Handling, collection, storage and transportation of straws

BANSAL M.C.* AND SINGHAL S.K.**

ABSTRACT

Use of non-wood raw materials have increased over the years but systematic information on collection, handling, storage, transportation and preparation is not readily available. This paper contains information on handling, collection, storage and transportation of rice and wheat straw. The paper envisages that the culms should be cut near the bottom of the plant, baled if possible, and suitably transported. The mills should encourage procurement of straw through straw centres located outside the mills, who shall supply it to the mill as per its daily needs at the cutters. This shall reduce the financial load and shall lead to much less arrangements in the stock yards. The duration for which the material is to be stored in the mills shall depend upon the policy adopted by the mill. Suitable fire protection arrangements shall have to be made in the stock yards. The bale sizes, stack sizes and methods of stacking shall have to be suitably adopted by each mill. With increased mechanization, better harvesting, baling, handling, transportation and storage can be maintained at reduced costs with improved overall availability and yield.

With the depletion of forest based raw materials, the use of non-wood raw materials is increasing over the years. Out of all the available non-wood raw materials, the use of agriresidues is increasing faster than other non-wood raw materials. In this category, the rice straw, wheat straw and bagasse are contributing to nearly 30 percent of the production in India and about 75 percent in China. Considering the present growth it can be expected that this figure may go upto 50% in next 5 years. Even with such large usage, the systematic information on handling, collection, storage, transportation and preparation of non-wood raw materials is not readily available. This has drawn the attention of the experts of NIEM (UNEP) during its workshop held at Beijing, China in Nov. 1990, and a project was awarded to the Institute of Paper Technology, Saharanpur, India on "State-of-the-Art Review of material storage, handling and preparation of Non-Wood Raw Materials in the Pulp and Paper Industry". In this paper, the information has been compiled only on handling, collection, storage and transportation of rice and wheat straw.

India ranks second in the world in rice production, though the yield per unit area is very low even when compared with Burma, Indonesia, China and Japan. Japan has a yield figure three times that of India. Table-1 gives the comparative data on the production of paddy and wheat, and the yield per hectare for a few Asian countries. Assuming grain to straw ratio of 1 : 0.8, rice straw yield would be 72 million tonnes. Similarly, wheat straw yield would be 59 million tonnes and the total straw production would be 131 million tonnes. Based on an annual growth of 4% a year in grain production, rice and wheat straw production together would be around 200 million tonnes in the year 2000 A. D., taking into account crop failures and unfavourable grain/straw ratio due to spread of high yield cereals (1).

*Professor, Institute of Paper Technology, Saharanpur.
**Consultant, 254, Bajaj Nagar, Nagpur.

TABLE - 1 : PRODUCTION OF CEREALS - 1986

Country	yield Kg/HA	Production X1000 MT
WHEAT :		
India	2032	46,885
Pakistan	1881	13,923
China	2997	89,002
PADDY :		
India	2195	90,000
Burma	3125	—
Indonesia	3979	39.275
China	5372	177,000
Japan	6322	—

Most of our straws are used as animal fodder, and for roofing, packaging, fuel and manuring It has been estimated that at least 20% of the total straw equivalent to 40 million tonnes could be made available for the paper industry. In States like Punjab, Haryana, Western U.P. and the eastern coastal belt, where land is fertile, irrigation facilities are available and yield productivity is high, surplus straw is available for industrial use. In fact, some of the paper mills located in these states are very successful in spite of their small size. Even with inferior pulping characteristics of straws, particularly paddy straw, some small mills based on paddy straw and waste paper have been running very successfully. If Government subsidies for straws are made at par with bagasse, it will make the operation still more attractive and successful. Proper planning to use the available straws in paper industry shall also greatly help the rural economy by using their products at remunerative prices.

Based on the above information, the fibrous raw materials available for paper industry shall be (in 2000 A D.) :

	Availability million TPA		Equivalent paper production million TPA.
	Potential	Practical	
Rice Straw	100	20	5.0
Wheat Straw	100	20	5.0
			10.0

In spite of such large resources of agri-residues, why is the paper industry not utilizing them properly. Some of the problems could be :

1. General reluctance to change from the existing practices and systems.
2. Apprehension about the sustained and assured supply of these materials.
3. Problems and high costs of procurement, collection, transportation and storage.
4. Existing technological gaps to get good quality of paper, even with inferior nature of these raw materials with regards to strength.
5. Uneconomical chemical recovery systems for small size mills.

An effort has been made in this paper to combine the available knowledge from literature, field and mills. The information about the practices followed regarding handling, collection, storage and transportation in the following mills, has also been incorporated to some extent —

1. M/S D. S. M. Papers, Sikandrabad, Bulandshahar.
2. M/S Aggarwal Pulp and Paper Mills, Muzaffar Nagar.
3. M/S Shakumbhri Pulp and Paper Mills, Muzaffar Nagar.
4. M/S Babri Paper Mills Ltd., Muzaffar Nagar.
5. M/S Shri Jagadamba Estates (P) Ltd. Muzaffar Nagar.
6. M/S Shamli Paper Mills (P) Ltd., Shamli, Muzaffar Nagar.
7. M/S Gaurav Paper Mills, Brahmapuri, Chandrapur
8. M/S Ellora Paper Mills, Tumsar, Bhandara.
9. M/S Simplex Paper Mills, Gondia

The handling, storage, collection and transportation of straws are to be considered from two basic considerations—

1. Outside the mill
2. Inside the mill

1. OUTSIDE THE MILL

The crop is first cut in the fields, then it is transported to the thrashing site, thrashed to recover

grain seeds and straws and then this straw is sent to the mill or middle man/liaison agency, either in baled or loose form.

1.1 IN THE FIELDS

In the fields, the grain plants are cut and handled either manually or mechanically.

In India, in most of the cases, the plants are cut manually and then the cut plants are manually collected at a place in the field (2). There these plants are thrashed to separate grains and straw. This results in some loss of straw, as the straw is normally collected on bare muddy grounds. This also brings in gravels stones or mud etc, with it, when lifted from the the ground. Sometimes even metal pieces and clothes also get in the straw, in the p.ocess.

The manual cutting of grain plants can be of advantage, if the plants are cut at proper heights in the culms near the bottom, as this only contains most of the strong fiber suitable for paper making, while the leafy material contains short and broken fibers (3).

Many mills have suitable incentive schemes and motivating agents/contractors for this purpose, who help and educate the farmers in this regard. These schemes help in achieving higher productivity per hectare of their products,and supply better and clean straw to the mills at reasonable prices. Thus with proper education of the farmer, both farmer and the mill gain in the process.

In some big farms mechanical harvesters are used to cut the wheat crop. Normally, it is observed that these harvesters are not able to cut the plants from near the bottom (4), as their aim is to get maximum grain yields with little emphasis on wheat straw collection. As indicated above, the culms contain major part of the good fibers and thus this results in a big loss both to the farmer and to the paper mill. Farmer is loosing in terms of weight and the mill in terms of good fiber and yield. To overcome this, some mills are educating the farmer for proper cutting of the plants and if possible to go for the suitable tailor made harvesters which can cut the plants near to the bottom. As the wheat straw is collected directly by the harvesters, it contains lesser undesired materials.

The wheat straw is now available in the thrashed form of 20-50 mm lengths, including some fines collected in the thrashing process. The bulk density of the wheat straw is around 50-60 kg/m^3 with 10-15% moisture in it. Due to seasonal availability (April-June), it has to be procured and transported to the storage sites in a smaller time. Many problems are faced during handling and transportation of wheat straw due to its bulky nature, and fines and dust associated with it. Sometimes the farmers also store it in their fields by making a pyramid type and covering it by thatch or mud.

In the case of rice, normally the rice plant is cut manually and thrashed to separate rice-seeds (munji) and rice-straw. The plant should be cut near the bottom in this case too, as explained above to recover most of the good fiber from the culms, as the rice plant contains more leafy material than even wheat straw. The whole straw can be stored in the field before transporting it to the depots/centres or to the mill. During collection of rice-straw too, some dirt, gravels, stones, rags etc. may get in the pile, which creat many problems later. The harvesting of rice-straw is also seasonal in nature and the first rice crop is available around Nov/Dec each year, while in some places they are able to get another crop around May/June, if wheat is not cultivated. The procurement of rice straw is thus accordingly planned. The rice-straw can be transported in the loose form or in the baled form. In some parts of the Maharashtra and Gujrat in India, baling of rice-straw is very common as this enables easy transportation of more straw. The bulk density of rice-straw in the loose from is around 30-40 kg/m^3 while in the baled form it can be between 60-130 kg/m^3 with 10-15% moisture, which obviously means more and easy transportation of straw in available vehicle volume. The bale size and its density shall depend on the baling machine capacity for compression. The loose rice straw is also sometimes stored by the farmers in their fields by covering it by thatched covers.

1.2 FROM FIELD TO DEPOTS/CENTRES OR THE MILL

1 2.1. Modes of transport

The straw is transported from the fields to the depots/centres or to the mill by various modes of tranport, such as :

(i) Bullock carts
(ii) Tractor trollevs
(iii) Trucks
(iv) Railway wagons.

Bullock carts are used, if the material is to be transported up to a distance of 10 km Tractor trolleys upto a distance of 20-25 km. and trucks for larger distances. Railway wagons are scarcely used due to economic considerations

1.2.2. Need for contractors / middleman / liaison agency (straw centres) :

Many of the mills are procuring the straw directly from the farmers and storing it in their own stock yards. Some of the mills are facing many problems due to this arrangement, such as

(a) Due to seasonal availability and bulkiness, very large storage space is needed.
(b) The capital involved is very large and thus the interest liability further builds up on the mill.

(c) The straw is normally stored in the open and thus decay of raw material can be as high as 20% in some cases. Such raw material cannot be used in paper making or even if used, shall lead to poor quality product with higher chemical and energy consumptions.

(d) The mill shall have to take suitable safety measures for fire etc.

(e) The labour involved is excessive, which could be that of the mill itself or that of a storage yard contractor. Due to political interference and severe labour laws, many of the mills have to face severe constraints on this front.

(f) The transportation of raw material in the mill itself, from storage yard to the feeding section, is a big problem, which require inside the mill bullock-cart or tractor-trollev transport system. During the rainy seasons and even in extreme summer months, some of the mills face acute problems, even to maintain this supply line.

In view of above problems, some of the mills have separate contractors/liaison agency/middle man to purchase the raw materials for them and store it outside the mills (5). These agencies, then supply the stored material at the required time and place, as per the mill needs. These agencies can then supply the material at negotiated price and form, on a sustained basis. The experience of some of the mills in this regard is very positive, and they have encouraged and supported some individuals/contractors to do this job as an enterprise. Such depots/centres procure unused land on hire or lease in various areas near the roadsides, may be upto 50 km from the mill. They can also plan by this arrangement that daily requirement can be delivered at the cutters, while the excess material can go to storage. This reduces handling inside the mill. By this process all the concerned agencies are at a profit with minimum of problems to the mill.

The wheat straw is also stored in open by these centres but in some cases big sheds have also been constructed to save it from rain and dust storms. This loose straw is then supplied to the mills or sometimes even in jute bags to have betterpacking densities during transportation.

1 2.3. Baling of straw :

The centre may have a baling machine to bale the rice straw and pile them up in a scientific way. The payment to the farmer is made by the contractor based on weight or bales made, at a negotiated price.

Some of the centres do not have baling machines but they collect the rice straw in loose form and convert them in bales of figure of eight which is called atree in Maharashtra in India. These bales are then stored in piles and transported in this form itself.

There is a need to standardize the bale sizes and their packing densities including moisture content. The typical specifications as used in U.K. (6) are given in Table—2.

From the above table, it is evident that cylindrical, cubical and Flat eight bales are commonly available. In India, the mills presently prefer to have conventional bales of around 30-40 kg in cubical shapes and between 10-15 kg in Flat Elght (Atree) shapes, for easy manual handling. It is expected that more mechanization shall have to be adopted in the fields, depots and mills to a large extent due increasing costs and many other related problems of labour Unions/Governmental agencies With this mechanization, we may have to go for higher bale sizes, considering our transportation means.

TABLE—2 : TYPICAL BALE SIZES AND WEIGHTS

Type	Dimensios, metres	Bulk density, kgs/m³	Weight, kgs	Volume, m³
Large Cylindrical	1.8 dia. X 1.5	130	495	3.81
Small Cylindrical	1.2 dia. X 1.2	130	176	1.36
Large Cylindrical	1.83 dia. X 1.52	113	450	4.00
Large Cubical	2.44 X 1.52 X 1.52	57	320	5.63
Large Cubical	2.4 X 1.2 X 1.2	150	519	3.46
Large Cubical	2.4 X 1.5 X 1.5	62	315	5.48
Large Cylindrical	1.8 dia. X 1.8	98	345	3.81
Conventional	0.9 X 0.46 X 0.36	110	16	0.15
Conventional	0.91 X 0.46 X 0.36	119	18	0.15
Flat 8	1.84 X 1.82 X 0.36	119	114	1.2

As a typical example, we have taken the truck body dimensions as below—

Width	2.25 meters
Length	5.50 meters
Height	3.75 meters

Taking the bale size 0.5 m×0.5m×1 m, we can pack the bales as below

Width side	4 No.	(0.5×4=2 0 m)
Length side	10 No.	(0.5×10 =5.0 m)
Height side	4 No.	(1 ×4=4.0 m)

Total bales 4×10×4 = 160 No. of 27.5 kg each with packing density as 110 kg/m³. In width and length sides some space has been left free for easy placement of bales, while in the height side we expect truck to be packed a little higher.

Thus total weight in a truck 160 × 27.5=4400 kg
=4.4 tonnes of straw

With the increasing packing density and bale sizes we can have even more material per truck and thus much less transportation cost per tonne of material.

2. INSIDE THE MILL

The straw is first procured by the mills, then shall be transported/unloaded in the stock yards, stored in the stock yards, transported from stock yards to the feeding section, and then finally shall be prepared for pulping in the raw material preparation section before feeding it to digesters.

2.1 PROCUREMENT OF STRAW BY THE MILLS

The procurement of straw by the mills is carried out by their purchase manager, either directly from the farmers or from the contractors/middle man maintaining the depots/centres.

The mills normally announce procurement price after each crop season considering the market trend. They also sometimes announce some incentive schemes based on different variables, such as-

(a) Supplied in loose form/bale form, as normally the bales are only preferred, if available.

(b) Quantity to be supplied.

(c) Undesired material pickups/cleanliness.

(d) Moisture content.

(e) Physical appearance.

(f) Assured supply at the right time and place.

The farmers and contractors/suppliers thus respond to the offers made by the mills and even sometimes mills have to send their agents/officers to motivate/educate the farmers to get the right supply. Normally, the mills make the payments on 10-15% moisture content basis, and if the moisture content is higher than the

standard adopted by the mill then suitable deductions are made. Similarly, higher quantity of good straw supplied at an assured schedule quite often gets some premium in payments.

The mill shall have to take a suitable decision about the quantity to be procured and stored. Many of the mills procure the materials keeping in mind the demand for the whole year, and thus accordingly create facilities in their stock yards and arrange finances. Some other progressive mills have started procuring the materials from contractors/suppliers with assured supplies, and maintain their own stocks for 10-15 days only. The advantages by having a middle-man/contractor have already been discussed in 1.2.2.

2.2. STACKING OF STRAW :

The size of stockyard shall depend upon the philosophy adopted by the mill as discussed above. In view of the above, following are the possibilities—

(i) Stock yard for full years ' supply
(ii) Stockyard for 2 to 3 months ' supply
(iii) Stockyard for 10 to 15 days ' supply

Some other suitable considerations shall also draw attention based on the duration of storage of straw in the mill.

2.2.1. Stock yard for full years ' supply :

As already discussed on long storage without proper protection against weather conditions, wheat straw rapidly deteriorates by microbial attack and natural weathering due to rain, duststorms and sunshine Weathered straw yields pulp of inferior quality, requires more chemical and yield percentage drops considerably. Even the storage of rice and wheat straw requires more elaborate fire protection facilities, being more susceptible to fire hazards. Due to short harvesting periods, the mill shall have to procure their annual requirements in 3-6 weeks time. As wheat straw is only available in loose form, while the rice straw could be available in loose or baled form, therefore very large area is required for storing the annual requirement of straws with properly laid out hydrant-system to combat the fire hazards.

Straw bales can be stacked as high as 12-13 meters, and can be of suitable sizes to occupy optimally the available storage area. This shall also help to minimize the exposure of the straw bales to weathering and microbial attack. On the contrary small stacks shall require more space for large quantities of straw to be stored. Straw stacks can be 150-160 meters long, 20-22 meters wide at the bottom and 12-14 meters in height. Stacks taper upward so as to give a stable form against possible violent wind, and also to minimize water penetration during rains. The stack forms the geometry of trapezium and can contain upto 3000 tonnes of straw (7).

Ample space should be provided between the stacks of straw for vehicular movement. When the straw stack is insured, even the Insurance Companies also demand certain minimum spacings between the stacks. If possible, raised platforms may be made considering the total requirement and roads may be properly laid considering vehicular movement. Stacking of straw on the raised platforms, shall save the straw from accumulated rain waters around and shall lead to reduced microbial attack from the ground. Water logging greatly accelerates rotting of straw (7).

Straw can be stored in the form of large size stacks for about a year unprotected against rain and sunshine. It is estimated that about 5% of total straw in a stack have to be removed from outside (depending upon the condition of the bales), as they are almost useless for pulping purpose. Similarly, the bottom layer of the stack is to be discarded, as it is mostly rotten and deteriorated by microbial attack (7).

The degraded straw can be baled and used as the bottom layer to prepare a base for the stacks in successive years of straw collection, which prevents the fresh straw bales from rotting at the bottom. Stacks can also be covered with polythene sheets, sheet metal or asphalted kraft-paper, to protect the straw stacks against weathering. However, the relative cost of the covering materials verses the saving achieved by avoiding decay of certain quantities of straw has to be assessed. It may prove more expensive to cover the stacks than to loose a small quantity of decayed straw. Even some of the mills burn out the decayed straw in their boilers and recover some heat value.

The moisture content of straw bales has an important bearing on the preservation of straw against rotting and microbial deterioration. The permissible moisture content in straw should be between 8-15%. Too high moisture content has a tremendous damaging effect on straw due to rapid and extensive rotting during storage. Furthermore, high moisture content in straw develops intense heat in straw stacks and form a potential source of fire hazard due to autocombustion.

Chemical preservatives such as Borax or Boricacid, and Sodium pentachlorophenate are quite effective to protect straw weathering and rotting. However due to the high price of these chemicals, their wide application seems uneconomical (7).

2.2.2. Stock Yard for 2 to 3 months ' supply :

In this case it is presumed that either the seasonally available material is used by the company alongwith other readily available raw materials such as waste-paper or purchased pulp or it has properly planned to purchase the agri-residues through the contractor/ middle man/liaison agency maintaining the depots/ centres outside the mill, as discussed in 1.2 2. With all the arrangements of raw materials supply, the mill may still plan to have raw materials storage for 2-3 months only to be on safe side. This reduced storage period may not lead to much of deterioration, as could be in the earlier case, when the mill had to plan for storage for full year, but more precaution is needed in the procurement from the contractor itself, as he may suppy deteriorated/decayed/rotten straw from his depot/centre Proper planning with assured supply shall require limited resources and storage space for raw materials . The risk involved is also small as always the mill plans to have a stock of 2-3 months at any time.

2.2.3. Stock Yard for 10 to 15 days supply

In this case the mill has to almost depend completely on the contractor/middle man or on the farmer for the supply of raw materials. The mill invests only a small sum directly for storage in their own storage yard but may have to support/promote contractors/suppliers to maintain a regular supply line. The problem of decay of raw material in the mills storage yard is completely avoided but shall have to procure properly cleaned and good raw material from outside sources all the time. Some of the progressive mills are trying ot follow this policy but have to keep a good field staff for this purpose, to properly maintain a continuous supply line. The rice straw should be properly procured in baled form and the possibility of baling wheat straw economically should also be worked out. Storage yard in the mills even for this small period should have a suitable fire protection arrangement, raised platforms and well laid out roads for transportation of raw materials by vehicles. The storage yard space and manpower requirement shall depend upon a number of variables such as the raw materials stored, the period of storage, means of handling and transportation in the mill, the weather conditions round the year etc.

2.3. HANDLING AND TRANSPORTATION IN THE MILL

In most of the mills the raw material is first stored for some time and then it is transported from the storage yard to raw materials preparation section. Some mills are having a suitable contracted schedule with farmers/contractors/middle man too, to supply the raw material directly in the raw materials preparation section. In this case they transport the materials by bullockcarts, tractors or truck directly at the desired mill-site/section involving minimum of labour and handling on the mills part. This is an ideal arrangement which shall involve minimum of risk and finances too.

In some of the mills, they have private contractors who carry out the stacking, handling and transportation of raw materials in the stock yards. The manual labour and vehicles involved are also that of the contractor who is paid on a lump-sum basis, based on the capacity of the mill. The labour laws are gradually coming in with such labourers too, and in some of the mills Unions are pressurizing to regularize these labourers on mills' rolls. This is a big overhead expenditure which can only be reduced if the mills go for more mechanization with reduced storage of raw materials, and maintain their supply directly through outside resources as indicated above.

In the mills bullock carts and tractor trolleys are quite often used with manual labour. The use of cranes for lifting of bales of straw and loading them in to trucks/trolleys should gradually be adopted by the

mills. The mechanical handling shall reduce the losses too, with decreased handling cost per tonne of straw.

RECOMMENDATIONS :

Based on the above discussions, following is recommended—

(i) The plants should be cut at proper hight of culms near the bottom of the plant, for better yields.

(ii) Suitable agricultural implements should be used to cut the plants and separate the food-grains and straw. This shall help to get cleaner straw which can be suitably baled, as per the needs.

(iii) The thrashed straw should be stored in clean spaces so that it does not carry any undesired material from the ground.

(iv) It should be covered so that it can be saved from rain and dust storms. This shall ensure a lower moisture content and lesser dust in the straw.

(v) The rice straw should be transported in the baled from, which helps in efficient transportation, handling and is sold at higher prices.

(vi) The baling of wheat should also be tried out in India.

(vii) The bale sizes should be standardized so that the cutters and other hadling equipments installed in the mills can also be accordingly standardized. The modes of transportation should also be kept into consideration. Heavy bales need more mechanization in the fields, centres and in the mills.

(viii) The contractors/middle man/liaison agency should be encouraged to procure and store the straw in depots/centres outside the mill and supply its needs. This shall reduce the financial load on the company and much less arrangements shall have to be made by it in the stock yards.

(ix) The mills should have a clear policy regarding procurement of straw, which may be announced openly to farmers, motivators and liaison agencies.

(x) The mill may decide about the duration for which it want to procure the materials i.e. for full year or for short durations. The facilities shall have to be created in the mill accordingly.

(xi) The straw should preferably be stored on the raised platforms, so that it can be saved from water logging and microbial attacks from the ground.

(xii) Suitable fire protection arrangements must be made in the stockyard, with well laidout water pipelines and provision for rubber hoses.

(xiii) The materials should be procured and stored preferably within 8-15% moisture content range, so that auto-combustion may not start due to excessive moisture inside in stacks.

(xiv) The stack sizes should be suitably decided by each company, according to its requirment. Larger stacks are preferred, as they enable to store much more straw, especially in the baled form, in smaller area. Further, the total losses accrued due to weathering are also low in properly stacked straw.

REFERENCES :

1. Dr. Ing A. Panda, "The Future of Cultural Papers in India", Silver Jubilee International Seminar and Workshop, IPPTA, New Delhi, 1989.

2. Rohit J. Patel, C.S. Angadiyavar, and Y. Srininivasarao, "Non-wood Fiber Plants for paper Making - A Review" TAPPI Monograph Progress Report No. 15, page 77-90.

3. H. Ibrahim and Y. Fouad, "Industrial Experience in the Utilization of Rice straw in the pulp aud paper Industries" TAPPI Monograph Progress Report No. 4, Page 37-48.

4. D.K. Mishra, "Comparative Study of Bagasse and Wheat straw for Pulp and Paper Making", TAPPI Monograph Progress Report No. 2, Page 31-49.

5. T. Jeyasingam, Illuck Grass, Rice Straw and Ken af from Field to Mills, based on Srilanka experience, TAPPI Monograph Progress Report No. 14 Page 65-69.

6. W.E. Bryden and R.K. Smith, The Economic Small Straw Pulp Mill, PIRA International Conference on "Straw—A Valuable Raw Material", Oct. 27-29, 1987. The Garden House Hotel, Cambridge, England.

7. D.K. Mishra, Modern Methods of Collecting, Purchase, Storing and Preservation of Straw, TAPPI Monograph on Non.wood Fibres, Vol. 2.

ACKNOWLEDGEMENTS :

This work is a part of the project financed by Network for Industrial Environmental Management (NIEM) of United Nations Environmental Programme (UNEP), on "State-of-the-Art. Review of Material storage, Handling and Preparation of Non-wood Raw Materials in the Pulp and Paper Industry", to the Institute of Paper Technology, Saharanpur.

Authors would welcome comments, suggestions and more information on these topics.