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

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

Reviewer 2 Report on the paper "A mathematical representation of microalgae distribution in aridisol and water scarcity" by A. Lababpour November 6, 2017

The author presents a model consisting of two diffusion-reaction equations for biomass and water development. The resulting model equations are solved using a Matlab toolbox. The author thoroughly discusses extensions of the modeling approach and

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Discussion paper

outline directions of further research. He particularly discusses influencing factors for the three dimensional development of the soil biocrust. Although this part is quite well explained and the topic itself is of interest, I do not recommend the manuscript in its current stage for publishing in Biogeosciences. For details see the following comments below.

Response The resulting model equations are solved using parabolic solver in Matlab 2014a (The Mathwork, Inc.) (Not by Matlab toolbox). The program was split into geometry definition, initial condition, boundary conditions and solver for both PDEs. The biocrust system is very complex, and the proposed model is preliminary trial compare to real conditions. Model could simply integrate illumination, biomass growth, soil water, and soil physical properties. These parameters are important in recognitions of soil restoration systems.

1. The model is very simplified although possible reasonable extensions are discussed. The predictive power is therefore questionable. A quantitative discussion e.g. in comparison with with data should be added.

Response To improve the predictive power of model, a more data and discussion were included.

2. The model under consideration and its precise mathematical formulation remains unclear. The author should clearly differentiate what could be done and what is done within the current research. The model that is implemented it not clearly stated in its whole at any point. Exactly this model should be summarized once in the paper including the domain of definition, the used variables and parameters.

Response Some parts of text were revised to clarify the model subsections such as domain, state variables and parameters. The goal of this research is to develop a simple model to predict the growth of photosynthetic microorganisms and their interactions with soil water content in water shortage conditions of arid areas. The results of this research provide some insight of such interrelationships.

(a) The geometric setting is unclear. First the three dimensional domain [0, Lx] $\times$ [0, Ly] $\times$ [0, Lz] is discussed. This is thereafter changed to the half space (which actually is not the half space but the first quadrant). Thereafter a square [0, 4]2 is considered.

Response The geometric setting was revised in the text to show more accurate the physical conditions. The selected domain was explained as "The u (x, y, t) satisfies in Ω and then, domain may be represented as ΩâĹű=[0,x_L)$\times$[0,y_L)$\times$[0,y_L)âŁĆRˆ3 (1) in which xL, yL, and Lz are upper and the original coordinate as lower bound in Ω, respectively. The zL was assumed negligible and then horizontal 2-D was investigated. ". Half space changed to positive semi-axis. "a square [0, 4]2 was removed.

(b) It is unclear how the porosity enters the investigations. The equation (4) is reasonable only in case that the porosity is independent of space. Otherwise I would expect that the diffusion terms reads 1âĹĞãČż (nV DBâĹĞB). However, it seems that there is no modulation of the porosity throughout the simulation scenario, e.g. in the initial conditions.

Response Yes the porosity is independent of space and was considered uniform throughout the selected small domain. The porosity was included in simulation by D* constant parameter, mentioned in Table 2. The porosity was considered as one of critical parameters of soil can affect main both state variables of biomass and soil water content and can be related to other soil parameters such as particle size, etc. we assumed homogeneous soil texture. And therefore porosity is constant. It is common to apply porosity as a constant for modeling. Porosity is considered in all modeling steps including initial conditions. The porosity inclusion in the model was modified in the model formulation. The equations presented in this paper do not consider the effect of coupled flow processes, i.e., solute transport due to hydraulic, thermal, or electrical gradients.

(c) The inclusion of the illumination rate into the growth term of equation (4) is unclear. How is I related to μ and how is it determined/defined in the simulation scenario? Along the same lines d is undefined in (8). Does the logistic model enter the proposed model in terms the growth rate μ in (4) and (8) and if so how does it?

Response The inclusion of illumination and logistic model was revised in the text as suggested. The function μ = f (I).f (B) indicate the situation of illumination and growth in equation (4). The coefficient of I was selected from literature such as Lababpour (2004), and their effects was included through simulation by μ. Dw is water diffusion which is included in the text. dB is biomass death rate represented highlighted in line 111.

(d) The statement of boundary condition in (11) makes no sense. First the boundary conditions must be prescribed on the boundary of the domain rather that in the domain itself. Second the variables are independent quantities. I assume the author means B = 0.02 and w = 0.2 are prescribed on the boundary.

Response To adopt reviewer comments, the position of boundary conditions were changed. Accordingly the results was modified. Both Dirichlet and Neumann boundary conditions were selected for simulation of variable's profile. The biomass concentration is highest in the origin and is equal to initial biomass concentration and zero in the domain's boundaries. The amount of biomass remain zero in the boundaries constant during simulation. The soil water content is saturated soil water throughout the domain in the beginning of simulation and remain saturated, constant in the boundaries. In the other word, the soil water consumption is highest in the origin and zero in the boundaries. Modifications was performed in the text accordingly. Actually it is not easy to describe soil water content, as it has several state terms such as saturated, welting, field capacity... Here we considered the range of saturated and wilting point between 0.3-0.7.

3. The outcome is of the simulations are not convincing: (a) The scaling in Figure 2 and 3 is unclear. Variations are seen in order 10−4 or even below. This seems not to be relevant compared to the initial/boundary values or even the reference value of 0.7921

and 0.5198 in Figure 2 and 3. The smallness of the variations could even be due to numerical or rounding errors. It is remarkable that the values for B and w are within the same order of magnitude directly although starting with one order of magnitude difference initially.

Response The figures 2 and 3 were modified accordingly as suggested by reviewer.

(b) The initial conditions are not matched for t = 0 in Figure 2 and 3. This does not make the results reliable.

Response The initial conditions for biomass is 0.03 kg.m-3 of soil porous volume at t = 0, and increased to 0.26 during 60 days growth period. The figures 2 and 3 were modified and corrected.

(c) It is unclear for which time the spatial distribution is plotted. The values are very small (order of 10−4) compared to the chosen initial values. Is zero maybe a steady state solution?

Response The 60 days was selected for simulation based on the normal experimental growth period of selected microalga. The time distribution in the figures 2 and 3 were modified as suggested. Unsteady state cell growth was applied throughout simulation.

(d) Explicit comparison to data is missing. This could maybe shed some light into the results and make the discussion more quantitatively.

Response The text was modified as suggested.

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-AC2-supplement.pdf

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