Bagasse Storage–Its Impact on Brightness

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ABSTRACT

The probable ways of overcoming the discoloration and degradation so as to utilise the maximum potential of bagasse in papermaking, have been considered. The study is very much pertinent in the Indian scenario, where the future has to depend solely on bagasse. TNPL being the first cf its kind in the world to produce mechanical pulp from bagasse, the present study will open new vistas to produce better mechanical pulp from bagasse.

KEY WORDS

BAGASSE STORAGE, BRIGHTNESS, SODIUM BI SULPHITE, CHEMICAL TREATMENT, BRIGHTNESS PRESERVATION, MECHANICAL PULPING.

Background

Bagasse, a proven raw material for papermaking, is fast emerging as the principal non-wood fibre source in India. With the fast depletion of the conventional raw materials like hardwood, bamboo, bagasse has gained its status as the only other alternative (1). The paper industry thus depends on bagasse for the future and hence it is very much essential to understand bagasse thoroughly.

Tamil Nadu Newsprint and Papers Ltd (TNPL), a bagasse based integrated mill with an annual capacity of 90 000 tons utilises bagasse to meet i's 75-85% requirement in paper furnish. With the present consumption of bagasse touching 3,00,000 metric tons per annum, TNPL has embarked upon an expansion programme of doubling its capacity. Also, TNPL is the first of its kind to produce mechanical pulp from bagasse and the brightness of bagasse determines the brightness of the mechanical pulp produced out of it and subsequently the final brightness of the newsprint. Bagasse received during the sugarcane crushing season has to be accumulated for utilization throughout the year. The bagasse stored at the mill site using the wet bulk storage method, is prone to discoloration and degradation.

The usage of fresh bright bagasse for mechanical pulping is not desirable owing to the stiff nature of the bagasse fibers and to the presence of adhered pith. Thus storage of bagasse before pulping is essential, so as to soften the fibre as well as to release the adhered pith.

Bagasse Storage - Methods Prevalent :

Various storage methods are being adopted for bagasse storage. Before storage, pith which is undesirable for papermaking is removed to the maximum possible extent. The various methods in common practice are described below.

1. **Celotex method**

   In the Celotex method (2) bagasse is baled in moist form at 50% moisture with holes in the centre of the bales and then stored. These holes in the bales help release of heat during fermentation, thereby preserve the bagasse by preventing the proliferation of thermophilic micro-organisms responsible for degradation of cellulose.

2. **Moist bulk storage**

   The moist bulk storage is designed to compact bagasse at 50% moisture in huge bulk piles to slow down the fermentation reaction. The inherent drawback of this system is that the outside layers of these piles upto 1.5 metres depth suffers severe damage (3).

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3. Wet Bulk Storage

In the wet bulk storage, the moisture of bagasse is kept through until it water holding capacity of 80% moisture is reached. This high moisture facilitates compaction and enhances anaerobic conditions in the pile. This slows down the fermentation process and prevents exorbitant damage to fibres (4).

4. Ritter biological process

The Ritter biological process (5) is the unique successful method of wet bulk storage of baga se, in which a biological fluid containing lactobacilli is mixed with a dilute suspension of bagasse. This enhances controlled fermentation and converts the residual sugars in bagasse to lactic acid, thereby maintaining a pile pH of 3.5 to 4.0 resulting in excellent preservation of bagasse fibres.

5. Bagatex - 20

The Bagatex-20 developed by Usina Santa Lydia, (5) basically involves rapid drying of bagasse in large bales from 50% moisture to 20% moisture by adding a biochemical catalyst, which will accelerate but carefully control the fermentation of the residual sugars, in bagasse.

Bagasse storage in TNPL

Among the various methods of storage, the wet bulk method enhances maximum bagasse storage in minimum area and also has many advantages over the baled storage with reference to degradation (6). TNPL utilises the wet bulk storage method for storing bagasse. Bagasse, after depithing, received at 50% moisture through trucks, is slurried with water at 30% consistency by means of boom stacker and then dumped over storage pads. Bagasse is piled to a height which ensures good compaction. The excess water from bagasse percolates into a side channel and is collected back into the central collecting channel and reused. Bagasse thus stored is reclaimed for pulping after a minimum period of 3 months which may also be extended to 9 months.

Significance of Bagasse brightness in mechanical pulp production

The aforesaid storage methods are oriented only towards reduction in the quality losses and storage losses. They are not able to take care of the brightness, which is very much essential for good quality mechanical pulp. Special problems develop when bagasse is stored for mechanical pulp production The influential parameter governing the mechanical pulp production is the initial brightness of bagasse reaching the refiners. Dark discoloured bagasse not only results in increased demand of expensive bleaching chemicals like hydrogen peroxide and sodium hydrosulphite, but it is also difficult to attain the desired degree of final brightness levels. Low brightness mechanical pulps ultimatety affects the final brightness of Newsprint.

The final brightness of the newsprint produced is dictated by the brightness of the mechanical component in the furnish (7) and ultimatelv the newsprint brightness has to be maintained by limiting the mechanical bagasse pulp component in the furnish. During the mechanical bagasse pulp production, a routine exercise was carried out in the raw material preporation plant to segregate and ensure that only good bright bagasse reaches the refiners. In spite of the above precautions, often problems are encountered in the production of acceptably bright mechanical pulp.

It is our experience that when a bagasse of 30% ISO brightness is fed to the refiners, a brightness gain of 5 points is observed at the refiner outlet and another 3 points gain after screening and cleaning. This ultimately yields a bleached pulp of 48% ISO brightness, after bleaching with 1.5% hydrogen peroxide. Whenever the bagasses brightness is lower, the final brightness that could be achieved, even with higher amount of bleach chemicals, was only about 40-42% ISO, which is not adequate to maintain acceptable newsprint brightness. Though the initial brightness has very little influence on the chemical pulping of bagasse, it has been observed that the quality of mechanical pulp is proportional to the brightness of the bagasse. This situation warrants an alternative modified storage method for bagasse under the wet bulk method with reference to brightness preservation and in turn the quality of bagasse.

The Ritter biological process, recommends a biological process instead of chemical methods owing to the mildness of the biological process. Infact, it was reported that bagasse can be stored for years without further deterioration (8). While the biological process definitely preserves the chemical characteristics of the bagasse which are certainly essential for chemical pulping, the starting color of the bagasse on the other hand repidly change even with the biological storage method. Since bagasse brightness is such a strongly influencing parameter for the production of mechanical pulp, our studies were focused on the factors that affect the brightness of bagasse and the ways and means of preventing/mitigating the discoloration. The real cause for the darkening is yet to be identified. To find out the cause, the effect of different parameters such as pH, temperature, aerobicity, consistency, chemical pretreatments, and micro-organisms was thoroughly studied.

Experimental

For all the storage studies fresh depithed bagasse as received was used. Throughout our studies brightness was measured at pH 5.0.

Bagasse brightness

The efficiency of all the parameters and different storage methods was evaluated on the basis of the improvement of the brightness. Hence, a specific method for measuring brightness was developed. This method was very simple and quick.

The New Rapid fractionation method for brightness measurement

Bagasse was diluted to 1.5% consistency with demineralised water and disintegrated for 5 min (15,000 revolns) in a Tappi disintegrator. The bagasse slurry was then washed over a ASTM 14 screen and the fraction passing 14 was collected on a ASTM 200 mesh. After adjusting the pH to 5.0, this collected fraction containing fibre fragments and pith was made into a pad, pressed in Tappi sheet press for 2 min at 0.27 mPa and dried at 60°C under an I R lamp. The brightness of the dried pad was measured in an Elrepho brightness tester using a blue filter at 457 nm (Paper maker's brightness).

The brightness values obtained by this quick method was compared with the ones obtained from those pads made by grinding the entire bagasse in a laboratory micro dust making machine. The comparison is shown in the Table 1. It can be observed that both values coincide with each other. Therefore, the newly developed rapid method was used throughout the bagasse storage studies.

Table 1
Brightness Measurement—A comparison

By Grinding Method %ISO	By Fractionation Method %ISO
36.4	35 9
35.5	34 7
33.1	32.9
36.1	36 8
26.9	26.4

RESULTS AND DISCUSSION

Field Studies on Bagasse storage with special reference to brightness

Bagasse is heterogenous in nature and the brightness fluctuates widely from sugar mill to sugar mill. The incoming bagasse was evaluated for its brightness. The results are presented in the Table 2. From the results it can be observed that bagasse is reasonable brighter as it comes out of the sugar mill to the paper mill storage yard. The brightness of bagasse varies from 35% ISO-44% ISO. The variation in the incoming bagasse brightness may be attributed to the age of the sugarcane, its variety, and cleanliness.

Table 2
Brightness of fresh incoming bagasse from sugar mills

Site	Undepithed bagasse %ISO	Depithed bagasse %ISO
Site 1	33—38	38—41
Site 2	33—36	36—40
Site 3	34—37	35—42

During the storage period brightness drop was found to occur in our depithed bagasse pile within a minimum period of 15 days from the date of receipt, The brightness at the different layers was evaluated (Table 3). The drop at the surface layers was as high as 16-19 points. However, the brightness reduction was not uniform throught out the pile. The surface layers upto 3 M depth suffered severe brightness loss while inner layers were not affected to that extent. Therefore, it was concluded that, the discolouration was not influenced by the duration of storage but by other parameters that develop during the storage.

Table 3
Brightness of bagasse in a storage pile

Location	Brightness Range %ISO
Fresh bagasse	38—41
Top Upper Layer	14—19
Middle Layer	22—30
Bottom Layer	38—40
Brightness drop at Top Layer	
1 Month	30—35
2 Months	21—24
3 Months	17—20
4 Months	14—19

These 'studies on the cut-cross section of a pile indicated the ·existence of three distinct brightness zones (Table 3 . The brightness stratification of the bagasse pile also indicated that the innermost layer were well preserved even upto 8 months. The exact mechanism of the discolouration process is still not understood thoroughly Routine physical observation of the pile suface layers revealed that bagasse starts turning deep yellow to orange within 6 days of storage and then starts darkening.

Refining studies on bagasse

Bagasse of different brightness levels was collected from the storage yard The starting brightness was varying from 15% ISO to 30% ISO. The samples were subjected to chemical treatment with 4% Sodium hydroxide and 4% Sodium sulphite which corresponded to the actual chemical charge in the plant. The chemical treatment was carried out at 110°C for 30 minutes. The chemically treated bagasse samples were then pulped in ihe 12″ Sprout–Bauer atmospheric refiner with a single pass with a plate clearance (0.04 mm) to get a freeness of 200 ml CSF. The samples were screened and the brightness of the unbleached pulps was measured. The results are shown in the Table 4 The results clearly show that the starting brightness has the immense effect on the unbleached stock prior to the peroxide bleaching. Hence, it is imperative that the prevailing storage parameters affecting the brightness of bagasse have to be studied.

Table 4
Effect of Starting Brightness
On the refined unbleached pulp

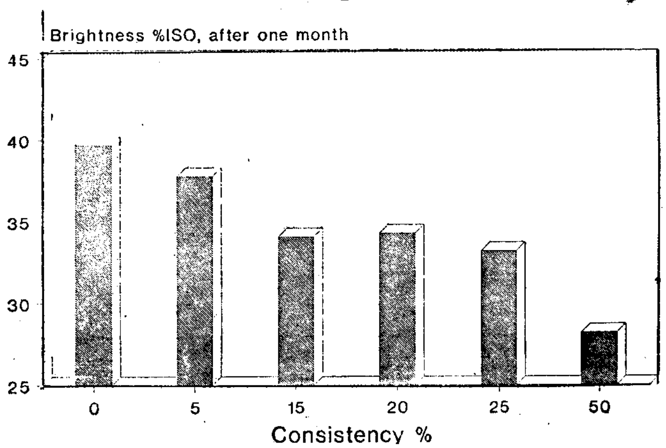
Brightness of Raw Bagasse %ISO	Unbleached Brightness After refining %ISO	Brightness Gain %ISO
30.0	45.6	15.6
23 3	36 2	12.9
14.7	27.7	13 0

Influence of Storage Consistency on brightness of bagasse

Bagasse as it comes from the sugar mill contains 50% moisture, but after the process of depithing, it is poured as a 3-4% slurry on the storage yard and the excess water drains for recycling leaving the bagasse for storage at 25% consistency Some times, if the crushed bagasse is accumulated at the loading site, bagasse is left at its loading point for some period of time at its initial moisture content of 50% Therefore, in order to study the effect of consistency on the brightness depithed bagasse was stored in the laboratary at different consistencies ranging from 5% to 50% for one month After one month storage period brightness pads were prepared according to the prescribed procedure. The results are shown in the Fig. 1.

The brightness measurements showed that the bagasse stored at 5% consistency was least affected while the brightness drop was profound at higher consistencies. The lowest brightness was obtained with 50% consi tency. Therefore, lower the consistency better the brightness preservation. However, it may be extremely difficult for the industry to maintain huge quantity of bagasse under these conditions. This study proved that the consisteny does have an impact on the bagasse brightness.

Fig.1 Influence of Storage Consistency on brightness



Influence of Storage pH on brightness of bagasse

Bagasse as received from the sugar mill possess high amount of acidity owing to the presence of residual sugar. Normally the pH of the fresh bagasse varies between 4-5. The fresh bagasse is stored at this pH. During the storage period the pH plays an important role on the brightness. The effect of pH on brightness was studied by storing the depithed bagasse at different pH at two consistency levels, namely I) at the original pile storage consistency of 25% and 2) at a consistency of 15% which corresponds to maximum water holding capacity of the bagasse. The results (Fig 2) show that very low pH and very high pH are favourable to the brightness preservation. Similarly, the influence of pH at 15% consistency was studied The desired pH was brought at 3% consistency and then the excess water was dewatered to 15% consistency. Again very low pH or very high pH favoured brightness preservation. pH range between 6-8 proved to be detrimental leading to maximum baga se discolouration.

However, it is to be emphasized that the addition of chemical (NaOH/HCl) for pH correction should just meet the requirement and if excess chemical is added it has negative effect.

Effect of oxygen during storage on the bagasse brightness

The loose bagasse received from sugar mills, is stored in the bagasse storage yard as described elsewhere and it is distributed throughout the yard by means of bulldozer. When these heavy bulldozers move on the bagasse pile, the pile gets well compacted and as the height of the pile increases the degree of compaction also increases. As a result, the bottom layer becomes anaerobic zone and the top layer becomes aerobic zone Therefore, laboratory studies were carried out to study the effect of aerobic/anaerobic storage conditions on discolouration of bagasse. The results shown in Fig 3 indicate that aerobic environment accelerates discolouration.

Fig.2 Influence of Storage pH on brightness drop

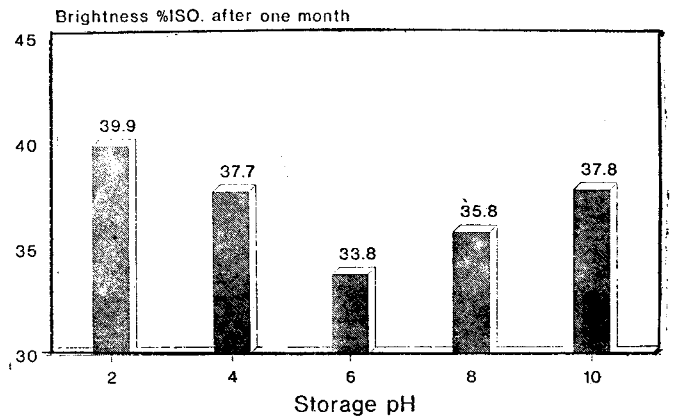
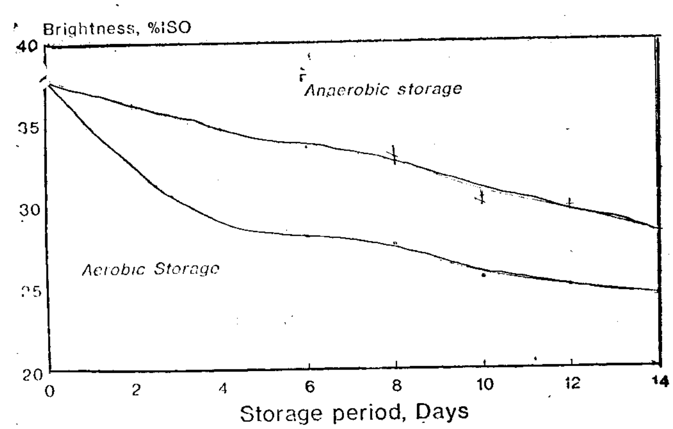


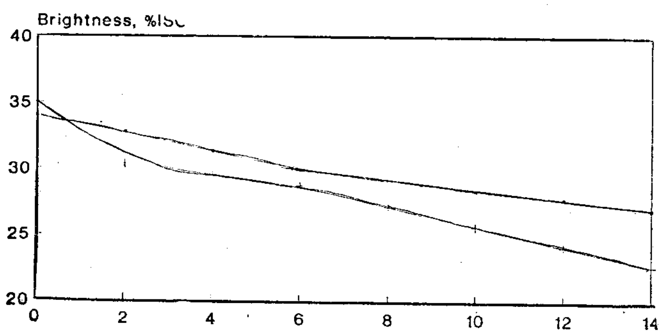
Fig.3 Influence of Oxygen during storage on brightness



Influence of Pith content on the brightness of bagasse

Approximately 30% of the oven dry weight of the cane stalk consists of pith cells which do not possess the fibrous character. In mechanical pulping the adition of chemicals and the retention time is very minimum If the pith cells are not removed they consume large portion of chemicals and yield very little usable pulp. Therefore as much of pith as possible is always removed before pulping. However, it may not be possible to remove the entire pith content from bagasse. So brightness studies on undepithed and depithed bagasse sample were carried out in the laboratory to assess the influence of pith content on the brightness of the bagasse. Fig.4 shows that, under compacted conditions at the pile consistency of 25% the brightness drop is relatively lower in the case of undepithed bagasse than in depithed bagasse.

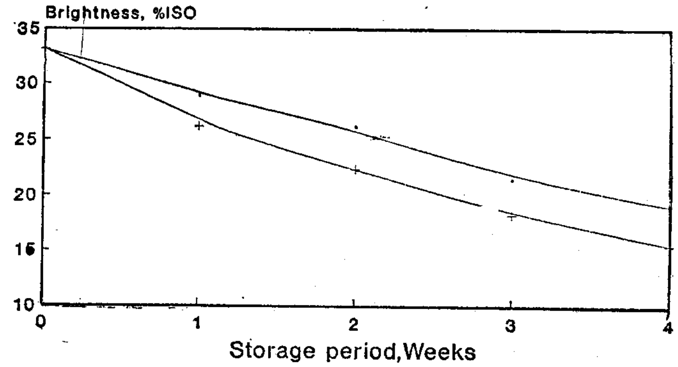
Fig.4 Effect of Pith Content on bagasse brightness



Effect of recycled water on the bagasse brightness

In the wet bulk storage, as followed in TNPL the excess water in the bagasse slurry percolates through the stack and flows to a collecting channel. If this drainage fluid is allowed to go in to the waste effluent system, the high content of soluble sugars cause an excessively high BOD. In addition to this the water consumption will soar enormously. To evade this problem, the back water is again reused to stack the incoming fresh bagasse. In order to understand the effect of this back water on the bagasse brightness, the fresh bagasse was stored in the labora tory with fresh water and the recycled water. Fig 5 shows that the recycled water accelerates the bagasse darkening. There was significant reduction in the brightness on account of the back water usage.

Fig.5 Influence of Back water on bagasse brightness

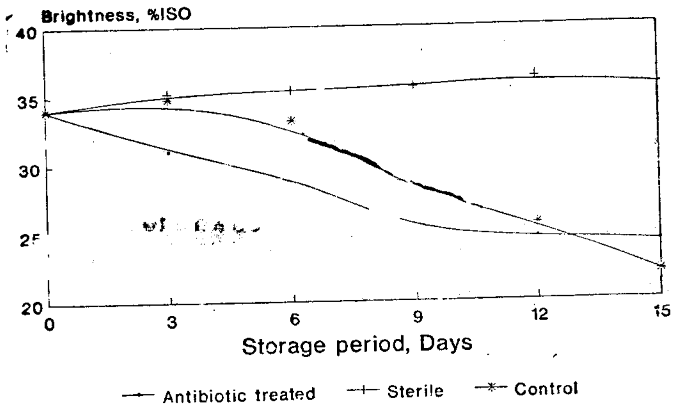


In all the foregoing studies, even if the favourable conditions such as high or low pH, low consistency, good compaction with anaerobic environment and the effective usage of fresh water, are maintained it is very evident that still they do not fully stop/retard discolouration. The tropical environmental storage conditions, the residual sugar content, the enormous exposed area of the bagasse pile facilitate the growth of microorganisms

Effect of microorganisms on the bagasse brightness

The systematic investigation of the micro organisms have led the reporters to conclude that the metabolic activity causes the detrioration of the fresh bagasse (9). Literature shows (10) that the micro organisms mainly fungi and bacteria present in bagasse ferment the sugars and also degrade the cellulosic materials. In order to study the effect of micro organisms on the brightness during storage depithed bagasse was stored at 25% consistency 1) as such 2) at sterile conditions and 3) with antibiotic treatment to avoid the bacterial growth. The results are shown in fig. 6. While there was a considerable drop in the brightness of the control sample and the antibiotic treated sample, there was no change in the brightness of the sterile sample which is persumably due to the absence of microbial activity. Hence, it can be deduced that the discolouration process of bagasse is primarily due the presence of fungi. This explains the reason for the brightness preservation at very low or very high pH and at low consistency and low aerobicity. All these conditions are not congenial for the microbial activity to thrive and hence the brightness is preserved.

Fig.6 Effect of microbial activity on bagasse brightness



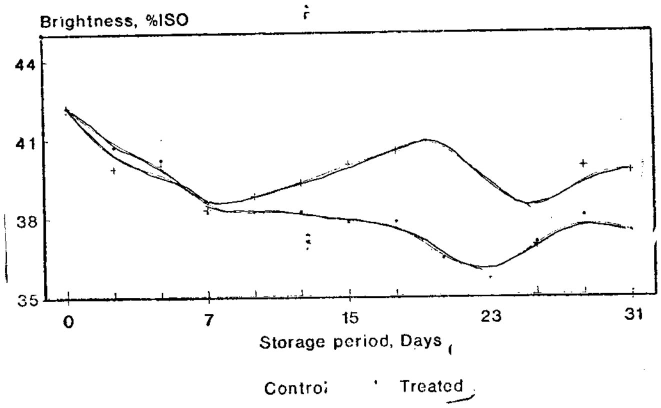
Chemical treatments to preserve the brightness during storage

Since the biological preservation processes, do not guarantee the brightness stability, laboratory studies were performed with chemical treatments to evaluate their effectiveness in maintainning brightness of bagasse It is reported that, (11) chemical treatments possess a higher controlling effect towards the process of wood discoluration. The chemical treatments are said to prevent the discolouration by way of modifying the light absorbing chromophoric structures (12). Various chemical treatments have been suggested to preserve the brightness of wood chips (12). Although, its physical structure is different from wood, bagasse possesses essentially the same chemical characteristics. Consequently, experiments were conducted with different chemical treatments with the fresh bagasse.

Effect of Chlorine water pre-treatment on the bagasse brightness

In the previous laboratory studies very low pH and very high pH were found to be favourable for the brightness preservation. In order to maintain a low pH chlorine water pre-treatment was considered. A very small quantity of 0.5% chlorine, sufficient to maintain the pH was applied on bagasse and then dewatered. 90% of chlorine applied was consumed. the brightness and pH were monitored for 30 days. The brightness trend during the storage period is illustrated in the Fig. 7. Chlorine water treated bagasse, owing to the very low pH and devoid of microbial activity was able to retain its brightness a large extent compared to the control.

Fig.7 Influence of chlorine water treatment on bagasse brightness



Effect of Sodium bisulphite treatment on bagasse brightness

Fresh depithed bagasse was manually mixed with 4% sodium bi sulphite at 5% consistency for 15 min and then the excess water was drained out. The treated bagasse was stored at the resultant consistency of 18%. A control was maintained in similar manner without the chemical. The effect of this treatment is shown in the Fig 8. It can be observed that, unlike the control sample, the brightness of the treated bagasse increases by 3.4 points. Inspite of this the brightness gradually drops to the same level of the control sample. Eventhough the addition is as high as 4%, the chemical uptake at 5% consistency was found to be very low (0.1%), since most of the sodium bi sulphite was carried away in the fitrate. This may be attributed for the poor response to the chemical treatment.

In order to enhance the chemical uptake another experiment was carried out, by dissolving the chemical in water and mixing with bagasse to achieve the ultimate consistency of 25% By this all the chemical was retained with the material. The outcome of this effort is shown in the Fig.9. The brightness was significantly maintained. Eventhen, after 3 weeks the brightness again showed declining trend which clearly indicated that the chemicals had been consumed. This can also be verified by the gradual increase in the pH. To maintain the brightness gain, yet another approach of supplementing the chemical after period of storage was thought of. As the figure shows split addition with a second stage sulphite treatment was given after 20 days of the initial treatment. 2% sodium bi sulphite was added to the 20 days stored bagasse which again resulted in brightness improvement.

Fig.8 Effect of Sodiumbisulphite treatment on bagasse brightness

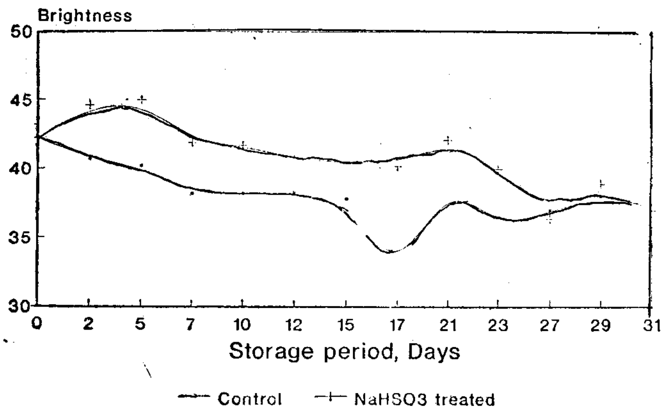
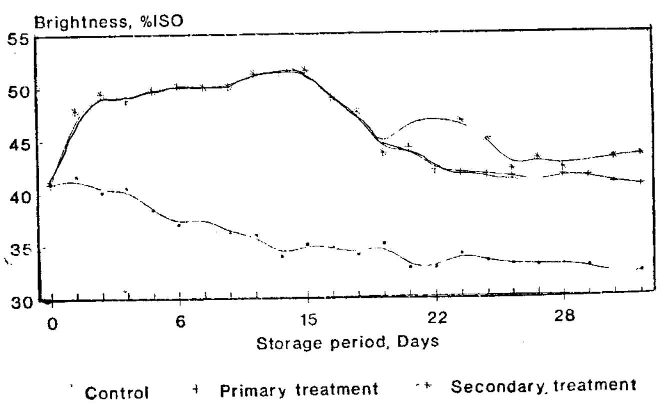


Fig.9 Effect of Sodium bi Sulphite treatment on bagasse brightness

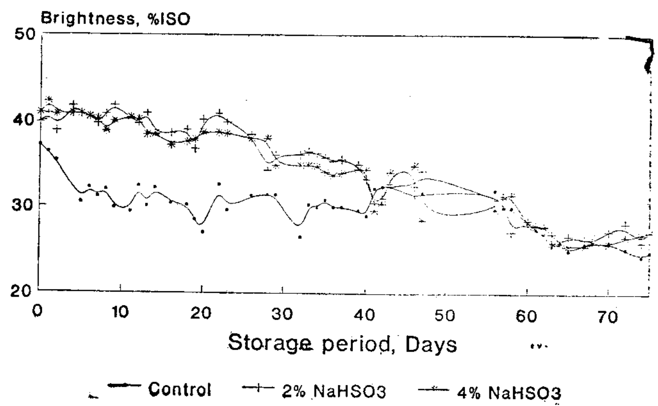


Pilot plant studies confirming the impact of chemical treatment on the storage brightness of bagasse

Based on the above studies, three experimental piles of 100 kg oven dry bagasse were made in the bagasse storage yard. Two piles treated with 2% sodium bi sulphite and 4% sodium bi sulphite respectively, were made and an untreated control was maintained. Sodium sulphite of 70 % purity was acidified to 5.0 pH with sulphuric acid for this purpose and the storage was carried out at 25% consistency.

The brightness of bagasse was monitored over a period of 75 days. The initial brightness of bagasse was 37.8% ISO for control pile and it was 39.8% ISO and 40.9% ISO for the 2% and 4% bi sulphite treated piles respectively. The observations are shown in the Fig 10. The results indicate that the $NaHSO_3$ treated sample showed 8-10 points higher brightness over the control for the first 25 days. Between 25-40 days the brightness differences narrowed down to 6 points. Beyond 40 days, the study was interrupted by rain, and the brightness diffrence still narrowed down to 2-3 points.

Fig.10 Pilot Plant study with Sodiumbisulphite



SUMMARY

Bagasse brightness is affected by the action of micro-organisms, mainly by fungi and the microbial activity is enhanced by neutral stong medium, high aerobicity, higher storage consistency and the recycled water. Chemical treatments with sodium-bi-sulphite acting as a chemical biocide was able to control the metabolic activity thereby preventing the discolouration to certain extent. However, the effect of weather, especially rainfall on the piles should be s udied. It may even be necessary to isolate the quantity of the bagasse required for mechanical bagasse pulp production and shelter the treated bagasse. On the basis of the available laboratory data, the treatment appears to be

effective. Further indepth studies to preserve the brightness of the fresh bagasse is warranted, to devise new storage methods.

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