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Editorial

Landfill Mining: Challenges and Perspectives

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Landfilling has been one of the most common methods to dispose waste in many regions worldwide. However, from the environmental and economic point of view such approach of waste management can be considered unsustainable since materials and energy that can be recycled and recovered are disposed and not used further. Landfills are well-known sources of contaminants released into the air, surface waters, groundwater and soil through long-term landfill gas emissions and leaching of hazardous substances. It is estimated that approximately 300 million tons of copper are currently disposed in landfills and other waste repositories (e.g. tailings and slag heaps) all over the world) corresponding to more than 30% of the remaining reserves of copper in known ores. Landfills contain significant amounts of combustibles and recyclable materials. It is estimated that there are between 150,000 to 500,000 old and still active landfills throughout the European Union (EU) representing the total volume of 30-50 billion m^3 of waste. These facts confirm the need to identify the potential recovery of secondary materials and energy in both, short and long-term, perspectives through the implementation of landfill mining projects. Furthermore, landfill mining has received insufficiently attention till now.

In Europe and Asia, the growing need for remediation of old landfills and removal of deposits obstructing urban development were important drivers for the increased interest in landfill mining since the end of 20^{th} century. Despite of such keen interest, the research activities focused on landfill mining suddenly decreased in 2000, and since then, only sporadic initiatives have been reported in the scientific literature. Economic downturns, difficulties in extraction of high-quality, marketable recyclables from the deposits, and lower demand for landfill space in certain regions of the world due to introduction of more sophisticated waste treatment and recycling programs have been some of the responsible factors.

During the period of last five years, performed research projects have shown that landfills contain large volume of valuable materials such as metals and plastics that constitute an important driving force for resource recovery. In contrast, remediation projects are always related to considerable societal costs and the implementation of integrated approach, while landfill mining involves both, profitable resource recovery and remediation, and, therefore, it offers more viable and efficient strategy than conduction of projects with remediation objectives solely. Such findings arouse the challenge of the current view on landfills as final disposal site of waste and indicate the emergence of shifting the old model of waste management into a landfill mining perspective in which the extraction of valuable material and energy resources is considered. There are still a number of challenges to reach the full potential of material recovery/recycling, energy utilization and nature restoration to be overcome mainly in terms of technological development.

On-going researches in many countries provide also comprehensive and systematic analysis to evaluate the suitability of closed landfill sites as power parks. The results of life cycle assessment show that both, solar and wind, turbine technologies are favorable with regard to energy consumption and greenhouse gas emissions. Synergies among these two technologies and landfill gas extraction in the closed landfill sites are studied. In principle the fourth technology, i.e., solid refuse fuel (SRF) production from excavated waste can be a part of such investigations.

One concept to be applied in Italy consists of cyclical process with especially designed steps like:

- Landfill cell preparation;
- Waste disposal and realization of leachate recirculation, and biogas collection systems in the prepared cells;
- Sequential cultivation of next cells repeating all the above described operations;
- Final stabilization of waste in each cell through air ventilation;
- Removal of temporary covering in order to allow the LandFill Mining (LFM) operations;
- Reuse of cells once completely empty, until the establishment of a cyclical process of landfilling, emptying and processing/recovery.

During the past decade, the EU Council Directive 1999/31/EC and the EU Council Directive 2008/98/EC, regarding landfilling have established that organic wastes and recyclables produced in the EU must be sent to incineration plants, composting plants and recycling units instead of disposing in landfills. Also, the HELCOM recommendation 24/5 has clearly stated and redefined the needs for proper handling of waste and landfilling, and relevant measures to remediate and prevent future pollution with the consequent restoration of the ecological status of the Baltic Sea Region, including Lithuania. The prevention of contaminants in the Baltic Sea originated from landfills and dumpsites has also been emphasized.

The research and international cooperation project "Closing the Life Cycle of Landfills - Landfill Mining in the Baltic Sea Region for Future" of Linnaeus University, Sweden was approved by Swedish Institute. The project is a joint venture of research groups and institutes of the participating countries (Sweden, Latvia, Norway, Italy, Denmark, Estonia, Lithuania and Ukraine). Partnership in this project have emphasized the importance of the cross-sector cooperation among the experts from universities, waste management associations, municipalities and companies working towards achieving the goals established by Swedish Environment Protection Agency, HELCOM and the EU Waste Framework Directive. The main objective of this project is to initiate new full-scale landfill mining projects in the Baltic Sea Region and compare the obtained results with landfill mining projects in different countries. The resource recovery as raw materials from excavated landfill waste as well as refuse-derived fuel (RDF) for energy recovery both are of the beneficial for generating revenues for the success of the project. The full-scale excavation and remediation of the Kudjape Landfill (Estonia) has been started in September, 2012, and it was finished in September, 2013. The manual sorting provides necessary information regarding the suitable techniques for material recovery from different fractions, however, due to the safety and efficiency issues in order to avoid any risk on human heath (workers) during waste separation by handpicking, automated sorting of waste using intelligent machinery (e.g., robots) were decided as future requirements for safe and effective LFM. Further research is needed towards the possible treatment of the fine fractions to remove the organic matter and to recover the valuable metals such as Cu, Al and Fe. Pilot studies have proven also the presence of other heavy and rare earth elements in the landfill mass. Last but not the least, cost-effective and environmentally-friendly washing techniques for cleaning the LFM waste and treatment of generated washing wastewaters should be the focus of future research.

Lithuania counted up to 843 of closed landfills of different sizes, where during their operation time about 3.4 million tons of waste have been landfilled (apart the old Kariotiškės landfill, where municipal waste from Lithuanian capital city Vilnius was formerly disposed). Regarding the EU support many of these landfills have been already remediated; the largest of which have installed landfill gas collection systems. Thus, a minimum for five-year period the mining activities in such landfills are in principle impossible; however, the above-described problems and opportunities do not disappear in this situation and will be important later. On the other hand, currently operated modern regional landfills will be fulfilled soon due to the inefficient separate waste collection and recycling. In this way, by implementation of mining projects for currently still used but almost fulfilled landfills the Lithuanian landscape would be improved and environmental impact of landfills through emitted landfill gas and generated leachate would be reduced.