II-462 Effect of Aeration on Drying Rate of Sludge in Composting Process

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1. Introduction

Composting process control involves the study of the inter-related factors of heat output due to microbial action, temperature elevation achieved, drying or moisture removal obtained and the necessary aeration rates. Air introduced into the system supplies oxygen to the microbes, and removes moisture and heat. Aeration requirements to achieve each of the above are different. The present research aimed at determining the rates of drying of raw dewatered sludge under various aeration rates and typical environmental conditions of composting.

2. Material and Methods

The laboratory scale experimental set-up used for the investigation is shown in Figure 1. Glass pans having the same surface area (56.75 cm^2)but of varying thicknesses are packed with raw dewatered sludge. Assuming the porous space within the sludge to be negligible after packing, each pan can be considered to be a piece of sludge having the same thickness as that of the pan. The pans are placed in a cylinderical vessel placed horizontally. The cylinderical vessel is placed in a wooden box provided with a heat source which is connected to a temperature controller. The temperature controller probe is placed inside the cylinderical vessel. Thus necessary temperatures can be maintained in the cylinderical vessel containing the pans.

De-humidified air enters and flows horizontally across the pans before finally exiting at the other end of the cylinderical vessel. The pans are removed at regular intervals of time and their weights determined.

The experimental conditions used are as follows:
Sample: raw dewatered sludge (lime treated) containing 70-75% initial moisture content and 40-43% volatile solids.
Pan Thicknesses: 1.3 cm, 1.6 cm, 3.5 cm, 5.7 cm, 8.7 cm.
Aeration Velocity: 0.058 cm/s, 0.29 cm/s, 0.58 cm/s
Temperature: 30°C, 40°C, 50°C, 60°C

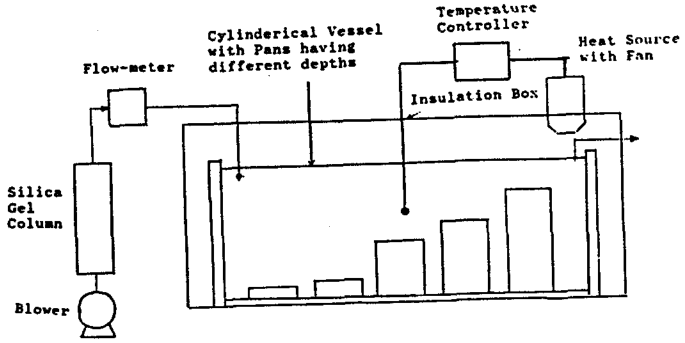


Figure 1 Experimental Set-up

3. Results and Discussion

Figure 2 is an illustrative plot of the moisture content (dry basis) as a function of time. Figure 3 has been derived from Figure 2 by taking the slopes over short periods of time, and calculating the rate in kg moisture/(h.m^2)by multiplying the slope by (S_s/A). The drying rate has been plotted with moisture content(dry basis). Here, S_s is the mass of dry solid and A the wet surface area over which evaporation occurs into the flowing air stream. In case of sludge, shrinkage occurs with increased drying, and A does not remain constant. A is approximated by the arithmetic mean of the values at the beginning and end of the time period under consideration.

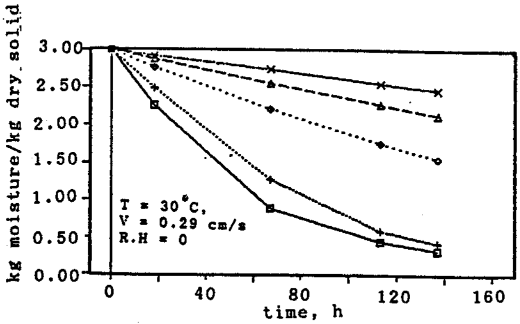
As seen in Figure 3, there is a constant drying rate period and a falling drying rate period. The falling rate period is difficult to analyse due to changing drying conditions in various pans due to sludge compaction. Here in this paper, drying rate during constant period is discussed.

Figure 4 is an illustrative plot of the drying rate versus thickness of sludge particles. From Figure 4, it is evident that the drying rate is not related to the thickness of the sludge particle for particle thickness below 8.7 cm.

The rate of drying, N expressed as kg moisture/h/m^2 is a function of temperature, air velocity, relative humidity of the the air and temperature of the air. Evaporation of unbound moisture occurs from a wet surface exposed to relatively dry air. In the constant drying period, the initial drying rate N could be expressed as:

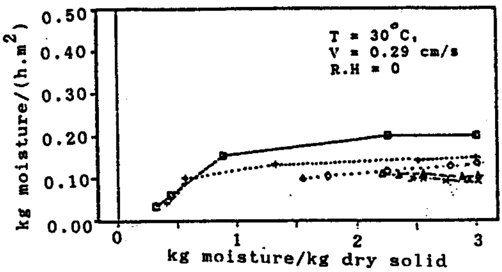
$$N = a + bV \quad (1)$$

where V is the air velocity and a,b are constants depending on temperature. Figure 5 is an illustration of this linear relationship between Initial Drying Rate and Air Velocity as determined from experimental investigations. The relative humidity of inlet air was maintained at 0%. The effect of increasing humidity in the inlet air on the drying rate is proposed to be studied in the future. As seen in Figure 6, the drying rate was found to increase with increasing temperature. This is to be expected since with increase in temperature, the saturation humidity of air increases, thereby increasing the moisture carrying capacity of the air.



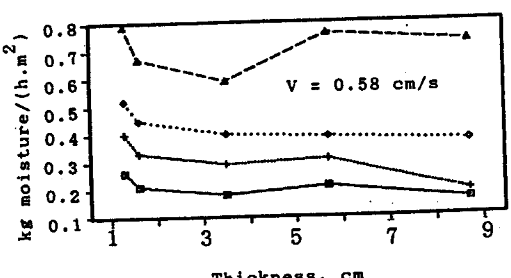
□ 1.3 cm + 1.6 cm ◇ 3.5 cm △ 5.7 cm × 8.7 cm

Figure 2 Illustrative Plot of Moisture Content versus Time



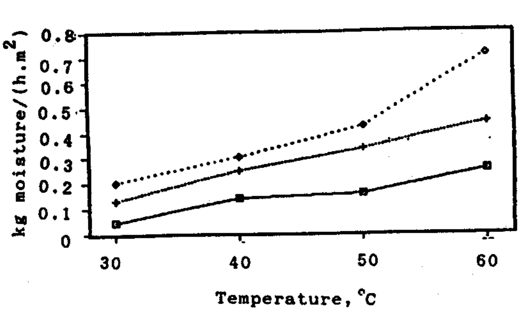
□ 1.3 cm + 1.6 cm ◇ 3.5 cm △ 5.7 cm × 8.7 cm

Figure 3 Illustrative Plot of Drying Rate versus Moisture Content



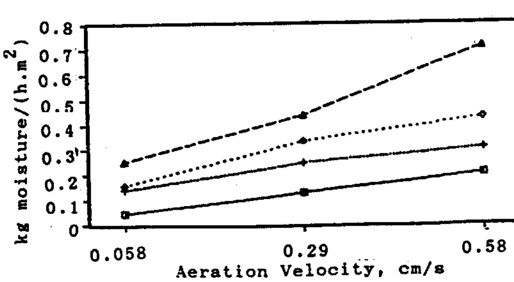
□ 30°C + 40°C ◇ 50°C △ 60°C

Figure 4 Illustrative plot of Drying Rate versus Thickness of Sludge



□ 0.058 cm/s + 0.29 cm/s ◇ 0.58 cm/s

Figure 6 Initial Drying Rate versus Temperature



— 30°C —— 40°C ····50°C ---60°C

Figure 5 Initial Drying Rate versus Aeration Velocity