Athens, Greece - September 24-25, 2015

ATHENS 2015 International Landfill Mining Conference

PHOTOS-MATERIAL-MINUTES

Edited by ENVECO A.E.

Beneficiaries of LIFE12 ENV/GR/000427 reclaim:

ENVECO S.A. ENVIRONMENTAL PROTECTION MANAGEMENT & ECONOMICS
HELECTOR
Municipality of Polygyros
NTUA School of Mining & Metallurgical Engineering

With the contribution of the LIFE financial instrument of the European Union

CONTENTS

Conference Programme

Thursday, 24 September 2015

09.30-10.00 Registration

10:00-10:15 Conference Opening

10:15-10:30 LIFE Reclaim: A Landfill Mining case study in Greece
Z. Gaitanarou (*ENVECO S.A.)*

10:30-12:15 **Session 1: LANDFILL MINING: SOCIAL AND POLICY ISSUES**
Chair: **S. Papagrigoriou** *(LIFE-Reclaim Coordinator)* • Co-Chair: **F. Giro i Fontanals**
First experiences on Landfill Mining in Catalonia
F. Giró i Fontanals, M. Madorell i Arbolí *(Spain)*
Introducing ecosystem services into LFM impact assessment
G. Tentes, D. Damigos *(Greece)*
What do people believe about landfill mining?
D. Damigos, G. Diamantoulakis, V. Chorinos, M. Menegaki, **D. Kaliampakos** *(Greece)*
Development of a landfill mining policy in Flanders (Belgium)
E. Wille *(Belgium)*
Local community participation in technological complex enhanced landfill mining projects
M. Ballard *(Belgium)*
Discussion

12:15-12:45 Coffee break

12:45-14:15 **Session 2: RESTORATION OF LANDFILLS AND CONTAMINATED SITES**
Chair: **E. Wille** • Co-Chair: **D. Kaliampakos**
History of dump sites in Greece: Integrated tools and methods for their registration
G. Perkoulidis, A. Malamakis, T. Tsatsarelis, I. Antonopoulos, N. Moussiopoulos *(Greece)*
Phytomining of heavy metals. Future perspectives
C. Tsadilas *(Greece)*
Reliable rehabilitation of uncontrolled dump sites
K. Hadjibiros *(Greece)*
Mechanisms of stabilization/immobilization of heavy metals in the geoenvironment
D. Dermatas *(Greece)*
Discussion

14:15-15:30 Lunch

15:30-17:00 **Session 3: NEW PERSPECTIVES IN WASTE POLICY**
Chair: **M. Ballard** • Co-Chair: **M. Menegaki**
From Brownfield to Brightfield. Revitalizing and re-powering derelict land in Flanders
E. Wille *(Belgium)*
Interconnectivity and the future of waste management
A. Mavropoulos *(Greece)*
The Zero Waste Concept towards integrated waste management
M. Loizidou *(Greece)*
Development of a Household Waste Recycling Centre Network in Cyprus
A.I. Iacovides *(Cyprus)*
Discussion

Friday, 25 September 2015

09:30-11:15 **Session 4: RECOVERY OF RESOURCES FROM MUNICIPAL SOLID WASTE**
Chair**: T. Wolfsberger** • Co-Chair: **G. Perkoulidis**
Waste management in the Municipality of Polygyros. Current situation and recycling projects
G. Diamantoulakis *(Greece)*
Treatment technologies and recovery of resources from waste in the UK

S. Ford, K. Warren, A. Read *(United Kingdom)*
Technology serving waste valorisation
A. Andreadakis *(Greece)*
Landfill Mining in Polygyros site. Results and discussion
V. Andrea, Z. Gaitanarou, E.N. Makrykosta, S. Sofianos, S. Stasinos, N. Tsigkas *(Greece)*
Recycling packaging materials
I. Razis *(Greece)*
Discussion

11:15-11:45 Coffee break

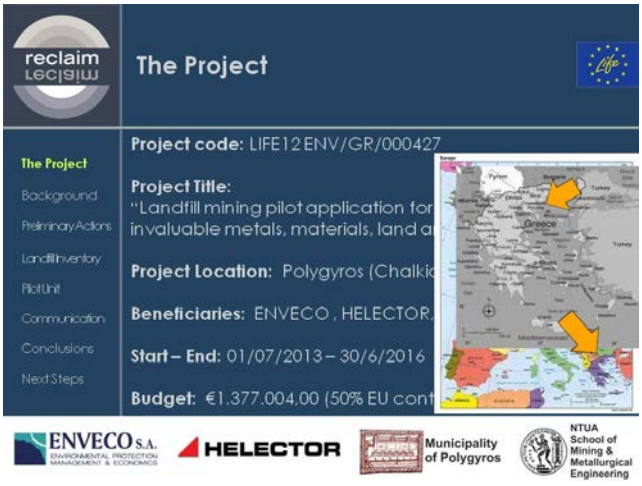
11:45-13:30 **Session 5: LANDFILL MINING: TECHNICAL, ECONOMIC AND ENVIRONMENTAL ISSUES**
Chair: **S. Ford** • Co-Chair: **A. Andreadakis**
Environmental monitoring of the Polygyros Landfill Mining Scheme
A. Benardos, M. Menegaki, D. Damigos, D. Kaliampakos *(Greece)*
Quality and recovery of specific waste fractions from Landfill Mining for material and energy recovery
T. Wolfsberger, R. Sarc, R. Pomberger *(Austria)*
Operation of the pilot demonstration landfill mining unit
D. Choidas *(Greece)*
Local community involvement in complex technological projects: Challenges for long term planning and dealing with uncertainty
K. Sips, M. Craps *(Belgium)*
Landfill mining potential in Spain and review of preliminary experiences
I. Puig-Ventosa, M. Calaf-Forn *(Spain)*
Discussion

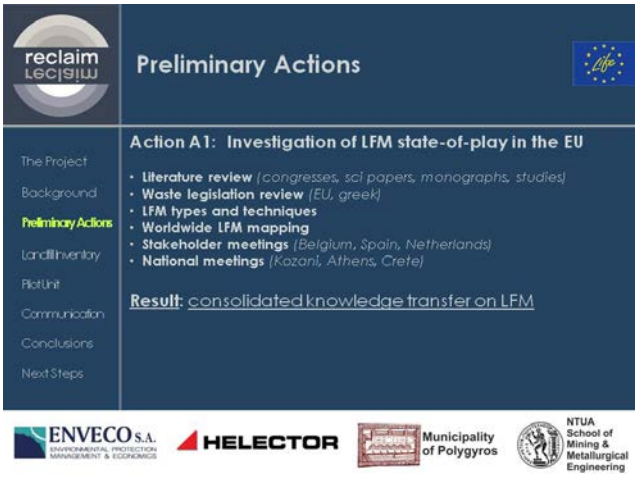
13:30-14:45 Lunch

14:45-16:30 **Session 6: NEW TECHNOLOGIES IN WASTE MANAGEMENT**
Chair: **I. Puig-Ventosa** • Co-Chair: **A. Benardos**
Uncontrolled industrial waste disposal in landfills: Case study in Attica Prefecture
L. Chalarakis, A. Korkolis, S. Kavouri *(Greece)*
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
G. Pantazis, P. Glinos, Ph. Adamopoulou, A. Rydén, G. Taralas, A.A. Zabaniotou *(Greece)*
Using ICT tools for achieving efficient and sustainable waste management, enabling GHG emissions reduction – The example of Life EWAS
A. Anthouli, I. Koukosia, M. Skarvelakis, M. Jofra Sora, I. Garcia Vega *(Greece-Spain)*
Recycling electrical and electronic equipment in Greece
A. Fafoutis *(Greece)*
Discussion

LIFE RECLAIM: A LANDFILL MINING CASE STUDY IN GREECE

` Zoi Gaitanarou






Preliminary Actions
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
Action A2: Permitting of LFM activity in Polygyros LF
• Description of current activity of the PL
• Presentation of existing monitoring results
• Preliminary description of LFM activity
• Submission of permit modification dossier
• Maintain contact with the authorities during permitting
Result: Permit signed 27/3/2014 and issued 2/4/2014
Action A3: Environmental & social baseline for Polygyros area
• Environmental data collection
• Social data collection
• Initial visits & meetings
Result: Technical Report on the Baseline environmental and social conditions
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Landfill Inventory
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
ACTION B1: Creating a landfill inventory to explore the LFM potential of Greece and selected EU countries
• EU Countries: Cyprus, Belgium (Flanders), Spain (Catalonia), Netherlands
• Construction of questionnaire for landfill characteristics
• Communications with national authorities responsible for waste management and with individual facilities (when needed)
•Additional data from national studies
•Data assessment and preparation
•Web-GIS creation: over 22,000 landfill sites were recorded
Result:
Data processed and published online: web-GIS application
Report on the methodology used and findings
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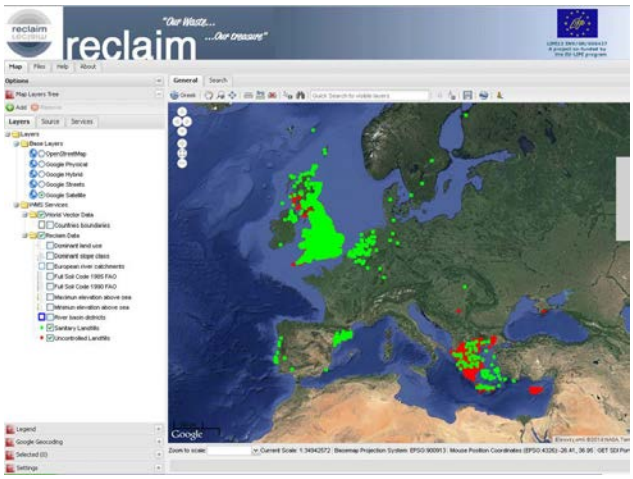
reclaim
"Our Waste... ...Our treasure"
Google


Pilot Demonstration Unit
Design
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
ACTION B2: Exploitation Plan development
• Description of available technologies & methods
• Visits to Polygyros Landfill
• Identification of target areas (waste age & content)
• Mining scheme – resources - operation details
• Environmental Monitoring system proposal
ACTION B3: Design of waste treatment process
• Waste sampling missions (2)
• Waste treatment methods review
• Adaptation of the proposed methods to sampling findings
• Design of the Pilot Demonstration Unit: type of machinery to be used, calculation of productivity and procedure of processing.
• Reporting
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Pilot Demonstration Unit
Installation
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
ACTION B4: Sub-contracting procedures for Demonstration Unit
• Call for tender and final contract on the provision and installation of necessary machinery and equipment
ACTION B5: Pilot-scale Demonstration Unit installation
• Defining roles and responsibilities
• Preparation of location of the Unit: landscaping, drainage system, waterproofing and formation of the space
• Delivery and installation of machinery
• Adjustments on the day-to-day activities
• Creation of a template to record production
• Installation of Environmental Monitoring equipment
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Pilot Demonstration Unit
Operation
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
ACTION B6: MSW mining, Operation and Testing of the Pilot Demonstration Unit
• During May – July 2015
• Extraction of waste with excavators and transportation of waste with tracks to the Unit location
• Regular weighting of inputs and outputs of the Unit
• Waste is fed to the Unit assembly using a backhoe loader
• A Trommel sieve separates smaller waste and soil from larger waste
• Hand-sorting of waste: Hard plastics, plastic bags, aluminum cans, glass, electrical waste
• Magnetic separation
• Other features: Washing Machine, Storage of waste
• Total amount of processed waste: more than 1200c.m. (~ 580tn)
• Beneficiation tests: ex situ (laboratory)
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Pilot Demonstration Unit
Other Actions
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
ACTION B7: Environment Rehabilitation Plan
• Literature review (congresses, sci papers, monographs, studies)
• Selection of alternatives for the Polygyros LF
• Development of tools to ease the selection process of the best option
• Design of a 3D model of a rehabilitation plan
• Reporting: A generalised Manual which can be used in many Landfill Mining cases
ACTION B9: Financial and Socioeconomic Analysis
• Development of a socioeconomic survey questionnaire
• Polygyros local survey (286 local residents)
• National survey: April-July 2015 (392 Greek households)
• Policy and economics analysis tool
• Socioeconomic analysis
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Pilot Demonstration Unit
Next Actions
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
ACTION B8: National Action Plan
• Opportunities, scope and feasibility for Landfill Mining in Greece
• Policy alternatives: description and assessment
• Description of road map for achieving goals
• Assessment of: available means, objective setting, intermediate goals, prioritization, timeline, need for capacity building
• Elaboration of a National Action Plan covering all regions of Greece (excluding islands)
ACTION B10: Strategic Environmental Assessment Study
• Screening phase: Establishing the context of the SEA
• Elaboration of a SEA for the NAP: Scoping phase, Environmental Baseline assessment, consideration of Alternatives, detailed description of the NAP, Impact assessment, Mitigation of Impacts
• Informing Decision Makers
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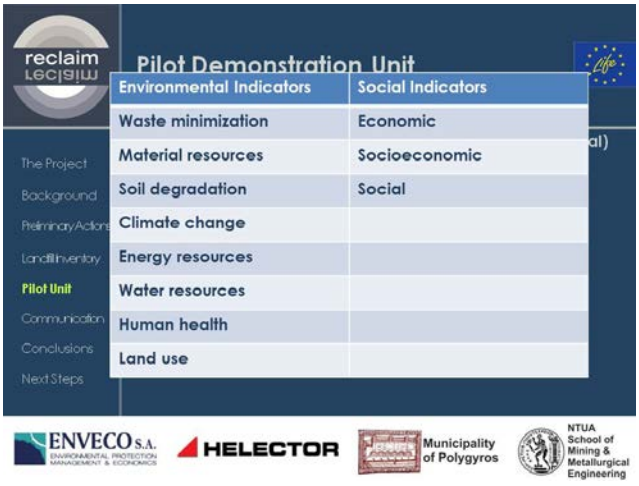
Pilot Demonstration Unit
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
Environmental Indicators
Social Indicators
Waste minimization
Economic
Material resources
Socioeconomic
Soil degradation
Social
Climate change
Energy resources
Water resources
Human health
Land use
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Communication Actions
of the project
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
ACTIONS D1, D2 & D3
• Notice Boards, Posters, Leaflets
• Press releases, newsletters, scientific newsletter
• Social media accounts (linkedIn, facebook)
• Media communication (wide impact magazines, online newspapers and blogs, local TV channels)
• Development of the project's website www.reclaim.gr
• Development of an online FORUM about Landfill Mining
• 1st Local Workshop (15th September 2014)
• 1st National Conference (16th September 2014)
• Participation in EURELCO consortium (European Enhanced Landfill Mining Consortium)
• Athens 2015 International Landfill Mining Conference (24th-25th September 2015)
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Communication Actions
of the project
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
2nd National LFM Conference
(Athens, 7th April 2016)
Papers accepted at life@reclaim.gr
Reclaim Forum: Join the discussion online!
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Conclusions
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
1. Landfill mining is still evolving (technology and process advances)
2. Need for standardisation; not only individual case applications
3. Preparation of Action Plans to solidify the technical and legal framework
4. Involvement of the public sector will affect the Solid waste management at a National level
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Next Steps
of the Project
The Project
Background
Preliminary Actions
Landfill Inventory
Pilot Unit
Communication
Conclusions
Next Steps
• Assessment of the data provided by the Pilot Demonstration Unit
• Rehabilitation manual for Landfill Mining projects
• Financial and Socioeconomic analysis of LFM
• National Action Plan elaboration + SEA study
• Information and Dissemination actions
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THANK YOU FOR YOUR ATTENTION!
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INTRODUCING ECOSYSTEM SERVICES INTO LFM IMPACT ASSESSMENT

F. Giró i Fontanals, M. Madorell i Arbolí

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Athens 2015 International LANDFILL MINING CONFERENCE

Athens, Greece
September 24-25, 2015

Session 1. *LANDFILL MINING: SOCIAL & POLICY ISSUES*

First experiences on Landfill Mining in Catalonia

Francesc Giró, Deputy Director, Waste Agency of Catalonia
Martí Madorell, Head of Disposal Department, Waste Agency of Catalonia

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CONTENT

- GENERAL DATA ON CATALONIA
- WASTE AGENCY OF CATALONIA
- 25 YEARS AGO IN CATALONIA...
- CURRENT SITUATION OF CLASS II LANDFILLS IN CATALONIA (2015)
- CATALAN WASTE MANAGEMENT MODEL
- WASTE MANAGEMENT TOOLS
- LANDFILL MINING
  - LANDFILL MINING. CASE 1. The landfill in Berga
  - LANDFILL MINING. CASE 2. The landfill in Clariana de Cardener

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GENERAL DATA ON CATALONIA

- Surface: 32,000 km²
- Population: 7,500,000 inhab.
- Municipalities: 948
- Regions: 43 small regions
- GDP per inhab.: 27,236 €
- Unemployment: 19.7%

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WASTE AGENCY OF CATALONIA

ARC is a public company within the Department of Planning and Sustainability of the Government of Catalonia.

ARC has some competences (planning, management, inspection, awareness campaigns) on waste generated or managed within Catalonia

- Municipal Waste
- Industrial Waste
- Construction waste and debris
- Waste from agriculture and livestock
- Sanitary waste and
- Soil recovery

www.residus.gencat.cat
https://twitter.com/residuscat
https://www.facebook.com/residuscat
https://www.youtube.com/user/residuscat

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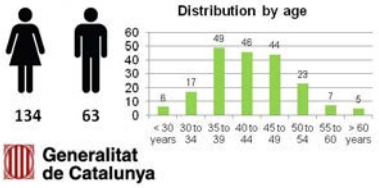
WASTE AGENCY OF CATALONIA



134 63

Profile 197 persons
- Directives: 28
- Technicians: 120
- Administrative: 49

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25 YEARS AGO IN CATALONIA...

Up to 1991:
- Collection of MSW (in mass, mixed MSW)
- Absence of treatment technologies
- Waste were thrown in uncontrolled landfills, which were it were covered or burned
- Near to 2,000 uncontrolled landfills !

View:
- Waste as a hygienic & health problem

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CURRENT SITUATION OF CLASS II LANDFILLS IN CATALONIA (2015)

Controlled Landfills in Catalonia

- With Environmental Permission
- Fulfilling the technical requirements in accordance with the Landfill Directive and Catalan legislation
  - control entrance
  - registration of waste
  - waterproofing
  - sealing
  - collection & treatment of leachates
  - collection & treatment of gases
  - post-closing management (30 years)

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CURRENT SITUATION OF CLASS II LANDFILLS IN CATALONIA (2015)

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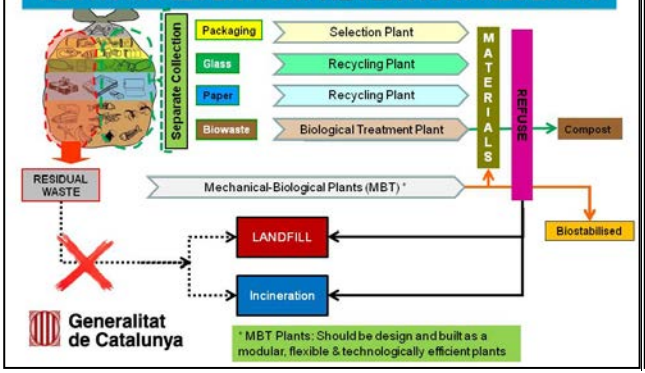
CATALAN WASTE MANAGEMENT MODEL

VENTIONPREVENTIONPREVENTIONPREVENTIO



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* MBT Plants: Should be design and built as a modular, flexible & technologically efficient plants

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WASTE MANAGEMENT TOOLS

- **LEGAL TOOLS**
  - Law on waste (>> MANDATES)
- **ECONOMICAL TOOLS**
  - Law for financing of waste treatment infrastructure and of waste disposal tax (landfilling + incineration) (>> MANDATES)
  - Subsidies for Local Authorities for boosting prevention, separate collection & recycling (specially of biowaste)
- **STRUCTURE TOOLS**
  - Creation of Waste Agency of Catalonia
- **PLANNING TOOLS**
  - Programme for MSW Management (>> TARGETS)
  - Regional Plan of infrastructure for municipal waste management

1 General Target → 10 Strategic Targets → 112 Specific Targets → 149 Actions

[ACT-014]. Development of a pilot project on extraction of material resources and reduction of environment impact through landfill mining techniques.

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LANDFILL MINING

- **But, what we understand by Landfill Mining ?**
  - Landfill Mining (LM) can be considered a process by which wastes which have previously been landfilled are removed and processed. Some of the wastes can be recovered while other not and can be returned to the landfill.
- **Which are the goals of Landfill Mining?**
  - Reduces the amount of waste in the landfill closed
  - Reduces the volume of waste in the landfill closed (which allows to enlarge the life of the landfill)
  - Recovers some valuable recyclable materials (metals, plastic, etc.)
  - Recovers, in some cases, some combustible fraction useful for the generation of power or for generation of methanol or ethanol.
  - Reduces the biogas generation (which in turn contributes to the reduction of climate change)

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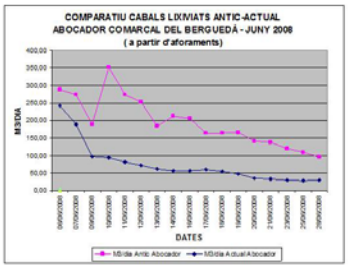
LANDFILL MINING. CASE 1. The landfill in Berga



- **The problem**
  - Generation of great amount of leachates
  - Risk of contamination of groundwater due to leachates

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LANDFILL MINING. CASE 1. The landfill in Berga

- Leachates Transport Cost [9.17 €/m³] : 182,734.20 €
- Leachates Management Cost [29 €/m³] : 597,754.80 €

TOTAL COST: 780,489.00 €

- Some studies conclude that 60 % of leachates comes from the ancient landfill (even when it was closed and sealed).
- The impact of the cost of leachate management in the overall cost of landfill management, according to the waste input in 2010 (17,660 tonnes) was 44.19 € / T
- It was absolutely unbearable

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LANDFILL MINING. CASE 1. The landfill in Berga

- **The solution (summer 2011)**
  - Excavation of the old landfill (approx. 100,000 m³ waste & soil)
  - Transport & deposition of all waste into the new landfill
  - Use of the cover soil of ancient landfill as a covering layer in the new landfill.
- **Positive aspects**
  - Environmental improvement:
    - Reduction of the impact of the "lost" leachate on groundwater
    - Reduction of emissions for leachates transport
  - Saving Money for local authorities
  - Gaining space, if needed, for future expansion of landfill
- **Negative aspects**
  - The current capacity of the new landfill is reduced.
  - The cost of this restoration action was 400,000 € (which was subsidized by ARC)

LANDFILL MINING. CASE 1. The landfill in Berga

LANDFILL MINING. CASE 1. The landfill in Berga

LANDFILL MINING. CASE 1. The landfill in Berga

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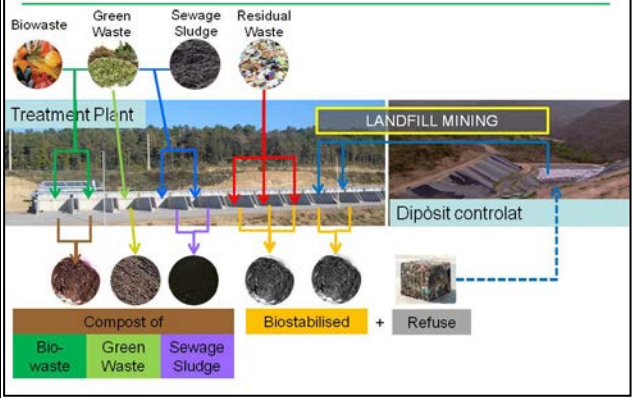
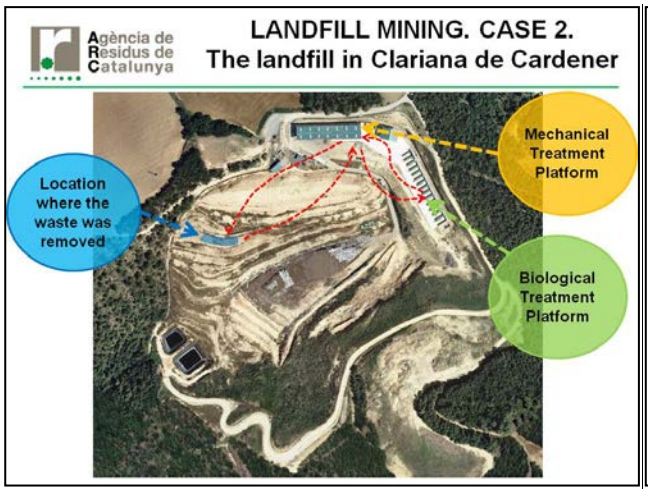
LANDFILL MINING. CASE 2. The landfill in Clariana de Cardener

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LANDFILL MINING. CASE 2.
The landfill in Clariana de Cardener
Location where the waste was removed
Mechanical Treatment Platform
Biological Treatment Platform


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LANDFILL MINING. CASE 2.
The landfill in Clariana de Cardener
Area for compacting waste and production of compacted bales
Area for mechanical treatment (waste shredding, trommel screening, metals extraction)
Area for biological treatment (aeration floor, technical cover, continuous monitoring of biological parameters (temperature and oxygen concentration), collection of leachates, irrigation system


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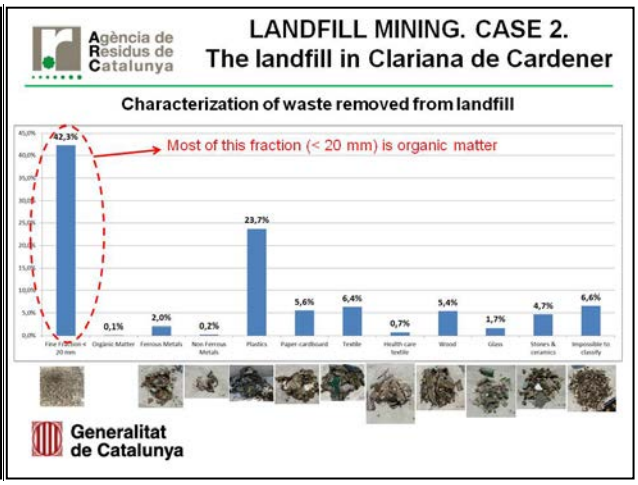
LANDFILL MINING. CASE 2.
The landfill in Clariana de Cardener
Material extraction
Material aspect
Age of material
Emptied space
Biological Treatment
Water content measure
25.7 %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LANDFILL MINING. CASE 2.
The landfill in Clariana de Cardener
Characterization of waste removed from landfill
Most of this fraction (< 20 mm) is organic matter
42,3%
0,1%
2,0%
0,2%
23,7%
5,6%
6,4%
0,7%
5,4%
1,7%
4,7%
6,6%
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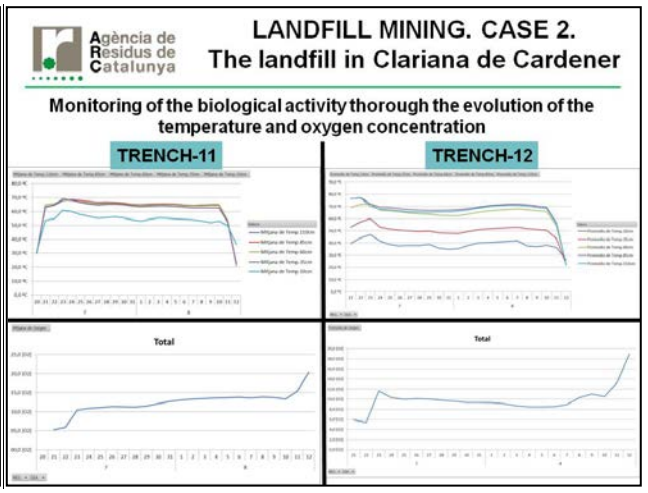
LANDFILL MINING. CASE 2.
The landfill in Clariana de Cardener
Irrigation of material
Irrigation of material
Closing of Trench
Waste characterization
Trench emptying
Loading the truck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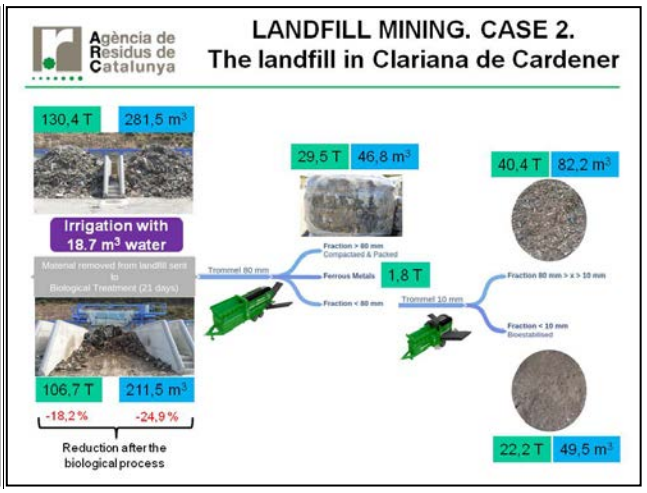
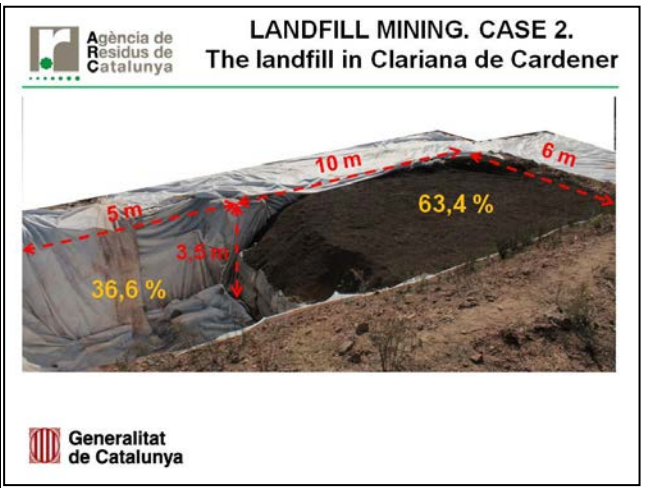
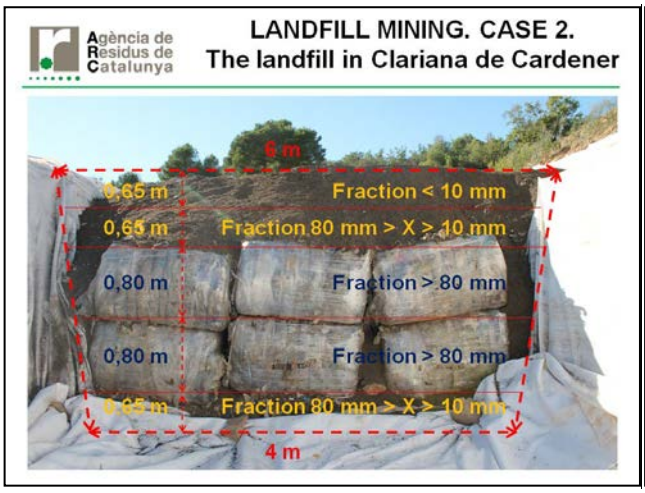
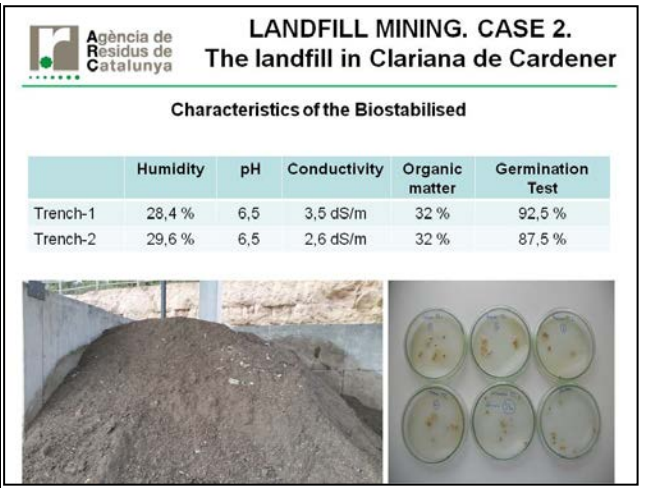
LANDFILL MINING. CASE 2.
The landfill in Clariana de Cardener
Monitoring of the biological activity thorough the evolution of the temperature and oxygen concentration
TRENCH-11
TRENCH-12
Total
Total









	Humidity	pH	Conductivity	Organic matter	Germination Test
Trench-1	28,4 %	6,5	3,5 dS/m	32 %	92,5 %
Trench-2	29,6 %	6,5	2,6 dS/m	32 %	87,5 %

Agència de Residus de Catalunya

LANDFILL MINING. CASE 2. The landfill in Clariana de Cardener

Overall reduction (of weight & volume) after the biological process and the mechanical treatment

	Option A (real)		Option B		Option C	
	Refuse (packed & bulk) and biostabilised are sent to landfill		Refuse (all is packed) and biostabilised are sent to landfill		Only refuse are sent to landfill. Biostabilised is recovered and used into the soil (not for food crops)	
	en Tones	en Volum	en Tones	en Volum	en Tones	en Volum
Refuse Fraction > 80 mm (in bales)	29,5	46,8	29,5	46,8	29,5	46,8
Refuse Fraction 80 mm > x >10 mm	40,4	82,2	40,4	41,9	40,4	41,9
Fraction < 10 mm (Biostabilised)	22,2	49,5	22,2	49,5		
TOTAL	**92,0**	**178,5**	**92,0**	**138,2**	**69,8**	**88,7**
Original amounts & volume of waste removed from landfill	130,4	281,5	130,4	281,5	130,4	281,5
Reduction of weight & volume (in absolute value)	38,4	103,0	38,4	143,3	60,6	192,8
% Reduction in weight & volume	**29,5%**	**36,6%**	**29,5%**	**50,9%**	**46,5%**	**68,5%**

Recovery Rate of Ferrous Metal Fraction

	Weight (T)
Ferrous Metal Fraction	1,8
Recovery Rate of Ferrous Metal Fraction	**70,2%**

Generalitat de Catalunya

Agència de Residus de Catalunya

LANDFILL MINING. CASE 2. The landfill in Clariana de Cardener

- **CONCLUSIONS (1/2)**
  - Landfill Mining (LM) allows to reduce the environmental impact (greenhouse gas emissions, organic content of the leachate, nuisance) generated by the waste that had been landfilled
  - LM implies the volume reduction of waste (36% and probably 50%) which in turn allows to extend the life of the landfill,
    - Leading to significant economic savings
      - In Catalonia, taking into account 40,000,000 m^3 of waste landfilled
      - If we reduce about 40 % of volume occupied by waste
      - **We would get back a new volume** (with permission) **of 16,000,000 m^3 (equivalent to 12,800,000 tonnes** if we consider a density of 0,8 t/ m^3)
      - If Catalonia is sending currently 1,500,000 tonnes of waste per year
      - **It represents an additional available capacity for more than 8 years**
      - **And a saving of 160,000,000 €** (if we consider an average cost of landfill enlargement of about 10 €/ m^3) **or 20,000,000 € per year**.

Agència de Residus de Catalunya

LANDFILL MINING. CASE 2. The landfill in Clariana de Cardener

- **CONCLUSIONS (2/2)**
  - reducing the administrative burden of promoting new landfills or the enlargement of existing landfills
  - reducing the social impact (NIMBY)
  - LM lets to recover material resources that were landfilled
    - in our case only ferrous metals (70% recovery rate)
    - in other cases also non-ferrous metals and all kind of plastics that are used as a source of energy or for obtaining methanol / ethanol
    - In some cases, also biostabilised for soils that don't produce food (gardens, civil works, etc.)

Agència de Residus de Catalunya

Σας ευχαριστώ πολύ

Moltes Gràcies

Generalitat de Catalunya

INTRODUCING ECOSYSTEM SERVICES INTO LFM IMPACT ASSESSMENT

G. Tentes, D. Damigos

Introducing ecosystem services into LFM impact assessment

G. Tentes and D. Damigos
National Technical University of Athens, Athens, Greece

Ecosystem Services

"…are benefits provided by the natural environment to human society and include, for example, food and water provision, flood control, purification of water, recreational and cultural benefits, soil formation, nutrient cycling, etc …"

Why Ecosystem Services?

ES concept…..

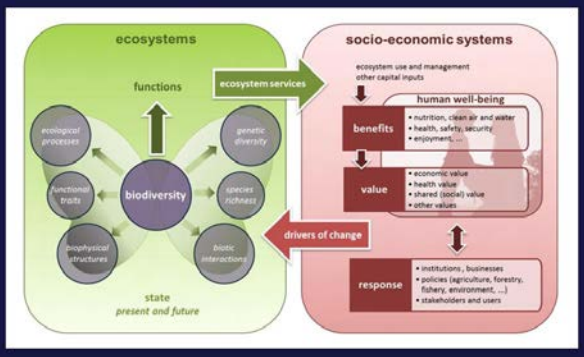
- describes some of the ways humans are linked to and depend on nature
- reveals that the environment is a social asset that should be preserved under increasing scarcity conditions
- Emphasizes the importance of economic benefits of certain habitats and land cover types

ES and environmental policy

ES concept is becoming an important component of mainstream environmental decision making:

- Convention on Biological Diversity's voluntary guidelines on including biodiversity and ES in EIA (2006)
- OECD's recommendations on how to include ES in SEA (2008)
- IPIECA/OGP's guidelines for considering ES for oil and gas developments (2011)
- UNEP's "Project for Ecosystem Services" (ProEcoServ) (2014)
- World Resources Institute's guidance framework "Ecosystem Services Review (ESR) for Impact Assessment (IA)" (2011 & 2014)

EU wide ecosystem assessment



ES in practice

ES framework provides….

- an effective framing of the environment in terms of communicating with and influencing stakeholders and decision makers
- a more complete, holistic and integrated consideration of the socio-ecological system

Yet…

- EIA practitioners have not been engaged, so far
- ES definitions are still confusing is some services

Ecosystem Services Classification Systems

ES Classification systems

- Millennium Ecosystem Assessment (MA)
- The Economics of Ecosystems and Biodiversity framework (TEEB)
- Common International Classification of Ecosystem Services (CICES)
- Classifications by individual researchers

Overview of classification

ES	MA	TEEB	CICES
Provisioning	o	o	o
Regulating (& maintenance)	o	o	o
Cultural (& amenity)	o	o	o
Supporting	o	-	-
Habitat	-	o	-
Sub-groups	-	-	o

ES classification systems

ES classification systems-MA

MA distinguishes four categories of ecosystem services:

- provisioning services (i.e., goods or products obtained from ecosystems)
- regulating services (i.e., contributions to human well-being arising from an ecosystem's control of natural processes)
- cultural services (i.e. recreation, aesthetic enjoyment, etc)
- supporting services (i.e. natural processes, such as nutrient cycling and primary production that maintain the other services), which are regarded as the basis for all the other services

ES classification systems-TEEB

TEEB proposes a typology of 22 ES divided in four main categories, following mainly the MA classification:

- provisioning services
- regulating services
- habitat services
- cultural and amenity services

TEEB omits supporting services, which are seen as a subset of ecological processes. Habitat services are identified as a separate category to highlight the importance of ecosystems to provide habitat for species and gene-pool "protectors".

ES classification systems-CICES

CICES refined MA framework to reflect some of the key issues discussed in the wider research literature and is more explicitly hierarchical at the highest level there are three familiar services used in MA called 'Sections':

- provisioning
- regulating and maintenance
- cultural

CICES excludes supporting services to avoid the problem of 'double counting' if ecosystem and economic accounts are to be linked.

Below these Sections a series of 'Divisions', 'Groups' and 'Classes' are nested

Use of Ecosystem Services approach

ES, Mining, Landfills and LFM

- The use of ES approach in EIA literature is limited
- Potential uses of the ES approach are related to differential changes in ES provision:
  - during ex ante impact assessment
  - for creation of Net Positive Impacts during operation
  - for optimization of after mine closure and rehabilitation
  - during design and operation of a LFM project

Tools for introducing ES approach

- **Correspondence between 'classic' impacts and ES changes**
  - Various attempts so far
  - Many impacts do not correspond to ES provision changes
  - Many ES have not been taken into account
- **Use of technical indicators for each ES**
  - First EU approach through MAES *(mapping & assessment of ES)*
  - Still many gaps and doubts
- **Economic valuation of ES differentiation**
  - Monetization of changes
  - Connection with financial valuations (social CBA analysis)

Landfill Mining

Landfill mining project

- Indicators for assessing the condition and biodiversity of the ecosystems
  - Forest land
  - Cropland & grassland
  - Rivers & lakes
  - Wetlands
  - Transitional waters and marine inlets
  - Coasts, shelves and ocean
- Indicators for assessing ecosystems services
  - Agro-ecosystems
  - Forest-ecosystems
  - Water-ecosystems
  - Marine-ecosystems

Landfill mining projects

Indicators for assessing ecosystems services	Controlled LF	Un-Controlled LF
Cultivated crops (area / yield)		
Reared animals and their outputs (livestock)		
Wild plants, algae and their outputs (wild berries)		
Wild animals and there outputs (populations)		
Plants and algae from in-situ aquaculture		
Animals from in-situ aquaculture (production)		
Water /nutrition (abstraction)		
Biomass /materials (area, yield, timber production)		
Water /materials (abstraction)		
Plant-based resources (fuel wood)		
Animal-based resources		
Animal-based energy		
Mediation of waste, toxics and other (area, nutrients)		
Mass stabilisation and control of erosion rates (risk)		
Buffering and attenuation of mass flows		
Hydrological cycle & water flow maintenance		
Flood protection (areas at risk)		

Landfill mining projects

Indicators for assessing ecosystems services	Controlled LF	Un-Controlled LF
Storm protection		
Ventilation and transpiration (biomass amounts)		
Pollination and seed dispersal (potential)		
Maintaining nursery populations and habitats (High Nature Value farmland)		
Pest and disease control		
Weathering processes (organic farming, soil properties)		
Decomposition and fixing processes (area N-fixing crops)		
Chemical condition of freshwaters (chemical status)		
Chemical condition of salt waters		
Global climate regulation by reduction of greenhouse gas concentrations (carbon storage/sequestration)		
Micro and regional climate regulation (forest area)		
Physical and experiential interactions (visitor statistics)		
Intellectual and representative interactions		
Spiritual and/or emblematic		
Other cultural outputs (protected areas extent)		

Landfill mining projects

- Overall positive picture
  - 32 categories
  - 9 positive impacts
  - 11 potentially positive (depends on land use)
- Carbon sequestration is a grey area
  - Pros: soil sequestration, energy consumption
  - Cons: circulation of organic materials, required processes
- Nuisances to humans during LFM processes not included in the assessment
- Indicators that cannot (yet) be addressed with existing data have not been included

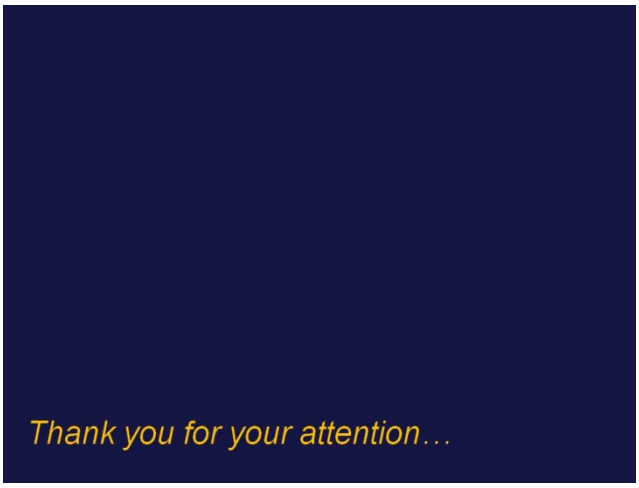
So, how do we plan policies?

Planning policies

- Ecosystem services provision changes are useful to understand and communicate negative and positive impact assessment
- Ecosystem services provision changes cannot always be monetized (yet), and we need more research
- ES indicators provide reasonable ground for the optimization of the LFM objectives and processes
- Impacts on manmade environment should be also put into perspective within this framework
- A national plan (at the strategic level) should not fail to analyze these aspects.

Concluding remarks

- ES approach is particularly relevant at the Strategic Impact Assessment level
- To improve this situation, a more consolidated methodological framework will have to be established based more on globally standardized classifications
- Scientists and practitioners involved in LFM should become more familiar with the concept of ES because it becomes mainstream in several standards and legislations, but also because it may help in successful conflict management


Thank you for your attention…

WHAT DO PEOPLE BELIEVE ABOUT LANDFILL MINING?

D. Damigos, M. Menegaki & D. Kaliampakos, G. Diamantoulakis & V. Chorinos

What do people believe about landfill mining?

D. Damigos, M. Menegaki & D. Kaliampakos
National Technical University of Athens, Athens, Greece
G. Diamantoulakis & V. Chorinos
Polygyros Municipality, Polygyros, Greece

Waste management

- Despite the emerging attention towards promoting 3R waste management policies (Reduce, Reuse, Recycle), landfilling remains the dominant waste management practice in many parts of the world
- Under the pressure of resources deficiencies and environmental challenges, certain steps have been taken to encourage integrated waste and materials management policies

Towards LFM concept

- The exploitation of old and existing municipal solid waste landfills via landfill mining (LFM) may be a promising solution in order to:
  - conserve landfill space
  - reduce the need for new landfill areas
  - eliminate potential contamination sources
  - recover energy from mined waste
  - reuse recovered materials
  - redevelop landfill sites

LFM benefits

LFM projects could….

- create economic opportunities from recovered materials, landfill space and land
- generate social benefits through reduced impacts, provision of secondary raw materials from recycling, job creation, etc.

However…

- recovery of materials and energy resources alone seldom seem to economically justify LFM projects
- LFM like any other economic activity, has to be economically feasible; otherwise it will never be implemented

Improved decision-making processes

- Private costs and benefits alone cannot reflect the true social worth of LFM projects
- Environmental and social benefits should be taken into account to come up with more informed and fair social choices

This means that we need to…

- identify the ways in which LFM projects affect human well-being and
- estimate the total economic value of these changes through appropriate valuation techniques

Total economic value

- The monetary measure of the change in society's well-being from a change in the quality of life is based on its Total Economic Value
- Use values:
  - direct use values (i.e. actual use of an environmental good or service for commercial purposes or recreation)
  - indirect use values (i.e. benefits from ecosystem services and functions rather than directly using them)
  - option values (i.e. value of ensuring the option to use a resource in the future)
- Non-use values include altruistic, bequest and stewardship motivations, reflecting the fact that people value resources for moral reasons, unrelated to current or future use

Scope of the survey

The present survey aims for the first time in Greece:

- to investigate people's knowledge and attitude about existing MSW management practices
- to understand people's beliefs about LFM and its perceived benefits
- to estimate people's support and their WTP for LFM projects

The survey was carried out between April and June 2015 involving residents of the Polygyros municipality. In total 286 questionnaires were collected via personal interviews and the response rate was around 70%

Methodological approach - The CVM

- 'Contingent Valuation', because valuation is contingent on the hypothetical scenario put to respondents
- It is a direct (stated preference) valuation method, i.e. it involves directly asking people how much they would be WTP or WTA for a utility change through a survey
- It is the most frequently and widely applied stated preference valuation technique – It has been in use for over 40 years in over 100 countries

CVM: Criticisms

- Respondents may fail to take payment seriously because they are non-binding or may manipulate the process by distorting their true WTP (i.e. strategic bias)
- Respondents do not understand what they are being asked to value (i.e. information bias)
- WTP-WTA estimates may be inconsistent (i.e. WTP and WTA disparity)
- Validity (i.e. 'accuracy') and reliability (i.e. 'consistency' or 'reproducibility') of estimates, etc.

CVM: Advantages

- The only method available, together with Choice Experiments, for capturing non-use values
- It is consistent with the theoretically framework of monetary measures of utility changes
- It is applicable to ex ante situations
- It is widely used through regulations by agencies with environmental responsibilities for natural resource damage assessments and policy evaluations

Main findings…

Survey results

- About 70% of the respondents state that they have seen, heard, or read about solid waste management (SWM) issues from internet, TV, radio, newspapers, magazines, etc., a few times and 6% many times. About 22% of them have never heard anything about SWM
- SWM problem is of equal importance to other environmental issues in their area, for the vast majority of the respondents (i.e. around 90%)

Survey results

- Almost all (i.e. more than 96.5%) believe that the uncontrolled waste disposal is associated with significant problems
- Almost four-fifth of the respondents believe that controlled landfills create less significant problems than the uncontrolled ones, while the rest say that the problems are of equal importance
- More than 70% of the respondents recognize water pollution as the most important disposal related problem, followed by soil pollution (9%), air pollution (6%), and global warming (4%) and deforestation (4%)

LFM benefits

Respondents were asked to evaluate the importance of LFM according to their opinion focusing on three fields:

- about 67% of the respondents characterize the benefits of resource and energy conservation as 'very important' and 26% as 'moderate important'
- about 21% of the respondents characterize the benefits of prevention and reduction of environmental pollution and nuisance as 'very important' and 69% as 'moderate important'
- about 22% of the respondents characterize the benefits of conservation of landfill space as 'very important' and 45% as 'moderate important'

Support for LFM projects

To investigate public support for LFM projects, respondents were asked to state which the following sentences best reflects their thinking:

- "I feel that there should be a LFM program, and I feel some responsibility for paying for it": 18.2%
- "I feel that there should be a LFM program, but I do not really feel that it is my responsibility to pay for it":77.3%
- "I don't think there should be a LFM program": 4.5%

In total, more than 95% of the respondents feel that there should be a LFM program

Support for LFM projects

- Average WTP amount for positive bids (excluding zero responses): 50€ per household per year in increased municipal taxes
- Average WTP amount for the entire sample (including zero responses): 12€ per household per year in increased municipal taxes

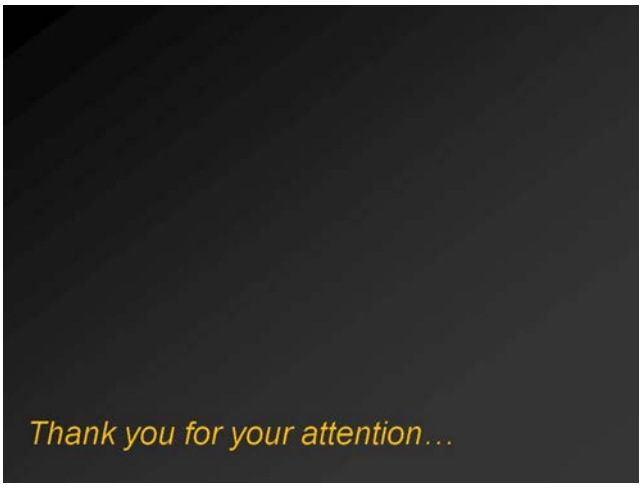
Support for LFM projects

- The respondents' attitude towards their financial responsibility is associated with the current economic situation in Greece
- More than 50% of the respondents said that they couldn't afford it due to low income
- About 95% of the respondents declared annual household income lower than 30,000€ and three-fourths of the respondents lower than 20,000€
- 'Unemployment' and 'poor economy' are mentioned as the most important problem by more than 85% of the respondents

Concluding remarks

- Although waste management policies, worldwide, aim at adopting a more environmentally-friendly and resource conserving hierarchy, waste disposal still remains the most common MSW practice
- As a means to reduce environmental impacts and conserve natural resources, LFM could be implemented provided that economic feasibility is ensured, not only from a private but also from a social point of view
- The most significant benefits of LFM are related to resource and energy conservation, followed by prevention and reduction of environmental pollution and nuisance, and the conservation of landfill space


Concluding remarks
• LFM receives wide acceptance from the society, as more than 95% of the respondents feel that there should be a LFM program
• About three-fourths of the respondents rejected to pay in order to financially support LFM programs
• This attitude is associated primarily with the current economic situation, and should not be considered representative of the beliefs of the society. In other words, society's WTP for LFM programs could be much higher under different economic conditions


Thank you for your attention…

DEVELOPMENT OF A LANDFILL MINING POLICY IN FLANDERS (BELGIUM)

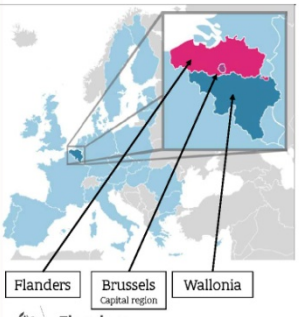
E. Wille

Outline of the presentation

- Introduction to Flanders and OVAM
- Waste management and landfills in Flanders
- Frameworks and trends
- Transition from Waste to Sustainable Resource Management
- ELFM²: Enhanced Landfill Management & Mining

Flanders State of the Art 23/09/2015 | 2 TOGETHER WE MAKE TOMORROW MORE BEAUTIFUL OVAM

Flanders



General information :

- Population : 6,4 M inhabitants
- Surface : 13.599 Km²
- Densely populated : 472 inhab./Km²
- Highly industrialised
- Regional policies
- Important harbours (nexus to Germany)
- Limited natural resources

"One of the virtues of Belgium is that its tininess allows you to be anywhere else within an hour or two. It takes a while to get used to the idea that the whole country is effectively a suburb of Brussels."

From: Neither here nor there - Bill Bryson, p.78

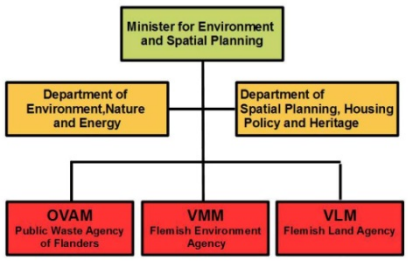
Flanders State of the Art 23/09/2015 | 3 TOGETHER WE MAKE TOMORROW MORE BEAUTIFUL OVAM

OVAM

- Public Waste Agency of Flanders
- Environmental Agency headed by the Flemish Minister of Environmental Affairs
- Established in 1981 (State reform of 1980)
- Competent Authority for:
  - Waste Management;
  - Sustainable Material Management;
  - Soil Remediation.
- Staff: approx. 310 FTE
- Offices : Mechelen – Belgium
- www.ovam.be

Flanders State of the Art 23/09/2015 | 4 TOGETHER WE MAKE TOMORROW MORE BEAUTIFUL OVAM

OVAM in the environmental policy arena



23/09/2015

Tasks of OVAM

To prepare legislation, implement and supervise the implementation of the Flemish legislation on waste management and soil remediation:

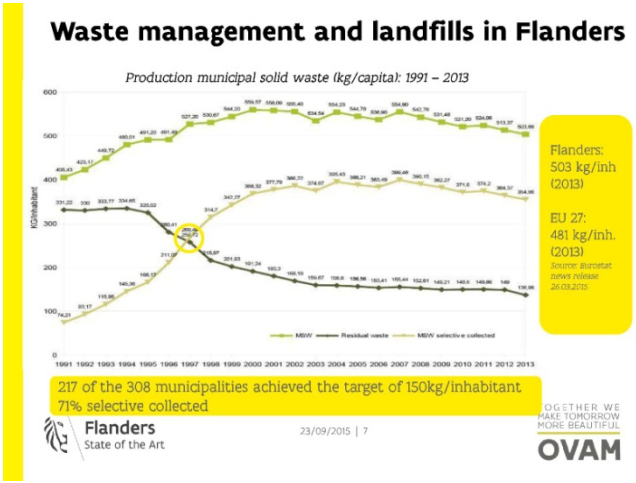
- Waste management Act (1981)
- Soil remediation Act (1996)
- Material Management Act (2011)
- ... 2026 ?

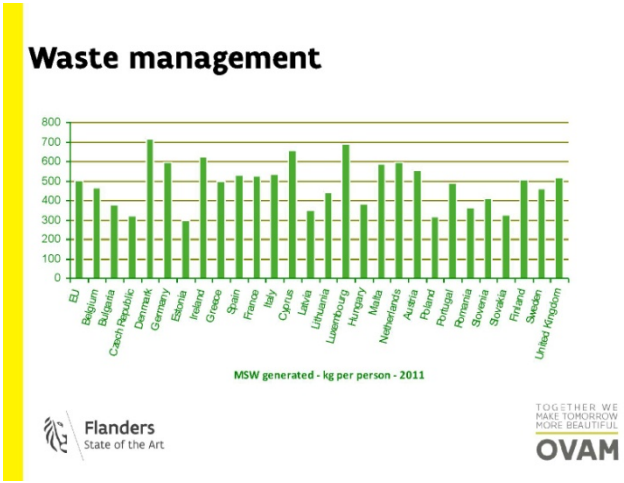
The overall goal is to contribute to a **better environment and quality of life** by:

- ensuring sustainable management of **waste** and **materials**
- preventing **soil contamination** and ensuring **soil remediation**

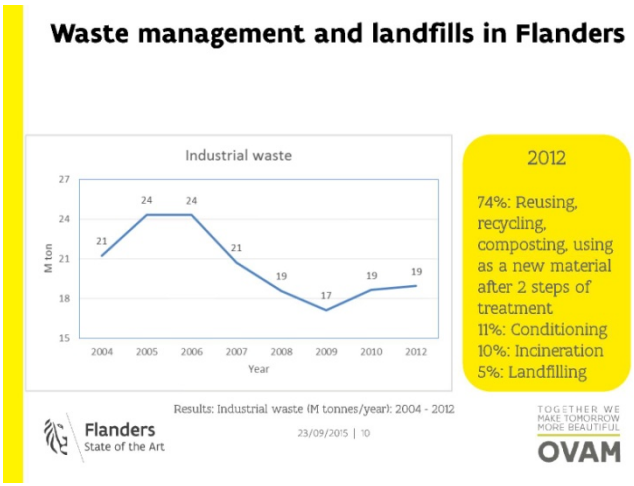
EU : Acts (Directives) on waste, landfills; not on soil contamination /remediation
USA : Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
EPA-mission : to protect human health and the environment

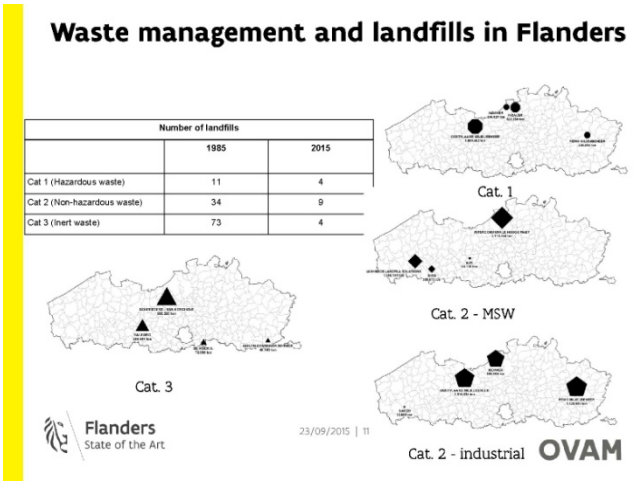
23/09/2015


Waste management and landfills in Flanders
Production municipal solid waste (kg/capita): 1991 – 2013
Flanders: 503 kg/inh (2013)
EU 27: 481 kg/inh. (2013)
217 of the 308 municipalities achieved the target of 150kg/inhabitant
71% selective collected
Flanders State of the Art
23/09/2015 | 7
OVAM


Waste management
MSW generated - kg per person - 2011
Flanders State of the Art
OVAM


Waste management and landfills in Flanders
Household waste per inhabitant of Flanders
2007
2013
555 KG
503 KG
How much food are we wasting?
How is residual household waste processed?
950,000 TONNES
92%
7%
1%


Waste management and landfills in Flanders
Industrial waste
M ton
Year
2012
74%: Reusing, recycling, composting, using as a new material after 2 steps of treatment
11%: Conditioning
10%: Incineration
5%: Landfilling
Results: Industrial waste (M tonnes/year): 2004 - 2012
Flanders State of the Art
23/09/2015 | 10
OVAM


Waste management and landfills in Flanders
Number of landfills
1985
2015
Cat 1 (Hazardous waste) 11 4
Cat 2 (Non-hazardous waste) 34 9
Cat 3 (Inert waste) 73 4
Cat. 1
Cat. 2 - MSW
Cat. 3
Cat. 2 - industrial
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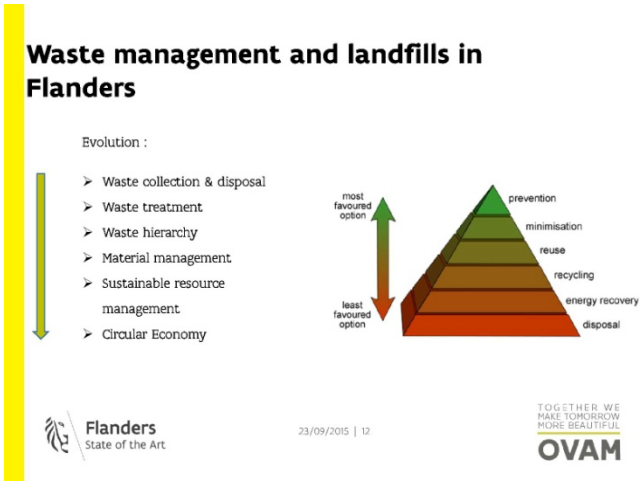
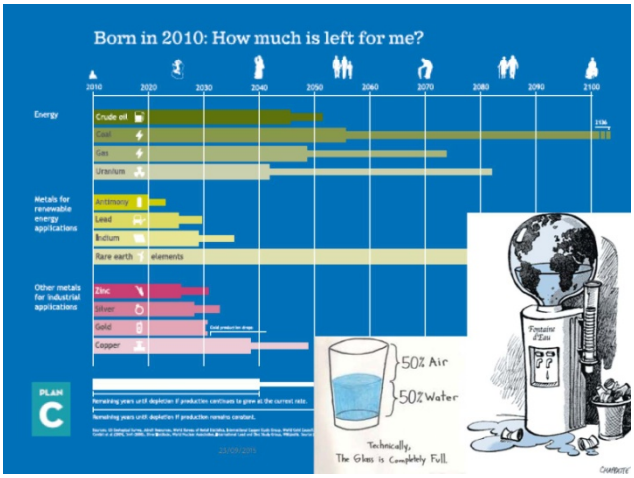
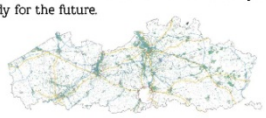
OVAM


Waste management and landfills in Flanders
Evolution :
Waste collection & disposal
Waste treatment
Waste hierarchy
Material management
Sustainable resource management
Circular Economy
most favoured option
least favoured option
prevention
minimisation
reuse
recycling
energy recovery
disposal
Flanders State of the Art
23/09/2015 | 12
OVAM



Frameworks and trends

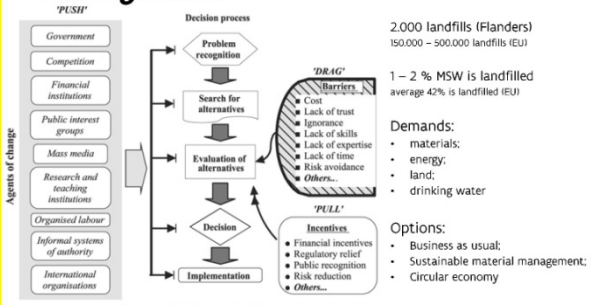
Increase of urban areas in Flanders: in total 7 ha/day; 5 ha/day transformed in residential landuse. Simulation made by Vito for the period 2010 – 2050 shows the impact of urbanisation in Flanders. According to the Planning Agency: population will rise significantly and assessments indicate the need of over 630.000 new dwellings by 2050.
'Ageing cities' is not limited to its inhabitants; infrastructure also requires retrofitting to become more sustainable and ready for the future.



Flanders State of the Art

TOGETHER WE MAKE TOMORROW MORE BEAUTIFUL
OVAM

Transition from Waste to Material Management



2.000 landfills (Flanders)
150.000 – 500.000 landfills (EU)

1 – 2 % MSW is landfilled
average 42% is landfilled (EU)

Demands:
- materials;
- energy;
- land;
- drinking water

Options:
- Business as usual;
- Sustainable material management;
- Circular economy

Decision-making framework (Adapted from Yap 1988)

Flanders State of the Art

23/09/2015 | 15

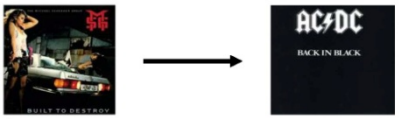
TOGETHER WE MAKE TOMORROW MORE BEAUTIFUL
OVAM

Transition from Waste to Material Management

Our Goals for a Sustainable Material Management :

- Closing material loops as efficient as possible : circular economy
- Eco-efficient production
- Innovation & Ecodesign
- Stimulate 'Green Consumption'
- Order in own house : green procurement

Transition : Cradle to grave → Cradle to cradle



Flanders State of the Art

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TOGETHER WE MAKE TOMORROW MORE BEAUTIFUL
OVAM

Transition from Waste to Material Management

Policy Instruments :

The implementation of the waste policy and strategy requires the use of three different types of policy instruments

- **legal** instruments (e.g. legislation, penalties, producers responsibility, voluntary agreement, etc ...)
- **economical** instruments (e.g. levies, taxes, financial support)
- **social** instruments (e.g. information and awareness raising campaigns, education programs at schools, etc ...)

The challenge is to find the most appropriate instrument or mix of policy instruments to achieve the targets

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ELFM – part 1

Policy development & Enhanced Landfill Mining in Flanders :

- OVAM Board of directors (2nd of December 2011). ELFM-research programme 2012 - 2015 approved.
- Government of Flanders Policy agreement 2014-2019. In the approved vision the aspects of circular economy, recycling of landfills and brownfield redevelopment were also confirmed as important policy goals.
- The Policy memorandum of the Minister of Environment (approved on 23rd of October 2014). This memorandum identifies the key strategic choices of her policy for the term of office (2014-2019). The issue of Landfill mining is clearly addressed in this memo and the Minister engaged herself to implement a vision on ELFM as well as on the sustainable stock management of (former) landfills.
- Vision 2050: a long-term strategy for Flanders (approved by Flemish government on 18th of September 2015). Transition to a circular economy and defining the role of landfills and ELFM.

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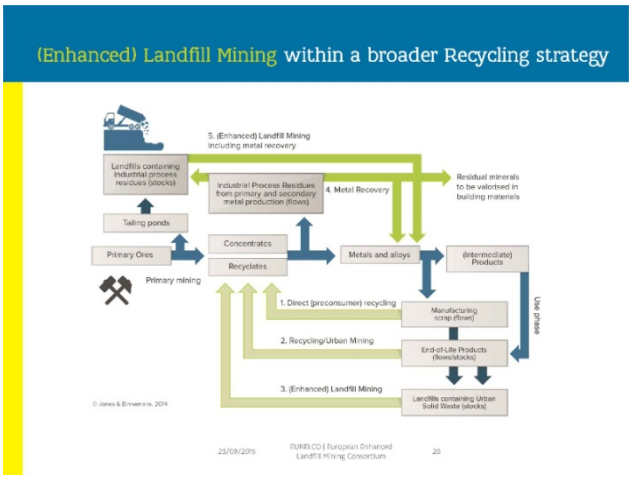
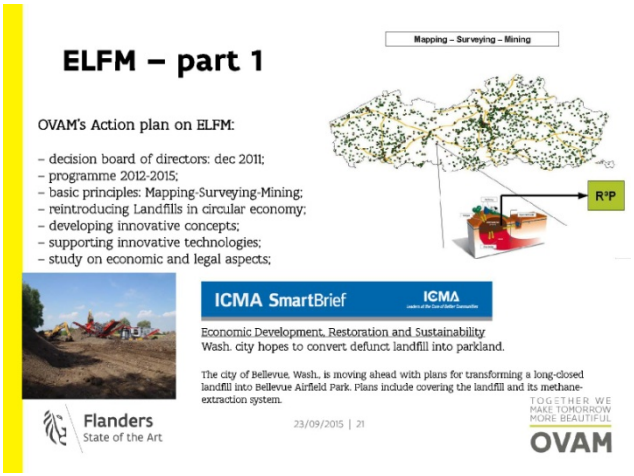
Definition ELFM:
Flemish ELFM-Consortium
Enhanced Landfill Mining =
"the safe conditioning, excavation and integrated valorization of (historic and/or future) landfilled waste streams as both materials (Waste-to-Material) and energy (Waste-to-Energy), using innovative transformation technologies and respecting the most stringent social and ecological criteria."
Enhanced Landfill Mining in view of multiple resource recovery: a critical review
23/09/2015
EURELCO | European Enhanced Landfill Mining Consortium
19


(Enhanced) Landfill Mining within a broader Recycling strategy
5. (Enhanced) Landfill Mining including metal recovery
Landfills containing industrial process residues (stocks)
Industrial Process Residues from primary and secondary metal production (flows)
4. Metal Recovery
Residual minerals to be valorised in building materials
Tailing ponds
Primary Ores
Concentrates
Recyclates
Metals and alloys
(Intermediate) Products
Primary mining
1. Direct (preconsumer) recycling
Manufacturing scrap (flows)
2. Recycling/Urban Mining
End-of-Life Products (flows/stocks)
Use phase
3. (Enhanced) Landfill Mining
Landfills containing Urban Solid Waste (stocks)
© Jones & Brunsmans, 2014
23/09/2015
EURELCO | European Enhanced Landfill Mining Consortium
20


ELFM – part 1
Mapping – Surveying – Mining
OVAM's Action plan on ELFM:
– decision board of directors: dec 2011;
– programme 2012-2015;
– basic principles: Mapping-Surveying-Mining;
– reintroducing Landfills in circular economy;
– developing innovative concepts;
– supporting innovative technologies;
– study on economic and legal aspects;
R³P
ICMA SmartBrief
ICMA
Economic Development, Restoration and Sustainability
Wash. city hopes to convert defunct landfill into parkland.
The city of Bellevue, Wash., is moving ahead with plans for transforming a long-closed landfill into Bellevue Airfield Park. Plans include covering the landfill and its methane-extraction system.
Flanders
State of the Art
23/09/2015 | 21
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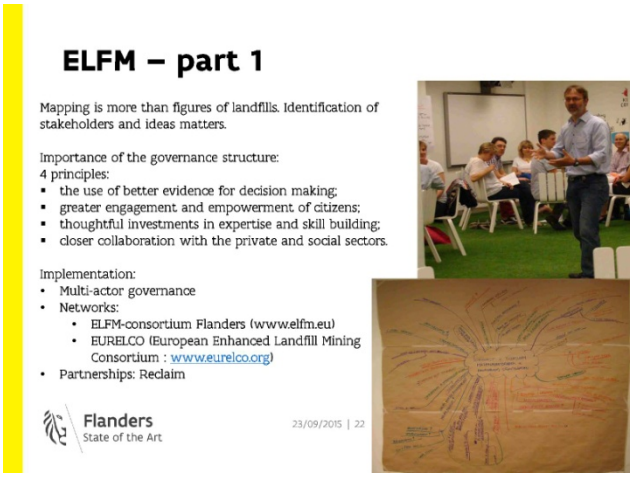
ELFM – part 1
Mapping is more than figures of landfills. Identification of stakeholders and ideas matters.
Importance of the governance structure:
4 principles:
▪ the use of better evidence for decision making;
▪ greater engagement and empowerment of citizens;
▪ thoughtful investments in expertise and skill building;
▪ closer collaboration with the private and social sectors.
Implementation:
• Multi-actor governance
• Networks:
▪ ELFM-consortium Flanders (www.elfm.eu)
▪ EURELCO (European Enhanced Landfill Mining Consortium : www.eurelco.org)
• Partnerships: Reclaim
Flanders
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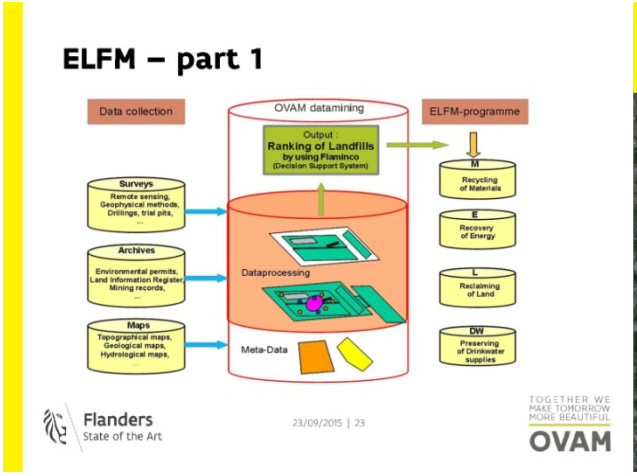
23/09/2015 | 22


ELFM – part 1
Data collection
OVAM datamining
ELFM-programme
Output
Ranking of Landfills
by using Flaminco
(Decision Support System)
Surveys
Remote sensing, Geophysical methods, Drillings, trial pits, ...
Archives
Environmental permits, Land Information Register, Mining records, ...
Maps
Topographical maps, Geological maps, Hydrological maps, ...
Dataprocessing
Meta-Data
M
Recycling of Materials
E
Recovery of Energy
L
Reclaiming of Land
DW
Preserving of Drinkwater supplies
Flanders
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23/09/2015 | 23
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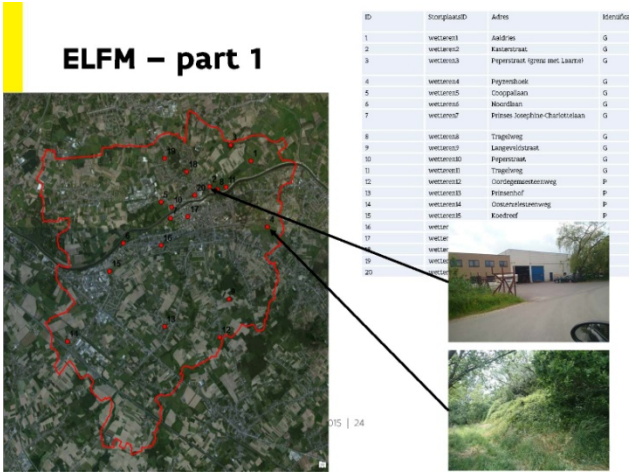
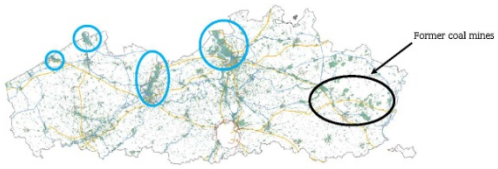

ELFM – part 1

ELFM - part 1



Land Information Register (OVAM) :

- Approx. ca. 34.000 locations investigated; approx. 2.700 remediations completed;
- Estimated risk locations : 85.000 (12.000 sites potentially require remedial actions);
- Links to industrial axes, harbours, mining areas.

Flanders State of the Art

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ELFM - part 1

Potentially contaminated sites in EU

Estimated number of landfills:

Flanders : 2.000

EU : 150.000 – 500.000 (Hogland)
(100.000 municipalities in EU)

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ELFM – part 1

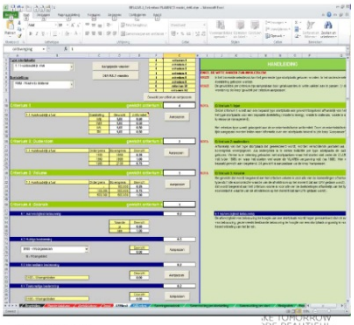
Flaminco (Flanders Landfill Mining, Challenges & Opportunities):
decision support system to manage landfills in a sustainable way.

2 main components:

- Mining potential;
- Potential environmental impact.

6 criteria to determine ELFM-potential:

- Type of landfill
- Period of landfilling
- Volume of landfill
- Land use of landfill
- Distance to transport modi (roads, waterway, railway)
- Proximity of other landfills



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ELFM – part 1

Surveying:
detailed investigation of the individual landfill site in order to assess the feasibility of ELFM (detailed identification of the landfill: composition of the landfilled waste, identification of the geophysical conditions and -chemical characteristics of the surroundings of the landfill site)

2 case studies at Municipal Waste Disposal sites
Case 1 : 1960s – 1970s; 2,55 ha; average thickness 1,5m
Case 2 : 1970s- 1987; 7 ha; average thickness 10m

University of Ghent tested 5 geophysical methods:

- Electromagnetical induction
- Magnetic method
- Electrical resistivity tomography (ERT)
- Ground Penetrating Radar (GPR)
- Seismic refraction

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Reclaim conference - Thessaloniki 16.09.2014

ELFM – part 1

Mining:
Valorization of the landfill: (pre)treatment of the waste to make it suitable for material reuse or valorization, extracting the waste (in situ/ex situ), valorizing the resources, reclaiming land, eliminating risks and aftercare.

Resources	Extraction method	Products	Pilot
Waste to Materials	Ex situ excavation	Several	Zuienkerke
	Ex situ excavation	Coal	Zwartberg
	Ex situ excavation	FeCl3	confidential
	In situ leaching	Sulphur	confidential
Waste to Energy	Ex situ excavation	RDF	Zuienkerke
	In situ gas extraction	Methane	Several projects
	In situ solar panel unit	Electricity	Zelzate, Ghent, Heusden-Zolder
Waste to Land	Excavation	Residential area	confidential
	Excavation	Industrial area	Heusksem
	Excavation	New landfill	Brecht
	Solidification	Salix	Desselgem
	Containment	Recreation	Aasz
	Containment/immobilizing	Container terminal	Ghent
	Containment/excavation	Park	Aalst
	Containment/excavation	Water basin	Zaventem
	Containment/excavation	Industrial/recreation	Zwijnaarde

Flanders State of the Art

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Resource Management version 2.0

Enhanced Landfill Management & Mining (ELFM²)

OVAM, decision Board of directors 18th September 2015:

- Broadening the concept of Enhanced Landfill Mining and introducing long-term management of landfills. Sustainable stock management is the key-issue and stock is defined as the content of the landfills, the surface of the landfills and its impact on the environment. Creating added-value such as materials and energy, beneficial landuse and protection of potable groundwater resources. Interim use as stage in the resource management and mining cycle.
- Concept of ELFM²-memorandum approved and transfered to Minister of Environment.

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23/09/2015 | 30

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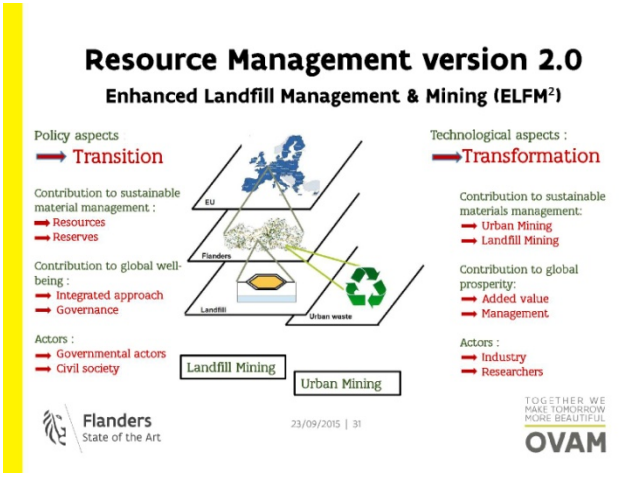
Resource Management version 2.0
Enhanced Landfill Management & Mining (ELFM²)
Policy aspects
Transition
Contribution to sustainable material management :
Resources
Reserves
Contribution to global well-being :
Integrated approach
Governance
Actors :
Governmental actors
Civil society
Technological aspects :
Transformation
Contribution to sustainable materials management:
Urban Mining
Landfill Mining
Contribution to global prosperity:
Added value
Management
Actors :
Industry
Researchers
EU
Flanders
Landfill
Urban waste
Landfill Mining
Urban Mining
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23/09/2015 | 31
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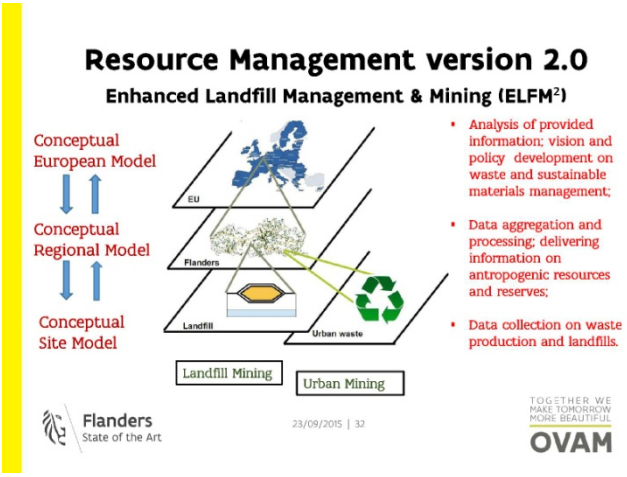
Resource Management version 2.0
Enhanced Landfill Management & Mining (ELFM²)
Conceptual European Model
Conceptual Regional Model
Conceptual Site Model
EU
Flanders
Landfill
Urban waste
Landfill Mining
Urban Mining
Analysis of provided information; vision and policy development on waste and sustainable materials management;
Data aggregation and processing; delivering information on antropogenic resources and reserves;
Data collection on waste production and landfills.
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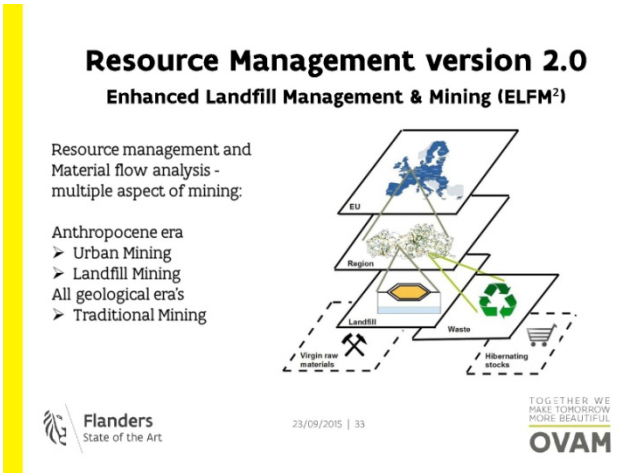
Resource Management version 2.0
Enhanced Landfill Management & Mining (ELFM²)
Resource management and Material flow analysis - multiple aspect of mining:
Anthropocene era
Urban Mining
Landfill Mining
All geological era's
Traditional Mining
EU
Region
Landfill
Waste
Virgin raw materials
Hibernating stocks
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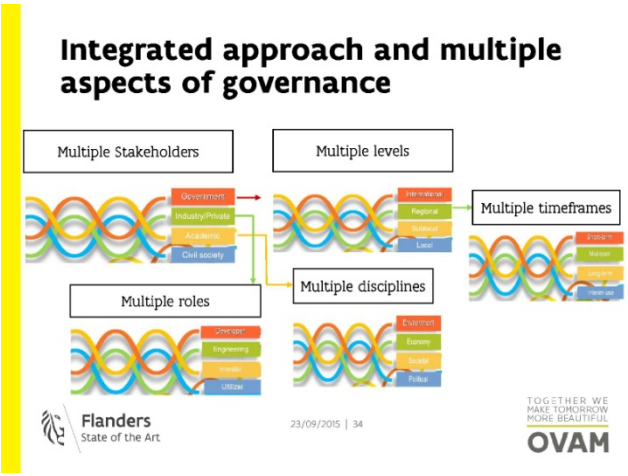
Integrated approach and multiple aspects of governance
Multiple Stakeholders
Multiple levels
Multiple timeframes
Multiple roles
Multiple disciplines
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Participation,(Risk)communication and governance
Specific attention on aspects of communication and governance:
When it comes to judging a risk, most people would rather trust the opinion of a friend than take the word of a scientist.
(new scientist, 28.09.1996)
Roles of the OVAM:
Further contributions on these aspects :
M. Ballard : Local community participation in technological ELFM-projects.
K. Sips : Local community involvement in complex technological projects: challenges for long term planning and dealing with uncertainty.
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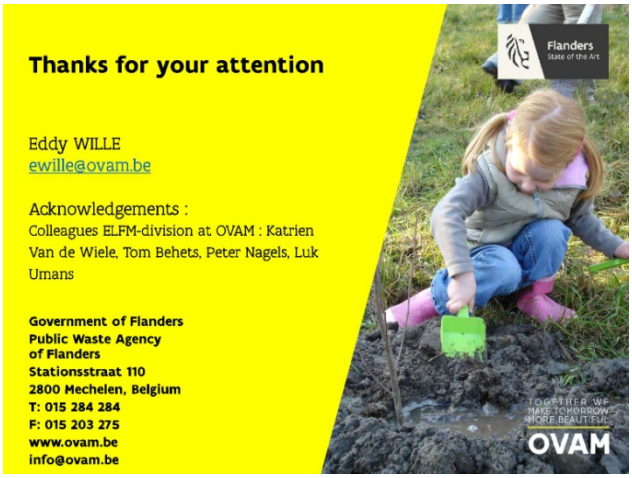
Thanks for your attention
Eddy WILLE
ewille@ovam.be
Acknowledgements :
Colleagues ELFM-division at OVAM : Katrien Van de Wiele, Tom Behets, Peter Nagels, Luk Umans
Government of Flanders
Public Waste Agency of Flanders
Stationsstraat 110
2800 Mechelen, Belgium
T: 015 284 284
F: 015 203 275
www.ovam.be
info@ovam.be
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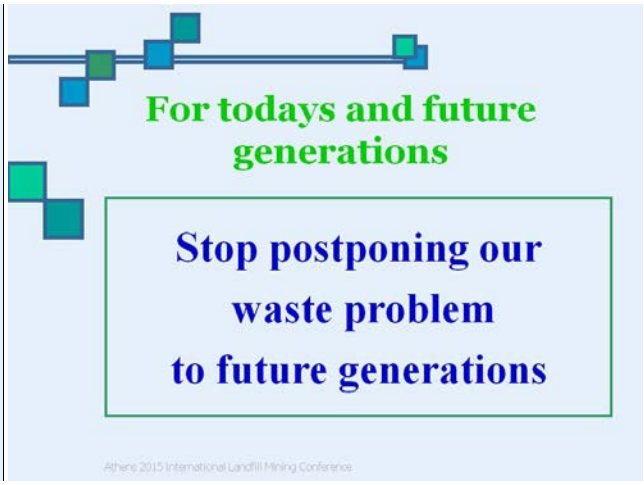
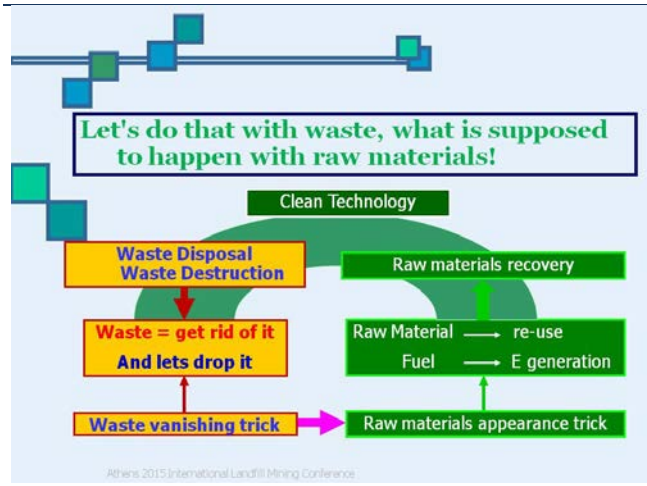
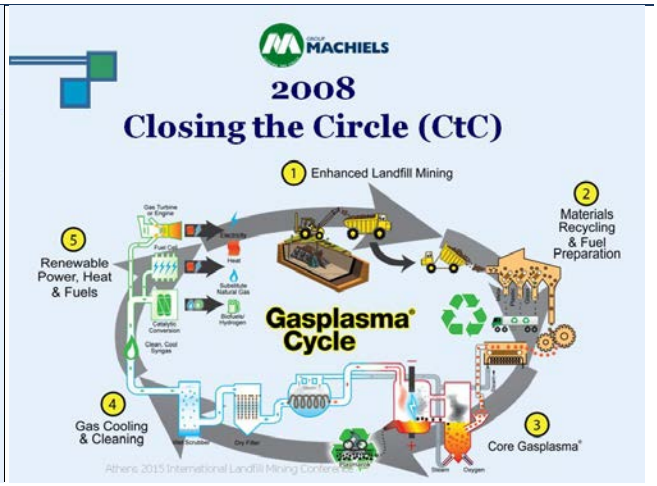
LOCAL COMMUNITY PARTICIPATION IN TECHNOLOGICAL COMPLEX ENHANCED LANDFILL MINING PROJECTS

M. Ballard




Let's do that with waste, what is supposed to happen with raw materials!
Clean Technology
Waste Disposal
Waste Destruction
Raw materials recovery
Waste = get rid of it
And lets drop it
Raw Material
re-use
Fuel
E generation
Waste vanishing trick
Raw materials appearance trick


MACHIELS
2008
Closing the Circle (CtC)
1 Enhanced Landfill Mining
2 Materials Recycling & Fuel Preparation
3 Core Gasplasma
4 Gas Cooling & Cleaning
5 Renewable Power, Heat & Fuels
Gasplasma Cycle

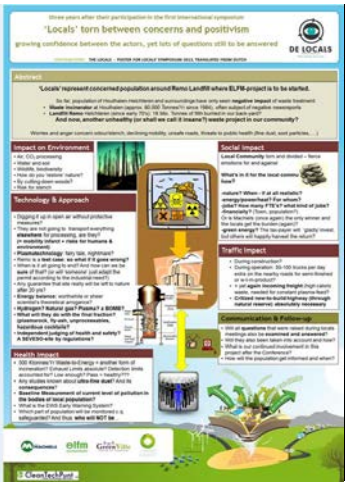
Obstacles towards transition

- Amusement and entertainment value in the being "for or against" the project
- Utility principle: what's in for me
- Polarisation: believers⇔non believers
- Neither officials, nor complainants have always right.

Athens 2015 International Landfill Mining Conference

2010
First Localsmeeting

DE LOCALS
Think Global, Act Local



The Locals, who are they?

DE LOCALS
Think Global, Act Local

The Locals, first stakeholders living within the surroundings of a waste facility.

DE LOCALS

1- Let's not forget …

- Don't forget **the past**
- Don't forget the **concerns of citizens**
- NIMBY is **no excuse** to **minimize** reality
- It's all about absolute **trust** and absolute **sertainty**
- Politicians don't decide on technical level but on **strategic level**

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2- Looking for new challenges

DE LOCALS

- increase **knowledge** to increase **involvement**
- Approach **social change** like any other **technological challenge**
- **Scientific** basis is always at the base of **innovation**

Athens 2015 International Landfill Mining Conference


Involving people = other debate

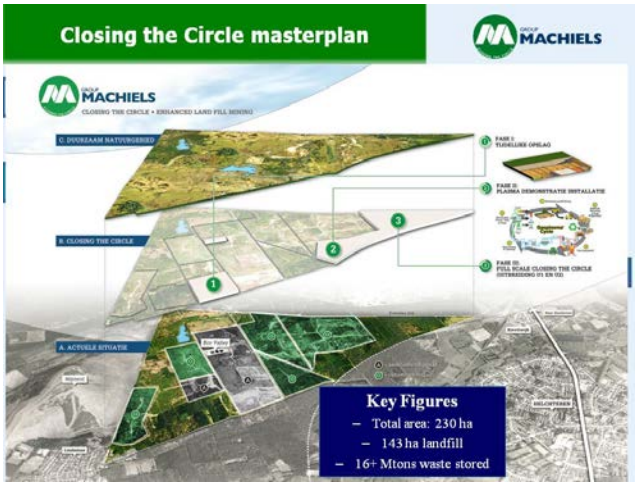

3- Sharing knowledge is exchanging trust
First 'see', then 'know'
so people can 'choose'
DE LOCALS
Give the opportunity to acquire insight as well as information organizing company visits, lectures, symposia
create confidence for a lasting dialogue:
let the experts explain: Scientists, technology holders, knowledge institutions... and Group Machiels


29th Locals meeting


Communication
DE LOCALS
From the Company to the Locals:
Locals will be informed, directly:
Receive always first hand information.
Confidence through openness.
Research group ←→Locals: open communication.
Site visits.
Locals do understand complex issues!


Communication
DE LOCALS
From the Locals to the Company:
Locals inform about the concerns of the society
Ask specific and concrete questions.
Feed the research group.
Proposals/following up on security agreements.

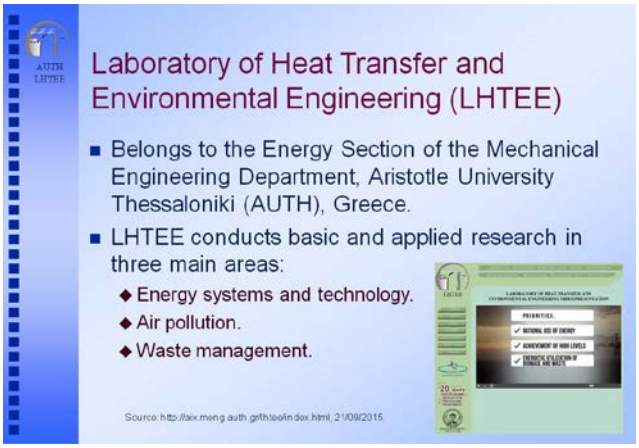

DE LOCALS
Communication
From the Locals to local residents:
Not all questions can be answered immediately (trajectory).
Science-based answers.
Learning Process by the experience of improvement.
Understanding makes people involved in the progress of society
Athens 2015 International Landfill Mining Conference

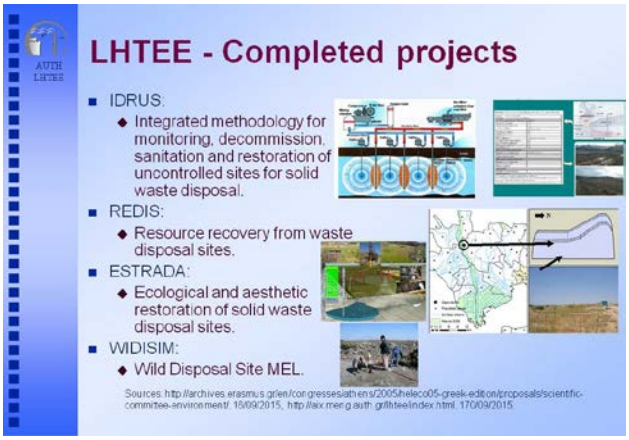

Closing the Circle masterplan
MACHIELS
Key Figures
– Total area: 230 ha
– 143 ha landfill
– 16+ Mtons waste stored


DE LOCALS
Think Global, Act Local
Thank you for your attention.
www.CleanTechPunt.be

HISTORY OF DUMP SITES IN GREECE: INTEGRATED TOOLS AND METHODS FOR THEIR REGISTRATION

G. Perkoulidis, A. Malamakis, T. Tsatsarelis, I. Antonopoulos, N. Moussiopoulos





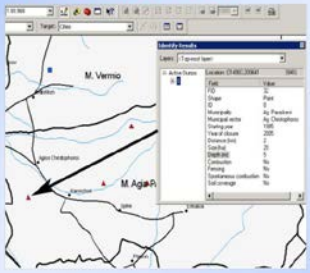
LHTEE publications - Integrated tools and methods

- Field survey, statistical analysis of characteristics, risk assessment.
- Registration, classification, rehabilitation strategies.
- Application of GIS as a decision-making tool for prioritizing restoration.
- Atmospheric dispersion and deposition of PCDD/Fs from landfill fire.

Field survey

- The fields that were required to be filled in for every open dump concerned:
  - Distance from the closest inhabited area.
  - Drill existence.
  - Site size.
  - Estimated depth of waste.
  - Estimated volume of waste.
  - Compression of waste.
  - Estimated type of contained waste.
  - Waste dumping around the site.
  - Fencing of the dump site boundaries.
  - Dumping of sewage and sludge.
  - Distance from surface waters – Waste dumping in surface waters.
  - Animal breeding in the site or in the close vicinity.
  - Incidents of spontaneous combustion.
  - Systematic soil coverage of waste.
  - Year of the open dump's operation initiation.
  - Type and density of vegetation near the site.
  - Systematic combustion of waste and its frequency
- All the above data were then collected, analysed and supplied a GIS database using the ArcGIS ® commercial software.

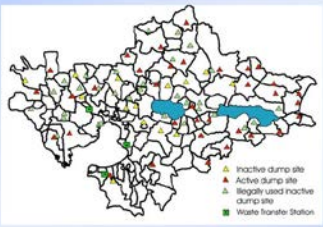
Fields that were required to be filled in GIS database



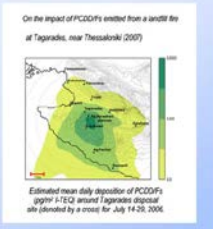
Source: Tsatsarelis et al., 2005.

- Name of municipality.
- Municipal setor.
- Starting year.
- Year of closure.
- Distance from populated area.
- Size of dept of dump site.
- Uncontrolled combustion.

From registration of dumps (2000) to the impact of PCDD (2007)



Source: Salonikidou et al., 2000



Source: http://aix.meng.auth.gr/lhtee/20th_LHTEE.pdf, 21/09/2015

Classification of landfills in the Prefecture of Thessaloniki in 2005

According to systematic uncontrolled burning of solid waste:

- Circle: yes.
- Square: no.
- Triangle: occasionally.

Community borders are drawn.
The Prefecture's two major lakes are filled in blue.

Source: Salonikidou et al., 2000.

Registration of dumps in the Region of Sterea Ellada in 2000

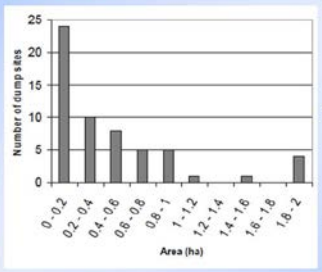
Source: Stamatis, 2000.

Active and inactive dump sites in the Prefecture of Kozani in 2005

- As tabular data - parameters were registered:
- Location name.
- Year of operation initiation.
- Existence of drills in the vicinity.
- Size, valued depth, volume and type of waste.
- Practice of compression.
- Practice and frequency of burning.
- Incidents of burning.
- Practice of systematic coverage.
- Fencing of boundaries.
- Incidents of animal breeding, type and density of nearby vegetation.
- Distance from surface water.
- Distance from aquifer, incidents of sewage dumping and water permeability.

Source: Tsatsarelis et al., 2005.

Size of dump sites in the Prefecture of Kozani



- Most of the sites covered a relatively small area.
- 21 of them covered an area between 0.5 and 1 ha.
- Only 7 of them covered an area more than 1 ha.

Source: Tsatsarelis et al., 2005.

Open combustion of waste in the Prefecture of Evros

- Open burning is responsible for generation of toxic byproducts of combustion, such as: polychlorinated dibenzodioxins and furans (PCDD/F), polycyclic aromatic hydrocarbons, particulate matter, benzene, carbon monoxide, carbon dioxide, nitrogen dioxide and sulfur dioxide.

Management practices in the Prefecture of Chalkidiki in 2005

Defining hazard degree

- Step 1 concerns the pollution sources that exist on the site and is conducted by taking into account the quantities, type of waste (household, construction and demolition) and the age of each open dump.
- Step 2 concerns the path of pollution dispersion.
- Finally, step 3 concerns the final receptor of the pollution.
- Open dumps are then ranked into 4 categories according to their hazard degree evaluation:
  - urgently restored, should be restored, should be restored in the future, do not need any restoration.

Hazard degree, restoration cost, external cost and selling price

External cost from CH_4 and CO_2 emissions into atmosphere

	CH_4	CO_2
External cost (€/t)	379	34

Source: Zhang et al., 2005

Recyclable material selling price.

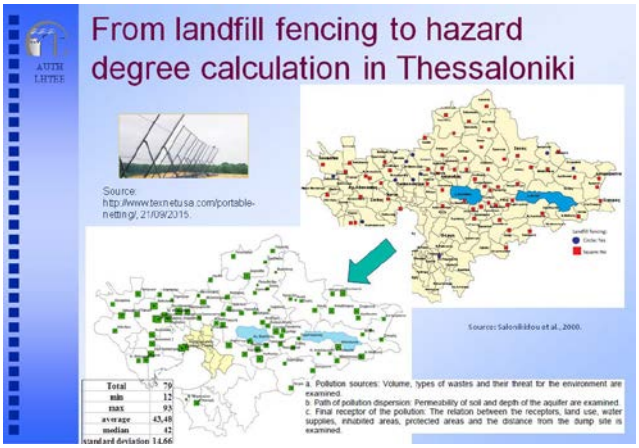
	Aluminum	Ferrous metals	Plastic
Selling price (€/kg)	0.83	0.16	0.03

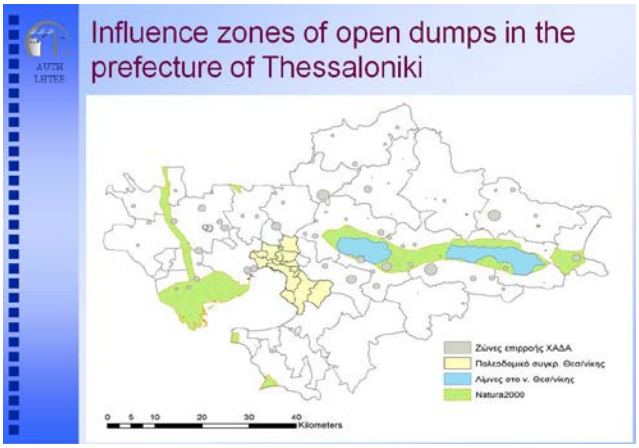
Hazard degree of uncontrolled landfills.

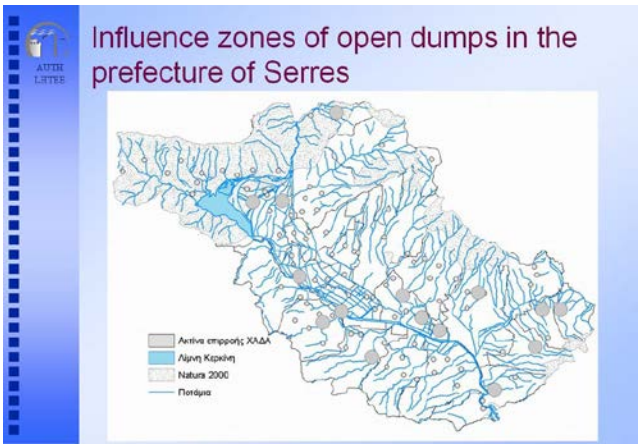
Category	Priority for action	Hazard degree
A	Direct need	≥ 90
B	Indirect need	70-89
C	Future need	30-69
D	Inexistent	0-29

Simple coverage restoration cost.

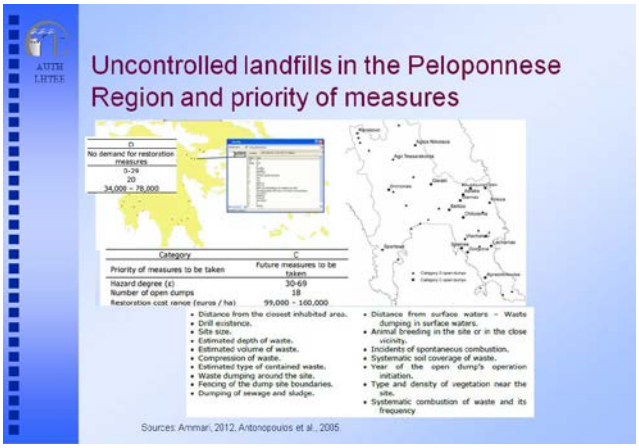
Risk degree	Mean value (€/m²)
<30	5.60
30-69	12.95
70-89	23.00
>89	31.00

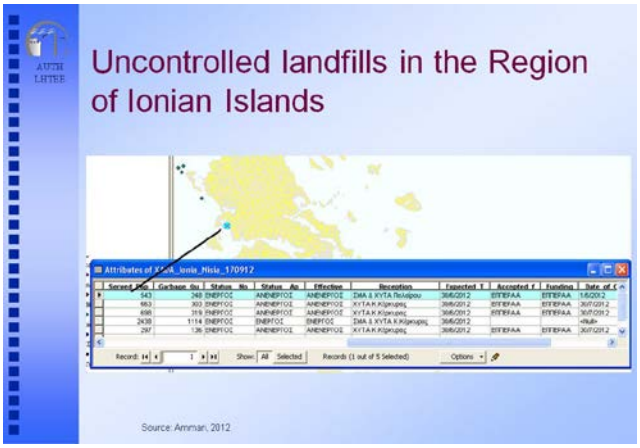

From landfill fencing to hazard degree calculation in Thessaloniki
Source: http://www.texnetusa.com/portable-netting/, 21/09/2015.
Source: Salonikidou et al., 2000.
Total 79
min 12
max 93
average 43,48
median 42
standard deviation 14,66
a. Pollution sources: Volume, types of wastes and their threat for the environment are examined.
b. Path of pollution dispersion: Permeability of soil and depth of the aquifer are examined.
c. Final receptor of the pollution: The relation between the receptors, land use, water supplies, inhabited areas, protected areas and the distance from the dump site is examined.


Influence zones of open dumps in the prefecture of Thessaloniki
Ζώνες επιρροής ΧΑΔΑ
Πολεοδομικό συγκρ. Θεσ/νίκης
Λίμνες στο ν. Θεσ/νίκης
Natura2000
0 5 10 20 30 40
Kilometers


Influence zones of open dumps in the prefecture of Serres
Ακτίνα επιρροής ΧΑΔΑ
Λίμνη Κερκίνη
Natura 2000
Ποτάμια

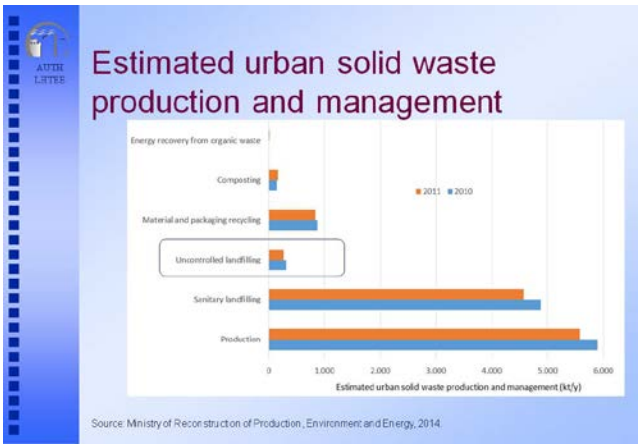

Database of open dumps

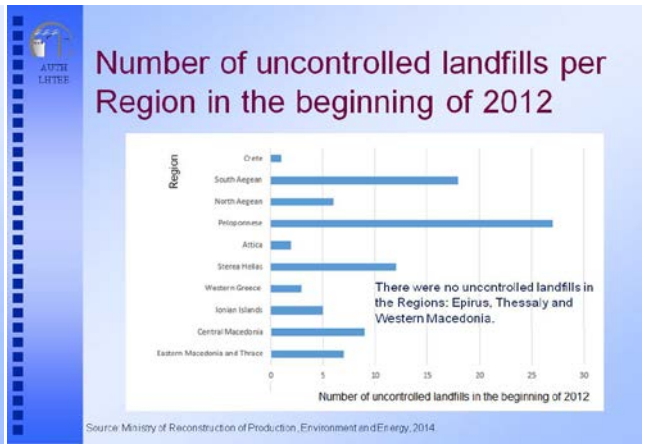

Uncontrolled landfills in the Peloponnese Region and priority of measures
Category
Priority of measures to be taken
Future measures to be taken
Hazard degree (€)
30-69
Number of open dumps
18
Restoration cost range (euros / ha)
99,000 - 160,000
Sources: Ammari, 2012, Antonopoulos et al., 2005.


Uncontrolled landfills in the Region of Ionian Islands
Source: Ammari, 2012

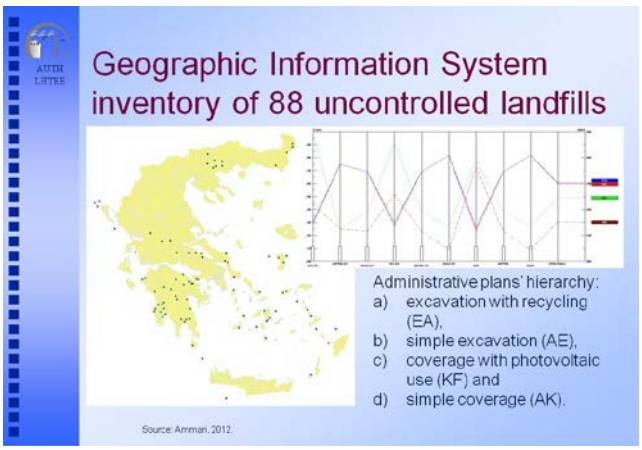

Landfill fire
Urban area of Thessaloniki
Study area
Kalamaria
Panorama
Thermaikos bay
Triadi
Airport
Tagarades
Vasilika
Ag. Paraskevi
Souroti
Galatista
Waste disposal site
K. Scholari
Ag. Pavlos
Study area
1 km
1.5 km
Waste disposal site


Quantities of waste disposed per region in the beginning of 2012 (kt)
Crete
South Aegean
North Aegean
Peloponnese
Attica
Sterea Hellas
Western Greece
Ionian Islands
Central Macedonia
Eastern Macedonia and Thrace
Amount of waste disposed in uncontrolled landfills in the beginning of 2012 (kt)
Source: Ammari, 2012

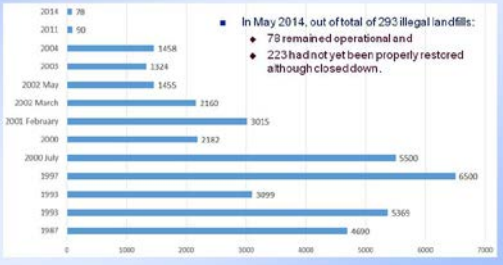

Estimated urban solid waste production and management
Energy recovery from organic waste
Composting
Material and packaging recycling
Uncontrolled landfilling
Sanitary landfilling
Production
2011
2010
Estimated urban solid waste production and management (kt/y)
Source: Ministry of Reconstruction of Production, Environment and Energy, 2014


Number of uncontrolled landfills per Region in the beginning of 2012
Region
Crete
South Aegean
North Aegean
Peloponnese
Attica
Sterea Hellas
Western Greece
Ionian Islands
Central Macedonia
Eastern Macedonia and Thrace
There were no uncontrolled landfills in the Regions: Epirus, Thessaly and Western Macedonia.
Number of uncontrolled landfills in the beginning of 2012
Source: Ministry of Reconstruction of Production, Environment and Energy, 2014


Uncontrolled landfills in Greece in Google Earth environment
Source: http://tripolisr-ews.blogspot.gr/2015/03/blog-post_53.html, 19/09/2015
Source: http://www.xanthipress.gr/dimosiografiki-erevna-ke-chartis-me-tis-paranomes-chomateres/, 8 September 2014


Geographic Information System inventory of 88 uncontrolled landfills
Administrative plans' hierarchy:
a) excavation with recycling (EA),
b) simple excavation (AE),
c) coverage with photovoltaic use (KF) and
d) simple coverage (AK).
Source: Amman, 2012

Urban solid waste disposal dump sites in Greece in 2014



- In May 2014, out of total of 293 illegal landfills:
  - 78 remained operational and
  - 223 had not yet been properly restored although closed down.

Source: Ministry of Reconstruction of Production, Environment and Energy, 2014.

Conclusions

- Less than 100 open dumps of municipal solid waste, are still used in 2015. They could be the firt target for excavation with recycling.
- Open burning took place in many dumps in regions, prefectures and municipalities during the last decades and materials as paper and plastic have been burned and they are not included in the mass and volume of the disposed waste.
- Future work:
  GIS models should be utilized for prioritizing and selecting restoration plans for uncontrolled landfills with the use of multi-criteria decision making methods.

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Thank you!

PHYTOMINING OF HEAVY METALS. FUTURE PERSPECTIVES

C. Tsadilas

«ΦΥΤΟΕΞΟΡΥΞΗ» ΒΑΡΕΩΝ ΜΕΤΑΛΛΩΝ ΑΠΟ ΑΠΟΒΛΗΤΑ

ΧΡΙΣΤΟΣ ΤΣΑΝΤΗΛΑΣ

ΕΛΛΗΝΙΚΟΣ ΓΕΩΡΓΙΚΟΣ ΟΡΓΑΝΙΣΜΟΣ ΔΗΜΗΤΡΑ
ΙΝΣΤΙΤΟΥΤΟ ΒΙΟΜΗΧΑΝΙΚΩΝ ΚΑΙ ΚΤΗΝΟΤΡΟΦΙΚΩΝ ΦΥΤΩΝ

Περιεχόμενο ομιλίας

- Εισαγωγή (Τα βαρέα μέταλλα στο περιβάλλον, επιπτώσεις στην ανθρώπινη υγεία, μέθοδοι αποκατάστασης ρυπασμένων εδαφών)
- Περιγραφή της τεχνικής της φυτοεξόρυξης
- Φυτά υπερσυσσωρευτές βαρέων μετάλλων
  - Ιδιότητες
  - Φυσιολογία
  - Είδη
- Τεχνικές φυτεξόρυξης
- Αποτελεσματικότητα
- Οικονομικότητα τεχνικής
- Ερευνητικά δεδομένα στον ελληνικό χώρο
- Συμπεράσματα

Τα βαρέα μέταλλα στο περιβάλλον

Η ρύπανση του περιβάλλοντος από βαρέα μέταλλα είναι ένα σοβαρό πρόβλημα παγκόσμια επιδεινούμενο συνεχώς λόγω της συνεχιζόμενης βιομηχανοποίησης και της διαταραχής των βιοχημικών κύκλων.

Τα βαρέα μέταλλα σε αντίθεση με τους οργανικούς ρύπους είναι **μη βιοαποδομήσιμα** και επομένως συσσωρεύονται στο περιβάλλον.

Μέσω του εδάφους και του νερού μεταφέρονται στους ζωντανούς οργανισμούς (βιοσυσσώρευση) και μέσω της **βιομεγέθυνσης** (αύξηση της συγκέντρωσης από τα χαμηλότερα επίπεδα της τροφικής αλυσίδας στα ανώτερα) η συγκέντρωσή τους μεγεθύνεται σε τοξικά επίπεδα.

Στο έδαφος έχουν τοξική επίδραση στους μικροοργανισμούς, μειώνοντας τον αριθμό τους και τη δραστηριότητά τους.

Τα βαρέα μέταλλα στο περιβάλλον

Με βάση το ρόλο τους στα βιολογικά συστήματα ταξινομούνται σε:

- **απαραίτητα** (χωρίς αυτά δεν είναι δυνατή η ολοκλήρωση του βιολογικού κύκλου των ζώντων οργανισμών) και
- **μη απαραίτητα**.

Απαραίτητα βαρέα μέταλλα: Fe, Mn, Cu, Zn, Ni.

Μη απαραίτητα βαρέα μέταλλα: Cd, Pb, As, Hg, Cr.

Πηγές βαρέων μετάλλων

Τα βαρέα μέταλλα εισέρχονται στο περιβάλλον από φυσικές και ανθρωπογενείς πηγές:

- **Φυσικές πηγές**
  - Αποσάθρωση ορυκτών
  - Διάβρωση και ηφαιστειακή δράση
  - Ατμοσφαιρικές αποθέσεις
- **Ανθρωπογενείς πηγές**
  - Εξόρυξη
  - Χρήση γεωργικών φαρμάκων
  - Εφαρμογή λιπασμάτων (κυρίως φωσφορικών)
  - Εφαρμογή ιλύος βιολογικού καθαρισμού στη γεωργία
  - Απόθεση ιλύος στις χωματερές
  - Βιομηχανικά απόβλητα
  - Ατμοσφαιρικές αποθέσεις

Επίδραση βαρέων μετάλλων στην ανθρώπινη υγεία (Ali et al., 2013)

Οξειδωτικό stress μέσω του σχηματισμού ελεύθερων ριζών. Το οξειδωτικό stress αναφέρεται στον αυξημένο σχηματισμό δραστικών μορφών οξυγόνου που πέραν ενός σημείου δεν μπορεί να αντιμετωπισθεί από την ενδογενή αντιοξειδωτική άμυνα του οργανισμού οδηγώντας σε βλάβη ή θάνατο των κυττάρων.

Αντικατάσταση απαραίτητων βαρέων στα ένζυμα και διακοπή της λειτουργίας τους.

Μέταλλο	Επίπτωση	Μέταλλο	Επίπτωση
As	Παρεμποδίζει την οξειδωτική φωσφορυλίωση (ομοιότητα με φωσφόρο)	Ni	Αλλεργίες, καρκίνος πνευμόνων, στομάχου και στόματος κ.λπ.
Cd	Καρκινογένεση, τερατογένεση	Pb	Μειωμένη πνευματική ικανότητα, έλλειψη συντονισμού κ.λπ.
Cr	Απώλεια μαλλιών	Zn	Ίλιγγος, εξάντληση
Cu	Βλάβες στο εγκέφαλο και στα νεφρά	Hg	Απώλεια ισορροπίας, απώλεια μνήμης κ.λπ

Απομάκρυνση βαρέων μετάλλων από ρυπασμένα εδάφη

Φυσικοχημικές Μέθοδοι καθαρισμού ρυπασμένων εδαφών με βαρέα μέταλλα

- Αποτέφρωση εδαφών
- Εκσκαφή και απομάκρυνση εδαφών
- Πλύση εδαφών
- Στερεοποίηση
- Σταθεροποίηση

Περιορισμοί:

- Υψηλό κόστος
- Μη αντιστρεπτές μεταβολές στα εδάφη
- Καταστροφή μικροχλωρίδας και πανίδας
- Εντατική εργασία

Εναλλακτική πράσινη λύση: Φυτοαποκατάσταση (Phytoremediation)

Φυτοαποκατάσταση

(Ali et al., 2013)

Τεχνική	Περιγραφή
Φυτο-εκχύλιση (phytoextraction)	Συσσώρευση μετάλλων στη συλλεγόμενη βιομάζα
Φυτο-διήθηση (Phytofiltraion)	Δέσμευση μετάλλων από νερά με φυτά
Φυτο-σταθεροποίηση (Phytostabilization)	Μείωση της κινητικότητας και της διαθεσιμότητας των μετάλλων στα εδάφη με τις ρίζες φυτών
Φυτο-εξαέρωση (Phytovolatilization)	Μετατροπή των ρύπων σε εξαερούμενη μορφή και απελευθέρωση στην ατμόσφαιρα
Φυτο-αποδόμηση (Phytodegradation)	Αποδόμηση ρυπαντών με ένζυμα φυτών εντός των φυτικών ιστών
Ριζο-αποδόμηση (Rhizodegradation)	Αποδόμηση ρυπαντών στη ριζόσφαιρα μέσω μικροοργανισμών των ριζών
Φυτο-αφαλάτωση (Phytodesalinization)	Απομάκρυνση αλάτων από τα εδάφη με χρήση αλοφύτων

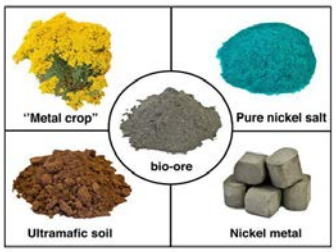
Φυτοεξόρυξη (Phytomining)

(Ent et al., 2015)

Σχηματικά η φυτοεξόρυξη παρουσιάζεται στο παρακείμενο σχήμα:

- Απορρόφηση βαρέων μετάλλων με φυτά υπέρ-συσσωρευτές βαρέων μετάλλων από τα εδάφη.

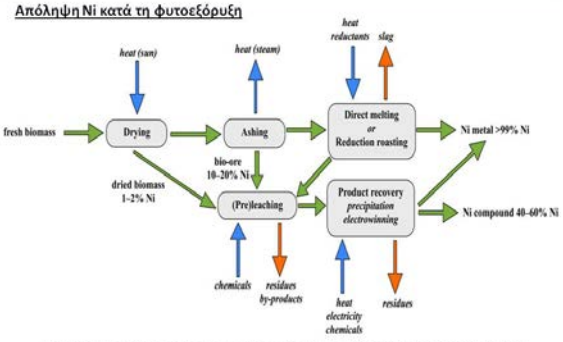
- Σχηματισμός βιομεταλλεύματος (bio-ore).
- Απόληψη μετάλλου.



Φυτοεξόρυξη (Phytomining)

(Ent et al., 2015)

Απόληψη Ni κατά τη φυτοεξόρυξη



Φυτά υπερσυσσωρευτές (hyperaccumulators) βαρέων μετάλλων

Η φυτοεξόρυξη είναι μια μορφή φυτοαποκατάστασης που βασίζεται στην φυτοεκχύλιση (phytoextraction). Αυτή η τεχνική βασίζεται σε κατηγορία φυτών που έχουν τη δυνατότητα να απορροφούν μεγάλες ποσότητες βαρέων μετάλλων χωρίς να υφίστανται βλάβη. Αυτά τα φυτά είναι οι λεγόμενοι υπερσυσσωρευτές (hyperaccumulators).

Τι επιδιώκεται με την φυτοεξόρυξη

Η ανάκτηση εμπορεύσιμων ποσοτήτων μετάλλων με τη χρήση φυτών από ρυπασμένα εδάφη.

Ιδιότητες υπερσυσσωρευτών (hyperaccumulators) βαρέων μετάλλων

Τα φυτά αυτά συσσωρεύουν βαρέα μέταλλα 50-500 φορές περισσότερο από τα συνήθη φυτά.

Ορισμός: Τα φυτά που μπορούν να απορροφήσουν βαρέα μέταλλα ως εξής (Verbruggen, et al., 2009):

- Au, Ag> 1 mg/kg
- Cd, Se, Ta> 100 mg/kg
- Cu, Co,Cr,Ni,Pb,U,As > 1000 mg/kg
- Mn, Zn > 10000 mg/kg

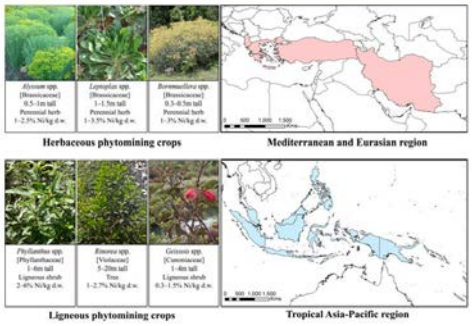
Συντελεστής βιολογικής απορρόφησης: > 1

Μέχρι σήμερα έχουν καταγραφεί περίπου 400 τέτοια φυτά.

Οικογένειες:

Asreraceae, Brassicaceae, Caryophyllaceae, Fabaceae, Flacourtaceae, Lamiaceae, Poaceae, Violaceae, Euphorbiaceae.

Φυτά υπερσυσσωρευτές (hyperaccumulators) βαρέων μετάλλων



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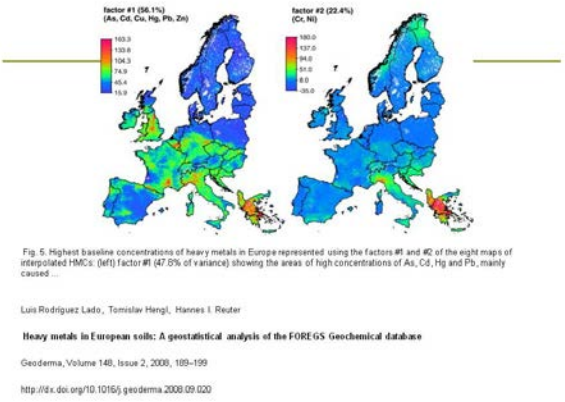


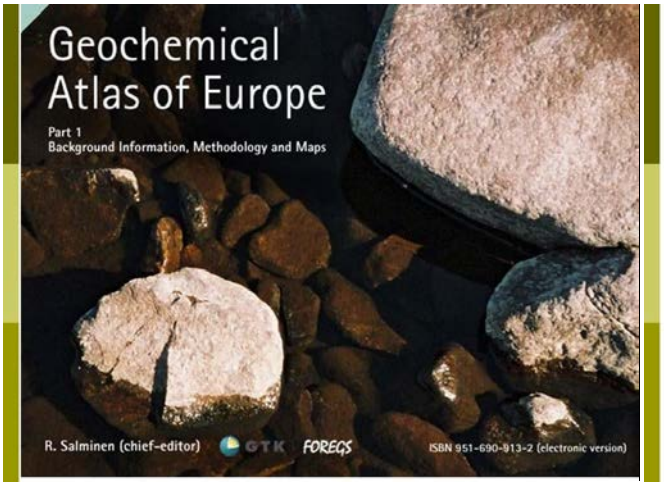
Fig. 5. Highest baseline concentrations of heavy metals in Europe represented using the factors #1 and #2 of the eight maps of interpolated HMCs: (left) factor #1 (47.8% of variance) showing the areas of high concentrations of As, Cd, Hg and Pb, mainly caused ...

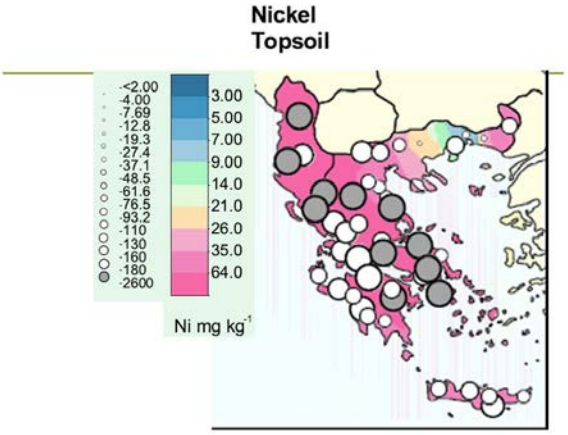
Luis Rodríguez Lado, Tomislav Hengl, Hannes I. Reuter

Heavy metals in European soils: A geostatistical analysis of the FOREGS Geochemical database

Geoderma, Volume 148, Issue 2, 2008, 189–199

http://dx.doi.org/10.1016/j.geoderma.2008.09.020





Φυτοεξόρυξη – Αγροεξόρυξη (Phytomining – Agromining)

Η φυτοεξόρυξη αναφέρεται σε περιπτώσεις καλλιέργειας φυτών σε θέσης σε θέσεις όπου αναπτύσσονται μεταλλευτικές δραστηριότητες κυρίως Ni σκοπεύοντας στην ανάκτηση μέσω της δημιουργίας βιοκοιτάσματος εμπορεύσιμων ποσοτήτων μετάλλου.

Η αγροεξόρυξη προτείνεται για περιοχές με γεωργική δραστηριότητα σε εδάφη ηφαιστειογενή με χαμηλή παραγωγικότητα για παραγωγή τροφίμων. Σε τέτοιες περιπτώσεις θεωρείται πολύ ενδιαφέρουσα η περίπτωση συγκαλιέργειας φυτών που παράγουν τρόφιμα (π.χ. ελιές) με φυτά που υπερσυσσωρευτές βαρέων μετάλλων (π.χ. Alyssum).

Αυτός ο συνδυασμός θεωρείται κατάλληλος για την Ελλάδα, στην οποία τα εδάφη λόγω προέλευσης περιέχουν αυξημένες συγκεντρώσεις Ni.

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Οικονομικότητα φυτεξόρυξης/αγροεξόρυξης

Η οικονομική αποτελεσματικότητα εξαρτάται από τους παράγοντες:

- Τιμή μετάλλου στην αγορά
- Απόδοση καλλιέργειας φυτού-υπερσυσσωρευτή ΒΜ
- Διαθεσιμότητα γης για καλλιέργεια φυτών υπερσυσσωρευτών ΒΜ
- Δυνατότητα δημιουργίας δευτερογενών προϊόντων (οργανικά λιπάσματα με αυξημένες συγκεντρώσεις ΒΜ).

Παράδειγμα:

Φυτό: *Alyssum murale* ή *A. corsicum.*

Αναμενόμενη απόδοση 5-10 ton/ha ξηρής ουσίας

Περιεκτικότητα σε Ni: 2%

Απόδοση σε Ni: 100 kg Ni/ha

Τιμή Ni: $15/kg, Ακαθάριστο έσοδο: 1500 $/ha

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Δυνατότητες εφαρμογής φυτο-αγροεξόρυξης στην Ελλάδα

- ✓Η φυτοεξόρυξη μπορεί να εφαρμοσθεί σε χώρους μεταλλείων μετά την ολοκλήρωση της εξόρυξης των μετάλλων
- ✓Σε χώρους ΧΥΤΑ
- ✓Πολλά από τα ελληνικά εδάφη βρέθηκε ότι περιέχουν υψηλές συγκεντρώσεις ορισμένων βαρέων μετάλλων, όπως π.χ. Ni λόγω προέλευσής τους . Σε πολλές περιπτώσεις οι συγκεντρώσεις Ni υπερβαίνουν τις επιτρεπόμενες ανώτερες συγκεντρώσεις από τη νομοθεσία για την εφαρμογή ιλύος βιολογικού καθαρισμού στα εδάφη (75 mg/kg εδ.) (Tsadilas et al., 2015)
- ✓Μεγάλες εκτάσεις της χώρας καλύπτονται από μη παραγωγικά εδάφη καλλιεργούμενα με ανθεκτικές καλλιέργειες, όπως η ελιά.
- ✓Σε αυτές τις περιπτώσεις μπορεί να δοκιμασθεί η συγκαλλιέργεια φυτών υπερσυσσωρευτών Ni (Alyssum, Leptoplax, Bornmuellera) με ελιές

Δεδομένα σχετικής έρευνας στην Ελλάδα

Μελέτη δυνατότητας του φυτού canola να δρα ως φυτό εκχυλιστής βαρέων μετάλλων (Tsadilas and Shaheen, 2013)
Σε εδάφη στα οποία προστέθηκε ιλύς βιολογικού καθαρισμού αναπτύχθηκε canola –ελαιοκράμβη- και διερευνήθηκε η απορρόφηση βαρέων μετάλλων. Βρέθηκε:
Το φυτό canola αύξησε το λόγο της βιοσυγκέντρωσης (bio-concetration ratio) (συγκέντρωση μετάλλου στο φυτό/συγκέντρωση μετάλλου στο έδαφος) σημαντικά.

ΣΥΜΠΕΡΑΣΜΑΤΑ - ΠΡΟΟΠΤΙΚΕΣ

Αν και επιστημονικά και οι δυο τεχνικές (phytomining-agromining) έχουν αξιολογηθεί

Κατά τις τελευταίες δύο δεκαετίες, προκειμένου να εφαρμοσθούν στην πράξη πρέπει να δοκιμασθούν από τη βιομηχανία σε μεγάλη κλίμακα.

Ήδη έχει κατατεθεί σχετική πατέντα (Chaney et al., 1998), η αξιολόγηση της οποίας θα δώσει τη δυνατότητα αξιολόγησης των επιστημονικών ευρημάτων σε κλίμακα παραγωγής.

Η μη εφαρμογή της αγροεξόρυξης σε μεγάλη κλίμακα, οφείλεται στην έλλειψη ενημέρωσης και πρέπει αυτό το κενό να καλυφθεί έγκαιρα ιδίως για μέταλλα όπως το Ni, με το οποίο είναι εμπλουτισμένα πολλά ελληνικά εδάφη.

Μία μεγάλη προσπάθεια ενημέρωσης των ενδιαφερόμενων (βιομηχανίες, υπηρεσίες παραγωγούς κ.λπ) πρέπει να αρχίσει το συντομότερο.

Η Ελλάδα προσφέρεται για ανάπτυξη αυτών των τεχνικών λόγω των εδαοκλιματικών συνθηκών της΄.

ΕΥΧΑΡΙΣΤΩ ΓΙΑ ΤΗΝ ΠΡΟΣΟΧΗ ΣΑΣ

RELIABLE REHABILITATION OF UNCONTROLLED DUMP SITES

K. Hadjibiros

Athens 2015 International Landfill Mining Conference

Reliable rehabilitation of uncontrolled dump sites

- *Kimon Hadjibiros*, 24 September 2015

- World: open uncontrolled dumping of municipal waste
- Greece, last 70 years: Thousands of uncontrolled dump sites
- Greece, last 20 years: many projects of rehabilitation

A generally accepted principle

- In 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

Landfill aftercare activities should include

- Water sampling and analysis of discharged rainwater, collecting and treating leachate, groundwater and surface water monitoring
- Measurements and visual inspections of settlement, slope stability and erosion evaluation, quality of vegetation, groundwater levels, visual inspections, gas measurements and analyses
- Cleansing and maintenance of leachate drainage, piezometers, monitoring drainage water
- Maintenance and operation of landfill gas extraction, utilisation and treatment systems, wastewater treatment plant and/or discharge systems, vegetation and cover repairs, safety, accessibility and other maintenance

Environmental reliability

- No toxic substances in the environment
- No pollution of underground water
- No greenhouse gases in the atmosphere
- No erosion
- Natural landscape, vegetation
- Monitoring of qualitative, quantitative parameters
- Reliable maintenance of technical infrastructure
- For 30 years at least

Basic requirements for closing an open dumpsite

- Providing final soil cover, vegetation layer, drainage control system, leachate and gas management systems, monitoring systems and site security (aftercare programme)
- Re-gradation of site slopes, capping of landfill with impermeable cover, placement of leachate collection and treatment systems, installation of landfill gas collection and flaring system, aesthetic landscaping of the closed dumpsite
- Three major design elements: slope stability, drainage and gas controls

Usual rehabilitation projects in Greece

- Are compatible with these criteria?
- Probably only with criterion 5
- Often the dump cover is poor or sporadic and a walk over of the dump area provides visual information on the type of waste
- Low cost projects
- The biodegradable components (food and yard waste) generally undergo anaerobic degradation in a closed dumpsite

Toxic liquids and greenhouse gases

- Leachate: water (due to rainfall, surface drainage, groundwater, etc.) percolates through solid waste undergoing decomposition
- Contains dissolved and suspended materials that may pass through the underlying soil and contaminate underground as well as surface water
- The decomposition of the waste brings about the generation of gases, mainly methane (about 50-65%, 21 times the global warming potential of carbon dioxide)
- About 5-15% of the methane released to the Earth atmosphere is related to waste dumping and waste landfilled

For many years..

- Gas surveys are necessary at most dumps
- This should be completed at least three to four times per year
- Ground water monitoring is necessary at all abandoned dumps
- The long-term effects of settlement, gas emissions and leachate production require aftercare measures for a closed dumpsite long after (30 years) ceasing operations

Informal scavengers/waste pickers at the disposal site

- A potential threat
- They could be formally hired in a Materials Recovery Facility since they are efficient in waste segregation

Mining

- Landfill mining: process of excavating existing or closed solid waste landfills or dumpsites and sorting excavated materials for recycling, processing or other disposition
- Operations to free new landfilling space
- Producing recyclable materials
- Extracting polluting substances
- Dumpsite mining has been used throughout the world since 52 years as a tool for sustainable landfill siting

Landfill and dumpsite mining

- Rehabilitation: a set of activities for re-establishing the productivity and business value of rehabilitated land
- Advanced environmental policy
- Sustainable development
- Material flow
- Cyclic industrial economy
- Reduced integrated cost (avoid environmental cost, costs of landfill closure and post closure care and monitoring)

MECHANISMS OF STABILIZATION/IMMOBILIZATION OF HEAVY METALS IN THE GEOENVIRONMENT

D. Dermatas

Heavy Metal Immobilization Mechanisms and Speciation in the Geoenvironment

by Prof. Dimitris Dermatas, .
National Technical University of Athens

Agenda

- Why bother with heavy metal immobilization mechanisms?
- Which are they?
- Examples
- How to delineate them?
- Application context
- Bottom line (Summary and conclusions)

2

100th International Symposium and Annual Meeting of the KSABC 11/24/2015

Significance of HM immobilization mechanisms

- Great number of contaminated sites (~500.000 in Japan, ~500.000 in US, ~ 3.000.000 in EU)
- Very high remediation cost (1-2 trillion USD only for G-20)
- Perspective: Arsenic groundwater contamination 2nd (to starvation) threat according to UNEP
- Assistance in prioritization of sites to be remediated
- Extremely costly to get it wrong!!
- Long-term remediation performance

3

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Significance of HM immobilization mechanisms → geoenvironmental testing

- The most *recent global shift to remediation approaches based on risk assessment*, makes it clear that total analyses (TA), Toxicity Characteristic Leaching Procedure (TCLP) and other *conventional geoenvironmental tests are no longer sufficient* as an adequate knowledge on the prevailing immobilization mechanisms is now required
- This underscores the significance of using *state-of-the-art geoenvironmental characterization* aiming predominately in obtaining a deeper understanding of the solid state *speciation of contaminants*, and thus their *bioavailability*, in the geoenvironment

4

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HM immobilization mechanisms list

- Macroencapsulation and Microencapsulation
- Inclusion (crystal or amorphous)
- Sorption (adsorption vs. absorption)
- Precipitation
- Detoxification (biological or chemical)

5

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Micro- and Macro-encapsulation

- Predominately physical mechanism
- Microencapsulation
  - Chelation (chemical) is mainly used in water decontamination applications → very rarely in soils
  - Asphalt & other non-polar organic emulsions (physical). Mainly prevent HM from dissolving in water
  - Rubber tire and Hg (Meng et al., 1998)
  - Macroencapsulation
  - Containers
  - Landfills & Impermeable Vertical Barriers

6

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Inclusion (isomorphous substitution & amorphous inclusion)

- Mainly a Stabilization/Solidification (S/S) mechanism
- Formation of pozzolanic products (CAH, CSH, etc.) during S/S applications (cement, lime, fly ash, etc.) (Dermatas & Meng 1995; 1996; 2003)
- Isomorphous substitution → Incorporation into the product crystalline structure: Cr^{6+} substituted ettringite (Dermatas 1995, Chrysochoou & Dermatas, 2006)
- Incorporation into amorphous (gel-like) pozzolanic products: Pb in CSH gels (Dermatas et al., 2006)

7

Sorption

- Absorption → via cation exchange in reactive clays: Cr and Pb substituted montmorillonites (Dermatas & Dadachov, 2003)
- Adsorption: in natural environments onto mainly amorphous or fine-grained oxide and hydroxide surfaces (e.g., iron, manganese, etc.)
- Adsorption: in remediation applications onto mainly fine-grained (lately nano) active surfaces.
- Adsorption examples: As onto iron oxides (Dermatas & Meng, 2004), Pb onto TiO_2, fishbone, biochar, etc.

8

Precipitation

- As immobilization by calcium-arsenic precipitates (Moon et al., 2004)
- Cr^{3+} immobilization as hydroxide precipitate (Dermatas & Meng, 2003; Dermatas & Moon, 2006)
- Cr^{6+} immobilization as barium chromate precipitates (Chrysochoou et al., 2006)
- Pb immobilization as pyromorphite precipitate (Chrysochoou et al., 2007; Dermatas et al., 2008)

9

Detoxification

- Chemical Reduction of Cr^{6+} to Cr^{3+}(Dermatas et al., 2006; Moon et al., 2007; Chrysochoou et al., 2008)
- Biological reduction of Cr^{6+} to Cr^{3+}(Chrysochoou et al., 2011)
- Extracellular reduction of uranium via Geobacter conductive pili as a protective cellular mechanism (Cologgi et al., 2011)

10

HM immobilization mechanism delineation

- Done in the lab but sampling (i.e., field) is important
- Determination of geochemical contaminant speciation is the key
- *Heavy metal remediation application* inadequacies are mainly traced to a *failure to qualitatively and quantitatively* recognize the *contaminant speciation* regime
- *Contaminant speciation*, i.e., the physicochemical state at which the contaminant exists, ultimately dictates the degree of *contaminant immobilization* and thus *its release and bioavailabilty* into the geoenvironment (USEPA 1999a; Dermatas et al. 2006b

11

What is contaminant speciation

- Chemical form of contaminant
  - Valence
  - Crystalline structure/amorphicity
  - Chemical formula
- Physicochemical association between contaminant & soil-water
  - Sorption (extraction tests and isotherms; both problematic)
  - Solid solution, i.e., crystal or amorphous inclusion (XRPD; SEM-EDS; EPMA)
  - Sediment hydraulic properties (*not* speciation but still needs to be considered)

12

Contaminant speciation importance

- Reliably evaluate public health risk associated w/ HM contamination
- Delineate mechanisms of contaminant release and ultimate fate under specific exposure environments
- Bioavailability=f (release potential)=f (speciation)
- Provide with context to leaching / release / extraction tests
- Provide with reliable basis for geochemical & groundwater modeling to be relevant (realistic)
- Provide with reliable environmental forensics context

13

State-of-the-art geoenvironmental characterization

traditional

- Traditional geotechnical analyses (e.g., particle size distribution, γ, w/c)
- Physicochemical analyses (e.g., pH, TA)
- Controlled pH extraction tests (*TCLP*, Synthetic Precipitation Leaching Procedure, *SPLP*, Sequential Extraction Test (*SET*), etc.) *coupled with*

State-of-the-art

- Quantitative mineralogical analyses (*X-ray Powder Diffraction, XRPD* combined with *Rietveld Quantitative Analysis, RQA*)
- Micromorphological (Scanning Electron Microscopy-Energy Dispersive Spectroscopy, SEM-EDS and / or Electron Probe Micro-Analysis, EPMA) and other contaminant speciation analyses (*X-Ray Absorption Near-Edge Structure, XANES* and / or *Extended X-ray Absorption Fine Structure, EXAFS* or other newly developed techniques) should be used once a more in-depth assessment is required

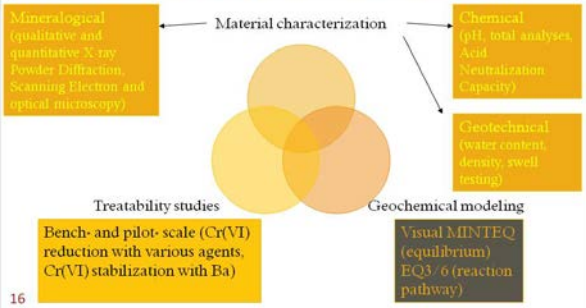
14

Contaminant Speciation-Based Assessment

- ***High fines content → availability of soil sorption sites → contaminant immobilization***
- ***Amount of fines ≠ amount of clay*** → other minerals (feldspars and other non-clay and non-reactive fines that would likely not significantly affect contaminant leaching) may contribute to the fine fraction (Mitchell, 1993).
- Soil mineralogy (XRPD) → verify and quantify the presence of active clays and amorphous and/or poorly crystallized metal oxides and hydroxides that would contribute to contaminant immobilization (Dermatas et al., 2006a) → ***XRPD complements conventional particle size distribution testing***
- ***Contaminant speciation analyses*** can be, and usually are, ***much more intricate*** then the simple example provided. They may ***involve sophisticated quantitative and/or qualitative tools*** such as ***XRPD with RQA***, SEM-EDS, ***XANES, EXAFS***, etc.
- ***Contaminant speciation*** → reliable ***input to geochemical models*** (e.g., PHREEQC and MINTEQ), to evaluate whether the system is at equilibrium or transient and to create different scenarios and project how contaminant speciation and availability, will change with time → ***sustainability***

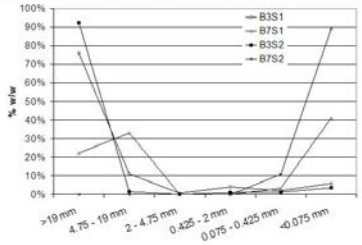
15

Methodology to determine sustainable treatment



16

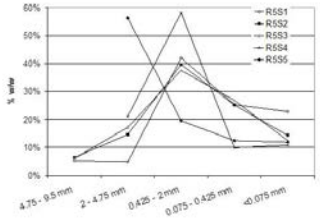
Grain-size distribution vs. total Pb analyses for firing range soils



>70% of the total Pb is present in the gravel fraction in B3 soil and >50% in the surface B7 soil
-> "cushioning" effect due to presence of clay

17

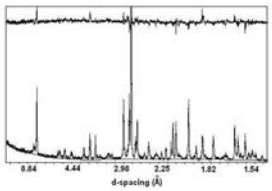
Grain-size distribution vs. total Pb analyses for firing range soils



- >50% of total Pb present in the fine sand and clay fractions (<0.425 mm)
- -> use of high velocity weapons leads to significant bullet fragmentation
- Use of angular sand to construct implies ricochet effects that, in turn, lead to a broad impact area surrounding the berm

18

XRPD quantitative analysis



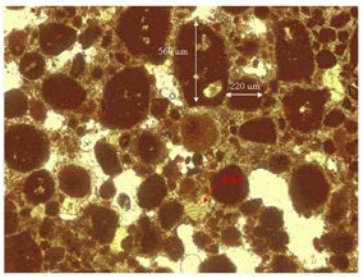
Rietveld-produced XRPD pattern and residual plot for an SA7-GB sample

Rietveld method:

- Production of a synthetic X-ray Diffraction pattern to match the experimental as closely as possible
- Least-square fitting algorithm for residual function
- Rarely used for multiphase systems because of pattern complexity
- Is the ONLY statistically reliable analysis method to determine bulk mineralogy

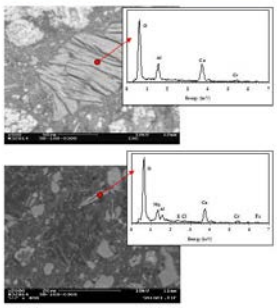
19

Optical microscopy image of GB COPR



20

SEM/EDX analyses



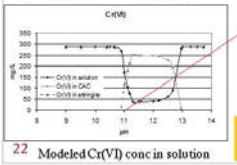
Two types of crystals identified

1. Large crystals (>20 µm diameter)
   Form mostly on rims of nodules
   Perfect basal cleavage
   Only Ca, Al and Cr in approx. 4:2:1 stoichiometry
   -> CAC
2. Small crystals in interior of cementing matrix Some with basal cleavage
   Extensive Mg for Ca substitution
   Mixed anions S (sulfate), Cl (chloride), Cr (chromate)
   -> hydrotalcite-like compound

21

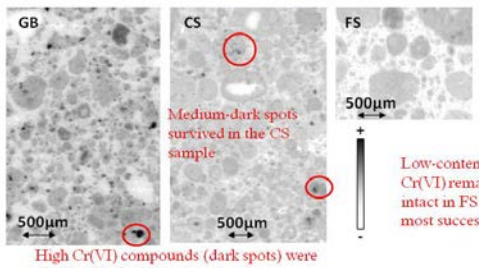
Implications for treatment

CAC-bound Cr(VI)	Matrix-bound Cr(VI)
CAC area Accessible to chemicals (acid, sulfate)	XRPD patterns of ANC residues at various pH values
pH <11 Cr(VI) released	Hydrotalcites are stable at lower pH values
FASTER RELEASE	Access to cementing matrix for acid or sulfate more difficult
	SLOWER RELEASE



22 Modeled Cr(VI) conc in solution

Cr(VI) maps using µXRF



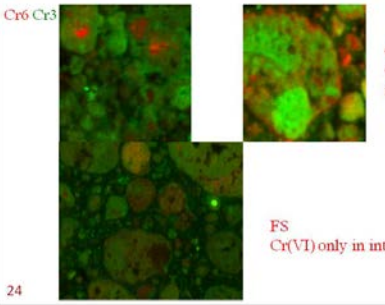
Medium-dark spots survived in the CS sample

Low-content Cr(VI) remained intact in FS BUT most successful

High Cr(VI) compounds (dark spots) were dissolved by both treatments
BUT significant residual Cr(VI) in both samples

23

Cr(VI) location using µXRD

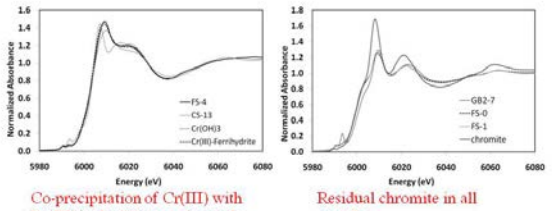


CS
Cr(VI) both on rin and interior of nodules

FS
Cr(VI) only in interior of nodules

24

Cr(III)-bearing compounds using point XANES analyses

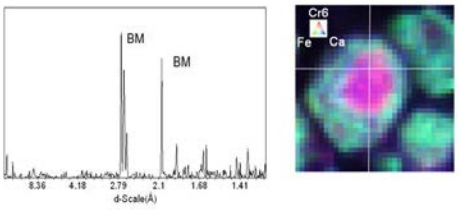


Co-precipitation of Cr(III) with Fe(III) in the FS-treated sample $Cr(OH)_3$ in the CS sample

Residual chromite in all samples

25

Low Cr(VI) compounds using point XANES and µXRD



µXRD of FS point

Physical or chemical inclusion of Cr(VI) in parent unreacted brownmillerite

26

Field methods

- Sampling undisturbed / disturbed →
  - At least preserve sample-based layering profile
  - Avoid cross contamination (is this really possible without associated major cost?)
  - Limitations are cost-associated (too many samples), cross contamination, sample preservation-→ R&D opportunities
- Penetration testing (CPT, SPT, etc.)
  - Relatively inexpensive and fast provide with continuous record
  - Instrumented with sensors for non-destructive (ND) testing (similar to down-hole survey). Major limitation is mechanical disturbance of sediment

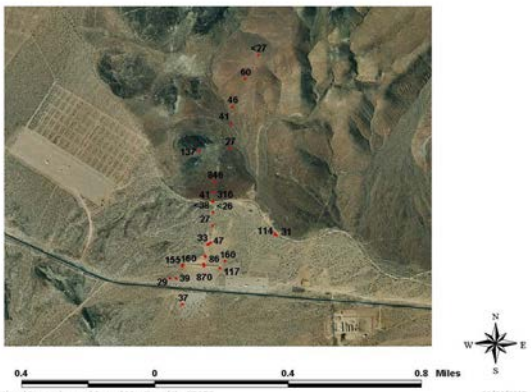
27

Field methods (cont'd)

- Geophysical:
  - ND, inexpensive but cannot be used alone (that's the major limitation)
  - Need more R&D to establish link between geophysical & traditional (sampling & testing)→ R&D opportunities
  - Still advocate combination of geophysical and traditional
- Other non-destructive:
  - Field XRF screening is an excellent tool
  - New laser-based (limitation of depth of penetration field; good for down-hole survey)→ R&D opportunities
  - Very high emergence rate of new technologies!! R&D opportunities

28

Plot of Lead Concentration From XRF Field Screening



29

Lab methods issues

- Sample preparation: Needs to be standardized especially for XRPD, EPMA, etc. (ASTM?)
- Material characterization analyses (traditional mostly geotech, XRPD-Rietveld, SEM-EDS, EPMA, etc.)
  - Need to accurately and reliably establish standard error involved across different samples (same medium) and then across contaminant media → Traditional QA/QC has been overcome by sample variability issues
- Traditional batch, leach/extraction tests (e.g., SET, etc.) → Problematic as contaminant speciation is altered during the test
  - Batch adsorption isotherm testing lamps sorption and precipitation together
  - SET tests are case-specific
  - Acid-based leaching/extraction tests are problematic for oxy-anion testing
  - Total analyses non-reliable either due to strong mineral associations or presence of reductant/treatment agent, etc. that would alter the contaminant speciation during the test

30

Lab methods issues (cont'd)

- ND (high energy → high sample penetration field (SPF); Synchrotron-based, i.e., XANES (X-ray Absorption Near-Edge Spectroscopy) or XFS(X-ray Fluorescence Spectroscopy))
  - Example AD results versus XANES results
  - Difficult to gain access
  - XFS is difficult to interpret (art form)
- Emerging ND (lower energy → low SPF; e.g., Time of Flight, Secondary Mass Spectrometer (TOF-SIMS), XPS, plus others usually laser-based → good for ONLY surface (1-10nm to molecular monolayer to sub-atomic penetration levels)
  - Need to "ground truth them" w.r.t. XANES and more traditional analyses
- A great (if not huge!) score of unresolved issues → opportunities for international R&D collaborative projects

31

Broader unresolved issues

- Link of measurement to pathway to receptors?
- Reliability of measurement
- Sample variability & variability in general
- Point-in-time measurements → changes with time
- Public perception of risk (politics)
- See the tree but miss the forest? (COPR Ba-treatment, use of flyash or CKD or fishbone or red mud, etc. → waste combination)
- Sustainability? (Phosphates and Pb)

32

Reliability of measurement

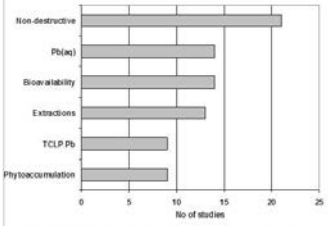
Table 1: Total Cr(VI) in six treatment plots as measured by XANES and alkaline digestion (AD)

	Ferrous sulfate heptahydrate dosage	%w/w*	Cr(VI) XANES (mg/kg)	Cr(VI) AD(mg/kg)	Ratio (XANES-to-AD)
HRM-5X			2100	1240	1.7
HRM-8X	5X	32	1848	1260	1.5
VA-5X (0-2m)	8X	51	588	154	3.8
VA-5X (2-4m)	5X	38	1685	460	3.7
PUG-5X	5X	32	1116	384	2.9
PUG-8X	8X	51	1656	421	3.9

- *XANES analyses* of S/S chromate waste → alkaline digestion *(AD) results underestimated the total Cr(VI) by a factor on the order of 1.5 to 4.0*
- Reasons for this discrepancy may be that residual ferrous reduced the liberated Cr(VI) during AD and/or that Cr(VI) was not 100% released from the solid during AD
- *Discrepancy between XANES and AD* results renders *AD unreliable for regulatory purposes*, when applied to ferrous-treated chromate waste (Dermatas et al. 2006d; Moon et al. 2007).

33

Geoenvironmental Characterization of Phosphate-Amended Pb-Contaminated Soils



Distribution of criteria and methods used to evaluate treatment performance in treatability and field studies (Chrysochoou et al. 2007)

The use of *EXAFS* clearly demonstrated that the *success and sustainability of applying phosphate as a Best Management Practice (BMP)* (USEPA, 2001) in firing range soils and other Pb contaminated solid media *remain questionable*

EXAFS (the only reliable method to identify and quantify Pb speciation in this case) showed that *Pb conversion to pyromorphite* in in-situ treated soils was *less than 45% after 32 months* (Chrysochoou et al. 2007)

34

Bottom line (instead of conclusions)

- Without *definitive knowledge of contaminant speciation and immobilization mechanisms*, remediation treatment design becomes unreliable in attaining *long-term treatment goals in terms of performance and overall sustainability*
- There have been many cases where *remediation treatment that appeared to be initially successful*, ended up *failing in the near or long term* (Dermatas et al. 2003). Moreover, lack of knowledge on immobilization mechanisms often leads to *remediation over-treatment* along with the associated *waste of energy and resources*

35

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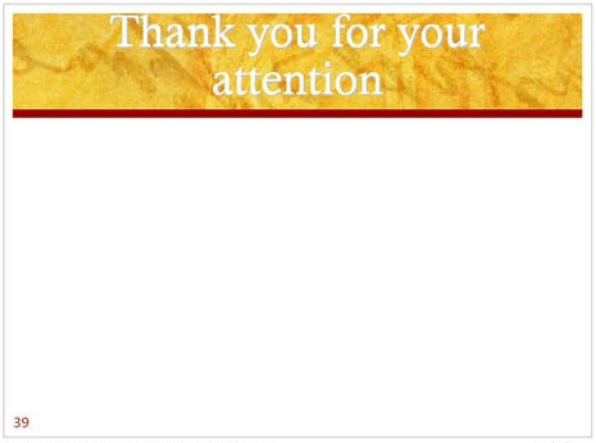
Thank you for your attention
39
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FROM BROWNFIELD TO BRIGHTFIELD. REVITALIZING AND RE-POWERING DERELICT LAND IN FLANDERS

Eddy Wille

Outline of the presentation

- Industrial activities and soil contamination in Flanders
- Frameworks to remember
- 'Multi' as a key to sustainable solutions and results
- Brownfield redevelopment and revitalization

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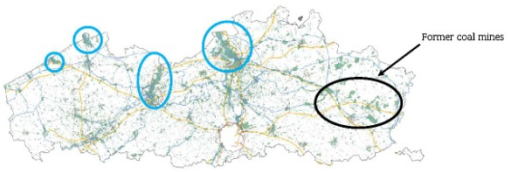
Industrial activities on regional scale (Flanders)



Land Information Register (OVAM) :

- Approx. ca. 34.000 locations investigated; approx. 2.700 remediations completed;
- Estimated risk locations : 85.000 (12.000 sites potentially require remedial actions);
- Links to industrial axes, harbours, mining areas.

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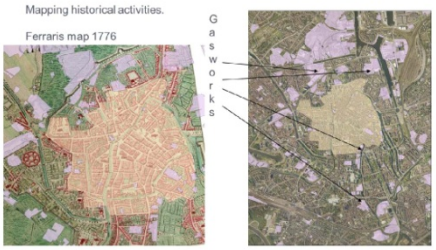
Industrial activities on local scale (Ghent)



Industrial activities are situated nearby the historical city center. E.g. former gasworks are close to the border of the center of 1776 and in the vicinity of waterways. Currently embedded in residential areas.

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Framework and objectives on soil remediation

Legislation

- Soil Remediation Act of 22 February 1995
- Soil Act of 27 October 2006

Aims of the Soil remediation Act

- To deal with soil contamination that has taken place in the past, over a period of 40 years, starting in 1996
- To prevent or immediately remedy new soil pollution

Tiered approach :

- investigating the problem
- risk analysis
- design of a remedial action plan
- tendering
- executing the remediation works
- Monitoring / aftercare

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Industrial activities and remediation:

getting started and searching dynamic processes.

Closure and remediation of a former steel cokes manufacturing plant. Full demolition. No conservation due to high pollution (PAHs, heavy metal,...).

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Industrial activities and remediation.

- more than 3.000.000 soil certificates are delivered
- 34.179 preliminary soil investigations are evaluated
- 12.548 descriptive soil studies are evaluated
- 4.494 soil remediation projects are approved
- 4.085 soil remediation works have been started and about 2.785 have already been finished

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Industrial activities and remediation.

General conclusions:

- particular large contaminated sites were selected and a specific remediation programme was developed (mines, gasworksites);
- focus on the contamination and the remedial actions / cleaning;
- first steps to an integrated approach by combining soil remediation and the redevelopment of the site;
- limited interest for the site in its broader spatial, economic and societal environment;
- limited multi-actor governance and essentially restricted to environmental issues and public actors (environmental and scientific steering committee installed for coal mines);
- brownfields remain often unaddressed and have adverse influence on neighbourhood;
- recommendations resulted in a specific legal instrument on brownfield redevelopment in Flanders.

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Brownfieldcovenant Act

March 22, 2007

Definition of brownfield :

- former abandoned or under-used industrial site
- (perceived) soil contamination
- redevelopment is a complex process
- active potential for reuse

Advantages :

- single contact point (Agency for Entrepreneurship)
- negotiator appointed by the Government
- guided participation process
- integrating multiple governmental permits
- follow-up and monitoring by steering committee
- tax reduction (10%) at land acquisition
- no financial guarantee on soil remediation
- covenant : signed agreement

Results (September 2015) :

- 6 calls -> 146 proposals introduced
- 70 signed covenants
- 1.250 ha redeveloped

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Governance and roadmap to redevelopment

The Regional Brownfield Committee (RBC) of Flanders plays a major role in policy-preparation and negotiation of brownfieldcovenants. The RBC is assisted by 3 negotiators (appointed by the Flemish government, March 2009). After approval and signing of the convenants, the negotiator become chairman of the steering committee.

Roadmap to brownfield redevelopment :

- Call for projects (RBC);
- Evaluation of proposals (governmental agents);
- Official publication of project zone (Belgian State Journal);
- Negotiation phase of individual projects (projectplatform);
- Public information sessions and publication on website;
- Covenant signed by Flemish government;
- Steering committee installed to monitor implementation

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Multiple aspects to manage: the quadruple helix model

The success of realizing complex projects such as town redevelopment and brownfield revitalization depends on the effectiveness of the integration of various parameters. This consists of a stepwise process of connection, building awareness, need of urgency, mutual trust-building and learning.

The Quadruple Helix is a user-oriented innovation approach and suitable for our purpose. It symbolizes the interlinkage between multiple aspects and encodes the instructions for a successful future.

- the Quadruple Helix model encourages to reflect on multiple possible dynamics in various systems;
- collection of potentially relevant data;
- bringing stakeholders together;
- development of relevant indicators.

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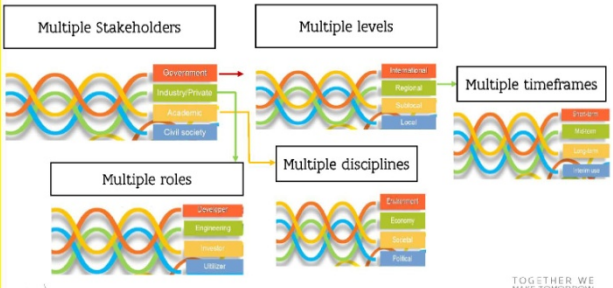
Multiple aspects to manage: the quadruple helix model



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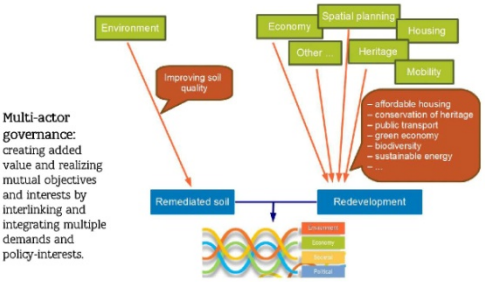
Multiple aspects to manage: the quadruple helix model



Multi-actor governance: creating added value and realizing mutual objectives and interests by interlinking and integrating multiple demands and policy-interests.

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Integrated approach on a site and regional scale (Ghent region)

From Brownfield to Brightfield. Terranova project – Harbour Ghent

- Former fertilizer production plant;
- Bankruptcy in 2009;
- 85 ha of gypsum waste landfill;
- Height : 30 – 40 meter;
- Approx. 25 million m³ of waste;
- Hydraulic transported to landfill:
- Pond containing 'water' at pH 1,5;
- Recent ponds contained by HDPE;
- Total landfill hydrogeological isolated by pumping system;
- Precautionary measures by OVAM;
- Brownfields redevelopment started after acquisition in 2010.

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From Brownfield to Brightfield. Terranova project – Harbour Ghent

The total project is split in to two autonomous projects:

Project CR²
- 40 ha
- Soil and groundwater remediation
- Sediment treatment center
- Redevelopment and sale of the site

Project Terranova
- 85 ha
- Groundwater remediation
- Landfill
- Solar energy plant

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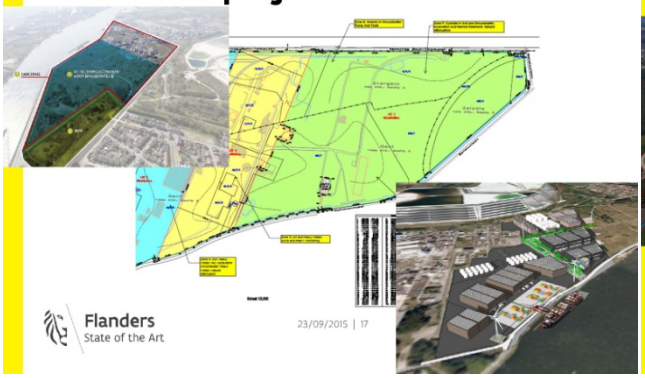
From Brownfield to Brightfield. Terranova project – Harbour Ghent



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From Brownfield to Brightfield. Terranova project – Harbour Ghent

Treatment of acid water

Capping of the gypsum

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From Brownfield to Brightfield. Terranova project – Harbour Ghent

Capping, installing drainage, final cover

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From Brownfield to Brightfield. Terranova project – Harbour Ghent

Construction of a 16,5 MegaWatt/year Solar Energy Plant :

- 56.000 panels
- average consumption of 4.000 households

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From Brownfield to Brightfield. Terranova project – Harbour Ghent

33.000 screw pillars each of 1,2 meter lenght

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From Brownfield to Brightfield. Terranova project – Harbour Ghent

Multi modal site:

- Waterway;
- Highway;
- Railway;
- High pressure pipeline LNG;
- High voltage power line.

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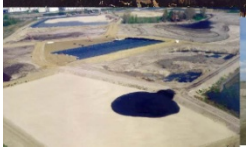
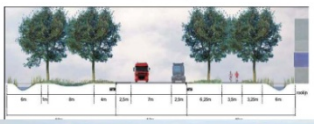
Brownfieldproject Eilandje - Ghent



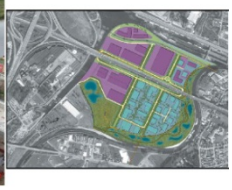
Former landfill site
Remediation method: containment

Redevelopment opportunities:
- vicinity city centre of Ghent;
- multimodal access;
- motorways E40 and E17;
- Scheldt river, canal Ringvaart;
- connection with harbour of Ghent

Brownfieldproject Eiland - Ghent



Redevelopment as research park and logistic facilities (35 ha) combined with new park area (12 ha)



Brownfieldproject La Floridienne – Ghent

The La Floridienne-site is an abandoned industrial site of 10 hectare at Ghent Harbour. Till 1960, the company produced metal salt such as zinksulphate and leadchloride, but also cyanidesalts. Soil and groundwater were heavily contaminated with arsenic and cyanides.
The remediation plan was a combination of containment, immobilisation and groundwater treatment. An important part of the vertical barriers were also functional as a quay of the new dock.

Brownfieldproject La Floridienne – Ghent

Thanks for your attention and enjoy the coming sessions

Eddy WILLE, negotiator & representative
Flemish government

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Bartel De Clercq, De.Clercq.Bartel@deme.be (Deme / DEC)

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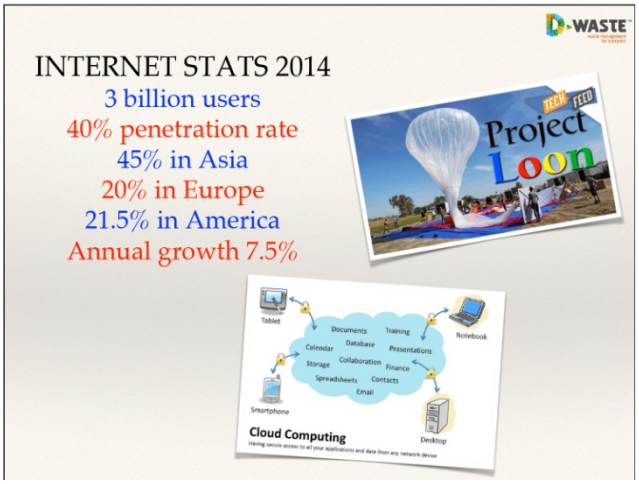
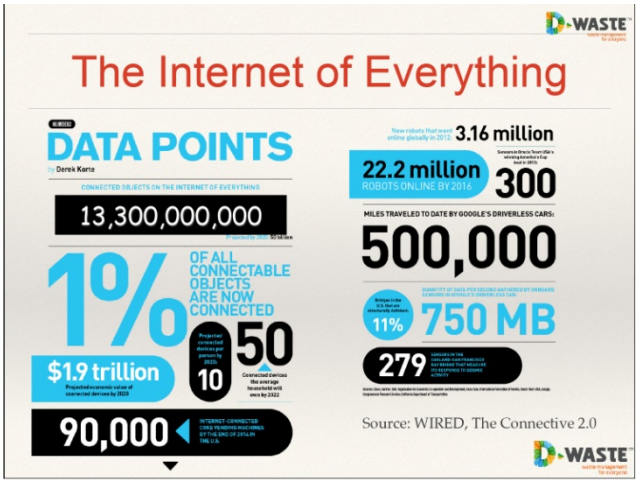
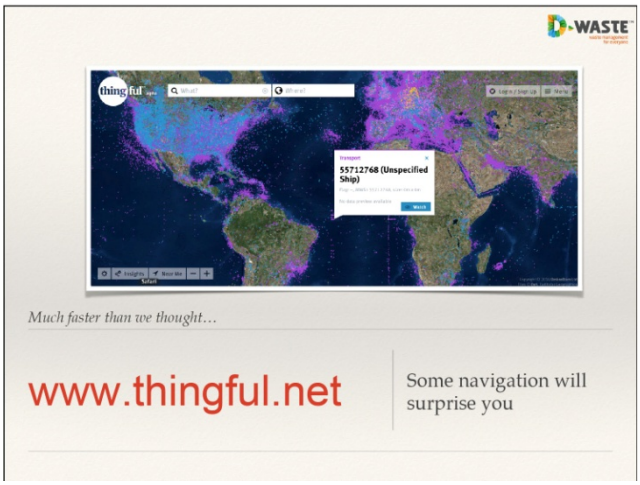
info@ovam.be

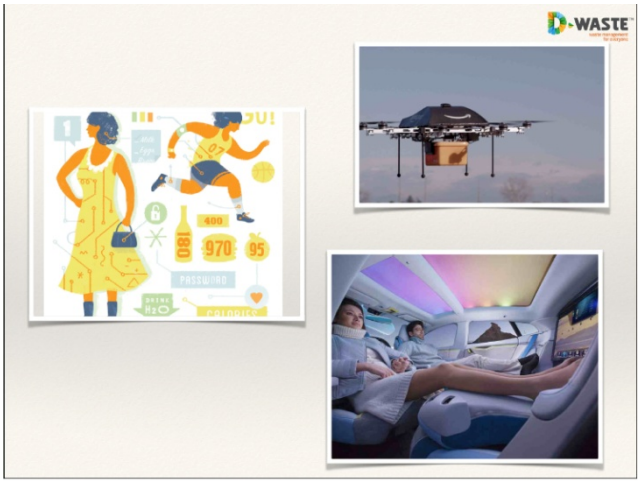
INTERCONNECTIVITY AND THE FUTURE OF WASTE MANAGEMENT

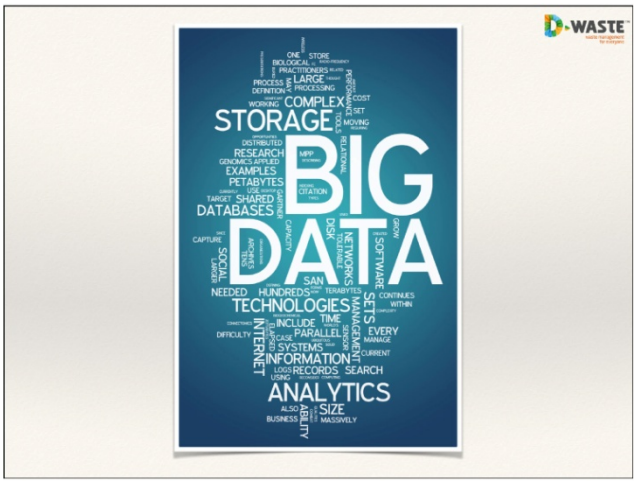
A. Mavropoulos







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SHARED
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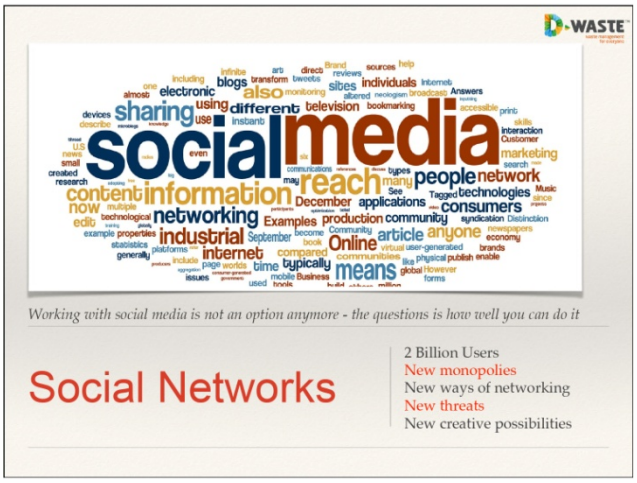
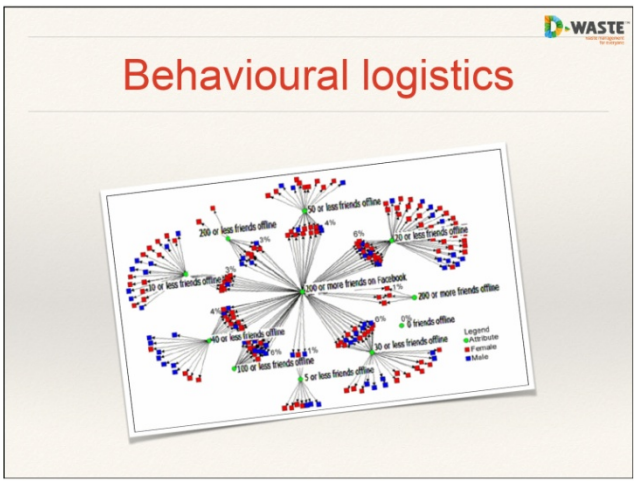
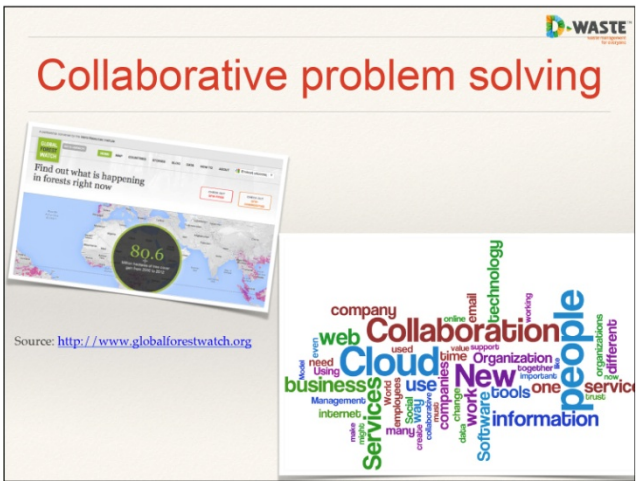

WASTE
social media
sharing
electronic
also
different
television
individuals
blogs
content
information
reach
people
network
networking
industrial
internet
Online
means
Working with social media is not an option anymore - the questions is how well you can do it
Social Networks
2 Billion Users
New monopolies
New ways of networking
New threats
New creative possibilities


WASTE
Human Social Networks


WASTE
From Smart to Engaged Cities
REACTIVATE ATHENS
Citizens Connect
New Report
Recent
My Reports
Favorites
Tweets
Reporter


WASTE
Behavioural logistics
50 or less friends offline
200 or less friends offline
20 or less friends offline
100 or more friends on Facebook
290 or more friends offline
40 or less friends offline
10 or less friends offline
100 or less friends offline
5 or less friends offline
0 friends offline
Legend
Attribute
Female
Male

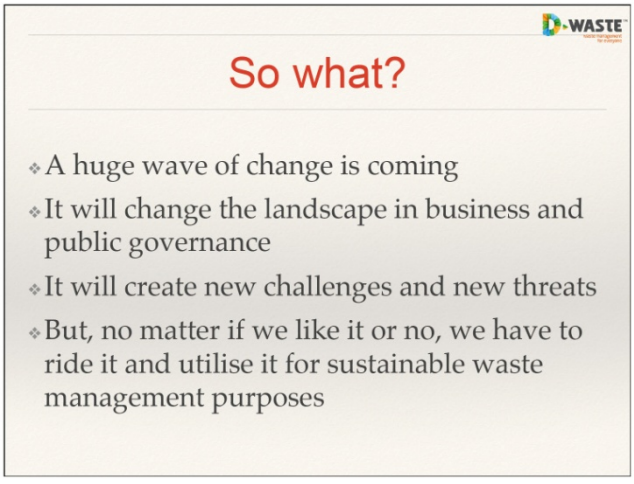

WASTE
Collaborative problem solving
Find out what is happening in forests right now
80.6
Source: http://www.globalforestwatch.org
company
Collaboration
technology
web
Cloud
business
Services
people
New
information
Software
tools
Organization


D-WASTE
the future is here
eWAS project, Seville
Sensors, mobile apps and optimisation of logistics in a single package


D-WASTE
We are in the middle of a shift…


D-WASTE
But we need one more shift…
GOOD NETWORKS
NETWORKS
INTERACTIONS


D-WASTE
Future comes faster than we think…


D-WASTE
So what?
A huge wave of change is coming
It will change the landscape in business and public governance
It will create new challenges and new threats
But, no matter if we like it or no, we have to ride it and utilise it for sustainable waste management purposes


D-WASTE
Thanks for your attention
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