Analysis the Purposes of Land Use Planning on the Hard Coal Tailing Dumps

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Abstract. The aim of this publication is to analyse the purposes of land use planning on hard coal tailing dumps. This issue is very topical because there are 46 tailing dumps and 281 reservoirs in the Ostrava-Karvina Mining District. They significantly affect the landscape of this region. A major problem is solving problems of reclamation of these geological environment. This means that it is necessary to think about it and start to solve it. It is clear that such reclamation is not simple both economic as well as environmental point of view. It is necessary to think carefully about what purpose would be tailing dump or reservoirs to utilize in a given location.

1. Introduction

The intention of this publication is to focus on the issue of hard coal tailing dumps and reservoirs that occur both worldwide and in the Czech Republic. This is especially the Ostrava-Karvina region in the Czech Republic. Hard coal tailing dumps there are found in relatively large numbers. These are specific anthropogenic elements that arose and still arise partly on the territory as a remnant of deep mining activities. Deep mining activities are currently on the decline in the Ostrava-Karvina region therefore the emergence of new tailing dumps and reservoirs is declining as well. Tailing dumps created in the past pose a problem. These anthropogenic elements significantly changed and influenced landscape character of this region. The purpose of this publication is to think about other possibilities for the use of this anthropogenic environment and the issues of rehabilitation, which will be necessary for further use.

2. Characteristics and formation of coal tailing dumps

Tailing dumps occurring in the Ostrava-Karvina region, they are composed of rock material, which are the remains of deep mining of hard coal. Currently, deep mining is almost does not occur in this area. Bodies of tailing dumps are formed not only the rock material but also contain residual materials from treatment of coal. From the viewpoint of engineering geology, it is a very interesting environment. This environment is totally different in contrast to natural or other anthropogenic geological environment.
For tailing dumps is special mainly their almost homogenous geological structure. This can complicate the remnants of coal. Under certain specific conditions then may trigger the thermal processes within the body of coal tailing dumps.

Coal tailing dumps arise because of the need for separation of the mined material (in the case of the Ostrava-Karvina region, it is hard coal) and residual material (tailings) from which the coal tailing dumps are formed. The largest amount of tailings generated during surface mining. As an example, it may be mentioned lignite mining in the Most (formerly North Bohemian deep) Basin, when in 1997 per 1 ton of coal mined accounted for only 7.95 tons of overburden. The ratio of hard coal mined in relation to the tailings is more favourable in the case of deep mining in the Ostrava-Karvina Mining District. It was calculated that to extract 1 billion tons of hard coal were needed to extract about 700 million tons of tailings. Surface impact on the geological environment is significant, even if deep mining is more environmentally friendly than mining on a surface. The total area of the Ostrava-Karvina Mining District is approximately 850 km2 of which 350 km2 is directly influenced by the deep mining. This is 46 tailing dumps from that area occupies an area of approximately 1 km2. Another 815 ha then accounted for by tailing ponds and the flotation reservoirs. It can therefore say that nearly 2 km2 in the Ostrava-Karvina region was completely converted from natural to anthropogenic environment. Total cubic capacity stored of tailings is approximately 90 million cubic meters in this area [3, 12].

Coal tailing dumps causing a number of other environmental issues besides the changed of landscape character. It was calculated that into the atmosphere annually receive 80 to 120 thousand tonnes of dust from tailing dumps and tailing ponds. The partially settle in this area. Remaining part is then taken away by the wind to neighbouring regions [3].

3. Possibilities of coal tailing dumps

In terms of land use planning, coal tailing dumps represent extensive and unused space. Since it is a brownfield, possibility of their utilization is not easy. For subsequent use of coal tailing dumps, there are many different variations that are not taken into account in other engineering geological zones.

The first option is to use original or modified geometry of the coal tailing dumps for the purpose of founding the building construction. An example of this solution can be mentioned the construction of Hornbach hobby market in Ostrava, on coal tailing dump called Jeremenko (Figure 1). This coal waste dump is situated in a busy area next crossing street Rudná and Místecká in Ostrava-Vítkovice. That is why the company Hornbach chosen as a suitable location for his hobby market. It was necessary to deal with several problems in order to hobbymarket built in such a place. First, it was necessary to solve the problem of thermal activity of coal tailing dumps respectively with a high proportion of combustibles.

This is because of the danger of re-ignition. It was also necessary to extract 270,000 cubic meters of embankments, which were composed of slag from the nearby ironworks and especially tailings from the deep mining industry. Conversely, for reclamation and preparation of areas for construction was needed to bring about 90,000 square meters of soil. Complications for earthworks were escaping mine gas besides the different quality of the soil. It was necessary to take away material with a high content of combustibles material and also search and provide the place where escaping gas. It was important for the completion of construction. The threat of potential sliding slope, it was another problem. Security slopes of coal tailing dumps was done by the construction of a gabion wall, south and east sides, as shown in Figure 2.
The second option is to use the body of coal tailing dumps for recreational and sports purposes. For such a purpose was elaborated a project to build a golf course on the coal tailing dump in Ostrava city-Hrabůvka. It was at the initiative of its owner, the engineering group Vítkovice Machinery Group (Figure 3). The project envisaged the construction of an 18-hole field on an area of 98 hectares. For this was to be used upper part of the coal tailing dump. In other places there were further develop routes for inline skaters, bikers and cross-country skiing. In order to realize this project, first overall remediation of the coal tailing dump had to be made. It was also necessary to solve the problem with burning inside the coal tailing dumps, where the temperature was measured until 300 °C.

There would be an extension of thermal processes in other part of the coal tailing dump if it was not extinguished. In places with thermal activity should be started to sink the soil. According to the original plan should be part of the course opened in 2011, but due to technical problems, the project still failed to realize. Whether golf course project will eventually realize at this location or there will be created a natural green area intended to leisure activities, it is currently not clear. However, the proposal can be applied to other locations in the Czech Republic and elsewhere in the world. Karvina city is an example where the golf course on the undermined territory was implemented. There was opened in 2012 as a nine-hole field for the public, as well as a nine-hole championship golf course for professional players, in part of Karviná-Lipiny.
The third option, it is the possibility of the use of tailings as a secondary raw material for construction purposes. In the world deals with this issue many authors who have studied the possibility of using waste products from coal washing. Authors Leventhal and De Ambrosis studied the possibility of secondary use as a laboratory, as well as through field tests. Here they examined samples of waste from coal washing for ten years. [5]. Other authors who have studied the waste from washing, were La Nauze and Duffy [4].

Most of the tailing dumps in the Ostrava-Karvina Coal Mining District originated from Carboniferous tailings. This represents a significant problem. As a result of oxidation of sulphides which contains the tailings, it leads to sustained release of sulphates into groundwater. From this perspective, the greatest hazards are a coal tailing dumps of deep mine Jan Šverma in Ostrava-Marianske hory. There is threatened with contamination of the water source called Nova Ves. Sulphates do not only threaten groundwater resources. Sulphates contained in the tailings is also problematic if you want tailings used for large-area changes the terrain, for reclamation of areas affected by deep mining or embankments to build roads. In this way the sulphate contamination spreads further into the space. We must remember the negative impact of sulphur for concrete and concrete constructions, if we use this tailing in the already mentioned road embankment or to edit the terrain designated for founding of construction. This problem it was necessary to solve for example during the construction of the D1 highway between Ostrava and Bohumin, where the tailings of this type was used partly to the embankment.

Reclamation of the coal tailing dumps for the purpose of afforestation is fourth, today largely used variant in the Czech Republic and worldwide. Reclamation takes place so that, according to a pre-prepared project will necessary adjustments of terrain (tailings) on which is subsequently laying of the layer of topsoil in a specified thickness. As an example coal tailing dump, among Karvina, Stonava and Louky (Figure 4). There was partially implemented this type of reclamation and in future years will continue (Figure 5). The coal tailing dump can be left to natural succession or will be planting suitable trees, after the laying of the topsoil. These can be planted for the purpose of future utilization. Some plants have proven themselves to phytoremediation (decontamination) purposes at more contaminated tailing dumps. Contamination can be either successfully extract or locally withhold due to processes such as phytoextraction or phyto-stabilization. Examples of plants suitable for phytoextraction and planted on tailing dumps may be sea buckthorn (Hippophae rhamnoides), which is able to extract Ni, Zn, Cu, Mg or Pb. Maize (Zea mays) or winter oilseed rape (Brassica napus) can be included among the other plants that have phytorextrace capabilities.

Phytoremediation capabilities of plants in the world, dealing with many authors. Authors Houben, D. et al. They investigated the long-term effects of these plants for extraction, for example Cd, Zn and Pb from an environment of old tailing dumps [2]. An example of the use of phytoremediation plants may be Mexico, where the authors Cortés-Jiménez, E. V. et al. explored the potential and possibilities
of local plants for extraction of heavy metals from the tailing dump in Taxco, Guerrero State, Mexico [1].

Phytoremediation ability of plants, it is also one of the reasons why the coal tailing dumps are not suitable for agricultural reclamation. Contaminants may be introduced via these plants disseminated into other environments. Small soil fertility (laying of the layer of topsoil for this purpose is small) and the slope of the terrain is another reason why agricultural reclamation is not possible. When planting the wide row crop like corn or canola would risk erosion during intense rainfall could lead to an overall erosion of topsoil layer from the body of coal tailing dumps.

![Figure 4. a) Topographical map b) Aerial photograph of coal tailing dumps among Stonava, Karvina and Louky showing already reclaimed part and prepared for reclamation (maps and aerial photograph [10, 7])](image)

![Figure 5. a) Part of the coal tailing dump ready for reclamation b) Reclaimed part of the coal tailing dump](image)

4. Conclusions
The aim of the publication was to analyse the land use planning for the purposes on hard coal tailing dumps. Coal tailing dumps play an important role in terms of land use planning, given the large scale, both in the Czech Republic and worldwide. These are specific anthropogenic environment, which significantly affects landscape character. For coal tailing dumps, formed after deep hard coal mining in the Ostrava-Karvina Coal Mining District, we can expect problems with their excessive thermal activity (burning), with a risk of groundwater contamination by sulphates and other harmful substances, as well as excessive dust. The publication described four options heap usage. It is the use of original or modified geometry of the coal tailing dumps for the purpose of founding the building, the use of body of coal tailing dumps for recreational and sports purposes, the use of tailings as secondary raw materials for construction and reclamation of coal tailing dumps for the purpose of afforestation. The fifth option
(agricultural reclamation) were classified as problematic and rather unsuitable for implement because of possible contamination, small thickness of soil or possible soil erosion. These four listed options are applicable to different types of other tailing dumps both in the Czech Republic and worldwide. Possibility to use for a specific coal tailing dump should be assessed individually, considering the possibilities and needs of the locality.

References
[1] Cortés-Jiménez, E. V., Mugica-Álvarez, V., González-Chávez, M. C. A., Carrillo-González, R., Gordillo, M. M., & Mier, M. V. (2013). Natural revegetation of alkaline tailing heaps at Taxco, Guerrero, Mexico. *International journal of phytoremediation*, 15(2), 127-141.
[2] Houben, D., Couder, E., and Sonnet, P. (2013). Leachability of cadmium, lead, and zinc in a long-term spontaneously revegetated slag heap: implications for phytostabilization. *Journal of Soils and Sediments*, 13(3), 543-554.
[3] Kukal, Z., Reichmann F., (2000). The geological environment of the Czech Republic: its status and protection. Prague: Czech Geological Survey, 2000. ISBN 80-7075-413-3. (in Czech)
[4] La Nauze, R. D., Duffy, G. J. (1985). Coal rejects - a wasted resource, *Environmental geochemistry and health*, 7(2), 69-79.
[5] Leventhal, A. R., De Ambrosis, L. P. (1985). Waste disposal in coal mining - a geotechnical analysis. Engineering geology, 22(1), 83-96.
[6] Mapy.cz, (2016). Aerial photograph – coal tailing dump Jeremenko. © www.basemap.at, © MicrosoftCorporation, © Seznam.cz, a.s. 1996–2016
[7] Mapy.cz, (2016). Aerial photograph – coal tailing dump among Stonava, Karviná and Louky. © www.basemap.at, © Mi-crosoftCorporation, © Seznam.cz, a.s. 1996–2016
[8] Mapy.cz, (2016). Aerial photograph – coal tailing dump in Ostrava-Hrabůvka. © www.basemap.at, © MicrosoftCorporation, © Seznam.cz, a.s. 1996–2016
[9] Mapy.cz, (2016). Topographic map – coal tailing dump Jeremenko. © OpenStreetMap, © Seznam.cz, a.s. 1996–2016
[10] Mapy.cz, (2016). Topographic map - coal tailing dump among Stonava, Karvina and Louky. © OpenStreetMap, © Seznam.cz, a.s, 1996–2016
[11] Msstavby.cz (2015). Golf course in Hrabuvka will not. Buildings in the Region. 31.7.2015, Ostrava (in Czech)
[12] Tylčer, J, (2011). Old burdens in Ostrava. In Regeneration of industrial areas, part II. 1st ed. Ostrava: VSB - Technical University of Ostrava, 2011. Chapter 3, pp. 32-41. (in Czech)