FOREST VEGETATION PECULIARITIES OF WASTE BANKS FROM UNDERGROUND COAL PRODUCTION

Maria Sokolovska, Raya Gateva, Alexander Delkov
Forest Research Institute - Sofia

Abstract

The ways of evolution of tree and shrub species, which have been used in the reclamation of a waste bank from underground coal mining were found, as well as the influences of these species upon the soil formation processes 35-40 years after planting. Their present status was determined, as well as the perspectives for their development in the future in this anthropogenic, both according to origin and way of using, system. The reclaimed waste bank is a part of the suburban park near the town of Pernik.

Key words: reclamation, waste banks, underground coal production, soil formation processes, anthropogenic system

INTRODUCTION

During the coal production in the mining regions, huge territories with fertile soil are being destroyed. Their reclamation and adaptation to the environment is a problem, which exceeds the national borders. The mostly radical way for reclamation of these lands is their treatment with different vegetation species.

First attempts for landscape design of terrains destroyed by underground coal production in Bulgaria have been carried out in the region of the town of Pernik, mine “Temelko Nenkov”, in 1957-1958 (Prokopiev, 1968). The results from the reclamation of this waste bank are very good. After the development of the introduced tree and shrub vegetation, the waste bank has been converted from a site with drastically disturbed by anthropogenic activity environment into a basic recreational place of the town. The place has been differentiated as suburban park and included in the green zone of the Sofia-Pernik agglomeration.

The purpose of this study is to establish the forest vegetation peculiarities of the waste bank, i.e. how the vegetation species have developed, what is their status today and what are the perspectives for their future development in this anthropogenic, both according to origin and way of using, system.

MATERIALS AND METHODS

The waste bank, where the suburban park has been created, has an area of 15 ha and is in a close proximity to the residential areas and the sport complex of the town.
of Pernik. It is situated in the southern slopes of the Lyulin mountain. Phytogeographically it belongs to the zone of the oaks and the Austrian black pine. The duration of the growing period is 6.5 months. The annual amount of precipitations is 604 mm and the average temperature – 9.9 °C. Pernik valley is characterised by durable drought period in July - August.

The suburban park has been created on a waste bank, formed by substrata with various composition and structure. Before the vegetation has been introduced, whole and half-weathered rock pieces from clay schists, marls, coaly shale have been observed in the upper layers. There is an absence of a humus horizon. During the period 1957 - 1968, a biological reclamation has been carried out on the waste bank through introduction of tens of thousands of trees and shrubs from 5 coniferous and 41 deciduous species, among them 19 tree and 22 shrub ones. The status of the tree and shrub vegetation has been determined through the route method according to external, visible indicators - condition and shape of the crown, changes in the leaves, including necroses, withering, falling, damages from pests and diseases. The biometrics indices average diameter and height have been compared with the standard tables for growth and productivity of the stands. Measurements have been carried out of the annual radial growth of the main species: Robinia pseudoacacia L., Fraxinus americana L., Quercus rubra L., Tilia sp. For the observation of the changes in the system “soil-plant”, the water-physical and chemical properties of the soil substrata have been studied, as well as the regime of the limiting factor - the moisture.

RESULTS AND DISCUSSION

As a result of the big drought during the last years, all tree and shrub species have worsened sanitary-hygienic and ornamental properties. There is a considerable amount of withered branches. Strongly damaged are Betula pendula Roth and Populus alba L. var. pyramidalis. In bad condition are the conifers. Only Thuja orientalis L. shows to a certain extent adaptivity to the conditions of the waste bank. In a best status are the shrubs, which form the open spaces. Huge tufts have been formed by Forsythia intermedia Zab., Symphoricarpos albus Blake, Philadelphus coronarius L., Spiraea sp., Berberis vulgaris L. and all species have reached their maximum size. The shrubs planted along the slopes are in considerably worse condition - poor flowering, shape and withered branches.

The unfavourable for the plants combination of worsened climatic indices (high summer temperatures and insufficient precipitation), the specific peculiarities of the soil substrata, determined by their technogenic origin, polluted environment, recreational overloading, have negatively influenced on the growing indices height and diameter of the tree species.

The data about the biometrics indices, measured 27-28 and 38-39 years after the planting, are given in Table 1. The height increment has decreased for all studied species. The diameter increment decreases in a less degree but it is a fact as well. The best indices has Gleditsia triacanthos L. (0.73 m/year against 0.45 m/year for 28-year period).

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<td></td>
<td>(m)</td>
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<tr>
<td>Betula pendula Roth</td>
<td>1.21</td>
<td>13.5</td>
<td>20.6</td>
<td>2.48</td>
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<tr>
<td>Fraxinus americana L.</td>
<td>1.06</td>
<td>8.7</td>
<td>16.5</td>
<td>0.66</td>
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<tr>
<td>Robinia pseudoacacia L.</td>
<td>1.72</td>
<td>23.2</td>
<td>37.7</td>
<td>0.99</td>
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<tr>
<td>Quercus rubra L.</td>
<td>1.1</td>
<td>10.3</td>
<td>17.5</td>
<td>0.11</td>
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<tr>
<td>Tilia sp.</td>
<td></td>
<td>10.5</td>
<td>22.9</td>
<td>0.17</td>
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During the last 14-15 years from the 38-39-year period, the diameter increment has increased for Betula pendula Roth (0.86 cm/year) and Quercus rubra L. (1.32 cm/year), which probably is due to the strong thinning of the stands.

As an addition to the studies in the suburban park, measurements have been carried out of the annual radial growth on stem discs of Robinia pseudoacacia L., Fraxinus americana L., Quercus rubra L., Tilia sp. (Fig. 1). Robinia pseudoacacia L. and Tilia sp. and Fraxinus americana L. have a period of adaptation during the first years after planting, which is expressed through slower growth. For Robinia pseudoacacia L. and Tilia sp. this period is 4-5 years and for Fraxinus americana L. - 5-6 to 11 years. Quercus rubra L. adapts most rapidly to the non-typical environmental conditions and as far as after the 2nd - 3rd year begins to increase rapidly its radial growth. The growth conditions of the waste bank provide relatively good conditions for development of the tree vegetation until its 23-24th year of age, after which the growth is considerably slower. By the 20th year the radial growth of Robinia pseudoacacia L. is 7-8 cm, of Quercus rubra L. - 6 cm, Tilia sp. - 6-8 cm and Fraxinus americana L. - 4-6 cm. The radial growth shows dependence on the exposure of the bank's slopes and in all measurements the growth is lowest in northern direction. Its values are higher in southern and western directions. For some of the species (Quercus rubra L.), growing on western slopes, the growth in eastern direction is bigger. It is obvious that the influence of the light is in close relation with the rest of the growth factors, i.e. the soil conditions, the air temperature, soil and air humidity. The complex influence of the high temperatures and the low values of soil and air humidity during the bigger part of the growing season, in connection as well with the soil substrata poor of nutrition elements, are a reason for the poor growth of the trees on the western slopes and also on the whole waste bank.

The time and the influence of the vegetation have reflected on the status of the soil substrata. The forest litter has begun a progressive evolution with a presence of fresh waste (f), fermentative subhorizon (f) and poor humification (h) only on separate places, on heavier and moist substrata. The bigger part of the soil cover has a coverage of fresh waste and on the slopes with a declination of 30° and more, the soil erosion dominates and there is an absence of litter.
From the data about the mechanical composition it can be seen that the soil substrata on the eastern part under the *Fraxinus americana* L. formations are most clay, heavier, poorly porous and aerated. The bigger quantities of silt fraction fill the gaps between the coal fragments and are situated in depth along the profile.

Peculiarity of the substrata under *Robinia pseudacacia* L. and mixed *Robinia pseudacacia* L. societies is that in the increased sandy fraction as quantity there participate many fine coal fragments and cinder, which have no qualitative, i.e. nutritional, value but increase as a whole the aeration of the soils and therefore the water perviousness of the root-inhabiting substrata. This protects the plants to a great extent in critical situations.

The different situations of the oak stands have not influenced significantly on the correlation between the clay and sandy fractions. According to the fine fraction - the silt - its increasing to 40-41% is observed on concave parts on the slopes. On the open areas or the glades there are difficult conditions in the surface layers, where the sandy elements or the similar ones are in abundance (77%). These substrata have low values of the relative density.

According to the data about the pH of the soils, the object as a whole is too alkaline, i.e. the soil substrata are rather slightly acid to neutral and in some cases even alkaline (pH over 7). Under the *Robinia pseudacacia* L. stands the acidity is higher, it can reach up to pH 3.1-3.4. In general, the higher parts of the object are with more favourable regime of acidity, higher degree of saturation with bases (over 90%). The phosphorus content is increased (15.22 mg/100 g of soil). According to the nitrogen and carbon, there were no tendencies established in their change. This has its explanation that here the processes of soil formation haven’t reached their balance situation, i.e. the pedoclimax. The influence of the vegetation factor is still low during the time because of the young age of the suburban park (35-40 years).

The analyses of moisture change in the soil for root-inhabiting layer show that even in the driest months for the region (July - August), the percentage of the moisture doesn’t drop under 12. The soils in the higher parts of the suburban park have a minimum of the moisture processes first in September, i.e. later compared to the surface layers. This is a reason to maintain that during the drought periods, in spite of the unfavourable, strongly heated dark surface layers, there is moisture in the root-inhabiting layer, which is enough for the plants. In this case, the loosened surface soil layer plays the role of natural mulch - a fact, pointed out by other authors as well (Prokopiev, 1968).

**CONCLUSIONS**

Having in mind the obtained results, it can be accepted that the landscaping of the waste banks of the coal production is a possible and radical activity for liquidation of their negative impact on the environment and an opportunity for establishing of recreational areas near industrial and urbanised centres.

During the selection of species, their tolerance to the environmental conditions must be taken into account. In this case most tolerant are: *Gleditsia triacanthos* L., *Quercus robur* L., *Fraxinus americana* L., followed by *Robinia pseudacacia* L. and *Tilia tomentosa* Moench.

During the maintaining activities, including watering, all studied deciduous species can successfully play their functions as healers of the environment.

The coniferous species must be used moderately, after a careful selection, and after their planting they need a systematically and purposefully carried out maintenance (earthing up, watering, manuring) is necessary.

After the forming of the canopy of the plantations, i.e. after they reach their 20th year of age, a yearly intervention is necessary for regulation of the composition and prevention of the ornamental values of the plantations.

In the future activity for reclamation of the waste banks, the soil formation process could be also supported by the formation of the relief through not allowing of slopes with big declinations. In spite of the soil-strengthening role of the planted vegetation there, because of the peculiarities of the forming material and the insufficient density in depth, the soil erosion cannot be avoided even after 35-40 years. Landslides can be often observed in some places, which have destroyed the entirety of the communication system.

**REFERENCES**


Forest Research Institute BAN,
132, St. Kliment Ohridski Blvd.; 1756 Sofia; Bulgaria;
e-mail: mariagrozewa@hotmail.com

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