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USE OF SOLID MINING WASTE TO IMPROVE SOIL QUALITY

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Abstract
The article discusses the possibility of using burnt-out mine rock, as components of nutrient additives to degraded soils, to increase the structural properties of clay and silty soils, as well as improving their water penetration and ability to accumulate moisture. The results obtained are new, since no previous research has been conducted on the use of burnt-out dump mass from coal mining enterprises as a soil former and fertilizer component.
Keywords: waste rock dumps, burnt-out rock, mining waste, sorbed and meniscal water

One of the most important environmental issues in the mining industry is the problem of managing solid waste from the mining industry. According to statistical data, before the start of the full-scale Russian-Ukrainian war, there was a tendency in Ukraine to increase the volumes of solid waste generated at mining industry enterprises. Thus, while in 2015 257.8 million tons of wastes were generated, then in 2020 this figure increased by 1.52 times and amounted to 391.1 million tons [1]. Over the last almost 1.5 years, the volume of solid waste generated has probably decreased due to a reduction in the number of coal-mining enterprises operating in the Donetsk and Luhansk regions.

The low level of utilization and recycling of waste rock (up to 25-30% of the created parameter) [2] results in its significant accumulation on the daylight surface in the form of waste rock dumps. Over the past 50 years, over 25 billion tons of mining waste have been accumulated in the coal-mining regions of Ukraine, occupying thousands of hectares of fertile land [3].

The negative environmental, economic and social impacts of mining industry waste indicate that the industry needs to rethink waste management methods and implement new solutions. One effective option in this direction is to reduce mining waste through the implementation of the advanced coal mining technologies and the use of more powerful equipment, as well as maximizing the use of waste rocks already accumulated in waste rock dumps as raw material for other branches of industry and agriculture.

Thus, reducing the technogenic burden of waste rock dumps on the environment by increasing the level of utilization of solid coal-mining waste is an urgent scientific and technical task.

The presence of a complex of mineral components in solid mining waste, as well as the transformation of burnt-out rock into a poorly soluble state similar to ceramics, opens up the possibility of using this material in agriculture. There is a well-known practice of using solid waste from crushed stone production as a fertilizer for growing energy crops. It has been proven that the addition of crushed stone increases the yield of agricultural crops due to more intensive development of the root system as a result of a change in the structure of peat soil [4].

At present, the soils of Ukraine can be characterized as intensively losing crop yield [5]. Due to the destructured upper layer, their ability to retain and accumulate moisture is reduced, resulting in the suppression of the development of plant root systems. In addition, the structural texture of soils is dominated by clay and silty components, which in turn also worsens the conditions for the full supply of plants with all the elements and minerals necessary for nutrition. Therefore, the possibility of increasing the structural properties of clay and silty soils, as well as improving their water penetration and ability to accumulate moisture is of interest.

An assessment of the ability of solid mine waste to influence the filtration and retention of sorbed capillary water is important for the possibility of using burnt-out rock to improve the moisture saturation parameters of degraded loamy soils.

The structural texture of most soils of Donbas and other regions of Ukraine is currently dominated by clay and silty components. Such soils are characterized by increased density and viscosity, as a result of which water does not pass through well and plants do not receive the amount of moisture necessary for nutrition. When dry, such soils become covered with a dense crust, preventing the flow of moisture, air and light to the plant root system. After the crust dries, wide frac-tures form in it, which, on the contrary, contribute to the removal of moisture from the lower layers of the soil.

Visual observations make it possible to specify the mechanisms of water saturation of different types of soil. So, as for loams, when first watered, water quickly penetrates into folds, fractures, and macropores, moistening a rather significant surface space. The wetted organic com-ponent particles of the soil medium begin to absorb water by their mass, increasing significantly in volume. With a sufficient amount of moisture, aggregation of particles is observed to form a hydrogel. A layer of fairly stable medium unsuitable for water filtration is formed. Water reaches the lower soil layers in a mode close to diffuse, and the velocity of such water front movement is orders of magnitude less than during filtration.

Sandy soils with limited organic constituents are not prone to significant water absorption by their mass, that is, water penetrates to the surface, but there is almost no increase in the volume of wetted particles. The particle sur-face is wetted with so-called film sorbed water, the capillaries and micropores are also gradually filled with meniscal water. The movement of water in depth occurs through macropores and cavities. Between parts of sandy soil, gravitational water moves in a filtration mode.

Laboratory experiments have confirmed a several-fold increase in water penetration when adding fine-grained material less than 5 mm in size to loam. Changing the soil structure by adding granular media can increase water penetration and prevent the surface crust formation [6].

To ensure the highest water penetration parameters, it is advisable to add at least 50% of solid mining waste. In terms of the availability of such a resource in Donbas, there are no restrictions, but in terms of logistics, as well as financial and labor costs, there is a problem.

We have conducted preliminary research on the possibility of using burnt-out dump mass as a fertilizer additive. Solid mine waste in itself is not a nutrient medium. Therefore, it was used to prepare a three-component nutrient mixture consisting of 25% burnt-out mine rock, 25% river silt and 50% degraded loamy chernozem treated with California red worms, on which tomato seeds were later planted. In the course of conducting laboratory research, it has been revealed that the highest germination rate – 100% – was in samples grown on a substrate with the addition of burnt-out mine rock. While the germination percentage of samples grown on the other two substrates (1 – reference, degraded loamy chernozem; 2 – a mixture of reference chernozem and treated with earthworms, in a proportion of 50 to 50%) was only 40% [7]. This makes it possible to confirm the hypothesis of the possibility of using burnt-out mine rock not only to improve moisture capacity, but as components of nutrient additives to degraded soils [8]. The results obtained are new, since no previous research has been conducted on the use of burnt-out dump mass from coal mining enterprises as a soil former and fertilizer component.

The widespread use of solid mining waste in agriculture requires research not only into changes in the water-permeable properties of soils when adding burnt-out rock to them, but also other agrochemical properties. Therefore, in the future, it is necessary to assess the minimum amounts of rock addition to specific types of agricultural land and ways of doing so. The issue of safe stripping of dumps and cost-effective obtaining of the necessary fractions of burnt-out rock also remains relevant.

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