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Moisture variation associated with water input and evaporation during sewage sludge bio-drying

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ABSTRACT

The variation of moisture during sewage sludge bio-drying was investigated. *In situ* measurements were conducted to monitor the bulk moisture and water vapor, while the moisture content, water generation, water evaporation and aeration water input of the bio-drying bulk were calculated based on the water mass balance. The moisture in the sewage sludge bio-drying material decreased from 66% to 54% in response to control technology for bio-drying. During the temperature increasing and thermophilic phases of sewage sludge bio-drying, the moisture content, water generation and water evaporation of the bulk initially increased and then decreased. The peak water generation and evaporation occurred during the thermophilic phase. During the bio-drying, water evaporation was much greater than water generation, and aeration facilitated the water evaporation.

1. Introduction

The moisture content (MC) of dewatered sewage sludge is about 80%, which causes a series of problems in terms of sludge treatment and disposal; therefore, reducing sludge moisture is important to the reduction of sludge volume and quantity (Zhao et al., 2010). Sludge bio-drying is an economical and energy-saving method of simplifying thermophilic aerobic fermentation that utilizes the biological energy produced by microbial fermentation to activate bound water and evaporate moisture (Navaee-Ardeh et al., 2010), resulting in rapid reduction of the moisture in the bio-drying material (Zhang et al., 2008). The main drying mechanism in bio-drying is convective evaporation, which utilizes heat produced from the biodegradation of organic matter and is facilitated by mechanically controlled aeration (Navaee-Ardeh et al., 2006). The process by which the moisture of the bio-drying material is reduced is as follows: water molecules evaporate from the surface of the material into the air, after which the evaporated water (vapor) is transported and removed by airflow (Velis et al., 2009). Air convection and molecular diffusion are the primary approaches to the removal of water from bio-drying material (Frei et al., 2004).

Moisture is a critical parameter involved in bio-drying technology that influences the complex biochemical reactions associated with microbial growth and the biodegradation of organic matter that occurs during the process (Ryckeboer et al., 2003). In addition, maximizing the removal of moisture present in bio-drying bulk is a crucial pre-treatment step that is beneficial to sludge treatment and disposal (Velis et al., 2009).

The water mass balance of bio-drying bulk indicates that variations in bulk moisture are associated with water input and water output. Water input includes: (1) water generation (WG), which is water produced by microbial metabolism during organic matter decomposition (Sole-Mauri et al., 2007; Zhang et al., 2010); and (2) aeration water input (AWI), which is moisture added to the bulk during forced aeration. In a study conducted by Chen (2010), the airflow from the air chamber under the bulk removed moisture from the bottom of the bulk and no leachate was collected; therefore, it is assumed that no leachate is produced during drying of the bulk. As a result, the water is removed by water evaporation (WE) during bio-drying. WE is achieved *via* the evaporation of free water and primarily removed by air convection (Velis et al., 2009). Accordingly, the water output is actually the water evaporated from the bulk material. In addition, the apparent moisture reduction (AMR) is defined as the difference between two MC values measured at different times. During bio-drying, the degree of drying depends on the ratio of water output to water input (Richard, 2004).

Investigation of the WG and WE during sludge bio-drying is beneficial to improving the efficiency of moisture reduction and contributes to reduction of the sludge volume. However, recent studies have focused on the MC of the bulk itself, and few studies have investigated the water mass balance. Accordingly, the water input and evaporation during sludge bio-drying is not fully

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