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The articles appearing in this journal are indexed and abstracted in: DOI, EBSCO Publishing Inc. and AGRIS (FAO). The journal is accepted to be indexed with the support of a project № BG051PO001-3.3.05-0001 “Science and business” financed by Operational Programme “Human Resources Development” of EU. The title has been suggested to be included in SCOPUS (Elsevier) and Electronic Journals Submission Form (Thomson Reuters).

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Ecological characteristics of reclaimed areas in Pernik mines region, Bulgaria

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(Manuscript received 5 August 2016; accepted for publication 29 April 2017)

Abstract. A referential literary analysis of the reclaimed area around coal mines near the town of Pernik, Bulgaria, is made in this paper. Affected areas (damaged, altered, etc.) around mining companies in the country are a serious environmental problem, including the territory of coal mines of Pernik which is a problem for the country. The area affected by the mining industry around Pernik occupies a territory of about 30 000 ha. As a result of the natural factors and the anthropogenic impact this region is characterized by a rather complicated soil situation. There are markedly expressed erosion and land-sliding processes on the slopes as well as conditions for surface over-humidification, swamping and salinization in some land lowering and on separate sections of the terraces of the rivers. The situation has acquired an exceptionally technogenic character after the development of the mines, the enormous pits and heaps and the construction of the industrial pads and equipment. The reclamation of environment in industrial areas is closely connected above all with the reclamation of disturbed areas and materials and can be performed in different ways according to their properties and economic effect. In connection with the extremely unfavorable conditions of a significant proportion of disturbed technogenic areas one of the basic methods is planting forests of production character or for recreational purpose. The inevitable degradation of the landscape can be corrected mainly by technical and biological reclamation of the disturbed terrains. A large part of the green belt of the town of Pernik was constructed on former heaps – mainly by afforestation. These activities have solved the problem of the separation of the town from the mining sites by a noise-preventing and dust-stopping embankment especially when the prevailing northwestern and northeastern winds are considered. Our main goal is to analyze and suggest the appropriate methods for biological reclamation of territories degraded by mining activities in Pernik coal mines region. That all proves the relevance and necessity of fundamental research and experimental work to identify opportunities for its targeted guidance and acceleration of the process. It has been established that almost all lands provided for agricultural uses are not cultivated and enter the fund of deserted lands. The basic reason for that fact is the lack of projects for biological reclamation and the insufficient justification of technical reclamation.

Keywords: Pernik mines region, coal mining, disturbed areas, biological reclamation, plants

Introduction

Modern intensive industrial development to a constantly growing degree reinforces the anthropogenic impact on the various components of the natural environment - terrain, soil, water, air, vegetation (Mitkov et al., 2013). One of the main problems in this regard is the total destruction of natural surface and vegetation by the influence of the mining industry, which leads to abrupt disturbance of the ecological balance in these areas and the transformation of large territories into “industrial deserts” (Zheleva, 2010). This issue is important and topical for our country. Banov (2005) reported that the greatest disturbances and contamination of environment in Bulgaria are due to the mining industry (Figures 1 and 2).

In aggregate data so far over 30 000 ha have been disturbed with a clear trend to progressive increase of the phenomenon
(Zheleva, 2010). In this regard, reclamation and optimization of these technogenic landscapes is becoming more and more important with a certain complex environmental, social and economic impact (Kuzev, 2002). Depending on the composition and properties of the substrates and the specific economic, environmental and social impact reclamation can be performed in different ways - biological, hydro-technical, residential and industrial development (Regulation No. 26, 1996). In recent decades, in Mini Pernik only technical reclamation has been used (Hristova et al., 2011). The main goal of this paper is to analyze and suggest the appropriate methods for biological reclamation of degraded by mining activities territories in “Pernik Mines” PLC region.

**Research sites in “Pernik Mines” PLC region**

The location of “Pernik Mines” PLC areas was conditioned by the natural development of mining in the Pernik mining basin (Arsov, 1997). To a great extent, the town planning of Pernik is a function of the occurrence and liquidation of mining pits and sites from the infrastructure of Pernik Mines. They are related to the regulations of coal mining. In different periods of time there have been the following mines:

- Mines for open pit mining: “Kutsian” (+9th of September), “Republika”, “Al. Milenov”.
- Mining sites: one in “Bela Voda mine”, one in “Sventa Anna mine” and one in “Teva mine”.

The harmful impact of the underground mining activities is connected with rock movement (sinking and destruction) on the surface, destruction of buildings and facilities and/or swapping of the sunken terrain. Generally the urban development of the town is outside the dangerous zones. And where the neighborhoods were built prior to the exploitation of the deposits, expropriation and compensation with houses in safe areas is necessary. The sunken land has been reclaimed and handed over to other organizations for use in accordance with applicable regulations.

As far as open mines are concerned there is just one that is still functioning – “Republika” mine. “Kutsian” mine was closed in 1958 and “Al. Milenov” mine was closed in 1981. At the moment part of the former pit of “Kutsian” mine is used as sludge storage for “Republika Thermal Power Plant”. The remaining part has been reclaimed and handed over to other organizations. The pit of the former “Al. Malinov” open mine is used for a railway dump of the “Republika” mine. Its bottom has turned into a lake as part of the water catchment area.

The impact of the open mining activities is expressed mainly in the following consequences:

- Disturbance of the landscape and the soil layer;
- Seismicity during the performance of explosion activities;
- Dusting of the air and noise from the heavy mechanization.

**Conditions of the above sites**

The scale of the transformations of the natural landscapes of the four sites from Pernik Mines – “Sventa Anna mine”, “Teva mine”, “Bela Voda mine” and “Republika mine” is extremely large as the share of the technogenic (anthropogenic) landscapes constantly increases (Arsov, 1997). The most essential changes in the existing landscape structure occur alongside the open mining developments. In them there already are new, totally different from the ones before combinations of landscape components. The disturbance of the natural landscapes is basically performed at the expense of agricultural land and partially at the expense of the forest fund, the settlement fund and infrastructure facilities (Donov, 1976).

It is necessary to add that in the natural landscape, outside the territories for open mining, there are already deformities of the terrain and landslides as a result of the underground mining. The deteriorated general technogenic landscape structure of the open mines is further worsened by the compacted technical infrastructure – facilities for transportation of the coal and rock waste, road network, railway lines, power lines, etc. The total transformation of the natural landscapes has led to a completely destroyed plant component and thorough alteration of the soil-ecological conditions.

Therefore, at first there must be development of a single concept of the structure of the territory and the landscape within the range of the open mining activities of Pernik Mines – a concept that will be based on the “Method of Landscape-Ecological Planning of Territories”. A separate project for the planning of landscape, based on the already developed concept must be implemented for every open mine and its adjacent dump heaps. Planting must be a priority in the transformation of landscape by reclamation.

In conclusion, we consider that an environmental risk exists due to the contaminated mining water, which flows into the gullies and therefrom into the Struma River. There is a necessity for establishment of a monitoring system for control of the mining water and design of the adequate water treatment facilities must be developed based on the data obtained.

**Total area of the territory of the site**

The terrains which have been acquired and conceded in the more than 100-year-old history of Pernik Mines at the moment amount to 13226 decares, including 2808 decares occupied by buildings and facilities. Besides the terrains of Mini Pernik PLC quoted above, there are also other terrains as follows:

- For the Central Management Department – 338 decares;
- For the area of the former Kutsian mine (+9th of September) – 100 decares;
- Rudartsi village – 182 decares for a recreation base.

**Geographical location, contemporary relief and soil differences**

The Municipality of Pernik is located in the Balkan sub-area of the Mediterranean soil area, the subtropical xerophyte-forest European soil sector of Luvisols, Leptosols and Vertisols. In the periphery of the valley large proluvial tails have been formed. According to the scheme of soil-geographic zoning of Bulgaria, the land of Pernik falls into the Kraishte-Gornostrumski soil region from the Southern Bulgarian xerothermal soil zone. The town of Pernik and its adjacent area falls into the Znepolski and Vitosha region from the Struma River. There is a necessity for establishment of a monitoring system for control of the mining water and design of the adequate water treatment facilities must be developed based on the data obtained.
The deteriorated ecological conditions are a prerequisite for better landscape architecture of the town of Pernik and for restoration of the healthy and sustainable urban eco-system by using the degraded terrains for planting. At the same time part of the degraded terrains can be used for other urban planning or industrial needs without disturbing the natural soils of the suburban eco-system.

Climatic and meteorological data of the studied area

The territory under survey occupies part of the Tran-Pernik sub-area of the Kraishite-Vitosha area. It has rounded hilly surface. The altitude is from 600 to 900 m, with an average altitude of 730 m. The highest peaks in the location are Kika and Uzusitsa – 854 m, and the lowest elevation is at Batanovtsi. Biala Voda Mine is located to the west of Pernik and exploits the raw materials from the northwestern slopes of Golo Bardo. According to the climatic zoning the area falls into the moderate continental climatic sub-area – the high fields of Western Middle Bulgaria (Sabeev and Staney, 1963). The terrain has a hilly relief and is situated in a valley of a comparatively high altitude. Winter is too cold here with minimal degrees from -2 to -3.5 °C in January on average. The number of days with minimal temperature of < 10°C for the three winter months is between 15 and 20. About 50-55 days of the winter the average temperature around the clock is below 0°C. A characteristic feature of the area is the large frequency of fog – about 15-20 days for the three winter months. Winter precipitation is the lowest – about 80-120 mm, mainly snow. Around 80 days of the year are characterized by snow cover. Spring is comparatively cool. Spring precipitation is higher than that of winter - 147 - 175 mm on average. Summer is also rather cool. The yearly precipitation has continental character, the maximum being in June and the minimum – in February. The morphographic conditions influence the regime of winds, which are light with frequent calms. The climatic elements: precipitation, temperature, evaporation and winds have an impact on the value of the run-off and regime of the surface and underground water. Having in mind all these characteristics, it is important to clarify the most essential meteorological elements. The data has been taken from the meteorological station of Pernik, which has an altitude of 700 m.

Plants

Data of previous research (Vasilev and Andreev, 1983) and present observation of the floristic composition of the grass vegetation having naturally occupied the terrain – vegetation of different origin and age, shows that three stages can be distinguished - weed - ruderal, wheat - ephemeral and rhubarb - leguminous. Sharp boundaries among the different stages are not available – neither in time, nor in space.

On the heap of underground mining Maksim Taban the total projective cover of the surface reaches 80-90 %, which already corresponds to a comparatively advanced stage of restoration of the grass vegetation – in 1978 it was 70-80%. The kinds of grass that are found there are Anthemis coluta L., Bromus commutatus, Avena fatua, Senecio vulgaris L., Poa anna L., Pestuca pratensis, Aramarthia albus L., Dacous carola L., etc. (Zheleva, 2002). In different parts of the heap of Maksim taban, which has a mound-shaped form with rather steep slopes there are the three types of plant vegetation. The prevailing type is the wheat – ephemeral one but in certain parts there are also the wheat-ruderal and the rhubarb-leguminous stages.

The aims of forest reclamation in the region are putting a stop to the erosion of heaps and the pollution of air by dust and gases from the self-igniting remains of coal. In the beginning, until 1990 the forestry activities were performed without any leveling of the terrains. At present the heaps are transformed into terrains which are more convenient to work on and favor the growing of the saplings. It must be noted down that in the aspect of afforestation or biological reclamation the main role is played by forestry. Pernik Mines provide the terrains in an unsuitable or difficult for assimilation state. The first attempts for landscaping of the heaps of Pernik mines began in the
1920s in the heaps of Kalkas Mine. They were mostly amateur and had mainly sanitation-hygienic purposes. However, in forestry afforestation is made not only for ecological but also for economic appropriateness. Therefore, an evaluation of tree production must be made assessing the sustainability of the tree types as well as their wood-producing opportunities.


The most sensitive kinds are *Acer negundo*, *Tilia cordata* Mill., *Aesculus hippocastanum* L., *Betula alba* L., *Acer dasyacarpum* Ehrh., *Fraxinus americana* L., *Tilia argentea* Desf. is in medium position. *Pinus nigra* Am., *Juniperus virginiana* L. and *Biota orientalis* Endl. are in good condition, but *Picea abies* is in very bad condition and is not to be recommended. The nature of its resistance must be appropriate to the purpose of landscaping. The use of favourable special functions of trees is most important and the logging function is secondary in importance. Out of all tree species *Pinus nigra* Am. has the largest participation by area – 60.4%, followed by *Robinia pseudoacacia – 7.1%. Betula alba L. and *Pinus sylvestris* are almost equal by area – 6%, followed by *Populus pyramidalis* Roz, *Quercus rubra* and *Fraxinus excelsior*.

Because of the heavy disturbance of the relief, the geological base and soils, the reclamation of the degraded terrains with valuable vegetation will be difficult and the types of trees that can be used in reclamation must be the same as the above mentioned. The selection of plant species is compliant with the environmental conditions of altitude, exposure, precipitation, acidity/alkalinity and partial salinization of the substrates with a lot of rock content. Forestry reclamation of the area aims at preventing erosion of the heaps and pollution of the air by dust and gases from the self-igniting water and waterside landscapes. The destroyed natural landscapes have is secondary in importance. Out of all tree species around the year 2016

<table>
<thead>
<tr>
<th>Tree Species</th>
<th>Sum of tree growth around 2016 in m³</th>
<th>Supply around the year 2016 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pinus sylvestris</td>
<td>2 495</td>
<td>5 015</td>
</tr>
<tr>
<td>2. Pinus nigra Am.</td>
<td>15 700</td>
<td>24 275</td>
</tr>
<tr>
<td>3. Quercus rubra L.</td>
<td>350</td>
<td>525</td>
</tr>
<tr>
<td>4. Quercus cerris</td>
<td>130</td>
<td>270</td>
</tr>
<tr>
<td>5. Ulmus</td>
<td>45</td>
<td>75</td>
</tr>
<tr>
<td>6. Betula</td>
<td>1 820</td>
<td>2 730</td>
</tr>
<tr>
<td>7. Acacia</td>
<td>1 600</td>
<td>2 830</td>
</tr>
<tr>
<td>8. Aesculus</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>9. Acer</td>
<td>80</td>
<td>205</td>
</tr>
<tr>
<td>10. Tilia platyphylllos</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>11. Fraxinus americana</td>
<td>85</td>
<td>130</td>
</tr>
<tr>
<td>12. Fraxinus excelsior</td>
<td>860</td>
<td>1 710</td>
</tr>
<tr>
<td>13. Populus Bachelieri</td>
<td>1 970</td>
<td>3 005</td>
</tr>
<tr>
<td>14. L - 214</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>15. Populus regenerata</td>
<td>150</td>
<td>225</td>
</tr>
<tr>
<td><strong>Total amount</strong></td>
<td><strong>24 200</strong></td>
<td><strong>41 075</strong></td>
</tr>
</tbody>
</table>

Landscape of the disturbed territories, measures for its restoration

The greatest risk for disturbance of environment in the area is the total alteration of landscape. As a result, the conditions for development of the flora and fauna in the region are completely disturbed, too. The hydro-geological and hydrological conditions have also been disturbed. The destroyed natural landscapes have been replaced by anthropogenic ones, which are aesthetically unacceptable being in proximity to the urban area. A profound development of a concept for landscaping of the whole region is necessary, considering the urban building plan for the suburbs of the town. As a result of this concept it is necessary to develop particular project solutions for landscape patterns (Zheleva, 2002)

The following prognosis principles for the impact and structure of landscape can be formulated:

1. Conservation and optimization of the existing natural landscapes, which are located outside the limits of the mines and the heaps in the outlined boundaries of the mine properties.

2. From the point of view of landscape in relation with ecology and aesthetics it is appropriate to fully preserve the agrarian, forest, water and waterside landscapes.

3. The already existing technogenic landscapes and those that will appear after the future open pit mining in Mini Pernik must be restored by engineering-technical and biological reclamation. The inner diversity of the cultural landscape must correspond to the conditions of its sustainability to the ecological and aesthetic requirements.

4. The reclamation of the territories in the mines where the mining activity has ceased must be accelerated. Deserted places such as heaps, technical equipment and infrastructure elements must not remain in the newly created cultural landscapes.

5. In the restructuring of landscape by reclamation priority must be given to planting, having in mind its special functions in the landscape and also the creation of pasture landscapes with good-
quality grass composition.

6. It is necessary to develop a single concept for the design of the territory and the landscape within the range of Pernik Mines.

**Results and recommendations based on research done over the years**

The inevitable degradation of the landscape can be corrected mainly by technical and biological reclamation of the disturbed terrains. A large part of the green belt of the town of Pernik was constructed on former heaps — mainly by afforestation with *Accacia, Betula Populus*, bushes, *Abies* and *Pinus* (Prokopiev, 1962). These activities have solved the problem of the separation of the town from the mining sites by a noise-preventing and dust-stopping embankment especially when the prevailing northwestern and northeastern winds are considered.

The issues of the harmful seismic effect are solved mainly by developing specialized projects for drilling-explosive activities of such parameters that can neutralize the seismic effect. The mining waters in underground and open pit mining are previously deposited and clarified in artificially formed water catchments. After that they are pumped out and gathered in natural water receivers such as gullies and rivers which flow into the Struma River.

It has been established that almost all lands provided for agricultural use are not cultivated and enter the fund of deserted lands. The basic reason for that fact is the lack of projects for biological reclamation and insufficient justification of technical reclamation (Zheleva, 1979) The submitted projects for technical reclamation and the condition of the already reclaimed terrains give the impression of inefficient use or not having been used at all. The results and recommendations based on the implemented scientific research and the carried out vegetation and field experiments require growing of agricultural crops directly on the heap substrates without covering them with humus. The conclusions by Lichev et al. (1973), as a result of their research are that marls, which have stayed on the surface for 2-3 years, are biologically appropriate for growing basic field and fodder crops. For instance, the yields of alfalfa grown on such marls without fertilizing and watering are the same as the yields of alfalfa grown under the same conditions on Vertisols. The results are also good with *Onobrychis sativa*, ryegrass, wheat and maize but only in certain combinations of mineral fertilization.

As a result of the natural factors and the anthropogenic impact the region of Pernik is characterized by a rather complicated soil situation. There are markedly expressed erosion and land-sliding processes on the slopes. There are conditions for surface over-humidification, swamping and salinization in some land lowerings and on separate sections of the terraces of the rivers. The situation has acquired an exceptionally technogenic character after the development of the mines, the enormous pits and heaps and the construction of the industrial pads and equipment. The most important is the fact that the natural hills, slopes, flat terrains, vales and low valleys have been wiped out and replaced by newly constructed and absolutely different chaotically dispersed negative (pits) and positive (heaps) relief forms.

The geological base in these terrains is also highly degraded (Lichev and Treykiashki, 1973). The geological layers at depth of 80 to 100 m have been excavated and at the same time they have been heaped on the surface without consideration of their natural stratigraphic order.

In the general context of the above stated conclusions the influence of Mini Pernik is displayed by alterations of the relief, dust and partial aerosol pollution of the atmosphere, destruction of vegetation, contamination and destruction of the soil cover and other components of the environment.

**Quality characteristics of the reclaimed land from the region of Pernik Mines - Survey of research**

The first research and practical activity in the area of biological reclamation of the technogenic landscapes in the developed industrial countries began at the end of the 19th century with the creation of forest areas (Gencheva and Zheleva, 1997). In Bulgaria the first surveys and afforestation were made in the 1950s in the region of Pernik (Gushevlov, 1977). Later two directions of biological reclamation were differentiated — forestry biological and agro-biological which have clearly defined specifics in both theoretical and experimental research and in practical activities. The theoretical concept is aimed at clarifying two main problems - the specifics of technogenic neo-relief and the opportunities for sustainable and ecologically balanced biocenoses (ecosystems), which defines the two main stages of reclamation:

1. Technical, which is connected with stabilization and correction of the neo-relief and its integration into the adjacent landscape.

2. Biological - characterization and assessment of the properties and fertility of substrates forming technogenic landscapes, determination of the type of vegetation, the application of appropriate technologies and amelioration of substrates (Ivanov et al., 2007).

At appropriate stages particular methods in the field of soil science, horticulture, forestry, agrochemistry, dendrometry, etc. were applied. The basic requirements for technical reclamation include preparation of disturbed areas for commercial use and its environmental inclusion in the adjacent landscape - creating rational forms of relief with a favorable structure of the heaps, planning their surface, leveling and normalization of the slopes (greater than 18-24 degrees), removal of the effects of subsidence, performing ameliorative activities; creating a road network; regulation of the hydrological regime (creation of drainage ditches, runoff regulation, moving riverbeds, etc.); creating the necessary engineering facilities (Miltchev, 2008). The link is the biological approach for restoration of the disturbed areas and to some extent the methodical approach in fundamental research (Gencheva et al., 1986).

The main problems of forestry biological reclamation are related to clarifying the complex relationships in the system "climatic factors - edaphic factors - biocenotic factors". The clarification of these interactions is the basis for sustainable forest ecosystems (Gencheva et al., 1995). Initially it is necessary to study the natural environmental conditions, the composition and properties of the geological materials on which to experiment and determine the type composition, options for melioration of substrates, methods and means of cultivation, afforestation and crop growing (Petrova, 1994). Subsequently the established sample sites and massive afforestation enable clarification of the reverse process - the effects of different dendrocenoses on the direction, the nature and intensity of soil formation processes under particular climatic conditions (Gencheva et al., 1986).

Until now studies both at home and abroad, are mostly focused on issues related to the opportunities of using different geological substrates as plant protection for forest trees most commonly as uniform plantations or in a group mosaic mixture as well as on the behaviour of the experimental tree types (Lichev et al., 1973). The properties of bulk materials in the major coal-producing areas in the country have been characterized. Research shows certain
Differentiation on different sites - disturbed by mining of coal, ores of nonferrous and rare metals, construction and inert materials, etc. (Gencheva et al., 1982). In the first years after the construction and beginning of reclamation activities heaps were loose and porous, but after 8-10 years, their density increased. Therefore, plants which do not tolerate heavy soils deteriorate their growth (for example P. nigra and P. silvestria).

Heaps from underground coal mining contain amounts of coal particles that change the properties of bulk materials due to the high temperature processes that develop in them - continuous burning and smoldering (Haigh and Gentscheva, 2002). Heaps which were formed as a tailing pond from processing and briquette factories in energy complexes have very bad forestry properties. Substrates in them are very toxic to the plants, due to the large amounts of salts and in some cases acidic compounds therein. All substrates have a low amount of key nutrients such as nitrogen and phosphorus but potassium has usually satisfactory or very good amounts in stock (Zheleva et al., 1995). To conduct reclamation on these heaps, especially in the lower altitudes the limiting factor turns out to be water - both underground water and air moisture is insufficient during the summer months. In the last 8-10 years drought has started from the beginning of April and has ended in late September. The plant type on these heaps complies with the forest zoning of Bulgaria, the climatic and edaphic factors of the area. The research findings require the use of xerothermic types typical of the forestry zone of the area, especially at the beginning of reclamation and also types which develop a strong root system early after afforestation or have extensive adaptive properties and ecological plasticity (Petrova, 1991). In this direction there are fewer studies and developments on land disturbed by mining and processing of ores of nonferrous metals and radioactive elements where problems of reclamation are connected not only with stone coverage, mechanical and granulometric composition, density and water regime but they are also in connection with the complex chemical composition and properties, the acidic regime, sorption properties of the substrates, the presence of elements and compounds that induce high acidity or alkalinity, etc. (Ivanov, 2007).

Key features of Waste Coal in Pernik coal province and the analysis of the geological map - Pernik map sheet (Figure 3). This map shows that the surveyed sites in the Pernik basin fall in areas built of rocks and are distinguished by a number of specific physical properties such as water absorption and degradation, poor ductility and primarily light colored (white, tan, gray, greenish-gray, reddish) (Kostadinova, 2016).

The study of the negative effects and the opportunities to overcome them has posed a major problem in research and practical activities in this direction. It is in connection with the standing problem of selecting the appropriate plant types to consolidate the steep heap slopes and creating economically valuable and sustainable ecosystems in these disturbed areas (Haigh, 2007).

Although forestry biological reclamation is a new direction in ecological restoration research attempts have been made to create technology for reclamation of areas disturbed by different mining activities. The emphasis is on ameliorative measures (fertilization, liming, sideration and cultivation care), schemes and density of afforestation, etc. There are certain results regarding the influence of mineral fertilization on forestry biological reclamation, but at this time of recession in our economy there is danger of underestimating the need of this activity and research on these issues. Technologically there is less research related to the opportunities of using mechanization in reclamation works (Zheleva, 2010). Changes in the nature of economy, inflation and difficult financing conditions of risky research at this stage direct our attention to methods with low investment. Under conditions of sloping terrains mechanization is specific, so research should be aimed at mechanizing operations of biological stabilization of reclaimed land, exploration of the opportunities of hand-held power tools in a spoil heap, exploration of the possibilities for remote introduction of chemical solutions hydraulically to stabilize the steeply sloping surfaces and mineral fertilizers, grass mixtures, etc., exploration of the possibilities for using existing or constructing new machines for slope correction, processing terraces on sloping land, fertilizing, afforestation, etc.

Research for clarifying the reverse process - the effects of different dendrocenoses on the direction, nature and intensity of soil formation, has begun only in the last 10 - 15 years (Filcheva et al., 2000). This is logical, since the processes of weathering and soil formation are very conservative and require longer period of influence of technogenic phytocenoses to establish some changes in geological substrates. A very important issue in methodical respect in these studies is to identify the most informative indicators affecting the degree and direction of soil formation processes - the amount and properties of diluvium, changes in acidity, organic matter, qualitative composition of humus, destruction processes and biochemical transformation of organic residues, etc. (Ivanov et al., 2007)

**Specific properties of bulk materials due to reclamation activities in the region of Pernik town**

The current studies have so far been focused on:
- determining the key diagnostic indicators for qualitative assessment of geological substrates in connection with forestry biological reclamation;
- optimizing the type composition of biocenoses on reclamation areas in order to create sustainable ecosystems;
- development of technological instructions corresponding to the specifics of the areas for reclamation, with special attention paid to melioration activities and mechanization;
- expanding research on the specific nature of the processes of weathering and soil formation with a view to their targeted management.

Underlying soil survey, biometric research, the assessment of soil fertility and carried out field trials give rise to certain conclusions.
about the reclamation of selected areas - heaps of open pit mining of coal in the city of Pernik (heap of Al. Milenov mine) (Ivanov, 2007). Heaps of coal mining, according to the way of mining are from galleries (underground) and open pits. Tailings ponds or tailing heaps received from the enrichment of coal emerge as a third category. Open pit mining turns out to be more economical so heaps of this type of mining are preferred as object of research (Shishkov, 1985). Soil forming materials have been irregularly layered in profile, which gives respective impact on the physical and chemical properties at depth. Selected soil sections in established crops have visibly marked differences in morphological terms. Soil materials in some layers have quite a lot of skeleton, mainly coaly shale, marls and slates in Pernik. The volume weight of samples does not differentiate a lot from that of natural soil. The results show that the total porosity is relatively good especially in the surface layers and newer heaps. In depth, however, it decreases as a result of subsidence.

Water properties of the tested materials are expressed by the basic hydrological constants (in weight percentage of water to that of the total sample). The results show that the materials of heaps in Pernik have comparatively high percentage of capacity of active moisture (CAM) (Kostova, 2013). In general, materials have relatively favorable water properties which do not differ substantially from the water properties of natural soils. Chemical analyses show neutral or alkaline soil pH, low contents of humus and low availability of basic nutrients (which does not apply to Potassium) (Hristov, 2015). The data exposed so far give us grounds to determine that forest plant properties of the tested materials are not good.

The forest plant properties of soils can be improved by performing a complex of activities causing a rise of the indicators of soil fertility (Bogdanov et al., 1994). Terrain experiments conducted on heaps were based on the results of soil research. The aim was to determine the most appropriate tree types on heaps of open coal mining, the most appropriate agricultural machines for their growth and mainly the most appropriate rates of fertilization and ratio of introduced fertilizers. Mineral fertilization was performed according to specific schemes appropriate for the technical possibilities of the terrain (mainly size and compactness of areas). Field trials were conducted with pure and mixed cultures of red oak, silver lime, plain and American ash tree, silver birch, black pine and sycamore. The results show that the applied fertilizers caused the greatest reaction by acacia, plain ash and birch, in which the absolute values of all biometric parameters were the greatest at the higher rates of fertilization. Sycamore and lime occupied average position. Generally they also had a positive reaction to mineral fertilization but the change of indicators of fertilized trees was slighter. As far as the studied parameters are concerned, the weight and volume of the roots change to the greatest extent in the control figures, followed by the height of seedlings and the diameter of the root collar. This is favorable because the bigger root system creates a better opportunity for feeding and growth of tree types. Full fertilization has a significant positive effect on the black pine and lime, nitrogen - on ash (more precisely ash suffers from lack of nitrogen) and phosphorus and potassium fertilizers have a favorable impact on the black alder. Mineral fertilization also affects in one way or another poplar planted as cuttings in the terrain. Poplars prove a significant effect of mineral fertilization.

Initial results of mineral fertilization show that it can and must be a serious ameliorative measure for acceleration of the soil forming process, improvement of soil fertility and better growth and sustainability of planted seedlings. Mineral fertilizers should be applied by strict differentiation into various plant types and in order to expand the range of vegetation used in biological reclamation we must always consider the climatic conditions, the fertility of soil materials and the biology of tree and bush types (Zheleva and Kostova, 1986).

In the geological structure of the coal bearing stratum in Pernik coal mining basin there are mostly marls, a large amount of clay, shale and sandstone. In our climatic conditions these geological materials weather relatively fast and homogeneous loose mass appears on the surface after 2-4 years. In connection with the technology of filling the relief of the heaps is either conical with high and steep slopes or ctenoid. For the same reasons and because of the differences in composition and thickness of different under-coal layers, the profile of industrial heaps is built by different in composition and power layers in the rotation of which there is no regularity (Gushevlov and Pascalev, 1977). The skeletal fraction has also a different participation and it also depends on the geologic products and weathering materials derived from them. Heaps of Pernik sometimes contain over 50% of skeleton, which is due to the larger factions of shale and marl. The heap material from Pernik contains a larger quantity of sand fractions. For these reasons reclaimed soils on these heaps will be formed more quickly and will be characterized by a light mechanical composition. The density of the soils in the area forms a typical porosity ranging between very good and unsatisfactory. However, it constantly changes because of the subsidence of heaps.

Properties and fertility of heap materials are determined by specific studies of the morphological features, the mechanical composition, the physical properties, water and temperature regime, chemical composition and properties and microbial activity of substrates. In a wetted condition they are cut and spread, being difficult to process, and when they are dry large crevices are easily formed. In water logging soil particles are not water proof, they are easily blurred and show a lack of organic matter (Ivanov, 2007).

The physical properties are reflected on water properties of heaps in the above mentioned areas (Kostova, 2013). Data show that productive water supplies, especially at shallow depth are too low in some periods during the vegetation season. Because of its clay composition the heap materials retain more moisture, but much of it is dead stock. For these reasons and because of lack of organic substance heaps do not have high capacity of active moisture. Changes in productive water supply during the summer months in Pernik are not so sharply defined although there are quite low values here, too. Studies of the chemical composition and properties of heap materials from the two terrains show that they differ significantly (Filcheva, 2007). The only similarity between them is the neutral soil reaction of the soil solution. Total nitrogen content also varies in different ranges from 0.012% to 0.065% in the heaps in Pernik. In most cases, however, absorbable forms of nitrogen are few, which is confirmed by the high values of the C:N ratio (mostly above 20). These results show that the rate of decomposition is low. Almost all substrates are very poorly stocked with absorbable phosphorus and well to very well stocked with absorbable potassium. The reaction of the soil solution is neutral to slightly alkaline. Only layers that contain more coal and cinder or black clays have more active and hydrolitical acidity.

The type composition of vegetation was determined according to the particular climatic conditions, the properties of the substrates, and also on the basis of the composition and condition of natural and cultural vegetation. Based on the complex ecological and biological evaluation of the determined appropriate plant species to create lawns of Montagu type, anti-erosion grassing and park grass arrays were recommended (Banov and Hristov, 1997). The main species
used by practical teams for afforestation of the new heaps in Pernik coal basin are black pine and acacia, which turn out to be suitable pioneer vegetation for these habitats because of their ecological and biological characteristics. In some cases other deciduous plants such as plain ash tree, birch and lilac bush are used. State and development of all species with the exception of the American ash tree are good, indicating that they can be successfully used in similar conditions. Fertilization combined with proper technology to create and maintain forest crops is a virtually possible activity for successful forest biological reclamation. Fertilization has positive impact on the fertility of substrates. In most cases, the amount of the imported nutrients increases, but it does not lead to accumulation and creating a deficit mode, which requires regular fertilizing in 3-4 years, thus establishing a rapid increase in organic matter (Banov et al., 1994). 

On the heap of an open development in Pernik the best effect is obtained with white acacia, white birch and American ash tree, followed by the hybrid sycamore (*Platanus Acerifolia*) and silver lime at the rate of N:P:K. Experiments continue with plain ash tree, chokeberry, large-fruited hawthorn and dog rose. Regarding ways of fertilization better results for the tree and bush vegetation are obtained by nest or row fertilization. Area fertilization produces massive wild development of weeds. In relation to the specific nature of industrial heaps in order to make them suitable for commercial use or green fields, scientists must deal with the problem through a comprehensive approach - carefully and reasonably. This is the only way for successful forestry biological reclamation to be applied to disturbed by coal mining terrains (Banov and Pavlov, 2014).

**Conclusion**

The affected areas (damaged, altered, etc.) around mining companies in the country are a serious environmental problem, including the territory of Pernik town coal mines. The area around that town, affected by the mining industry occupies a territory of about 30 000 ha. As a result of the natural factors and the anthropogenic impact this region is characterized by a rather complicated soil situation. There are markedly expressed erosion and land-sliding processes on the slopes as well as conditions for surface over-humidification, swamping and salinization. The situation has acquired an exceptionally technogenic character after the development of mines, the enormous pits and heaps and the construction of the industrial pads and equipment. In general, the influence of Mini Pernik is displayed by alterations of the relief, dust and partial aerosol pollution of the atmosphere, destruction of vegetation, contamination and destruction of the soil cover and other components of the environment.

The reclamation of the environment in industrial areas is closely connected above all with the reclamation of disturbed areas and materials and can be performed in different ways according to their properties and economic effect. The inevitable degradation of the landscape can be corrected mainly by technical and biological reclamation of the disturbed terrains. A large part of the green belt of the town of Pernik was constructed on former heaps – mainly by afforestation. These activities have solved the problem of the separation of the town from the mining sites by a noise-preventing and dust-stopping embankment. The recommendations based on the implemented scientific research and the carried out vegetation and field experiments require the growing of agricultural crops directly on the heap substrates without covering them with humus.

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Review

Alternatives for optimisation of rumen fermentation in ruminants
T. Slavov

Genetics and Breeding

Characterization of a new winter malting barley cultivar Ahil
B. Dyulgerova, D. Vulchev, T. Popova

Evaluation of high yielding mutants of *Hordeum vulgare* cultivar Izgrev
B. Dyulgerova, N. Dyulgerov

Nutrition and Physiology

In vitro gas production of different feeds and feed ingredients at ruminants
E. Videv, J. Krastanov, S. Lalova, T. Angelova, M. Oblakova, N. Oblakov, D. Yordanova, V. Karabashev

Evaluation of chemical composition of raw and processed tropical sickle pod (*Senna obtusifolia*) seed meal
Augustine C., Kwari I.D., Igwebuike J.U., Adamu S.B.

Effect of urea-fortified all concentrate corncob diets on serum biochemical and hematological indices of West African dwarf goats
U. M. Kolo, A. A. Adeloye, M. B. Yousuf

Production Systems

Analysis of the technological dairy cows traffic "to and from" herringbone milking parlors
K. Peychev, D. Georgiev, V. Dimova, V. Georgieva

Effect of pre-sowing soil tillage for wheat on the crop structure and the yield components under the conditions of slightly leached chernozem soil in Dobrudzha region
P. Yankov, M. Drumeva

Study on the process of unloading grain harvesters at the end of the field
G. Tihanov

Agriculture and Environment

Modeling and simulation of fuzzy logic controller for optimization of the greenhouse microclimate management
Didi Faouzi, N. Bibi-Triki, B. Draoui, A. Abene
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floristic diversity of ‘Chinarite’ protected area – Rodopi municipality, Bulgaria</td>
<td>140</td>
</tr>
<tr>
<td>L. Dospatliev, M. Lacheva</td>
<td></td>
</tr>
<tr>
<td>Heavy metal pools in urban soils from city parks of Sofia, Bulgaria</td>
<td>144</td>
</tr>
<tr>
<td>V. G. Kachova, I. D. Atanassova</td>
<td></td>
</tr>
<tr>
<td>Ecological characteristics of reclaimed areas in Pernik mines region, Bulgaria</td>
<td>151</td>
</tr>
<tr>
<td>I. Kirilov, M. Banov</td>
<td></td>
</tr>
<tr>
<td>Reclamation of soil excavated from construction and mine searching areas in Turkey</td>
<td>160</td>
</tr>
<tr>
<td>F. Apaydin</td>
<td></td>
</tr>
</tbody>
</table>

**Product Quality and Safety**

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration of sulfur-containing amino acids at turkey broilers during and after muscle dystrophy, fed with deficient feed supplemented with oxidised fat</td>
<td>164</td>
</tr>
<tr>
<td>K. Stoyanchev</td>
<td></td>
</tr>
<tr>
<td>Exopolysaccharide influence’s on acid gel formation</td>
<td>167</td>
</tr>
<tr>
<td>K. Yoanidu, P. Boyanova, P. Panayotov</td>
<td></td>
</tr>
<tr>
<td>Carcass characteristics and technological properties of <em>Musculus Longissimus Lumborum</em> at lambs from the Bulgarian dairy synthetic population and its F1 crosses with meat breeds</td>
<td>171</td>
</tr>
<tr>
<td>N. Ivanov, T. Angelova, S. Laleva S. Ribarski, D. Miteva, D. Yordanova, V. Karabashev, I. Penchev</td>
<td></td>
</tr>
</tbody>
</table>
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