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Agricultural Residues in the Future Set Up of Indian Pulp and Paper Industry

The Indian Pulp and Paper Industry is depending mainly on bamboo and hardwoods for sustenance and growth. The supply position of bamboo in the context of ever-increasing demand for pulp and paper has almost reached the limit, and under the present set up of the country's forest, that of the hardwoods is also not unlimited.

To feed the increasing population, the country has taken up intensive and extensive cultivation. This has also resulted in increased production of agricultural residues. Without depriving the cattle of the fodder, the surplus (wheat and rice) straws and those agricultural residues which have no other use, can be pressed into service to supplement the pulp production.

The main problems, associated with the use of agricultural residues by large mills, on a sustained basis, are (a) ready and adequate availability at a remunerative price, (b) economic collection and transport, and (c) proper storage to ensure little or no deterioration. Economics, rather than technology, appear to be the main factor for successful use of agricultural residues for pulping.

Various advantages and disadvantages of pulping of agricultural residues and the processes available for pulping have been discussed.

The production of paper and board in the country is increasing, year after year. Thus, against a production of about 1,14,000 tonnes in 1951, the production rose in 1958, to about 2,52,600 tonnes[1] (that is, an increase of more than twice) and to about 3,65,000 tonnes[2] during 1961-62, (that is, more than three fold increase). However, the growing demand of paper and board in the country, always excelled the production.

During the First Plan (1951-55), the demand was cheerful and elastic, and in consonance, the production increased at an average rate of 14,8 and 4 percents per year for writing and printing papers, newsprint and industrial paper respectively[3]. However, during the Second Plan (1956-60), although the demand for the commodities continued to increase, the supply could not keep pace with the demand, and was thrown out of balance, increasing the gap between supply and demand, due partly to restrictions of import, but mainly due to the scarcity of fibrous material. The ever-expanding need of paper and kindred products of the country and availability of limited pulpable raw material resources, lead to the shortage of the commodities with their concomitant disappearance from the consumer's market, sending prices irrationally high and almost out of reach of the common man. The supply of the cellulosic raw material, *vis-a-vis*, the production and the demand schedules of paper and board during the third (1961-64) and Fourth (1965-69) Plans continued to deteriorate on account of the rising cost and increasing requirements of the raw material. Indeed a serious shortage of the pulpable resources was and is still apprehended[4] and many minds were agitated with the idea that a paper famine in India is likely to take place in mid-seventies.[5]

According to Tapadar[6] during 1973-74 about 9,60,000 tonnes of paper and board was expected to be produced. The production is expected to reach 19,50,C00 tonnes in 1980 and 26,40,000 tonnes during 1983 84 (*loc cit*) It is presumed, that the above estimates have been arrived on the basis of a limited supply of pulpable mate-

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rial. However, given an unrestricted supply of fibrous material, the estimated out-turn of paper and allied products will be more[7]. A perusal of figures in Table 1, will be of interest.

TABLE I

Estimated Production of Paper, Board, Newsprint and Chemical Pulp (million tonnes)

Year	On restricted supply of fibrous material	On unrestricted supply of fibrous material
1970–71	–	1.70
1973–74	0.96	
1975–76		2.85
1978–79	1.33	
1980	1.95	
1980–81		4.20
1983–84	2.64	

The estimated fibrous raw material required[6] for the production of paper, board, newsprint and rayon grade pulp is expected to be around 5 million tonnes in 1978-79 and around 10 million tonnes in 1988-89 (that is, almost double in production (see Table II) and in raw material need in 10 years) According to an earlier estimate made by Seetharamiah[8], the fibrous material requirement, in million tonnes in 1970-71, was around 4.2 and 7 2 in 1975-76 and that, the expected requirement in 1980-81 will be around 10.2. A comparison of the foregoing figures detailed in Table II will show that Tapadar's estimates[6] are rather conservative and in his opinion (even) to meet this (conservative) requirments, the country's fibrous sources are "likely to be severely strained" (*loc cit*)

TABLE II

Estimated Pulpable Material Required For Paper, Board, Newsprint and Rayon Pulp

(Million tonnes)

Year	Pulpable Material Required
1970–71	4.2*
1975–76	7.2*
1978–79	5.0**
1980–81	10.2*
1988–89	10.0**

Source–*Vide, Seetharamiah, A, IPPTA, Souvenir, p. 6, Apr. 1964.
**Vide, Tapadar, D. C., IPPTA, 9 (4) : 340 (1972)

The Indian Pulp and Paper industry is mainly dependent on bamboo and hardwoods for sustenance and growth. While the pattern of demand of paper in India has remained more or less static during the last decade, a shift in the pattern of fibrous material consumed is noticeable. Thus in 1965, of the total production, cultural papers accounted of 69% (=52% writing printing plus 17% newsprint) and the balance (31%) constituted the industrial paper. In 1975, the cultural papers are expected to account for 71% (=54% writing printing plus 17% newsprint) and the industrial paper 29%. However, the quantum and pattern of raw material requirement has undergone a remarkable change. In 1965, around 1 million tonnes of bamboo and 0.2 million tonnes of agricultural residues (like straw, bagasse, jute stick and grass) were used beside 0.2 million cubic meters of hardwoods, (average sp. gr. 0.45). As compared to this the, estimated fibrous material required in 1975 is around 2.1 million tonnes of bamboo plus 1 million tonnes of agricultural residues and 1.6 million cubic meters of hardwoods[3]. The figures detailed in Table III are interesting.

There is a noticeable change in the pattern of consumption of long-fibred and short-fibred pulpable material. The long-fibred material (mainly from bamboo) which used to account for nearly 60% of the pulp requirement (even in 1960) is slowly giving place to short-fibred material

TABLE III

Comparison of Pulpable Material Required During 1965 & 1975

	YEAR/REQUIREMENT 1965	1975	REMARKS
Bamboo (million tonnes)	1.0	2.0	An increase of 2 times.
Agricultural Residues (million tonnes)	0.2	1.0	An increase of 5 times.
Total (million tonnes)	1.2	3.0	An increase of 2.5 times.
Wood (million cubic meters)	0.2	1.6	An increase of 8 times.

(wood, grass and agricultural residues) which accounted for about 24% of the pulp need in 1960, The balance (15%) of the requirement being supplemented by waste paper. In 1963 the long fibred material (bamboo) accounted for 55% of the pulp need, and the short fibred material (wood, grass and agricultural residues) for 32%, the balance (13%) being provided by waste paper. In 1975, about 42% long-fibred and 46% short-fibred material is expected to be the proportion beside the usual requirement (13%) of waste paper. This shift in the pattern of fibre consumption is in broad agreement with the global tendency to depend more and more on short-fibred material due to the shortage of the long-fibred material.

So far India is concerned, the supply position of bamboo, (—the main source of long-fibred pulp—), has almost reached the limit. Further supply of bamboo for pulping, (—accounting for 17% of the annual availability of bamboo—), is not possible without creating an imbalance for other end-uses of bamboo (—accounting for 83% of the yearly bamboo production—). The quantum of various pulpable materials required in 1965 and 1975 (see Table III) has been estimated, keeping in view of the trend of shift from long-fibred materials for pulp production. It is possible to interchange within limits, different pulpable materials, without detriment to the quality. However, such interchanges, in actual practice, are limited by the respective availability and price of the individual material.

Regarding the use of hardwoods for pulping, it may be significant to note that although the industry is the largest consumer of wood, its capacity for payment for the wood is lowest in comparison to other end-users of wood[9]. Further, all and sundry species of wood, that are available may not be technically and/or economically suitable for pulping (*loc-cit*). The quantum of pulp wood required has increased tremendously during the last twelve years. Thus, in 1963, when the *wood era* of the Indian Pulp Industry began, nearly 0.1 million (or 1.0 lakh) cubic meters of wood was consumed. In 1975, the estimated pulpwood required is of the order of 1.0 million (or 10.0 lakh) cubic meters[8]. The increased demand is ten times the pulpwood requirement of 1963, and is unlikely to be accomplished, not only due to technical disability to immediately utilize "the existing hardwood on a large scale", but also due to economic inability *(loc-cit)*, even if, the required volume of wood be made available from the forest, depriving the necessities of other end-users of wood.

The requirements of industrial wood by 1975 have been assessed at 24 million cubic meters per year[10], and that for fuel wood at about half of above, making a total of 36 million cubic meters a year[3]. According Seth[11], who is long associated with various aspects of Indian forestry, the requirement of industrial wood in 1975 will be of the order of 13.3 million cubic meters a year and is likely to be around 32 million cubic meters a year in 1985; whereas, the estimated yearly yield in 1985 will be around 12 million cubic meters. The gap (20 million cubic meters per year) between the requirements of industrial wood and its availability can be reduced to some extent (but not covered) by undertaking intensive forest managements, raising more industrial wood by plantation and by tapping unexploited forest areas (*loc-cit*). Compared to countries with developed forest resources, the present off take of wood (for industrial and domestic purposes) in India is low. There is at present just an even balance between the demand for wood and its supply. Increased demand for supply of wood without increased production of wood will lead to a serious deforestation.

The raising of suitable species in man-made forests in various parts of the country is way out to increase the output of wood. However, the investment for the programme is locked up for a long period of gestation. Even quick growing species (like eucalyptus) mature in about fifteen years. The felling cycle for other hardwoods are more. It cannot be inferred, that if and when in future increased production of wood from the forest is available, the entire excess, (as compared to present output), or the bulk of the excess will be diverted to the pulp industry, (which has the least capacity to pay), in preference to other wood-based industry. Such being the supply position of wood one should ponder whether or not the increased further demand of pulp can be met by pulp wood. A saturation point in the supply position of pulpwood is likely to be met in a not very distant future.

In the context of ever increasing requirement of pulpable material to keep pace with increased production, availability and uses of fibrous material, other than bamboo and wood, need careful consideration. It is rather unusual for an agricultural country like India, not to undertake the pulping of agricultural residues in a big way, to supplement the pulp production. Aggarwala[12] has rightly remarked that basically India is an agricultural country and with the progress of agriculture, surplus wheat straw, rice straw and bagasse will be available for pulping. He has also opined[13] that agricultural residues are secondary fibres and being available in plenty, their utilization is of utmost importance for national economy.

According to Sen[14], with increase in population, the availability of wood for industrial purposes is likely to decrease, unless a breakthrough in increasing yield of wood is achieved; whereas, with population increase, agricultural increase is inevitable with consequent increase of agricultural residues (presumably, not only for cattle feeding but also for pulping). Tapadar[6] has also expressed that "agricultural residues... can be effectively used to supplement the usual raw material" (for pulping). Identical views have also been expressed by the author[9]. A rough and ready estimate of straw can be made from the yield of grains[15], as shown in Table IV.

TABLE–IV
Yield of Straw per tonne of Air Dry Seeds

Crop	Straw yield
Wheat	2.6 tonnes
Rice	1.4 ,,
Flax (for oil seeds)	3.3 ,,
Oats	1.8 ,,
Rye	3.5 ,,

A nmber of agricultural residues, e.g., bagasse, wheat straw, rice straw, other cereal straws, the stem of some of edible leguminous (that is, pulses) crop, stem of non-edible leguminous (for fibre) crop, stem of cotton plant, the stem of jute and other fibre plant (after removal of the bast fibre), stem of many oil seed crops, stem of maize, jwar, bajra and the like are available. The above list is illustrative but not exhaustive. In general, the utilization of agricultural residues for pulping depends to a large extent on the economics of procurement and transport and has a direct bearing on its suitable storage to ensure little or no deterioration during the storage period. Proper storage is important for quality and yield of pulp.

As a rule, the crops are harvested when very dry and sufficiently mature. They should be properly baled and stored in piles (as in the case of bagasse bales) under shade with access to free flow ef air. The floor should be brick-layed. All other necessary precautions should be taken as a safeguard against decay during storage. The freshly harvested stem of mai ze and kindred crop contain considerable amount of moisture and should, therefore, be dried before storing.

The agricultural residues are destined to play an important part in the future set up of the Indian Pulp and Paper Industry, in as much as the sources and supplies of bamboo for pulping has almost reached the limit and that of hardwoods are also not unlimited. To meet the increasing demand of pulp. from year to year, increased utilization of agricultural residues is necessary. As compared to bamboo requiring a felling period of at least about four years after cultivation and (quick growing) hardwoods twelve to fifteen years, the agricultural residues are available in a few months after cultivation. If agricultural residues of both of the spring harvested and autumn harvested crops are used for pulping the storage will not be necessary for a year.

Bagasse The use of bagasse for pulping on a commercial scale is dependant on its economic availability and in adequate quantity. It is used as a fuel in the sugar mill and much of it is not available, as surplus. The release of bagasse by substitution of coal and/or oil is also beset with many techno-economical problems. The author has discussed these and other aspects of using bagasse for pulping in several publications[16,17,18,19]. Other workers have also examined the commercial possibilities of using bagasse for pulping in India. There is nothing inherently wrong with the (pith-free) bagasse fibre. which can be pulped by any of the known chemical methods or other modifications. The possibilities of bagasse for pulping are rendered infructuous by non-availability in adequate quantity, and high price (including transport charges). As far as the informations are available except one mill in the south bagasse is not used on a large scale for pulping in the country.

Wheat and Rice Straws – Both wheat and rice straws are used as cattle fodder. Only after meeting the bovine need, the surplus should be diverted for pulping. A large number of small units, situated all over the couutry are using bagasse and/or straw with waste paper for production of card board and cheap paper. Sometime, a small quantity of rag pulp is also used in the furnish to improve the strength and quality of the papers. In general these small units only cater the local needs.

Commenting on the prospects of utilization of straw, Podder[20] has remarked that although straw is one of the largest potential sources of raw material for pulp and paper, it has not found a sustained use, as high costs are involved in transport of the bulky straw over long distances (from the field to the factory) Additional costs are involved in bailing and proper storing. Being bulky in nature, the straw (loose or in bales) is more prone to fire. The quantum of supply is uncertain, and is subject to the preceding flood or drought conditions, and hence is susceptible to wide fluctuations of price. In case of small units using straw, as a (or one of the) pulp furnish (es), transport over long distance is not necessary and expenditure on that account is small. Poddar has suggested either the mechano-chemical or the cold soda pulping of straw (in small units) (*loc-cit*)/and blending the pulp with waste paper and/or rag pulp. The selection of a process or the chemical (s) to be used will depend primarily on the end-product in view. Thus, for the production of boards and low quality wrapping papers from straw, the lime process will be cheap and suitable. If products of improved quality be in view either the soda or the sulphate process can be followed. If facilities exist, the monosulphate process can be adopted.

The Linseed Straw

The straw of linseed (or oil flax) grown for the seeds is not put to commercial uses. The straw is also nct suitable as a cattle fodder. At present after removal of the seeds from the harvested crop, the linseed straw is allowed to decay in the field.

A bast fibre can be extracted from the (retted or unretted) linseed straw by breaking and scutching. For purity and softness of fibre, retting of the straw is desirable. Retting is controlled rotting of the stem by microbiological process and is a step of great industrial importance in the production of fibre. Studies in the retting of linseed straw has been carried out by the author[21]. In the process of retting, the cementing material is loosened due to microbiological activity and dissolved out partially or wholly, with lateral loosening of the fibre bundles. Since during retting, the encrusting material is removed, the retted fiber is softer and chemically more pure than the unretted fibre. This effects in consumption of less cooking chemicals for pulping of the retted fibre as compared to the unretted fibre.

The proximate chemical analysis of unretted and retted linseed fibres[22] and the shives thereof[23] is given in Table V.

Table–V

Proximate chemical Analysis of linseed Fibre and Shive

(Figures expressed on 100 g. oven dry basis)

	Fibre		Shives	
	Unretted	Retted	Unretted	Retted
Ash	1.72	1.00	2.66	1.87
Fat and Wax	3.02	2.43	1.76	0.89
Gum and resin	5.88	4.82	2.50	0.99
Aquaus extract (cold)	3.02	2.43	3.88	2.68
,, ,, (hot)	5.03	2.29	—	—
1% Alkali extract	27.71	10.15	28.52	26.69
Alpha hydrolysis	21.44	7.96	9.67	9.04
Beta hydrolysis	29.42	12.28	28.89	27.56
Cellulose(Cross&Bevan)	72.91	80.89	46.15	48.85
Ash in Cellulose	0.13	0.12	0.57	0.43
Ash free Cellulose	72.28	80.59	45.58	48.42

The alpha cellulose content, an important factor from industrial stand point, has been found to be high in both retted and unretted linseed fibres. The estimition of Cross and Bevan cellulose seldom gives a correct idea of the pulp yield. Howely and Fleck[24] have pointed out the limitations of Cross and Bevan cellulose estimation and have suggested the determination of the hydrolysis number which gives a fair idea of pulp yield. The hydrolysis number was estimated after Howley and Fleck (*loc-cit*) and calculated on fibre and shives. The results are in Table VI.

Table–VI

Alpha cellulose and Hydrolysis number of linseed fibres and shives

	Fibre		Shives	
	Unretted	Re.ted	Unretted	Retted
Alpha cellulose on	64.88	72.68	28.98	30 89
Alpha cellulose on Cellulose of	88.98	90.03	62.97	63.24
Hydrolysis number on wt.of	11.14	9.93	14.26	13.10
,, ,, on wt of cellulose of	15 29	18 3	26.70	23.96
Unhydrolysed residue	61.77	70.79	31.89	35.75

Note:—If "A" represents the percentage of hydrolysis number on the weight of the material, "B" the percentage of cellulose and "C" percentage of hydrolysis number on the weight of cellulose, then—

$A=\frac{B\times C}{100}$ and the unhydrolysed residue is (B—A) %

The paper making qualities of linseed fibre has been discussed by the author[25]. By using soda process an yield of 72.0% of unbleached and 64.6% bleached pulp could be obtained in the laboratory[26]. The bleached pulp was found to contain little lignin and pentosans indicating thereby the suitability of the fibre for the prodution of high grade paper and the possibilities of using the fibre for high alpha pulp. Jauhari and Biswas[27] have carried out the sulphate pulping of linseed fibre for a higher yield and purer pulp than that produced by the soda process. The presence of the shives is a disadvantage for using of linseed fibre for paper. The shives should, therefore, be removed to the extent of 90% (if not more) if the fibre is to be used for high grade paper. If the shives are not removed, not only chemical consuption in cooking will be more, but the presence of the shives will be conspicuous in the finished product in the form of specks.

The pulping condition of the bast fibre (in the case of flax and linseed) is different from that required for the shives. The removal of the shives from the bast fibre is, therefore, a necessity for satisfactory pulping and clean pulp. According to a method[28], the clean to fibre of flax or linseed can be pulped using 20 to 22% Sodium Hydroxide and 3% Sulphur at about 155° ±5°C for 6 hour to produce a pulp capable of bleaching to a brightness of 70 to 75%, in a six stage system, consuming about 6% chlorine, and to a brightness of 80%, with 10% chlorine consumption, in a conventional three-stage system. The yield of bleached pulp which is suitable for cigarette paper, currency paper and other fine printing papers, is about 70% on the fibre and about 43% on the entire straw.

The Cotton Stalk

The stem of cotton plant can be used for the separation of the bast fibre. The bast-free stem may then be used for pulping. If desired the stem containing the bast can be pulped. Some are of the opinion that it is not necessary to separate the bast fibre from the stem before pulping and that the bast fibre if present in the stem will produce a stronger pulp of higher yield. Much of the success in commercial utilization of the cotton stalk will depend on its availability and price. Economic collection and proper storage are two crucial points for successful utilization of this material and of other agricultural residues. The burs in the stem of cotton may cause some trouble in pulping but this difficulty is not unsurmountable.

In the case of agricultural residues like caster plant and stems of many edible legumes (pulses and gram), the separation of the stem fibre is not necessary before pulping. The entire stem can be subjected to pulping for production of commercial grades of pulp. In case of those plants which are known to contain a bast fibre for textile use, like jute, sunn fibre, Mesta or Bemli jute (*H Canabinus* fibre) it will be profitable to separate the fibre for use in textile and the fibre-free stem (or stick) for pulping.

In general, the agricultural residues contain more hemicelluloses than bamboo and hardwoods. They are more suitable for production of grease proof and glassine paper. They generally produce easy beating and slow drainage pulp. They require less cooking chemical than bamboo and hardwoods, the pulp yield is generally lower in the case of agricultuaal residues as compared to bamboo and wood. Being short-fibred material, pulp from agriculture residues need blending with a quantity of long-fibred pulp for strength and quality of the product.

Pulping Processes— For pulping of straw and bast fibres, rope cutting and the like, the soda process is suitable. The use of sulphate process for pulping is also known. For pulping of jute sticks and fibre-free sticks of sunn hemp, Mesta and the like, the monosulphite process with magnesium base is more suitable than the alkaline processes. Cooking of mixed hardwoods and mixed grasses has been carried out by various workers, but the commercial possibilities of cooking of mixed agricultural residues have not received the attention of workers. Such a study will be of advantage, if a single agricultural residue is not available in adequate quantity and if a mixture of residues be found available for a sustained supply.

Diverse nature of fibre are readily available in the form of agricultural residues. Their judicious use will greatly benefit the ever expanding pulp and paper industry of the country. The industry should not remain content with the use of conventional fibrous material in the form of bamboo and hardwoods, the supply, of which is limited, hence difficult to arrange and due to tight supply position, the price is increasing. A liberal outlook should be developed by the industry for use of non-conventional pulpable material. The use of agricultural residues for pulping will not only augment the pulp supply but also help in diversification of products. With such an orientation of view research and industry can work in close co-operation to solve the challenging problems of raw material shortage and usher in new and improved products.

References

1. Shah, Manubhai, Foreward, "Paper Industry in India", 1959, Delhi, by V. Podder.

2. Biswas, B., "Conf on utilization of Hardwoods for Pulp and Paper", Forest Res. Inst. Dehradun, p. 27, Apr., 1971.
3. Chitale, V. P. and Roy, P.K., "Pulp and Paper, Prospects for 1975", Econ. and Sci. Res. Foundation, 1969, New Delhi, p. 46, p. 83, p. 85 p. 110.
4. Biswas, B. *Ippta*, Souvenir, International Seminar, 5 (S) ; 65 (1969).
5. Anon, "The Statesman" (Delhi Edn.), p.7, Sept. 16, 1969.
6. Tapadar, D.C., *Ippta.*, 9 (4) : 340 (1972).
7. "Forest Raw Materials for Pulp, Paper and Newsprint", Plan Comm. Rept., 1965.
8. Seetharamiah, A., *Ippta.*, Souvenir, p.6, Apr. 1964.
9. Biswas, B. *Ippta.*, 9 (1) : 10 (1973); 9 (1) : 14 (1973).
10. "Plan Comm. Rept.", Govt. of India, 1967.
11. Seth, V.K. *Ippta.*, 8 (2) : 61 (1971).
12. Aggarwala, J.C.. Welcome address, 10th Annl. Genl. Meeting, *Ippta.*, Dec. 19, 1973.
13. Aggarwala, J. C., *Ippta.*, 11 (1) : 16 (1974).
14. Sen, B.N., *Ippta.*, Souvenir, P. 174, Apr. 1964.
15. Aronovsky, S. I., *Tappi*, 37 (9) : 34 A (1954).
16. Biswas, B., and Lal, J.B., 27th *Proc. Sugar Tech. Assoc. India*, 108, Part III, 1959.
17. Biswas, B., and Lal, J. B , *J. Indian Chem. Engg.* 3 (2) : 68 (1961); 3 (4) : 193 (1961).
18. Biswas, B., *Indian Pulp and Paper*, Anniversary No., 51-61, July 1961.
19. Biswas, B., *Ippta.*, Conf. No. Vol. III, 14 (1970).
20 Podder, V., "Paper Industry in India", Delhi, p. 54, 1959.
21. Prakash, Rudra, and Biswas, B , *Indian J. Microbiol*, 2 (1) : 1962.
22. Prakash, R , and Biswas, B., *Text Mfr.*, 488, Nov. 1962.
23. Prakash, Rudra, and Biswas, B., *J. Sci. Soc., H.B.T.I. & N.S.I.*, (9); 4 (1960).
24. Hawley, L.F., and Fleck, L.C., *Ind. Eng. Chem*, 19, 850 (1927).
25. Biswas, B., *Indian Pulp and Paper*, 14 (2) : 117 (1959).
26. Prakash, Rudra, and Biswas, B , *Indian Pulp and Paper*, 15 (12) : 730 (1961).
27. Jauhari, M.B., and Biswas., B., *Indian Pulp and Paper*.
28. Anon, *Tappi.*, 37 (9) : 36 A (1954).