Soil Physical and Hydraulic Parameters as Indicators for the Soil Quality of Land Use Systems in Degraded Areas in the Central Amazon.

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Abstract

Large areas in Central Amazon were deforested and abandoned after a short period of cultivation. There is a need to develop alternative land use systems, which allow the utilization of degraded areas in an economically viable and socially and ecologically sustainable way. If this can be achieved, there is a chance to reduce the rate of deforestation and to reintroduce those areas in the production process. Determinations of physical and hydraulic soil properties are required in studies involving, soil degradation, water balances and chemical transport through the soil. The uses of sophisticated water fluxes models require spatially representative parameters describing the soil physical and hydraulic properties. However, reliable characterization of the soil properties requires complex and time-consuming measurements. The lack of data is a problem for Amazonian soils where very little is known about the physical and hydraulic properties of the soil, and even less about how they change as a result of deforestation and differences land use systems. The objectives of this work were to evaluate the soil physical and hydraulic parameters in different land use system in the Central Amazon. Studies were carried out within a field experiment at the experimental station of the Centro de Pesquisa Agroflorestal da Amazônia Ocidental at Manaus (Embrapa – Amazônia Ocidental), Brazil. The soil is a Xanthic Ferralsol. The following land use system were investigated: i) a conventional monoculture of peach palm (*Bactris gasipaes*); ii) a monoculture of cupuaçu (*Theobroma grandiflorum*) and iii) a complex agroforestry association with peach palm, cupuaçu, Brazil nut (*Bertholletia excelsa*) and annatto (*Bixa orellana*). The soil was covered by Pueraria phaseoloides in all systems except the peach palm monoculture, which does not permit ground vegetation. Adjacent areas of primary and secondary forest were investigated for comparison. The parameters investigated were concerning: soil structure, porosity, retentivity, and saturated and unsaturated hydraulic conductivity. The methodologies used are found in TEIXEIRA (2001). We used a disk infiltrometer to measure the unsaturated and saturated hydraulic conductivity in the field. After completion of infiltration measurements soil cores was taken under the area of the disk and saturated hydraulic conductivity using the constant head method was determined in the laboratory. Soil cores were also used to determine soil water retention curve and bulk density. The results showed not only high variability on the saturated hydraulic conductivity among the sites but also between methods. An abrupt increase of the unsaturated hydraulic conductivity near saturation at the soil surface was verified in the field; it is a consequence of a bimodal pore size distribution with a mode in the macropore range. The investigated soil shows an unusual behavior: the hydraulic conductivity was high close to and at saturation as it is commonly found in sandy soils; however, at high soil water suction, it can retain large amounts of water which is a typical characteristic for clayey soils. This phenomenon may be explained to the particle size distribution (predominantly clay) and its strong aggregation. The sustainability of this soil is related with the stability of its aggregation; therefore the flocculation index may be a good parameter to evaluate its physical quality. Soil pores vary in size and shape, and manifest an interconnected framework typical for each particular soil type, which, however, may change as a consequence of different land use systems. The porosity (f) controls the storage, availability and transport of water and air in the soil, however, this control depends not only on the total volume occupied by pores, but also and specially on how the porous space is distributed and connected. It is therefore important to determine not only the f, but also the pore-size distribution. Pore-size distribution was evaluated using the desorption method, where a saturated soil sample is subjected to a stepwise series of incremental water pressure heads (h), and the paired data are collected relating the volumetric water content (_) and h. The capillary theory was used to obtain the "equivalent radius" of the soil pore-sizes. The soil water retention curve (SWRC) in which (_) is a function (h) is one of the most important hydraulic function governing the movement of water and solutes in the soil. In well-aggregated soils the pore system is frequently partitioned into intraaggregate or textural pores

and interaggregate or structural pores resulting that the pore-size distribution has bi or tri modes; because of this fact, the original van Genuchten equation (VG) has not the necessary flexibility to fit reasonably the measured data. The clayey Ferralsols in the central Amazon show in their original conditions a high f and their pore-size distribution is bimodal, with a large proportion of the f concentrated in the extremely fine pores and a further large proportion concentrated in the macro and large meso pores. The results show that using a bimodal approach by linearly overlapping two functions of VG, excellent fits and resulting curves were obtained, relating q and h for the soil surface for different land use systems and also for different depths in the soil profile. The parameters n and a in the VG models were interpreted in its physical meaning and were useful to confirm a presence of a layer with higher porosity and pores with higher radius located about 60 cm deep, between two more compact ones. Pueraria seems to reduce larger pores than drain water very quickly for a range of pore radii with is more effective to hold water and maintain it available in a short term analyses. The soil near the peach palms has a concentration of pores with a reduced radius in the micropore range. The soil, with was not well covered by cover crops (among the cupuaçus growing in monoculture), showed a reduced total porosity and a pronounced reduction in the macropore range. The soil covered by the primary forest shows more than 30% of the total porosity in the macropore range, this macropore system which drains water rapidly and are responsible for the soil aeration and the deep penetration of water and nutrients (or pesticide, herbicides) into the soil. However, the macroporosity may reduce the leaching rate when the nutrients or defensives are already into the soil matrix, because it reduces the amount of water that percolates through the matrix. The relative volumetric fractions of the pores between the primary and secondary forest are very similar. It shows a relative fast capacity of the spontaneous vegetation to rehabilitate the soil porosity to the values found in the original conditions. The pore-size distribution on the original conditions (soil covered by primary forest) in the clayey Ferralsol seen to be very well adapted to the climate conditions in that region. It allows a rapid drain of large amount of water, and avoids runoff and consequently erosion process. Further it may also reduce the nutrient leaching of the soil matrix by passing the water to deep layers through the macropores. Furthermore, under unsaturated conditions, transmission of water across the soil matrix occurs basically through micropores. This remaining water flows slowly enhancing time for the nutrients in solution be up taken by plant roots, macro and micro fauna or absorbed by the soil matrix.

Literature:

TEIXEIRA, W. G. Land use effects on soil physical and hydraulic properties of clayey Ferralsol on the Central Amazon. Bayreuther Bodenkunde Berichter. Vol 72. University of Bayreuth. Bayreuth.

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Basis for a Decision Support System (DSS) for Water System in Brazilian Semi-arid

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The Semi-Arid Integrated Model – SIM, designed by WAVES Research Program members, has the purpose of evaluating vulnerability of society and ecosystem of Brazilian semi-arid depending on water availability. An important task of the model is to assess adequately demand-offer water balance in all "municípios" in the States of Ceará and Piauí. An important decision procedure is expected when long-term water stress is found in a certain region: what should be done, increase water offer (how much, where...), decrease the demand (how much, where...) or a combination of both? To help answer that question a Decision Support System (DSS) is under design: several water offer prices are investigated as well as some water demand prices. The main water sources investigated were: bulk surface water, groundwater (crystalline or sediment bedrock) and reuse water. The demand management possibilities considered are mainly: technological improvement of irrigation and urban processes. Capital as well as operation, administration and management (O&M) costs are evaluated for the whole State of Ceará. The DSS will use linear programming, in which the objective function is cost per volume of water. Main constraints are physical (hydrological) availability of water and investment capacity of each sector. The system will be applied to pilot