Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2017-359-AC1, 2018

Biogeosciences
Discussions
Open Access

Interactive comment on "A mathematical representation of microalgae distribution in aridisol and water scarcity" *by* Abdolmajid Lababpour

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Received and published: 8 January 2018

I acknowledge the reviewers, whose reviews led to important changes and clarifications.

Reviewer 1 In the manuscript entitled "A mathematical representation of microalgae distribution in aridisol and water scarcity", Lababpour presents a mathematical model of microalgae development on surfaces. The presented model attempts to describe the interaction between cyanobacteria and soil water with the possible inclusion of climatic variables.

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Discussion paper

Although the approach of using a reaction diffusion equation of biomass and water is interesting, the manuscript does not provide in-depth tests to grasp the applicability and predictability of the model. Furthermore, the presented equations raise some questions regarding the model capability that author discusses. I enjoyed reading about the work, but have several major issues with the model and its presentation for the publication.

Response: Thank you very much for reading and for the useful comments and suggestions. The manuscript was fully revised considering the recommended suggestions. The model was developed to predict water consumption and microalgae biomass growth on the soil surfaces of aridisol as well as other photosynthetic microorganisms. The model capability is demonstrated with description of cell growth, water consumption contours, required parameters, mass transport, coupled soil biomass-water effect, and biomass distribution profiles. The simulation results of the present study show that the concentrating capability of a model can be augmented by well-selected parameter sets.

Firstly, the author describes the growth of cyanobacteria to be a function of light intensity (which should be time dependent, day and night) and water. However, the growth term is not well described in the manuscript and the solution does not reflect such behavior.

Response: We considered constant artificial continuous illumination which is common in greenhouse systems. It prohibit complexity arises of light variations. In the other word, many reports were explained the effects of natural illumination, which can be replaced by the illumination model was used in this study12. The growth term including logistic relation was explained in more detail and the biomass growth shown in Fig. 2 shows its spatial and temporal distribution.

Secondly, unlike the title highlights that the model is for aridisol, the mathematical description does not include any of the properties of such soils. Using water as one of main variables and introducing the multiplication of the porosity n might imply such application to dry soils. However, the coupled PDE only replaces the limiting nutrient to water in the conventional reaction diffusion equation for microbial growth. Especially, without including the input and output of water in the equation, the role of soil physical property (porosity in this work) cancels out, thus no soils in the equation. To be constructive, using water content instead of water concentration (it is quite difficult to understand what this term means) can be considerable to include properties of soils. The Richards equation with the saturation based soil water diffusivity can provide the proper water dynamics in dry environments.

Response: The main soil characteristics are soil texture, or particle size and porosity; and soil structure related characters, or θ, h, and K. The relationship of two biomass and water state variables with soil characters are used through diffusivity and effective diffusivity. Aridisol hydraulic properties of soil moisture w, hydraulic conductivity K and soil water head, h are included in the model through model parameter of effective diffusivity coefficient, D* will be assumed known. More detail linear and non-linear diffusivity in a saturated and unsaturated soil, which is depends to factors such as tortuosity, makes the model more complex and thus omitted. The summarizing of nutrient compounds in water solution helped in simplifying the model. Otherwise it is required to write similar PDEs for all culture medium components which makes the model solution very complex. However, it is possible to expand the model equations for important nutrients such as nitrogen and phosphorous by adding similar to water PDE. The water solution was used instead of water to show inclusion of soil water nutrient ions and it was used to prohibit model complexity arises by various soil soluble ions. The effects of soil such as hydraulic properties is included in the equations through diffusivity coefficients and unit porous volume. The input and output terms, or mÌĞ = AV demonstrate the mass or volumetric flux which are depend to porosity by themselves through unit porous volume. The water concentration was changed to soil water content and the equation unit consistency was changed accordingly. Since the soil water mass flux go beyond the scope of this paper, did not discussed here and can be well explained by Richard equation. The text was modified for above suggestions accordingly.

Thirdly, the example solution of the model in this manuscript is too simple, even trivial. Simulating without any heterogeneity in the domain and uniform distributions of both variables as initial conditions should result in no differences during the dynamics (as the figures show and the author has mentioned in the result section). Furthermore, I cannot find any physical reasoning for the used boundary condition, equation (11).

Response: As a first work, even the uniform results are interesting as declare the behavior of biomass and water solution and their interrelationship. In addition, adding heterogeneity to the system of equations make their mathematical solution very difficult. We try to develop a simple model can be used for practical applications. Integrating the input and output water, in addition to diffusion, and 3-D modeling is under investigation for now. The boundary conditions were explained in more detail in the manuscript. The domain is square. In the initial condition, the domain is water saturated, without input and output water, and the biomass inoculated only in the origin of Cartesian coordination, will propagate all around in the surface as shown in Fig. 2. The biomass concentration is zero in the domain two edges, and its maximum is in the origin. For water, which is saturated in the beginning, it reduce by consumption mostly from origin, and it remains saturated in the boundaries. Two Dirichlet and two Neumann boundaries were considered.

Finally, the units provided in Table 3, do not seem to be correct. All units and dimensions need to be checked again in the model.

Response: The units were checked and corrected in the table for unit consistency.

Unfortunately, the model has major issues and needs further development. The attempt, however, to seek for a simplified representation of such a complex system is gratefully acknowledged.

Response: The comments of the reviewer were carefully considered and manuscript was revised. I hope it can be acceptable for now.

4. The language should be improved throughout the manuscript.

1. Kurano, N. & Miyachi, S. Selection of microalgal growth model for describing specific growth rate-light response using extended information criterion. J. Biosci. Bioeng. 100, 403–408 (2005). 2. Martínez, M. E., Camacho, F., Jiménez, J. M. & Espínola, J. B. Influence of light intensity on the kinetic and yield parameters of Chlorella pyrenoidosa mixotrophic growth. Process Biochem. 32, 93–98 (1997).

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2017-359/bg-2017-359-AC1-supplement.pdf

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Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2017-359, 2017.