West Virginia University
Extension Service

Soil Management

DANA O. PORTER, P.E.
WVU Extension Service - Agricultural Engineering Specialist

Considerations for Organic Waste Utilization in Agriculture

This article is intended to help agricultural producers make well-informed decisions about applying organic wastes, and whether they should consider applying "raw" untreated waste, partially treated waste, or treated waste, such as compost. The focus will be upon two common practices in production agriculture: direct land application of raw waste and direct application of composted waste. Keep in mind, however, that organic wastes may prove beneficial or detrimental, depending upon how wisely they are used and upon waste characteristics. One waste material may provide valuable nutrients and improve soil productivity if applied appropriately, or damage soil productivity and possibly contaminate water resources if applied inappropriately. Another waste material may benefit one cropping system and harm another. Still another waste may contain some valuable nutrients, but also contain high levels of undesirable elements, such as heavy metals or salts.

While the general discussion is about utilization of animal wastes, these same concerns can be applied to food processing wastes, domestic and municipal sewage and sludges, and industrial organic wastes. Future articles will explore waste handling, treatment, and utilization alternatives in greater detail.

Benefits of organic waste utilization

Farmers and gardeners have long recognized the importance of replacing nutrients and organic matter that are depleted under continuous cropping. Renewed and growing interest in "nutrient recycling" can be attributed to high costs of synthetic fertilizers and the increasing need for suitable disposal of wastes generated by Concentrated Animal Feeding Operations (CAFOs).

Depending upon the material, organic wastes can supply macronutrients (N, P, and K) and micronutrients to the soil for use by crops. These materials can replace part of or all synthetic fertilizers used in an operation. Adding organic matter to mineral soils can improve their physical properties (infiltration, water holding, structure, etc.) and chemical properties (Cation Exchange Capacity, fertility, etc.) Through agricultural utilization of organic wastes, producers can benefit (and possibly derive marketing potential) from materials that otherwise may be placed into landfills or present environmental pollution problems.

Direct land application

Direct land application of raw or partially treated wastes is a well-known method of waste utilization. Animal wastes and sewage sludges contain both plant-available nutrients and immobilized nutrients (which may become available as the organic material decomposes). Waste characteristics, soil moisture, and temperature will affect the rate of decomposition in the field. Application rates should be based upon soil fertility, crop requirements, and chemical characteristics of the waste(s). Timing will depend upon crop needs and the weather. Application method will depend upon the physical characteristics of the waste and upon equipment availability. Generally, solid wastes can be applied with a manure spreader or common tillage equipment. Liquid wastes may be injected, broadcast, or applied through an irrigation system. Semi-solid or slurry wastes may require special equipment or may be modified so they can be handled with available or conventional equipment.

Waste generators consider direct land application an economical means of waste "disposal" in which they may seek to minimize land area required for disposal (i.e., apply waste at the highest allowable rates). For example, a CAFO facility operator may be required to demonstrate in his Pollution Prevention Plan that he has sufficient land for environmentally safe application of wastes generated at his facility. The size of his operation, therefore, may be limited by the amount of land available for waste application. Alternately, the CAFO operator may seek alternate "disposal" options, which include selling the animal waste as fertilizer.

A farmer who purchases the waste material as fertilizer is interested not in maximizing the amount of material that can be applied to his fields, but rather in maximizing his net return on his input investment. It is not in his best interest to overapply the waste. He will supplement the waste with "complimentary" wastes or synthetic fertilizers to provide a nutrient balance appropriate for his crop. He will optimize the value of the material by balancing costs of the waste (including transportation and application costs) against costs of synthetic fertilizers and the expected benefit (in crop productivity) from the fertilizer application.

Composting

Composting is a biological treatment in which microorganisms (bacteria, fungi, and actinomycetes) decompose and stabilize organic material. Managing a composting system generally involves providing an environment that supports (maximizes) microbial activity. As microbes consume organic material to grow and metabolize, some of the waste mass (including nutrients) is immobilized in the cells of the microorganisms. As a result of microbial metabolism, water vapor, carbon dioxide, and heat are released. Loss of water vapor results in a gradual drying of the waste; loss of carbon dioxide and water vapor result in reduction of mass. Heat generated in composting increases temperature of the material, which generally increases microbial activity. High temperatures maintained in the composting process also can destroy weed seeds, insects, and pathogens. (Composting organic wastes will be discussed in greater detail in an upcoming article.)

Because composted waste is "treated," it is more stable than an untreated or partially treated waste. Easily decomposed fractions in the material are metabolized or "immobilized" in the bodies of microorganisms. As a result, some nutrient loss may occur. Under ideal aerobic conditions, however, nitrogen may be transformed from an ammonia to a nitrate, minimizing the volatilization loss of the ammonia. Immobilized nutrients can become available with slow decomposition of organic matter, in effect a "timed release" of nutrients. The nutrient content of compost will depend upon the nutrient content of the raw materials, management of the composting system, and the relative "decomposability" of the compost materials. **A chemical analysis is necessary to verify the fertilizer value of the final compost product**.

Since compost is a stable, bulky material, it is relatively easy to handle and transport with conventional equipment. Because it has a relatively low moisture content, compost may be less expensive to transport than many untreated high-moisture wastes. Further, because of its biological stability, it is easy to store and unlikely to smell at time of application.

Direct land application vs. composting: Which is best?

Comparing advantages and disadvantages of direct land application of raw wastes with composted wastes may be helpful in determining which is appropriate for your operation. In general, untreated waste can be obtained at lower cost than compost because composting involves some investment of time, equipment, and labor. Untreated waste may also contain higher concentrations of readily available nutrients, especially nitrogen. However, broadcast application without timely incorporation can result in significant ammonia losses.

Compost can provide a farmer with greater scheduling flexibility. While an untreated waste must be applied and incorporated promptly to prevent nitrogen loss and nuisance conditions, compost is stable and can be stored safely. You can store, apply, and incorporate compost when you and your operation are ready. Compost presents little or no odor. Provided it is adequately treated and cured, compost is not likely to "burn" plants. Further, aerobic (high temperature) composting kills pathogens and weed seeds, and will not contribute to pest problems.

Organic waste utilization: Potential problems and how to avoid them

Potential problems related to nutrient management in agriculture can be avoided by following relatively simple guidelines.

Nutrient overloading, through a one-time heavy application or through accumulation of nutrients over time, can contribute to pollution of surface or ground water. Some micronutrients can even accumulate to levels that may prove toxic to plants and/or grazing animals. Before applying organic or inorganic fertilizers to a field, collect soil samples and analyze them for fertility levels. Contact your county agent for assistance with soil sampling and analysis. Estimating how much N, P, and K your crop will need and determining residual nutrient content of your soil will help determine how much supplemental fertilizer is needed. Utilizing organic fertilizers (including wastes) is similar to applying synthetic fertilizer in that you need to know how much N, P, K, etc., you are applying. If the material has not been analyzed, collect a representative sample and have it tested at the West Virginia Department of Agriculture Moorefield Field Office (HC 85, Box 302, Moorefield, WV 26836); or send it to your preferred soil testing laboratory. Be sure to note whether the lab reports values in NO_3-N, NH_3-N, P_2O_5, and K_2O or elemental N, P, and K. You can save money and reduce pollution risks by using your fertilizers more efficiently.

Nutrient losses from applied organic waste can result from volatilization and/or leaching. Ammonia volatilization losses will be reduced if the waste is applied through subsurface injection or, if surface-applied, waste is incorporated soon after application. Leaching losses will be reduced if the waste is applied shortly before the crop needs it (in the spring rather than in the fall). Careful control of compost mixtures and aerobic conditions will limit nutrient losses in composting.

High salt levels are found in some organic wastes, including many animal wastes. In land affected by high salinity and/or high sodicity (sodium content), it is particularly important to monitor salt and sodium levels in materials applied. When farming with saline conditions, producers should consider salt levels in the soil, in applied materials, in irrigation water, and the "salt tolerance" of crops produced. In many cases, salinity can be managed effectively through irrigation.

Excessive heavy metals and/or other hazardous materials may be found in some wastes, especially industrial wastes, municipal sewage sludges, and dredging products from contaminated lakes. Before you agree to accept wastes from these sources, be sure that levels of lead, cadmium, arsenic, copper, etc., are not excessive. Contact qualified personnel from the Cooperative Extension Service, the Natural Resources Conservation Service (NRCS), or an agricultural consultant for assistance with gathering and interpreting the information you need to make an informed decision.

Pollution of surface waters may result from runoff of applied waste materials. To prevent this, do not apply waste to frozen or saturated soils. Incorporating surface-applied waste and fertilizers into soil will limit overland movement of nutrients and organic matter detrimental to water quality. Check "hydraulic loading" of waste application to ensure that the volume of liquid applied does not exceed the soil's percolation and water holding potential.

Imbalanced nutrient levels may interfere with efficient use of the nutrients by the crop. An applied waste that provides N, P, K, and micronutrients may not provide them in appropriate ratios for many plants. Be careful not to overload the soil with accumulated phosphorus to supply sufficient nitrogen for your plants. Generally, it is safer to add supplemental "complimentary" wastes or synthetic fertilizers to meet nutrient demands. Be aware that some wastes contain high levels of organic matter (carbon sources) but low nutrient levels. These wastes may temporarily increase fertilizer demand and reduce nutrients available to the crop, because the nutrients are used by soil microorganisms as they "feed" on the organic matter. The effect is to bind the nutrients, particularly nitrogen, in organic forms not readily available for crop uptake. Over time the nutrients may be released gradually as the organic material decomposes. Also be aware that nutrient availability and metal solubility may be affected by pH of both the soil and the waste.

Nuisance complaints from neighbors or visits by environmental agency personnel responding to complaints of offensive odors are a common problem for producers using untreated or partially treated wastes. Odor problems can be minimized sometimes by scheduling applications when wind will carry odors away from neighbors. Wind can, however, also disperse odors. Timely incorporation of applied materials and subsurface injection of wastes reduce emissions of odorous gases. Sometimes nuisance complaints are reduced through better communication between neighbors. If possible, talk with your neighbors so they understand what you are doing. Perhaps you can agree on preferred application times or even develop a cooperative waste application effort that benefits all concerned. (Your neighbor may agree to an application on Monday if you are willing to wait to fertilize until after his weekend family reunion.)

Look out for your own interests, your land's productivity, and the quality of the environment. Waste suppliers are trying to eliminate a problem and potentially make a profit. You are trying to optimize your production system. Both parties can benefit from proper waste utilization.

Where to go for more information

This list of references can help you locate more information about utilization of organic wastes. Many references may be ordered from publishers, some of which are available at local and university libraries. The World Wide Web provides access to many related materials and experts. Your local agricultural consultants, county agents, and NRCS personnel can also assist.

MidWest Plan Service. 1993. Livestock Waste Facilities Handbook. MWPS-18. ($8) MidWest Plan Service, 122 Davidson Hall, Iowa State University, Ames, IA 50011-3080. (800) 562-3618

Northeast Regional Agricultural Engineering Service. 1994. Fertilizer and Manure Application Equipment. NRAES-57. ($6) Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853-5701.

Northeast Regional Agricultural Engineering Service. 1994. Liquid Manure Application Systems: Design, Management, and Environmental Assessment. NRAES-79. ($25) Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853-5701.

Northeast Regional Agricultural Engineering Service. 1992. On-Farm Composting Handbook. NRAES-54. ($15) Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cooperative Extension, Ithaca, NY 14853-5701.

("On-Farm Composting Handbook" is a good "how to" book for composting on the farm. Discussed are benefits, drawbacks, raw materials, equipment, and compost use. Contact WVU Extension Service, for NRAES publications.)

BioCycle Journal of Composting and Recycling, 419 State Avenue, Emmaus, PA 18049, phone (610) 967-4135 (BioCycle, a monthly journal, addresses large-scale composting and recycling. Composting equipment is advertised and addresses of equipment manufacturers are listed. Single copy price (as of April 1996) is $6; the one-year subscription rate is $63. You may be able to locate the journal in a nearby public library or university library.

U.S. Environmental Protection Agency. Guide to Septage Treatment and Disposal. 1994. EPA/625/R-94/002. U.S. EPA Center for Environmental Research Information, Cincinnati, OH 45268.

("Guide to Septage Treatment and Disposal" is a handbook detailing procedures and regulations applicable to treatment and disposal of sewage sludge and liquid from septic systems.)

U.S. Natural Resources Conservation Service (formerly Soil Conservation Service). Personnel and publications are available for assistance and information.