CHEMICAL CHARACTERIZATION OF CAMBISOLS
IN THE HIGHLAND REGION OF RILA MOUNTAIN, BULGARIA

Miglena Zhiyanski
Forest Research Institute – Sofia
Bulgarian Academy of Sciences

Abstract

Soil chemical properties of Cambisols under two mountain land-uses (three forest lands formed by *Picea abies* Karst., *Pinus mugo* Turra., *Pinus sylvestris* L. respectively, and one mountain grassland) in Rila Mountain, Bulgaria, were studied to assess the role of vegetation on soil acidification. Soil organic matter content (SOM), pH, cation-exchange capacity (CEC), exchangeable cations with strongly acidic functions (CECSA), the type of ions exchange over the plant roots and the ion exchange capacity of SOM were analysed. The studied forest soils are characterized with medium to high SOM content, medium to low colloidal functions and low to medium level of bases saturation. Soils under tree and grass vegetation differed in their level of acidification, characterized by a strong total acidity of soils under forest type of land-use. Over 70% of CEC of forest soils are characterized by abundance of exchangeable aluminum, which may facilitate the transfer of amphoteric metals in toxic quantities. Under grass vegetation the bases were between 44 and 91% of soil sorption capacity, and exchangeable aluminum was present in minimum quantities, which indicated the lack of destructive processes. The treeline Dwarf pine communities influence the soil formation process in the highland zone of NW Rila, where the transitional dark-coloured forest soil type (Mollic Cambisols) is observed. It could be concluded that grassland vegetation has the potential to reduce rates of soil acidification in studied mountain land-uses. Different vegetation and respectively the land-use type could be assumed as factors, which play important role in the processes of soil formation and explain the transitional soils observed in the studied highland region.

Key words: land-uses types, soil CEC, highland region

INTRODUCTION

Acidification and land management exert important control on physico-chemical properties of mountain soils (Brais et al., 2006). Previous studies (Ganev, 1990; Ganev, Arsova, 1980; 1989; 1991; Arsova, Yorova 1996; Malinova et al., 1994) have shown that soil acidity is crucial for the functioning of a number of processes upon soil formation in forests, as well as for processes related to plant nutrition, microbial activity, and the
behaviour of different pollutants, under the climatic conditions of mountain ecosystems in Bulgaria. These facts are supported by other studies from different regions (Driscoll et al., 2001; Bååth, Anderson 2003). Demchik, Sharpe (2000) confirmed the importance of soil pH and study suggested that nutrient deficiency and associated Al toxicity may be causing stress for the studied tree species (Northern red oak) in Pensilvania. Alfredsson et al. (1998) established that the land-use change from grassland to conifers decreased levels exchangeable cations and increased exchangeable acidity in the upper 20–30 cm of soil. In Bulgaria, forest soils are significantly affected by acidification due to additional anthropogenic depositions, which requires research related to acid destruction and its impact on woody plants (Fikova, Ignatova, 2002; Ignatova, 2006; 2007). The exchangeable acidity and insufficient provision of cationic nutrients in forest soils affect roots and their exposure to toxic ions, which is considered to be a major factor for forest decline (Goodbold et al., 1988; Rehfues, 1991). The resilience of forest ecosystems with respect to soil acidification is determined by the buffering capacity of soils, and biological characteristics of the forest’s tree species. On highly acidic soils with high content of exchangeable aluminum and high level of exchangeable acidity, one of the most productive coniferous forests in the country are growing and some of these forests form the treeline in highland mountain regions (Turok et al., 2000; Stoyanova et al., 2011). This provoked more detailed studies on the chemical reactivity of soils under different mountain-related land-uses, which are present in highland regions and characterization of various acidic and salty adsorption systems determining soil acidity as well as the type of cation exchange with the plant roots. Under natural conditions, these studies may allow assessment of both physical and chemical properties and specifics of acid forest soils. The present study aimed at investigating the role of land-use and vegetation type on soil chemical properties of Cambisols under two mountain land-uses – forests formed by *Picea abies* Karst., *Pinus mugo* Turra., *Pinus sylvestris* L. respectively and one mountain grassland in the highland region of NW Rila Mountains located in Ovnarsko, Moussala and Yasterbovo oko localities.

**MATERIAL AND METHODS**

Four experimental sites in two land-uses (forest land and grassland) typically presented in highland areas were chosen in the region of Northwest Rila Mountain, located between 1600 and 2400 m a.s.l. on slopes with north-eastern exposition. The studied forest land-uses present different pure forest ecosystems formed by *Picea abies* Karst. (Norway spruce), *Pinus mugo* Turra. (Dwarf pine) and *Pinus sylvestris* L. (Scots pine) respectively, while grassland is dominated by species from fam. Poaceae. These sites allow defining the influence of treeline vegetation (trees and grasses) on some chemical properties of soils.

On the basis of the analyses performed for the climatic data collected in FRI-BAS ecological stations located in the treeline area in Northern Rila, some specifics in dynamics of mean annual temperature (MAT) and mean annual precipitation (MAP)
are outlined. The analyzed climatic information for 31 years (1979-2009) in ecological station of FRI-BAS in the treeline area of ‘Govedartsi – Mechit’ in Northern Rila allowed to define a warmer period between 1990 and 1994. For the region it was established a total MAP of 956.9 mm and MAT of 3.7°C, the driest and warmest years being 1993 and 1994. After 1995 it was observed a decrease in mean annual temperature and increase in precipitation. Analyses of precipitation and temperature showed a tendency of decrease of MAT from 1994 to 2009 with one exclusion 1994 (5.3°C). Within the period 1990-2009, 2005 is characterized with the coldest MAT (1.9°C) and the highest MAP (1277 mm). Because of the specifics of the region and local climate no drought period is determined.

The relief is characterized by steep slopes with north-western aspect. The differentiated environmental conditions are suitable for growth of coniferous forest and highland treeline vegetation. The type of soils is Cambisols (WRB, 2015) developed on same underlying geology formed by granite-gneisses rocks. The soils are differentiated according to the national classification of soils of Penkov (1992) and WRB (2015).

Soil chemical properties were determined according to the methodology of Ganev, Arsova (1980) and include: pH in H2O, cation exchange capacity CEC – as indicator for chemical reactivity and colloidal construction of soil profile; strongly acidic ion-exchanger CEC_{SA} - determining the dominated clay minerals; total acidity – H_{8,2}; exchangeable cations with acid and bases functions – exch. Al., exch. Ca, exch. Mg – as indicators for the formed acidic and salty adsorption systems, which determine the soil acidity and agrochemical mobilization or immobilization of elements and therefore the type of cation exchange via plant roots. The cation exchange capacity of soil organic matter (CEC_{som}) is determined theoretically according Schaeffer, Schachtschabel (1982) as indication for participation of SOM in soil CEC. Organic matter has a very high CEC ranging from 250 to 400 meq/100 g (Moore et al. 1998).

The results of chemical properties of studied soils under different vegetation in the highland region of NW Rila are presented in meq/100g and in percent of cation exchange capacity - % CEC.

Experimental site 1 is located at 1600 m a. s. l. in pure forest stand of P. abies with a mean age >120 years in the region of Yastrebovo oko locality. Soil is referred to unsaturated brown forest soil or Dystric Cambisols with full soil profile type OABC.

Experimental site 2 is located at 2380 m in forest formed by pure P. mugo treeline formation in Moussala locality. The soil, characterized by a full soil profile with OABC horizons, is referred to as transitional dark-coloured forest soil between brown forest and mountain-meadow forest soil or Mollic Cambisols.

Experimental site 3 is located at 1740 m in pure forest stand formed by P. sylvestris with a mean age >120 years in Ovnarsko locality. The soil is characterized by full profile with OABC horizons and is referred as unsaturated brown forest soil Dystric Cambisols.

Experimental site 4 is located in the upper part of the slope at 2250 m and forms a grassland in Moussala locality. The land-use history showed that the grassland vegetation has been established there during the last 60 years. The grassland species are presented
by species of fam. Poaceae, *Luzula* sp., *Carex* sp. With relatively plain cover (85%). The thickness of organic horizon is 4.2 cm. The thick A-horizon is followed by AB<sub>1</sub>, and B<sub>2</sub> horizons. This soil is referred to Modic Cambisols.

The soils were sampled in 2017 following the same design for each experimental site: one representative soil profile per site was studied including morphological description on the field and sampling of soil horizons. The analyses were performed in the laboratories of the Forest ecology Department in FRI-BAS following the above mentioned methodology.

**RESULTS AND DISCUSSION**

The soil chemical properties in forest vegetation and land-use in experimental site 1 are presented in Table 1.

The studied soil under *P. abies* is characterized by a strongly acidic soil solution (pH 4.2 – 4.7). The content of soil organic matter in A-horizon was also high (6.2%) and decreased toward depth (1.8%). Accordingly, the cation exchange capacity of organic matter in A-horizon is high, accounting for 50% of CEC. This soil in its organo-mineral constitution could be defined as medium humic soil – organic matter participates in soil CEC in a moderate degree. An essential feature of this Dystric Cambisols formed under an mature pure Norway spruce stand is the progressed acidification - total acidity (H<sub>8.2</sub>) is 79-53% of CEC, and exch. Al is 31 - 25% of CEC. Both parameters have the highest values due to the forest vegetation of Norway spruce, which is a stronger acidic soil conditioner. It covers both weak acidic surfaces of soil colloids and a significant part of the strong acidic positions. Basic exchange cations (exch. Ca and exch. Mg) occupy only smaller shares of strong acidic positions of soil colloids (bases < CEC<sub>Sa</sub>). This indicates that clay mineral structures may be instable, possibly leading to a destruction of clay minerals. This interpretation is confirmed also by the presence of exch. Al which occurs as a result of disintegrated octahedral layer of the crystal lattice. These processes are largely

<table>
<thead>
<tr>
<th>Horizon depth (cm)</th>
<th>pH (H₂O)</th>
<th>SOM (%)</th>
<th>CEC</th>
<th>CEC&lt;sub&gt;Sa&lt;/sub&gt;</th>
<th>Exch. H&lt;sub&gt;8.2&lt;/sub&gt;</th>
<th>Exch. Al</th>
<th>Exch. CA</th>
<th>Exch. Mg</th>
<th>Ca+Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (0 -17)</td>
<td>4.2</td>
<td>6.2</td>
<td>30.3</td>
<td>12.1</td>
<td>23.9</td>
<td>8.5</td>
<td>5.4</td>
<td>1.0</td>
<td>6.4</td>
</tr>
<tr>
<td>B&lt;sub&gt;1&lt;/sub&gt; (17 - 45)</td>
<td>4.5</td>
<td>3.0</td>
<td>17.2</td>
<td>5.5</td>
<td>12.4</td>
<td>5.4</td>
<td>4.3</td>
<td>0.5</td>
<td>4.8</td>
</tr>
<tr>
<td>B&lt;sub&gt;2&lt;/sub&gt; (45 - 63)</td>
<td>4.7</td>
<td>1.8</td>
<td>9.9</td>
<td>2.6</td>
<td>5.3</td>
<td>2.5</td>
<td>3.8</td>
<td>0.8</td>
<td>4.6</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>in meq/100g&lt;sub&gt;soil&lt;/sub&gt;</th>
<th>50</th>
<th>100</th>
<th>40</th>
<th>79</th>
<th>28</th>
<th>18</th>
<th>3</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>in % of CEC</td>
<td>100</td>
<td>32</td>
<td>72</td>
<td>31</td>
<td>25</td>
<td>3</td>
<td>28</td>
<td></td>
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<tr>
<td></td>
<td>100</td>
<td>26</td>
<td>53</td>
<td>25</td>
<td>38</td>
<td>9</td>
<td>46</td>
<td></td>
</tr>
</tbody>
</table>
hidden by the significant SOM content, which contributes much to the formation of cation exchange capacity of these soils (SOM sorption capacity is 50% of T_{8.2}). The physico-chemical mechanisms are resulting in exhaustion of the three-layer clay minerals and formation of kaolinite: oxide-hydroxide mineralogy amid intense formation of acid SOM in the upper soil profile, where it contacts with forest floor and fresh litter inputs, generating organic acids (Ganev, Arsova 1980). This is confirmed by the fact that the total acidity in the A-horizon is nearly two times higher than in the B-horizon.

The soil chemical properties in treeline forest vegetation and land-use in experimental site 2 are presented in Table 2.

The studied soil under treeline Dwarf pine forest is characterized by a strong acid reaction (pH 4.3 – 4.8). SOM content is 6.9% in A-horizon and decreases to 3.5 - 4.6% in B-horizons. The comparatively higher content of SOM in the deepest soil horizon and similar depths with other studied profiles could be indication for a different distribution of roots of this tree species and its root-related inputs into the soil, or bioturbation, but due to the lack of such analyses or studies this could be considered as assumption.

Cation exchange capacity of SOM in this layer, 60% of CEC, is very high. Concerning the sorption capacity the soil is moderate colloidal over the whole profile, based on quantitative diagnosis of studied parameters and colloidal evolution along the soil profile (Ganev, Arsova, 1980). This is a different feature of soil in this site compared with the spruce forest. The soil in this site is similar to dark-coloured forest soils according to the Bulgarian soil classification of Penkov (1992), which are transitional form between typical brown forest soils and mountain-meadow soils, determined by the higher altitude (2300 m) and the treeline vegetation formed by Dwarf pine communities. This soil type corresponds to Mollic Cambisols according to WRB (2015). The content of SOM (%) does not decrease rapidly in depth as soils 1 and 3. Moreover the CEC is relatively stable 20.7-29.4 within the soil profile, which indicates a typical forest soil formation process. Same is observed for the exch. H_{8.2}, while for the typical brown forest soils it decreased sharply below 44-45 cm depth. Regarding the other studied parameters this transitional soil has similarities to sites 1 and 3.

Similar to experimental site 1, an important specific of this soil is progressed

Table 2. Chemical properties of dark-coloured forest soils (Mollic Cambisols) in P. mugo ecosystem, 2380 m

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>pH (H_2O)</th>
<th>SOM (%)</th>
<th>CEC</th>
<th>CEC_{ss}</th>
<th>Exch. H_{4+2}</th>
<th>Exch. Al</th>
<th>Exch. Ca</th>
<th>Exch. Mg</th>
<th>C_ao+Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (0-20)</td>
<td>4.3</td>
<td>6.9</td>
<td>29.4</td>
<td>15.1</td>
<td>21.2</td>
<td>6.7</td>
<td>7.4</td>
<td>0.8</td>
<td>8.2</td>
</tr>
<tr>
<td>B_1 (20-47)</td>
<td>4.8</td>
<td>4.6</td>
<td>20.9</td>
<td>8.2</td>
<td>15.7</td>
<td>6.5</td>
<td>3.5</td>
<td>1.7</td>
<td>5.2</td>
</tr>
<tr>
<td>B_2 (47-58)</td>
<td>4.3</td>
<td>3.5</td>
<td>20.7</td>
<td>4.6</td>
<td>15.4</td>
<td>4.5</td>
<td>3.9</td>
<td>1.4</td>
<td>5.3</td>
</tr>
</tbody>
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<th>CEC</th>
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<td>15.1</td>
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<td>7.4</td>
<td>0.8</td>
<td>8.2</td>
</tr>
<tr>
<td>B_1 (20-47)</td>
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<td>4.6</td>
<td>20.9</td>
<td>8.2</td>
<td>15.7</td>
<td>6.5</td>
<td>3.5</td>
<td>1.7</td>
<td>5.2</td>
</tr>
<tr>
<td>B_2 (47-58)</td>
<td>4.3</td>
<td>3.5</td>
<td>20.7</td>
<td>4.6</td>
<td>15.4</td>
<td>4.5</td>
<td>3.9</td>
<td>1.4</td>
<td>5.3</td>
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<th>CEC</th>
<th>CEC_{ss}</th>
<th>Exch. H_{4+2}</th>
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<td>4.5</td>
<td>3.9</td>
<td>1.4</td>
<td>5.3</td>
</tr>
</tbody>
</table>
acidification and its chemical characteristics resemble those reported in Table 1 for Cambisols under spruce.

The soil chemical properties in forest vegetation and land-use in experimental site 3 are presented in Table 3.

It shows that similar to other forest land-uses – sites 1 and 2, the studied soil is characterized by a strong acid reaction (pH 4.3 – 5.0). Its soil organic matter content is also high in A-horizon (6.7 %), and sharply decreases with depth down to 2.0 %, which is specific feature of Cambisols. The sorption capacity of SOM in A-horizon is high – 58 % from T_{8.2} and this similarity to the experimental site 2 referred this soil to a strong humic type.

Like the two other studied forest soils, site 3 is also characterized by an advanced acidification, which decreases toward deeper soil horizons. The total acidity H_{8.2} is 75-54 % from CEC, while exchangeable Al varying between 25 % and 46 % of CEC. The strong bases exchangeable cations are bound only partially via strong acidic ion-exchange of soil colloids (bases < CEC_{SA}), indicating that acidity cannot be fully neutralized by strong basis and, therefore, clay structures are thermodynamically instable. In this soil, clay minerals are about to be disintegrated. This interpretation is supported by significant contents of exchangeable Al, the highest value compared to other studied soils and increased toward 46 cm of depth. It is resulting from the destruction of the octahedral layer of the clay crystal lattice. According to the physico-chemical properties, such processes occur along the entire soil profile and are very advanced, probably resulting in a complete exhaustion of montmorillonite and a significant part of illite-kaolinite clay minerals. These data tentatively indicate changes in clay mineralogy from illite-kaolinite dominated (CEC_{SA} 60-50 % of CEC), through kaolinite dominated (CEC_{SA} 40-30 % of CEC) to kaolinite oxide-hydroxyde (CEC_{SA} 30-20 % from CEC) dominated groups in superficial horizon (Ganev, Arsova, 1980).

Morphologically these processes are hidden because of the high SOM content that contributes substantially to the formation of ion exchange capacity of these soils (CEC_{SOM} is 58 % of CEC). Therefore, this ongoing process of clay mineral disintegration is combined with intense formation of acid SOM accumulating in the surface horizon.

**Table 3.** Chemical properties of unsaturated brown forest soils (Dystric Cambisols) in a *P. sylvestris* ecosystem, 1740 m

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>pH (H₂O)</th>
<th>SOM (%)</th>
<th>CEC</th>
<th>CEC_{SA}</th>
<th>Exch. H₈₂</th>
<th>Exch. Al</th>
<th>Exch. CA</th>
<th>Exch. Mg</th>
<th>Ca+Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (0-21)</td>
<td>4.3</td>
<td>6.7</td>
<td>27.1</td>
<td>13.8</td>
<td>20.2</td>
<td>6.9</td>
<td>6.4</td>
<td>0.5</td>
<td>6.9</td>
</tr>
<tr>
<td>B₁ (21-44)</td>
<td>5.0</td>
<td>6.2</td>
<td>22.7</td>
<td>8.8</td>
<td>15.8</td>
<td>7.7</td>
<td>2.9</td>
<td>1.5</td>
<td>4.4</td>
</tr>
<tr>
<td>B₂ (44-66)</td>
<td>5.7</td>
<td>2.0</td>
<td>15.2</td>
<td>4.9</td>
<td>9.9</td>
<td>5.7</td>
<td>2.3</td>
<td>0.3</td>
<td>2.6</td>
</tr>
</tbody>
</table>

in meq/100g soil

| 58 | 100 | 75 | 26 | 24 | 1.8 | 26 |
| 100| 38  | 70 | 34 | 13 | 6.6 | 19 |
| 100| 32  | 54 | 46 | 18 | 2.4 | 21 |
The soil chemical properties in grassland vegetation and land-use in experimental site 4 are presented in Table 4.

It shows that the soil is strong to medium acidic (pH 4.3 to 5.3). The high SOM content in the topsoil gradually decreases with depth from 7.0% in A-horizon to 3.5% in B2-horizon). Accordingly, the cation exchange capacity of SOM in the surface horizon is 36% of the soil sorption capacities, i.e. only about half of that of the forest soils. This soil in its organo-mineral composition can be refereed as humic-mineral soil, which differs from the soils under coniferous treeline vegetation.

An essential feature of the soil under mountain grassland is its low acidity. The total acidity (exch. H$\text{\textsubscript{8.2}}$) is 15-13% of CEC, and the content of exchangeable aluminum accounts for only 1 to 3% of CEC. Bases exchange cations (Ca and Mg) contribute significantly to the soil sorption capacity (44-91%), which, together with the low acidity, is an indicator for the important role vegetation plays in controlling soil physico-chemical properties in the highland mountain area of Moussala locality in Rila.

The data suggest that clay minerals consist mainly of montmorillonites, with the soil evolving towards illite-kaolinite mineralogy. These properties also distinguish the grassland soil from those under coniferous forest land-use in the studied highland region where the predominant clay mineralogy is supposed to be kaolinite-oxide-hydroxide structures and contemporary disintegration of clay minerals. Together, grass vegetation provides more exchangeable bases that neutralize the reactivity of acidic OM functional groups and aluminum and protects the soil from destructive processes, as it is observed in the forest soils.

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>pH (H$_2$O)</th>
<th>SOM (%)</th>
<th>CEC</th>
<th>CEC$_{\text{SA}}$</th>
<th>Exch. H$_{\text{8.2}}$</th>
<th>Exch. Al</th>
<th>Exch. CA</th>
<th>Exch. Mg</th>
<th>Ca+Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>A$_1$ (0-18)</td>
<td>4.3</td>
<td>7.0</td>
<td>43.3</td>
<td>24.9</td>
<td>6.6</td>
<td>0.6</td>
<td>11.2</td>
<td>7.9</td>
<td>19.1</td>
</tr>
<tr>
<td>B$_1$ (18-40)</td>
<td>5.1</td>
<td>4.5</td>
<td>30.5</td>
<td>18.2</td>
<td>4.8</td>
<td>0.6</td>
<td>8.3</td>
<td>12.2</td>
<td>20.5</td>
</tr>
<tr>
<td>B$_2$ (40-54)</td>
<td>5.3</td>
<td>3.5</td>
<td>20.8</td>
<td>10.4</td>
<td>2.7</td>
<td>0.6</td>
<td>11.2</td>
<td>7.7</td>
<td>18.9</td>
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</tbody>
</table>

The soil chemical properties in grassland vegetation and land-use in experimental site 4 are presented in Table 4.

CONCLUSIONS

Soil chemical properties of studied land-uses in the highland region of NW Rila showed that forest (Norway spruce, Dwarf pine and Scots pine) soils have relatively similar acidic characteristics that define their soil taxonomy as Dystric or Mollic Cambisols. These soils are strongly humic, moderate colloidal, with low to moderate bases
saturation. They are most likely dominated by a kaolinite-oxide-hydroxide mineralogy. Their exchangeable aluminum is substantial and distributed along the entire profile. Consequently, in these soils podzolisation is commencing, optically hidden by the high content of organic colloids and the intensive SOM accumulation in topsoil induced by the regular inputs of organic acids from forest litter. In contrast, the soil under grassland vegetation has little exchangeable aluminum but a high base saturation, which increases with depth, classifying this soil as a Modic Cambisols.

Coniferous vegetation fosters disintegration of clay minerals and ongoing acidification, whereas, under otherwise similar climatic and geological conditions, grassland use is characterized by an absence of these processes. Differences in content and composition of SOM influence the characteristics of these soils especially in the A-horizons. High levels of exchangeable aluminum and a common high acidity may lead to a phosphate and molybdenum deficiency, ammonium negatively feeding deficiency of bases and an toxic excess of amphoteric elements, due to mobilization of strong-acidic system of soil colloids in soils under forest land use.

In conclusion, soil chemical properties can be used as valuable indicators to assess the effect of land-use on the stability of the soil system in mountain ecosystems of Rila Mountain.

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REFERENCES


Ganev, S., Arsova, A. 1980. Methods of determining the strongly acid and the weakly acid cation exchange
in soil. Soil Sci. and Agrochemistry, 15(3), 22–33 (In Bulgarian)

E-mail: zhiyanski@abv.bg