Contribution to the edaphic component definition in the desertification susceptibility index

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ABSTRACT

Many of the biophysical processes involved in the scope of desertification depend on the hydric characteristics of the soils that impact on vegetation cover. To protect soils against desertification, it is necessary to understand how some of these characteristics (such as water storage) interact in a complex and integrated chain of degradation processes. Several works have been developed to contribute to the definition of a Index of Desertification Susceptibility (DSI) expressed as a function of several components, climatic, edaphic, vegetative and slope. However, the various built-in edaphic components already defined, leave aside the water retention in soil. Furthermore, these components only focus on the characteristics of the uppermost surface soil layer (A-layer). In fact, desertification is simultaneously cause and consequence of the depleted soil water retention with a positive feedback on the plant life and on the hydrological cycle.

This work intends to respond to the question of assessing if the B-layer exerts a significant influence in the definition of the edaphic component of the DSI. This may reflect the influence of the B-layer on the soil resilience to external factors.

An experimental study has been performed on several profiles (n = 50) of representative soil units at Mértola, Southern Portugal (a region classified as having high DSI). Soil columns, have been delimited having at the upper and lower boundaries respectively the soil surface and the C-layer. The total volume (V_T) of the Soil Available Water Content (AWC) was calculated as the sum of the elementary volumes (in the case, V_A and V_B) stored in each layer of the prospected soil column. Furthermore, volumetric ratios V_A/V_T and V_B/V_T have been determined. A possible existing empirical relationship between the ratios V_A/V_T and V_B/V_T, was investigated aiming to establish the relative importance of each term to the total volume V_T.

The results reveal a clear linear trend between V_A/V_T and V_B/V_T suggesting that the B-layer assumes the greater importance in terms of the holding water capacity of soil. It was found that except for soils constituted only by the A-layer, or when this layer is deeper than 45 cm, the relative weight of the B-layer is preponderant. For the most representative soil units of the study area, the referred relationship is persistent and is dependent on the layer thickness.

To conclude, the foregoing relationship allowed identifying the soil units with greater desertification susceptibility through their inability to store sufficient water to maintain vegetation. It also allowed one to identify soil units whose B-layer assumes the greater importance in this soil function, and therefore should be take into account in defining the edaphic component of DSI. Thus, it is understood that the results of the present exercise have contributed to a better understanding of desertification processes, allowing to outlining strategies of action and implementing technologies for soil and water conservation, more appropriate to each situation. A more extended and detailed study will have to be done in order to more effectively contribute to upscale the results to the regional level.

Keywords: Desertification Assessment; Indicators; Soil Layers; Available Water Content

INTRODUCTION

It is allready known that desertification is a complex phenomenon which reduces the soil fertility involving ecological and economic processes that characterize the environment at different geographic scales (Thornes, J.B., Brandt, J.,1995). A number of indicators of desertification is commonly used which especially includes those describing climate, soil characteristics and erosion risk, vegetation quality and plant productivity, fire risk, land fragmentation and management (Kosmas et al., 2000a, 2000b). So, it is important to evaluate the impact of some climates on soils, ecosystems, water balance and several other factors in many regions (Sivakumar, 2007). After listing a selection of indicators and isolating the most relevant ones for desertification risk assessment, each potential parameter can be evaluated to be submitted to further evaluation.

Water unavailability is one of the most dramatic consequences of climate change for the agricultural sector being expected to be even more limited in the future. Water scarcity is due to potential evapotranspiration increase. It is related to an increase in air and earth surface temperatures. This phenomenon is important in low-precipitation seasons, being more intense in dry areas. The number of regions with a loss of soil moisture is expected to increase, resulting in direct economic consequences on the production capacity (IPCC, WGII report, 1996 and following). Humidity soil decline implies a significant reduction in the potential productivity of dry land crops.

Thus, many of the biophysical processes involved in the scope of desertification depend on the hydric characteristics of the soils that impact on vegetation cover. To protect soils against desertification, it is necessary to understand how some of these characteristics (such as water storage) interact in a complex and integrated set of degradation processes. Several works have been conducted to contribute to the definition of a Desertification Susceptibility Index expressed as a function of components like: climate, soil, vegetation and slope (F. Mestre-Sanchís and M. L. Feijóo-Bello, 2009; M.L. Silveira, N.B. Comerford, K.R. Reddy, J. Prenger and W.F. DeBusk, 2009; J. L. Rubio and E. Bochet, 1998; L. Salvati, M. Zitti and T. Caccarelli, 2007; Hans-Martin Fussel, 2007 and others). However, many of the various built-in edaphic components already defined, do not include the water retention in soil. Furthermore, these components only focus on the characteristics of the uppermost surface soil layer (A-layer). This limitation should be overcome since soil water depletion and desertification display a strong positive feedback.

The objective of this paper is to provide a better foundation for the establishement of the Desertification Susceptibility Index responding to the question of knowing if the water storage by B-soil layer, exerts a significant influence in the definition of the edaphic component. This may reflect the influence of the B-layer on the soil resilience to external factors like enhancing resilience to climate extremes.

METHODOLOGY

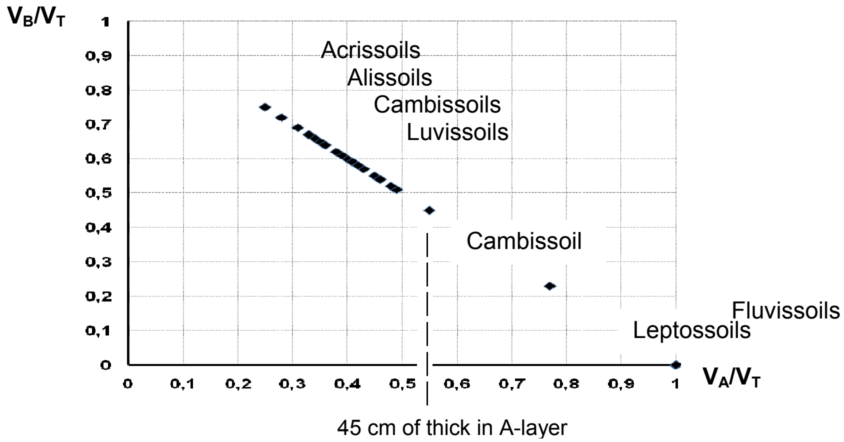
An experimental study has been performed on fifty profiles of representative soil units at Mértola, Southern Portugal (a region classified as having high Desertification Susceptibility Index). This area is very homogenous in terms of climate and agricultural practices. Climate is classified like semi-arid with 450mm of average annual rainfall and temperature ranging between 5ºC at the coldest month and 45ºC at the hottest. Its water resources come from one river (Guadiana), some temporary rivers and the rainfall regime. Agricultural practices are based on systems of crop production with soil mobilizations, pasture or land abandonment caused by the intensification of the desertification process. The soils are, in general thin but with a varied diversity of units: leptossoils; luvissoils, cambissoils; acrissoils; lixissoils alissoils and fluvissoils.

In each sampling site (three by homogeneous unit) soil columns were delimited having the soil surface and C-layer as the upper and lower boundaries respectively. The total Volume (V_T) of the Soil Available Water Content (AWC) was calculated as the sum of the elementary volumes stored by each layer of the prospected soil column (in the case, V_A and V_B if present). Further, volumetric ratios V_A/V_T and V_B/V_T have been determined and investigated a possible existing empirical relationship between them, aiming to establish the relative importance of each to the total volume V_T.

RESULTS AND DISCUSSION

The referred volumetric ratios V_A/V_T and V_B/V_T are projected in Fig.1 that shows the frontiers that represent the relative importance of the Volume of the AWC of each soil layer.

Fig.1- Importance of the Volume of AWC stored by A-layer or B-layer in relation with the volumen of AWC stored by the entire soil profile



As can be seen in Fig.1, the results reveal a clear linear association between V_A/V_T and V_B/V_T suggesting that the B-layer assumes the greater importance in terms of soil water holding capacity. According to Fig.1, except for the soils constituted only by the A-layer (Leptossoils and Fluvissoils) or when A-layer is deeper than 45 cm (some Cambissoils), the relative weight of the B-layer is always preponderant. Therefore, for the most representative soil units of the study area, the foregoing relationship seems to be persistent and dependent on the thickness of the A-layer.

It seems important that the scientists in building up a Desertification Susceptibility Index be taken special precautions regarding to the edaphic component of that Index. To be precise, the role of a B-layer, when present, should be included in the edaphic component of the selected DSI, depending on the soil units being studied.

CONCLUSIONS

The main idea underlying the paper is to show the importance of B-soil-layers in the Edaphic component of Desertification Susceptibility Index which is much more relevant than considered now.

In fact, the ratio, of the contribution, of each soil layer to the AWC of the soil profile, allow identifying the soil units with greater desertification susceptibility, through their inability to store sufficient water to maintain vegetation.

The presence of a B-layer or one thick A-layer may have the capacity of long term storage of water in the soil, thus facing the consequences of climate change, affecting crops life cycle. Moreover, if vegetation cover remains longer on the soil surface, the protection against desertification is more effective.

The results of the present work may contributed to a better understanding of desertification, allowing to outlining strategies and to implementing technologies for soil and water conservation, more appropriate to each situation. A more extended and detailed study, with more diversity of soil units, is being planned in order to more effectively contribute to upscale the results to the regional level.

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