Biomethanation Technology - An Option for Treatment of Effluent Generated in Recycled Fiber Based Mills

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ABSTRACT

In recent years, the use of recycled fibers has increased tremendously world wide and the present trend shows that in the coming years recycled fiber will be a major raw material for pulp and paper making. The effluent generated during processing of recycled fiber contains easily degradable organic matter and the conventional effluent treatment process which these mills normally use, consume huge amount of energy and chemicals. In recent times there has been a growing interest in application of ***Biomethanation Technology*** *for treatment of effluents due to the added advantage of cogeneration of energy alongwith reduction in pollution load. The present paper explores the techno economic viability of installation of biomethanation plant for collective treatment of effluents from a cluster of recycled fiber based mills located in close proximity (as prevails in Indian scenario). The concept if practically realized can, help in meeting the energy requirement of these category of mills to a certain extent along with appreciable reduction in pollution load.*

INTRODUCTION

In the present scenario of shortage of forest based fibrous raw material, problems in processing of agro residues increasing environmental pressures, stringent discharge norms and high cost of inputs for treatment of effluent, it has become imperative for the Indian paper industry to increase the use of waste paper / recycled fiber for the production of paper so as to sustain the growth of paper industry. The major advantages associated with increasing use of recycled fiber by the paper industry are its sustained availability & ecofriendly usage, low cost, higher fiber yield, less capital investment and lower water, energy and chemical consumption compared to integrated mills based on wood or agro residues.

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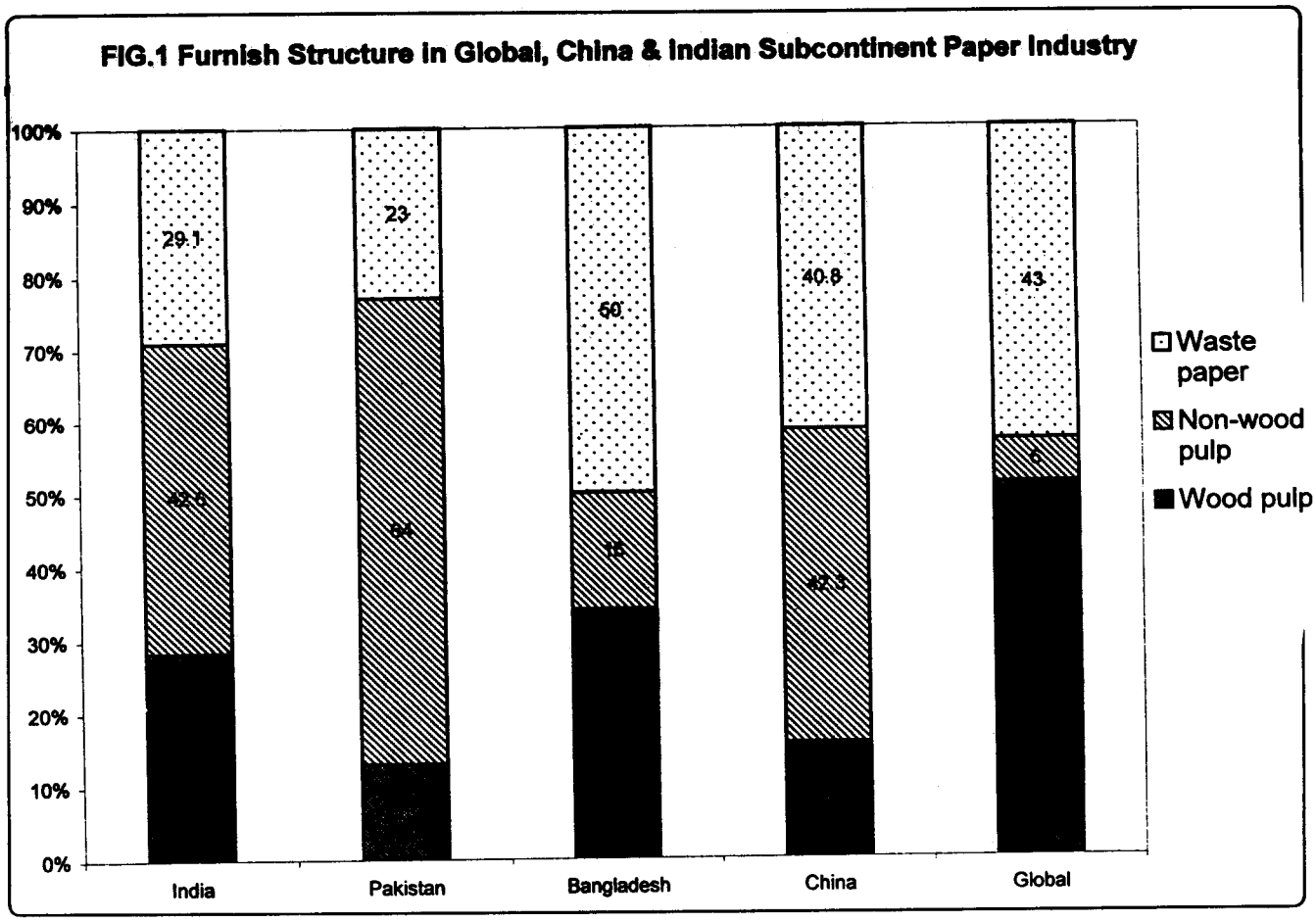

RECYCLED FIBER BASED MILLS STATUS IN INDIA & ABROAD

The increase in recycled fiber consumption worldwide has been significant and the growth pattern forecast the use of recycled fiber as a major raw material by the paper industry in the new millennium. Countries like Netherlands, Singapore and Taiwan have achieved recovered paper utilisation rates more than 85%. It is reported that secondary fiber is the second largest source of fiber in USA. Indian comparative analysis of the furnish structure in global, China and Indian subcontinent's paper industry is depicted in Fig.-1. Trends in fiber furnish in paper industry globally from 1990 to 2000 and forecast till 2010 is depicted in Fig. 2. The data on recycled fiber recovery and consumption in different countries is given in Table-1. In India more than 250 mills manufacture various grades of paper using recycled fiber fully or partially along with chemical pulp produced from agricultural residues to an extent of 25-40% and these category of paper mills are contributing around 40% of total paper and paperboard production of the country. These recycled fiber based mills are largely dependent on imported waste paper. The major exporters of recovered paper to India are USA (60-65%) and Middle East (25-30%) while some quantity is also imported from Singapore and Europe.

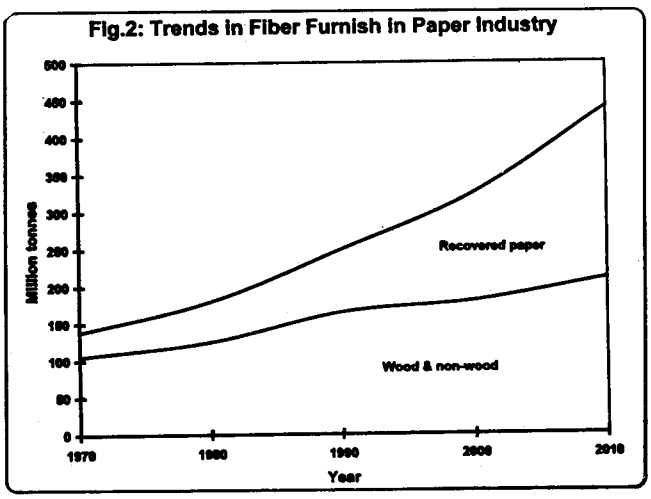

TABLE-1

RECYCLED FIBER RECOVERY & CONSUMPTION IN PAPER AND BOARD INDUSTRIES OF DIFFERENT COUNTRIES

Country	Apparent P & B Consumption X1000 Ton	Recycled fiber recovery X1000 Ton	Recycled Fiber Use %
China	32,701	8,760	37.8
Japan	31,569	16,546	53.5
Korea	6,842	4,531	72.8
Taiwan	5,074	2,789	90.8
Indonesia	3,694	1,163	46.6
Thailand	2,215	943	68.9
Malaysia	1,721	698	90.5
Philippines	810	211	50.4
TOTAL ASEAN	**4,578**	**3,509**	**57.2**
India	3,934	650	31.8
Australia	3,137	1,458	59.8
New Zealand	701	210	17.0

STATUS OF POLLUTION LOAD IN INDIAN RECYCLED FIBER BASED MILLS

The recycled fiber based paper mills in India has a wide spectrum in terms of production capacity ranging from 5 ton per day to 350 ton per day. The mills are characterised by simplicity in process as compared to wood based or agricultural residues based paper mills producing chemical pulp since the complicated pulping and exhaustive bleaching process which contribute maximum pollution load are not practiced in these recycled fiber based mills.

The main steps involved in processing of waste paper includes removal of ink, glue, grits and debris. Most of the non-fibrous raw material is dissolved or separated during processing of waste paper. The solid waste generated include plastic, ink, grit ETP sludge etc. While liquid waste includes fiber fines, dissolved organics, etc. by use of water. The water consumption in these mills varies between 40-100m^3/ ton of product depending on the extent of recycling which is quite high compared to waste paper based mills in Europe (Table-2). The major factors for high water consumption in Indian mills based on recycled fiber are low capacity, obsolete machinery and equipments multiple no. of machines etc. Recently

TABLE-2

SPECIFIC WATER CONSUMPTION IN RECYCLED FIBER BASED MILLS IN EUROPEAN COUNTRIES

Type of Mill	Water Consumption m^3/ton of product
Packaging Board	6-8
Newsprint & Tissue	12-15
Writing & Printing	20

Central Pollution Control Board has prescribed the discharge standards for Indian Paper Mills (Table-3) which will make imperative for these mills to reduce their water consumption. The general characteristics of the waste water generated in these mills are given in Table-4.

EFFLUENT TREATMENT PRACTICES IN RECYCLED FIBER BASED MILLS

The major pollutants in the effluent of waste paper based mill include fiber, fines, fillers, ink particles, colloidal organic and inorganic substances like adhesives, coating binders etc. Some mills practice mild bleaching chemicals like hydrogen

TABLE-3

STANDARDS FOR WATER DISCHARGE IN INDIAN PAPER MILLS

Mills	m^3/ton of paper
Large Mills :	
Writing & Printing	200 (100)*
Rayon Grade & Newsprint	150
Small Mills :	
Based on agricultural Residues	200 (150)
Based on Waste Paper	75 (50)

*** Figures in ( ) are for new mills set up after 1992**

TABLE-4

CHARACTERISTICS OF WASTE WATER IN RECYCLED FIBER MILLS

S. No.	Particulars	Value
1.	Waste Water Generation m^3 / ton of paper	40-100
2.	pH	6-8
3.	Total Dissolved Solids, mg/l	1000-2500
4.	Total Suspended Solids, mg/l	750-1800
5.	COD, mg/l	400-1500
6.	BOD, mg/l	150-600
7.	Chlorides, mg/l	300-750
8.	Colour, Pt Co unit	200-500

peroxide which results in dissolution of natural resin and fatty acids in the effluent.

Some of the mills have installed **Krofta Dissolved air Floatation System** where the suspended and dissolved matter in the process back water (generated during pulping) are removed in the form of sludge and the clarified back water is reused in the internal process. However the maximum percentage of pollution load is generated in the deinking plant.

The major pollutant in the recycled fiber based mill effluent are suspended solids as such removal of which is carried out either simple sedimentation and polishing ponds (in areas of easy availability of water) while in mills with high production capacity and also restricted availability of water, the conventional effluent treatment system is practiced which include primary clarifier, aeration tank/aerobic lagoon and secondary clarifier/ polishing pond. In these mills more than 50% of treated waste water is recycled in the internal process and the remaining is utilized for irrigation of crops or discharged as such in the receiving stream.

BIOMETHANATION PROCESS AS AN ALTERNATIVE TO CONVENTIONAL TREATMENT PROCESS

The biomethanation process has been practiced for treatment of industrial effluents including pulp and paper mills. The technology has now been accepted world wide for treatment of even more complex industrial waste water. A number or full-scale biomethanation plant are operating in paper industry worldwide and most of these installation are working in recycled fibre based mills. Biomethanation process offers a dual advantage of treatment of effluents along with cogeneration of energy in form of methane rich biogas, which can be used as a fuel. The anaerobic treatment has several advantages over aerobic treatment process, which are summarised below:

- Less space requirement.
- Low capital investment.
- Less generation of biosludge due to slow growth rate of anaerobic bacteria.
- Low cost of disposal of excess biosludge since biosolids generated during anaerobic treatment are relatively stable and have high densities (8-13%) compared to aerobic sludge.
- Low chemicals and nutrients requirement.
- Lower energy requirement.
- Generation of biogas.

TABLE-5

POLLUTION LOAD IN A 100 TPD RECYCLED FIBER MILL

S. No.	Particulars	Value
1.	Waste Water Generation m^3 / day	5000-7500
2.	Suspended Solids, ton/day	4.0-5.0
3.	Dissolved Solids, ton/day	6.0-7.5
4.	COD, ton/day	5.0-7.5
5.	BOD, ton/day	2.0-3.0

The biomethanation technology has been well accepted in developed countries for cogeneration of energy from mechanical, semi-chemical, prehydrolysis liquor, evaporator condensates etc. and a number of full scale biomethanation plants are working in pulp and paper mills worldwide. In India a full scale biomethanation plant has been successfully commissioned by CPPRI in collaboration with MNES at Satia Paper Mills Ltd., Muktsar, Punjab for treatment of complex black liquor with an average reduction in COD and BOD of around 45-50% and 75-80% respectively. The biogas generated (~ 10,000m^3/day) is flared in the boiler which supplement about 15-20% of energy requirement of the mill.

APPLICATION OF BIOMETHANATION PROCESS IN RECYCLED FIBER BASED MILLS

The installation of biomethanation plant in an individual recycled fiber based mill (even in a 100 tpd mill) may not be technically and economically feasible owing to low pollution load as indicated in Table-5.

However the concept of cooperative biomethanation plant where the effluents from three or four recycled fiber based mills located in a close vicinity is collectively treated together and the bio gas generated is utilised together among the mills not only make application of biomethanation feasible but also economically viable. The concept was realized in practice at the biomethanation plant at Industries water Eerbeek, B.V., Netherlands where the effluent from three recycled fiber mill is treated collectively.

DESCRIPTION OF THE INDUSTRIE WATER EERBEEK B.V. ANAEROBIC TREATMENT PLANT

The schematic diagram of the biomethanation treatment plant is given in Fig-3. The three different wastewater streams, discharged by the mills, flow by gravity through an independent sewage system to the treatment plant, where the combined waste water is received in the collection sump.

The waste water is taken to primary clarifier after passing through a pre-aeration tank to remove odorous components. The pre-aeration tank is

CASE STUDY : STATUS OF BIOMETHANATION PLANT AT INDUSTRIE WATER EERBEEK B.V., NETHERLANDS TREATING EFFLUENT OF THREE RECYCLED FIBER BASED MILLS

Name of the Mill	Production, ton/day
Reedpack de Hoop	750
Mayr Melnhof Eerbeek	250
Coldenhove Paper Mill	60

Pollution Load from the Mills

Name of the Mill	Flow m^3/day	Soluble COD kg/day	Soluble BOD kg/day	Settlable Solids kg/day
Reedpack de Hoop	5000	14000	8000	2000
Mayr Melnhof Eerbeek	5900	5000	2000	14000
Coldenhove Paper Mill	1400	200	100	1000
TOTAL	12300	19200	10100	17000

Salient Features of the Biomethanation System

PARTICULARS	
Reactor Type	UASB
Reactor Capacity, m^3	2200
Organic Loading Rate, kg COD / m^3/day	10-12
Waste Water Flow, m^3/hr	600-650
Temperature of Waste Water, °C	28-32
COD Reduction %	60-70
BOD reduction %	70-75
Specific Biogas Production, m^3/kg COD removed	0.35-0.45

covered with a compost filter to prevent air containing H_2S from entering the atmosphere. The clarified waste water is then pumped into a BIOPAQ Upflow Anaerobic Sludge Blanket reactor (UASB reactor) of capacity 2200 m^3.

The biogas after scrubbing H_2S is utilized in a gas engine to generate 155 kw of electric power Excess anaerobic sludge is sluiced periodically from the reactor and stored before it is deliverd to other sites for start up of new reactors.

FIG-3 FLOW DIAGRAM OF BIOMETHANATION PLANT AT INDUSTRIE WATER EERBEEK, NETHERLANDS

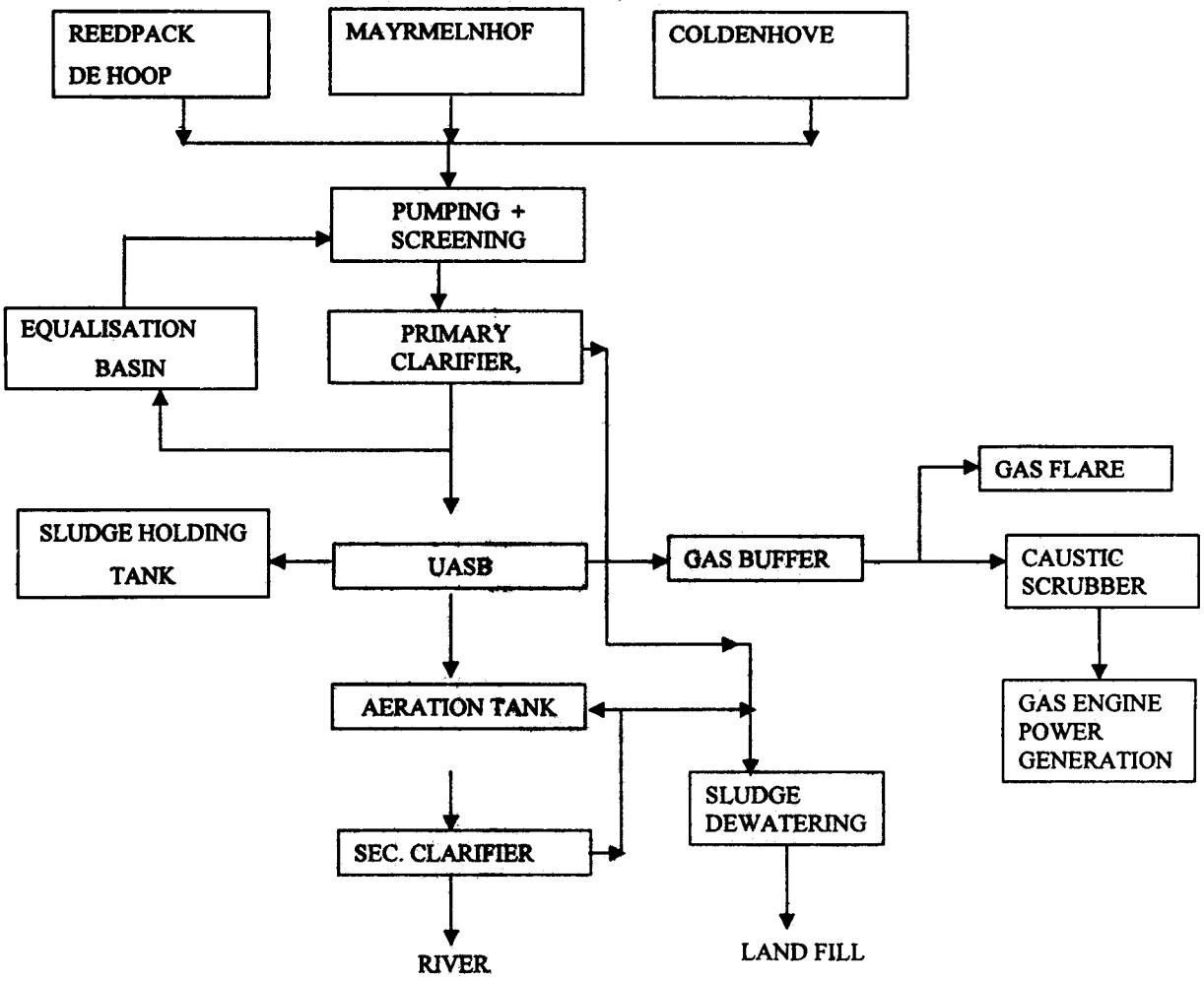

TABLE-6

POTENTIAL OF BIOENERGY GENERATION IN A COOPERATIVE BIOMETHANATION SYSTEM OF 3-4 RECYCLED FIBER BASED MILLS

S. No.	Particulars	Value
1.	COD Load, ton/day	15-18
2.	BOD Load, ton/day	6.0-7.5
3.	COD Reduction %	60-65
4.	BOD Reduction %	80-85
5.	Biogas Generation m^3 / day	4000-4500
6.	Calorific Value, kcal/m^3	6200-6500
7.	Coal Equivalent, ton/day	5-6
8.	Fuel Oil Equivalent, ton/day	2.5-3.0

The anaerobically treated waste water is further treated by an extended aeration system, consisting of two aeration tanks, each one with a volume of 4,000m^3, and two final clarifiers. The return aerobic sludge is pumped back to a sludge thickner and mixed with the primary sludge. The sludge mixture is dewatered on two belt presses and discharged for land fill. The final effluent, with BOD concentrations of 5-15 ppm, is discharged to a river.

POTENTIAL OF BIOMETHANATION IN RECYCLED FIBER BASED MILLS IN INDIAN SCENARIO

In present scenario of increased recycling of waste paper, the cooperative biomethanation plant system has a good potential for recovery of energy from the waste generated especially where 3-4 recycled fiber based mills are located in close proximity. The potential and techno-economic viability of biomethanation system evaluated for a cluster of mills are given in Table 6 & 7.

CONCLUSION

The increased trend in recycling of waste paper world wide indicates that the recycled fiber will be a major raw material in the coming years to reduce the dependency of the paper industry on the natural resources and also to save the environment. In India around 40% of the total paper production comes from recycled fiber. Though the activated sludge process

TABLE-7

ECONOMICS OF THE PROPOSED BIOMETHANATION PLANT

Particulars	Value
Installation Cost, Rs (Lacs)	150
Operation of Maintenance Cost Rs (Lacs)/ Year	20
Total Savings due to biogas utilisation, (Rs Lacs)/Year	40
Net Savings after considering operating costs, Rs. (Lacs)/Year	20
Pay Back Period, Years	7-8

widely used by the paper industry is efficient to treat the effluents to discharge norms, it is energy and chemical intensive. Biomethanation process has the advantages of cogeneration of energy along with treatment of effluent thus preventing it from becoming a liability.

The full scale biomethanation plant have been already working successfully for treatment of effluent generated in recycled fiber based mills abroad. The biomethanation technology has demonstrated successfully for treatment of black liquor in agro based paper mills. In view of increased cost of energy and also high operating cost of conventional aerobic treatment process, the biomethanation process has a good potential in recycled fiber based mills specially where number of mills are operating in close proximity.

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