Selected Black-Coal Mine Waste Dumps in the Ostrava-Karviná Region: An Analysis of Their Potential Use

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Abstract. The paper aims to analyse the options for the use of selected black-coal mine waste dump bodies in the Ostrava-Karviná Region. In the Czech Republic there are approximately 70 mine waste dumps, out of which 50 are located in the Ostrava-Karviná Coal District. The issue is highly topical, particularly in the region, because the dump bodies significantly affect the landscape character of the Ostrava-Karviná Region and pose ecological risks. In such cases, their redevelopment and land reclamation are not easy either from the environmental or economic points of view. It is clear that the redevelopment of such geological environment is difficult, and it is vital to make the right decisions as for what purposes the mine waste dumps should be used. Next, it is important to take into account all the economic and environmental aspects of the locality in question.

1. Introduction
The paper deals with the issue of black-coal mine waste dumps in the Czech Republic, particularly in the Ostrava-Karviná Region, where the majority of them are located. These anthropogenic bodies have been formed as the by-products of underground coal mining in the region. Despite the fact mining operations in the Ostrava-Karviná Coal District have been gradually phased out, their consequences, including mine waste dumps, are problems that need to be dealt with. Underground mining and the related formation of mine waste dumps have significantly participated in changing the landscape character of the region. The aim of the paper is to consider the options for the future use of selected black-coal mine waste dumps in the Ostrava-Karviná Coal District.

2. Characteristics of mine waste dump bodies in the Ostrava-Karviná Region
Mine waste dumps are anthropogenic forms of the Earth surface that have been man-made. Professional literature contains a number of terms referring to mine waste bodies, such as waste piles, heaps, and dumps. The different terms are used to distinguish the manner the mine waste body has been formed. If a mine waste body contains waste materials from underground mines, which is typical for the Ostrava-Karviná Region, we refer to it as a heap or dump. In case of open-cast mines, which are located in the area of Most and Sokolov Coal Basin, the term of waste piles is used.
In the Ostrava-Karviná Region we distinguish two groups of anthropogenic forms. The first group is represented by active forms (dumps) which have been formed by dumping waste rock and tailings. The second group is represented by passive forms (depressions) which have been formed due to undermining. [1]

In the Ostrava-Karviná Coal District, the active forms, i.e. dumps/heaps, are further classified into 8 major shapes: conical, pile-type, board-shaped, terrace-shaped, inclined, ridge-shaped, straightening, or flat coverings. [2]

Conical dumps are usually dominant in the landscape. They have a big relative height and the layers of the dumped waste rock are thick. Some of them are as 80 m high, and thus cause deformations of the surrounding ground due to pressure. Conical dumps prevail in the Ostrava-Karviná Region, and three of them have been thermally active due to the burning of the dumped material. They are Hermanice Dump, Ema Dump and Hedvika Dump. The thermally active dumps have been the most problematic and caused much damage. The most troublesome are the air pollutants that may be toxic. In this type of dump, partial removal of the waste rock, particularly in the lower section of the dump, may be highly problematic as the access of air may accelerate fire or reactivate it.

Pile-type dumps used to be shaped on central dumps. When the apex of a conical dump reached a certain height, it was gradually extended sideways by piling side dumps. Another method of shaping pile-type dumps lies in shaping an existing conical dump via spreading the tip because of vital technical modifications. This leads to the expansion of the dump sideways and reduction in its height. Both conical and pile-type dumps belong among dominant landscape forms in the Ostrava-Karviná Coal District. In addition, other smaller dumps were also formed this way, for example, in former mines, such as Jiří Mine in Ostrava-Přívoz.

Board-shaped dumps in the Ostrava-Karviná Region are of all sizes. They are widespread due to piling central dumps and dumping waste rock and tailings. The board-shaped plane dominates over its slopes and thus, this shape is highly suitable for land reclamation purposes. Without any extensive modifications, such a dumps may be covered with topsoil as in the case of a dump near Petr Bezruč Mine in Ostrava.

Terrace-shaped dumps have similar shapes to board-shaped dumps, but terrace-shaped dumps have a lower thickness and are located along river beds. They used to be formed to reduce the risk of floods in flood plains. Next, material to form terrace-shaped dumps is used to fill in subsided localities or low swamps. Artificial terraces are thus made, for example as in the Strachov Mine in Ostrava-Hrušov.

Inclined dumps are rare in the Ostrava-Karviná Region. This region is characteristic for only partially built slopes of the dumps as embanking was carried out gradually along the natural slope. It may be stated that today dumps to a certain extent copy the natural ground. In the Ostrava-Karviná Coal District, specimens of inclined dumps may be found in the dump complex of the former Emma Mine and Trojice Mine, or near the former Eduard Urx Mine in Ostrava-Peřtikovice.

Ridge-shaped dumps are characteristic of an elongated and narrow ridge. The ridge is built due to the specific construction of a dumping cableway to transport tailings onto the dump. The occurrence of such dumps is rare in the Ostrava-Karviná Region as they were re-shaped later on, e.g. a dump of the Stalin I Mine in Ostrava-Hrušov.

Straightening dumps are numerous in the Ostrava-Karviná Coal District. Straightening dumps may be found in the sites of extensive depressions to level off or raise the ground. Such areas are easily recognisable in the terrain. They prevail in the Karviná part of the district, where natural depressions used to be filled in too. Nowadays, the dumps are gradually redeveloped with grass or forests, or they are left to natural succession. The municipalities of Stonava and Petřvald are typical for this type of dump. An example of a straightening dump in the Ostrava part of the district is the dump of the Petr Cingr Mine in Ostrava-Michálkovice.

Flat coverings are vertically indistinct, but spatially they are very extensive forms. They are abundant in all parts of the Ostrava-Karviná Coal District, but they do not have a strong influence on the final landscape character, [2, 3].
Apart from the above mentioned 8 major shapes, there are also dumps of transitional types, such as inclined piles or irregular piles. The final shape of a dump depends on the surface area, on pre-planning the height and shape of the dump, on the filling method as well as on unplanned interference, e.g. later removal of waste rock, increasing or decreasing the dump height as opposed to the original plan, etc. [2]

3. The possible uses for the dumps based on their material composition

This From the point of view of the building industry, dumps are interesting sources of materials that may be used when duly processed. First, waste rock for the building purposes is rid of coarse stone. Next, it is crushed in a mobile crusher and stored in a bin along with crushed aggregates from the next processing stage. Selectively extracted and crushed rocks from mine openings are added into the bin. Such sorted waste rock may be used to make embankments for various line structures, as materials for land reclamation works, or ground modifications for future industrial or residential development [4]. An example of a dump from where materials were removed, sorted and used in a line structure embankment is the Ostrava dump called Jeremenko in Ostrava-Vítkovice (see Figure 1). In total, 270 000 m3 of the embankment containing slag from ironworks and mine waste rock were removed there. [5]. The provision of building material was a secondary goal in that case. The primary goal was the modification of the dump’s shape and stabilisation of its walls in connection with the construction of a hobby-market Hornbach and other premises in the future (see Figure 2). To build the hobby-market there, the dump had to be lowered and its conical shape had to be modified. A gabion wall was also built in order to stabilise the slope and protect the railway tracks.

The use of waste rock or tailings as the secondary building material is not always possible. The waste rock must comply with certain physical and chemical parameters. If not, the material composition needs to be modified, either physically or chemically. If this was too costly, such material is not suitable. In this respect, the use of waste rock or tailings from the dumps in the Ostrava-Karvíná Coal District is highly problematic because of the Carboniferous waste rock with a high content of sulphides. Sulphates liberate from these due to oxidation, which makes the material unsuitable for two reasons. The first is the risk of ground water contamination, as in the case of the dump of Jan Šverma Mine in Ostrava-Mariánské Hory, which is located near the water supply in Ostrava-Nová Ves. The second reason is the negative impact of sulphates on concrete, which leads to the formation of large crystalline neoformations, e.g. rock gypsum. At first, such neoformations are convenient as they increase the compactness of concrete. But because of the subsequent growth of the crystals in the concrete’s microstructure, there is an increase in the tensile stress, which may lead to the overall destruction of concrete. An example of an inappropriate use of such waste rock is the construction of a D1 motorway section between Ostrava and Bohumin, where sufficient counter-measures had not been implemented. In other cases, when a concrete construction is exposed to the action of sulphates, it may degrade due to the synergetic effect of the corrosion of the second and third type. An example may be the so-called magnesium sulphate corrosion, when concrete is exposed to the action of magnesium sulphate. The undergoing reactions may be expressed as below:

\[
Ca(OH)_2 + MgSO_4 + 2H_2O \rightarrow CaSO_4 \cdot 2H_2O + Mg(OH)_2
\]  

Another option to use mine waste as raw materials for the building purposes is the use of washery dirt, which is the subject of many studies, for example La Nauze and Duffy [7]. Among the other authors who dealt with this issue there were Leventhal and de Ambrosis, who studied washery dirt samples via field and laboratory tests for the period of ten years [8].
Figure 1. a) Aerial photo; b) Topographic map showing Jeremenko Dump, hobby-market Hornbach and free plot for future development [9, 10]

Figure 2. a) Hobby-market Hornbach b) A free plot for future development

4. Possible uses for mine waste dumps - recreation, sports and tourism

As for the recreation, sports and tourism, dumps are very interesting sites that may be suitable after due modifications. The most suitable are the dumps situated in the centre of the city, where there is a shortage in greenery. The use is conditioned by the health soundness of the material used. An example may be the already reclaimed dump in Ostrava-Hrabová that has already been reclaimed, afforested and made accessible to the public. The former metallurgical slag dump belongs to a private company Vítkovice.

Another example of a dump, where land reclamation works are still under way and which is not accessible to public, is the dump in Ostrava-Hrabůvka. It also belongs to the company Vítkovice and is situated between an express road Místecká and the Ostravice River (see Figure 3). The land redevelopment plan proposed constructing a golf course there, but the project has been postponed due to burning in the dump. Instead, an artificial lake was constructed on the top of the dump and it is charged from the Ostravice River (see Figure 4). The surface area of the lake is 4.5 ha, and its volume is 180 000 m³ [11]. The newly forming lake that should be filled by the end of 2017 should serve for several purposes. The major purpose will be an area for sports and recreation, and a free-time space for the public. At the same time, the lake will embody a new landscape element, which shall become home for a number of animals and plants. Its secondary purpose is to extinguish fire arising in the dump via preventing oxygen supply. The dump mainly comprises of non-flammable slag, but the base is made of mine waste rock that is flammable. The centres of fire are found about 30 m below the dump surface. The temperature reach as high as 300°C and products of combustion have the temperature about 40°C. The opening of the dump to the public is planned for 2022. Apart from the lake, and grass plots, the land
reclamation plan also includes trails for pedestrians, cyclists and roller-skaters. In winter, there should be trails for cross-country skiing.

Figure 3. a) Aerial photo; b) Topographic map showing the dump in Ostrava-Hrabůvka [12, 13]

Another example of a dump that has been very popular with tourists is Ema Dump in Ostrava (see Figure 5 and Figure 6). It was reclaimed in the 1960s, when different decorative trees and shrubs were planted there. However, allochthonous species were also planted there, e.g. Quercus rubra. The further development on the dump was left to spontaneous succession, thanks to which the decorative and self-seeding plants mixed to form an interesting community. As the dump has been thermally active, we may find various thermophilic plant and animal species there. Due to the thermal activity in the dump an access used to be banned in the past. Nowadays, Ema Dump belongs to popular touristic localities in Ostrava. It is the only dump in Ostrava that is officially maintained and it has a footpath with signboards. A number of running races are held there regularly.

Figure 4. a, b) Artificial lake on the dump in Ostrava-Hrabůvka [11]

Figure 5. a) Aerial photo; b) Topographic map showing Ema Dump in Ostrava [14, 15]
Figure 6. a, b) Ema Dump in Ostrava

5. Conclusion
The aim of the paper was to analyse the possible uses for selected black-coal mine waste dump bodies in the Ostrava-Karviná Region in the Czech Republic. The environment of dumps is a specific type of anthropogenic environment situated in the geoenvironment, which significantly influences the landscape character. Due to their sizes and surface areas, dumps concern considerable territories in the Czech Republic, and thus are important from the point of view of land use planning. The paper discusses the possible uses for dumps related to underground mining. In the dumps in the Moravian-Silesian Region, we must consider a substantial heterogeneity in the dumped materials. This means there may be problems with differential settlement, increased thermal activity (burning), risk of groundwater contamination by sulphates, negative impact of sulphates on concrete and concrete constructions. In detail, the paper focuses on two major options for the use of black-coal mine waste dump bodies, i.e. the use of the dumped materials, and the use for recreation, sports and tourism. The above mentioned examples, which have been implemented in Ostrava, may be applied on other types of dumps in the Czech Republic and world-wide. However, the specific use must be considered for each dump subjectively taking into account the needs of the public and the circumstances in the given locality.

Acknowledgment(s)
The authors would like to thank VŠB–Technical University of Ostrava for the support within the project (SP2017/22).

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