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Athens 2015 INTERNATIONAL

LANDFILL MINING CONFERENCE

September 24-25, 2015

Athens, Greece | Divani Palace Acropolis Hotel

Organised by:

ENVECO S.A.
ENVIRONMENTAL PROTECTION MANAGEMENT & ECONOMICS

HELECTOR

Municipality of Polygyros

NTUA School of Mining & Metallurgical Engineering

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water+waste

Book of Abstracts

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Welcome Message

Dear Colleagues and Friends,

It is a great honor and pleasure to welcome you to the Athens 2015 International Landfill Mining Conference of the LIFE+ Reclaim project, in Athens, Greece, on September 24-25, 2015.

The Scientific Committee planned an informative programme, which includes lectures and presentations. As the Landfill Mining concept is rather new, we anticipate that many lively and interesting discussions will take place, with distinguished specialists from different backgrounds addressing issues of multidisciplinary interest, such as the benefits and the drawbacks of the method, its applications and its potential for Greece and the rest of the European Union Member-Countries.

We have chosen Divani Palace Acropolis as our venue, with a direct view of Acropolis from its roof garden and we are confident that you will find your stay very enjoyable.

Thank you for joining us and welcome to Athens!

Spyridon Papagrigoriou,
Managing Director of ENVECO S.A.
Coordinating Beneficiary of LIFE+ reclaim

Committees - Organisation

Organising Committee

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Scientific Committee

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Antonis Mavropoulos (CEO of D-Waste and Chair of the Scientific and Technical Committee of the International Solid Waste Association-ISWA, Greece)
Eddy Wille (Responsible of the ELFM Programme of OVAM, Flanders, Belgium)
Nikolaos Mousiopoulos (Professor at the Department of Mechanical Engineering, Polytechnic School of the Aristotelian University of Thessaloniki, Greece)
Francesc Giró i Fontanals (Deputy Director Waste Agency of Catalonia, Barcelona, Spain)

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Session Presentations

LIFE Reclaim: A Landfill Mining case study in Greece

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The LIFE+ Reclaim project with the title "Landfill mining pilot application for recovery of invaluable metals, materials, land and energy" which is co-funded by the EU, has officially started in July 2013 and it is expected to be completed in June 2016. The project is coordinated by ENVECO S.A., while the Associated Beneficiaries are HELECTOR S.A., the Municipality of Polygyros and the School of Mining and Metallurgical Engineering of the NTUA. The project aims at building a temporary pilot application on productive scale in order to mine parts of a Sanitary Landfill in Northern Greece (the Polygyros Landfill in Chalkidiki), separate useful materials and produce marketable products, introduce innovation elements from the mining industry and suggest a new concept of waste valorisation. It will also assess the viability of the proposed method, as well as provide a scientific evaluation on the potential alternatives of the management of waste disposal sites.

To date, the results of the project come from various different actions: a research about the concept of Landfill Mining, knowledge sharing with experts from abroad (Belgium, Netherlands, Spain, UK and Cyprus), as well as mapping landfills of Europe to explore the true potential of the method. Furthermore, investigation and planning of the Landfill Mining Pilot Demonstration Unit took place whereas the actual installation and operation works which included mining and processing of waste were carried out during May-July 2015, in the Polygyros Landfill.

Along with these actions, public awareness activities are organized in relation to the benefits of Landfill Mining and Post-disposal waste treatment, such as the possible recovery of precious natural resources, the rehabilitation of the environment and the reclamation of land.

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Session 1: LANDFILL MINING: SOCIAL AND POLICY ISSUES

First experiences on Landfill Mining in Catalonia

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Catalonia is probably one of the most advanced regions on waste management in the Mediterranean basin. Since year 1,991, when the Environment Department was created, up to now, the management of wastes has significantly improved. The law on waste (1993) represented an inflection point which led towards a management approach based on prevention, recovery and disposal of waste. Some years later (1997), Catalonia legislated, for the first time, on the disposal of waste in landfills, establishing among other legal requirements, the technical conditions to be met by controlled landfills.

It should be highlighted the use of landfill tax (since 2004 for municipal waste and since 2013 for industrial waste) and incineration tax (since 2008 for municipal waste), as an important economic-legal tools, which contribute significantly to the improvement of waste management.

Twenty years later, about 50% of all waste is managed as material recycling or thorough energy recovery options, as indicated in Table 1.

In this context, two experiences on landfill mining were done in recent years in Catalonia: the total emptying of Berga-1 landfill (2012) and first landfill mining trials in Clariana de Cardener landfill (2015). The most important data of those landfills are shown in Table 2.

Generation & management of waste (Data 2012)	**Municipal Waste**	**Industrial Waste**	**Construction & Debris Waste**	**TOTAL Waste**
	3.731.437 T [35,8%]	4.147.650 T [39,8 %]	2.540.320 T [24,4 %]	10.419.407 T [100,0 %]
Material Recycling	37,3 %	60,0 %	43,0 %	47,7 %
Energy Recovery	13,3 %	3,5 %	0,0 %	6,2 %
Global Recovery	**50,6 %**	**63,5 %**	**43,0 %**	**53,9 %**

Table 1

Landfill		Berga-1 (old)	Berga-2 (new)	Clariana de Cardener
Compliance with regulations	Sealing of the landfill vessel	No	Yes	Yes
	Leachate collection	Yes	Yes	Yes
	Biogas collection and treatment	No	Yes	Yes
Type of waste		MSW	MSW	MSW
Period of operation of the landfill		~ 1.960 to 1.996	Since 1.996	Since 1.987
Current status of the installation		Fully emptied	In operation	In operation
Estimation of the amount of waste emptied (in m^3)		100.000	-----	500

Table 2

1. The case of Berga Landfill. Emptying a landfill for environmental and economic reasons

This old landfill probably started to operate in the year's 60's. In such time there were no legal requirements for the construction or operation of landfills neither in Catalonia nor in Spain. This landfill was in operation until year 1.996. This landfill received mainly MSW from its own region (Berguedà).

Once Catalonia legislated in 1997 on the disposal of waste in landfills, at the same time that new and modern landfills were built (meeting all technical legal requirements), all the ancient and uncontrolled landfills were gradually closed. For this reason, the new landfill was built (Berga-2) and the old landfill (Berga-1) was closed and sealed. It must be said that the leachate generated in the old landfill (Berga-1) were sent to the leachate pool that was built for the new landfill (Berga-2).

During the first years nothing strange was observed, but in 2010 it was detected an unusual and excessively generation of leachate coming from the old landfill. In 2010, it was quantified a generation of about 20.000 m^3 of leachates per year (at least 60% of which coming from the old landfill). It had a great economic impact due to the transport & treatment cost in a sewage treatment plant, of about 470.000 €/year.

This situation was unbearable for public authorities. After some research, it was concluded that this was not due because of the rain but due to the upwelling of water from inside the mountain. Because of this great problem, it was decided to completely empty the old landfill (Berga-1) and transferring all the waste to the new landfill (Berga-2). About 100.000 m^3 of waste and covering soil were fully removed from the old to the new landfill. After that, the mountain was absolutely cleaned and was possible to find the upwelling of clean and transparent water. This operation was made in a short period of time (along three months of 2.011 summer) and the supported overall cost was about 400.000 €.

In the middle of this quick intervention (landfill should be emptied during summer, before autumn rainfall arrived), a small trial was done with some removed waste; this trial was made with deeper landfilled waste and it was not difficult to estimate the age of such material because some newspaper and magazines remained intact after so many years of being landfilled.

The trials, under the supervision of the university, consisted to subject about 80 tonnes of waste to an aerobic stabilization process along near one month; it was possible to check that thermophilic temperatures (up to 55-60 ºC) were reached in the first fifteen days of process. This allowed us to verify that the material showed activity even after 20 years of being landfilled, and although the waste had a low biodegradability potential, it was concluded that there had been some degradation of organic matter during this process.

2. The case of Clariana de Cardener Landfill. The first tests on Landfill Mining in Catalonia

The Clariana de Cardener landfill started to operate in 1987. The landfill has permission since 1996 and the corresponding environmental permission since 2006. This landfill is receiving mainly MSW and also similar waste from two nearby regions (Solsonès and the northern part of Bages). This small landfill has expanded its deposition capacity several times since its creation. Currently it is receiving about 10.000 tonnes of mixed MSW per year.

Catalonia has faced in recent years some problems due to economic crisis, the reduction of waste generation and, therefore, the lack of waste to be treated in some MBT plants with great treatment capacity.

We, as a competent authority in waste, had thought that despite the economic crisis will finish one day or another, such problem may reappear, because the trend of European policies will continue promoting prevention and selective collection and recovery of waste. So, the solution is to rethink the kind of facilities that we design, build and operate. In this sense, we have to join different interests which have to come together in a technological solution valid for any type of waste despite these vary over time.

At this point, we must remember that organic matter is present both in biowaste from separate collection and also in mixed residual waste (MSW). Here is the key. We have to reconcile the biological treatment of bio-waste with the stabilization of the mixed residual waste previous to its landfilling, in order to fulfil the landfill directive requirements.

This is the reason why we have constructed next to the landfill of Clariana de Cardener, a versatile, flexible and technologically simple plant where it is possible to deal with several waste streams simultaneously but conveniently separated:

a) Biowaste from separate collection
b) Residual waste (mixed MSW)
c) Residual waste already landfilled (landfill mining)
d) Green waste, sewage sludge and others

The plant came into operation last march and in only four months we have got very promising results (in terms of yields, reduction of volume and weight, degree of stabilization material removed from the landfill, material recovery and operation cost) to be presented in the framework of this conference.

Introducing ecosystem services into LFM impact assessment

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Assessment of Ecosystem Services (ES), their relation to human activity and their monetary value has entered the discussion on the valuation of natural resources, and as of late it has entered the environmental impact assessment (EIA) analyses. After a full decade of discussion on the various ES classification systems and the conceptual models for their assessment, the literature has now concentrated around more practical issues and, thus, the benefits generated by ecosystems for human well-being, seem to become an important component of mainstream environmental decision making.

This paper wishes to contribute to a better understanding of the role of ES on EIA, by providing literature review and highlighting central topics in regard to potential applications, perspectives and challenges around this issue. Despite the fact that the international literature connecting ES and EIA is still immature, it would be of great benefit to the discussion, if various sectors began analytic assessments on the connections of their activities to the ES provision. Among these sectors, this paper focuses on the waste management sector and the mining sector, and, through them, it attempts to provide an initial approach on the Landfill Mining impact assessment, using the ES concept.

What do people believe about Landfill Mining?

D. Damigos, G. Diamantoulakis, V. Chorinos, M. Menegaki, D. Kaliampakos
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Under the pressure of resources deficiencies and environmental challenges, certain steps have been taken to encourage integrated waste and materials management policies, e.g. sustainable materials management (SMM), 3R related initiatives (Reduce, Reuse, Recycle) and circular economy approaches for systematically addressing the movement of materials through the economy and the environment from extraction to end of life.

In this context, the exploitation of old and existing municipal solid waste (MSW) landfills via landfill mining (LFM) may be a promising solution for the recovery of recycling materials and energy, as well as the reclamation of valuable land. Technically, LFM is the process of excavating buried waste from operating or closed MSW landfills by employing the method of open cast mining, and sorting the unearthed materials for recycling, processing, or for other dispositions. From a private point of view, LFM projects will be implemented as long as revenues from the process exceed costs. However, this may not be always the case. Thus, there is a need for considering not only the financial but also the social and environmental benefits related to LFM to assess the true social worth of such projects.

This paper wishes to contribute to the discussion surrounding these issues by exploring society's perceptions and beliefs about the potential social and environmental benefits of LFM. More specifically, the paper analyzes the results of a survey conducted via face-to-face interviews in Polygyros, Greece, where a pilot LFM project is currently under way. The findings of the survey reveal critical information regarding the social and economic values that people hold for LFM projects and, thus, provide valuable input in order to encourage more informed and socially fair decisions.

Acknowledgements: This work was supported by the LIFE+ financial instrument of the European Community in the context of LIFE RECLAIM "Landfill mining pilot application for recovery of invaluable metals, materials, land and energy" (www.reclaim.gr), Grant: LIFE12 ENV/GR/ 000427. The coordinating beneficiary is ENVECO S.A. and the associated beneficiaries are the Municipality of Polygyros, School of Mining & Metal Engineering NTUA and HELECTOR S.A.

Development of a Landfill Mining policy in Flanders (Belgium)

E. Wille
OVAM, Flanders, Belgium

Landfilling evolved to a minor component of waste treatment in Flanders. Currently, less than 2% of waste is landfilled and only 20 landfills are still operational. Although the waste policy gradually shifted from waste disposal systems to an integrated waste management system, the former linear one-way production model resulted in moreover 1.700 landfills.

OVAM's programme on landfill mining indicates that Enhanced Landfill Mining (ELFM) is a feasible option for gaining added value in a broader perspective: the recycling of resources (material, energy, land), cost-effective soil remediation and the preservation of resources such as drinking water. The Policy memorandum of the Minister of Environment identifies ELFM as a key strategic choice of her policy for the term of office (2014-2019).

The basic element of this policy transition is the shift from a "avoid-negative-impact-approach" to a resource management approach with respect to landfills. This shift is epitomized by the concept "Enhanced Landfill Management & Mining" (ELFM²), which implies an investigation of the opportunities and possibilities to introduce landfills (content and surface) in a circular economy. With the emphasis on the potential resources, new approaches on landfill characterization were developed.

Prior to the mining phase, landfills should be managed as a stock and interim use contributes to this objective, creating added value in the meantime. Several projects, ranging from a golf court to solar panel systems, illustrate the opportunities of interim use. The management component of ELFM² applied on 2.000 former landfills requires a decision support system (DDS). The Flaminco-tool (**F**landers **La**ndfill **Min**ing, **C**hallenges and **O**pportunities) was developed as a ranking system for landfills based on the environmental risks and the redevelopment opportunities. Flaminco will be extended to a material flow model taken landfills into account.

Local community participation in technological complex enhanced Landfill Mining projects

M. Ballard
CleanTechPunt VZW, Houthalen-Helch, Belgium

Today we see the evolution of the "great waste vanishing trick" into a "raw materials and energy appearance trick" called Landfill Mining. These are projects who represent opportunities for creating knowledge, business or societal benefits from the perspective of the community of driving actors. They often represent a potential threat towards health, safety or prosperity from the perspective of the community of people who happen to live near the facilities. Therefore, the idea that landfills will be "re-opened" is a formula where civil resistance can be expected.

In the beginning of 2010, Maurice Ballard, president of CleanTechPunt vzw was asked to join the consortium as a local representative in this consortium of independent scientists, industrialists and representatives of Group Machiels.

The number one priority for him was the safe conditioning and excavation of landfill waste using the most stringent technical, social and ecological criteria. He believes that the involvement of local residents should be done as professionally as any other technological challenge facing this research consortium.

Today the Locals are representing a group of 18 interested and extremely critical people who examines and discusses the whole project, studying the smallest details of the project including the planning and continuing to follow them up. The Locals receive thorough answers to their questions directly from the ELFM Consortium members, technology holders and the scientists.

Being part of the Locals group requires commitment and dedication. Local members disseminate information, share their gained knowledge and discuss matters with their neighbours, acquaintances, friends and family members.

In the lecture of Maurice Ballard, he will demonstrate the benefits and the needs of the functioning of an organized group of local inhabitants in the development of an Enhanced Landfill Mining project, where previously landfilled waste is going to be used for recycling and energy production.

Session 2: RESTORATION OF LANDFILLS AND CONTAMINATED SITES

History of dump sites in Greece: Integrated tools and methods for their registration

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In many regions of Greece, waste was historically disposed of by uncontrolled landfilling. Local excavations and quarries for gravels became full with waste because they represented an opening in the ground. From the year 2000 till now, inactive, active and illegally used dump sites have been revealed by models that were based on Arc-Info Geographical Information System®; this article discusses the integrated tools and methods that were used for their registration. Dumps were revealed by the developed System for the Prefectures of Chalkidiki (2006) and Thessaloniki (2000) in Northern Greece, the Prefecture of Kozani (2005) which is located in the eastern part of Western Macedonia, the Regions of Sterea Ellada (2000) and Peloponnese (2012) and for all over the country (2012 and 2014). Thus, administrative plans for the mining and material recovery from these registered uncontrolled disposal sites could be coordinated and implemented for returning the land in the given areas to some degree to its former state.

Phytomining of heavy metals. Future perspectives

C. Tsadilas
Hellenic Agricultural Organization DEMETER, Directorate General of Agricultural Research, Institute of Industrial and Forage Crops, Thessaloniki, Greece

The amount of produced hazardous wastes including those contain significant quantities of heavy metals is continuously increasing and its management constitutes a serious problem for the society from both point of view i.e. the human health protection and the sustainable use of natural resources. Wastes contain elements which after the appropriate separation may be reused resulting in saving of natural resources. So, the development of recovery techniques of useful elements from the wastes and their reuse seems to be a sound approach. Among these techniques in the last two decades, those exploiting the properties of certain plants to absorb significant amounts of heavy metals without inhibiting their growth, looks to gain ground. These plants are called heavy metal hyperaccumulators and have the possibility to survive even when they uptake multiple quantities compared to normal plants. According to the most acceptable definitions, hyperaccumulators of heavy metals are considered plants that can survive when they contain in their dry biomass concentrations >0.01% for cadmium (Cd), >0.1% for cobalt (Co), for copper (Cu), for lead (Pb) and nickel (Ni) και >1.0% for manganese (Mn) and zinc (Zn).

By utilizing the properties of these hyperaccumulators of heavy metal plants, polluted soils may be cleaned with techniques such as phytoextraction, phytomining or agromining (a variant of phytomining which is conceived to be part of an integrated agricultural chain). Growing such plants on disposal sites of wastes, after their harvest and incineration of their biomass, a bio-ore is produced from which is relatively easy to separate the heavy metals included. Phytomining or agromining may be used for extraction of the metals Cd, As, Se, Cu, Mn, Ni, Tl, Zn since for these metals hyperaccumulators were found. The economic feasibility of these techniques depends on the price market of the metal, its yield per surface cultivated unit and the available amount of wastes and the extend of the polluted areas. Recent data showed economic feasibility of these techniques for the metals Ni, Se και Tl.

Reliable rehabilitation of uncontrolled dump sites

K. Hadjibiros
National Technical University of Athens, Athens, Greece

Open uncontrolled dumping of municipal waste used to be practiced worldwide for many years. Only in Greece, it is estimated that thousands of uncontrolled dump sites existed most of which have undergone rehabilitation during the last 20 years. Generally, according to waste management regulations, aftercare (or post-closure care) has to be carried out until landfills or dumpsites no longer pose a threat to human health and the environment.

To ensure the environmental reliability of a closed landfill site, no toxic substances should be released to the environment, the underground water quality should not deteriorate, the emission of greenhouse gases in the atmosphere must be eliminated, erosion must be avoided, the natural landscape and vegetation has to be restored and the continuous monitoring of qualitative and quantitative parameters, as well as the reliable maintenance of the technical infrastructure must be ensured for at least 30 years. It is questionable if the usual rehabilitation projects are reaching the aforementioned

standards and often the dump cover is poor or sporadic. Toxic liquids are also generated by poorly remediated landfills, as well as greenhouse gases as from the total methane released to atmosphere about 5-15% is estimated that it is related to waste dumping and waste landfilled.

Landfill mining is the process of excavating existing, closed solid waste landfills or dumpsites and sorting excavated materials for recycling, processing or other disposition. It has been used throughout the world for many years as a tool for sustainable landfill siting and it could provide a viable solution for reliable dumpsite rehabilitation in the framework of a cyclic industrial economy. This solution also eliminates the unbearable monitoring costs which would be necessary otherwise for many years.

Mechanisms of stabilization/ immobilization of heavy metals in the geoenvironment

D. Dermatas
National Technical University of Athens, Athens, Greece

Heavy metal contamination of the geoenvironment is one of the most challenging environmental problems in today's world. Heavy metals are introduced via several pathways to the geoenvironment and once there, they may retain water solubility levels that will directly or indirectly threaten living organisms by passing onto the biological food chain. In order to minimize or even avoid altogether the adverse effects that heavy metal contamination poses, a wide array of remediation and filtration technologies have been developed and are currently being used with varying degrees of success. These technologies are mostly based on the immobilization of heavy metals in soils and other engineered filtration media and to a significantly lesser degree are based on the extraction of the heavy metals from the contaminated media. In any case, these technologies carry significant financial burdens once tested and applied to actual field scenarios, which, coupled with the inherent uncertainties on their respective effectiveness, makes imperative the understanding and deliniation of the underlying phsysicochemical mechanisms. In this presentation the main mechanisms of heavy metal immobilization in the geoenvironment will be presented and discussed based on As, Pb and hexavalent Cr contamination actual field cases involving mainly stabilization/solidification (S/S) technologies. Knowledge of the principle heavy metal immobilization mechanisms at play, provide the founding block upon which remediation treatment sustainable design and overall effectiveness are based. Consequently, there will also be an overview of the state-of-the-art field and laboratory investigation tools that currently appear to be the most promising in evaluating S/S treatment alternatives and developing sustainable S/S treatment design and field implementation.

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Session 3: NEW PERSPECTIVES IN WASTE POLICY

From Brownfield to Brightfield. Revitalizing and re-powering derelict land in Flanders

E. Wille
OVAM, Flanders, Belgium

At the harbour of Ghent, an abandoned fertilizer facility and the adjacent landfill site is transformed into an innovative brownfield regeneration project. Through the Brownfield Covenant Act and the system of "green certificates" to promote energy generation from renewable sources, the government of Flanders supports these initiatives of sustainable development. This paper outlines the Flemish approach and the results of this project.

Former industrial sites are often strongly contaminated and remain under-used or abandoned land, so-called brownfields. As an important European economic hub and nexus to the hinterland of NW- and Central Europe, leaving such economical valuable sites un(der)used is not an option. The Flemish Government introduced a transversal approach towards the redevelopment of brownfields: the Brownfield Act of March 22, 2007. This Act offers developers the opportunity to sign a contract (a brownfieldcovenant) with the Flemish Government and other involved private and public parties with mutual commitments on the realization of a brownfield project.

In July 2012, the brownfieldcovenant of project number 54 – Kuhlmann site was signed. The total surface of 135 ha consist of the former production facilities (50 ha) and the gypsum landfill (85 ha). Hence an integrated project approach between cleanup, sustainable spatial planning and reuse was set up. Precautionary measures on the landfill were taken to avoid further infiltration and improve the stability of the waste tip. A large plume of contaminated groundwater undergoes remediation. Small quantities of specific gypsum are valorized as soil substrate for mushrooms. On top of the existing landfill, a new landfilling area is created. The coverage and capping of the finished parts is partly provided by HDPE-layers and recycled soil. A solar panel system was installed and provided 15 MegaWatt /year.

Interconnectivity and the future of waste management

A. Mavropoulos
D-Waste, Athens, Greece

This lecture will focus on understanding the emerging interconnectivity as a major driver for the future of waste management. According to the Wiktionary definition, interconnectivity is "*the state or quality of being interconnected*". Globalization, information highways, social media, mobile phones and the Internet of things create a world where interconnectivity becomes a central element of our daily lives.

The figures are striking. There are 3 billion Internet users, with more than 2.2 of them active in social media. The number of mobile phones has already exceeded the world's population and smart phones reached 1.8 billion. Almost 10 billion sensors are already online and it is expected to at least double by 2020.

Human networks can be better understood through social media studies and there is a lot of evidence documenting the substantial influence of large-scale networks in individuals' behavior. Crowdsourcing becomes a micro trend and digital citizenship drives the movement from smart cities to engaged ones.

At the same time, waste management industry shifts from traditional approaches to the circular economy concepts, with waste hierarchy leading the relative decision-making in the EU. Waste management becomes part of the broader resource management approaches and new business models are gradually applied.

The rapidly increasing interconnectivity in combination with the shift towards a circular economy creates a new landscape for waste management in all of its phases. From waste prevention, collection and recycling up to treatment and final disposal, new concepts, tools and solutions are already available and many more are underway. Interconnectivity, in all its forms (human to human, machine to machine, machine to human), will transform waste management in an unimaginable way, as it will be the case with almost every part of our life.

The lecture will outline how interconnectivity affects waste management practices and concepts and it will demonstrate tools and applications that are already available or about to be developed within the next 3 to5 years.

The Zero Waste Concept towards integrated waste management

M. Loizidou
National Technical University of Athens, Athens, Greece

Considering that each year in the European Union 3 billion tonnes of waste is generated, waste definitely represents a considerable loss of resources in the form of materials and energy. Much of this waste recycled, reducing the amount of waste that ends up in landfill sites, while cutting down on the amount of material needed from the natural environment. This is important because Europe is dependent on imports of scarce raw materials, and recycling provides EU industries with essential supplies recovered from waste such as paper, glass, plastic and metals, as well as precious metals from used electronic appliances.

What is more, the complete life-cycle thinking should be considered and integrated in the design stage of the products, which can also reduce greatly the amount of produced waste. Thus, simplified linear consumption patterns must be abandoned and replaced by life-cycle thinking. In this context, Zero Waste strategies can ensure resource efficiency and sustainable development. In the end, it is imperative to realize the role that we all as individuals, householders, businesses and local and national governments have to play.

Development of a Household Waste Recycling Centre Network in Cyprus

A. I. Iacovides
I.A.CO Environmental & Water Consultants Ltd, Cyprus

Waste management has been an open issue in Cyprus' agenda for effectively addressing related environmental impacts and securing a high level of environmental protection and public health, over the last decades. While all European waste management policies are applied in Cyprus, the sector lacks of an integrated and robust waste management approach, negatively affecting the environment and the sustainable use of available resources.

In the last decade however, there has been a sincere effort by the government to address to these issues. To this end, significant decisions have been taken, which were included into a municipal waste prevention and management plan, which included, amongst others, the development of an initial Household Waste Recycling Centre Network - the so called Green Points - allowing for its future expansion.

The presentation emphasises on the anticipated role of Green Points in the Cyprus waste management plan, and in particular on the upper levels of the waste management hierarchy - reduction, reuse, and recycle. It is anticipated that Green Points will manage to reduce waste quantities currently being illegally dumped in uncontrolled sites, by providing the means to safely dispose bulky household waste which cannot be collected by existing collection

systems, will facilitate the growth of the currently undeveloped second hand market (aka reuse / preparation for reuse), and will enhance recycling rates of otherwise difficult to recycle waste streams.

All the necessary methodological steps taken towards securing an effective, viable and user friendly network of Green Points, as these were taken within the context of a project contract awarded to "EPEM SA and I.A.CO Ltd" will be presented in brief. Finally, an overview of the lessons learnt during the process of developing the network, from its conception, to its design, permitting, construction and promotion of it, will be provided.

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Session 4: RECOVERY OF RESOURCES FROM MUNICIPAL SOLID WASTE

Waste management in the Municipality of Polygyros. Current situation and recycling projects

G. Diamantoulakis
Municipality of Polygyros, Polygyros, Greece

Polygyros is the capital city of Chalkidiki Prefecture. Municipality of Polygyros came out after the "Kallikratis" low (2011) with the union of four (4) smaller municipalities (Polygyros, Zervochorion, Anthemountas, Ormylias).

Mo Polygyros covers a large territory of Chalkidiki. Starting from northwest, from Thessaloniki to Ancient Olynthos, southwest, it goes south till the beginning of Sithonia Peninsula and ends to mount Cholomontas, northeast. Thirty-five (35) small and larger villages are built all over.
At the end of 2013 there were left five (5) Uncontrolled Waste Landfills. Today all of them have been restored leaving for last the UWL of Polygyros. There with the only thing left to do is the tree planting that will happen during the next few weeks.

Two (2) Landfills are running in Mo Polygyros area: Landfill of Polygyros and Landfill of Anthemountas. Waste from other municipalities goes there, especially in Polygyros Landfill making its projected lifetime go shorter and shorter.

Enviroment and its protection is one of the first priorities of Polygyros township. Two (2) programs of recycling are running the last few years (packaging materials and home composting). The local township now focuses on educating and involving local society in a larger volume using the moto "We first have to change ourselves to change the world".

Treatment technologies and recovery of resources from waste in the UK

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Landfill dominated UK waste management practices in the twentieth century. Today, it retains a significant role but this is fast changing, having dropped from 79% in 2000/01 to 31% in 2013/14 for municipal solid waste. This has been driven by diminishing suitable landfill locations, increased regulation, EU Landfill Directive diversion requirements, landfill tax and a waste strategy favouring the "hierarchy" approach to waste management. The result has been an explosion in the number and variety of modern waste facilities being built and a need to address liabilities at closed landfills.

This change can be characterised as being highly diverse, with circa 80 anaerobic digestion sites, 80 composting facilities, 20 mechanical biological treatment plants, 40 incinerators (some with CHP), 100 material recycling facilities, 15 multi-facility sites and a small number of advanced thermal treatment plants operational across the UK. Many more facilities are in planning and construction.

Lessons have been learnt in the UK which any country or region contemplating the development of alternative solutions would benefit from considering. Many UK landfills have seen a drop in gas yield as biodegradable waste has been diverted from them to upstream treatment facilities. Some of these have only recently been subject to gas collection, with utilisation infrastructure and contracts based on predicted gas yields that have failed to materialise. A common issue is the extent to which the composition of municipal solid waste can change in a relatively short space of time. In some instances composition has changed beyond the predicted range for the typical 20 to 25 year life of a new facility before the facility has been fully built and commissioned. This can make processes unsustainable, can increase wear and tear, impact performance and cause financial problems. Another common problem is trying to design a process and business case for a facility when the sale of products is subject to fluctuating commodity markets. Finally, the funding and contractual models employed in the UK to develop waste facilities have seen varied success, with the last minute withdrawal of Private Finance Initiative (PFI) funding on some projects and, in some instances, the termination of long-term PFI contracts soon after facilities open.

Many closed landfills in the UK have proven to be an environmental liability and a high financial burden upon operators. As such, there is increasing interest in the UK concerning landfill mining. However, operational experience is limited and, as with any new waste management

initiative, implementation is far from straight forward. There have been some, albeit limited, attempts to recover resources from landfilled waste in the UK. Whilst landfill gas collection and utilisation in the UK is commonplace and effective, recovery of materials from landfilled waste is not. One recent project (Sandford Farm) utilised material recovery, but the prime driver was real estate value.

Moving away from reliance upon landfill is a necessity in a world of increasing population, diminishing resources and increasingly strict regulatory controls. Whilst there are many opportunities, there are also many potential pitfalls. It is important that experiences, good and bad, are shared for the advancement of technologies and approaches to waste management, the avoidance of time delays and the learning of lessons from one location to another.

Technology serving waste valorisation

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The international perspective on management of waste is constantly evolving. In the beginning, the only concerns were the protection of public health and the environment but today focus has shifted towards waste utilisation and valorisation. As most of the contents of the produced mixed waste are biodegradable materials (at more than 40%), all the available possible routes for its maximised recovery should be explored. Alongside the recycling of packaging materials which could potentially reach a 30-40%, the organic fraction could be recovered through methods such as composting, anaerobic digestion but also incineration.

In particular, composting is the ideal method for the best material recovery from organic waste, however, the quality of the produced products are depending greatly on their separation from the other waste streams. The method which combines both material and energy recovery is anaerobic digestion. The organic fraction, combined with other wastes could also be led to incineration. Modern incinerators have minimised most environmental concerns by implementing new design aspects such as higher combustion temperatures and better emission gas treatment.

All three methods could be combined in an integrated solid waste management system, according to the specific characteristics and needs.

Landfill Mining in Polygyros site. Results and discussion

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The presentation will be about the main aspects of landfill mining and processing of municipal solid waste at Polygyros landfill site. Specifically, the selection of the optimal places for processing of MSW and for the storage of recyclables, the design and construction of the necessary area for the installation and operation of the demonstration unit and the measures for environmental protection. The results from the operation of the plant will be demonstrated with emphasis on the quantities of MSW treated, of materials reclaimed through mechanical and hand separation (i. mixed hard plastic such as PET, HDPE, PP, ii. plastic bags, iii. Glass, iv. Ferrus material and v. nonferrous material such as aluminum cans) and the quantity and quality of soil/compost reclaimed by landfill mining. Also, all other streams of byproducts produced through landfill mining will be listed and a mass balance of waste, products and byproducts will be presented. Economic data concerning the operation in situ will be quoted.

The recycling of packaging materials

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About HERRCO: The Hellenic Recovery and Recycling Corporation (HERRCO) was established by industrial and commercial businesses, which either place packaged products in the Greek market or manufacture packaging. HERRCO has today over 1.732 cooperating businesses. The Central Union of Municipalities (KEDE) is also a shareholder in HERRCO, which operates as a not for profit organization and serves the public interest according to the Law 2939/2001.

HERRCO following the European practice organizes the Collective System for the Alternative Management of packaging waste (CAMS-Recycling) to tackle with the recycling of the packaging according to the goal set by the legislation.

Following a successful 1st six year period of its operation (2003 – 2009), the Ministerial Decision 118019/18-3-2009, gave approval to the System operation for a second six year period (2009 – 2015).

For more information regarding HERRCO one may visit the site www.herrco.gr

The blue bin / blue bells project at a glance (May 2015):

- **455.000 tons of packaging materials and printed paper** were recycled with the blue bin / blue bells in 2014. The amount includes the certification which the System provides for the relevant authorities regarding Industrial and Commercial Packaging Waste (ICPW) and other sources of recycling.
- **9,5 million inhabitants** are served under the Blue Bin projects (88% of the total country's population)
- **165.000 blue bins** and **434 special collection vehicles** have been given to the Local Authorities
- **4.400 blue bells for glass collection** have been placed at public and private areas
- The **national targets are met** with the exemption of glass.
- More **than €280 mil.** have been spent for capital and operating expenses in the 12 year period.

HERRCO, in a permanent effort to cover the needs for improved recycling methods, proceeded in modern solutions in order to maximize results and to assist the citizens. Towards this direction, a separate collection stream for Glass Recycling was launched in 2013. In cooperation with the Local Authorities, Blue Containers (igloos) are put at various points to serve HORECA businesses, where the significant consumption of glass packaged products is carried out.

Session 5: LANDFILL MINING: TECHNICAL, ECONOMIC AND ENVIRONMENTAL ISSUES

Environmental monitoring of the Polygyros Landfill Mining Scheme

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The monitoring process is a crucial step in order to safeguard the successful implementation of any Landfill Mining (LFM) scheme and the protection of the environment. More particularly, environmental monitoring aims to provide the tools for a quantitative assessment of the environmental conditions and identify solutions and measures for tackling the impacts deriving from the LFM operations.

This paper presents the environmental and safety monitoring program taking place at the Polygyros site, where a pilot LFM project is currently under way. This allows the assessment of the environmental conditions in the working area and for the proactive assessment of potential risks to the personnel's health. Emphasis is given to the particulate and dust monitoring (especially related to mining and transport operations) and gas emissions from the waste. The air quality monitoring involves continuous direct mass measurements of PM-10 using a tapered element oscillating microbalance (TEOM) sampler installed permanently on-site and by a number of portable air sampling units to measure landfill gases in the excavating and processing area where the main working activities take place. Furthermore, water samples are collected from the secondary valorization process and the washing of the wastes, and the noise levels at the PL area are checked with periodic measurements covering the whole facility.

The findings of the monitoring campaign indicate that the environmental impacts of the LFM project are minimal when considering the background values of the most important indicators. The gases generated were below detection threshold, while the air-quality of the area is not affected by the mining and the processing of the wastes.

Quality and recovery of specific waste fractions from Landfill Mining for material and energy recovery

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Landfill Mining offers the opportunity to recover potential secondary raw materials. To what extend the excavated materials can actually be used for material or energy recovery is mainly dependent on the quality of the waste. To estimate the quality of Austrian landfilled materials, waste samples were taken on two landfill sites. One part of the excavated waste from each landfill was subsequently hand sorted. Among others, the fractions paper, paperboard and cardboard (PPC), wood and metals were separated. The other part of the waste was fed into a mobile treatment plant, were fines (smaller than 20 mm) and a fraction with a high net calorific value were retrieved. Thus, the quality of these five fractions (of every landfill) was characterized closely by means of visual assessment and chemical, physical and mechanical investigations. Additionally, in order to assess the material and/or energetic recyclability of these waste fractions in certain industries, quality requirements for feedstock materials (which must be complied with according to industry and legislation) were determined and compared with the investigation results obtained. In the paper the implementation of the sampling procedure and the mobile treatment conducted on the site, the hand sorting process as well as the examinations of selected waste fractions will be described. Moreover, the results of these examinations and a conclusion derived in terms of material and/or energy recyclability will be presented.

Operation of the pilot demonstration Landfill Mining unit

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RAM Europe, Orchomenos, Greece

In this presentation will be described the demonstration unit, its operation and performance and will be revealed any potential difficulties with the process and any suggestions for process optimization.

Depending on the complexity of the process more or fewer machines can be used. At the Polygyros landfill are in use machinery easily transported on trucks; an excavator and a front end loader uncovers the landfilled materials and places them on a trommel sieve to separate materials by size allowing the biodegraded soil fraction to pass through leaving non-biodegradable, recyclable materials to be collected at a conveyor belt. Any very large objects are removed prior to placement on the screen.

The recyclable fraction is forwarded onto a conveyor belt and it is separated into hard plastics (bottles, etc.), soft plastics (mainly bags), glass, aluminum cans and other materials by skilled workers. An electromagnet is used to remove the ferrous material from the waste mass as it passes along the conveyor belt.

The operation of the demonstration unit will allow the determination of the operating conditions and the establishment of performance parameters for large scale and assist in techno economic evaluation of the process.

Local community involvement in complex technological projects: Challenges for long term planning and dealing with uncertainty

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Enhanced Landfill Mining (ELFM) is offering a promising perspective for sustainable materials management on a global scale. Positive impacts connected to primary mining, climate change, export and treatment of waste streams, etc are put forward. However positive these effects might be on the larger scale, they are rarely perceived in the same way on the local community level where landfill mining and recycling activities actually take place. Local inhabitants who live nearby are more often than not caught into the NIMBY syndrome.

This paper draws on earlier research of the authors and articles concerning the dynamics of stakeholder management and multi-actor collaboration in the development of the ELFM domain in Flanders, Belgium, and specifically on local community participation in the renowned Closing the Circle Project, that is piloting the ELFM practice in Belgium. We draw on empirical research on organised and un-organised groups of local inhabitants near the site.

Two elements are focused upon: long term planning and the possibilities and challenges for inter-generational solidarity on the one hand, and dealing with uncertainty on the other hand.

Both these elements are crucial for the management of complex technological projects. Not only in terms of research and innovation in both academic and business life, but also, and especially, in the interaction with local stakeholders and in communication with society at large.

Uncertainty is manifested manyfold: technological, economical, legislative, and health related. Each type of uncertainty requires specific behavior from various actors involved, being it business, local and national authorities, research communities and NGO's. Several of the uncertainty types have been documented in transition management literature, but little is know about the connection with the challenges for long term planning and community involvement. We also adress the scale issues that influence the framing of problems and solutions on different levels (f.i. local authorities, provincial, regional government). Based on interviews, document analysis and observations, we illustrate the positions of local inhabitants living nearby the landfill site and how they account the costs and benefits from a complex technological project like ELFM.

Landfill Mining potential in Spain and review of preliminary experiences

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In Spain there are at least 275 million tons of household wastes deposited in landfills. An estimated 50% of the content is land (with some organic matter strongly degraded), between 20 and 30% are fuels (plastics, paper and wood), a 10% inorganic materials (glass, cement and stones) and the remainder are metals (2-5%) (mostly ferrous).

Among the materials landfilled during the period 1980 and 2010, there is an estimated content of around 10 million tonnes of ferrous and 1.8 million tonnes of non-ferrous metals, including very valuable materials such as gold, palladium, beryllium, gallium, platinum and the so-called rare earth group (neodymium, scandium, yttrium, etc.) which were part of electric and electronic devices, mainly mobile phones, MP3, headphones, microphones, speakers, computers, televisions, etc.

Several projects have been carried out to date on resource extraction from landfills all around the planet, mainly in the United States but also in Europe and Asia. In most cases the initiative has come from the government and had as the main objective to solve a specific problem in the region, such as the conservation of the area where the landfill was located or the prevention of soil or water pollution.

It was not until more recently that proper landfill mining projects have been developed, putting the main emphasis on the recovery of the resources contained in landfills, in an experimental way. This new perspective of landfill mining, in addition to an economic interest, has an environmental potential in terms, for example, of climate change mitigation and of pressure reduction on scarce natural resources, and a social potential for the creation of new jobs. The materialization of this potential, however, depends on several factors, including the quantity and quality of resources deposited in landfills, the technological capacity available for the separation of materials, the cost of extraction and separation technology or the price of certain resources on the market, which in turn depends on their demand.

The present research aims, on the one hand, at reviewing some preliminary experiences of landfill mining in Europe and in Spain, and on the other hand, at offering a prospect for landfill mining in Spain by providing some estimations of the number of potential landfills in Spain, their main characteristics, their estimated waste composition, the prospects of material recuperation and their relation with the import/export Spanish material flows.

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Session 6: NEW TECHNOLOGIES IN WASTE MANAGEMENT

Uncontrolled industrial waste disposal in landfills: Case study in Attica Prefecture

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A very important environmental problem in Greece is the illegal disposal of industrial waste, commonly hazardous, in municipal landfills. In the case described below, the dump site was supposed to stop operating in 2010, while various audits carried out by the Hellenic Environmental Inspectorate before, had revealed illegal disposal of industrial waste. Eventually, in the summer of the same year, an extensive fire broke out, which was expanded in the nearby area.

The local municipality assigned to POLYECO an environmental audit in order to clarify whether hazardous and industrial waste was dumped in the landfill site. Polyeco proceeded to sampling in six subareas of the landfill that were pointed out as the most suspicious. Leaching test concentrations, as well as total concentration of heavy metals and organic compounds indicated the presence of a waste with different composition compared to typical municipal waste, including oily sludge, industrial

inorganic sludge and dust, polluted soil, unknown waste, etc. All samples included parameters that exceeded landfill disposal criteria (2003/33/EC).

Considering that this landfill is not a unique case, but the same situation may exist also in other landfill sites in Greece, POLYECO supports waste mining, enhancing thus the recovery of raw materials and energy. The waste, sampled and analyzed as part of the environmental audit of the landfill, meets the specifications for further valorization as secondary solid fuel and/or raw material. Special treatment in the production lines of POLYECO is essential in order to ensure the stable quality of the final products and the acceptance and recovery by the Greek cement industry.

Intelligent energy production from Greek industrial/municipal solid waste and potentially Landfill Mining: Computational fluid dynamics for an industrial unit Bubbling Fluidized Bed (BFB) – Boiler/gasifier

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Intelligent energy generated from utilization of Greek non-fossil fuels viz., municipal/industrial solid waste and potentially landfill mining (LFM) due the process of bubbling fluidized bed (BFB) or stationary fluidized bed (SFB), is also one of the most important strategies for a clean future and promotion of the circular economy based on substitution of fossil energy by renewable energy and lowering global CO_2-emissions. Therefore, domain experts are interest in developing new technologies and techniques in waste management for getting better understanding of underlying processes and their mutual dependence in BFB/SFB-boiler/gasifier for possible introduction to the Greek waste management market.

In this article we consider an application of a two-flow model data methodology for the bed of a BFB/SFB using the Eulerian-Eulerian approach. The effect of bubble rise and qualitative gas-solid flow pattern of a two-dimensional gas-solid fluidized bed reactor unit is investigated. Computational fluid dynamics (CFD) used to solve the standard two-flow bubbling model is an in-house code. The model has been used in order to meet industrial needs, especially the distinct feature of gas-solid fluidized beds which is the bubbles (region with high solids) since them affect fluidized bed reactor performance.

Using ICT tools for achieving efficient and sustainable waste management, enabling GHG emissions reduction – The example of Life EWAS

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The LIFE EWAS Project "Efficient and sustainable waste management methodologies using ICT tools enabling GHG emission reduction" has been developed to highlight successful waste prevention and collection ICT activities in order to promote their wider adoption across Europe.

In particular, non-optimized waste collection services cause environmental problems related to GHG emissions, high operation costs, noise, and traffic problems. Innovation and ICT tools can optimize waste collection and lead waste management systems to a more sustainable model. Also, new technologies, through ICT, web, and mobile tools, can increase citizens' awareness and promote e-democracy, and citizens' participation.

The core actions of the LIFE EWAS project include the creation of an online citizens' platform to raise awareness and foster recycling; the establishment of standard waste management technologies for collecting waste - i.e. sensors that control the filling levels of bins, vehicles' dynamic routes, etc.; and the setting up an online global platform for stakeholders to improve waste collection management that includes best practices, reference data & aggregated open data from the waste management tools.

EWAS expected results are the reduction of the cost of waste management activities by 15-30%, and GHG emissions by over 10%; detailed analysis of existing waste collection methodologies and European legislative frameworks and the new opportunities using ICT tools; integrated ICT solution to increase waste management efficiency that will be assessed using different usability and performance indicators, and by conducting surveys of the pilot users and external citizens; and innovative waste management methodologies based on advanced ICT Tools that will reduce GHG emissions, noise pollution and costs.

The project is taking place in Seville and Chania, and will use two platforms, namely eGarbage and Smart City Brain.

eGarbage Platform carries out data collection in real-time from containers through the installation of remote agents. After, automatic analysis and planification of data is

performed and results are delivered to the waste managers.

Smart City Brain is an information management platform for multiple vertical technologies setting, aiming at managing and displaying information in a simple and fast way.

This paper will examine and analyse the benefits deriving from the implementation of such a project in cities and waste management regions, and investigate the barriers and opportunities from its implementation.

Recycling electrical and electronic equipment in Greece

A. Fafoutis

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In our presentation we analyze the proper ways for e-waste management in accordance with the appropriate methods for the separation of waste.

We also present their exploitation through disposal for further management, with environmentally friendly disposal of hazardous and non-hazardous materials.

Those procedures help us achieve not to use raw materials, and saving large amounts of energy that would be used for the extraction-transport-industrial production of primary materials.

Poster Presentation

PP01: The transition to landfill mining in developing countries: The case of Bangladesh

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In Europe, landfill mining has become a common concept, and most landfills are designed in order to preserve waste materials for the future. Unfortunately, this is not yet the case in many developing countries, where mixed waste is basically disposed in open landfills without any health, nor safety measures. Current waste dumping and littering practices cause major environmental hazards and negative impacts on the living conditions in the cities.

In 2009 the Government of Bangladesh received a loan from the Asian Development Bank for the implementation of the Urban Public and Environmental Health Sector Development Program (UPEHSDP). The UPEHSDP aims to improve the public and environmental health conditions in the urban areas of Bangladesh, particularly in the City Corporations (CCs) of Dhaka-N, Dhaka-S, Chittagong, Khulna, Rajshahi, Barisal and Sylhet. The solid waste management component of the program establishes a framework to improve the efficiency of municipal solid waste management services, including the collection, separation, transportation, but also the construction of integrated waste treatment facilities and the remediation of existing waste dumps. European solid waste management knowhow and experience are applied to propose and implement sustainable solutions.

In Khulna a new confined disposal facility was designed according to EU standards, incl. liners, drainage and water treatment facilities, recycling and composting units and landfill gas recovery systems. In other CCs dumping sites are to be remediated through basic measures like waste covering, leachate pumping and treatment systems.

Being the first large-scale waste management project in Bangladesh, many challenges had to be overcome. The scarcity of land, the many resettlement issues and the limited local knowledge of complex project procurement and environmental technologies, demanded a specific approach.

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