



MINING the  
EUROPEAN  
ANTHROPOSPHERE



# Country report - Denmark

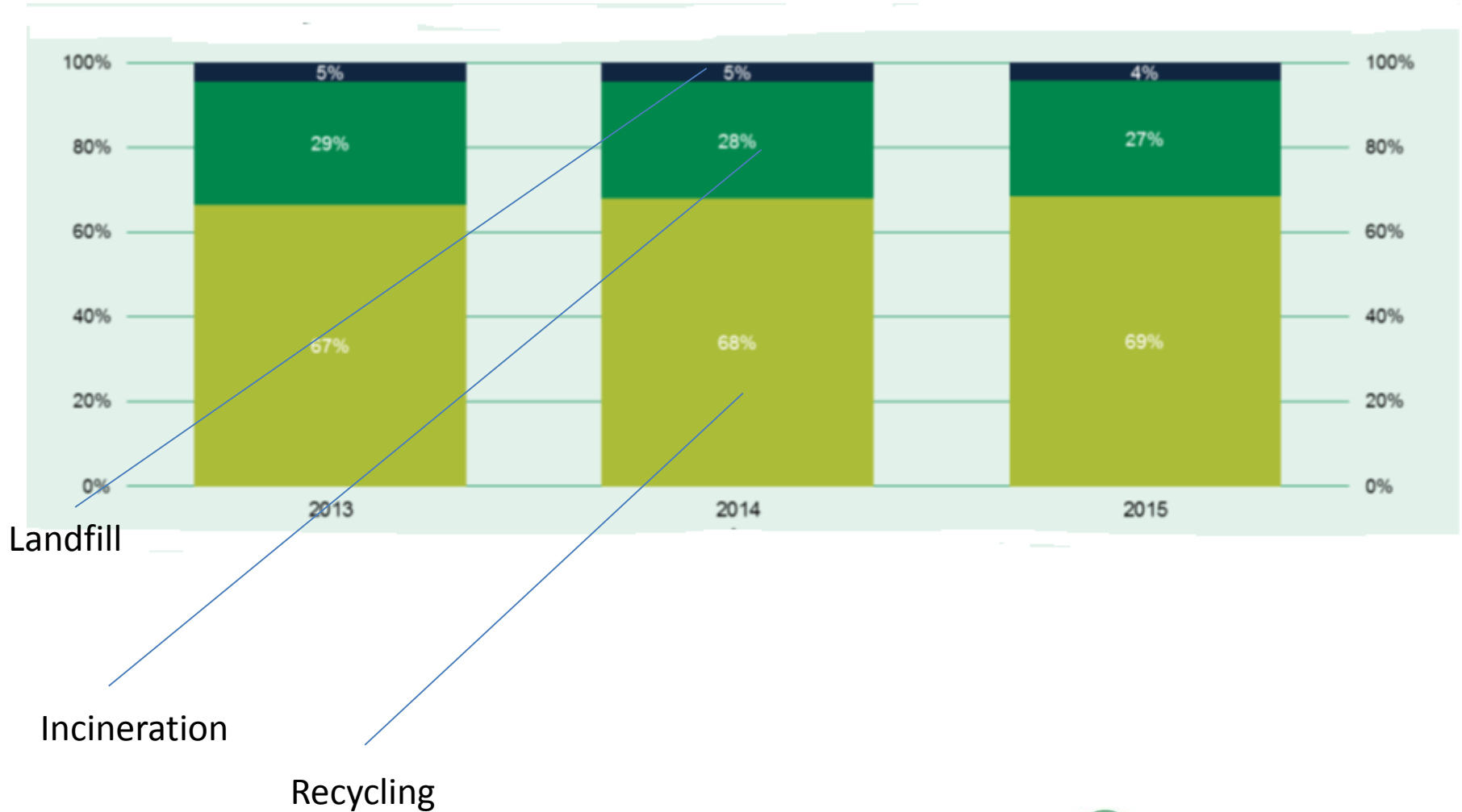
## René Møller Rosendal

WG 2 meeting in Tallinn, Estonia 9-11 August

# MSW generation and treatment

	2013		2014		2015	
	Tons (1.000)	Procent	Tons (1.000)	Procent	Tons (1.000)	Procent
Recycling	7.312	66 %	7.784	67 %	7.710	68 %
Incineration	3.085	28 %	3.081	27 %	2.987	26 %
Landfill	474	4 %	474	4 %	423	4 %
Temp. storage	109	1 %	96	1 %	74	1 %
Special Treatment	76	1 %	102	1 %	114	1 %
	11.056	100 %	11.536	100 %	11.307	100 %

# MSW generation and treatment



# Waste policy and regulatory frameworks

- Present an overview of the main policies and regulations influencing the management of MSW and landfills in your country
  - EU waste and landfill directives
    - If applicable, also give examples of specific policy instruments aiming to improve the management of MSW and/or reduce the amount of landfilling?
  - Landfill tax (1987)
  - Ban on landfilling of combustible/organic waste (1997)
- Describe the regulatory and gate requirements for the most important MSW treatment options available in your country
  - Acceptable criteria/limit values in terms the chemical and/or physical properties of the waste (could involve both regulatory and industry requirements)
  - Related costs (e.g. gate fees) or revenues for the waste producer/owner

- Inert Waste IA0, IA1, IA2
- Non-hazardous (mix waste and mineral waste)
- Hazardous Waste (FA0, FA1, FA2, FA3)
- Dependent on the location of the landfill

Anlægsfaktoren (AF) beregnes af følgende ligning:

$$AF = (DA \times FK_i) / (SA \times \text{Aktuel fortynding})$$

hvor:

DA: Det aktuelle deponeringsareal i m<sup>2</sup>, for både deponeringsenheder der er nedlukket efter den 16. juli 2001 samt enheder i drift.

FK<sub>i</sub>: Minimumsfortyndningen i overfladevandområdet, jf. tabel 3.13.

SA: Standardareal anvendt ved beregning af grænseværdier = 10.000 m<sup>2</sup>.

Aktuel fortynding: Fortyndingskapaciteten 5% minimumsfortynding i det marine vandområde ved deponeringsanlægget – udtrykt i antal gange.

**Grænseværdi for faststofindhold af organiske stoffer i inert affald.**

Parameter	Grænseværdi (i mg/kg TS)
TOC (Total organisk kulstof)	3 % <sup>1)</sup>
BTEX (Benzen, toluen, ethylbenzen og xylener)	6, heraf benzen max. 1,5
PCB (Polyklorerede bifenyler) <sup>2)</sup>	1
Sum af kulbrinter (C6 – C40)	150
PAH (Polycykliske aromatiske kulbrinter) <sup>3)</sup>	4
Naphthalen	0,5

**Grænseværdier for udvaskning fra affald til deponering på ikke kystnære deponeringsanlæg for inert affald i Klasse IA0.**

Stof/Parameter	Grænseværdi, L/S = 2 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi, L/S = 10 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi for C <sub>0</sub> <sup>1)</sup> (mg/l)
<b>Sporelementer/metaller</b>			
Arsen (As)	0,10	0,50	0,060
Barium (Ba)	7,0	20	4,0
Cadmium (Cd)	0,030	0,040	0,020
Krom total (Cr)	0,20	0,50	0,10
Kobber (Cu)	0,90	2,0	0,60
Kviksølv (Hg)	0,0030	0,010	0,0020
Molybdæn (Mo)	0,30	0,50	0,20
Nikkel (Ni)	0,20	0,40	0,12
Bly (Pb)	0,20	0,50	0,15
Antimon (Sb)	0,020	0,060	0,010
Selen (Se)	0,060	0,10	0,040
Zink (Zn)	2,0	4,0	1,20
<b>Salte, phenolindex og DOC</b>			
Klorid (Cl <sup>-</sup> )	550	800	460

Fluorid (F <sup>-</sup> )	4,0	10	2,5
Sulfat (SO <sub>4</sub> <sup>2-</sup> )	560	1.000	1.500
Phenolindex	0,50	1,0	0,30
DOC	50	140	30

<sup>1)</sup> Grænseværdier angivet med »fed« og »kursiv« skrifttype er sammenfaldende med grænseværdierne for deponering af inert affald i EU-Rådsbeslutningen (2003/33/EF).

Grænseværdier for udvaskning fra affald til deponering på kystnære deponeringsanlæg for inert affald i Klasse IA1 - dvs. med »Anlægsfaktor  $\leq 0,5$ «.

Stof/Parameter	Grænseværdi, L/S = 2 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi, L/S = 10 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi for C <sub>0</sub> <sup>1)</sup> (mg/l)
<b>Sporelementer/metaller</b>			
Arsen (As)	0,10	0,50	0,060
Barium (Ba)	7,0	20	4,0
Cadmium (Cd)	0,030	0,040	0,020
Krom total (Cr)	0,20	0,50	0,10
Kobber (Cu)	0,90	2,0	0,60
Kviksølv (Hg)	0,0030	0,010	0,0020
Molybdæn (Mo)	0,30	0,50	0,20
Nikkel (Ni)	0,20	0,40	0,12
Bly (Pb)	0,20	0,50	0,15
Antimon (Sb)	0,020	0,060	0,10
Selen (Se)	0,060	0,10	0,040
Zink (Zn)	2,0	4,0	1,20
<b>Salte, phenolindex og DOC</b>			
Klorid (Cl <sup>-</sup> )	550	800	460
Fluorid (F <sup>-</sup> )	4,0	10	2,50
Sulfat (SO <sub>4</sub> <sup>2-</sup> )	560 <sup>2)</sup>	1.000 <sup>2)</sup>	1.500
Phenolindex	0,50	1,0	0,30
DOC <sup>3)</sup>	240	500	160





Grænseværdier for udvaskning fra affald til deponering på kystnære deponeringsanlæg for inert affald i Klasse IA2 - dvs. med »0,5 ≤ Anlægsfaktor ≤ 1,0«.

Stof/Parameter	Grænseværdi, L/S = 2 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi, L/S = 10 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi for C <sub>0</sub> <sup>1)</sup> (mg/l)
<b>Sporelementer/metaller</b>			
Arsen (As)	0,10	0,50	0,060
Barium (Ba)	4,0	12	2,50
Cadmium (Cd)	0,030	0,040	0,020
Krom, total (Cr)	0,20	0,50	0,10
Kobber (Cu)	0,90	2,0	0,60
Kviksølv (Hg)	0,0030	0,010	0,0020
Molybdæn (Mo)	0,30	0,50	0,20
Nikkel (Ni)	0,20	0,40	0,12
Bly (Pb)	0,20	0,50	0,15
Antimon (Sb)	0,020	0,060	0,10
Selen (Se)	0,060	0,10	0,040
Zink (Zn)	2,0	4,0	1,20
<b>Salte, phenolindex og DOC</b>			
Klorid (Cl <sup>-</sup> )	550	800	460
Fluorid (F <sup>-</sup> )	4,0	10	2,50
Sulfat (SO <sub>4</sub> <sup>2-</sup> )	560 <sup>2)</sup>	1.000 <sup>2)</sup>	1.500
Phenolindex	0,50	1,0	0,30
DOC <sup>3)</sup>	240	500	160



**Grænseværdier for udvaskning fra affald til deponering på ikke kystnære deponeringsanlæg for farligt affald i Klasse FA0.**

Stof/Parameter	Grænseværdi, L/S = 2 l/kg (mg/kg TS)	Grænseværdi, L/S = 10 l/kg (mg/kg TS)	Grænseværdi for C <sub>0</sub> (mg/l)
<b>Sporelementer/metaller</b>			
Arsen (As)	0,080	0,37	0,043
Barium (Ba)	10	30	6,0
Cadmium (Cd)	0,090	0,14	0,070
Krom total (Cr)	0,39	1,1	0,23
Kobber (Cu)	6,8	15	4,4
Kviksølv (Hg)	0,012	0,051	0,0064
Molybdæn (Mo)	0,52	1,0	0,36
Nikkel (Ni)	0,25	0,53	0,16
Bly (Pb)	0,32	0,72	0,21
Antimon (Sb)	0,025	0,08	0,014
Selen (Se)	0,21	0,39	0,15
Zink (Zn)	2,4	5,3	1,6
<b>Salte og DOC</b>			
Klorid (Cl <sup>-</sup> )	2.300	3.300	1.900
Fluorid (F <sup>-</sup> )	15	38	9
Sulfat (SO <sub>4</sub> <sup>2-</sup> )	3.100	6200	2.200
DOC <sup>1)</sup>	100	280	60

<sup>1)</sup> Hvis affaldet ikke opfylder disse værdier for opløst organisk kulstof (DOC) i testen uden styring af pH, kan det som alternativ testes ved L/S = 10 l/kg og en fastholdt pH-værdi på mellem 7,5 og 8,0. Affaldet anses for at opfylde modtagelseskriterierne for DOC, hvis resultatet af denne prøve ikke overstiger 280 mg/kg.

Grænseværdier for udvaskning fra affald til deponering på kystnære deponeringsanlæg for farligt affald i Klasse FA1 - dvs. med »Anlægsfaktor  $\leq 0,16$ «.

Stof/Parameter	Grænseværdi, L/S = 2 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi, L/S = 10 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi for C <sub>0</sub> <sup>1)</sup> (mg/l)
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<b>Sporelementer/metaller</b>			
Arsen (As)	6,0	25	3,0
Barium (Ba)	100	300	60
Cadmium (Cd)	3,0	5,0	1,7
Krom total (Cr)	25	70	15
Kobber (Cu)	50	100	60
Kviksølv (Hg)	0,50	2,0	0,30
Molybdæn (Mo)	20	30	10
Nikkel (Ni)	20	40	12
Bly (Pb)	25	50	15
Antimon (Sb)	2,0	5,0	1,0
Selen (Se)	4,0	7,0	3,0
Zink (Zn)	90	200	60
<b>Salte og DOC</b>			
Klorid (Cl <sup>-</sup> )	17.000	25.000	15.000
Fluorid (F <sup>-</sup> )	200	500	120
Sulfat (SO <sub>4</sub> <sup>-2</sup> )	25.000	50.000	17.000
DOC <sup>2)</sup>	480	1.000	320

Grænseværdier for udvaskning fra affald til deponering på kystnære deponeringsanlæg for farligt affald i Klasse FA2 - dvs. med » $0,16 \leq \text{Anlægsfaktor} < 0,31$ «.

Stof/Parameter	Grænseværdi, $L/S = 2 \text{ l/kg}^1$ (mg/kg TS)	Grænseværdi, $L/S = 10 \text{ l/kg}^1$ (mg/kg TS)	Grænseværdi for $C_0^1$ (mg/l)
<b>Sporelementer/metaller</b>			
Arsen (As)	6,0	25	3,0
Barium (Ba)	100	300	60
Cadmium (Cd)	3,0	5,0	1,70
Krom total (Cr)	12	35	7,0
Kobber (Cu)	30	70	20
Kviksølv (Hg)	0,50	2,0	0,30
Molybdæn (Mo)	20	30	10
Nikkel (Ni)	20	40	12
Bly (Pb)	25	50	15
Antimon (Sb)	2,0	5,0	1,0
Selen (Se)	4,0	7,0	3,0
Zink (Zn)	90	200	60
<b>Salte og DOC</b>			
Klorid (Cl <sup>-</sup> )	17.000	25.000	15.000
Fluorid (F <sup>-</sup> )	200	500	120
Sulfat (SO <sub>4</sub> <sup>2-</sup> )	25.000	50.000	17.000
DOC <sup>2)</sup>	480	1.000	320



Grænseværdier for udvaskning fra affald til deponering på kystnære deponeringsanlæg for farligt affald i Klasse FA3 - dvs. med  $\geq 0,31 \leq \text{Anlægsfaktor} \leq 1,0$ .

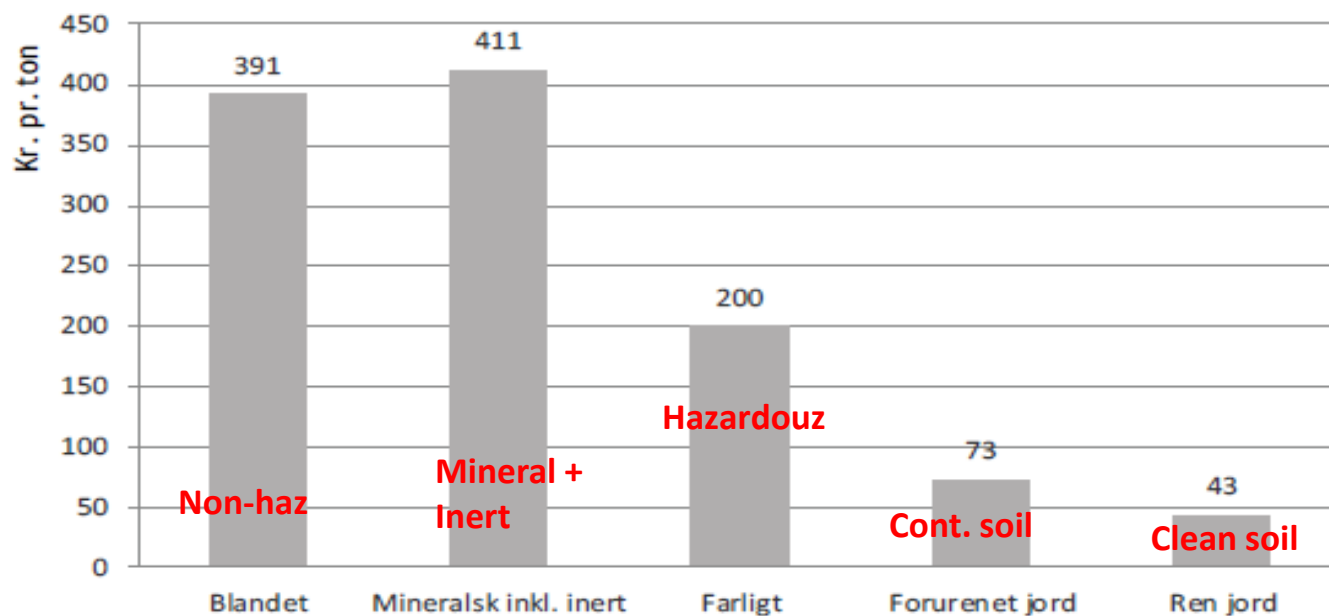
Stof/Parameter	Grænseværdi, L/S = 2 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi, L/S = 10 l/kg <sup>1)</sup> (mg/kg TS)	Grænseværdi for C <sub>0</sub> <sup>1)</sup> (mg/l)
<b>Sporelementer/metaller</b>			
Arsen (As)	6,0	25	3,0
Barium (Ba)	25	75	15
Cadmium (Cd)	3,0	5,0	1,70
Krom total (Cr)	3,5	10	2,5
Kobber (Cu)	25	55	17
Kviksølv (Hg)	0,50	2,0	0,30
Molybdæn (Mo)	20	30	10
Nikkel (Ni)	20	40	12
Bly (Pb)	25	50	15
Antimon (Sb)	1,0	3,5	0,6
Selen (Se)	4,0	7,0	3,0
Zink (Zn)	90	200	60
<b>Salte og DOC</b>			
Klorid (Cl <sup>-</sup> )	17.000	25.000	15.000
Fluorid (F <sup>-</sup> )	200	500	120
Sulfat (SO <sub>4</sub> <sup>2-</sup> )	25.000	50.000	17.000
DOC <sup>2)</sup>	480	1.000	320



Tabel 2: Takst pr. ton, ekskl. afgifter (uden sikkerhedsstillelse), 2008-2015, løbende priser

	2008	2009	2010	2011	2012	2013	2014	2015
<b>Mineral + Inert</b>								
Mineralsk inkl. inert	55	116	239	334	339	351	422	411
<b>Hazardous</b>								
Farligt	273	277	288	227	212	192	196	200
<b>Non-haz</b>								
Blandet	335	378	358	366	366	364	382	391
<b>Clean soil</b>								
Ren jord	-	-	-	21	22	30	44	43
<b>Cont. soil</b>								
Forurennet jord	-	-	-	64	64	69	73	73
Jord	68	72	56	-	-	-	-	-

Figur 8: Gennemsnitligt ventede takster pr. ton mængde affald, ekskl. afgifter (uden sikkerhedsstillelse), 2015



# Overview of available data on landfills

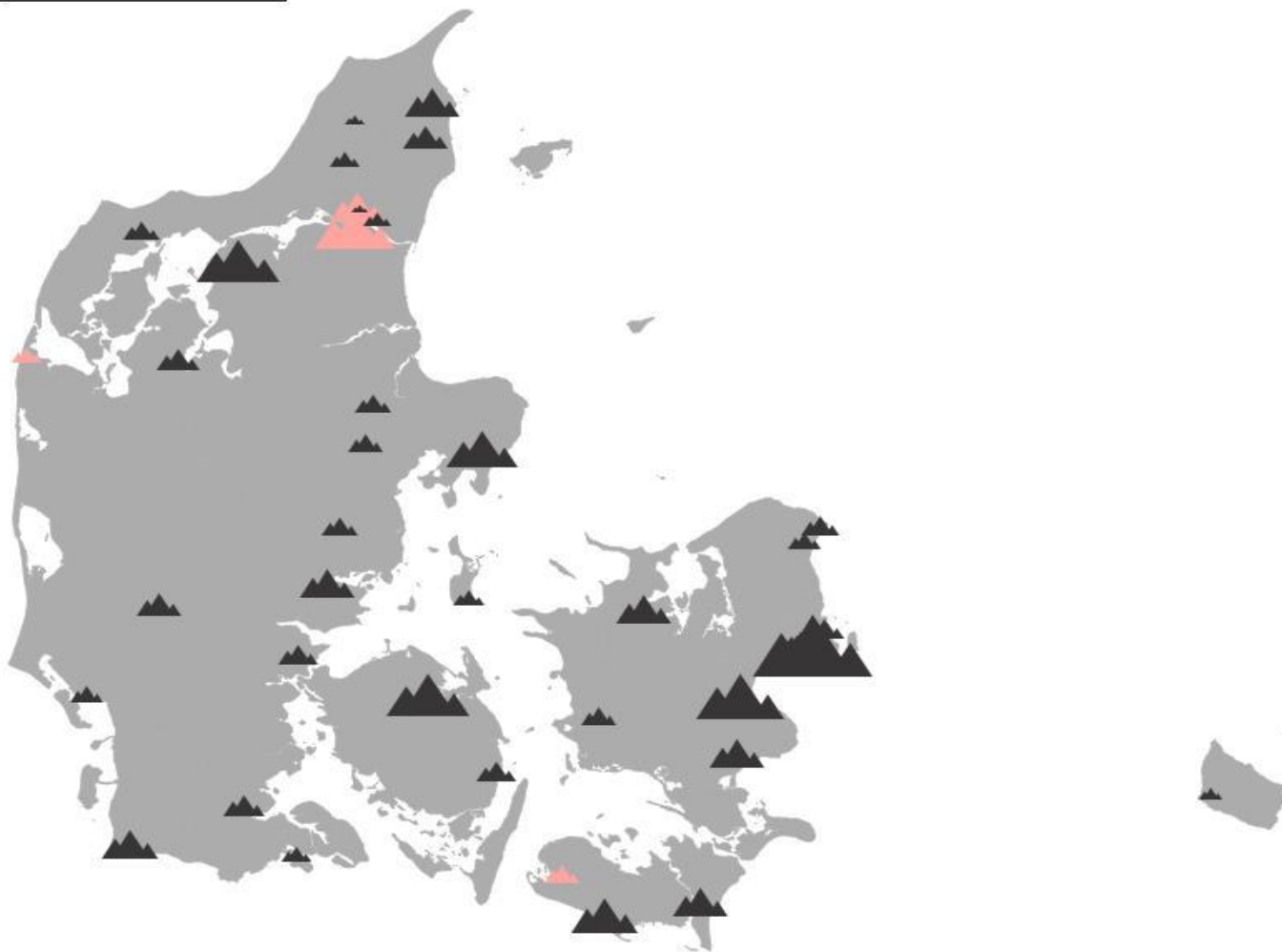
- Provide a brief overview of what type of data and information that is available on landfills in your country
  - Are there any national landfill surveys, reports, databases, etc. available in your country?
    - Waste Statistics (annual - but 1 year behind)
    - Annual benchmarking data on landfills and Incineration (since 2010)
  - Are there any specific investigations on occurrence and management of contaminated areas incl. landfills in your country?
    - Database but not very good
    - Locations are mapped on 2 levels - (V1 suspected) and (V2 actual contaminated)
    - Landfills are categorized as V2
  - Are there any other types of studies (e.g. case-specific investigations, research papers, etc.) involving complementary data/information about specific sites or groups of landfills?
    - A lot of data and specific investigation but they are stored case to case and depends on the public interest/prioritization by the Regions (mainly)

# Landfill situation

- Present the current landfill situation in your country with respect to:
  - Operational MSW landfills (sites containing a mix of MSW/Industrial wastes included)
    - 34 MSW landfill (owned by municipality)
    - 4 Industrial landfills (private owned)
    - 2 Landfills for contaminated soil
    - 2015: 724.000 MSW and 2.100.000 soil
  - Closed sanitary MSW landfills and non-sanitary MSW landfills
    - 3.200 registered as contaminated sites, and data are normally not very good.
    - We might know the location, age, old monitoring reports, drilling reports etc.
  - If applicable, indicate the number of landfills that currently are in aftercare treatment
    - Approximately 180 sites (within the 30 years)
  - Are there any national action plans for addressing health and environmental risks related to closed landfills (not eligible to the EU landfill directive)?
    - Need to be addressed according to surface water problems and we are currently working on a National risk assessment tool to have a better understanding of the risk that they are posing (GRUNDRISK) and Estimation of the aftercare tool ver. 1. 0



Ejerskab  
■ Kommunalt/Offentligt ejet  
■ Privat ejet



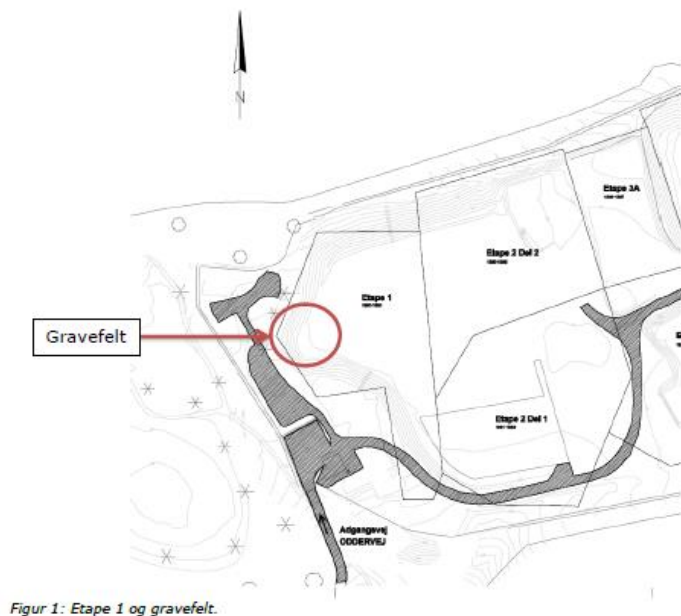
# Landfill technology and practice)

- Describe current practices for the operation of MSW landfills in your country
  - Overall design of operational MSW landfills
  - Employed technologies for leachate and landfill gas collection/utilization, protection layers and barrier systems, etc.
    - Leachate is shipped to local waste water treatment system – one on site plant
    - Few LFG plants (32) and Biocover systems
    - Soil cover (min 1 permeable soil or compost - No top cover with plastic liner is allowed
    - Bottom liner system is clay, plastic liner or bentonite systems with drainage systems
  - Requirements on documentation of waste to be landfilled
    - Acceptance criteria,
    - approval before landfilling (papers + on the list of acceptable waste)
    - Characterization (leaching test) or analyzes
    - Visual inspection

# Landfill technology and practice

- Describe current practices for the operation of MSW landfills in your country
  - Acceptable criteria/properties of waste to be deposited in MSW landfills
    - Inert and hazardous Waste
  - Main practices for closure and aftercare treatment
    - Financial provision (collected by gate fee)
    - Monitoring (programme and analyzing) – comply with criteria which is not clear
    - Removal of buildings, roads and other waste activities

# RenoSyd LFM –Skaarup landfill



Owned by RenoSyd I/S, Stage 1 (1979-81), MSW, bulky waste, slagg, C&D, sludge etc.

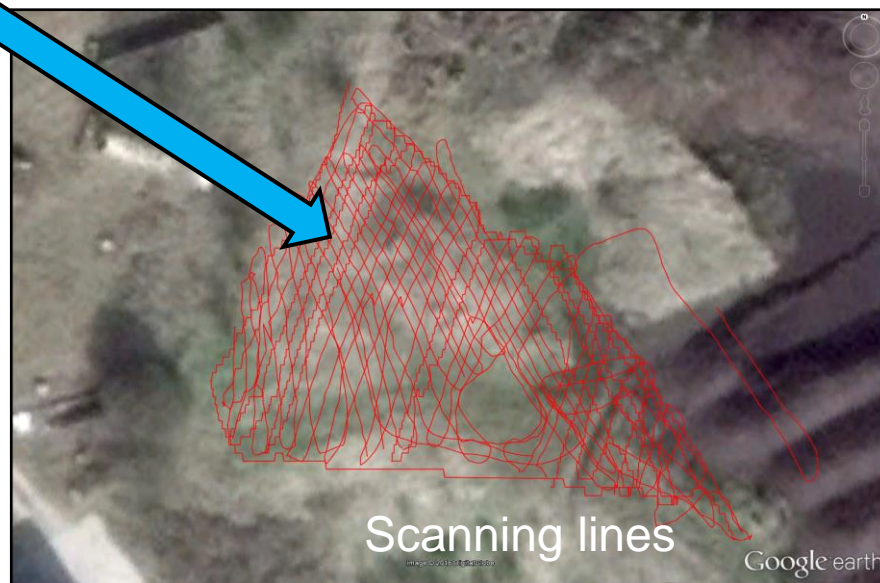
# Excavation and sorting

- Excavation and sorting with excavator and sorting grab
- Large Bricks and stones, large metal pieces, Tyres, large plastfoil, textiles and accumulators etc.
- **Sorting with** Keestrack 175 vibration and screening
- Coarse Screening: Heavy Duty Finger screen 51mm
- Punched plate & full Hardox top deck 40 mm
- 2 Magnet-belts on midsize fraction og coarse fraction
- Plastfoil-sucktion on the coarse fraction

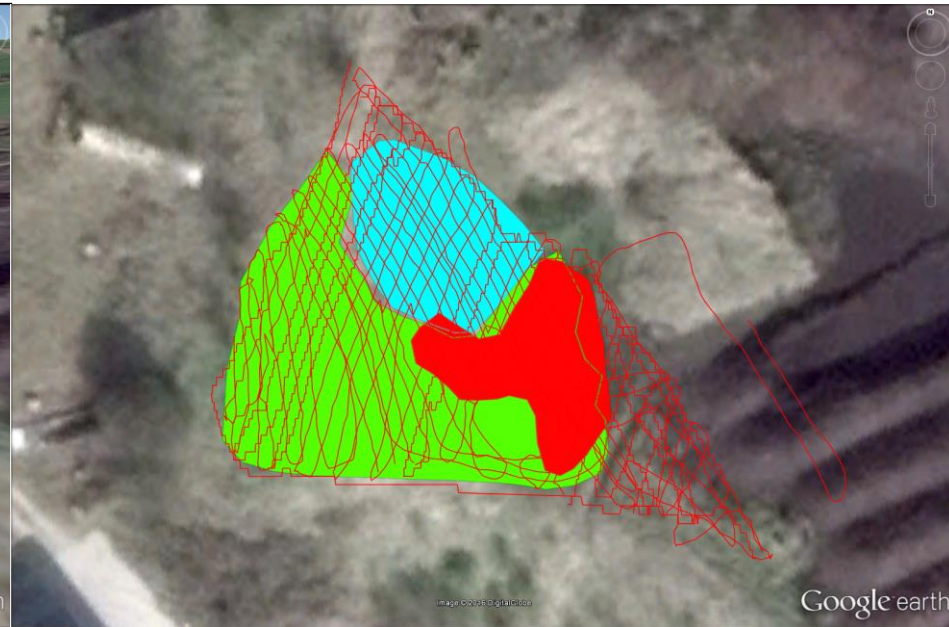
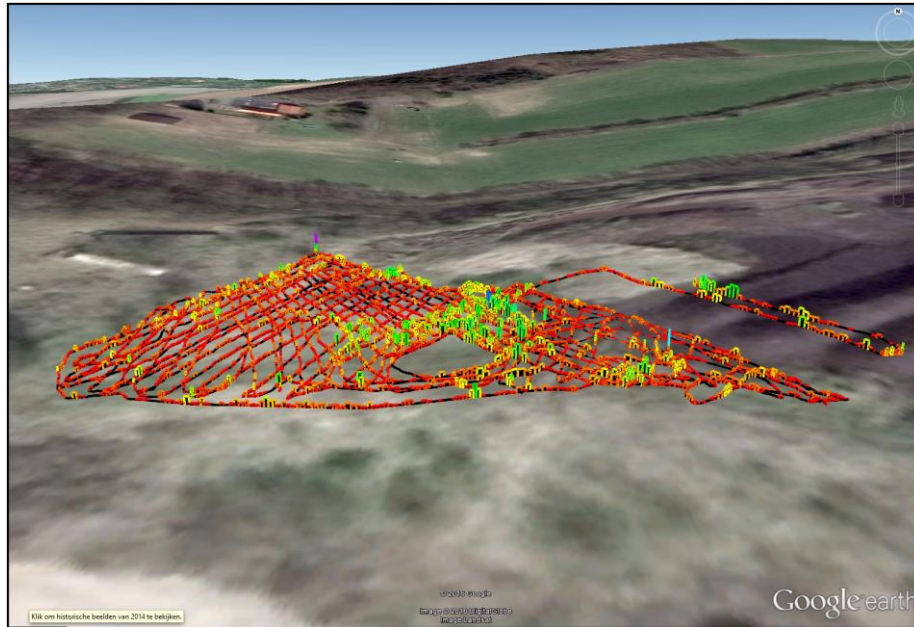







# Field Study



# Tracer results



-  Rubble and objects
-  Layering to approx 1.5 m bgl
-  Homogenous conductive soil up to 6 m bgl

# Results

Fractions	%
<b>Recycling</b>	
Stones (crushing and recycling)	0,7
Iron and metals	1,3
<b>Incineration (also plastic)</b>	5,1
<b>Landfill</b>	91,5
Fine fraction (soil)	67,9
Remaining fraction (not sorted)	23,6
Hazardous waste	0,002
PAH contaminated soil	1,4
<b>Total</b>	<b>100</b>



# Cost-Benefit calculations

	Actually Projects Costs	Full Scale Costs
	kr./ton	kr./ton
<b>Costs</b>		
Project and Planning	65	6,4
Sampling and Analyzing	19	2,8
Practice Facility	13	0,8
Removal of topsoil	16	16
Excavation and Sorting	367	367
Re-establishment and cover of landfill	44	0
Clean Up	7	0,4
Relandfilling (fine fraction) cell 1	14,259	0
Relandfilling (waste fraction) cell 1	4,956	0
Costs Incineration	26,01	26,01
Costs Landfilling Cell 3	0	384,3
Costs Crushing of stones	0,42	0,42
Costs Treatment of hazardous waste	0,06	0,06
Costs Clean Up contaminated soil	5,04	5,04
<b>Total</b>	<b>581,745</b>	<b>809,23</b>
<b>Revenues</b>		
Sale of materials		
Stones (recycling)	0,7	0,7
Iron and metals	15,6	15,6
New landfill capacity	0	0
Tax (pay back)	0	0
Pay back final provision	0	17,7
Saved costs on leachate treatment etc.	0	59,3
<b>Total</b>	<b>16,3</b>	<b>93,3</b>
<b>Cost pr. tonnes</b>	<b>565</b>	<b>716</b>
	<b>80 Dollars</b>	<b>102 Dollars</b>

In Dollars divide with 27

# Conclusions

- We tried different techniques but could be developed especially with a shredder
- Large items (tires and foils should be removed before sorting)
- Still not feasible (hard to predict)
- Non-invasive methods could be used but should be used active before choosing where to excavate
- Weather conditions are important

[www.landfillmining.dk](http://www.landfillmining.dk)