PROCESS FOR PRESERVING LIGNOCELLULOSIC MATERIAL BY CONTROLLING AIR FLOW THROUGH A PILE OF LIGNOCELLULOSIC MATERIAL

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References Cited
UNITED STATES PATENTS
1,633,594 6/1927 Lathrop et al. 162/96 X

ABSTRACT
A process for preserving a pile of individual lignocellulosic material components by controlling air flow through the pile to provide a controlled temperature environment within the pile which favors the growth of microorganisms which consume soluble nutrients present in the lignocellulosic material while retarding the growth of other microorganisms which degrade the lignocellulosic material.

18 Claims, 7 Drawing Figures
FIG. 1

FIG. 2
PROCESS FOR PRESERVING LIGNOCELLULOSIC MATERIAL BY CONTROLLING AIR FLOW THROUGH A PILE OF LIGNOCELLULOSIC MATERIAL

The present invention relates to a process for preserving lignocellulosic material and more specifically to a process for preserving lignocellulosic material by controlling its temperature and moisture content. The term lignocellulosic material as used in the specification and claims includes, among other similar materials, small components or particulate, bagasse, wood chips, sawdust, bark, twigs, and leaves. These lignocellulosic materials constitute important raw materials for the industrial production of pulp, paper, hardboard, particulate board and other products widely used in a number of applications.

Cellulosic materials used for pulping may be conveniently divided into two broad categories, depending on the morphology of their individual component cellular elements.

1. Relatively short fibrous elementary cells (short fibers), e.g., hardwoods, bagasse, and straws; and
2. Relatively long and strong fibrous elementary cells (long fibers), e.g., coniferous woods.

Products produced from the first category will generally have smooth surfaces and low strength because of the intrinsic properties of the raw materials (hardwoods, bagasse, straws) and require the addition of variable amounts of stronger fibers (generally obtained from softwoods) to attain sufficient useful strength.

Since short fiber, low strength, materials are more plentiful and cheaper to obtain than the long, high strength, material, it is evident that the preservation of fiber strength, a property that is relatively expensive, is an essential prerequisite for the economical usage of the lignocellulosic material for paper making or any other application. That is, the raw materials, whatever their origin, should not be degraded during any phase of their industrial processing.

Generally, if biological degradation can be avoided completely, the results of an industrial operation based on any lignocellulosic material will be better. However in some cases, a mild biochemical reaction that may weaken only the intercellular matter, i.e., the cell-to-cell bonding in the plant tissue, may not be harmful to a pulping operation since any pulping process has precisely the same purpose. But, if the strength of the material is desired to be preserved in full, for instance for the preparation of particle board or similar products made with unpulped materials, the proper conservation of the intercellular bonding matter becomes necessary. Therefore, it would appear that a mild biochemical attack on the intercellular matter, not affecting the cellulosic fiber proper, would not be harmful if the fiber were to be used for pulping. However, in actual practice, this is not entirely the case, since there is no clear or sharp way to select or separate the biochemical reactions that attack only the intercellular matter and those which degrade the cellulosic fibers themselves.

Various techniques are known in the art for preserving lignocellulosic material; such techniques include sterilization, chemical addition, elimination or decrease of oxygen in the environment and pH decrease.

Wood chip piles have generally resisted special treatment in an effort to eliminate storage loss due to microorganism growth. Research has been done on this subject as disclosed in the article written by R. L. Thornton, H. E. White and J. N. Stone, entitled, "Influence of Chip Preservation on Fiber and Byproduct Yield," appearing in SOUTHERN PULP AND PAPER MANUFACTURER, dated Aug. 10, 1969.

In the case of bagasse, piles of this material have often been irrigated with water containing chemicals or special strains of bacteria (lactic acid forming bacteria), that live in an acid environment and lower the pH of the material, as a means to block or delay the action of those strains of bacteria or fungi that attack the structure of the bagasse, specifically the cellulose, hemicelluloses, and other portions. However, these techniques, which derive from the practice of sillage of fresh agricultural products, containing large amounts of soluble sugars, do not provide for full preservation of the bagasse; the acid environment created by these techniques degrades the bagasse, particularly the intercellular material. Further, the action of other cellulose destroying bacteria is not completely retarded and the control of the pH in the pile is practically impossible. As a result, the bagasse fibers are ultimately weakened and, in some cases, may not be fully suitable for their intended purpose, e.g., particle board production.

In summary, even under the most favorable conditions, biochemical degradation of the bagasse cannot be avoided using wet storage methods. Since bagasse degradation increases with time, the yield and quality correspondingly decreases.

It is an object of the present invention to provide a process for preserving lignocellulosic materials during storage.

It is another object of the present invention to control the microorganism growth which occurs in a mass or pile of lignocellulosic material to provide preservation of the lignocellulosic material.

It is another object of the present invention to provide means for rapidly depleting the soluble nutrients present in the stored material that sustain the bacteria and fungi.

It is another object of the present invention to provide a process for preserving lignocellulosic materials that is simple and economical to employ.

It is still a further object of the present invention to provide a process for preserving lignocellulosic material which is stored in a mass or pile by controlling the temperature and moisture content thereof.

Briefly, the present invention provides a process for preserving lignocellulosic material including the steps of arranging the lignocellulosic material in a pile, controlling the flow of air through the pile to create a controlled temperature environment for substantially optimum growth of microorganisms which consume and exhaust the soluble nutrients present in the material, and for retarding the growth of other microorganisms that degrade the lignocellulosic material, the flowing air also serving to simultaneously reduce the moisture content of the lignocellulosic material, and maintaining the controlled temperature environment during storage.

Other objects, aspects, and advantages of the present invention will be more apparent when the detailed description is considered in conjunction with the drawings as follows:

FIG. 1 is a graph showing the natural temperature variation occurring within a bagasse pile, the tempera-
ture being taken at approximately 4 feet from the outside surface; FIG. 2 is a graph showing the relative growth range of the two extreme types of microorganisms at different temperatures under favorable nutrient availability (Other microorganisms thrive at intermediate temperatures and their activity generally follows the shape of the curves shown); FIG. 3 illustrates an upward controlled air flow arrangement used for the preserving process according to the present invention; FIG. 4 illustrates an upward controlled air flow arrangement in use with various pile configurations; FIG. 5 illustrates a downward controlled air flow arrangement used for the preserving process according to the present invention; FIG. 6 is a longitudinal sectional view taken through a typical pile; and FIG. 7 is a vertical sectional view taken through a typical pile, showing the approximate location of various pressure and temperature measuring devices employed for experimental purposes. In order to more fully understand and appreciate the broad application of the process herein described, it is believed helpful to consider, with some degree of simplification, the natural biological processes that occur within a large pile of lignocellulosic material, specifically bagasse, stored outdoors over a period of time. (Wood chips generally follow the same biological pattern as the bagasse example. Therefore, the discussion of bagasse may be considered as generally representative of the behavior of stored lignocellulosic materials).

Referring to FIG. 1, the approximate temperature variation of the bagasse pile, taken 4 feet from the outside surface, is shown. The graph shows two distinct temperature periods, the first lasting approximately eight days at the beginning of which the temperature steadily increases from ambient to a maximum of about 43°C, and the second temperature period in which the temperature increases to a new maximum of about 60°C, remaining at that level for a few days and then slowly decreasing. The maximum temperature, the periods of time mentioned as well as the rate of cooling and other factors are dependent in part on the size of the pile, on the ambient temperature, wind conditions, sugar and nutrient content and other factors. (Deeper within the bagasse pile the temperature may reach a level slightly above 60°C).

Bagasse includes relatively large amounts of sucrose, other sugars and soluble compounds which constitute substantially an ideal medium for microorganism growth. For this reason, bagasse is very vulnerable and decays very rapidly. At ambient temperature, approximately 18°-20°C, the most active microorganisms are fungi, saccharomycesceae or yeasts, which feed mainly on soluble sugars and produce through their metabolism, principally ethanol and carbon dioxide. Simultaneously, this initial oxidation process releases heat, causing a rise in temperature, see FIG. 1. However, the activity of yeasts decreases quite sharply at about 30°C. Thus, the increase in temperature above 30°C is due to the presence of other microorganisms that are more active at higher temperatures. As the temperature rises and the activity of yeasts decreases, some fungi, particularly bacteria, begin growing.

The temperature within the bagasse pile appears to be the most influential factor in determining the growth of the various strains of microorganisms since nutrients are present in abundance. During this process of biological activity, the nutrients are gradually consumed. Initially, the relatively high abundance of yeasts will preferentially consume the soluble sugars; however, since their activity decreases with a rise in temperature, at some temperature the heat loss by the pile will become greater than the heat being generated by the biochemical reaction. (Also to be considered is the heat transfer within the pile, the gradual exhaustion of the soluble sugars, the ventilation of the pile due to the wind, the ambient temperature, etc.). The result is that after the initial period of intense biological activity associated with a relatively high heat release and an increase in temperature, the activity decreases while heat dissipation continues and the temperature starts to decrease. Further, during the initial period the pH generally decreases, preventing other bacteria which are unfit for an acid environment from multiplying at a fast rate. After a brief period of decreased microorganism growth (shown by decreasing temperature in FIG. 1), other strains of bacteria, specifically the thermophiles, begin to multiply. This secondary biological activity results in the secondary temperature increase shown in FIG. 1.

The yeasts that develop initially at ambient temperature only consume soluble sugars and do not degrade the chemical or physical structure of the lignocellulosic material. However, the thermophiles which appear at higher temperatures and higher pH, are generally cellulose destroying bacteria. Those microorganisms whose maximum growth rate is between the two mentioned extremes, i.e., the saccharomycetaceae and the thermophiles, have generally some degrading effect on the bagasse fibers, either directly or through the generation of enzymes. Saccharomycesceae growth is illustrated by curve S and thermophile growth by curve T in FIG. 2.

The present process controls the temperature environment within a pile of stored material to favor the growth of harmless yeasts which exhaust the soluble nutrients, and control of the moisture content by drying the material, which if dried to a moisture content of below 28 percent will effectively prevent the growth of any microorganism which requires water for its existence.

The process according to the present invention is obtained by controlled ventilation of the pile. Adequate ventilation of the pile by means of a controlled air flow (upward as shown in FIGS. 3 and 4 or downward as shown in FIG. 5) produces several desirable affects. Assuming an upward air flow as shown in FIGS. 3 and 4, the predominant biochemical reactions in the ventilated bagasse pile will be summarized with reference to FIGS. 3 and 4.

Initially, a layer or pile 10 of bagasse is deposited over storage area 12 which includes conduits or channels 14 beneath the bagasse pile 10. The channels 14 are arranged in any desirable pattern, e.g., one suggested pattern is shown in FIG. 3, to provide even distribution of exiting air upwardly through the pile 10, see FIG. 4.

Biochemical activity or fermentation will begin as previously described; initially the predominant active microorganisms are the yeasts which cause oxidation of
the fermentable sugars into ethyl alcohol and carbon dioxide. The acetobacteria present will oxidize the ethyl alcohol into acetic acid. As a result, the pH of the bagasse will decrease to about 6 or lower. This acid environment further enhances the growth of yeasts, while inhibiting the growth of other microorganisms.

The bioactivity mentioned will release heat, and the temperature of the pile will start increasing, see FIG. 1. However, the flow of air injected at the bottom of the pile will dissipate this heat (evaporative cooling) so that the internal temperature of the pile will reach an equilibrium that is a function of several variables, including the following:

a. The rate of heat release brought about by the biochemical activity;

b. The temperature of the outside air;

c. The moisture content of the outside air; and
d. The rate of air flow through the material.

On the “high” temperature side of the curve of FIG. 1, corresponding to the yeasts, an increase of air flow will result in a decrease in temperature, the effect of which will increase the biological activity in the pile and, consequently, the rate of heat release which in turn will increase the temperature. It appears that due to this compensating effect the temperature will remain with the range of approximately 22° to 26° C. (The maximum growth rate of yeasts occurs at about 20° to 22° C.).

Simultaneously, the air flowing through the material will evaporate and carry off any volatile material present in the fermenting pile, including water, alcohol, etc., up to its saturation point. (The heat generated by the biochemical activity will also help in the evaporation of such volatile compounds).

The flowing air will also displace the carbon dioxide and other non-condensable gases formed during this early fermentation period, and also maintain aerobic conditions that will slow down or prevent altogether the proliferation of anaerobic bacteria.

Full control of the environment within the bagasse pile 10 is achieved by forcing a stream of air, e.g., at ambient temperature, up through the pile of lignocellulosic material. The rate of air flow is adjusted to reach the most favorable environmental conditions for the maximum growth rate of yeasts (Saccharomycetaceae) which corresponds to a temperature of around 20°-22°C. When no more soluble sugars are present, the activity of yeasts will decrease and eventually cease completely.

A new second layer (not shown) can be placed on the lower one, while air continues to flow upward through the resulting pile. This second layer will undergo the same fermentation cycle as described before, while air passing through the lower layer will continue the process of evaporation of water contained in the lower layer until its moisture content is in equilibrium with the moisture content of the ambient air. Layer upon layer can be laid on the pile, each layer being at a different stage of fermentation and moisture content.

After the last layer is deposited the air flow may be stopped or continued for a few days until the whole pile reaches the desired moisture content to provide proper conservation of the lignocellulosic material over extended storage periods.

Since the basic requirement for bagasse conservation is the proper control of temperature, a complete drying of the material is not required. Consequently, the ventilation of the pile can be discontinued as soon as the content of soluble nutrients in the bagasse falls to a specified maximum value. After this condition is reached ventilation may be started intermittently whenever the temperature in the pile tends to increase, in order to lower it to the desired level.

A different procedure may be adopted in the case of particle board production, where, in contrast to the pulpmaking operation, fresh bagasse cannot be used directly in the process because of the pressure of sugars. For particle board production, it may be desirable to form separate bagasse piles 11 and 13, see FIG. 4, instead of forming layers as previously described, the separate piles can be readily ventilated for a few days until the sugars are exhausted and the bagasse is then ready for use, even if not completely.

Referring to FIG. 3, the channels 14 include a primary air duct 16 and four secondary air ducts 18, 20, 22 and 24. The air ducts 16, 18, 20, 22 and 24 are shown in FIG. 3 as channels or ditches beneath the pile 10. However, pipes, conduits or any kind of duct may be employed for adequately distributing air through the pile 10. The pile 10 has a perimeter indicated at 26 and a general hemispherical configuration indicated at 28.

The individual particulate components of the pile 10 will rest on top of the air ducts 16, 18, 20, 22 and 24, which have openings 30 of a size sufficient to allow air to exit from the ducts in a general upward direction, while preventing the particulate components of the pile 10 from falling through the openings 30 and clogging the ducts.

One advantageous arrangement, as shown in FIGS. 3 and 4, employs ducts having wire mesh upper surfaces 32 for retaining the lignocellulosic material piled thereon and preventing it from falling into and clogging the ducts. The flowing air will exit through the wire mesh 32, entering into and through the voids in the bagasse pile 10 which are formed by the irregular shape and position of the individual particulate components of the pile.

A motor driven blower 34 may be connected to the primary duct 16 for forcing a flowing air into the primary duct 16 and eventually into the secondary ducts 18, 20, 22 and 24. A heater 35, e.g., steam, gas flame or any other heating means, may be interposed between the blower 34 and the primary duct 16, so that, if desired, the steam of flowing air from the blower 34 may be heated prior to entering the primary conduit 16.

As seen in FIG. 4, the amount of air flowing through the pile 10, as indicated by the arrows, may vary somewhat depending on the resistance of the pile to the air flow and length of the flow path. If a more even distribution of flowing air is desired, the pile 10 may be shaped as shown in dotted outline at 36 or a different arrangement of the ducts may be utilized.

In utilizing the process of the present invention, the lignocellulosic material may be distributed over the ducts as a layer, as shown in dotted outline at 38, or alternatively as shown in dotted outline at 36. The blower 34 is started, forcing streams of air through the ducts 22 and 24 and eventually through the layer 38 or 36. A sufficient quantity of air is flowed through the layer 38 or 36 to provide an average layer temperature of approximately 20°-22° C; the optimum temperature for the growth of yeasts which consume the soluble nutri-
ents while such temperature control prevents the growth of microorganisms which degrade the material fibers. It should be understood that some deviation from this optimum temperature is permissible and may be economically desirable, especially in hotter climates.

If the average temperature is maintained near the optimum temperature, the complete fermentation of the soluble sugars normally requires about a week. At the conclusion of the fermentation process, a second layer (not shown) may be deposited over the first layer 38 or 36; while the flow of air through the layers is continued. Thus, successive layers of material may be applied at intervals of one week or slightly more. This successive build-up of layers ultimately results in a pile having the configuration indicated by 10 or 36. Air entering the pile from below the first layer will tend to evaporate the moisture from the second layer and reduce its temperature to provide a favorable environment for the growth of yeasts and the consumption of soluble sugars.

When it is desired to dry the material, it may be advantageous to heat the flowing air after the fermentation of the sugar in the first layer is completed. (The temperature increase in the flowing air will not prevent alcoholic fermentation from proceeding in the subsequent layers, since the evaporation of the water from the lower layers provides a cooling effect.)

A downward air flow control arrangement is illustrated in FIG. 5. Since the freshest lignocellulosic material which has the largest amount of soluble nutrients and moisture is in the top layer, it may be desirable to have the least saturated air initially contact the top layer (freshest layer). The outside or ambient air is made to flow into the pile 10A (arrow), and is drawn downwardly or sucked through the pile 10A into the low pressure zone 40 beneath the pile 10 by vacuum pump 42.

By controlling the temperature during the fermentation period, to optimize the growth of yeasts, the soluble sugars are consumed without the development of the thermophilic strains of bacteria which degrade the fibers of the lignocellulosic material. After the soluble sugars have been consumed, the growth of thermophilic strains of bacteria can be prevented by controlling the temperature environment in the pile.

Advantageously, it may not be necessary to dry the material until its moisture content decreases below its critical moisture, which for bagasse is about 28 percent.

In actual practice, the amount of air injected into the bagasse pile is not large and only requires a low pressure if the channels are properly arranged for good air distribution. Therefore, the power consumption is relatively low in comparison with other methods that use water and require pumping. Further, the yield and quality of the stored material, when used, are both very high.

Recapitulating, the process for preserving lignocellulosic material may generally include the steps of:

a. maintaining the average temperature of the mass substantially close to the average temperature required to optimize the growth of the microorganisms which consume the soluble nutrients present in the mass without damaging the fibers of the material;

b. dissipating the heat released in the metabolism of the microorganisms mentioned in (a) to provide a controlled temperature environment which retards or prevents the growth of other microorganisms (thermophiles) which degrade the lignocellulosic material;

c. providing an oxygenated environment within the mass of material to retard the growth of anaerobic microorganisms while nutrients are still available;

d. aiding in the evaporation of moisture present in the mass by removing it from the mass; and

e. controlling the environment to facilitate the depletion, during a relatively short period of time, of the nutrients present in the stored material.

EXAMPLE

In this example, two bagasse piles were formed. One served as the control pile and the other pile was formed over perforated air ducts, indicated at 46, positioned under the storage floor level, as shown in FIGS. 6 and 7. At the completion of the example, each of the piles were composed of approximately one thousand tons of dry bagasse.

An axial flow fan 48 provided a flow of air for ventilation of pile 44 and an anemometer 50 was employed to measure the air flow entering the fan 48. A network of plastic tubing was installed in the pile 44 during its formation to measure the static air pressure in air duct 46 and at various locations in the pile 44 as schematically shown in FIG. 7. Each tube 52 was connected to pressure indicators 54. This arrangement allowed measurement of the static pressure drop throughout the pile 44 while the fan 48 was in operation.

A number of thermocouples 56 were also installed throughout the pile 46 during its formation, each thermocouple 56 being connected to a recording potentiometer 57 for measuring and recording the temperature during storage.

Pile 44 was continuously ventilated while the control pile was not. Both piles were formed at approximately the same time during the cane harvesting season.

After the season ended these two piles were left standing for approximately a month and were removed a little at a time in order to investigate the conditions of the material, as well as the amount of storage loss. The piles had no protection whatsoever against the weather and went through a complete rainy season.

The material in the ventilated pile 44 did not suffer any biochemical attack and produced a pulp comparable in yield and physical properties to pulp made with fresh material. Periodic samples taken during the storage period showed rapid depletion of sugar, lowering of the pH and a steady decrease in the moisture content of the stored fiber. These samples also showed that the temperature in the pile 44 becomes quite steady at a lower level than the outside air, and that this pile temperature is a complex function of many factors including the microbiological activity intensity. After depletion of sugars, the pile becomes quite stable, even without further drying and only occasionally some hot pockets developed that were traced to the uneven density of the bagasse pile that did not allow for an even distribution of the air flow.
The only material that became degraded and discolored was the top layer of the pile, about eight inches thick that became water soaked during the rainy season. It was interesting to note that the parenchyma (pith) of bagasse acted as a sponge and did not allow the rain water to seep deeper into the pile, thereby facilitating its evaporation during the periods between rain falls.

The non-ventilated pile became quite hot as soon as the bagasse was stored and remained so during the entire storage period. The majority of the bagasse material in this pile became discolored and was unsuitable for pulping; fiber losses were high. In some locations, within the pile, the stored bagasse was less degraded, apparently the pH at this location was lower, aiding in retarding but not preventing micro-biological attack.

Further experimentation indicated that it is advantageous to distribute the bagasse over the storage area and duct system in successive layers and begin ventilation as soon as the first layer is formed; this procedure allows uniform ventilation without increasing the total amount of air needed, while decreasing the amount of power consumed for ventilation.

Intermittent ventilation was also found to contribute substantially to bagasse conservation.

It should be apparent to those skilled in the art, that various modifications may be made in the apparatus employed to carry out the process of the present invention which controls the environment within a pile of lignocellulosic material by controlling the flow of air through the pile as described in the specification and defined in the appended claims.

What is claimed is:

1. Process for preserving lignocellulosic material comprising the steps of:
   arranging individual lignocellulosic material components in a pile;
   controlling air flow through the pile to provide a controlled temperature environment within the pile which favors the growth of microorganisms which consume the soluble nutrients present in the lignocellulosic material while retarding the growth of other microorganisms which degrade the lignocellulosic material, the flowing air also serving to simultaneously reduce the moisture content of the lignocellulosic material;
   maintaining the controlled temperature environment at least until the soluble nutrients are substantially eliminated; and
   continuing the controlled air flow through the pile after the substantial elimination of the soluble nutrients present in the first layer;

2. Process as claimed in claim 1 wherein:
   the controlled air flow through the pile creates a controlled temperature environment in the pile having an average temperature of about 20° to 22° C.

3. Process as claimed in claim 1 including the step of:
   heating the air flowing through the pile, after the soluble nutrients are substantially eliminated.

4. Process as claimed in claim 1 wherein:
   the lignocellulosic material is bagasse;
   the controlled air flow through the pile is continued to reduce the moisture content of the pile of bagasse to a maximum of about 28%.

5. Process as claimed in claim 1 including the step of:
   heating the air prior to the step of continuing the controlled air flow through the pile.

6. Process for preserving lignocellulosic material comprising the steps of:
   providing a conduit arrangement for distributing air;
   placing a layer of lignocellulosic material over the conduit arrangement;
   providing a controlled air flow to the conduit arrangement and therefrom through the layer of lignocellulosic material, the air flowing through the layer providing a controlled temperature environment for increasing the growth of microorganisms which consume the soluble nutrients present in the lignocellulosic material while retarding the growth of microorganisms which degrade the lignocellulosic material, the flowing air also serving to simultaneously dry the lignocellulosic material;
   maintaining the controlled temperature environment at least until the soluble nutrients are substantially eliminated; and
   continuing the controlled air flow through the layer after the substantial elimination of the soluble nutrients to reduce the moisture content of the layer to a level which will inhibit the growth of microorganisms.

7. Process as claimed in claim 6 including the steps of:
   depositing a second layer of lignocellulosic material over the first layer after substantially complete fermentation of the soluble nutrients present in the first layer;
   continuing the controlled air flow through the first layer;
   repeating the depositing and air flowing steps with subsequent layers.

8. Process as claimed in claim 7 including the additional step of:
   heating the flowing air after the soluble nutrients present in the first layer are substantially eliminated and after the second layer is deposited over the first layer.

9. Process as claimed in claim 6 wherein:
   the controlled air flow through the layer of lignocellulosic material creates a controlled temperature environment having an average temperature of about 20° to about 22° C.

10. Process as claimed in claim 9 wherein:
    the lignocellulosic material in bagasse;
    the controlled air flow through the layer is continued to reduce the moisture content of the layer of bagasse to a maximum of about 28%.

11. Process for preserving lignocellulosic material comprising the steps of:
    arranging individual lignocellulosic material components in a layer;
    drawing air downwardly through the layer to provide a controlled air flow which creates a controlled temperature environment for increasing the growth of microorganisms which consume the soluble nutrients present in the lignocellulosic material, while retarding the growth of other microorganisms which degrade the lignocellulosic material, the flowing air also serving to simultaneously reduce...
the moisture content of the lignocellulosic material; maintaining control of the temperature environment at least until the soluble nutrients are substantially eliminated; and continuing the controlled air flow through the layer after the substantial elimination of the soluble nutrients to reduce the moisture content of the layer to a level which will inhibit the growth of microorganisms.

12. Process as claimed in claim 11 including the steps of:
   depositing a second layer of lignocellulosic material over the first layer after substantially complete fermentation of the soluble nutrients present therein;
   drawing air downwardly through the new layer which has become the top layer;
   repeating the depositing and air drawing steps with subsequent layers.

13. Process for preserving lignocellulosic material comprising the steps of:
   forming individual lignocellulosic material components into a mass;
   introducing to the mass a controlled air flow and thereby creating a controlled temperature environment in the mass for substantially optimizing the growth of microorganisms which consume the soluble nutrients present in the lignocellulosic material while retarding the growth of microorganisms that degrade the lignocellulosic material; and simultaneously reducing the moisture content in the mass; and continuing the air flow through the mass so as to reduce the soluble nutrients.

14. Process as claimed in claim 13 including the step of:
   maintaining an oxygenated environment within the mass of lignocellulosic material to retard the growth of anaerobic microorganisms.

15. Process for preserving lignocellulosic material comprising the steps of:
   forming a mass of lignocellulosic material;
   controlling the environment within the mass to influence the microorganisms that develop naturally in the mass of lignocellulosic material with the passage of time, the environment being controlled by controlling the flow of air through the pile, the air flow:
   a. maintaining the average temperature of the mass substantially close to the average temperature required to optimize the growth of the microorganisms which consume the soluble nutrients present in the mass without damaging the fibers of the material;
   b. dissipating the heat released in the metabolism of the microorganisms mentioned in (a) to provide a controlled temperature environment which retards the growth of microorganisms which degrade the lignocellulosic material;
   c. providing an oxygenated environment within the mass of material to retard the growth of anaerobic microorganisms while nutrients are still available;
   d. aiding in the evaporation of moisture present in the mass by removing it from the mass; and
   e. controlling the environment to facilitate the reduction of the nutrients present in the mass of material.

16. Process as claimed in claim 15 including the additional step of:
   continuing the controlled air flow through the mass to reduce the moisture content of the material to a level which will inhibit the growth of microorganisms.

17. Process as claimed in claim 16 wherein:
   the lignocellulosic material is bagasse.

18. Process as claimed in claim 15, wherein:
   the lignocellulosic material is bagasse; and
   the controlled air flow through the mass is continued to reduce the moisture content of the mass of bagasse to a maximum of about 28 percent.
CERTIFICATE OF CORRECTION

Patent No. 3,802,957 Dated April 9, 1974

Inventor(s) Dante S. Cusi

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 10, "pressure" should be--presence--;

Column 8, lines 40 and 41, "temperature" should be--temperatures--;

Claim 10, line 2 (col. 10), "in" should be--is--;

Signed and sealed this 5th day of November 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR. C. MARSHALL DANN
Attesting Officer Commissioner of Patents