

Physico-hydrical mapping of the soils of the Santa Maria and Cambiocó Basin, Rio de Janeiro State.

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Abstract

The physico-hydrical classification system (PHCS) proposed by Ottoni Filho (Ottoni Filho 2003) categorizes soil profiles according to their aeration and water capacities based on in situ tests to determine field capacity and steady state infiltration rate, and systematically adds this information to the pedological survey. However, this system still lacks a systematic procedure of classification of pedological mapping unities in terms of physico-hydrical characteristics. Thus, the use of pedological mapping would have its potential enhanced if such characteristics were included. This study defined the physico-hydrical mapping methodology of soils based on pedological mapping units; the method has been applied to a 13-km² watershed in the state of Rio de Janeiro. A direct correspondence was not found between the physico-hydrical and pedological classifications. The main physico-hydrical limitations of the soils of the studied basin were related to the low aeration capacity of Haplic Gleysols and Red-Yellow Argisols, the low water availability of Gleic Haplic Cambisols and Litholic Neosols, as well as the small depth of Litholic Neosols. In conclusion, the physico-hydrical mapping was both satisfactory and advantageous, and its application to other soils from diverse pedoenvironments is recommended.

Key Words

soil classification, soil aeration, water availability in soil.

Introduction

The physico-hydrical classification system (PHCS) (Ottoni Filho 2003) is a pioneer proposal in the classification of soil profiles in terms of aeration and water capacities. This information can be systematically added to the pedological classification system. The PHCS methodology was first applied in a study by Brito (2004). The present study presents an extension of this classification system to make possible the physico-hydrical mapping of soils and shows its application to a 13-km² watershed located in the northeast of Rio de Janeiro State. The aim is to introduce a more specific soil mapping in terms of physico-hydrical attributes.

Methods

A. Description of the study area and field tests

The study area is a 13-km² watershed located in the municipality of São José do Ubá, in the northeast of Rio de Janeiro State. The watershed, called Santa Maria and Cambiocó Basin, is formed by 9 soil mapping units made up of associated soil classes. In the 9 mapping units, the prevailing classes are Leptic Haplic Cambisol (CXbe2, CXve2, CXve3), Litholic Haplic Cambisol (CXbe1), Gleic Haplic Cambisol (CXve1), Red-Yellow Argisol (PVAd and PVAe), Litholic Neosol (RLve), and Haplic Gleysol (GXve). These units were described based on a survey of 36 soil profiles (Bhering et al. 2005), 12 of which were considered characteristic soil profiles of the area. The physico-hydrical characteristics of the latter were determined as described in Ottoni Filho (2003) using in situ field capacity and double-ring infiltration tests. The physico-hydrical variables that were used are: total porosity (TP), volumetric field capacity (FC), volumetric permanent wilting point (PWP), and steady state infiltration rate (SSIR). These properties are the input variables for the definition of the physico-hydrical mapping of soils of the basin under investigation.

B. Physico-Hydrical Mapping

The physico-hydrical classification of the soils (Ottoni Filho 2003) is based on two properties, water capacity (W) and aeration capacity. Water capacity (or available water) is determined as the difference between the field capacity and the permanent wilting point, while the aeration capacity is evaluated from the values of

SSIR and minimum air availability (A). The minimum air availability (A) (or available air) is defined by subtracting the field capacity from the total porosity. Two physico-hydrical classifications are proposed in Ottoni Filho (2003): i) “standard classification”, based on the physico-hydrical attributes for a maximum profile depth of 70 cm, and ii) “surface classification”, based on the physico-hydrical attributes for a maximum profile depth of 30 cm. This system comprises 9 main orders and 27 main classes, with each order having three soil classes. However, this methodology still lacks a systematic physico-hydrical mapping procedure to draft physico-hydrical maps. The main items of our procedure are summarized below:

- a) Every soil class identified in the pedological mapping, whether associated or not, must correspond to one or more profiles that will be submitted to the physico-hydrical tests (in situ field capacity and double-ring infiltration tests). The values of TP, FC, PWP at different sampling depths and the value of SSIR at the profile are determined from these tests and laboratory analyses (Ottoni Filho 2003).
- b) Based on these results, the integrated mean values of TP, FC, PWP for the profile lengths of 30 and 70 cm are defined as \overline{TP} , \overline{FC} , \overline{PWP} and are obtained from the Equation 1 described in Ottoni Filho (2003). From these values are calculated the mean values $\overline{A} = \overline{TP} - \overline{FC}$ and $\overline{W} = \overline{FC} - \overline{PWP}$ for the same profile lengths of 30 and 70 cm. These values correlate with the SSIR value of the profile.
- c) When a representative profile of one class is truncated by rock (R) or phreatic level (P) above the 30 cm or 70 cm depths, the mean physico-hydrical variables (\overline{TP} , \overline{FC} , \overline{PWP}) are calculated up to the truncation depth.
- d) The physico-hydrical classification of the soil profiles is obtained by plotting the corresponding values of \overline{A} and \overline{W} for the two depth profile lengths of 30 and 70 cm in the triangles of physico-hydrical classification, which vary with the SSIR variation range (Fig.1A, 1B, and 1C). This plotting gives the order and the physico-hydrical class of the soil.
- e) The colors in the physico-hydrical classification triangles identify the main soil orders, from I to IX. The colors are chosen based on the three ranges of variation (low, mean, high) of the aeration and water capacities. The physico-hydrical classes are defined based on labels for the three ranges of variation (low, mean, high) of A, W, and SSIR of a soil (Fig.1).
- f) The notation of truncated profiles is formed by adding an R (truncated by rock) or a P (truncated by phreatic level) at the end of the corresponding order and main class label of both the standard and the surface classifications.
- g) When a soil class identified in the pedological mapping corresponds to two or more representative profiles, its physico-hydrical classification (order and class) is obtained from the arithmetical means of the respective values of \overline{A} , \overline{W} and SSIR obtained for each of the representative profiles. When a soil class is represented by only one profile, its physico-hydrical classification is the same as that of the profile.
- h) When the mapping unit is composed of associated soils, the physico-hydrical order and class of the prevailing soil define, respectively, the color and the labeling of the physico-hydrical mapping of that unit.

Results

The experimental results of the 12 studied profiles and the list of representative profiles of each of the soil classes in the pedological mapping units of the area (Ottoni 2005) made it possible to determine the physico-hydrical mapping of the Santa Maria and Cambiocó Basin using the proposed methodology. Fig.2 and 3 present the maps of the surface and standard classifications, respectively, as well as the physico-hydrical legend and labels of the mapping units. The analysis of Fig. 2 and 3 allows concluding that there was not necessarily a single direct correspondence between pedological and physico-hydrical classifications. For example, mapping unit GXve (in fact, its prevailing soil class) had the same physico-hydrical classification as PVAd and PVAe, in which Red-Yellow Argisols predominated. Furthermore, it was observed that soil orders II, VI, VIII, IV (surface classification) and IIR, VIII, VIR, VI, and IVR (standard classification) prevailed in the basin in the given decreasing order of area size. The most limiting physico-hydrical restrictions were related to the anaerated character of the soils of order VIII (Gleisols and Argisols), the low water availability of order VI soils (Gleic Haplic Cambisols) and the litholic character of order VIR soils (Neosols). The latter also had low water availability and were located in mountainous terrain incompatible with sustainable agriculture. These soils that had a more limited agricultural use potential (orders VIR and VIII) constituted about 40% of the basin. In contrast, it was observed that a large extension of the basin was formed by soils without any marked aeration or water capacity limitation (Orders II or IIR); however, these

terrains, which correspond to Leptic Haplic Cambisols, had in their low depth a restriction for their agricultural use.

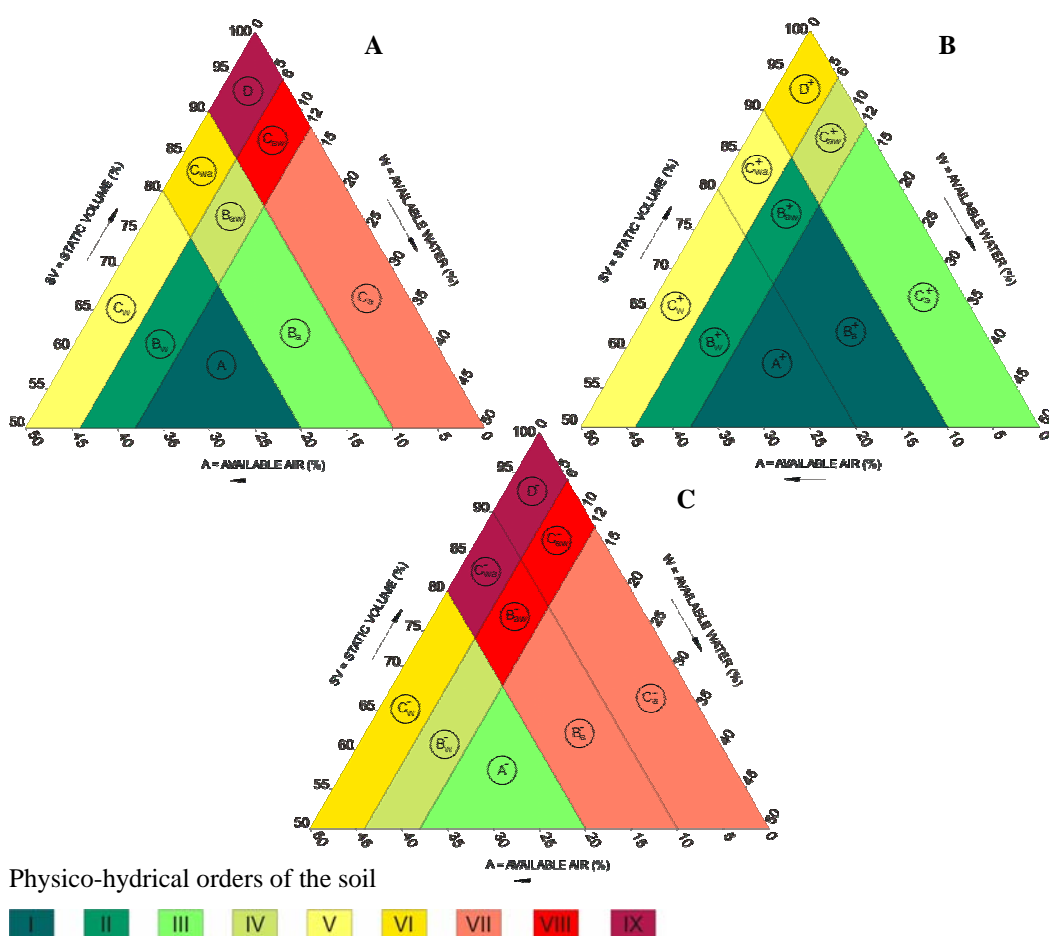


Figure 1. Triangles of physico-hydrical classification of soils: A – soils with moderate hydraulic conductivity ($2.0 \leq SSIR \leq 12.5 \text{ cm h}^{-1}$); B – soils with high hydraulic conductivity ($SSIR > 12.5 \text{ cm h}^{-1}$); C – soils with low hydraulic conductivity ($SSIR < 2.0 \text{ cm h}^{-1}$). Source: Ottoni Filho (2003)

Conclusion

The Physico-Hydrical Classification System (PHCS) is based on standardized field and laboratory tests and is associated with conventional pedological survey. Its application to the investigated watershed showed that it can be a useful tool to understand the pedogenetic processes and to characterize the agricultural suitability of soils regarding the physical structure of the profiles and their capacity to exchange air with the atmosphere and release water to plant roots. The physico-hydrical variables and maps obtained by the proposed methodology were conceived to aggregate information to the pedological knowledge and to reinforce the applicability of such knowledge in the fields of engineering and soil and water conservation. Aiming to strengthen the PHCS, it is recommended that it be applied to soils from diverse pedoenvironments.

References

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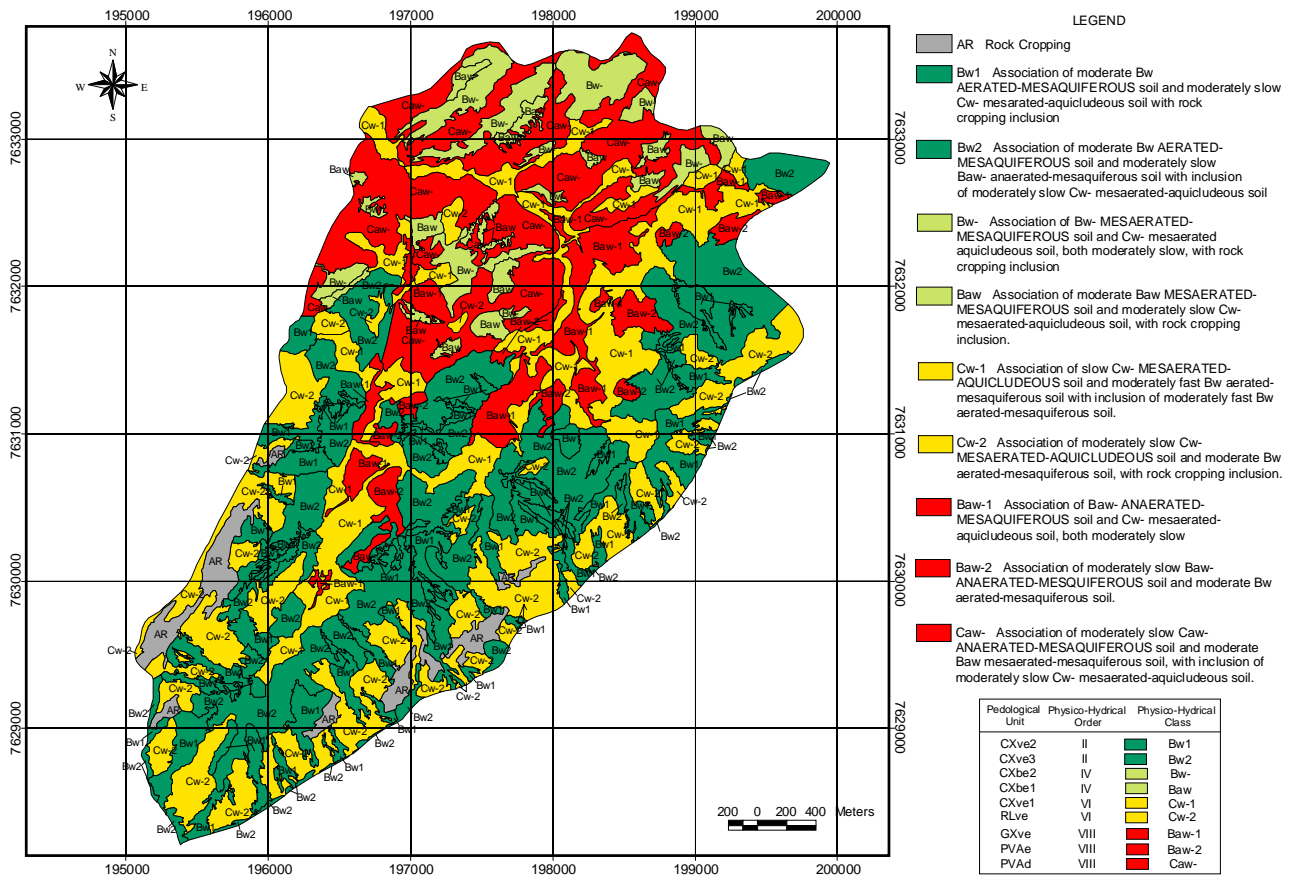


Figure 2. Surface physico-hydrical map of the Santa Maria and Cambiocó Basin – Municipality of São José de Ubá, Rio de Janeiro State.

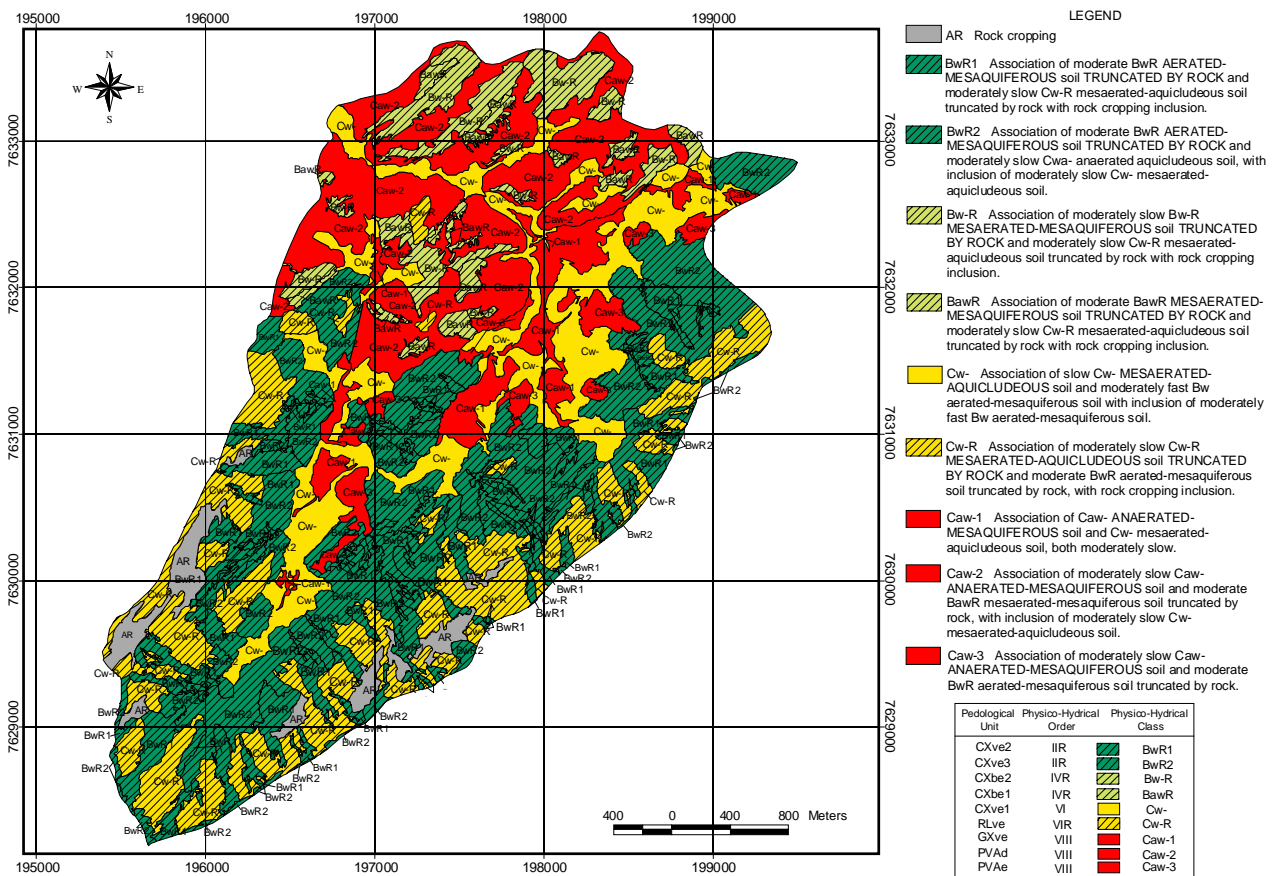


Figure 3. Standard physico-hydrical map of the Santa Maria and Cambiocó Basin – Municipality of São José de Ubá, Rio de Janeiro State.