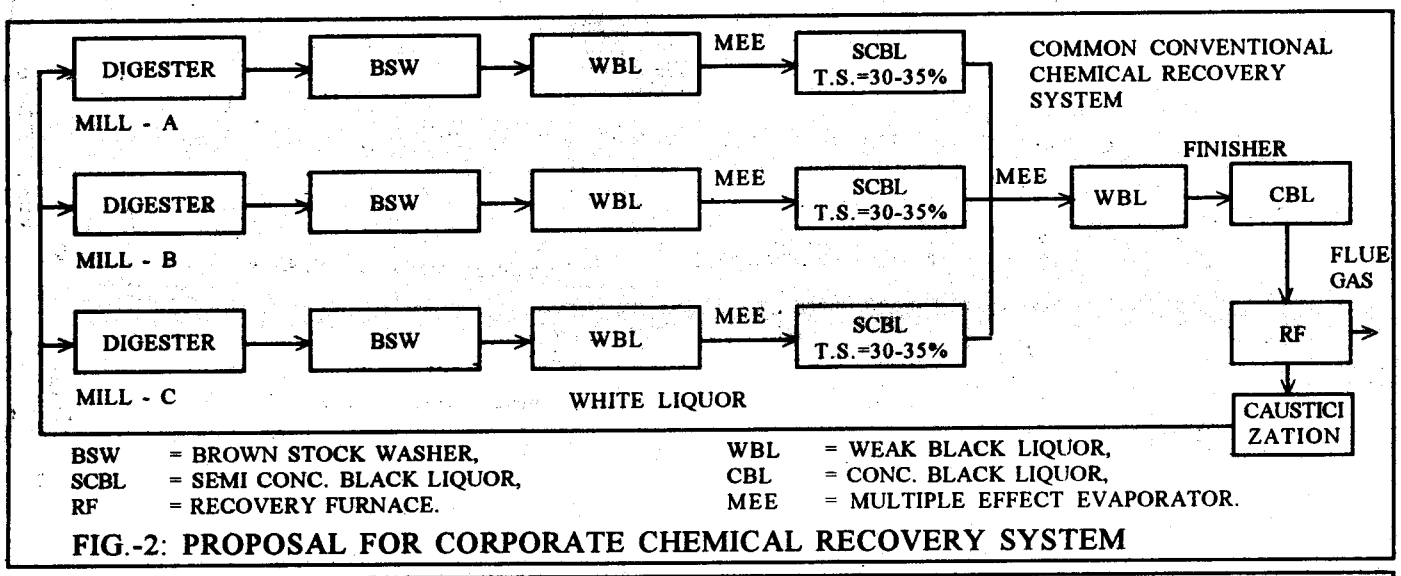

FIG.-2: PROPOSAL FOR CORPORATE CHEMICAL RECOVERY SYSTEM

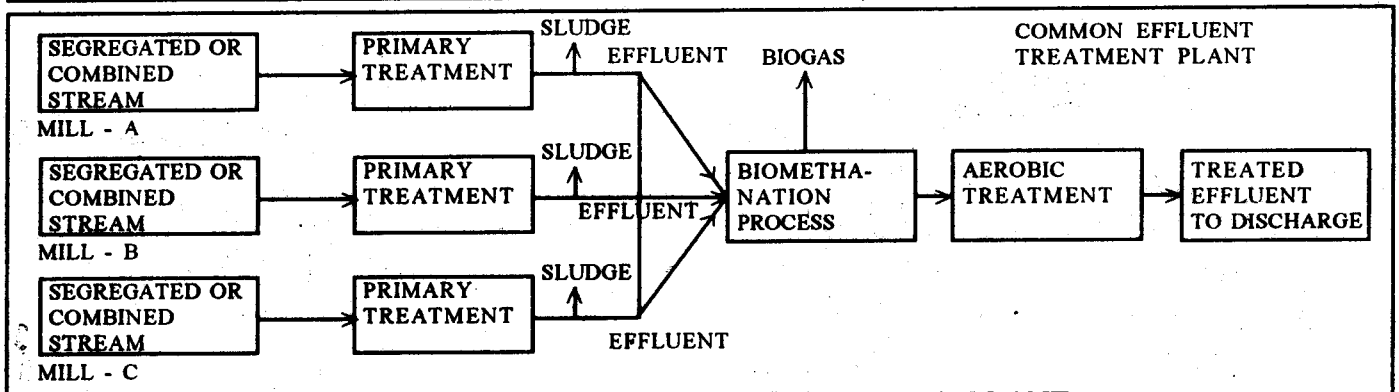

FIG.-3: PROPOSAL FOR COMMON EFFLUENT TREATMENT PLANT

system is shown in Fig.-2.

Common Effluent Treatment Plant (CETP)

Another alternative in the mills which have very small capacities (5-30tpd) if located at close proximity of each other can have combined effluent treatment plant based on lignin removal followed by biomethanation and activated sludge process. In this case, lignin removal process has to be carried out at the mill site & the spent liquor after lignin removal can be brought to the common treatment plant to treat the effluent by biomethanation process followed by conventional activated sludge process. Schematic of CETP is shown in Fig.-3.

CONCLUSIONS

The main reason for heavy pollution in the small pulp & paper mills is discharge of spent pulping liquor carrying high proportions of organic mass rich in highly polluting lignin macromolecules. Due to economic reasons these mills can not afford to go for chemical recovery systems. Some of the promising options before these mills are:

- Substitution of virgin pulp by recycled waste paper in appropriate proportions.
- Segregation of spent liquor streams followed by various treatment options possibly by incineration, removal of highly polluting lignin & treatment of resultant spent liquor by anaerobic followed by aerobic treatment method should be explored by these mills. Further, there is an urgent need for installation of Common Effluent Treatment Plants like some of the installation in Europe.