Is there still a role for composting?

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Biotechnological processes have been widely applied to manage biodegradable wastes mainly by composting and anaerobic digestion, with the ultimate goals of waste stabilisation, elimination of pathogens, and volume reduction. Composting in particular has been used primarily to treat so-called 'dry biodegradable wastes' with a water content of less than 60%. Standard composting processes yield a humus-like final product, which can be used as soil amendment in agricultural or silvicultural systems depending on the quality of the product. Compost can also have a fertiliser value, but only if the organic waste feedstock contains sufficient nitrogen.

Energy recovery from bio-waste has, however, become more important, as the question of how to satisfy the increasing demand for raw materials and energy in a sustainable economic, environmental, and social way remains open and is one of the most compelling challenges for the coming years. New technologies have been developed and/or adapted for organic waste treatment in this sense, including gasification for the production of synthesis gas, fast pyrolysis for the production of liquid bio-oil, slow pyrolysis mainly for the production of biochar, and torrefaction for the production of torrefied materials with enhanced properties, such as grindability and high energy density. Even biorefinery processes are now on the agenda, promoting the simultaneous recovery of energy, biomaterials, and fine chemicals from biomass. All these technologies seem to be in direct competition with composting. So, is there any role remaining for composting, or is it destined to become an obsolete technology in the future?

Composting processes and monitoring have evolved over the years, from very simple techniques to more complex and effective levels. In fact, composting processes might include specific reactor and aeration designs, water and nutrients supply controls, as well as odour treatment. In addition, composting monitoring procedures include steps to measure organic waste porosity and oxygen concentrations during the process. Finally, methods are used to monitor the quality of compost product, as measured by maturity and stability indexes.

The main advantages of composting compared with other technologies are its low costs and its flexibility. Owing to relatively low investment in infrastructure and low operational costs coupled with a stable process, composting can be used, not only as a main process to treat organic wastes running continuously, but also as a back-up process when other technologies (e.g. anaerobic digestion) are not running as smoothly as expected or are off-line for maintenance.

Taking these facts into account, it seems that composting will still play a key role in organic waste management in developing as well as developed countries in the foreseeable future, owing to robustness and cost competitiveness. Recent figures (published in the January–February 2014 issue of *Waste Management World*) indicate that in Italy, a developed economy, about 4.5 million tonnes of organic waste collected yearly are used to produce nearly 1.3 million tonnes of compost, which is used in agriculture, landscaping, and other activities; composting is this country's largest avenue for waste diversion from landfills. In addition, composting is still being practiced widely in developing countries, and in India and China it is still important for rural farmers. Bangladesh as well has established an exemplary composting plant for green waste from municipal solid waste too. However, it is very clear that there will be fewer traditional open-windrow composting sites in the near future, mainly owing to environmental problems associated with odour and air emissions, water run-off from feedstock and piles, as well as diesel generators used to produce on-site energy at the more remote sites. In this sense, even if the main competitive advantage of composting is its relative simplicity and low cost, there is still room for advancing knowledge in composting science and technology.

One important element of composting operational costs is the energy demand for forced aeration in composting piles and reactors. Here, composting systems using solar energy may prove practical in the future. A solar composting pilot plant, including solar panels to power positive aeration, is already running in San Joaquin Valley, in California, USA, with the aim to reduce the total air emissions of the composting facility by replacing diesel generators and optimising solar energy use to power aeration equipment (see the January–February 2014 issue of *Waste Management World*).

The development of improved passive aeration systems, where the heat generated in the compost is the driver of airflow through the mass, is another possible energy-efficient solution. A challenge is to combine this method with the control of important process conditions, such as temperature, oxygen concentration, and odour emissions.

Process management indicators and sensors that can aid in understanding and managing the process are still important. Moreover, greenhouse gases can be formed during composting and have to be managed properly and, therefore, there is a need for additional knowledge about how substrates, microbial communities, enzymes, and process conditions can be handled to minimise methane and nitrous oxide emissions during composting.

For future research, there is a challenge to test at pilot-scale how easily measurable basic parameters can be used as indicators for more complex processes, and to aid a proper control of composting operations. In this sense, sensors capable of measuring gas phases online, reducing the need for tedious and time-consuming sampling steps, can provide more opportunities for improving composting plants. Moreover, lower costs for DNA sequencing and other genetic methods may enable deeper understandings of the microbial community and enzyme activity involved in composting, including organic waste decomposition rates, greenhouse gas production, and odour generation.

The compost product is a key benefit of the composting process, and a better understanding and control of its quality and how it can be beneficially used in different applications is still needed. These different applications may include the development of specialised products with higher quality, aiming not only to provide nutrients to soil when possible, but also suppressing pathogens, providing growth media and soil organic carbon. To produce a valuable compost product, the substrates used for composting must have adequate quality and low content of metals, organic pollutants, and other contaminants. Viewing composting not only as a waste management option, but as a process producing a beneficial material, will be a key issue for the future of composting technology.

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