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A Joint Effort to Reduce Hazards to the Environment and Water Resources by Rehabilitating Open Dumps

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Abstract

The management of municipal solid waste is a primary and overwhelming task for local governments all around the world. In Europe, the disposal of municipal solid wastes by incineration, composting or landfilling is laid down by EU directives in the member and candidate countries of the European Union. Accordingly, many member and candidate countries have started to use the landfilling by closing open dump sites, as it is a healthier, environmental friendly, viable and economical method especially for the disposal of urban solid wastes. During the transition to landfilling, rehabilitation of old open dump sites in many countries has been overlooked and they still exist as a potential hazard to environment and water resources. Furthermore, several countries in Europe and around the world still use open dumping in some parts of their countries. Universities, companies, municipalities and related research, training and nonprofit organizations from five different countries, namely Turkey, Italy, Poland, Bulgaria, and Romania, came together under a EU project to tackle the issues related to open dumps in an effort to reducing hazards to the environment and water resources. This paper presents the most recent situation in respective countries regarding the open dumps and critical discussion of the up to date developments. The intellectual outputs of the project aim to develop competences in various sustainability-relevant sectors so that decision makers, engineers, technicians, and vocational trainers adapt themselves and keep up with the most recent developments and technologies regarding rehabilitation of open dumps for a better and sustainable environment, human health and ecology.

Keywords: *Leachate, Municipal Solid Waste, Open Dumps, Rehabilitation, Slope Stability*

1 Introduction

Solid waste created by people especially in urban areas is a significant problem all over the world that governments are obliged to solve. According to Worldbank, the world generates 2.01 billion tonnes of municipal solid waste (MSW) annually and waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms (Worldbank, 2021). The disposal of large amounts of these solid wastes from multiple sources generates a high economic and environmental burden to local governments. If not disposed properly, solid waste cause environmental problems and affects human life adversely. Nowadays, the global COVID-19 pandemic has necessitated the reconsidering of solid waste and open dumps rehabilitation management practices and approaches (Das et al., 2021). Today, the most commonly used method for the disposal of solid waste in developed countries is the landfill method. However, before the landfill applications, solid waste were disposed randomly to any area outside the city by open dumping. Even in the countries which started to use the landfill method, abandoned open dump sites continue to danger the environment and human health. Figure 1 shows global treatment and disposal of waste in the world. Worldbank (2021) states that open dumping accounts for at least 33 percent of waste in the world ð extremely conservativelyð not managed in an environmentally safe manner. There are three significant and vital problems in the open dumps: 1) CH_4 gas, a greenhouse gas thatôs 28 times more potent than CO_2, generated from biodegradable solid wastes in anaerobic conditions. The CH_4 is explosive when present in the range of 5ï 15% by volume in air, and becomes flammable when this rate is higher than 15 %. 2) Leachate and the change in soil properties. Leachate is caused by infiltration of rainwater into the solid wastes as well as by the water content of the solid wastes themselves. Change in the soil properties accelerate the magnitude and speed of the leachates which may contain many organic and inorganic pollutants. This leachate percolates through the soil and reaches the groundwater resulting in a substantial risk to local groundwater resources and to the natural environment. 3) Structural stability in open dump sites. Slope failures at open dumps may lead to serious environmental issues. It becomes more critical especially if the open dumps are close to water bodies.

Due to the abovementioned vital problems, open dump sites that are no longer in use need to be rehabilitated and the existing ones should be improved. The European Union has a directive on landfill of wastes (No: 1999/31 / EC), which defines the limitations and procedures to be taken in order to prevent or minimize the threats to the environment. Within the scope of this international project, it is planned to produce outputs for target groups on the rehabilitation of open dumping sites which are forgotten and/or ignored after the establishment of a landfill, but still exist as a potential hazard. In many countries that are members or candidates of the European Union, open dumps still represent environmental problems. The target groups of the project are, including but not limited to decision makers, engineers, technicians, and vocational trainers. The partners of this international project come together because open dumps represent an environmental hazard in their countries and there is substantial need for decision tools incorporating new technologies, up to date modern training tools and materials, and methodologies (SMARTEnvi, 2021). They follow one of the mottos of the Green Deal óno person and no place left behindô, to mainstream their efforts in decreasing pollution of our planet (European Green Deal). The SMARTEnvi project is developed as well to reflect the current economic (Industry 4.0) and educational (Education 4.0) perspective (Wibrow et al., 2020).

2 State of MSW and Open Dumps in Partner Countries

The partnership in this project consists of universities, private organizations, and municipalities with high reputations in their respective fields which got together according to requirements of the project and experience of the partners. There are nine formal partners and six associated partners from five different countries in the proposed project. The formal partners are: the promoter, Gebze Technical University, Pamukkale University, and Denizli Metropolitan Municipality, from Turkey; Training 2000 and Municipality of Fano from Italy; Silesian University of Technology from Poland; Sofia University St. Kliment Ohridski and R & D Center Biointech from Bulgaria; and Universitatea Petrol-Gaze din Ploiesti from Romania. Associated partners comprises of professional organizations like chamber of civil and environmental engineers, network of municipalities, private organizations, and societies. All consortium members have necessary experiences which fulfill different tasks foreseen in the project. Because the problem is a common problem in the countries of partners, the solution requires transnational cooperation and sharing the resources and developing results applicable to this international problem (SMARTEnvi, 2021).

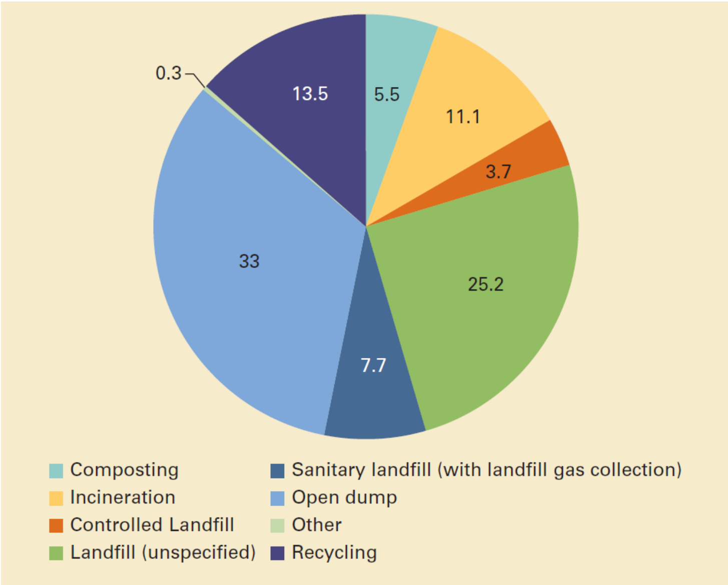
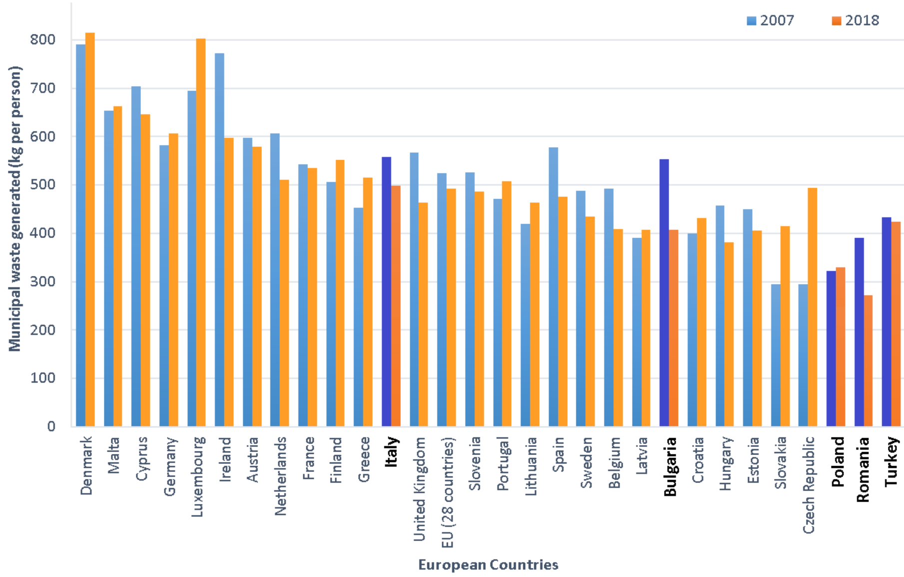


Figure 1. Global treatment and disposal of waste in percentages (Worldbank, 2021).

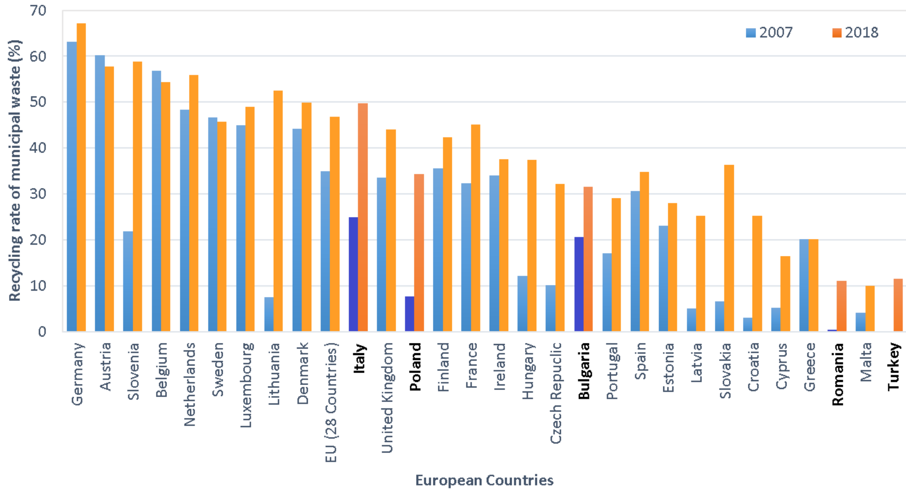
Figure 2a shows the distribution of municipal waste generation in European countries. The comparison of the results for years 2007 and 2018 indicates that changes per person within this period are not significant for many countries. However, recycling rate of municipal waste increased considerably in many European countries as shown in Figure 2b. This trend clearly demonstrates the importance of keeping up with the policies of zero waste in the coming years. There have been continuous studies in partner countries to find the alternatives and practices necessary to be implemented to reduce the landfilled municipal waste and to increase the degree of recycling (e.g., Panaitescu and Bucuroiu, 2014). The figures also indicate the situation for the countries of the partners in this project as darker colors. Regarding the partner countries, the municipal waste generation per capita is the highest in Italy and the lowest in Romania. And the percentages of recycling rate of municipal waste is highest in Italy and the lowest in Romania according to 2018 statistics. The graphs in Figure 2 were drawn by using the data of Eurostat (2021). Particular years in the graphs were selected according to availability of data for partner countries of the project.

Countries followed their unique path approaching to environmental problems in terms of legislation and other regulations. For example, Bulgaria enacted in 1997 ñLimiting the Harmful Impact of Waste on the Environment in Bulgaria. In 2003, Bulgaria adopted the Waste Management Act fully corresponding to the EU Council Directive 75/442/EEC of 15 July 1975 and the legislation in the sector was harmonized with the European law in 2007, at the time of Bulgaria's accession to the EU. Amendments were made in 2010, introducing economic incentives of local authorities. Furthermore, requirements of Directive 2008/98/EC were introduced in 2012, including the principles of "polluter pays", "extended producer responsibility" and the ñwaste management hierarchyò. In Turkey, there are many legislations related to environment such as the regulation of water pollution control, regulation of air pollution control, etc. In line with the Environment Law, several regulations about solid waste have been issued since 1983 (Agdag, et al., 2009). Some of them are: Control of Solid Waste Regulation (1991); Regulation on Control of Medical Waste (1993, updated in 2005); Control of Hazardous Wastes Regulation (1993, updated in 2005); Regulation on Waste Batteries and Accumulators (2004); Packaging and Packaging Waste Control Regulations (2004); Regulation on Sanitary Landfill of Waste (2010); Regulation on Waste Management (2015).

According to the domestic waste action plan of the Ministry of Environment and Urbanization in Turkey, there are more than 800 open dumps in Turkey as of 2016 and 8 million tons of MSW disposed of by open dump. Figure 3 shows the percentages of solid waste disposal methods in Turkey. Over the years, the number of existing open dumps has been decreasing in Turkey as some of them were rehabilitated. As an example, Figure 4 show the pictures of an open dump in Cameli, Denizli, Turkey before and after the rehabilitation. There were 1426 illegal dumps and 440 local contaminated sites existed in Bulgaria before 2009. An action plan was underway in July 2009 with the intention of closure of all of landfills that do not meet the requirements of the regulations. However, more than 120 open dumps were still detected in the country by 2012. Up to 2018, rehabilitation and closure of at least 37 municipal landfills and landscaping of at least 1620 acres of municipal land that the open dumps occupied was achieved. National waste management plan 2021 ï 2028 adopted currently with foreseen investment of 1.5 billion leva for waste management. There is a target of 55% of waste to be recycled in 2025.



a) Municipal waste generated in European countries



b) Recycling rate of municipal waste in European countries

Figure 2. Municipal waste statistics in European countries (drawn by using data from Eurostat, 2021).

3 Intellectual Outputs

This project produces significant intellectual outputs (IOs), namely a smart decision tool for rehabilitation of open dumps (IO1), a multilingual e-learning-platform (IO2), a competence tool (IO3), learning modules (IO4), and a smart guidance manual (IO5). These innovative results representing training methods, tools and materials become imperative for reducing hazards to our environment and water resources by rehabilitating open dumps. The target groups benefits from these outputs and develop competences in various sustainability-relevant sectors so that they will be able to handle issues related to rehabilitation of open dumps.

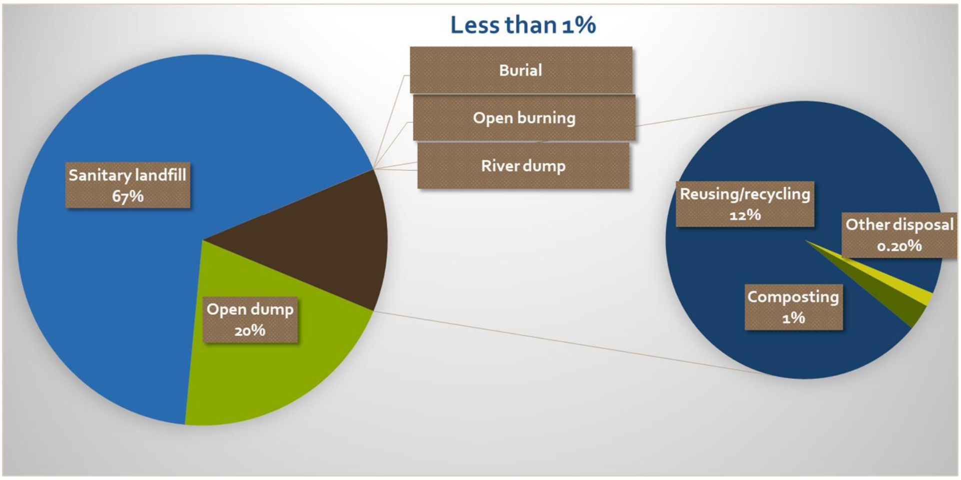


Figure 3. Solid waste disposal methods in Turkey.

a) Cameli, Denizli open dump before rehabilitation

b) Cameli, Denizli open dump after rehabilitation

Figure 4. Rehabilitation at open dump at Cameli, Denizli, Turkey.

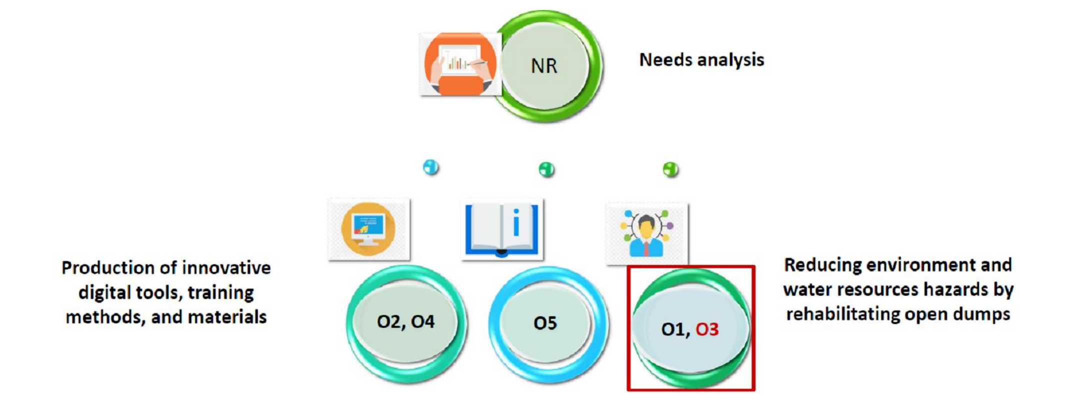
The smart decision tool for rehabilitation of open dump is created for target groups guiding them interactively through the process of open dump rehabilitation evaluation and help them for risk based optimum decisions. The tool incorporates the algorithm and methodology developed in this output with available input from the user to guide the users to choose the best decision for the rehabilitation. The tool functions in web platform and smart devices (e.g. android).

The competence tool is based on modern learning outcomes (LO) which satisfy up to date and most recent requirements of the environmental regulations, rules, EQF and ECVET. This innovative tool is designed as smart adjusted according to pace and needs of individuals with free source of online education in the field of open dump rehabilitation. The output is expected to be influential in the way the learning content is produced. The multilingual e-learning-platform includes the competence path of the learning process in smart devices and web platform according to Learning Outcomes (LO) and Training Units (TU) forming personalized training paths for specific professional competence and reference level. Training material is developed according to learning modules and units.

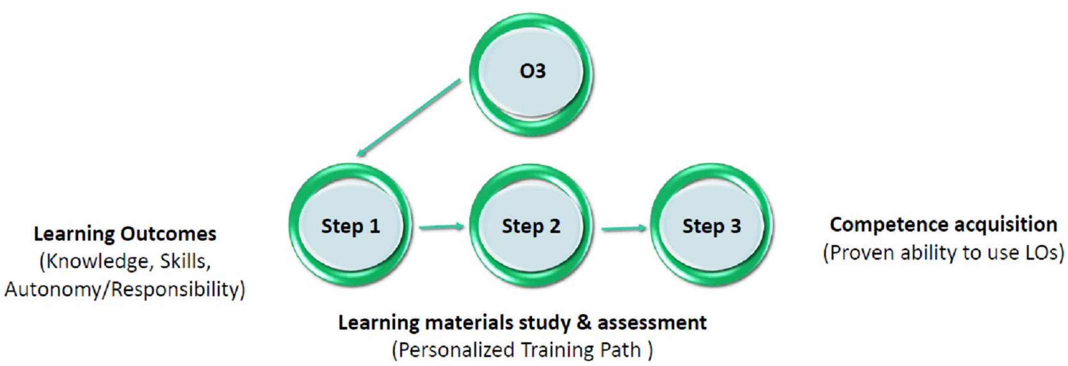
The learning modules which are the part of specialized training curriculum focuses on key issues regarding rehabilitation of open dumps for environmental health and ecology. There are new developments and technologies available in the assessment and rehabilitation of open dumps. This intellectual output produces training modules covering basics, fundamental and the new developments and technologies (e.g., Toprak, et al., 2013). The target groups are expected to learn and apply these up to date information by using the training modules produced in this output. The output comprises nine modules including case studies from each country.

3.1 Competence Tool

The competence tool provides a bridge between different intellectual outputs of SMARTEnvi project as shown in Figure 5a. Competence is defined by the European Centre for the Development of Vocational Training (Cedefop) as ñability to apply learning outcomes adequately in a defined context (education, work, personal or professional development)ò or ñability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal developmentò. According to Cedefop, competence encompasses: i) Cognitive aspects: the use of theory, concepts or tacit knowledge (Knowledge), ii) Functional aspects: technical skills (Skills) iii) Interpersonal attributes: social or organizational skills, ethical values (Autonomy & Responsibility). Figure 5b shows the scheme in this project to develop competences.



a) Competence tool linking intellectual outputs



b) Developing competences in sustainability-relevant sectors

Figure 5. SMARTEnvi Competence tool-a means for competence gaining.

There are different EU standards and tools to describe competences (e.g., Vassilev, et al., 2015). Some principal ones are: the e-competence framework (e-CF); the European qualifications framework (EQF); the European credit system for vocational education and training (ECVET); the European multilingual classification of skills, competences, qualifications and occupations (ESCO); the digital competence framework for citizens (DigComp); the entrepreneurship competence framework (EntreComp). This study primarily focus on the EQF and ECVET. The EQF consists of 8 levels covering all levels and all sub systems of education and training, focusing on Learning Outcomes (LOs) and the personôs knowledge, skills, autonomy and responsibility. The ECVET is a technical framework for transfer, validation and accumulation of LOs by individuals, to achieve a qualification; the LOs are transferable and accumulatable units, to which credit points are attached. The competence tool is developed to embed the innovative concept of Education 4.0 perspective.

3.2 Smart Decision Tool

There are many components and risk evaluations in deciding the best way for the rehabilitation of open dumps. The legal, technical, technological, environmental, and economical dimensions should be taken into account. These multi dimension considerations and complexity of the problem makes it a requirement to apply smart digital systems in the solution. Therefore, this study develops a smart decision tool for rehabilitation of open dumps which will be beneficial for decision makers, engineers, technicians, and vocational trainers. This smart tool guides them interactively through the open dump rehabilitation assessment process and help them for risk based optimum decisions. As the tool will be functioning in web platform and smart devices, it will be accessible worldwide a large number of people will benefit.

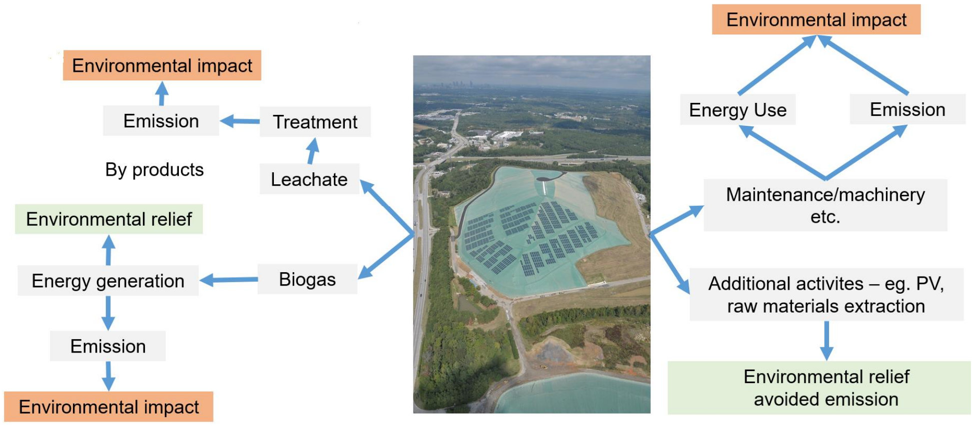


Figure 6. Environmental evaluation aspect of the smart decision tool.

The smart decision tool incorporates several elements of the following methods: life cycle assessment (LCA); life cycle impact assessment (LCIP)-ReCiPe; life cycle costing (LCC); cost benefit analyses; eco invent database plus dedicated inventory; multicriteria analyses (MCA); risk assessment and expected values (e.g., Pikon et al., 2021; Bogacka and Pikon, 2014). The process considers assessment of current environmental footprint, assessment of environmental impact of defined options of rehabilitations, and different types of impact resulting from emission to air, emission to waters (leachates), structural stability including slope failures, waste, use of resources, land occupation, relevance to circular economy concept. Some airborne technologies, such as LiDAR can be integrated for monitoring and assessment purposes (e.g. Toprak, et al., 2018). Some soil improvement techniques are available to enhance the stability conditions at sites against multiple hazards (Manav, et al., 2019). Figure 6 shows only the environmental evaluation aspect of the smart decision tool.

4 Conclusions

Open dumps have still been used in many countries as a way for municipal solid waste disposal. Even in the countries which started to use the landfill method, abandoned open dump sites continue to danger the environment and human health. Their main environmental impacts include visual concerns, air contamination, odors and green-house gasses (GHG) emission, sources of diseases, surface water and groundwater pollution. Universities, companies, municipalities and related research, training and nonprofit organizations from five different countries, namely Turkey, Italy, Poland, Bulgaria, and Romania, came together under a EU project to tackle the issues related to open dumps in an effort to reducing hazards to the environment and water resources by rehabilitating open dumps. This project produces significant intellectual outputs, namely smart decision tool for rehabilitation of open dumps, competence tool, multilingual e-learning-platform, learning modules, and smart guidance manual. The intellectual outputs of the project have significant potential for the sustainability because they were determined via discussions and communications among all partners, including associated ones. Hence, up to date products of this project can continue to match the needs of the sector for a long time after the projects finishes. They will be available after the project is completed for decision makers, engineers, technicians, and vocational trainers who want to perform the open dump rehabilitation process for risk based optimum decisions. The digital capacity of the applicant organization, GTU will be used primarily for serving the intellectual outputs of project at least five year after the end of the EU funding. In some aspects, it is expected that the organizations of the target groups (e.g., municipalities) support and maintain some of the results and outputs. Moreover, the consortium will be in communication with associated partners about the sustainability of the project after it is completed as some of these partners have a policy of supporting activities in long term if it is beneficial to their members.

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References

Agdag, O.N., Toprak, S., Koc, A.C., Selcuk, H., Firat, M., Dizdar, A. (2009). Improving solid waste management skills with blended learning: WASTE-TRAINing project. Local governments and waste management in the framework of EU-Turkey relations international conference, 23-24 Oct. 2009, Istanbul, Turkey, pp. 9-18.

Bogacka, M. and Pikon, K. (2014). Best practice in environmental impact evaluation based on LCA – methodologies review. 14th International Multidisciplinary Scientific GeoConference SGEM 2014, www.sgem.org, SGEM2014 Conference Proceedings, ISBN 978-619-7105-18-6 / ISSN 1314-2704, June 19-25, 2014, Book 5, Vol. 2, 101-108 pp.

Das, E.K., Islam, M.D., Billah, M.M., Sarker, A. (2021). COVID-19 and municipal solid waste (MSW) management: a review. Environmental Science and Pollution Research. 28. 28993–29008.

European Green Deal. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

Eurostat (2021). For recycling; https://ec.europa.eu/eurostat/databrowser/view/sdg_11_60/default/table?lang=en; for waste generation: https://ec.europa.eu/eurostat/databrowser/view/ENV_WASMUN__custom_1154443/default/table?lang=en

Manav, Y., Toprak, S., Karakaplan, E., Inel, M. (2019). Soil improvement to counter liquefaction by colloidal silica grout injection. Journal of Environmental Protection and Ecology (JEPE), 2019, 20 (1). 135-145, http://www.jepe-journal.info/journal-content/vol-20-no1.

Panaitescu, C. and Bucuroiu, R. (2014). Study on the composition of municipal waste in urban areas of Prahova county. Environmental Engineering and Management Journal. 13. 1567-1571. 10.30638/eemj.2014.173.

Pikon, K., Poranek, N., Czajkowski, A., Łaźniewska-Piekarczyk, B. (2021). Poland's proposal for a safe solution of waste treatment during the COVID-19 pandemic and circular economy connection. Applied Sciences. 11. 3939. 10.3390/app11093939.

SMARTEnvi (2021). https://smart-envi.gtu.edu.tr/

Toprak, S. and Koç, A. C. (2013), Contribution of Leonardo projects to education in technical fields. Journal of Education, Pamukkale University No.33, (January 2013/I), s. 73-91.

Toprak, S., Koc, A. Cem, Pilcher, R., Kara, I., Angelis, E., Fatih Dikbas, Kylene De Angelis, K., Firat, M., Bacanli, U. G., Dizdar A. (2013). New trends in water infrastructure education: PROWAT project case study. Technics Technologies Education Management (TTEM), Vol. 8. No.1 129-142.

Toprak, S., Nacaroglu, E., Koc, C., O'Rourke, T. D., Hamada, M., Cubrinovski, M., and Ballegooy, S. (2018). Comparison of horizontal ground displacements in Avonside area, Christchurch from air photo, LiDAR and satellite measurements regarding pipeline damage assessment. Bulletin of Earthquake Engineering. 16. 10.1007/s10518-018-0317-9.

Vassilev, N., Vassileva, M., Kujumdjieva, A., Nedeva, T.,Pankov, R.,and Avsec, S. (2015). The state of art and challenges of an EC lifelong learning/leonardo da vinci project. International Journal of Arts & Sciences. ISSN. 1944-6934.

Wibrow, B., Circelli. M., Korbel, P. (2020). VET's response to Industry 4.0 and the digital economy: what works. NCVER, Adelaide.

Worldbank (2021). https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html