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The impact of compaction, moisture content, particle size and type of bulking agent on initial physical properties of sludge-bulking agent mixtures before composting

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ABSTRACT

This study aimed to experimentally acquire evolution profiles between depth, bulk density, Free Air Space (*FAS*), air permeability and thermal conductivity in initial composting materials. The impact of two different moisture content, two particle size and two types of bulking agent on these four parameters was also evaluated. Bulk density and thermal conductivity both increased with depth while *FAS* and air permeability both decreased with it. Moreover, depth and moisture content had a significant impact on almost all the four physical parameters contrary to particle size and the type of bulking agent.

1. Introduction

The key role played by physical properties of organic materials treated by composting has been brought to light by several studies (Druilhe et al., 2008; Gea and Richard, 2008; Malinska and Richard, 2006; Mohee and Mudhoo, 2005; Van Ginkel et al., 2002; Veeken et al., 2003). Bulk density, Free Air Space (*FAS*), air permeability and thermal conductivity are four physical parameters of particular importance. These parameters are all interconnected and have an impact on biodegradation kinetics and also on heat and mass transfer in the composting system (such as oxygen supply, water evaporation and heat balance). Lower permeabilities result in a decrease in oxygen availability and airflow across the matrix, causing heat accumulation and high temperatures which inhibit microbial activity (Haug, 1993). With low thermal conductivities, heat generated by the metabolic activity of micro-organisms is not evacuated efficiently (even more if thermal Péclet values are low), causing high temperatures too. Low *FAS* decreases the degradation rate (Richard et al., 2002) and may lead to anaerobic conditions with gaseous and odorous emissions (Veeken et al., 2003).

Difficulties often occur in composting experiments because the effects of compaction on physical properties are ignored, or information about these effects is lacking. As soon as the pile of waste is built, the settlement of the composting matrix begins. This settlement, called primary settlement or physical compressive settlement (Gourc et al., 2010; Yue et al., 2008), is related to the vertical load and results in compaction. At local scale, it leads to a decrease in *FAS* and air permeability and can therefore affect the efficiency of oxygen supply and heat and moisture removal (Veeken et al., 2003; Yue et al., 2008). These effects of compaction on physical properties are often ignored; or information about these effects is lacking. Similarly, despite its obvious importance on the process, thermal conductivity is currently not well considered in the existing literature. The link between compaction and thermal conductivity is, therefore, rather unclear.

This study had two main objectives. Firstly, it aimed to investigate the impact of compaction on initial physical properties of organic solid wastes. Leaning on the existing literature, four key parameters were selected (among the numerous parameters which play a role in the composting process): bulk density, *FAS*, air permeability and thermal conductivity. Secondly, the study investigated how three preparation parameters (moisture content, particle size and the type of bulking agent) impacted these physical properties. The study was carried out on mixtures of urban sludge and bulking agents. Sludge could not be composted alone because of their lack of physical structure. Hence, they had to be mixed with bulking agents. Two moisture contents, two particle sizes and two different bulking agents were, therefore, selected and tested.

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