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Oxygen and Carbon Dioxide Distribution And Movement in Passively Aerated Compost Piles

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Distributions of O_2 and CO_2 concentrations across a cross section of a full-scale passively aerated, mechanically turned, compost piles were measured as a function of time over an 11 day long period covering two pile turnings. The compost pile had a triangular cross section, was 1.8 m high, 4.4 m wide, 80 m long and consisted of sewage sludge, yard/park waste and screening residue from previously composted materials. The measurements were conducted in one cross section of the pile. The O_2 and CO_2 concentration measurements were used in combination with earlier published measurements of air permeability and air pressure inside the compost pile to calculate O_2 and CO_2 fluxes across the pile surface as functions of time and location as well as estimation of total specific oxygen consumption rates in the compost. Distributions of O_2 and CO_2 concentrations inside the pile were relatively constant with time and exhibited high O_2 concentrations near the surface and high CO_2 concentrations near the center of the pile. Maximum O_2 fluxes in the compost occurred along the lower edges of the pile and equalled up to 15 kg/m^{-2} h^{-1} while maximum CO_2 fluxes occurred at the center top of the pile and equalled up to 700 g m^{-2} h^{-1}. Average daily CO_2 emissions from the compost were up to 3.4 kg m^{3} d^{-1} while the corresponding O_2 flux into the compost pile was up to 53 kg m^{3} d^{-1}. Average O_2 consumption was 1.4 kg m^{-3} d^{-1} while average CO_2 production was 1.5 kg m^{-3} d^{-1} at the measurement location over the 11 day experimental period.

Introduction

Due to its relatively low operation costs, composting in passively aerated windrows or piles is a widely used method. The compost piles are turned at regular time intervals to ensure sufficient oxygen supply and optimal degradation. The main process responsible for oxygen supply is the heating of air by microbial activity inside the compost piles which reduces air density and creates an air influx near the bottom of the pile and an outflux at the top. Water evaporation from the compost adds to this effect by further reducing air density. The supply of oxygen to any part of the compost pile therefore depends on air temperature, humidity, pressure, and oxygen concentration distribution inside the compost. This means that both understanding of the temporal and spatial variation in the physical parameters controlling the air flow as well as the temporal and spatial variations in oxygen concentration in the compost is necessary to assess the oxygen supply to the compost. Improved understanding of oxygen supply can be used to optimize compost process design and operation and reduce overall composting time and energy consumption, thereby improving composting economy.

Spatial and temporal variations in compost temperature, air permeability and air flow velocity has been the objective of several studies. Some examples are: Fernandez *et al.* (1994), Das and Keener (1997), Nogueira *et al.* (1999), Patni *et al.* (2001), Barrington *et al.* (2002), Agnew and Leonard (2003), Barrington *et al.* (2003), Richard *et al.* (2004), Poulsen and Moldrup (2007), Kulcu and Yaldiz (2007), Ahn *et al.* (2008), and Luo *et al.* (2008). Temporal and spatial variations in gas pressure and gas flow in full-scale compost piles were investigated by Poulsen (2010) but published research in this area is extremely limited. Research on oxygen distribution and oxygen flow in compost is also relative limited. Oxygen concentration near the surface of a full- scale compost pile was measured as a function of time by Wang *et al.* (2007) while oxygen and carbon dioxide distributions in cross sections of full-scale manure compost piles were measured by Lambert (1934). Oxygen flow as a function of time in laboratory-scale reactors was investigated by Bari and Koenig (2001) and Yamada and Kawase (2005). In general the quantity of information with respect to oxygen and carbon dioxide distribution and transport in full-scale passively aerated compost piles is very limited. Present research has either assessed gas flow velocities or gas concentration distribution but not both