

THE INDUSTRIAL WASTE LANDFILLS – CHALLENGES REGARDING THE SIDERURGICAL SLAG DUMPS LOCATED IN HUNEDOARA MUNICIPALITY

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Abstract: Currently, approximately five percent of Hunedoara county area, Romania (Vajdahunyad [hu], Eisenmarkt [ge]), is occupied by industrial landfills. In case of dumps, such as the siderurgical slag dump located in Hunedoara, the slags can be recycled even for road building. Regarding the slag dumps located in the area of former mines, where the materials (complex ores) cannot be reused, they remained abandoned pending for greening projects. For now, the greening price exceeds the possibilities, and the environmental issues persist in these areas. But, although were repeatedly discussed about the possibility of using the slag, nothing happened on a large scale until now. The paper presents an assessment of wastes recycling potential from siderurgical slag dumps. Therefore, the companies that make highways must include in their projects the option of using tailings if they aim the economic performance, because the alternative of using stone from quarries is more expensive, increasing the price of the works. There are many economic arguments, the most important being the reduction of expenses required for building one kilometre of highway, which impose the use of these type of slags instead of ballast for the construction of highways.

Introduction

In general, due to lack of facilities and deficitary operation, the waste landfills are acknowledged as generators of risk and impact on the environment and public health. The waste, especially the industrial and mining waste, are sources of health risk due to their toxic content, such as heavy metals (lead, cadmium), pesticides, solvents, and used oils (EUROPEAN ENVIRONMENT AGENCY 2009; REGIONAL DEVELOPMENT AGENCY WEST 2008). The landfilled hazardous materials (including toxic sludge, petroleum products, paint residues, and metallurgical slags) are the most challenging issue. This situation can cause environmental pollution (NATIONAL AGENCY FOR ENVIRONMENT PROTECTION 2006, MINISTRY OF ENVIRONMENT AND WATER MANAGEMENT 2009).

The removal from the natural or economical circuit of the lands to be used for waste landfills is a process that can be considered temporary, but in terms of “sustainable development” spans at least two generations if totalising the periods required for development (1–3 years), use (15–30 years), ecological reconstruction and subsequent surveillance (15–20 years). The main impact and risk types determined by the industrial waste landfills, listed in the order in which they are perceived by the population, are (REGIONAL DEVELOPMENT AGENCY WEST 2008):

- significant landscape changes;
- air pollution with suspensions brought by the wind;
- surface water and groundwater pollution;
- surrounding soil fertility changes;
- visual discomfort.

The runoff on the slopes of waste landfills located near the surface waters affects the soil quality, contributes to pollution with organic substances and suspensions, which in turn affect their utilization. The waste landfills are often the source of groundwater contamination by polluting elements.

Likewise, habitat changes may occur in most cases of ongoing industrial projects, resulting in damage to flora and fauna, mainly produced by the need to landfill the waste resulted from the industrial processes. In terms of biodiversity, a landfill means the removal from the area dedicated to that purpose of a number of 30–300 species/ha, without considering the soil microbiological population. Although the effects on flora and fauna are theoretically limited in time, occurring only in the period of landfill exploitation, the ecological reconstruction performed after relieving from its technological tasks will not be able to restore the original biological balance, the biosystem evolution being irreversibly modified (REGIONAL DEVELOPMENT AGENCY WEST 2008). Thus, in the waste landfill vicinity, some mammals, birds and insects leave the area to the benefit of those who find their food in garbage (rats, crows). Also, in the vegetal associations, the species specific to the polluted areas become dominant.

The total quantity of wastes generated by the siderurgical industry continues to grow (HEPUȚ et al. 2001a, HEPUȚ et al. 2003, HEPUȚ et al. 2001b, REGIONAL DEVELOPMENT AGENCY WEST 2008). The storage of these siderurgical wastes involves:

- occupying large areas of land,
- pollution potential of all environmental factors,
- expenses related to land storage etc.

In order to eliminate the disadvantages entailed by the storage of the siderurgical wastes one must find feasible solutions for their recycling or recovery (HEPUȚ et al. 2001a, REGIONAL DEVELOPMENT AGENCY WEST 2008).

The waste management issue – Challenges and policies

The waste management issue, manifested also in Romania, is more and more keenly, due to increasing of waste quantity, diversity and negative impact, more and more pronounced, on the environment (MINISTRY OF ENVIRONMENT AND WATER MANAGEMENT 2009, REGIONAL DEVELOPMENT AGENCY WEST 2008). The urban and industrial development of localities involves the production of continuously increasing quantities of waste. Greater efforts are made to encourage the use of industrial waste in the areas where it proved its suitability for use, for the purpose of more efficient recovery of the natural resources. At European level, there is the legal framework under which the road builders should provide 20–30 percent of the necessary materials by industrial waste recycling, the slag being included in this category (NATIONAL AGENCY FOR ENVIRONMENT PROTECTION 2006).

The issues facing the waste management in Romania can be summarized as follows (NATIONAL AGENCY FOR ENVIRONMENT PROTECTION 2006, REGIONAL DEVELOPMENT AGENCY WEST 2008):

- the most important way to eliminate the industrial waste is to landfill it, especially in open grounds,
- the existing industrial waste landfills are sometimes placed in inappropriate places (close to urban areas or even near the groundwater or surface water),

- the landfills are improperly designed in terms of environmental protection, leading to water and soil pollution in those areas,
- the current waste landfills are not properly operated and there are no coherent plans regarding the use of industrial waste in the fields which shown possibilities of use,
- landfills are not fenced, have no appropriate entrance and no warning signs;
- the lands occupied by landfills are considered degraded lands that cannot be used for agricultural purposes.

Currently, in Romania, more than 12,000 ha of land are affected by industrial and mining wastes (REGIONAL DEVELOPMENT AGENCY WEST 2008). All these considerations lead to the conclusion that the waste management requires the adoption of specific measures, appropriate to each phase of waste disposal in the environment. The compliance with these measures shall be subject to the oversight of the environmental factors affected by the industrial waste presence, the results being:

- the environmental risk mitigation (uncontrolled industrial waste disposal, pollution of soil, water, etc.),
- avoiding the overcrowding of the industrial waste landfills (dumps),
- improving the environmental image (close to the urban areas and near by the ground-water or surface waters).

The main goal of the industrial and mining waste treatment is to avoid its disposal. The challenges, such as environmental pollution, health hazards and disfiguration of the landscape must be urgently and responsibly addressed. Currently, no country can afford to disregard the potential for recycling the waste obtained from using raw materials. Being aware of the cost to the environment, human health and society, abandoning these wastes without pre-treatment, just because it's cheaper, it is not an option anymore.

Treating these types of wastes for economic purposes can help improve the environment, landscape, employment and social conditions in the communities affected. By eliminating the pollution risk to the population and environment, the living conditions in these regions would be improved, creating favourable conditions for all the parties involved (REGIONAL DEVELOPMENT AGENCY WEST 2008). That's why the proper use of these wastes should be considered as part of the Sustainable Development Strategy and a compensatory measure for the local urban communities affected.

The industrial and mining wastes are still a challenge for many Member States, where have been or still are industrial and mining plants. These landfills can be a threat or an opportunity for the local communities. They become a threat when they are simply abandoned without having taken steps to reduce the environmental risk, but, in some cases, they can become an opportunity when the discharged waste could generate activities involving the recovery of metals and other useful secondary raw materials.

The industrial and mining waste issue is a major concern for the local and regional communities (REGIONAL DEVELOPMENT AGENCY WEST 2008, NATIONAL AGENCY FOR ENVIRONMENT PROTECTION 2006). In many cases, the local and regional authorities have to face the issue of industrial and mining waste, because the old dumps and landfills are located within their territory. Therefore, certain solutions should be found at local level to transform this challenge into an opportunity, by encouraging private initiatives and public-private or administrative partnerships, in order to create "industrial parks" which fully use the waste by combining horizontal and vertical approaches in the processing, construction and infrastructure sectors.

The environmental benefits from the proper use of the waste from industrial and mining plants are (CHAURAND et al. 2007):

- the improved environmental quality near the urban areas,
- the saved natural resources,
- the saved storage spaces.

We highlight the need for developing effective policies on industrial and mining waste landfills (in the context of Europe 2020 strategy, EUROPEAN ENVIRONMENT AGENCY 2009, NATIONAL AGENCY FOR ENVIRONMENT PROTECTION 2006) which, by means of a comprehensive approach, to make explicitly the connection between a sustainable industrial policy and the innovative processes, the efficient use of resources and improved access to raw materials. A material that could open a new perspective for the construction of dams and roads in Romania lies now in the industrial and mining waste landfills, especially in the siderurgical slag dumps.

Siderurgical slag processing – in terms of environmental protection

The industrial waste landfills located in Hunedoara are defined as the waste produced by the industrial activity in siderurgy, which includes any material that is rendered useless during a manufacturing process such as that of iron and steel factories. From the environmental protection point of view, the siderurgical slag processing aimed, directly and indirectly, the following goals (HEPUȚ et al. 2001a, HEPUȚ et al. 2003, HEPUȚ et al. 2001b):

- the industrial waste management, in general terms, including the processing or disposal, managing and monitoring of these industrial waste materials;
- the soil pollution control and reduction, including the use of “clean technologies” by processing the ferrous metallurgical slag from Hunedoara siderurgical plants, for obtaining recycled materials used in construction;
- the protection of the natural resources, by bringing this alternative on the construction market, thus reducing the exploitation of stone from the river or mountain quarries.

After decades of research on the siderurgical slag, it has been found that these non-toxic materials have turned from undesirable wastes into valuable materials. The aspect of “non-toxic” derives from the fact that, in the mineral and oxide composition of the slag, none of the substances have a negative impact on the environment (HEPUȚ et al. 2001a, HEPUȚ et al. 2003, HEPUȚ et al. 2001b). The activity of siderurgical slag processing meets the trends of enforcing and checking the application of the environmental protection conditions, and complies with the European directives on environmental protection.

Slag processing is a technique practiced worldwide, the transformation of these solid wastes into valuable mineral granular materials being an old concern (CHAURAND et al. 2007, GÜNAY et al. 2004, KARA et al. 2004). The ferrous siderurgical slags are perhaps the only materials, included in the broad category of metallurgical slags, which through use have no negative influences on the environment. The processing technology is part of the “clean technologies”, since it does not involve chemical, but only physico-mechanical transformations of the slag, and the equipment is no different than the natural stone processing plants.

The processing of siderurgical slag brings benefits in terms of environmental protection, either from the community and agricultural point of view, or technically: the ferrous

slag, being a non-toxic material with similar physical and mechanical properties with the stone, is a viable alternative in some applications even more valuable than the natural variants available in the construction field (HEPUȚ et al. 2001a, HEPUȚ 2003, HEPUȚ et al. 2001b, GEISELER 1996, MOTZ and GEISELER 2001, LU and LI 2012, SHI, CAIJUN, 2004).

By harnessing the slag dumps, it will be possible to recover large areas of land that can be restored for agricultural use (after a prior improvement), or used as industrial areas. Moreover, the negative effects of the “mountains” of siderurgical slag, deposited mostly vertically, exercise, because of their weight, high pressure on the underground water crossing the dump area, practically “bottlenecking” the water supply of the neighbouring localities (HEPUȚ et al. 2001a, HEPUȚ et al. 2003, HEPUȚ 2001b).

Case study – Discussions and opportunities

The iron and steel plants built in Romania, including Hunedoara, are well-known. Most of these iron and steel plants are dormant since 1990, and a small part of them were privatized, of which only a few are still in operation. Meanwhile, the landscape of the place began to change, because after the plant privatization it was started the dump exploitation, to recover the iron pieces. The environmental rules agreed with the European Commission imposed the requirement that all the deposits that do not meet these standards, the so-called “non-conforming landfills”, to be closed by 1st July 2014. And, because the siderurgical slag dump is a non-conforming landfill, it must be closed as well. After 2014, this slag dump will become dormant, and the only possible operations will be the ones for greening the area, although it is unlikely that something will grow there. The dump representatives and the slag processors have shown willingness to provide the resources landfilled in the slag dump to be harnessed, without any additional cost. The derogation from the European Directive and extension of the slag dump exploitation period will bring significant benefits to the Romanian economy.

Here are deposited over 30 million cubic meters of slag from blast furnaces and steel works. Currently, the slag dump is exploited for slag, pig-iron skull and other types of ferrous scrap.

Currently, according to the representatives of the National Environment Guard, approximately five percent of Hunedoara county area is occupied by industrial landfills (REGIONAL DEVELOPMENT AGENCY WEST 2008). In case of dumps, such as the slag dump located in Hunedoara, the slag can be recycled even for road building. The metallurgical slag forming the slag dumps located in Hunedoara municipality had resulted from the technological process of iron and steel-making at the former iron and steel plant. The deposit contains about 70 million tons of metallurgical slag, sufficient for the construction of 800 kilometres of highway and 5,000 kilometres of national roads.

According to the environmental authorities, the slag dump is a deposit of non-hazardous waste materials – known as “sterile”. The deposit contains blast furnace slag, steel slag, refractory wastes and other types of waste materials.

Millions tons of slag, scrap, lime, bricks and other industrial waste, gathered in the dump from the plant commissioning till 2009, when the storage was completely stopped and began the material exploitation. The scrap goes back into production, being used to make steel, and the blast furnace slag and steel slag are processed, being used in road

construction and cement manufacture. In some cases, the concentration of metals in the mining waste can be equally or even higher than the concentration of metals in ores. We can say the same thing about the metallurgical waste. The recovery technologies have evolved, and now we have the opportunity to reassess the potential of waste from the existing industrial activities and to ensure they are ecologically rational.

The blast furnace slag and steel slag deposited in dump, one of the main sources of environmental pollution in Hunedoara area, can become a real gold mine. The slag deposited in the huge dump mountain, as experts say, has the required qualities to be used in making roads. Thus, the tailings extracted here will be used in the construction industry, for the development of roads and highways. There are several projects in this regard. The only solution is the road infrastructure development programs.



Figure 1. The slag dump – the “slag mountains”
1. ábra A salaklerakóhely – a “salakhegy”

The “slag mountains” are an environmental hazard due to the dust particles carried by the wind in atmosphere. For this reason, in 2014, the place where the siderurgical plant of Hunedoara deposited its waste materials should be closed for good. According to the commitments made by Romania to the European Union, the slag dumps are going to be closed in 2014 and covered with soil and vegetation. With the onset of this process, a huge amount of valuable raw materials will be permanently lost. It is preferred the more expensive exploitation of the riverbeds and mountains to obtain gravel and ballast, where the environmental impact is very negative. But, until then, the mountain of waste – here

and there it reaches tens of meters high! – may become cheap raw material for the construction of highways.

Although, there were many discussions regarding the benefits of using the slag in construction works, for building roads and highways, but so far no effective solution was found and only a few applications were submitted for processing this material. In this moment, the slag from the slag dump is used only for making village roads, where the demands regarding the road quality are not very high. Now, it is assessing the possibility to use slag for road and highway construction, not only for the current project, but also for the future ones. The first quantities of slag are used for the highway section Deva–Orăștie (Déva–Szászváros), with a length of 32.8 km. The construction of this highway section, part of the section IV of the Pan–European corridor, will surely bring good things for many companies in the county, for Hunedoara business environment. The companies that extract and process slag from the slag dumps of Hunedoara steel plant have a bright future in this regard. The construction of the Pan–European Corridor IV is a welcome opportunity to get rid of the bleak landscapes and “slag mountains”.



Figure 2. A1 Motorway in Romania (according to <http://commons.wikimedia.org>)

2. ábra A1 autópálya Romániában (a <http://commons.wikimedia.org> szerint)

The A1 motorway, according to the Romanian National Company of Motorways and National Roads, is planned to connect Bucharest (Bukarest [hu]) with the Banat region (Bánát [hu]), in the western part of the country. It will be approximately 581 km long and will follow the route: Pitești, Sibiu (Nagyszeben [hu]), Orăștie (Szászváros [hu]), Deva (Déva [hu]), Timișoara (Temesvár [hu]), Arad, connecting with the Hungarian motorway network near Nădlac (Nagylak [hu]).

As of May 2013, the sections in service include a 110 kilometer long motorway linking Bucharest with Pitești, the Sibiu motorway bypass (17.5 km), the Orăștie–Deva segment (32.5 km) and the Timisoara–Arad motorway (54 km, in the western part of Romania). The total length of the opened sections is 213 km, according to the Romanian National Company of Motorways and National Roads, with another 137 km under construction.

The products resulting from slag processing are slag aggregates used in road, railway, civil and hydro–technical constructions, as an alternative to the traditional aggregates of natural stone, extracted from quarries. Bringing this alternative on the construction market, the stone exploitation from quarries will be substantially reduced.

Instead of using slag, in many cases it is preferred the mutilation of riverbeds and tearing down the mountains, because for the infrastructure is mainly used river and mountain stones which, on long–term, can mean the destruction of nature. In accordance with the practical performance parameters, defined in the norms and standards for re–usable waste and products that incorporate it, in the construction industry were developed technologies that have used, for a long time, granulated “waste” (such as slag), ecologically inert, as substitutes for the traditional materials. The slag should be used in this way, at the expense of the natural resources.



Figure 3. Using siderurgical slag aggregates for road and highway construction
 3. ábra Salak aggregátumok a közúti és autópálya építésében

Finally, Hunedoara County will benefit from the opportunities that occur from running a site of huge proportions and, last but not least, we should not forget the benefits of a highway linking the area with the rest of the country and Europe. It could be a real opportunity for effective harnessing of the metallurgical slag dumps located in Hunedoara.

Summary – Conclusions

The siderurgical slags are a valuable raw materials which can be converted into economically and ecologically desirable products. Increased efforts are being made for encouraging the use of slags in the fields that have proved suitability, meaning more efficient exploitation of the natural resources. In Romania, these efforts are still very weak, and this is due to lack of education in the field of environmental protection, inefficient use of natural resources and lack of adequate environmental legislation.

It's a long-established practice for residual metals contained in the steel and blast furnace slags to be recovered and recycled into the production process. Now more than ever it is essential to make intelligent use of other products derived from slag – products in strong demand by the market. Rather than dumping slag into landfills we can convert it into high quality products used in constructing highways, farming and forestry roads, inland waterways, fertilizers, and as a raw material by the cement industry. Precious natural resources are conserved by using high-grade reprocessed slag instead.

Since the beginning of the industrial age, the slag has been considered ugly, but harmless. Because it has been considered chemically inert, slag has been mixed with cement and used to construct roadways and railroad beds.

However, an important fact still remains: the slag dump is a pollutant. The agricultural lands located in the neighbouring villages are less fertile because of the slag dust carried by the wind. Using the mountain of tailings could mean the cleaning of a land, fewer ballast pits and quarries in the mountains of Romania, and cheaper infrastructure works. Since the start of work on the highway that is going to cross Hunedoara County, over two million tons of tailings coming from the slag dump located on the outskirts of the municipality were delivered to the highway builders. This year, the shipments have been resumed, and approximately 400,000 tons of the steel and blast furnace slags will be delivered.

This would be an important solution not only from the economic point of view – lowering the cost per kilometre of highway –, but also in terms of environmental protection, because the riverbeds will not be disturbed to find the gravel needed for the construction of highways.

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AZ IPARI HULLADÉKOS LERAKÓKRÓL – ÉRDEKLŐDÉSKELTÉS A VASKOHÁSZATI SALAKOK LERAKÓKRÓL HUNYAD VÁROS TERÜLETÉN

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Kulcsszavak: vaskohászati salak, ipari hulladék lerakóhelyek, hulladékgazdálkodás

Jelenleg Hunyad megye – Románia (Vajdahunyad [hu], [ge] Eisenmarkt) – mintegy öt százalékát foglalják el az ipari hulladéklerakók, mint Hunyad-on található lerakott vaskohászati salakok. Ezek újrahasznosíthatók, pl. útépités során. Az egykori bányák területén található komplex érceket is tartalmazó salakokat nem lehet újra felhasználni, így az elhagyott bányák környezetbarát projektekre várnak. Jelenleg a környezetbarát ár meghaladja a lehetőségeket, így ezeken a területeken a környezeti problémák továbbra is fennállnak. Bár többször is szóba került a salakok felhasználási lehetőségei, mostanáig nem történt semmi nagy léptékű beavatkozás. A cikkben bemutatjuk a lappangóban álló vaskohászati salaki hulladékok újrahasznosítási értékelését. Az autópályákat építő vállalatoknak olyan projektek beállításával kell foglalkozniuk, melyeknek tartalmaznia kell a gazdasági teljesítmény célját, tudniillik, hogy drágább az újon kitermelt bányai kő használata, és ez rendszeresen növeli a munkálatok árát. Vannak erre gazdasági érvek (pl. az egy kilométerre eső költségek csökkentése) az autópályák építésében, de a legfontosabb, hogy az ilyen típusú salakok alkalmazását mindenek előtt előírják, az újonnan kitermelt kő helyett.