Problem of Slagheaps of Donbass

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Abstract. The intensive development of the coal mining industry has led to an increase in a number of environmental problems that have turned the Donbass region into a depressed one. The coal seam is mined at depth. As a result, in many places, groundwater flows into the formed openings, which leads to the disappearance of water from wells and boreholes, dehydration of the upper soil layers and even the disappearance of a number of natural lakes and rivers, and the impossibility of irrigation in agriculture. The second side of the problem is the appearance of the so-called mine dumps or slagheaps during the operation of any mine. These human-made conical pyramids have become a serious environmental hazard. The solution to these problems is possible through the creation of a free economic zone and the introduction of innovative approaches to solving a set of problems.

1 Introduction

The first mine (coal mine) was built on the territory of the Donetsk Ridge in 1795 in Lisichya Balka (now the territory of Lisichansk). Over time, the intensive development of the coal mining industry led to an increase in a number of environmental problems that turned the Donbass region into a depressed one. Coal enterprises in the region have their own characteristics [1]. This is primarily an underground method of mining at depths exceeding 1000 meters for most mines (although there are illegal "digging", at a relatively shallow depth), and as a result - difficult working conditions. For example - at such a depth - an increase in temperature, sudden outbursts of coal and gas, which leads to collapses and rock bumps, etc. The considerable depth also determines the high prime cost of 1 ton of coal, labor intensity and high prime cost. Half of the developed seams have a thickness of less than 1.2 m, and a significant part of them are dangerous.

Since the coal seam is mined at depth, in many places groundwater flows into the formed openings, which leads to the disappearance of water from wells and boreholes, dehydration of the upper layers of the soil, and even the disappearance of a number of natural lakes and rivers. As a result, in a number of cities tap water is available only once a day for several hours, and even then it is of poor quality. Farming has become much more difficult due to the difficulties with irrigation.

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The second side of the problem is the appearance of the so-called mine dumps or slagheaps during the operation of any mine. These man-made conical pyramids have become a serious environmental hazard [2-3]. In the rock mass, anthracite and ash, 18 toxic elements have been identified [5-6]. They can be divided: into highly toxic - arsenic, antimony and mercury - permissible concentration - 2 g /t, beryllium (10 g/t) and lead (30 g/t), medium toxic - phosphorus (90 g/t), chromium, cobalt, nickel, copper (100 g/t), vanadium (150 g/t) and slightly toxic - fluorine (500 g/t) and manganese (1500 g/t). In addition to coal dust, their second danger is that the physical and chemical processes occurring in the burning dumps lead to the release of toxic gaseous and radioactive substances [7]. Contamination of groundwater and soil occurs due to the washout of soluble salts from the surface of the dump. In addition, the absence of rubbish processing factories has led to the emergence of unauthorized dumps at the foot of the slagheap.

The third problem is their smoldering, leading to the possible release of toxic substances, the concentration of which in the ash increases 10 times [2]. There are especially many oxides of nitrogen, sulfur, hydrocarbons and carbon monoxide.

The study of the problems of smoldering slagheaps is carried out, as a rule, by ground-based methods. Of course, the main disadvantage of this approach is the high labor intensity and cost of work, which does not allow the use of ground-based methods for the study of large areas. Modern operational methods of searching for areas of long-term burning are remote sensing of the Earth from space with subsequent processing of data, which are also being tried in the post-Soviet space [8]. Also noteworthy is their study using dromes aerial vehicles [9]. But in general, no matter how much you study them, the main thing is their reclamation and processing.

Their number on the territory of Donbass region is more than 1500 [2]. Moreover, they all have a lot in common. Any slagheap has the shape of a pyramid, the height of which is up to 100 m and higher, the slope angles are 20-45º, and the base area is several hectares (Figю 1). They are assigned numbers, usually in accordance with the number of the mine, and if there are several of them on this mine, then a secondary number is assigned.

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Fig. 1. Slagheaps.

Therefore, knowing the number of mines and the year when commissioning began, you can roughly find out the number of slagheaps in any region. On average, one slagheap appears in 10 years of mine operation. Another method is also known - when mining 1 ton of coal, on average 0.7 tons of rock are extracted with coal, the disposal of which is even more expensive than mining. Therefore, it is poured into the embankments, which over time will take on the shape of pyramids. Sometimes they are even given folk names, but the number is preserved. It is almost impossible to find out the exact numbers (only roughly) due to the appearance of illegal digging and war"s hostilities in the territory of Donbass.

They can be classified into several types, for example - working and abandoned, old and new, burning and extinct. What do you mean - old and new? If a mine has recently closed, a slafheap is considered new, even an abandoned one, but if illegal diggers start working on the site of an abandoned mine, the slagheap can be considered new. Usually the old slagheaps are red in color, since the waste rock has oxidized and darkened over the years, and the new ones are dark gray. There are also intermediate types with a color transition in the lower part, as the trolley drives into the ridge, pouring out a new batch of rock, most of which accumulates in the upper part. Burning slagheaps are called so because sometimes the relatively recently poured rock inside the pyramid ignites spontaneously from high pressure.

For successful recommendations for solving problems with waste heaps, it is relevant to study them and develop a methodology for this, which was the topic of research.

2 Materials and methods

For certification and further processing of the rock in the slagheap, it is important, first of all, to determine its total amount in cubic meters. For this, the following parameters were measured: height, average diameter at the base, slope angle. Samples for analysis were taken along the steep ridge of the slagheap by a point method in the direction from the base to its top every 10 m in accordance with the works of T. Chekushina [4]. The slagheap was preliminarily divided by parallel horizontal planes into sections, in each of which 4 average samples weighing 1 kg were taken using a soil drill 1.5 m long, at a depth of 10, 20, 50, and 100 cm. The selected samples were placed in glass jars.

Determination of the granulometric composition was carried out by sieving on sieves with holes of diameter: 10; five; 2; 1; 0.5; 0.25 and 0.1 mm. Each retained fraction was weighed and the percentage calculated based on the total weight. Moisture and temperature were measured at a depth of 50 cm with a Tr 46908 soil moisture thermometer in the sand mode.

Measurements of the radioactive background were carried out by us using a portable β- and γ-radiation radiometer RKS-20-03 "Pripyat" according to experience Vorobiev S. [4].

3 Results and discussion

Measurements have shown that the largest number of large fractions of the slagheap lies in the lower part (base or bottom). This is due to the fact that when the rocks are dumped down a slope, large pieces roll further than small pieces, accumulating in the lower part of the dump (Fig. 2).

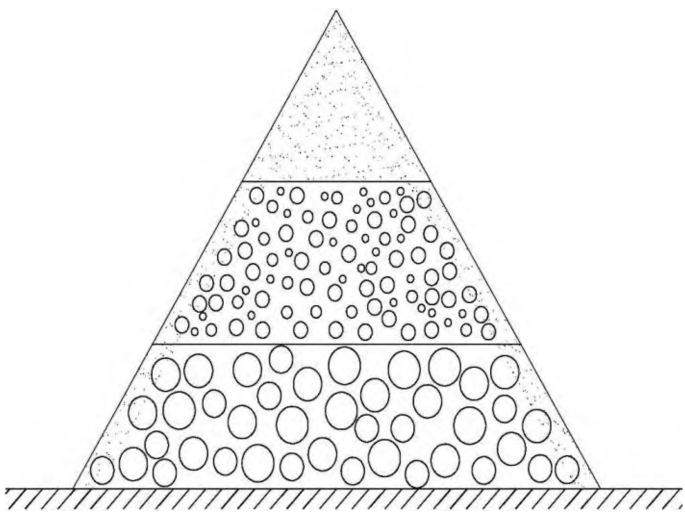

Fig. 2. Scheme of the waste heap section with the indicators of the granulometric composition.

In the lower 1/3 part, the content of large fractions larger than 1 cm is from 30% of the sample in a layer of 20 cm to 53% at a depth of 50 cm. The temperature increases on average by 1°C for every 20-25 cm. It is highest in the lower and middle parts - 35.2-36^{o}C. The radioactivity of dumps varies from (β + γ = 26.22 mR / h, including β = 19.40 × 10^2 parts/min × cm^2), to (β + γ = 30.06 mR/h, including β = 22.67 × 10^2 parts\minute × cm^2). At the same time, the value of radioactivity is always higher in burning waste heaps, over which smoke is emitted.

The method of point temperature measurement for assessing the thermal state of waste dumps, although it allows one to obtain information about the thermal state of any slagheap in the absence of visible combustion of burning, is still outdated, even with the use of electronic digital thermometers with long probes. The future, without a doubt, belongs to the methods of space sensing and infrared imaging. Such measurements require significant financial investments, which are very limited today in the Donbass region.

One more curious fact can be noted: in some slagheaps, in particular those that formed after 1994, layers of physical clay were revealed. This is due to the fact that after 1994, to prevent combustion, the rock layers were covered with layers of clay solution. This is undoubtedly a step forward, but the solution to the problem consists in 2 ways of developing the coal mining industry. In coal mining, it is necessary to install modern equipment that ensures complete regeneration of the water used for coal enrichment and a closed production cycle that does not require sludge ponds, which occupy huge areas and pollute the environment [11]. The second is the recycling of slagheaps, in which it is necessary to carry out their certification and take into account research data. Which speak about the most difficult for processing the soles of the slagheap.

Processing of waste dumps, provides for the extraction of iron-containing raw materials, germanium; rare earth elements (REE); aluminum containing raw materials [12]. At the same time, one cannot say about the risk assessment of such investments [6]. For example, at the beginning of 2014, the price of 1 hectare of land in the areas adjacent to Donetsk was on the secondary market from 170-380 thousands USD. Therefore, it was quite possible to hope for a quick return on investment in the reclamation of slagheaps, in the place of which expensive land would be freed. At such prices, the payback period would be no more than 1 year. At current prices, the payback period has increased to 10-12 years. But due to the high technogenic hazard, there is still no alternative to the disposal of slagheaps.

4 Conclusions

Re-equipment of all coal mining enterprises with new modern equipment and agglomeration (as the most progressive way) can give a significant backthrough to the development of Donbass. Research confirms once again that there is no alternative. Given the limited financial resources for this, a large-scale attraction of investments to Donbass is possible on condition of creating a SEZ (Special Economic Zone) which in all cases gave a positive effect [13-14], both in individual cities and in entire regions. The main directions of the activity of economic entities are directly linked to production of wide range of high competitive products by implementing modern high-tech equipment, technology lines and the introduction of innovative technologies in coal mining industry. When introducing methods for extracting a number of rare earths and other valuable elements from slagheaps, residual silicate materials can be used for the production of building materials [15].

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