Analysis of Chemical Properties of Forest Soils from Bacau County

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Abstract: State forests are analyzed periodically, once every 10 years. This includes an analysis of forest soils. The present paper describes and interprets the chemical properties of forest soils from Bacau County focusing on the period 1983-2015. As such, 823 soil profiles and 2435 pedogenetic horizons were analysed taking into consideration the soil type, pH, humus content, nitrogen content, base saturation degree and the total cation exchange capacity. The most widespread types of soils are: eutric cambisol, luvisol, preluvisol, and dystric cambisol. The dystric cambisols from Bacau County are strongly acid soils, while eutric cambisols and preluvisols are moderately acid. All forest soils from this area have a high cation exchange capacity and are very well (dystric cambisol, eutric cambisol, luvisol) or well supplied (preluvisol, rendzina) with nitrogen. Knowing the chemical properties of soils is important for the analysis of stand variability and for adopting silvicultural methods adequate for the management of long-lasting forests.

Keywords: forest soils, Bacau county, soil reaction, nitrogen, humus.

1. Introduction

Bacau County occupies 2.8% from Romania’s total surface, namely 662,052 ha. The county’s relief is relatively equally distributed between mountains, hills, and plains. The highest altitude is 1,664 m in Tarcaului Mountains, while the lowest one which is 100 m can be found on Siretului Valley (Figure 1). Arable fields occupy 48.5% of the county’s surface, followed by forests with 39.8% [1]. The most widespread soil at a national level is dystric cambisol, followed by luvisol and eutric cambisol (Figure 1) [2].

State forests cover a surface of 174,267 ha, being managed by Bacau Forest District through its 14 Forest Districts: Bacau, Caiuti, Ciobanus, Comanesti, Darmanesti, Fantanele, Livezi, Manastirea Casin, Moinesti, Oituz, Sascut, Targu Ocna, Traian, and Zeletin [3].

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2. Materials and methods

Romanian forests are inventoried and described every ten years through forest management plans together with the description of all environment characteristics such as flora type, soil type or station type and stand factors like: age, diameter and height, volume, growth. In this context, the main soil types are also identified through control profiles placed in all parcels and main profiles from the representative areas. Usually there are made approximately 10-20 profiles in each forest district. Soil samples are collected from pedogenetic horizons and are analysed through performing analysis methods accordant with European methodologies [4-6].

We used the soil analyses realized in the period 1984-2016 for 823 soil profiles [7]. The large number of measurements (2,435 for each chemical parameter) is the guarantee of a good statistical insurance of the results obtained. The following soil chemical parameters were analysed: soil reaction (pH), base saturation degree (V, %), total cationic exchange capacity (T, meq/100 g soil), humus content (H, %) and total nitrogen content (N, %).

Assessment methods of the investigation:
The soil’s pH was determined by potentiometric method (aqueous suspension, 1:2.5, w/v) the readings being fulfilled with a Thermo Orion 3 pH-meter. The humus from the soil was established through the humid oxidation method and titrimetric dosage by Walkley-Black-Gogoasa method. The total nitrogen from the soil was established through the humid mineralization method and titrimetric dosage by Kjeldahl method with Gerhardt automatic analyser. The exchange acidity (Ac), the extract of potassium acetate and the basic cations (K⁺, Na⁺, Mg⁺⁺, Ca⁺⁺) were determined through the repeated bleeders with ammonium acetate. The total cationic exchange capacity (T) was calculated by summing Ac, K⁺, Na⁺, Mg⁺⁺ and Ca⁺⁺. The base saturation degree was calculated using the following equation (1):

\[ V = \frac{(K^+ + Na^+ + Mg^{++} + Ca^{++})}{T} \times 100 \]  

3. Results and discussions

The most widespread type of soil are eutric cambisol and luvisol, both soils occupying 55%, which means more than half of the Bacau county forest surface (Figure 2). Lower surfaces are occupied by dystric cambisol, preluvisol, rendzina, phaeozem. There are also other soils which together occupy less than 3% from county’s total forest surface like: fluvisol, chernozem, gleysol, regosol and solonchak (Figure 2). In Bacau County, the difference from the national average is represented by the preponderance of eutric cambisol instead of dystric cambisol, due to an increased presence of pre-mountain and low mountain areas in comparison with the superior mountain area where dystric cambisols prevail. In comparison with other areas from our country like Braila County[8], chernozem and phaeozem soils occupy narrower areas in Bacau County.

Figure 2: Types of forest soils from Bacau County

Eutric cambisol is a soil characteristic to the inferior mountain level [9,10], a level named “pedocambic level” by N. Barbuin 1987 [11] due to the predominant presence of these soils. Luvisol is
spread out in hill and plateaus or high fields[12], while dystric cambisol occupies inferior and superior mountain areas(Fig. 3) [13, 14].

In Bacau’s agricultural fields, preluvisol occupies 23%, regosol 14%, luvisol 11%, eutriccambisol 11%, and cambic chernozem 4% [16]. For the entire county’s surface which includes both forest soils, agricultural soils and non-productive fields, the hierarchy of soil types is the following: preluvisol 23%, luvisol 18%, regosol 16%, eutriccambisol 15%, fluvisol 7%, and dystric cambisol 7% [17]. The predominant soils from the Moldavian SubCarpathian Slot are: luvisol (37,155 ha), chernozem (21,731 ha), regosol (20,092 ha), preluvisol (19,631 ha), fluvisol (18,387 ha), phaeozem (9,966 ha), and eutriccambisol (9,729 ha) [18].

Dystric cambisols from Bacau County are strongly acid soils, while eutriccambisols and luvisols are moderately acid. Phaeozem is neutral in the A/C horizon and weakly alkaline in the C horizon. For rendzina, in Bacau County, soil solution reaction varies between weakly acid and weakly alkaline (Figure 4).

Regarding agricultural soils from Bacau County, moderately acid soils occupy 18%, followed by the weakly acid ones (41%), neutral (9%), weakly alkaline (31%) and moderately alkaline (1%) [16].
Dystric cambisols are oligo-mesobasic, while preluvisols and eutric cambisols are mesobasic and phaeozem is eubasic (Figure 5). In Maramures County, eutric cambisols are also mesobasic [19] while in Cluj County preluvisols are mesobasic [20].

The total exchange capacity has the highest values in rendzina, while the lowest ones were found for preluvisol (Table 1). It is well known that cation exchange capacity depends on the stabilizing capacity of different size fractions [21, 22], a fact that explains these differences. However, the factor that most influences total cation exchange capacity is the quantity of organic matter from the soil [23, 24], calculus also shows that the soil with the smallest cation exchange capacity (preluvisol) also has the lowest quantity of humus.

**Table 1.** Total cation exchange capacity and average humus and nitrogen content for forest soils from Bacau County

| Soil Type     | Eutric Cambisol | Dystric Cambisol | Preluvisol | Luvisol | Rendzina | Phaeozem |
|---------------|----------------|-----------------|------------|---------|----------|----------|
| Total cation exchange capacity (Tmeq/100 g soil) | 22.68          | 20.84           | 19.80      | 21.68   | 30.25    | 24.25    |
| Average humus content in the A horizon (H%) | 5.59           | 6.62            | 4.01       | 5.75    | 4.11     | 4.32     |
| Average nitrogen content in the A horizon (N %) | 0.36           | 0.35            | 0.21       | 0.31    | 0.21     | 0.19     |

Half of the forest soils from this area are intensely humiferous: distyric cambisol, luvisol and eutric cambisol, while preluvisol, phaeozem and rendzina are moderately humiferous (Fig. 6).
The humus content for agricultural soils from Bacau County is distributed as follows: very weak (6%), weak (58%), average (31%) and high (5%) [16]. For the forest soils, the average values from other areas of the country show that eutric cambisol and preluvisol can be moderately humiferous in Romanian West Plain[25], while luvisols can be intensely humiferous in Arges[26].

The most well-supplied forest soils with nitrogen from Bacau County are eutric cambisol and dystric cambisol. Rendzina and preluvisol are well supplied with nitrogen, while the poorest ones isphaeozem. The nitrogen quantity from the soil depends on the type of land use [27], vegetation type[28], or soil water content [29]. Other forest soils from the country like eutric cambisols and preluvisols from Arad region are also well-supplied with nitrogen[30].

4. Conclusions
The biodiversity of forest soils from Bacau County is high. As such, the soils from the mountain area (dystric cambisol, rendzina), hills area (eutric cambisol, luvisol) and plain area (preluvisol, phaeozem) were inventoried. Based on this analysis, the most widespread types of soils from this forest area are eutric cambisol and luvisol. Eutric cambisol is moderately acid, with a high total cationic exchange capacity and intensely humiferous. Dystric cambisol is strongly acid, oligo-mesobasic, with a high total cationic exchange capacity and intensely humiferous. Preluvisol is moderately acid, oligo-mesobasic, with an average total cationic exchange capacity and moderately humiferous. Luvisol is moderately acid, oligo-mesobasic, with a high total cationic exchange capacity and intensely humiferous. Rendzina is a neutrally-weak alkaline soil, with a very high total cationic exchange capacity and moderately humiferous.

Knowing and understanding the chemical properties of soils from this area, with a considerable percentage in the national forest fund, is useful for future soil deficits that can affect forest vegetation. Furthermore, this extends towards the adoption of proper and performing silvicultural measures corresponding to the requests of species for certain soil characteristics.

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