Manure Management – Have You Considered Composting?

John W. Paul

Transform Compost Systems Ltd. 34642 Mierau St. Abbotsford, BC. V2S 4W8 Canada
Email: transform@bc.sympatico.ca

Take Home Messages

- Composting may be an option on large farms with a small land base or where an opportunity exists to market the product.
- The type of composting system depends on the nature of the manure being composted, the end use of the material, the resources available on farm, and the environmental constraints.
- We are working to develop composting systems that reduce the amount of bulking agent required to allow us to compost liquid manure.
- Composting with worms may be a good option for some farms.

Introduction

As we approach the 21st century, manure management presents increasing environmental challenges in terms of air, water and soil quality. Farms are getting larger, which means that a greater quantity of manure has to be transported further from the farm in order to utilize the manure as a fertilizer. Manure application rates and times of application are being restricted in some geographical areas because of ground and surface water concerns. Concerns about odor are universal. Concerns with pathogen transmission are increasing in some areas. Environmental concerns with manure management drive the search for new manure management technologies that reduce the risk of pollution at the lowest cost. Composting is one of these technologies that is being considered.

A few questions and comments arise when talking to dairy producers about composting. Some of these include; "Why should I bother doing this extra work if storing and applying raw manure works just fine for me?" "I've heard

that some of the nutrients are lost during composting, so is this really a good thing?" "It would be great if you could figure out a way to compost liquid manure, it sure might save hauling costs, and may reduce the amount of storage I need." Manure management is a net cost to most dairy producers. The cost of manure management is usually greater than the value of the nutrients that are returned to the land.

Not all dairy farms should compost their manure. Composting should only be done if it makes both economic and environmental sense, if it reduces the cost of managing the manure in a manner that does not increase the risk of environmental pollution. Composting can be considered for farms that have too many manure nutrients for their land base, for large farms where manure has to be transported long distances to utilize the manure nutrients effectively, and for organic dairy farms where the manure is required to be composted before use on crops. Composting may be an option for producers looking to reduce odor, reduce weed seed and pathogen levels, and reduce volume and weight.

Organic waste has been composting since time began. Any pile of organic waste will compost, given enough time. There are some good practical guides for composting of farm manures (1, 8). We like to optimize the process, to make it work faster in order to minimize the time and the space required for the process. This will decrease the cost of composting and provide high quality compost.

In this paper, I will discuss why composting may be an option on some farms, explain some of the benefits of composting, and discuss implementing a composting system on a farm that utilizes a liquid manure management. I will include a short discussion on worm composting.

▪ Composting is Just Extra Work, So Why Bother?

Managing dairy manure as a liquid or as a semi-solid has always been the least cost option for managing dairy cattle manure. If managed properly, it can be one of the most effective methods for conserving and recycling manure nutrients. When manure is applied and incorporated before crop growth in the spring, the manure nitrogen can be used very effectively by the crop. What about manure that is applied to land during the fall and winter? What about manure that is applied in excess to fields close to the manure storage? This type of manure management may be simple and least cost, but is it always environmentally sustainable?

It is extra work, and hence extra cost, to manage manure in an environmentally sustainable manner. If manure application limits become based on the recycling of phosphorus in the manure, a lot of land will be required to apply the manure, especially for large dairy farms. This dramatically increases transportation costs to the costs of manure management, particularly if the

manure is 90% water. If manure application is limited to the time of the year where the risk of environmental pollution is minimized, this may add some challenges to traditional manure management. How do you apply liquid manure to fields in the spring when the lagoon is frozen until June? If your window for planting is short in the spring, should you be spending your time hauling manure to the field? If fall application of manure results in significant loss of manure nitrogen, is there a better way?

Composting is indeed extra work, and extra bother. On some farms, it may become less work and less bother than traditional manure management if the manure is to be managed in an environmentally sustainable manner. Times are changing, we are being called to account for our manure management. We are called to be stewards of the land. In being stewards of the land, it may be more economically viable to compost manure on some farms.

▪ Are Nutrients Lost During the Composting Process?

Composting does not have to result in nutrient loss. Nitrogen is the nutrient that is at greatest risk of loss through the process of ammonia volatilization, where the nitrogen is lost to the air as ammonia. Nitrogen losses can range from less than 10% with manure composted with straw to over 75% with poultry manure composted without any straw or wood waste. An understanding of how ammonia is lost and how composting works is required to minimize nitrogen losses. None of the other nutrients are lost during the composting process, as long as the compost process is done in a manner than minimizes leaching losses. For example, other nutrients will definitely be washed out of the composting material if the material is exposed to excess rainfall.

With proper composting, nitrogen loss should be no higher than typical traditional manure management. During traditional manure management, nitrogen losses can range from 10% during liquid storage to over 25% with solid storage. If the manure is not incorporated within 24 hours of application to the field, a further 30-40% of the nitrogen could be lost with liquid manure, and 10-30% with solid manure. This means that a nitrogen loss of over 50% with traditional manure management is not uncommon. These nitrogen losses are easier to control during the composting process than during traditional manure management.

▪ If I Have Liquid Manure, Do I Need to Separate Before Composting?

Many dairy producers like liquid manure management. It is one of the simplest methods of managing manure in the barn. One of the main reasons for liquid manure management is because it is simpler to store and apply to the field than semi-solid manure. Many dairy producers still have visions of semi-solid

manure management, where it can feel like it takes ages to fill the manure spreader only to have half of the manure spill out before the spreader reaches the field. Liquid manure management seems so much more efficient.

Removing the liquids from dairy cattle manure for the sole purpose of composting the solids may not be a viable option because of the high cost of separating. Manure separation should only be done if it fits into the manure management plan on the farm. Reasons for separating could include using the liquids to flush the barn, or because it makes manure application by irrigation to the field much simpler.

Composting separated solids is a very simple process and works extremely well. There is no one separator that is much better than all others if the manure is going to be composted. A screw press type separator delivers a drier product, but is also more expensive to run. Drag chain or incline plane separators have higher capacities, but don't have as much of the liquids removed. Agriculture and Agri-Food Canada (Agassiz) has worked extensively with turned windrow composting of separated solids produced using a drag chain type separator. The composting process results in a 60% volume reduction and a highly desirable end product (5).

▪ Can Worms be Used for Composting?

Dairy cattle manure composts very well with worms, a process called vermi-composting. Worm composting is becoming more popular. Some of the reasons for this include a potentially high value plant growth promoting product, simplicity of the composting, low cost, and simply curiosity. Worm composting does have specific requirements, which means that not all animal manure can be effectively composted with worms under all climatic conditions.

The most popular worm used for worm composting is *Eisenia fetida*, otherwise known as manure worm or red wriggler (2). These worms can be found in many manure or compost piles that have been in the same place for several years. Optimal conditions for composting of animal waste using worms include a temperature of 15-20 ^{o}C (limit 4-30 ^{o}C), moisture content between 80 to 90%, aerobic conditions, less than 0.5 g/kg ammonia, less than 0.5% salt, and a pH between 5 and 9.

Most dairy cattle manure could be readily composted using worms. There are some organic farms in Ontario that windrow manure that contains straw bedding along the side of the field in the fall. Worms work their way into the material throughout the winter and spring. By the summer, the manure has been totally changed into an odorless and friable product.

We have been using worm composting to process separated dairy solids using an indoor growing bed. The process takes between 30 and 60 days to

complete. The resulting product has demonstrated some good potential with early tree fruit growth in research conducted by Agriculture and Agri-Food Canada at Summerland, BC (Gerry Neilsen, personal communication).

▪ Can Liquid Manure be Composted?

What if the manure could be changed from a semi-solid to a solid that would be much easier to apply to the fields? It would be appealing to be able to scrape the manure from the barn, or remove it from a pit in the case of slatted floors, compost it, and leave the manure in a form that is dry, concentrated and easy to apply to the field. It would also make manure transportation costs much lower. And what if it could be done without liquid-solid separation?

Composting is rarely considered as an option for liquid manure because of the amount of bulking agent required to create a solid material having a moisture content of 50-60%, which is the moisture content at which composting works best. For example, the volume of bulking agent required to bring a 75% moisture content waste to 60% is similar to the volume of waste to begin with, which means that you now have double the volume of composting waste to process. As the moisture content of the initial waste increases, so does the bulking agent requirement.

Agriculture and Agri-Food Canada in Ontario (3) proposed a passive aerated composting system whereby liquid manures could be added to peat. Assuming a bulk density of 60 kg m^{-3}, the amount of peat that was required was 1.7 cubic meters per tonne of liquid. This is somewhat cost restrictive, and adds considerably to the bulk of the final product. Patni and Kinsman (4) used the passive aerated compost system with liquid hog manure and straw, and showed that additional hog manure could be added during the process because water evaporated during composting. They mixed 333 kg straw (1.6 m^3 assuming bulk density of 200 kg m^{-3}) per tonne of liquid manure. An additional 2 tonnes of liquid was added during the 60 day composting process, as moisture evaporated. Total moisture removal from this composting process was approximately 7.8 tonnes per tonne of straw.

Using an enclosed composting system, Richard and Choi (7) showed that bulking agent requirements could be reduced by a factor of 5 or more during composting of poultry manure, by using the heat of composting to evaporate moisture. In research at the Pacific Agri-Food Research Centre, Paul and Barton (6) composted 5580 kg liquid hog manure with 2400 kg broiler litter and 1040 kg shavings during the winter. It was calculated that 75% of theoretical efficiency of moisture removal was reached, based on calculations of the degradable energy in the manures. It was calculated that with a moisture content of 90% in liquid hog manure, there was enough energy in the manure to evaporate the moisture to produce a dry fertilizer material.

When designing and developing compost technology, it is important to understand the theory of how moisture can be removed during the composting process.

▪ How Moisture Evaporation Occurs During Composting

First Principle: Composting Requires Oxygen and Produces Heat

Composting is the aerobic decomposition of organic waste by bacteria. Bacteria utilize the waste as an energy source. These bacteria require oxygen for this process. The end products are carbon dioxide, heat, water and compost (Figure 1).

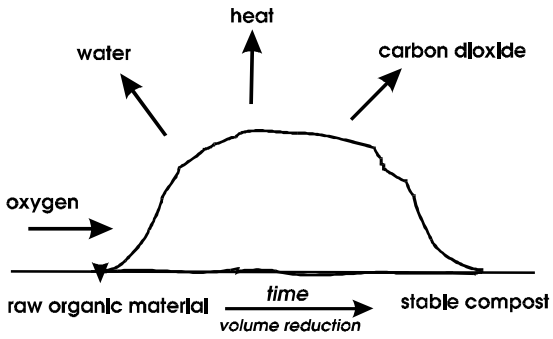

Figure 1. The Composting Process

The compost heats, and the rate of decomposition increases. The optimum temperature for composting is 50-60 ^{o}C. High temperature itself is not an indicator of the speed or efficiency of the process. Compost also has a high insulating value and holds heat well. Oxygen is often the limiting factor in the process, especially if compost turning is the only method of supplying air. Depending on the physical structure of the material, and the degradability, compost piles can become anaerobic within an hour of turning. Therefore, in order to maintain an efficient composting process, compost piles should be aerated. It is less costly to supply air through an aeration system, than by mechanical turning of the compost. With most waste materials, the air required to maintain optimum oxygen concentrations in the compost is much lower than the amount of air required to remove the heat. This means that a properly designed aeration system will optimize the composting process without excess cooling of the compost. The size of the compost pile, degradability of the wastes, physical and chemical characteristics of the waste, and the outside temperature also play an important role in determining heat loss and aeration requirements.

Second Principle: The Moisture Capacity of Air Increases with Temperature

Air at low temperature cannot hold as much water as air at high temperature as shown in Figure 2. This is a simple principle that we observe every day as the kettle boils. Steam is produced because the air can no longer hold the moisture as it cools, and steam is formed.

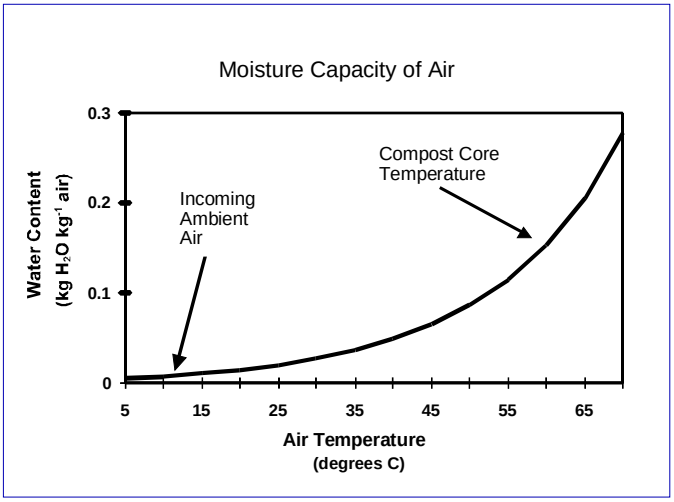

Figure 2 Moisture content of air with increasing

Similarly, steam rises from composting material during turning. With a pile of compost, if the air comes up from the bottom of the pile, the bottom of the pile usually dries out first because low temperature air (e.g. (10 ^{o}C) enters the pile at the bottom and picks up moisture as the air warms. The warm saturated air (60 ^{o}C) rises to the surface and equilibrates with the outside air. If the outside air temperature is low, there is a zone of equilibration near the surface of the compost, where the moisture in the hot rising air is condensed onto the surface of the composting mass. If the outside air temperature is high, the air has much more capacity for holding moisture, which means that the compost pile dries out faster. This can be observed during the summer months, where compost piles often require water addition because they dry out very quickly.

▪ Developing Composting Systems That Optimize Moisture Removal

With an understanding of the heat produced during composting, and the moisture content of air at various temperatures, we understand more about

what is happening during the composting process. We know that composting piles dry out rapidly during the summer, but not during the winter.

It is difficult to develop composting systems that optimize moisture removal year round using conventional windrow type composting. These systems will work well during the summer, but not so well during the winter. An ideal system is an enclosed system, where both mixing and aeration occurs. The air is required to supply the bacteria with oxygen. The mixing is required so that the material at the bottom does not dry out.

There are currently two companies in Canada that are working to develop composting systems to remove moisture during composting of animal manure. These include our company, Transform Compost Systems, and another company in Ontario, Global Earth Products. There is still some research and development that is required to optimize the composting process on the large scale.

▪ What are the Benefits to Composting?

The benefits of composting include reduction in the volume of organic material, weed seed and pathogen kill, elimination of odor with field application, stabilization of nutrients, and a material that is much easier to transport and market.

The volume reduction as a result of composting means that less time is required to apply the compost to the land. The composted material can be transported further from the manure storage, which reduces the risk of excess nutrient application to the land near the manure storage facility. It also means that the nutrients in the manure are at a higher concentration, which means that the material can be applied at lower rates of application.

Weed seed kill breaks the cycle of weed production that can happen when manure is not composted. With low transportation costs, animal feeds are imported from long distances. Weed seeds are imported along with these feeds. Many weed seeds are not destroyed during the visit to the cow's stomach or during manure storage. Weed seed distribution back to the land increases weed problems, which either reduces crop yield, increases the cost of controlling the weeds by herbicides, or a combination of both. In order for all of the weed seeds to be killed, all of the composting material must reach temperatures above 55 ^{o}C for a few days.

Composted material is much easier to transport and apply than raw manure. If the material is well composted, it is relatively dry and can be spread with trucks having a spinner spreader. This results in a much more uniform nutrient application. There is no odor associated with the application of the composted manure. These characteristics of the compost add to its market value. On

large dairy operations, there may be incentive to market some of the compost to offset the manure management costs and reduced the risk of environmental pollution.

Pathogen kill during composting also breaks certain disease cycles, including organisms that cause contamination of water supplies. Fly populations can also be minimized if the material is composted properly. In order to minimize fly populations, the compost should be mixed or turned once per week, because fly cycles are between 7 and 10 days.

The risk of environmental pollution is reduced with compost application because there is no odor to the compost and the BOD (biological oxygen demand) is reduced, resulting in reduced risk of surface water pollution. The concentration of inorganic nitrogen is lower which reduces the risk of surface and groundwater contamination by nitrate.

▪ Could I Market the Compost?

A high quality compost produced from dairy waste can be easily marketed for use in the greenhouse or for consumer use. If the process is done correctly, there are no odors, the material is relatively dry and handles very well. The electrical conductivity of compost is a very important characteristic, because it will determine how well plants grow with the composted material. High electrical conductivity prevents seed germination and root growth. For example, composted dairy solids has a low electrical conductivity and an excellent porous structure, which provides good aeration porosity for plant roots. These two qualities make it especially attractive to using composted separated dairy solids to replace some of the peat moss in nursery and greenhouse growing media. The composted dairy solids also contains macro and micro nutrients required for plant growth. Using sawdust for bedding rather than shavings increases the potential for marketing a quality compost.

Agriculture and Agri-Food Canada (Agassiz) has tested composted, separated dairy solids for commercial tomato and cucumber production. Preliminary results indicate a 5-10% yield increase in production when using composted separated dairy solids compared with sawdust only (Dave Ehret, pers comm). This translates to $0.25-0.50 worth of compost yielding an additional $10 worth of produce.

Other potential applications for composted dairy cattle manure are for use in hydrocarbon (oils and gas) contaminated site reclamation, where manure and compost is required to optimize conditions for contaminant decomposition. Composted separated dairy solids compost has also been used very effectively in reseeding existing lawns.

A well produced dairy solids compost with consistent quality can be marketed at a premium for use in potting soil mixes, and may obtain a price of more than $30 per cubic meter ($22.50 per yard). For a premium price to be obtained, the composting process requires exceptional quality control.

▪ Summary

Although composting of organic waste has been going on for a long time, we are continually improving the process by reducing costs and improving compost quality. Composting is a good option for dairy producers where there is straw available to mix with the manure, where odors may be an issue, and where the animal density is too high to utilize manure nutrients effectively close to the farm. There are many benefits to composting, including volume reduction, weed seed and pathogen kill, and nutrient stabilization. The composting process must be done in a manner that minimizes the risk of air and water pollution.

The choice of composting system depends on the volume and type of material being composted, the desired end product of composting, and the resources available on the farm. Composting doesn't have to cost much money, especially if the compost is being utilized on the farm. Marketing compost off-farm may require a more consistent product and the assurance of weed seed and pathogen kill. This type of composting may require a larger capital input for turning and aerating the compost.

▪ References

1. B.C. Ministry of Agriculture, Agriculture and Agri-Food Canada, Hog Producers Sustainable Farm Group. B.C. Agricultural Compost Handbook. 1993., Set of Factsheets, Agdex 537/727. B.C. Ministry of Agriculture, Fisheries and Food.
2. Edwards, C. 1998. Earthworm Ecology. CRC Press, Florida.
3. Mathur, S.P., N.K. Patni and M.P. Levesque. 1990. Static pile, passive aeration composting of manure slurries using peat as a bulking agent. Biological Wastes 34: 323-333.
4. Patni, N.K. and R.G. Kinsman. 1997. Composting of dilute manure slurries to reduce bulk by water evaporation. ASAE Technical Paper No. 974115. ASAE, St. Joseph, MI.
5. Paul, J.W. 1996. Composting separated solids…worth the bother? Proceedings of the 28th annual BC Dairy Short Course. South Coastal Dairy Education Association and the BC Ministry of Agriculture and Food. Pp. 37-47.

6. Paul, J.W. and P.K. Barton. 1997. Enhancing moisture removal during composting of liquid hog manure with shavings or poultry litter. Pacific Agri-Food Research Centre (Agassiz) Technical Report No. 135.
7. Richard, T.L. and H.-L. Choi. 1996. Optimizing the composting process for moisture removal: theoretical analysis and experimental results. ASAE Technical Paper No. 964014. ASAE, St. Joseph, MI.
8. Rynk, R., ed. On-Farm Composting Handbook. NRAS-54. 1992. Northeast Regional Agricultural Engineering Service. 152 Riley-Robb Hall, Cooperative Extension, Ithica, NY. 14853-5701.