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

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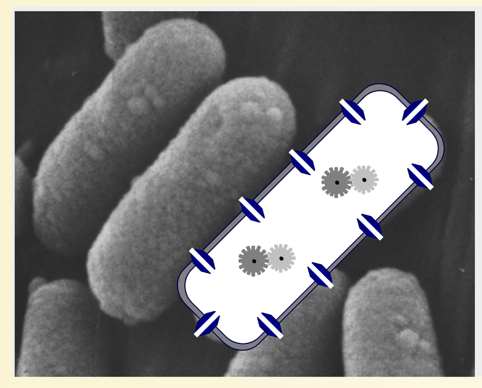

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Introduction

Most of the existing mathematical models in microbiology consider an 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 microbiology cultures 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].

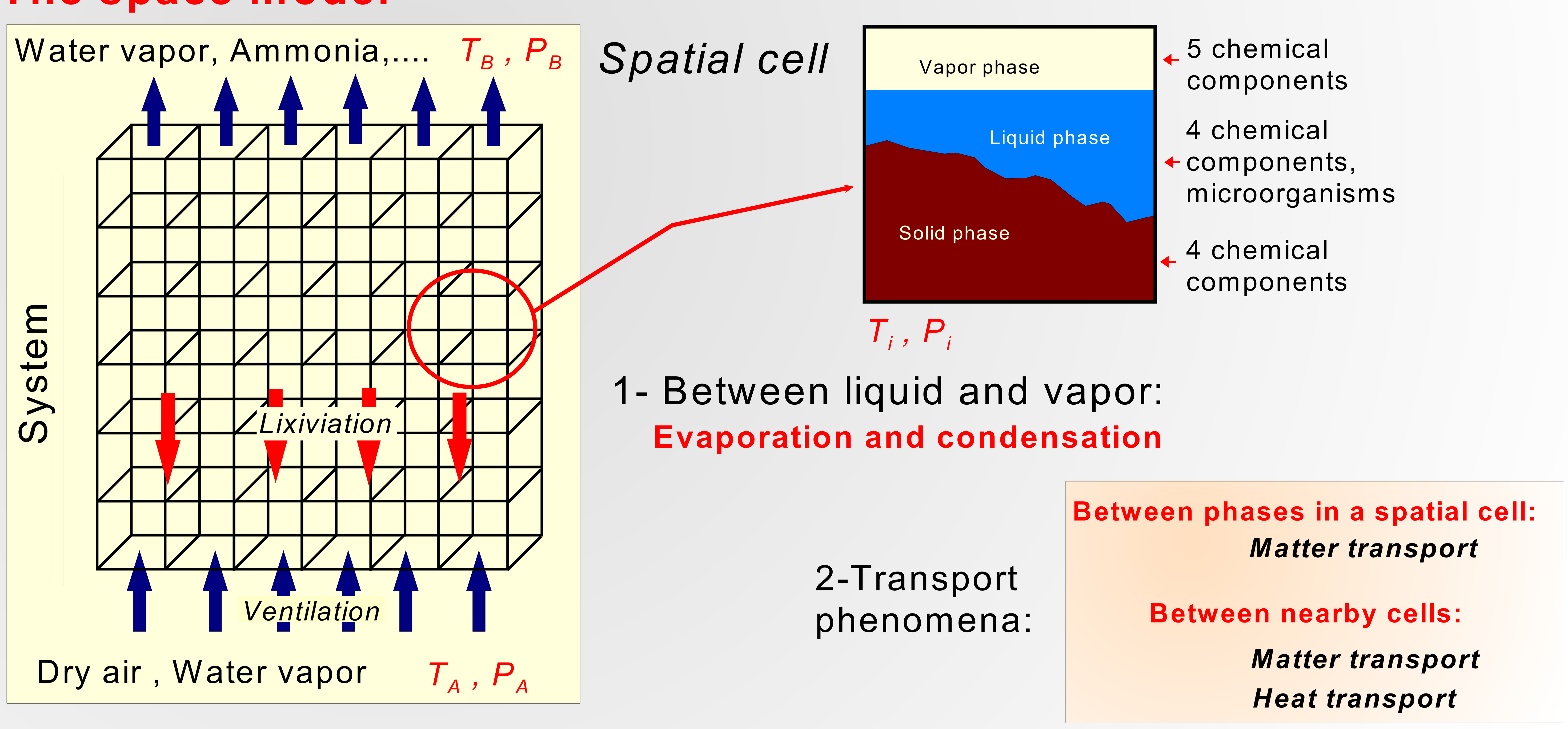
***INDISIM enables the study of the evolution of a microbial culture based on the individual behaviour of the microorganisms**, over a period of time in a specific environment, in wich space and time are discrete. "Eigen experiments" controlling all the elements of the system can be done [2]. It's an interesting methodology to study the temporal evolution of complex systems.*

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



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 aereations
- the liquid water mass can remain constant if there are the appropriate conditions (aeration frequence, 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

[1] *M. Ginovart, D. López, J. Valls, M. Silbert.* Physica A. ***305*** *(2002),p. 604*
[2] *M. Ginovart, D. López, J. Valls.* J. theor. Biol. **214** (2002), p. 305
[3] *A. Gras.* INDISIM-SOM, un model discret per a l'estudi de la dinàmica de la matèria orgànica i la nitrificació en sòls. Ph.D. Thesis, University of Lleida, Spain (2004).
[4] *A. Gras, C. Prats, M. Ginovart.* An Individual Based Model to study the main groups of microbe active in composting process. BioMicroWorld 2005 (Badajoz)

Aknowledgements

- Ministerio de Ciencia y Tecnología REN2000-0049-P4-04
- DURSI. Generalitat de Catalunya 2003ACES00064
- Plan Nacional I+D+i of the Ministerio de Educación y Ciencia CGL 2004-01144

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