A system for leachate valorization based on renewable energy sources and minimized chemicals use - Social impact assessment

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Abstract

Landfilling is the predominant method of solid waste disposal, accounting for 80% of waste in developing countries. This process produces a liquid fraction called Leachate. The systems that are used for treating the leachate are mostly consuming a lot of energy and use chemicals. The Leachless system aims to combine widely known technologies, such as Evaporation/Condensation and Forward Osmosis, with the use of Renewable Energy Sources, to treat the leachate. The applicability of the proposed system was tested in a Greek and Spanish landfill and in order to evaluate the Social Impact of the implemented process a hotspot and a site-specific analysis were conducted of both of the case studies.

Introduction

Throughout the years, municipal solid waste management has been a great struggle for local authorities. Even though recycling, reuse, and the energetic valorization of waste has been largely advanced in the last decade, landfill disposal remains one of the most predominant methods of garbage disposal around the world [1]. Europe generates substantial quantities of leachate, which possess a significant pollution burden due to its composition [2]. Approximately, 10m^3 of leachate is generated per 115 tons of solid waste. The produced leachate from the landfill activities is the liquid fraction of the already existing moisture within the solid waste and the continuously formed liquid with dissolved and suspended solids extracted from the waste while rainfall percolates through it [3].

The LIFE LEACHLESS system, as a universal solution independent of the leachate composition, aims to treat leachate in situ via evaporation/condensation and forward osmosis in combination with a Renewable Energy Source (solar energy, biomass) (Figure 1). The system results in reducing the environmental impact associated with leachate generated at waste management activities. In addition, the system valorizes pollutant effluents by completely reusing the streams generated in the treatment process, with the minimum amount of chemicals.

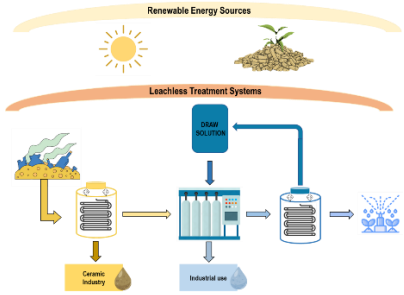

Figure 1: Flow diagram and end products of the leachate treatment system.

In this study, a Social Life Cycle Assessment (S– LCA) was also conducted, in order to identify and assess the social advantages and disadvantages in developing the proposed leachate treatment system. The S – LCA consists of a hotspot and a site-specific analysis for both of the case studies of the LEACHLESS project. The Hotspot analysis is centered on the major commodities of the system and their origin. For that, the Social Hotspot Database was selected as the resource for data and endpoint indicators [4]. A site-specific analysis was also conducted to assess the social responsibility of the examined

demonstration landfills. A questionnaire was created and forwarded to the landfill managers of the collaborating landfill facilities. The data gathered from the landfill managers were converted to scores using the Subcategory Assessment Method (SAM) and were compared to the basic requirements of global and national regulations respectively [5].

Materials and Methods

The feasibility of the proposed system was assessed with the construction and operation of the systems for 2 years. The construction was carried out in Spain and the operation was held out for around two years and in two different landfills. The results of the system's operation were assessed by the Greek and Spanish team with collecting and analyzing the samples.

The S – LCA was conducted using the Social Hotspot Database (SHDB) which is compatible with SimaPro. The SHDB enables S-LCAs and hotspot assessments of products by utilizing software or online resources. It comprises data for 26 subcategories encompassing more than 160 qualitative, quantitative, and semi-quantitative indicators of social risks, opportunities, and positive impacts. Currently, it is based on the GTAP Input/Output database covering over 13,000 country-specific economic sectors in 244 countries. Furthermore, it incorporates a technique for impact evaluation. The SHDB utilizes worker hours and value-added activity variables to quantify social risks and opportunities for each process.

Furthermore, a questionnaire regarding the social responsibility of the landfills has been developed, specifically tailored to the needs of the survey, and has been distributed to the representatives of the two landfills where the pilot LEACHLESS system was implemented.

Results and Discussion

After 15 weeks of operation in a Greek Landfill, the treatment process resulted in an effective reduction of various pollutants in the final treated water. Parameters such as TSS, BOD_5, COD, total phosphorus, total nitrogen, and heavy metals were significantly reduced, with the majority of the analyzed values in the final effluent being within the permissible limits according to regulations. In addition, no E. coli was detected in the final effluent, indicating the successful elimination of harmful bacteria. The only limit according to the regulation, was that the system didn't meet the Total Nitrogen removal. To this end, a pre-treatment process is recommended.

The social life cycle analysis of the LEACHLESS System examined the origin of its commodities and their social footprint. In both Spanish and Greek case studies, approximately 96% of the system's commodities are imported from European countries. Spain stands out as the primary supplier contributing around 72.73% of the system commodities. Other countries such as Belgium, Italy, China, and Austria also play a role in supplying imported commodities.

The social footprint assessment revealed the risks associated with the system, with the highest risks identified in the categories of Health & Safety, the Governance, and labor rights & decent work. Based on the SAM scores, both landfills meet the basic requirements for the worker stakeholder groups. The Greek landfill demonstrated strong policies on local hiring and equal opportunities/discrimination, while the Spanish one score was lower due to a lack of annual hiring frequency.

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