FACTSHEET ON

COMPOSTING BIOSOLIDS

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WHAT ARE BIOSOLIDS?

Biosolids are the nutrient-rich organic product of wastewater treatment (sewage sludge). As a beneficial resource, biosolids contain essential plant nutrients and organic matter and may be recycled as fertiliser and soil amendment.

WHY COMPOST BIOSOLIDS?

BENEFITS: Composting is an efficient and economical technique for managing biosolids. The process has been utilized successfully in the United States since the 1970s, where currently, there are approximately 350 facilities in operation. Composting can be done both in- and outdoors with minimal environmental impact or risk to public health. Composting is also one of the only biosolids management techniques that can produce a product that is saleable, on both a commercial and retail basis.

REGULATORY DRIVERS: The historic route of disposal of biosolids to sea was banned by the European Union (EU) Urban Waste Water Treatment Directive (91/271/EEC), which required alternative 'land based' options for managing biosolids to be pursued. Guidelines for the Application of Sewage Sludge to Agricultural Land (ADAS 2001), sets parameters for "enhanced treatment" of biosolids, based on levels of pathogen kill, using E.coli as an indicator. It effectively ends the land spreading of untreated sludge and requires treatment to take place. Under The Waste Management Licensing Regulations 1994 the management of certain wastes, including biosolids, is exempt from licensing and can be applied to land providing other appropriate Codes of Practice (Scottish Executive 1997) are met. Sewage and sewage-derived materials are governed by The Sludge (Use in Agriculture) Regulations 1989 (as amended by the Public Health (Scotland) Act 1990) specify the maximum permissible limits for contaminants such as heavy metals, that may be applied to land. This is currently subject to further revision and details are yet to be published. It is expected that the application of untreated biosolids to land will be banned and that two levels of acceptable treatment will be specified.

PROCESSING BIOSOLIDS

Fig. 1. Compost pile construction.

Following the dewatering process, which creates a biosolids 'cake' typically ranging from a solids content of 15%-35%, the biosolids are blended with a bulking agent and carbon source. Wood chips, and other various types of recycled wood materials, are typically used to meet both the bulking agent and carbon requirements of the process. Acquiring recycled wood products, or actually processing them yourself, will allow for improved composting economics. To allow for rapid composting, the initial compost mix (recipe) should possess the following characteristics:

C:N Ratio	25-30:1
Moisture Content	50-60%
pH	6-8
Oxygen Concentration	5-15%

Since biosolids are not generally in a form that allows for the free movement of air (oxygen), creating a porous mass through the use of proper bulking agents is important (Fig. 1 & Fig. 2). A portion of the bulking agent requirement may be filled through the use of woodchips, etc. that were "screened" from a previously composted pile. This process will actually 'seed' the new pile with necessary microbes, speeding up the composting process.

Homogenous blending of the biosolids and bulking

Fig. 2. Peanut husk used as a source of carbon and also provides structure to composting mass.

agent is very important, as it will allow for more uniform aeration during the process. Aeration may be provided to the system 'by passive air exchange (natural convection and diffusion) or by forced aeration (blowers/fans - Fig. 3)' (NRAES 1992).

Once blended, composting pile temperature should increase rapidly to a temperature range of 45 - 60 ºC.

Fig. 3. Fan used to aerate composting pile.

Research has shown that by maintaining a 55ºC for 72 consecutive hours at all points in the mass, human pathogen reduction requirements, necessary to assure that health and safety issues, can be addressed. Shorter high temperature periods are acceptable but only if higher temperatures are achieved. Managing this 'time/temperature' relationship is critical to meeting regulatory requirements. Comparable to the pasteurisation process used to sanitise milk, the temperatures must be sufficient to destroy not only human pathogens, but also plant pathogens, disease organisms, nematodes, and weed seeds when they are subjected to these temperatures over a specific period of time. During the early stages of the composting process (first two weeks), the potential for the generation of odours is at its greatest. Therefore, the proper management of process-air and pile porosity is extremely important during this phase. The initial or 'high temperature' composting phase usually takes 2 to 4 weeks and is followed by a 30 to 90 day curing (low temperature) phase. Curing allows for further composting and stabilization to take place, as well as cooling of the compost mass.

Biosolids are a unique feedstock to compost because they typically possess a high moisture content, high levels of biodegradable organic matter (volatile solids) and are rich in nitrogen (undigested biosolids, even more so than digested biosolids). Because of these innate characteristics, biosolids composting may produce odours and attract vermin (e.g., flies). The moisture content of biosolids can also vary widely, and various types of chemical agents (e.g., lime, polymers) may be used to assist in the dewatering process. These agents can affect the chemical characteristics of the finished compost. For these reasons, proper process control, as well as analysis of incoming materials is paramount. Since biosolids composting must be completed on an impermeable surface, a leachate collection system will reduce the potential for environmental, health and safety issues to develop. Proper aeration during the composting process can help to avoid odours. Where economically viable, in-vessel or totally enclosed composting operations can also help to capture potential odours as well as reduce vector attraction potential. Without proper aeration, anaerobic conditions are likely to occur and generate volatile fatty acids that can be odorous. Maintaining the proper C:N ratio can also reduce odours. Low C:N ratios can lead to the volatilisation of ammonia and other odorous nitrogen-based compounds.

TECHNOLOGIES

Fig. 4. Open windrows.

Several technologies have been used to compost biosolids; they are typically categorized as windrow, static pile and in-vessel systems.

WINDROW SYSTEMS: The windrow composting process calls for the compost mass to be placed in manageable windrows that can be turned to allow aeration (Fig. 4). Windrow composting may allow for rapid drying of the compost mass, as moisture is released when piles are turned. The system has the capacity to handle large volumes of material and provide good product stabilisation. Windrowing also possesses a relatively low capital cost. However equipment and equipment maintenance costs can be significant, depending on the pile turning equipment utilised. Windrow systems are not very space efficient, requiring substantial space between rows for turning equipment. Pile sizing should not exceed approximately 1.5 meters in height and 3.5-4 meters in width. Unless piles are extremely porous, passive aeration in windrows may not be sufficient to maintain aerobic conditions. Poor aeration may cause low or non-uniform pile temperatures, pathogen survival and odours. Odours also tend to be released whenever piles are turned, and odour management is difficult with this system (unless piles are housed in a building with air-handling controls). Windrows can be influenced by the weather and process rate will fall slightly in winter. Perhaps more importantly in Scotland, under wet conditions, pile temperatures can be reduced, thus reducing process efficiency, and so feedstock preparation (mixing of biosolids and bulking agents) may be problematic.

Fig. 5. Static pile with aeration tubing.

STATIC PILE SYSTEMS: Unlike larger unturned static piles of garden waste, biosolids should be actively aerated during composting. The aerated static pile (ASP) composting process calls for manageable windrows to be formed over an aeration plenum, pipe or trench (Fig. 5). The compost mass is then covered with a layer of finished compost, to act as an insulating blanket. Air is pulled (negative) or pushed (positive) through the pile, to provide aeration, and the pile is therefore not turned (Figure 6). By operating under negative aeration, process air can be captured and treated, for instance through a simple biofilter. ASP composting requires relatively low capital cost, with the greatest expense going towards surfacing and material handling and loading equipment (front end loaders). The system can provide fast and thorough pathogen destruction, and good product stabilization. ASP composting can also provide better odour control than can outdoor window composting. However, ASP composting still possesses a greater odour generation potential than do in-vessel systems, and operations may still be influenced by climate, particularly cold and wet weather. To minimise these issues, today, more ASP systems are being housed within buildings. The system has greater land requirements than in-vessel composting, but lower than windrowing.

IN-VESSEL SYSTEMS: Various types of in-vessel composting systems exist which may be used to process biosolids (Fig. 6). Edwards (1998) categorizes in-vessel systems as agitated bays, container systems, tunnel systems and enclosed halls. Each system has its own set of advantages and disadvantages, but the agitated bay, tunnel and larger container technologies have been the most popular in-vessel systems used for composting biosolids. However, aside from patented technologies, the operation of windrow and ASP systems within a building is also becoming popular. In-vessel systems typically require the lowest land requirements, being very space efficient. They can provide good odour control because exhaust air can easily be directed to biofilters. In-vessel systems are less affected by climate than either windrow or static-pile systems, can allow for better process control, but have much higher capital costs. These systems rely on specialized mechanical equipment, which may require specialized repair knowledge. In-vessel systems typically do not allow for proper stabilisation within the 'vessel' and outdoor curing is still required. It is very important that any in-vessel system allows for proper aeration of the entire composting mass and this will influence choice of feedstock mix, to minimise compaction. Addi-

Fig. 6. In-vessel bunker with aeration system on the floor.

tionally, some tunnel systems have proven difficult to provide uniform aeration and process control.

ENVIRONMENTAL PROTECTION AND HEALTH & SAFETY

Biosolids are known to possess particular chemical pollutants, as well as primary pathogens that have the potential of causing health risk. Allowable pollutant and primary pathogen limits are outlined in the Guidelines for the Application of Sewage Sludge to Agricultural Land (ADAS 2001). Primary pathogens, such as bacteria, viruses, helminthes and protozoa can all be destroyed through proper composting. In fact, in the United States, where biosolids have been composted since the mid 1970s, there has never been a proven health problem associated with biosolids composting or product end use. Nutrient runoff (nitrogen and phosphorus) from biosolids composting sites is a serious potential environmental issue. However, runoff can be easily managed through the installation of a leachate collection system, and/or by operating the active composting stage of the process under cover.

OFFICIAL GUIDANCE

PROCESS: Guidelines for the Application of Sewage Sludge to Agricultural Land (ADAS 2001), sets parameters for treatment of biosolids. Irrespective of treatment method (e.g., lime stabilisation, digestion or composting), amended regulations are expected to set two levels of conventional and enhanced treatment resulting in reduction of no less than 3 LOG(10) and 6 LOG(10) reduction in faecal coliforms respectively. In addition, enhanced treatment must be shown to eradicate Salmonella and be carried out under a process of Hazard Analysis (HACCP) as defined under The Food Safety Act. The revised Regulations will not only set targets for faecal coliforms but will also state the process conditions under which material has to be treated, for instance time / temperature interactions during composting.

Furthermore, the Regulations will define subsequent use of land to which material of any particular process-grade (conventional or enhanced) has been applied.

It is important to note that at the time of writing, Draft Regulations differ in detail between England Wales and Scotland and so readers should be cautious when considering reports in the press or applying summary information to Scottish circumstances.

FINISHED PRODUCT

QUALITY: Biosolids composts are typically rich in a variety of plant nutrients and typically possess a pH (6-8) appropriate for a variety of plants and end use applications. Biosolids composts may possess an elevated soluble salts content; however, these levels are not typically a problem when the product is used properly. When composted using uniform protocols, biosolids composts can be among the most consistent composted products manufactured. This is helped by the fact that the source material (biosolids) is typically consistent in nature. If the biosolids used to produce compost have been dewatered using lime, or ash by-products added during the composting process, the pH and soluble salt levels of the compost will be elevated, as will the buffering capacity. These characteristics may limit the horticultural application of the product.

END USES: Biosolids composts have been used successfully in the production and establishment of a broad variety of horticultural, turf and agricultural crops. Although popular in some countries with nurserymen, the typical characteristics of biosolids compost lend it nicely for use in landscaping and turf management, as well as agriculture. Biosolids compost is ideal as a soil improver for turf establishment, as well as a turf top dressing if properly screened. Various biosolids composts have been found to suppress soil-borne diseases in research on turf grasses. When used in a variety of horticultural, turf and agricultural applications, biosolids composts have been able to reduce supplemental fertilizer requirements. Biosolids compost is also used in some areas as a decorative mulch, because of its dark, rich colour.

REFERENCES

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