AN INDIVIDUAL BASED MODEL TO STUDY THE MAIN GROUPS OF MICROBES ACTIVE IN COMPOSTING PROCESS

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INTRODUCTION

Composting has been defined as "the biological decomposition and stabilisation of organic substrates under conditions which allow the development of thermophilic temperatures as a result of biological heat production, with a final product sufficiently stable for storage and application to land without adverse environmental effects". The compost pile is described as a man-made microbial ecosystem. If the composting process is carried out as a batch culture it proceeds in various more or less distinct phases, which are identified superficially by the stages of temperature rise and decline. These temperature phases reflect the activity of successive microbial populations performing the degradation of OM and the increase of stable organic matter (MOE) [1]. Despite there are a lot of facts describing this degradation qualitatively, there are no standard mathematical or computational models of composting processes. There are, however, many ways in which relevant knowledge and hypothesis can be expressed in models [2, 3].

MODELLING THE COMPOSTING PROCESS.

A discrete methodology which shares the philosophy of the individual based models has been developed to study the mineralization and immobilization of soil C and N and nitrification process [4, 5]. The aim of this work is to develop an Individual based Model to deal with the composting process. The adaptation of the simulator INDISIM-SOM will permit to begin to study the complex biological phenomena that take places in such system. The cell model controls the following actions for each individual of these microbial populations: motion, uptake, metabolism, reproduction, death and lyses.

The **MEDIUM AND SPATIAL MODEL** is shown in figure 1, and it considers:

COMPOSITION

- There are six different types of organic substrates, depending on their composition on C and N and their bioavailabily.
  - Soluble and/or labile compounds: glucose and fatty acids like substance without N (C_L) and aminoacids like substance with N in them (CN_L)
  - Polymerised compounds: polymers of compounds described above (C_P and CN_P).
  - Resistant carbon: structural matter added to improve the structure and facilitate the aeration (C_R).
  - Stable Organic Matter : end organic product of composting process (CN_{MOE}).
- There are 3 mineral compounds
  - Compounds in the gaseous phase: CO_2, O_2 an water vapour $(H_2O)_{vap}$
  - Mineral compounds in the liquid phase: water (H_2O_{liquid}) and ammonium (NH_4^+)

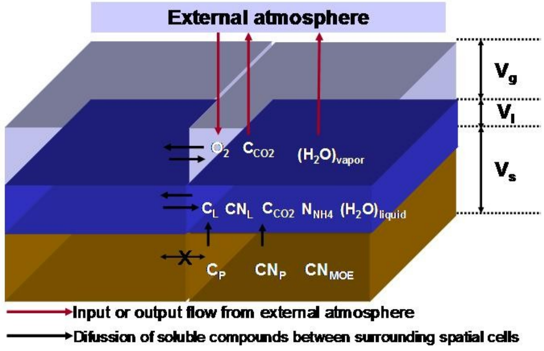


Figure 1: Scketch of the spatial model

PROCESSES

- Hydrolysis reactions of the complex to simple compounds.
- Output or input flows of the gaseous compounds from or to the external atmosphere.
- Heat transfer processes, mainly driven by the evaporation of water and the aeration.
- Diffusion process of soluble organic and mineral compounds (Fick's law).

The **BIOTIC MODEL**, represented in figure 2, considers:

- Three microbial populations: **mesophilic bacteria**, **thermophilic actinomycets** and **mesophilic fungi**. They differ on their microbial biomass composition defined by their C/N ratio, their optimum temperatures to develop, and their metabolisms.
- The evolution of these microorganisms takes into account their motion, uptake, metabolism, reproduction, death and lysis. Some special characteristics are:
  - The individual maximum uptake rate depends on temperature following Ratkowsky model.
  - The availability of substrates in the medium increases with the medium temperature.
  - All the microorganisms modelled have heterotrophic metabolisms. The difference between them is the capability they have to metabolise polimerized and/or resistant organic compounds (figure 2)

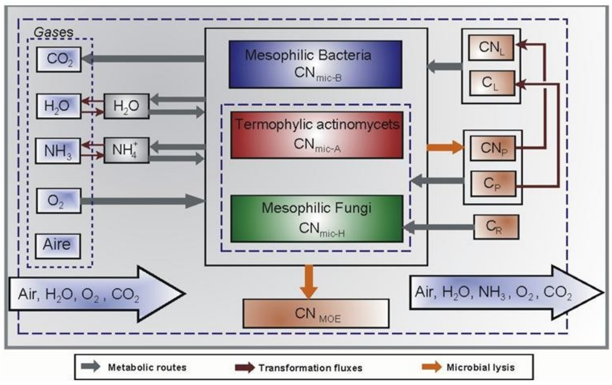


Figure 2: Scketch of the INDISIM-COMP model

RESULTS.

Figures 3 and 4 present two examples of composting simulation results.

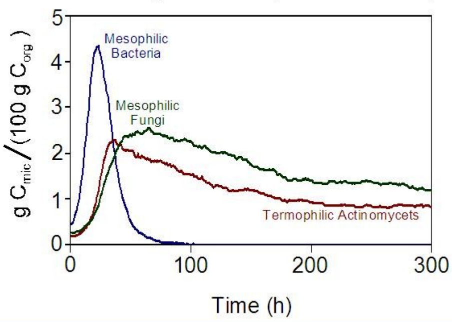
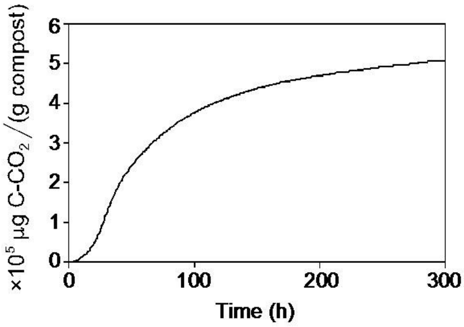


Figure 3: evolution of the three microbial populations through time. The succession of the different species is clearly observed.

Figure 4: accumulated CO_2, produced by microbial metabolism through the composting process.



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