INDISIM-SOM: AN INDIVIDUAL-BASED SIMULATOR ON A WEBSITE FOR EXPERIMENTING AND INVESTIGATING DIVERSE DYNAMICS OF CARBON AND NITROGEN IN MINERAL SOILS

A. GRAS[1], **J.C. CAÑADAS** [2], **M. GINOVART** [3]

[1] Department of Agri-Food Engineering and Biotechnology
[2] Department of Physics and Nuclear Engineering
[3] Department of Applied Mathematics III

Technical University of Catalonia
Barcelona, Spain

BioMicroWorld 2009
2-4 December
Lisbon, Portugal

INTRODUCTION

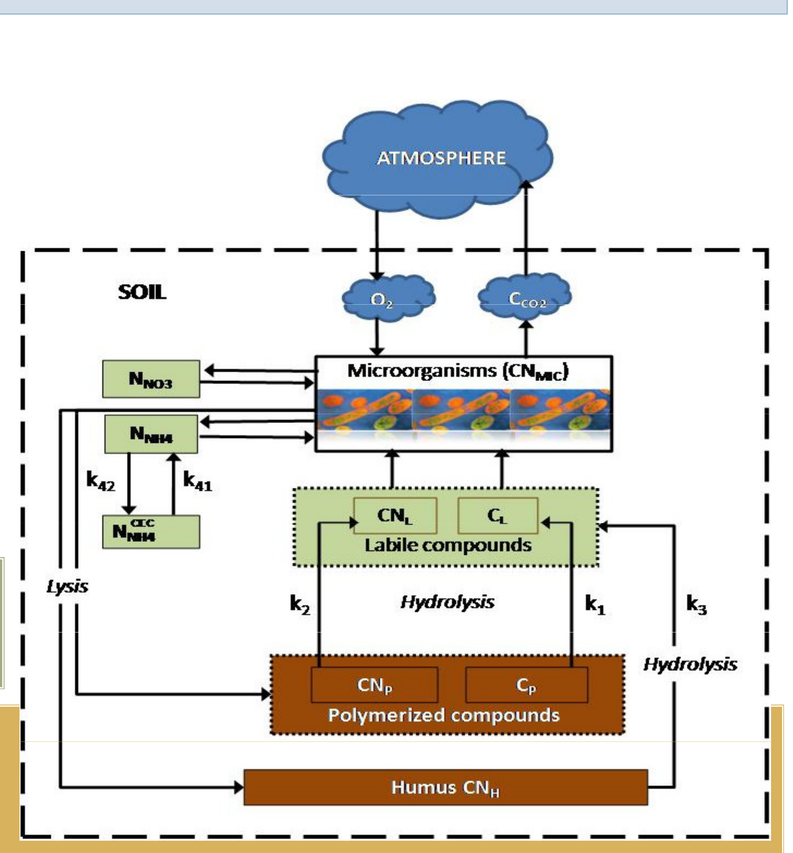
A very interesting review of soil biogeochemical models, with an extensive comparison of mathematical approaches to soil C and N cycling, has been provided by Manzoni and Porporato [3]. Some key processes in C and N cycling in soils are the decomposition and mineralization of organic matter, OM, N immobilization and nitrification. These processes, in the majority of models developed during the last decades, are analyzed under the common framework of substrate-decomposer stoichiometry, thus stressing the role of the microbial biomass as a Soil Organic Matter (SOM) degrading agent and as a controlling factor of N cycling.

Most new models in recent years are improvements over earlier ones, leading to many similar model structures and formulations. While this has generally produced more robust and effective models, on the other hand, it may have delayed significant theoretical advances and shifted attention from some important questions that have therefore remained unexplored. There are fewer models explicitly describing the spatial dynamics of water, organic matter, or nutrients at specific microscopic scales. Manzoni and Porporato conclude their review by discussing some of the theoretical gaps identified and suggesting how they could be addressed by future modelling efforts [3].

In some contexts, computational models offer the potential to reduce, or even replace, the need for physical experimentation when exploring new substrates and/or process options. Individual-based models (IbMs), in which individuals interact dynamically with each other as structural elements in the model world, exemplify this view of simulation modelling [4]. In this context, the present study is based on the perspective that a mechanistic and scale-dependent description f microbial activity, with detailed formulations of decomposer population and their relationships with organic and mineral substrates, it is essential when dealing with the dynamics of C and N in SOM.

Nevertheless, the level of microbial activity is fundamental to describe transient fluxes in response to environmental fluctuations. To provide the generality needed for diverse scenarios, under different conditions, one way to proceed is by using IbMs or agent-based models, from which macroscopic patterns may be inferred [2]. IbM's are generally built upon more realistic assumptions than classical continuous models, in the sense that they can be biologically based. A further effort is certainly necessary to extent the use of IbM's in soil research.

INDISIM-SOM models the dynamics and evolution of C and N related to organic matter in soils by using IbM simulations [1]. It controls a group of microbial cells at each time step, using a set of time-dependent variables for each microorganism. The space is divided into square cells. In each spatial cell, the amounts of different types of organic compounds are controlled. These are identified as polymerized organic C and N, labile organic C and N, mineral compounds like NH4, NO3, CO2 and O2. The model takes into account the activity of two types of microorganisms: decomposers (heterotrophic) and nitrifiers. Metabolic pathways and sources of C and N that they can use are identified. Some state variables and parameters related to SOM and microbial activity are studied [1].



AIM

The purpose of this work is to develop and present a website from which the simulator INDISIM-SOM is accessible, and to explain how to carry out some virtual experiments, in order to further advance the skills associated with this simulation model.

THE INDISIM-SOM WEBSITE:

https://aneto.upc.es/simulacio2/hoja-portada.html

It is composed by the following:

i) INTRODUCTION: a brief theoretical introduction of the general model,

ii) DEMO OTPION: a demonstration of the simulator with graphical outputs for some variables related to C and N and

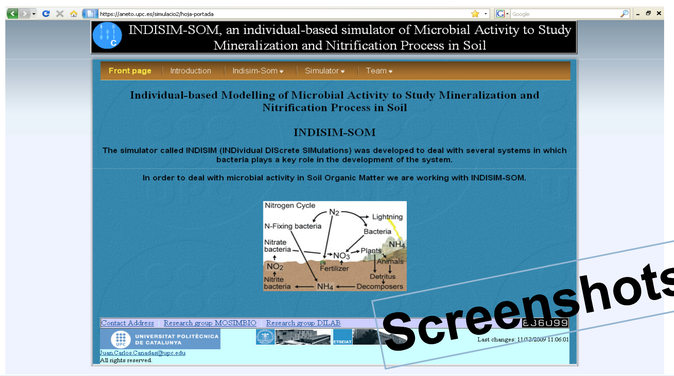
iii) LOG IN OPTION: an access to an executable version of the simulator allowing to change the values of some parameters

The input data offered for modification, jointly with graphical outputs, make it possible to configure virtual experiments and observe their behavior through the simulator.

The parameters which can be changed before starting the simulation are related to i) soil properties, ii) fractionation constants, and iii) microbial characteristics. The first one is related to soil determinations of C and N, and the second one is made up of the constants that relate the soil properties to discrete model soil compartments. The last consists of data related to soil microorganisms, and related output variables: number of heterotrophic individuals, number of nitrifier bacteria, ratio of microbial C to organic C, C to N microbial ratio and oxygen in soil atmosphere (%).

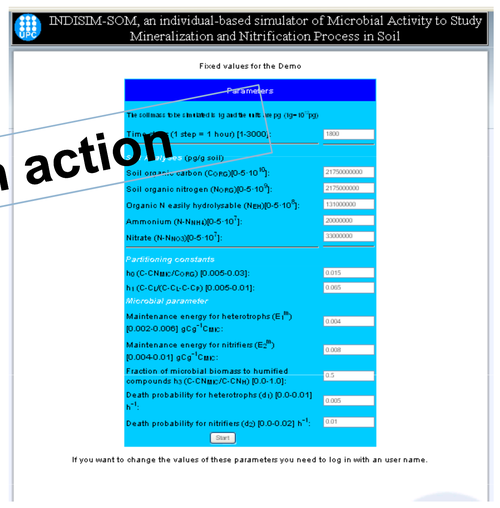
The other set of output graphics is: net production of CO_2 (μg CO_2 g^{-1}), easily hydrolysable N (μg N-N_{eh} g^{-1}), net N mineralization (μg N_{MIN} g^{-1}), total ammonium in the medium (μg N-NH_4 g^{-1}), and nitrate in the soil solution (μg N-NO_3 g^{-1}).

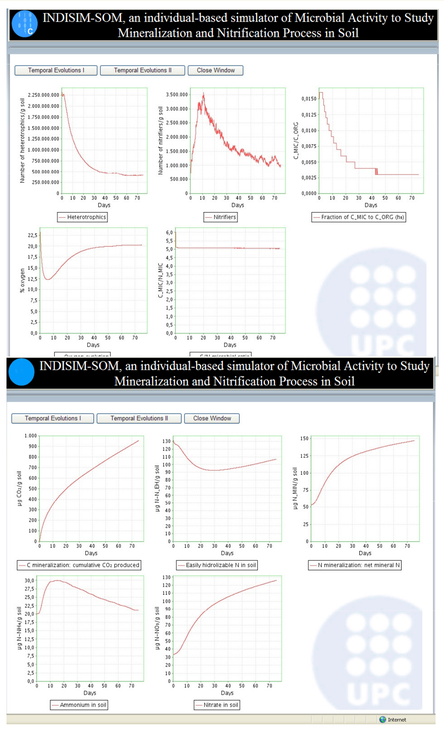
The graphical output shown allows the user to visualize how system variables emerge from different scenarios.



Log in:
Username:*****
Pasword: *****

Screenshots of INDISIM-SOM in action





CONCLUSION

This web application results in a very versatile program that could be used in controlled simulation experiments via Internet, and it is a useful way to analyze the INDISIM-SOM simulator in order to achieve further understanding of soil system discrete modelling.

REFERENCES

[1] Ginovart M., Gras A. and López D. (2005) Individual-based modelling of microbial activity to study mineralization of C and N and nitrification process in soil. NonLinear Analysis: Real World Applications 6, 773-795.

[2] Hellweger F.L. and Bucci V. (2009) A bunch of tiny individuals-Individual-based modeling for microbes. Ecological Modelling 220, 8-22.

[3] Manzoni S. and Porporato A. (2009) Soil carbon and nitrogen mineralization: Theory and models across scales. Soil Biology & Biochemistry 41, 1355-1379

[4] Peck S. L. (2004) Simulation as experiment: a philosophical reassessment for biological modeling. TRENDS in Ecology and Evolution 19, 530-534.

We gratefully acknowledge the financial support of the Plan Nacional I+D+i from the Spanish Ministerio de Educación y Ciencia under funding number: CGL2007-65142/BOS.