Partial Composting for Biodrying Organic Materials

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What is biodrying?

Biodrying, as the name implies, is a drying technique that relies on biological activities of microorganisms, bacteria and fungi, to reduce the moisture content of wet biomaterial waste. The drying effect is achieved because of the microbial activity as well as forced aeration. As the microorganisms feed on the nutrients, carbon (C), nitrogen (N) and other elements available in the waste, heat is produced as part of the metabolic activities. This heat, assisted by air, is used to evaporate the excess moisture.

What is the difference between biodrying and composting?

Although there is much in common between biodrying and composting, the essential difference is the process goal. Composting aims at fully decomposing the biomass, removing odors and killing pathogens. The duration of composting can extend to several months. Biodrying, on the other hand, aims at removing as much moisture as possible in the shortest time. The process duration varies with the waste material type and the system setup, but it typically should last between two to three weeks. A biodried pile may require mixing at least once a week for moisture redistribution. Composted material can be used as a soil amendment while biodried material has potential value for bioenergy production.

Is biodrying an old concept?

The biodrying concept is not very old. It was adopted in the last two decades to dry municipal solid wastes (MSW) in various European countries (Ragazzi et al., 2006). The term biodrying was created in the mid-eighties during an investigation of dairy manure drying.

What can be biodried?

Many higher moisture organic materials (60%-65% wet basis) can be biodried. Common examples include livestock manure slurries and municipal solid wastes. However, other materials such as food processing and paper mill residuals may also be suitable for biodrying. A potential limitation on what is suitable for biodrying is that the dryer bulking agent (often necessary) tends to have carbon-to-nitrogen (C/N) ratios higher than desirable for composting. This means the material to be biodried must have lower C/N ratios so the final C/N ratio of the mix is appropriate for composting.

Why use biodrying?

Biodrying, as the name implies, removes moisture from the organic material. The reduction of moisture reduces the weight of the material and can significantly change its handling characteristics. The reduction in weight reduces the cost of transporting material from its source to end use destination. It is also possible that the reduction in moisture results in a product that can be more easily handled as solid than in its original slurry or sludge form.

Additional benefits include the reduced potential for odors since the resulting material is well aerated and partially stabilized. Finally, the resulting material with its lower moisture content is more suitable for energy production by thermochemical process such as complete combustion, pyrolysis or gasification.

What are the levels of aeration required for biodrying?

Airflow is a critical factor that should be controlled properly during the biodrying process. Low aeration rates result in decomposition without significant moisture removal – in other words, composting. Higher values of aeration rates will quickly cool the material down and stop microbial activities.

There is a wide range of recommendations as to suitable aeration levels for biodrying. However, all are higher than those required for conventional composting. Generally, aeration levels should be between 7 and 20 cubic feet per minute (cfm) per 1 short ton (2,000 lbs) of fresh material (assuming 30% volatile matter fraction of fresh weight and 60% moisture content). To achieve this level of aeration, biodrying systems usually use fans to force air through the organic material.

What are the factors affecting the biodrying process?

Since biodrying is both a biological and a physical process, it is affected by a number of factors. The biological factors that directly influence the microorganisms include material composition, carbon/nitrogen ratio (C/N), moisture content and pH. Physical factors include the pile geometry (shape), void ratio, airflow rate and mixing intervals.

What are the recommended values for the various biodrying factors?

Values of biodrying parameters are similar to those of composting. Table 1 shows the recommended values for biodrying parameters:

Table 1. Biodrying process recommended values.

Factor	Range
Moisture content (M.C. %)	60% - 65%
Carbon/Nitrogen (C/N)	20 - 30
pH	5.5 - 8.0

Initial moisture content should be between 60% and 65%. When moisture levels are too low (below 40%), microbial activity slows because water is needed for the microbial metabolic processes. If the moisture level is above 65%, anaerobic conditions are more frequent because water rather than air fills the pore space limiting available oxygen. The initial C/N ratio should be from 20 to 30 for optimal composting. The ideal pH range for biodrying is between 5.5 and 8.0.

How can I measure these factors?

These factors are evaluated in biomass characterization labs using specialized instruments. Operators can collect samples from both the manure and the bulking agent and send them for analysis. Your local county Extension office can provide access to information on how to collect samples and have them analyzed. The results of the testing process can be used to develop the desired ratio of materials for the mixture to be biodried.

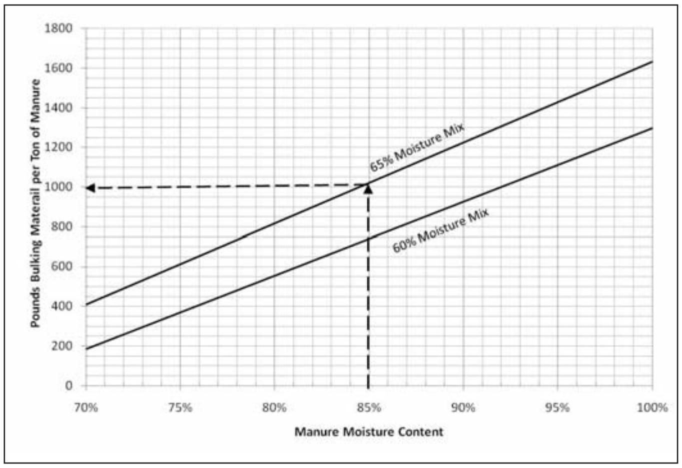
What is the bulking material and why do I need it for biodrying?

Bulking material is a fluffy material with relatively low bulk density. Bulking material should contain moisture content significantly lower than the optimum starting level of 60%. Mixing bulking material such as sawdust, wheat straw or corn stalks adjusts the moisture content and facilitates air movement due to the increase in voids ratio. The voids ratio in the waste material is an important factor since it controls air and moisture movement. Also, bulking material is usually rich in carbon; therefore, incorporating this material also improves the C/N ratio. For example, the carbon-to-nitrogen ratios in sawdust, wheat straw and corn stalks are 250:1, 150:1 and 60:1, respectively (Sullivan, 2003). The pile's carbon-to-nitrogen ratio should be maintained around 20 to 30 to ensure that microorganisms have balanced nutrients for their metabolic activities.

How much bulking material is needed for 1 short ton (2,000 lbs) of manure?

As mentioned earlier, the manure-bulking agent mixture should have around 60%-65% moisture content in order to achieve a biodrying effect. Assuming that the bulking agent (i.e., straw or sawdust) has 11% moisture content, which is usually the case, the following graph (Figure 1) can be used to determine the amount of bulking agent required for 1 short ton (2,000 lbs) of manure. For example, for 1 ton of manure at 85% moisture content with target mixture moisture of 65%, the amount of required bulking material will be 1,020 lbs.

Figure 1. Biodrying mixing ratios based on moisture level only.



It was mentioned earlier that the C/N ratio should be in the range of 20-30. Therefore, you need to calculate the mixture C/N ratio.

How can I calculate the manure-bulking material mixture C/N ratio?

You need to know the moisture content, carbon content and nitrogen content of the manure as well as the bulking material. The formula for calculating the C/N ratio for only two ingredients is listed below. While the formula involves only simple math, there are enough steps that the use of specialized programs or spreadsheets is usually preferred. The use of a computer program is necessary when more than two ingredients will be blended for biodrying.

$$C/N = \left[\frac{(Q1*(100 - m1)*c1+Q2*(100 - m2)*c2)}{(Q1*(100 - m1)*n1+Q2*(100 - m2)*n2)}\right]$$

Where:
- Q1 = Manure weight, pound
- Q2 = Bulking material weight, pound
- m1 = manure moisture content, %
- c1 = manure carbon concentration, g/kg
- n1 = manure nitrogen concentration, g/kg
- m2 = bulking agent moisture content, %
- c2 = bulking agent carbon concentration, g/kg
- n2 = bulking agent nitrogen concentration, g/kg

It is important to calculate the C/N ratio and maintain it in the optimum range mentioned earlier.

How is biodried material produced?

The process is achieved by mixing the wet bio-waste with the bulking material, then either loading the mixture into biodrying units (i.e., reactors, Figure 2) or arranging them in open-pile arrangement in a covered area (Figure 3). Our practical experience showed that the range of 3 to 4 feet for the height of the pile worked well.

Figure 2. Biodrying unit.

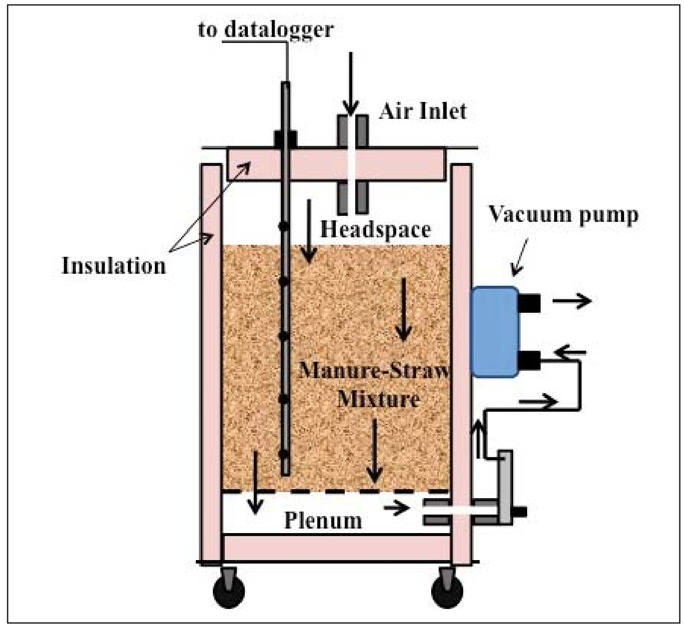


Figure 3. Biodrying pile preparation.

What types of waste can be processed?

Examples of waste matter that can be biodried include municipal solid waste (MSW) sludge, paper mill solid wastes and manure-separated solids.

What are the characteristics of biodried materials?

The biodried material is a partly decomposed material with less odors and moisture content between 20% and 30%.

What is the profile of the temperature in a biodrying pile?

Temperatures usually increase during the second to third day to reach 100-120°F. After reaching an upper limit, usually 140°F, temperatures self-adjust and return again to around 110°F. Also, while turning the pile to ensure homogenous distribution of moisture, the temperature drops sharply but usually recovers in a day or two to the 100-120°F range.

How does the biodrying pile moisture content vary with time?

The moisture reduction trend starts very flat, i.e., no apparent moisture reduction in the beginning. After three to four days, however, sharp moisture reduction takes place due to the high temperatures and the aeration. After two weeks, the moisture reduction rate gradually decreases, signaling the completion of the biodrying process

How can I evaluate the success of my biodrying process?

The biodrying process is evaluated based on the targeted moisture level and the time duration required to achieve this level. Generally, the process should not exceed 21 days. Also, this method is useful to reduce the moisture content to 20% to 30%. Any further moisture reduction will have to utilize either conventional oven drying or natural (sun) drying.

How much biodrying material could be produced from 1 ton of manure-bulking material mixture?

The amount of biodried material that can be produced from one ton of the original mixture depends largely on the moisture reduction. For example, if one ton of 60% moisture material is dried to 30%, the weight of the water removed would be the original mixture weight times the moisture reduction (60%-30%). Mathematically this would be 2,000 lbs*(0.6 – 0.3) or 600 lbs of water loss. Therefore the expected final weight would be 2,000 lbs – 600 lbs = 1,400 lbs. Actually it should be a little less because the loss of organic material due to emissions has not be considered.

What are the benefits of biodrying?

The biodrying process is beneficial in preparing wet biomass for transportation as it effectively reduces the weight to be transported. It can also be used to prepare bio-waste for energy generation through combustion and/or gasification. Since water is removed, using this biodrying technique increases the energy ratio which is the retrieved energy divided by the input energy.

Although the biodrying process technically requires energy to remove moisture, the energy form used in this case is the chemical energy stored in the waste material. Therefore, it may offset additional cost that would be required for using coal or natural gas to fire up material dryers. This improves the economics of this process and justifies the investment in energy retrieval from low-heating-value waste streams.

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