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Study of waste dumps impact on the adjacent areas

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S u m m a r y . The paper presents the results of field studies of the agricultural soil contamination resulting in washout where the soil are contiguous to the waste dump. To study the contamination of the soil contiguous to the waste dump site, plant samples were taken. Based on the findings, statistical data processing and checking for uniformity and authenticity were carried out.
Soil and vegetation analyses for heavy metals content were carried out.
K e y w o r l d s : waste dump, soil, toxic elements, heavy metals

INTRODUCTION

Coal mining in Donbass has been carried out for over 200 years.

Coal enterprises stand with the largest industrial polluters in importance. Therewith, colossal environmental damage is inflicted not only directly in the process of coal mining, but also many years after its termination [8].

One of the most important technical processes that accompanies coal mining and processing at the coal-preparation plants is the transportation and storage of the waste rock that comes from coal mines heaps and coal-preparation plants. Currently Ukraine's coal industry has about 1130 waste dumps. On the balance sheet of coal mining and coal preparation companies of Lugansk region, there are about 537 waste dumps, covering the area of more than 3100 hectares [12].

It is set that the size of the territory, exposed to harmful-influence of waste banks, 10-15 times exceed the area of dumps. Under every dump from 2 to 10 ha of fertile and suitable for industrial and housing development earth is occupied. The sizes by the affected of dumps zones hesitate within the limits of a 500-1000 m. Accordingly, more than 11 thousand hectares of soils are not suitable for the economic use.

Stockpiling of the dumped rock that operates the coal companies, has a range of significant drawbacks. One of the most significant is the unintelligent use of the space under the dumps, which leads to the reduction of agricultural land and, as a result of wind and water erosion, to contamination of the abuttal.

Large harm is done by the development to erosion on the slopes of dumps, because overwhelming majority of them presented by waste banks with pouring out of breed in form of a cone.

The washed off breed is very toxic, because oxidization of brazil stimulates the poured out neutral breed becoming sulfur-acid in course of time. Sulphuric acid derived as a result of oxidization of brazil dissolves different metals, and they migrate on adherent territories. In course of time soil adherent to the waste banks becomes not suitable for the development of agriculture from solutions,

getting to soil from dumps, that have high concentrations of sulphuric acid, sulfates and movable forms of heavy metals quite often.

The scientists found out that from 1 hectare of a waste dump surface are windblown up to 10 tons of dust and more than 35 tons of silt, a significant amount of water-soluble salts, radionuclides and heavy metals are water flown. Consequently, the erosion processes lead to transportation of heavy metals in a mobile form into the soil [14, 16]. At a distance of 0.5 km along the perimeter of the waste dumps, chernozem completely loses its properties to a depth of 0,6 m, in the area of 5 km can be observed such phenomena as accumulation of heavy metals, loss of humus and soil degradation [9].

Considerable damage to the natural environment brings spontaneous combustion of the waste dumps. The main cause of spontaneous combustion is coal oxidation accompanied by release of a large amount of heat which accumulates in the interstices of soil and provides the ignition of combustible materials. In some dumps, these processes are so intense that the debris is heated to high temperatures and burn, releasing substantial amounts of hydrocarbons, soot, nitrogen oxides, sulfur, carbon, etc. Even those waste banks that seem extinct actually continue to smoulder. Waste banks keep high inner temperature, besides arsenic, mercury, cyanides, sulphur and other harmful substances and their compounds are accumulated surplus. On the average, from one smouldering dump an amount of 10 ton of oxide of carbon, 1,5 tones of sulphureous anhydride and far of admixtures of other gases.

Due to the fact, arrangement of protection zones around the waste dumps becomes necessary, which leads to the extension of safety exclusion area [5]. Up to 86% of the waste dumps are exposed, 10% - partially overgrown and only 4% have a developed vegetation cover [11].

MATERIALS AND METHODS

Environmentally safe existence of all natural components of the soil is one of the main tasks of our time. Various aspects of the ecological safety problem is the object of attention of many researchers , among them are: Abrosimov E.I , Averin G.V., Alekhin Y.I, Baklanov V.I., Gavrilenko Y.M , Driban V.O., Ermakov V.M., Zborschik M.P., Zubova L.G., Zubov A.R., Kolesnik V.Y, Krasavin A.P., Krenida Y.F., Maksimovich M.G., Motorina L.V., OsokinP.P., Panov B.S., Pop Y.M., Prosvirnye Y.A., Rud'ko G.I. and others [3, 6]. The work of scientists is dedicated to different aspects of protection from water and wind erosion on the surface of the waste dumps by mine technical and biological recultivation. These measures can reduce the solid runoff, but have almost no effect on the heavy metals ion sink, sulfate ions and hydrogen ions sink.

The purpose was to study the effect of a coal mine waste dump on the contiguous agricultural crops area. To reach this goal the following problems were set and solved:

- examine the condition of the waste dump No. 3, Lisichansk,
- identify growth index of the crops growing in the contiguous areas using the quantitative estimation method,
- study the geochemical characteristics of the contiguous soil (to determine soil acidity and sulfate ions content),
- Perform the spectral analysis of soil and plant samples for the presence of heavy metals mobile forms.

RESULTS, DISCUSSION

The research work was carried out on the waste dumps No. 3 Matrosskaya Mine, Lisichanskugol OJSC, which in 2010 was transformed from a conical (Fig. 1) into a flat one by flushing and lowering its top (Fig. 2), as well as its contiguous areas (the agricultural fields of the state owned farm Lisichanskiy).

Up to 2009, the waste dump No. 3 has been burning. In 2010, the waste heap was merged with the waste dump No. 4, terraced (Fig. 3), though, it wasn't planted. Consequently, the surface of the above waste dump is constantly exposed to water and wind

erosion, the rocks break and fall to the foot and adjacent areas [4].

Fig. 1. Dump and adherent to him sowing to reforming

Fig. 2. Reformed waste dump and adherent to him sowing

On a figure 4 the investigated dump (kind from above) is presented.

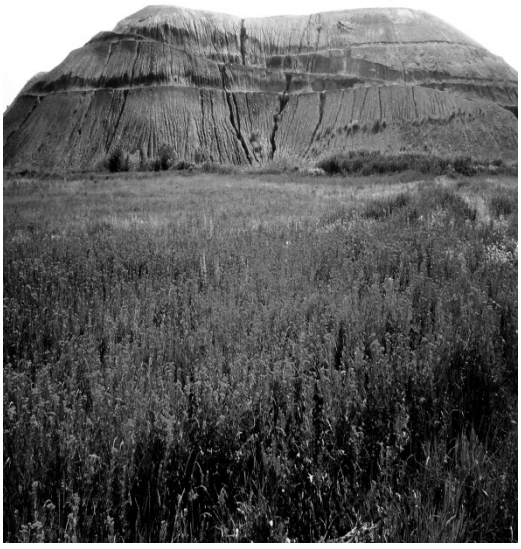

Fig. 3. Incorporated and terraced waste dump

Fig. 4. Investigated dump (kind from above)

Observations showed that while melting of snow or thundershowers the streams of water from the surface of dump movelget on the field and move along it, bringing products the erosions deposited on the field as loops breadthways up to 50 m (Fig. 5).

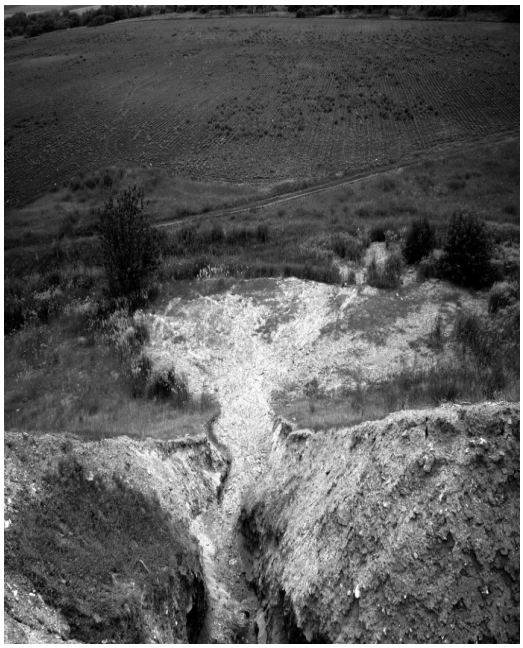

Fig. 5. The rock, washed out to the adjacent areas

For studying the dynamics pollution of soils contamination neighborhood territory works were performed in two stages. At the first stage sampling of winter wheat was

carried out in July, 2006. At the second stage (July, 2012) were selected sunflower vegetable samples. Tests were selected selectively, at distance of 50, 100 and 150 m from the bottom of a dump and at the same distance out of its zones (control).

During the vegetation development the samples were measured by the following indicators:

- number of plants per 1 m^2, units,
- plant height, cm,
- an amount of grains, units,
- weight of 1000 grains, g.

For further analysis and evaluation of the data received, the data were checked for uniformity and the statistical ratios were calculated [6]. To check the data uniformity the Student's t- test analysis method was chosen [12].

According to the data received, tables and diagrams were compiled. The diagrams quantitatively illustrate how the washed-out rock influences and changes the establishment and the growth index of crops as exemplified by the sunflowers and winter wheat in the zone of influence of the waste dump (i.e. gray) and control points (i.e. light-gray), (Fig. 6-13).

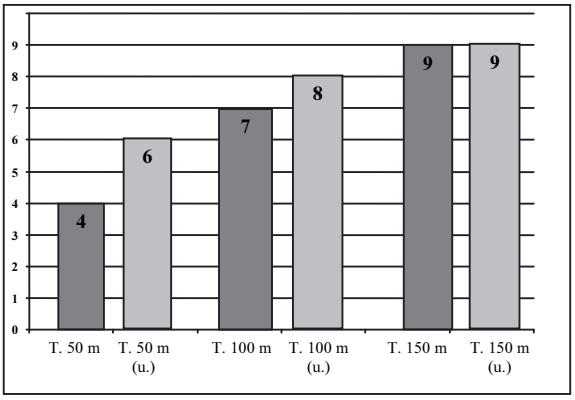

Fig. 6. Number of plants per 1 m^2, units (sunflower)

The change of indexes number of plants per $1m^2$ of winter wheat and sunflower is traced. The number of plants hesitates from 4 to 9 units (sunflower) and from 56 to 88 units (winter wheat).

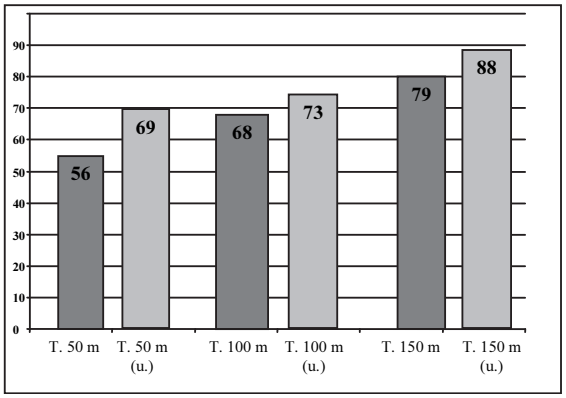

Fig. 7. Number of plants per 1 m^2, units (winter wheat)

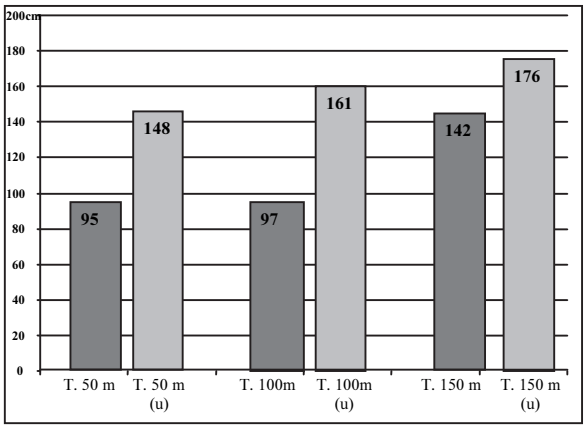

Fig. 8. Plants height, sm (sunflower)

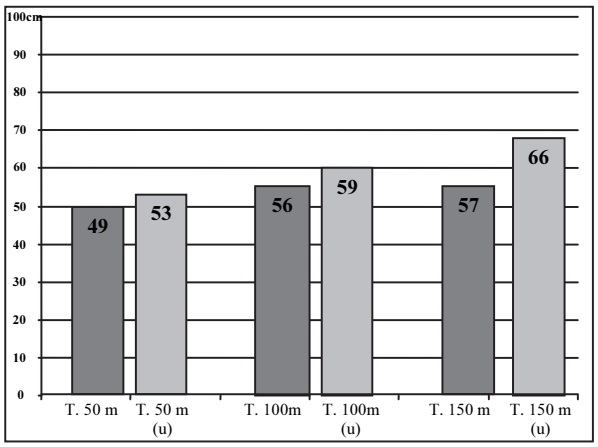

Fig. 9. Plants height, sm (winter wheat)

Proceeding from the presented charts, the change of indexes of height the winter wheat and sunflower is traced. The height of plants hesitates from 313 to 1041 sm (sunflower) and from 49 to 66 sm (winter wheat).

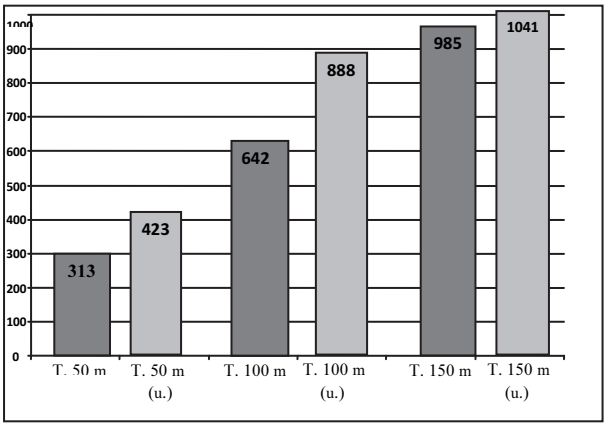

Fig. 10. An amount of grains, units (sunflower)

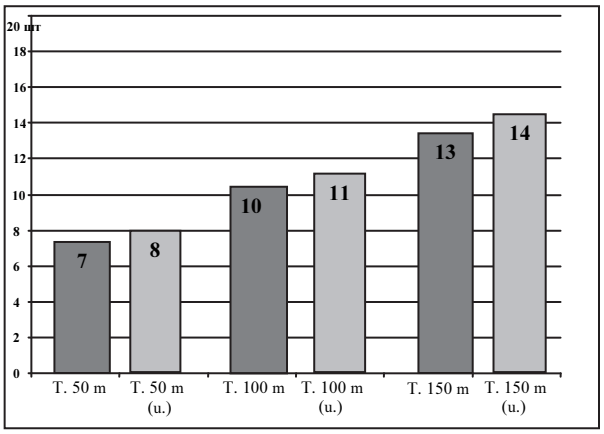

Fig. 11. An amount of grains is in an ear, units (winter wheat)

Indexes of amount of grains in an ear hesitate in limits from 8 to 14 pieces (winter wheat) and from 95 to 176 pieces (sunflower).

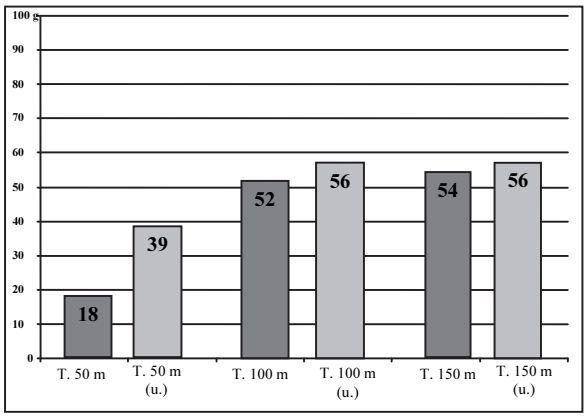

Fig. 12. Weight of 1000 grains, g (sunflower)

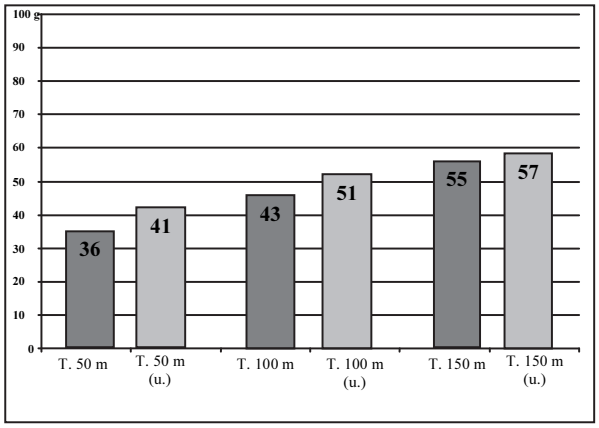

Fig. 13. Weight of 1000 grains, g (winter wheat)

Proceeding from the presented charts mass of 1000 grains are varied from 18 to 56 g (sunflower) and from 36 to 57g (winter wheat).

The charts show that the indicators within the area of the rocks wash-out are significantly lower than the ones outside the waste dump influence zone, which indicates the negative impact of the waste dump on the establishment and growth rate of crops. Based on the foregoing, it can be concluded that vegetation within 150 m is exposed to contamination, and the growth of crops reduces significantly.

In the course of study the spectral analysis of the soil and sunflower seeds was carried out, as well as the chemical analysis of the soil. To determine the pH, the potentiometric method was used, to determine the sulfate ions rate - the quantitative method [14]. Trace element content in the soil and plant samples was determined by approximate-quantitative emission spectral analysis method (Table 1).

Based on data from Table 1, pH changes and different sulfate ion content can be observed in comparison with the zonal steppe soil.

Acidity ranges from 6.0 to 8 (i.e., from acid to alkaline).

Sulphate content ranges from 0,004 to 0,31, indicating a significant increase of these ions in comparison with their natural level in steppe soil.

Table 1. Soil test results (soil acidity and sulfate ions content)

	Sampling location	Rates	
		pH	SO_4^{2-}
1	50 m from the waste dump foot	6,0	0,012
2	50 m from the waste dump foot (verification)	7,4	0,019
3	100 m from the waste dump foot	7,8	0,004
4	100 m from the waste dump foot (verification)	7,9	0,031
5	150 m from the waste dump foot	8,0	0,013
6	150 m from the waste dump foot (verification)	8,0	0,007

Thus, the data obtained shows that the adjacent area is characterized by a high content of sulphate ions. According to our data the territory that is adjoint to the dump is characterized by more intensive content of sulfate-ions. There are, also, changes as comparison with natural terms in content of hydrions, i.e. from weak-acid to the neutral reaction. It can be explained by the strongest washing off of dump breed as a result of water erosion on adjoint territory. There are also changes in the content of hydrogen ions in comparison with the natural conditions, i.e. from the weak acid to neutral reaction. These effects can be explained by a strong debris washout in consequence of water erosion to the adjacent area.

At the junction of sulfuric acid migration flows with natural soil, represented by common chernozem with neutral or faintly alkaline reaction of the environment, alkaline barriers are formed. As a result of pH increasing a number of elements are deposited on the alkaline barrier forming a geochemical anomaly (Fig. 14).

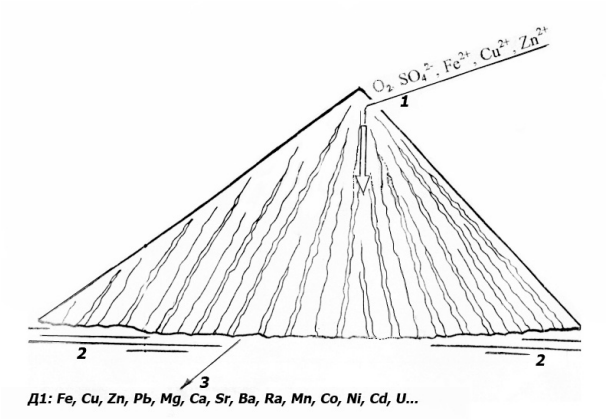

Fig. 14. Anomaly of type of $Д_1$ at the foot of waste bank
1 - acid solution,
2 - chernozem,
3 - alkaline barrier (D_1)

It is known that barriers for alkali (as in this case, which protrude prairie soil) deposited : Mg, Ca , Sr, Ba , Ra, Mn, Fe, Co, Ni, Cu , Zn, Pb, Cd, Hg, Be, Al , Ga, Y, Tr, Cr, P, As, U [1, 17, 18, 19]. The deposition of the heavy metals lead to contamination of the adjacent areas (Table 2).

Table 2. The results of spectral analysis of the soil adjacent to the waste dump

Element	Clark %	Content (thousandths %)					
		50 m from the waste dump	50 m from the waste dump (v.)	100 m from the waste dump	100 m from the waste dump (v.)	150 m from the waste dump	150 m from the waste dump (v.)
Pb	$2*10^{-3}$	5	3	2	2	2	1,5
Cu	0,01	3	3	2	3	3	3
Mn	0,08	100	70	70	70	100	70
Ni	0,018	7	5	5	5	5	3
Cr	0,033	20	15	10	10	15	10
Bi	$N*10^{-6}$	0,3	0,2	0,2	0,2	0,2	0,2
Mo	$N*10^{-4}$	0,3	0,3	0,2	0,2	0,2	1,15
Li	0,004	3	3	3	3	3	3
Zn	0,004	15	15	10	10	20	15
Co	0,01	1,5	1,5	1	1	1,5	1

Table 3. The results of the spectral analysis of sunflower seeds (ash), adjacent to the waste dump

Element	Clark %	Content (thousandths %)					
		50 m from the waste dump	50 m from the waste dump (v.)	100 m from the waste dump	100 m from the waste dump (v.)	150 m from the waste dump	150 m from the waste dump (v.)
1	2	3	4	5	6	7	8
Pb	$2*10^{-3}$	0,1	0,1	0,1	0,15	0,2	-
Cu	0,01	5	5	7	10	7	5
Mn	0,08	15	30	50	30	5	50
Ni	0,018	2	1	1	0,7	1	0,5
Cr	0,033	0,5	0,2	0,1	0,5	-	-
Bi	$N*10^{-6}$	0,5	0,5	0,3	0,3	0,3	0,5
Ba	0,047	10	10	-	10	-	-
Mo	$N*10^{-4}$	0,3	0,1	0,3	0,2	0,15	0,1
Li	0,004	1	1	1	1	-	-
Zn	0,004	7	5	10	20	30	5

Penetration of heavy metals into a plant tissues in excess amount leads to the malfunction of its organs and structures, and the greater the excess of toxicants is, the stronger the violation will be. As a result, plant productivity reduces (Table 3).

As seen from the data received as part of the study, build-up of polluting heavy metals (Pb, Zn, Cr, Cu) in the mobile form can be observed increased in the soil and seeds.

Based on the foregoing, it can be concluded that the heavy metals found in the adjacent soil are involved in the biological cycle and, thus, may further be passed on through the foodchain to man, causing a variety of diseases [2].

CONCLUSIONS

1. The results of measurements near the waste dump show that the survival index and plants productivity decrease. The indicators in the zone of rock washout are lower than the ones outside the waste dump influence zone, this goes to prove a significant contamination of plants with the washout of rock from the waste dump.

2. On adjoint to the waste banks territories, polluted with heavy metals, biogeochemical barriers appear, id est, by virtue of biogenic migration, there is an accumulation in the plants of chemical elements in anomalous concentrations substantially different from MPK (maximum possible concentration).

3. Therefore, we can conclude that the waste dumps are objects, causing significant damage to the adjacent soil, since in the process of burning, oxidation, and weathering, the whole spectrum of components within the dispersion halo is localized in the topsoil, which at a later stage of hydrogenous migration considerably impairs the vegetation regime.

4. The research results reasonably likely allow to assert that the soil contamination in the studied area is associated with the waste dumps. Therefore, continuous watch in the waste heaps impact area is a great currently important research and practice.

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ИССЛЕДОВАНИЕ ВОЗДЕЙСТВИЯ ТЕРРИКОНОВ НА ПРИЛЕГАЮЩИЕ СЕЛЬСКОХОЗЯЙСТВЕННЫЕ ЗЕМЛИ

Елена Савельева

Аннотация. Изложены результаты полевых исследований загрязнения сельскохозяйственных почв, прилегающих к отвалу, в результате смыва породы. Для изучения загрязнения почв прилегающей к отвалу территории были отобраны растительные образцы. По результатам произведена статистическая обработка данных и проверка на однородность и достоверность. Определены кислотность и содержание сульфат-ионов в почве. Произведены анализы почвы и растительности на содержание в них тяжёлых металлов.

Ключевые слова: террикон, почвы, токсичные элементы, тяжёлые металлы.