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# Air Space in Composting Research: A Literature Review

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Free air space (FAS), as a representation of the available air filled voids in a composting matrix, is considered an important parameter to define optimum substrate conditions for gas transfer. However, this parameter has been determined, interpreted, and employed in several ways by researchers. On this basis, the objective of this paper is to review the previous work related to the application of FAS in composting, providing information about the FAS concept and its importance for composting research. Also, relevant details of the methods currently used for FAS measurement and estimation are discussed. Other aspects of this review are FAS management in composting and its implications for physical and numerical models. In this way, the presented discussion provides a basis to understand the FAS concept and its potential application to future research.

## *Introduction*

Over the last decades, research studies have focused on the design, optimization, and development of composting systems. Composting is optimized when physical properties, nutrient content and C/N ratio, temperature, pH, moisture, and oxygen supply are adequate, since all these factors influence optimal conditions for microbial development and organic matter degradation (Agnew *et al.* 2003; Das and Keener 1997; de Bertoldi *et al.* 1985; McCartney and Chen 2001; Richard *et al.* 2002). Thus, the measurement, management and control of important biological, chemical and physical parameters has been incorporated in composting research in order to optimize the process, reduce composting time and costs, and enhance the quality of the end products.

Since composting is a biological process that must be kept aerobic, the air content and its distribution through the composting substrate greatly influence the composting performance. These factors affect oxygen supply to microorganisms, removal of carbon dioxide, ammonia and excess moisture, as well as avoiding or preventing an excessive heat accumulation (Haug 1993; Jakobsen 1992). No matter if aeration is achieved passively or actively, substrate air space plays an important role in the composting process. Not all the air contained in a compost material is available so the most important term related to air space for composting is the concept of free air space (FAS).

In order to provide and review the FAS information found in the composting literature, the first part of this paper explains the concept and definition of FAS and its importance for composting researchers. Then a comparison of the most common methods for measuring and estimating the air space in organic materials is made, and their applications and limitations are also explained. A summary of previous applications of FAS and how this parameter has been managed in composting research is presented, and finally its importance in physical and numerical models is reviewed.

## *Definition of the Term "Free Air Space" (FAS)*

Bulk density, particle density, porosity or air filled porosity are common terms cited in the composting literature to characterize the physical environment within a composting matrix and these have been reviewed widely in Agnew and Leonard (2003). Bulk density is a measurement of the compost material mass in a specific volume. In a composting matrix, the total volume is occupied by solids, liquids (considered to be water), and gases (considered to be air). Particle density is a measurement of the solids mass within the volume of solids.

Porosity is a measurement of the total pore volume and includes both water and air filled voids; while air filled porosity refers to air filled voids solely. Although authors normally employ the term FAS as