Spatial properties in Individual Based Modelling of Microbiological Systems. Study of the composting process.

C. Prats, J. Ferrer, A. Giró,
D. López, J. Valls
Departament de Física i Ingeniería Nuclear
Escola Superior d’Agricultura de Barcelona, Universitat Politècnica de Catalunya

Research Group:
“Modelling and discrete simulation of biological systems”
Escola Superior d’Agricultura de Barcelona
Universitat Politècnica de Catalunya

Introduction
Most of the existing mathematical models in microbiology consider a uniform, homogeneous and isotropic culture medium. Nevertheless, in many real systems the spatial characteristics are complex and essential to understand the observed behaviours. An interesting example is the bacterial growth on agar plates with a low nutrient concentration, and some certain spatial properties [1] (non-homogeneous medium), where the nutrient concentration gradient causes different growth behaviours. Spatial characteristics are also important in many systems of industrial interest; in several food microbiologies culture the growth takes place in mediums with different interacting phases. Other systems with great spatial complexity are the soil or the composting systems, where the environment plays an important role.
The main concern of this work is to develop some methods to be applied in the space modelling of complex systems like those aforementioned below. In concrete, we develop a specific space model to be used on composting processes modelling. In this work we have used an Individual based Model (IBM) to begin this study. It is done with the INDISIM (INDividual DIScrete SIMulation) methodology developed by Ginovart et al. [2].

Objective
The spatial structure of the composting processes is of great complexity: it is heterogeneous (with coexistence of solid, liquid and gaseous phases), anisotropic, and variable through time. Any mathematical model for describing such a process must be an important simplification of the real system. The aim of this work is to develop a first spatial model for studying the composting processes with the aid of Individual-based Model simulations.
We develop this spatial model for simulating the processes that take place in a compost tunnel, where the air is pumped inside from the bottom, at time intervals that depend on the system’s temperature and humidity state.

The space model

1- Between liquid and vapor:
Evaporation and condensation

2-Transport phenomena:

First results and outlook
First of all we have considered the space without microorganisms but with an internal water and heat generation each time step. We have taken into consideration the transport of energy and matter (conduction, convection including forced aeration, and diffusion). We have checked the correct behaviour of some parameters (temperature, pressure, liquid and gaseous water concentration) and their evolution along space and through time, for example:
- the temperature and humidity decrease after an aeration, and increase between aerations
- the liquid water mass can remain constant if there are the appropriate conditions (aeration frequency, air temperature, cells temperature, ...)
- the pressure gradient between cells is reduced by means of the diffusion
On further simulations, the microorganisms actions shall be taken into account [4].

References

Aknowledgements
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- DURSI. Generalitat de Catalunya
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