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Technological and life cycle assessment of organics processing odour control technologies

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HIGHLIGHTS

• Assessment of odour control technologies for organics processing facilities.
• Comparative life cycle assessment of three odour control technologies was conducted.
• SimaPro 8 software supported by Ecoinvent databases used.

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ABSTRACT

As more municipalities and communities across developed world look towards implementing organic waste management programmes or upgrading existing ones, composting facilities are emerging as a popular choice. However, odour from these facilities continues to be one of the most important concerns in terms of cost & effective mitigation. This paper provides a technological and life cycle assessment of some of the different odour control technologies and treatment methods that can be implemented in organics processing facilities. The technological assessment compared biofilters, packed tower wet scrubbers, fine mist wet scrubbers, activated carbon adsorption, thermal oxidization, oxidization chemicals and masking agents. The technologies/treatment methods were evaluated and compared based on a variety of operational, usage and cost parameters. Based on the technological assessment it was found that, biofilters and packed bed wet scrubbers are the most applicable odour control technologies for use in organics processing faculties. A life cycle assessment was then done to compare the environmental impacts of the packed-bed wet scrubber system, organic (wood-chip media) bio-filter and inorganic (synthetic media) bio-filter systems. Twelve impact categories were assessed; cumulative energy demand (CED), climate change, human toxicity, photochemical oxidant formation, metal depletion, fossil depletion, terrestrial acidification, freshwater eutrophication, marine eutrophication, terrestrial eco-toxicity, freshwater eco-toxicity and marine eco-toxicity. The results showed that for all impact categories the synthetic media biofilter had the highest environmental impact, followed by the wood chip media bio-filter system. The packed-bed system had the lowest environmental impact for all categories.

1. Introduction

For a typical municipality in North America and Europe, organic waste makes up to 40% of the municipal/residential waste stream (Environment Canada, 2013). Therefore, from a sustainability perspective, diverting organic waste from land filling is a very important component of any effective sustainability strategy. In Canada and around the world, more and more municipalities are implementing/upgrading options for processing organic waste. Although there have been great technological improvements in recent years, odour from composting facilities continues to be a major issue, both in terms of cost & effective mitigation. Odour can be a real nuisance for nearby communities and residents, especially those who are downwind from a composting facility. Complaints often bring legal problems and in some cases can even lead to suspension of operations or even closure of the facility.

For organic waste management, odour control is one of the most expensive and environmentally impactful components of the facility. Therefore, a good understanding of the different technologies available for odour control, their advantages/disadvantages and most importantly their impact on the environment is crucial. The objective of this study is two-fold: first provide a technological assessment of the many different odour control technologies that can be used in composting facilities, then based on the results of the technological assessment conduct a life cycle assessment of the most applicable odour control technologies that can be used in such facilities. The LCA will look at the environmental

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impacts of the implementation, operation and end-of-life disposal of select technologies. Technologies/treatment methods that are assessed include biofilters, packed bed wet scrubbers, fine mist wet scrubbers, activated carbon adsorption, thermal oxidization, oxidization chemicals and masking agents.

2. Odour control technologies and treatment methods

There are many different types of odour treatment technologies available on the market; some have been in use for decades, such as wet scrubbers and carbon adsorption. Other treatment technologies, such as biofilters have only recently been implemented on a wide scale for composting facilities. In this section, a brief description of each technology is given.

2.1. Biofilters

Biofilters function by passing the odorous air stream through a porous media which can be composed of organic (such as bark and wood chips), inorganic (such as ceramics) or synthetic materials (such as granulated carbon or plastics) (Environment Canada, 2013). Odorous compounds adsorb to the media, where the compounds are then degraded and oxidized by microbial organisms. The most important performance parameters for the proper functioning of biofilters are humidity, pH control and residence time of the air in the media. The air stream can have a drying effect on the media, microbial organisms cannot grow and function in a dry environment, therefore some type of humidity control system is generally required (Burgess et al., 2001). Microbes also need close to a neutral pH environment to survive and reproduce, but as odour compounds containing sulphur are degraded, sulphuric acid is produced, which can decrease the pH of the media (Burgess et al., 2001). Therefore, some type of acid buffering capacity is generally required, through addition of lime or calcium carbonate, otherwise frequent media replacement maybe required due to acidification.

2.2. Activated carbon

Activated carbon works by adsorbing odour compounds to the surface as the odorous air stream is passed through the material. What makes activated carbon an exceptionally effective absorbing media is that it has a very high surface area to weight ratio, it is an extremely porous material (Pelekani and Snoeyink, 1999). Activated carbon also has a very deep and complex pore structure that is hydrophobic with good surface tension properties (NBP, 2005). The way the technology works, is by trapping odour compounds in these porous spaces as the odorous air stream passes through the material. The most widely used materials for activated carbon manufacture are coconut shells, charcoal and coal.

2.3. Packed tower and fine mist wet scrubbers

Packed bed and fine mist wet scrubbers are a proven and tested technology. For both packed bed and fine mist wet scrubbers the packing material, which is typically made from an inert plastic or ceramic material, is housed in a vertical tower or horizontal structure (Gabriel et al., 2004). The air stream is pumped through the packing material, where a chemical solution is sprayed into the packing material and the odour compounds are transferred from the air into the scrubbing solution through mass transfer (Gabriel et al., 2004). For the packed bed system, this solution is collected and re-circulated through the system until it becomes saturated with the odour compounds and can no longer absorb more compounds (Lang et al., 2000). For the fine mist system, the solution becomes waste. The major difference between fine mist and packed bed wet scrubbers is that in the former, the chemical solution is sprayed as very tiny droplets, up to 10 micron-sized droplets (Lang et al., 2000); this increases the surface area of the contact solution and increases the odour absorption efficiency for many compounds. However, in the fine mist system, the solution is not re-circulated through the system, thus there is a continuous waste discharge (Environment Canada, 2013). For the packed tower system, where the solution is re-circulated, once the solution is used up, it must be properly disposed.

2.4. Thermal oxidization

Thermal oxidization systems have been used in various industries such as pig production (Hanzen, 2011) to treat odorous air, although there is no literature suggesting that they have been used in composting facilities to date. This system works on a simple premise, use of very high temperatures to destroy odour compounds (US EPA, 2000). The air stream is sent through a combustion chamber, where it is combusted at a temperature between 1300 and 1600 °F (US EPA, 2000). If the air stream does not contain sufficient volatile compounds, oil or natural gas is typically added to the air mixture in order to ensure complete combustion. The important parameters to consider are the same as any combustion process, the volume of inlet air, ensuring sufficient oxygen and turbulence in the combustion chamber (US EPA, 2000). The system also uses heat exchangers for heat recovery and heating the incoming air.

2.5. Oxidization chemicals

Oxidizing chemicals have been widely used in the wastewater industry for disinfection and to treat odours for many years. In the wastewater industry chemicals such as hydrogen peroxide are typically used to disinfect and eliminate odours (Harshman and Barnette, 2000). Oxidizing agents such as potassium permanganate have been used to treat odours from composting processes on a small scale, where the oxidizing chemical is spread directly over the compost pile in low concentrations (Richard, 1996). There is a potential to use oxidizing agents in organics processing facilities on a large scale to oxidize odour compounds at the source. However, the oxidizing chemicals while effective at reducing odours, can also kill and inhibit microbes and alter the composting process depending on the concentration applied (Richard, 1996).

2.6. Masking agents

Masking agents are the simplest method to control odour from organics processing facilities. Masking agents can be composed of patented compounds, essential oils and can be in solid, liquid or gel like form. Masking agents are generally made of non-toxic compounds that are not hazardous for breathing and are not harmful to the environment (US EPA, 2000). In composting facilities, they can be dispersed into the air in a mist or into the exhaust air stream to mask the odours (US EPA, 2000). The masking agents can come in a variety of different perfumes and fragrances and many of which are patented (Decottignies et al., 2007).

3. Technology assessment

In this section a technological assessment based on literature review is done of the treatment technologies described in the previous section. Information for the assessment was gathered from a variety of sources, including research journals, articles, industry assessments, composting guideline manuals and the U.S. EPA. Odour control is also an important issue in wastewater treatment and many of the technologies that are currently being used for odour control in organics processing facilities were first implemented in wastewater treatment facilities to control odours. Thus, research journals evaluating odour control technologies in wastewater facilities were also considered during this evaluation.

The technology assessment evaluates the suitability of each technology for use in organics processing facilities. The most important factors