The Study Of Soil And Agrochemical Features Of Zonal Soils Of Coal Mining Enterprises In Kemerovo Region

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Abstract. The paper represents the results of the study of soil and agrochemical features of zonal soils: the grain-size composition, the content of humus, phosphorus and potassium, and heavy metals, the reaction of soil solution of the territory of the open-pit coal mine No12 of Kemerovo region in the areas of the working enterprise. The species composition of the lignose and herbaceous vegetation of the undisturbed territories has been studied. It has been revealed that the fertile soil layer of the studied areas of the open-pit coal mine is characterized as fertile but can't be removed and stored because the surface of the whole area under study is forest-covered very much, rumpled, there are gullies and a lot of wind-fallen trees.

Introduction

Huge coal reserves are concentrated in Kemerovo region, which are estimated as 524.4 billion tons. The total area of Kuznetsk Basin accounts for 27 thousand km^2. Nowadays the coal extraction in the region is conducted by more than 50 mines and 30 open-pit coal mines which extracted more than 310 million tons in 2015. Coal extraction is followed by a significant ecological damage. About 5 800 ha of forests, meadows and fields are destroyed in Kuzbass for a year, and then borrow cuts, rock dumps, technological roads, depositing tanks, etc. appear instead of them.

Therefore, restoration of economic and ecological value of the lands disturbed by mining should be undoubtedly considered as an important question for the territory of Kemerovo region.

The dumps and open pits which are often situated nearby and within the settlements reduce the green area around cities and towns, pollute the environment and herewith worsen living conditions of people. The territories situated in the immediate proximity to the open pits gradually become unsuitable for life [1].

Among negative consequences of the open pits there is withdrawal of huge land areas from agricultural production and their disturbance, change of hydrogeological conditions of the region, development of erosion processes, as well as mixing of rock along with removal of infertile and even toxic rock to the surface [2].

The process of restoration of the disturbed lands is called reclamation, that is, the measures directed to productivity restoration of the disturbed lands, as well as to improvement of the environmental conditions.

The main tasks of the biological reclamation are formation of the soil layer, soil aggregation, humus and nutritional substances accumulation [3,4].

Since the beginning of the biological reclamation of the disturbed lands there begin complicated processes which in total influence on trend and intensity of soil formation with an active participation of plants and microorganisms [5,6].

The research objective

In this context the question of pollution and loss of soil fertility becomes urgent for the territories of the so-called environmentally unfriendly regions which Kemerovo region can be reckoned among. The research objective is to study the agrochemical features of the undisturbed soils nearby the rock dumps of the open-pit coal mines and to determine their quality.

The research object and methodology

The open-pit coal mine Co Ltd «Mine No12» is a working coal mining enterprise which is situated in the town of Kiselevsk in Kemerovo region. In the north the territory of the enterprise borders with the closed mine «Krasnokamenskaya», in the west – with Co Ltd «Uchastok Koksoviy», in the south – with the field of the closed mine «Cherkasovskaya». The region has a developed infrastructure: approach roads, loading dead ends, electric power substations and so on.

The full capacity of the mine accounts for 1 million tons of coal a year. Coal reserves account for 76 million tons of coal. Nowadays coal extraction is done both by underground method at the depth of 250-350 m and by open-cut method – there is a production area of coal extraction by open-cut method.

The enterprise includes: the areas of underground works, the areas of open-pit mining, the crushing-and-sorting complex (CSC), the central and buffer coal stores, technological roads, the boiler plant, the machine shop, the garage, ventilation shafts, degassing units.

A production activity of the subdivisions of the enterprise is performed on the land areas leased from the municipal government. Co Ltd «Mine No12» is one of the enterprises forming a company town of Kiselevsk. The number of people working at mine No 12 accounts for 1755 persons.

The distance from the border of the allotment to the border of the nearest residential areas of Kiselevsk accounts for:

- in the northern direction – the region «Afonino», in the distance of 90 m;
- in the northeastern direction – the region «Boynya», in the distance of 100 m;
- in the eastern direction – the region «Zelenaya Kazanka» and the settlement Shakhta No12, in the distance of 100 m and 20 m correspondingly;
- in the southern direction – the region «Surtaikha», in the distance of 290 m.

The climate of the region is acutely continental. The lowest temperatures are in December and January. The absolute minimum at this time reaches -43.9°C, and in some winters -50-54°C.

The snow cover is stable from the beginning of November till the end of April, and on the northern slopes – till the middle of May. The thickness of the snow cover on the northern slopes of ravines reaches 2 m. The hottest month is July, its average monthly temperature reaches +19.4°C, maximum is +36.7°C.

The average annual precipitation total accounts for 400-700 mm. Prevailing winds in the region are southern and south-western. The winds of these directions have a maximum speed of 17-24 m/s, the average annual speed – 4.9-5.2 m/s.

According to the soil and geographical zoning of Kemerovo region, the lands of the open-pit coal mine №12 are situated in the south-west of the Kuznetsk Alatau, belong to group E – Kuznetsk-Alatau high soil district with four belts of vertical soil zonality.

The zonal soil cover of the soil and geographical region, including the area of ecological investigation on fund materials and soil map of Kemerovo region, is represented by zonal types and subtypes of soil for the given geographical region:

- sod-medium-podzol;
- mountain-sod-podzol;
- light-grey forest;
- grey forest.

Soil as any natural substance has some external features - morphology. The most important morphological feature of the soil is an external structure of its genetic horizons forming soil section [7,8].

On the area under study nearby the working enterprise of the open-pit coal mine No 12 the soil sections were done: plot No 1 (picture 1, 2), plot No 2, plot No 3. The samples for agrochemical analysis were selected in July 2016 according to State Standard 17.4.4.02-84 «Nature protection. Soils. Methods of samples selection and preparation for chemical, bacteriological, helminthological analysis».

Results and discussion

Plot № 1. The square is 47 ha. The relief: a slope of the northern aspect (5-7^o). The surface is rumpled, with gullies along the dells. There are tussocks, and anthills. The soil-forming and bed rock: heavy brown noncalcareous covering loams and clays. The soil: deep-sod, deep-podzolic, heavy loam.

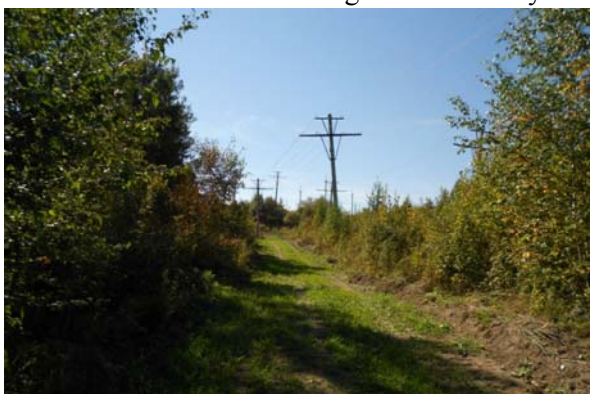

Figure 1 – A general view of the landscape(plot 1) deep-podzolic heavy loam

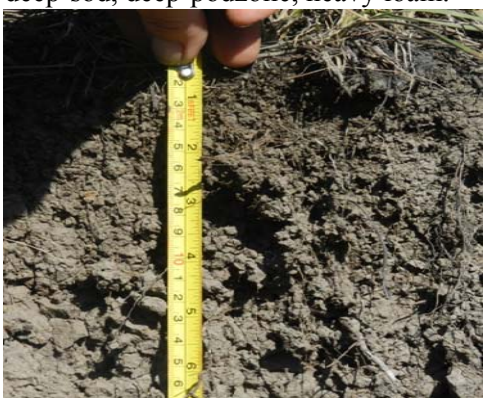

Figure 2 – The soil – deep-sod

In the soil profile the following soil horizons are revealed:
$A_1 – A_2 – A_2B – B – BC – C$.

Table 1 – Soil horizons of plot No 1

A_1 - 0-18	Dry, grey, heavy loam regarding granule-size composition, fine clot structure, loose, plenty of plant roots, noticeable transition in density.
A_2 18-25	Dry, whitish-grey, heavy loam, clot-laminated structure with whitish overburden, compacted, rare plant roots, noticeable transition in density.
A_2B-25-40	Fresh, light-brown with whitish shade, heavy loam, rough-nuciform with noticeable siliceous overburden, compact, rare roots, gradual transition.
B - 40-61	Damped, light-brown, heavy loam, prism-like structure, very compact, gradual transition in colour.
BC – 61-90	Damped, light-brown, heavy loam, cloddy, compact, gradual transition.
C 90 - 154	Damped, light-brown, heavy loam, unstructured, compact, carbonate horizon is not opened.

According to the soil classification and diagnosis (1977) the names of soils with respect to the granule-size composition are given regarding top humus soil horizon.

The solid phase of soils and soil-forming rocks consists of the particles of different size which are called mechanical elements. With respect to correlation of physical clay (particles <0.01mm) and physical sand (particles > 0.01mm) a granule-size (mechanical) soil composition is determined.

The species composition of plant communities in the studied territory of plot №1 of the field of mine No12 is represented by 37 species of 21 families. The territory is forest-covered, with silver birch

prevailing (*Betulapendula*), with rare representatives of *Píceaábies,* bird cherry *(Padusavium),* cranberry high (*Viburnumopulus, Acernegundo*), red raspberry (*Rubusidaeus).* A significant part of grass vegetation is represented by perennials [8, 9].

Plot No 2. The square is 6.5 ha. The soil profile No 2. The relief: a slope of the southern aspect (4-6^{o}). The surface is flat, hollows are found. The soil-forming and bed rock: stone field. The soil: light-grey podzolized undeveloped-skeleton.

In the soil profile the following soil horizons are revealed:

A_1 – B – BC – C_c

Table 2 – Soil horizons of plot No 2

A_1 - 0-14	Dry, grey, medium-loam, fine-nuciform structure, loose, plenty of plant roots, noticeable transition in colour and inclusion of skeleton rock.
B 14-32	Dry, grey, nonhomogenously coloured, medium-loam, pulverescent-cloddy-friable structure, loose, solid inclusions in the shape of aleurites and others, gradual transition.
BC-32-63	Dry, brown-grey with brown inclusions, cloddy-friable, loose-compact, solid inclusions in the shape of small and large aleurites, noticeable transition in density.
C_c63 cm.	Dry, a mixture of solid inclusions in the shape of small and large aleurites with sand and clay.

The vegetation of plot No 2 is represented by 30 species of 16 families. The whole territory of the field is forest-covered with silver birch (*Betulapendula)* forming dense stand of trees, along the edge of the field there are vast bushes of pea shrub (*Caragana pygmaea)* [8,9].

Plot №3. The square is 4.5 ha. The relief: a slope of the northern and north-eastern aspect (4-6^{o}). The surface is cut, by gullies and hollows. The soil-forming and bed rock: heavy brown noncalcareous covering loams and clays. The soil: deep-sod fine-podzolic heavy loam.

In the soil profile the following soil horizons are revealed:

A_1 – A_1A_2 – B – BC – C

Table 3 – Soil horizons of plot No 3

A_1 - 0-26	Dry, grey, heavy loam, cloddy-nuciform structure, loose, plenty of tree and grass roots, noticeable transition in structure.
A_1A_2 -26-37	Dry, grey, heavy loam, cloddy-laminated structure, loose-dense, plant roots, noticeable transition in density.
B – 37-51	Damped, brown-grey, heavy loam, coarse-cloddy-prismlike, siliceous overburden (SiO_2), dense, gradual transition.
BC – 51-80	Damped, brown, heavy loam, cloddy-prismlike structure, dense, gradual transition.
C – 80 -130	Damped, brown, heavy loam, unstructured, dense, with rusting in the top part of the horizon, with gleization in the bottom part of the horizon.

The vegetation of plot No 3 is represented by 30 species of 16 families. The whole territory of the field is forest-covered with silver birch (*Betulapendula)* forming dense stand of trees, along the edge of the field there are vast bushes of pea shrub (*Caragana pygmaea)* [8,9].

According to the classification and analysis data the granule-size composition of medium-sod fine-podzolic soils of plots No 1, No 2, No 3 of the field of mine No 12 by the method of N.A. Kachinskiy is presented in table 4.

Table 4 – Granule-size composition of the plots by the method of N.A. Kachinskiy

Plot	Soil name	Content of fractions, %	
		Fine sand	dust
No1	Coarse-pulverescent silty heavy loam	15.3	39.4
No2	Light loam	14.3	30.3
No3	Coarse-pulverescent silty heavy loam	15.3	39.4

The availability of basic elements of nutrition in the soil was determined according to State Standard 26204-91 «Determination of labile phosphorus, potassium and nitrogen compounds by the method of Chirikov in the modification of Central Institute of Agrochemical Service of Agriculture». The investigation results are presented in table 5.

The reaction of soil solution in the top horizon 0-14 cm was determined according to State Standard 26483-85 «Soils. Preparation of salt extraction and determination of its pH by the method of Central Institute of Agrochemical Service of Agriculture». The investigation results are presented in table 5.

Table 5 – Agrochemical parameters of the plots

Plot	Humus, %	pH	Content of nutrition elements		
			Nitrogen, %	Phosphorus, %	Potassium, mg/kg
No1	6.2	5.8	0.48	0.13	50.2
No2	3.1	5.2	0.31	0.13	50.0
No3	5.0	5.6	0.12	0.13	48.2

Conclusions. The analysis of the investigation data shows that humus amount in the top soil horizon (A) 3.1-6.2% falls sharply as the depth increases. In the transitional horizon BC only humus traces were found.

Total phosphorus content 0.13% in the soil is low, it falls sharply as the depth increases. Total potassium content is medium through the whole profile, and nitrogen content in all the plots varies from 0.12 to 0.48%, which is undoubtedly connected with a natural-climatic location of the plots.

According to the study results of the plots of the open-pit coal mine of the territory of Co Ltd Mine No12 of the town of Kiselevsk in Kemerovo region the conclusion is as follows:

- the surface of soil cover of plots No1 and No3 is represented with deep-sod deep-podzolic and fine-podzolic heavy loam soils, and that of plot No2 – with light-grey undeveloped-skeleton light-loam soils;
- the reaction of soil solution is from weak-acid to strong-acid in the bottom horizons.

The content of labile forms of heavy metals in the soil samples doesn't exceed APC (mg/kg) their content in the soil taking into account Clarke [10].

The fertile soil layer of the studied areas of the open-pit coal mine is characterized as fertile but can't be removed and stored because the surface of the whole area under study is forest-covered very much, rumpled, there are gullies and a lot of wind-fallen trees.

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