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Landfill aftercare and enhanced stabilisation in The Netherlands

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LANDSS Forum meeting, Birmingham, 21st October 2015

Outline

- Dutch regulations
- Development of landfill
- Financial aspects
- Risks for closure and aftercare
- Landfill stabilisation
  - Background
  - Technology
  - Asssessment
- Demonstration project
- Message, outlook and challenges

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Dutch aftercare regulations

- All landfills need to be capped with a surface sealing
- The Dutch regulator subsequently reasoned (and regulated):
  - Relying on a surface sealing for protection of soil and groundwater, implies continued functionality: it has to be replaced every 50 to 100 years
  - The average lifespan of a company is 50 years: the responsibility for aftercare is better positioned with the competent authority
  - The financial provision has to accommodate never ending aftercare
  - It is calculated site-specifically for each landfill by the competent authority
  - During operation the competent authority imposes an annual levy based on the amount of waste landfilled in each year
  - A provision for closure and capping has to be made by the operator

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Dutch aftercare regulations

- Although consistent in itself, this approach has various problems:
  - Due to the extremely long time frame a provision is very sensitive to the applied discount rate and the moment it is needed
  - Reduced landfill rates result in later closure and lower provisions
  - Competent authorities can unilaterally change the discount rate and many have recently lowered it, resulting in unforeseen costs and uncertainty
  - A discount rate in itself provides an incentive to ‘postpone environmental problems to the future’ and not solve them now
  - By definition ‘eternal aftercare’ is not in compliance with sustainable development

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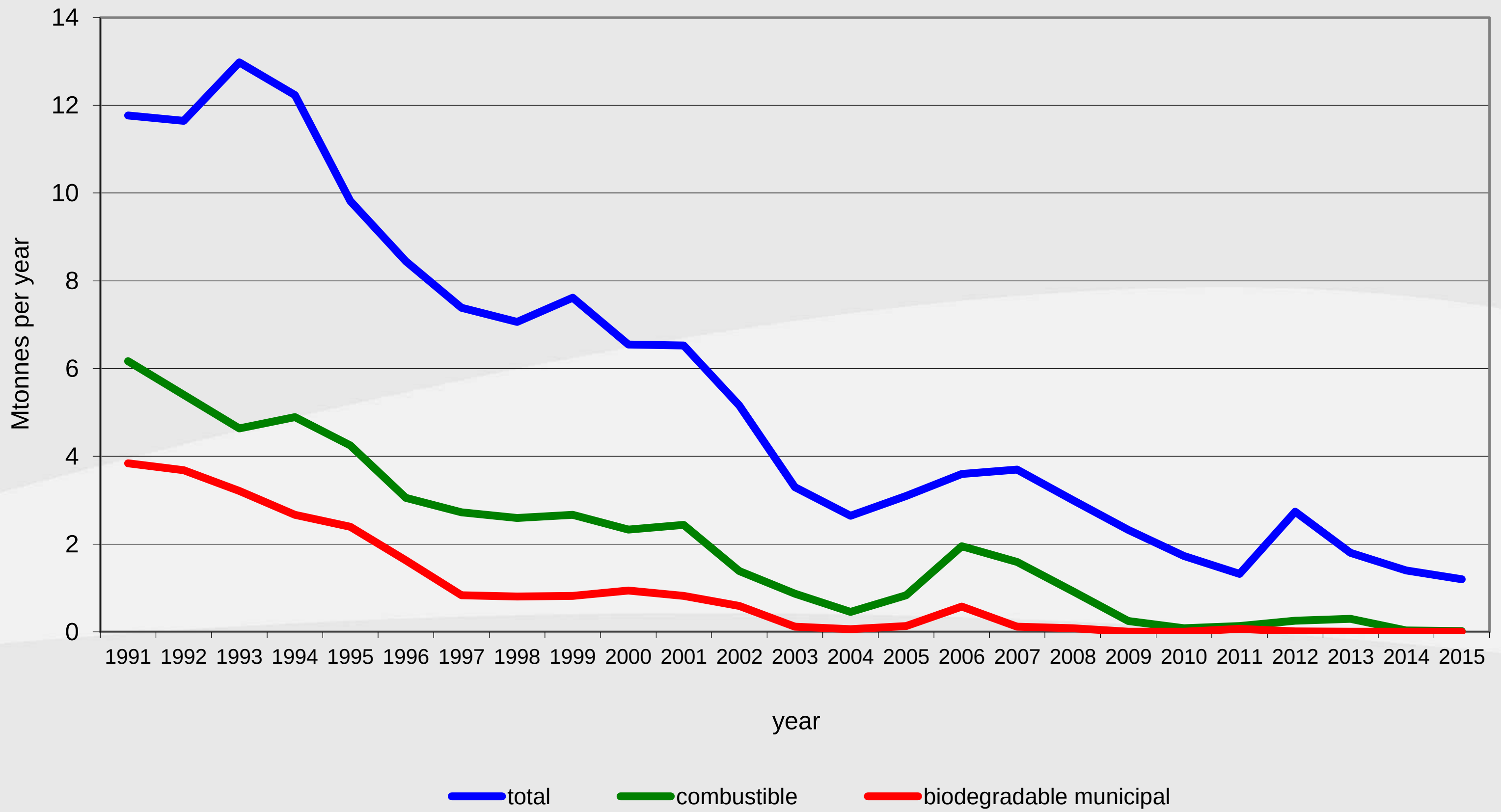
Development of landfill in NL



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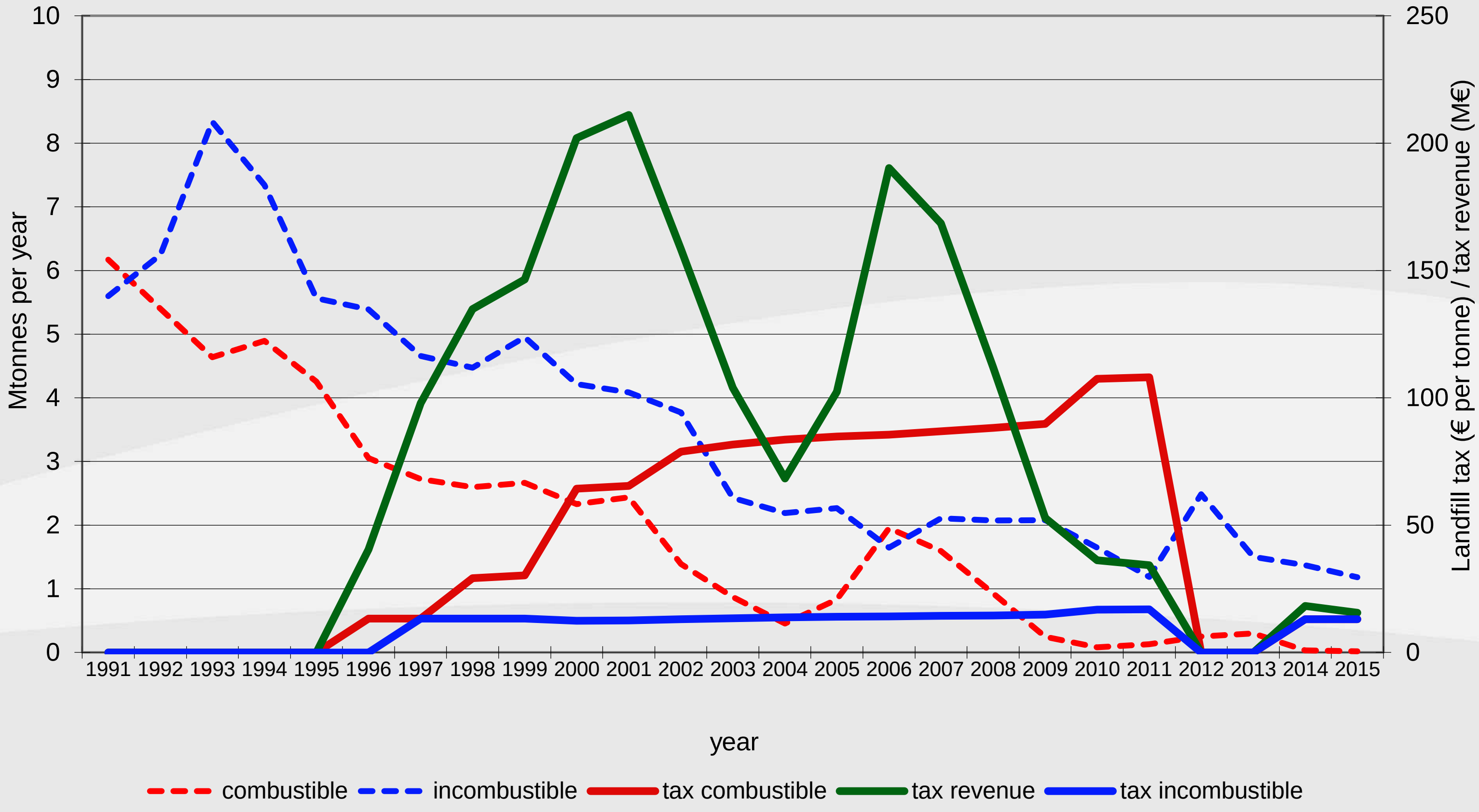
Development of landfill in NL



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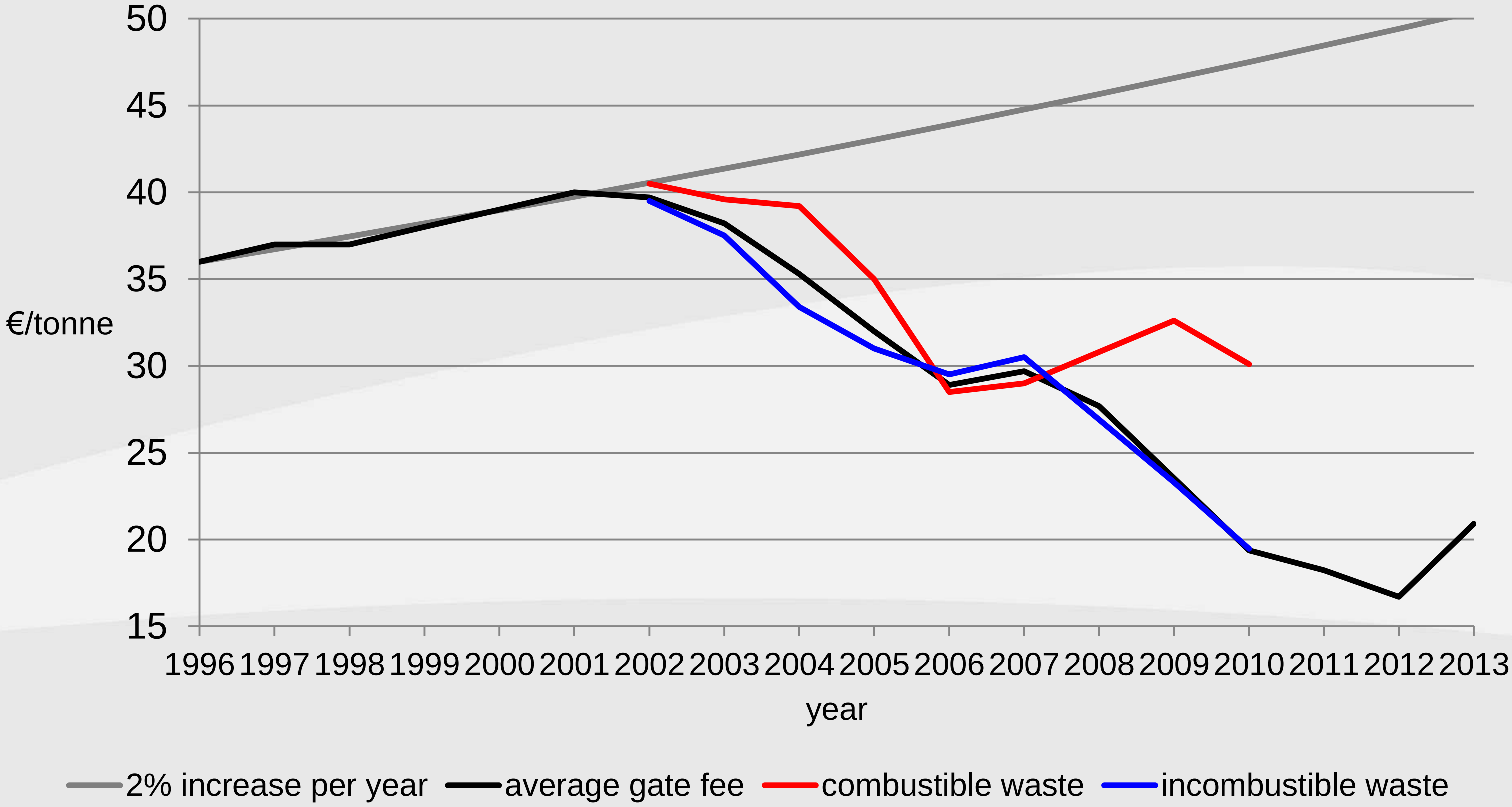
Development of average NL gate fee

(Source Hopstaken et al., 2013)



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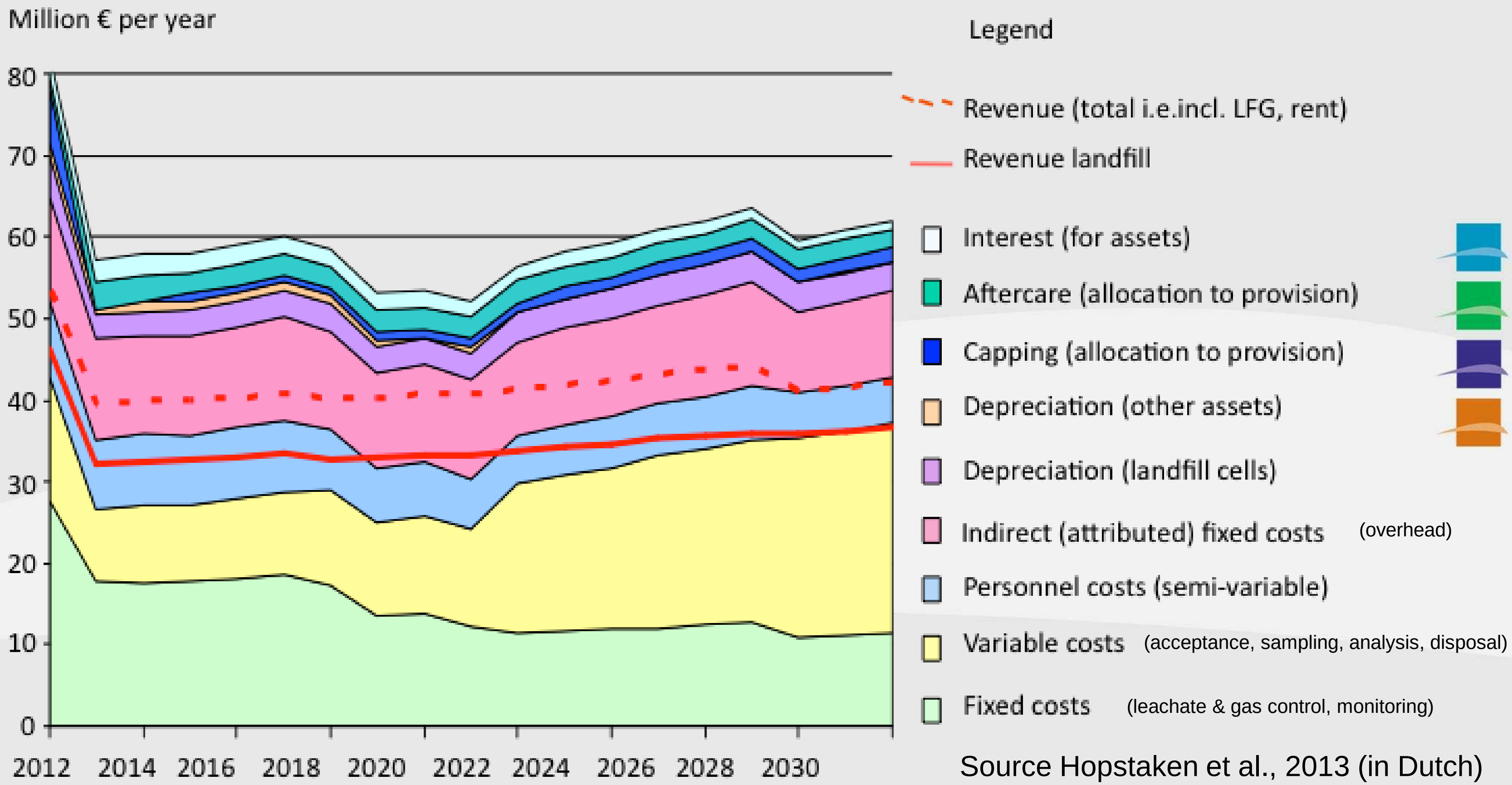
Cost structure of landfill



Source Hopstaken et al., 2013 (in Dutch)

Scharff, H. (2014) Landfill reduction experience in The Netherlands, Waste Management (34) 2218–2224

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Result of landfill operation

Calculated result of Dutch landfill operation in 2013

(derived from Hopstaken et al., 2013)

Scharff, H. (2014) Landfill reduction experience in The Netherlands, Waste Management (34) 2218–2224

	€/1.7 Mtonne	€/tonne
Fixed costs	€ 17,600,000	€ 10.35
Variable costs	€ 9,900,000	€ 5.82
Personnel	€ 9,000,000	€ 5.29
Indirect fixed costs	€ 11,900,000	€ 7.00
Amortisation of landfill cells	€ 2,900,000	€ 1.71
Amortisation of other assets	€ 1,800,000	€ 1.06
Financial provision for closure and aftercare	€ 2,800,000	€ 1.65
Interest for assets	€ 2,400,000	€ 1.41
Total costs	€ 58,300,000	€ 34.29
Revenues landfill	€ 33,000,000	€ 19.41
Revenues landfill gas and rent	€ 7,000,000	€ 4.12
Net result	(€ 18,300,000)	(€ 10.76)

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Result of landfill operation

- Many Dutch landfill operators claim they do not recognise this financial assessment
- But the same landfill operators have confidentially given the researchers access to their financial accounts
- When asked more firmly the landfill operators do admit that other activities compensate for low landfill income and to ‘eating into’ their financial provisions for closure and capping
- (NB: not into the financial provision for aftercare, by law the competent authorities impose an annual aftercare levy based on the amount of waste landfilled and manage the provision)

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Risks for closure and aftercare

- Due to landfill reduction it takes longer before the landfill volume is completely filled and the provision has to be used
- Reducing financial provisions for closure and capping could be justified: the period the provision generates interest is longer
- But there is more uncertainty that it will be sufficient in the end
- In addition more and more waste management companies are privatised and there is an increasing risk that landfill companies will go bankrupt
- Although in NL the financial provision for aftercare by law is with the competent authority there is a similar risk that accumulated interest in the end will not be sufficient

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Risks for closure and aftercare

Province	Provisions per 1.1.2012	Provisions required at closure
Zuid-Holland	€ 22.255.000	€ 38.078.000
Noord-Holland	€ 21.965.393	€ 59.098.851
Friesland	€ 5.214.636	€ 6.352.923
Groningen	€ 6.287.711	€ 7.649.552
Utrecht	€ 2.593.372	€ 7.225.037
Drenthe	€ 4.929.120	€ 110.052.800
Zeeland	€ 5.834.000	€ 11.000.000
Flevoland	€ 72.000	€ 41.240.000
Noord-Brabant	€ 12.866.195	€ 109.917.000
Gelderland	€ 9.306.760	€ 33.211.527
Overijssel	€ 10.711.534	€ 52.582.046
Limburg	€ 13.065.221	€ 40.816.190
Total	€ 115.100.942	€ 517.223.926

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Risks for closure and aftercare

- The final sum of money for aftercare is determined after closure
- Recently a competent authority decreased the discount factor from 3.06% to 1.99% which increased the provision from € 38 to € 60 million euro for two landfills while one was closed
- The length of aftercare is not an issue: it is not foreseen to end
- Dutch operators formed a foundation with the goals:
    - to cost-effectively reduce the emission potential of the waste body so that no threat to HHE remains and a simple soil cover suffices;
    - to realise regulations enabling simpler and cheaper covers and aftercare;
    - to realise cost reduction and more financial certainty without compromising environmental protection

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Background of the project

- In 2007 the Dutch government started a project to modernise the landfill regulations and the technical guidelines
- Soon it became clear that it was important to address reduction of the leaching of the waste: the ‘emission potential’
- In 2010 the Dutch government launched the project ‘Introduction of Sustainable Landfill Management’
- Insufficient proof of effectiveness of stabilisation technology
- A demonstration project is necessary to show long-lasting reduction of the emission potential below acceptable levels
- For specific landfills exemptions on parts of the existing landfill regulations will be issued to enable the project

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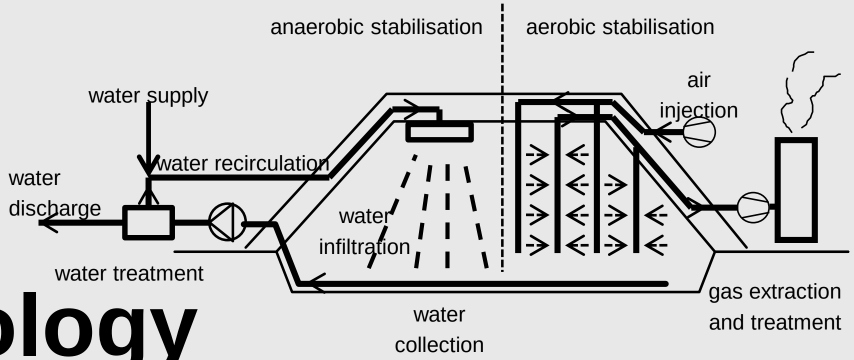

Stabilisation technology

- There are not too many options to accelerate degradation and stabilisation of landfills
- Infiltration and recirculation of water can enhance anaerobic degradation, but degradation will not be completed
- Aeration is necessary to aerobically degrade remaining carbon
- These technologies have successfully been applied on landfills and for in-situ soil and groundwater remediation
- The issue is not whether the technology works
- The issues are: can acceptable levels be reached and can it be guaranteed they will not change in the far future?

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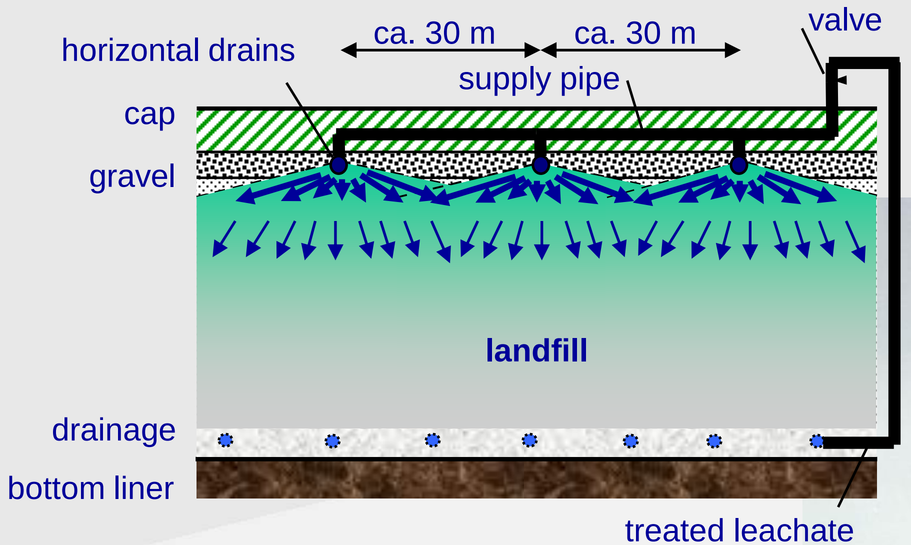
Stabilisation technology: Kragge



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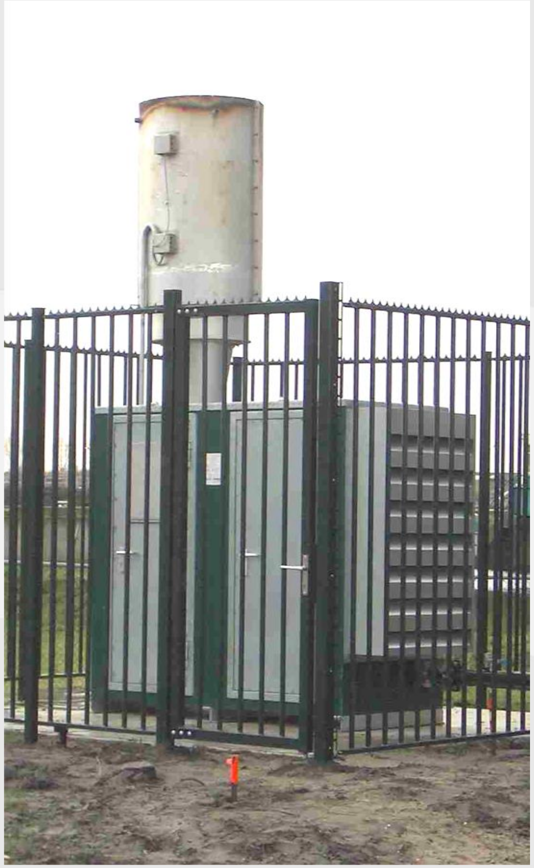
Stabilisation technology: aeration

Stabilisation technology: Braambergen Wieringermeer



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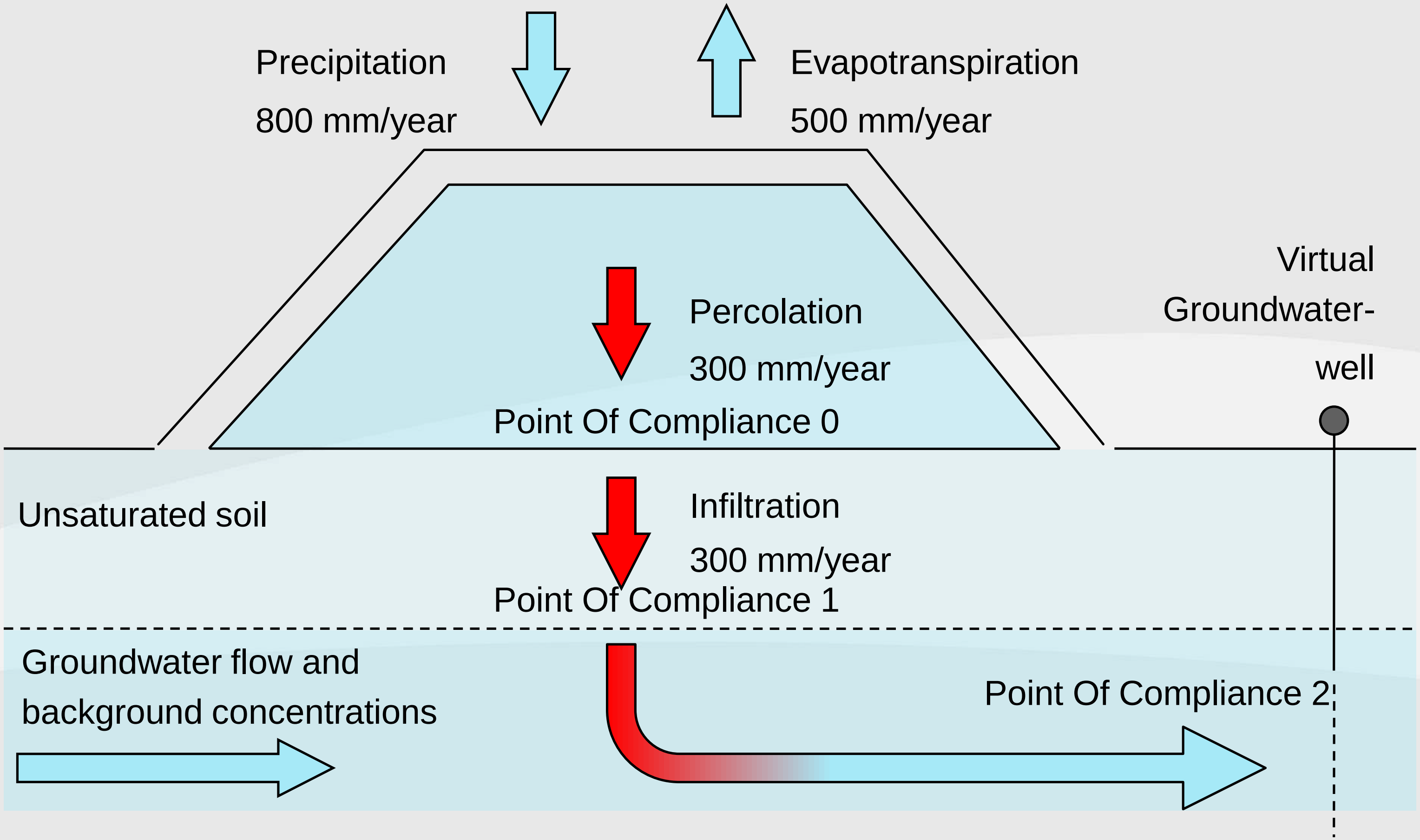
Background of assessment

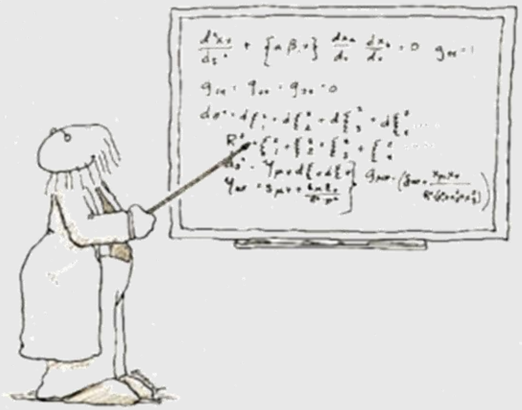
- To demonstrate reaching acceptable emission, it needs to be quantified and an assessment framework is required
- In order to protect human health and the environment, it is necessary to start thinking from the threatened object
- Once the acceptable exposure of the threatened object is clear, the acceptable emission from the landfill can be determined
- The acceptable emission will automatically indicate whether eternal isolation is needed or release from aftercare is possible
- Determination of acceptable emission can only be done site-specifically since the sensitivity of the environment varies

http://www.rivm.nl/en/Documents_and_publications/Scientific/Reports/2014/mei/Development_of_emission_testing_values_to_assess_sustainable_landfill_management_on_pilot_landfills_Phase_2_Proposals_for_testing_values

Source: E. Brand, T. De Nijs, J. Claessens, J. Dijkstra, R. Comans, R. Lieste, 2014, Development of emission testing values for pilot landfills for sustainable landfill practices - Phase 2: Proposals for testing values, RIVM Report 607710002/2014, RIVM, Bilthoven, Netherlands

Conceptual model





Determination of criteria

- Environmental criteria applicable at point of compliance 2
- For metals and macro parameters: ‘maximum permissible risk’
- For not-naturally occurring organic substances: ‘negligible risk’
- The ‘maximum permissible risk’ is taken as the concentration at which less than 5% of the species are affected
- The ‘negligible risk’ is that concentration divided by 100
- The values where derived from abundantly available ecotoxicity data (e.g. no observed effect concentration data)

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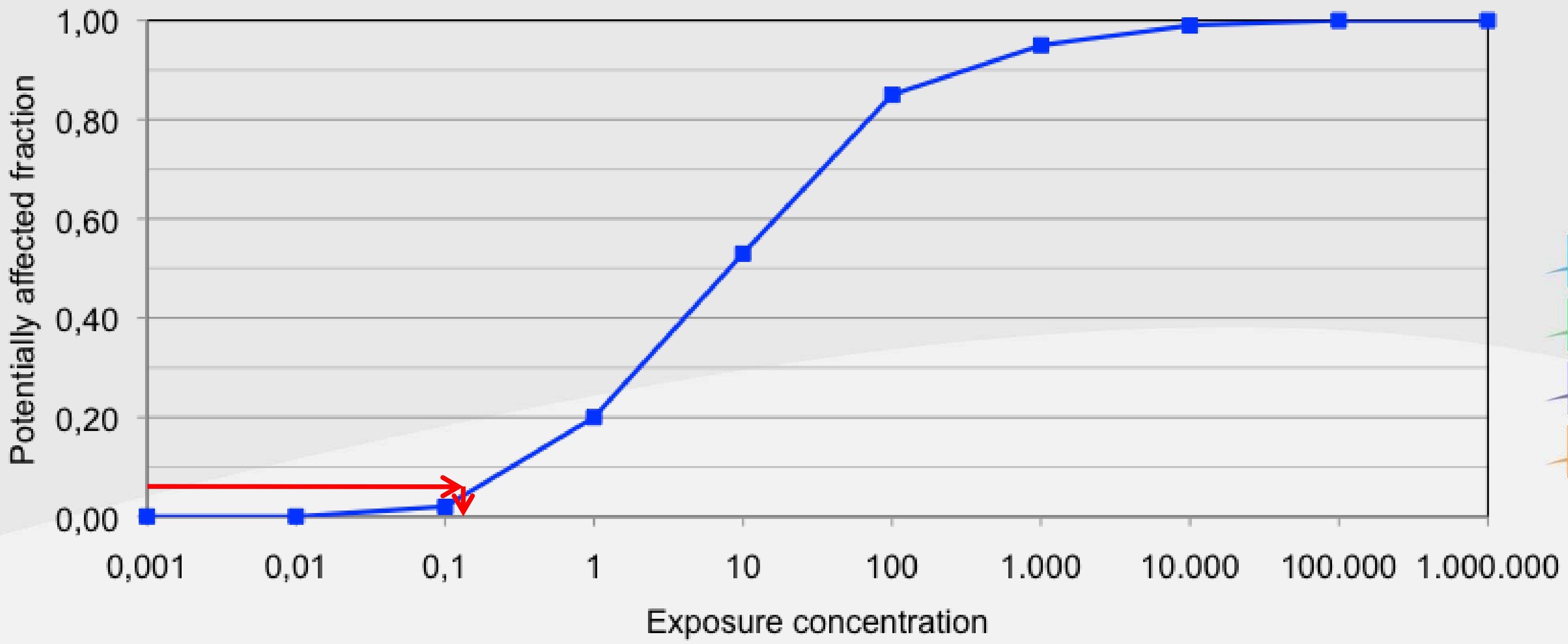
Determination of criteria





Selection of relevant substances

- Landfill regulations
- Soil quality regulations
- Landfill permits

Metals	Organic substances	
Arsenic	VOX	PAH
Cadmium	Vinylchloride	Naphtalene
Chromium	Dichloromethane	Phenantrene
Copper	1,1 dichloroethane	Antracene
Mercury	1,2 dichloroethane	Fluoranthene
Lead	1,1 dichloroethene	Chrysene
Nickel	1,2 dichloroethene (cis,trans)	Benzo(a)antracene
Zinc	Dichloropropane (1,2)	Benzo(a)pyrene
	Dichloropropane (1,3)	Benzo(k)fluoranthene
(Antimony)	Trichloromethane (chloroform)	Indeno(1,2,3cd)pyrene
(Barium)	1,1,1 trichloroethane	Benzo(ghi)perylene
(Cobalt)	1,1,2 trichloroethane	
(Manganese)	Trichloroethene (tri)	(Acenaftylene)
(Molybdenum)	Tetrachloromethane (tetra)	(Acenaftene)
(Tin)	Tetrachloroethene (per)	(Fluorene)
(Vanadium)	Mineral oil	(Pyrene)
	Sum EC10-EC40	(Benzo(b)fluoranthene)
	Aliphatic EC5-EC6	(Dibenzo(a,h)anthracene)
	Aliphatic EC6-EC8	
	Aliphatic EC8-EC10	
Macroparameters	Aliphatic EC10-EC12	Site specific additions
Chloride	Aliphatic EC12-EC16	Phosphate
Sulphate	Aliphatic EC16-EC21	Cyanide
N-Kjeldahl/ammonium	Aromatic EC5-EC7	Fenols
	Aromatic EC7-EC8	
	Aromatic EC8-EC10	BTEX
	Aromatic EC10-EC12	Benzene
	Aromatic EC12-EC16	Xylene
	Aromatic EC16-EC21	Toluene
	Aromatic EC21-EC35	Ethylbenzene

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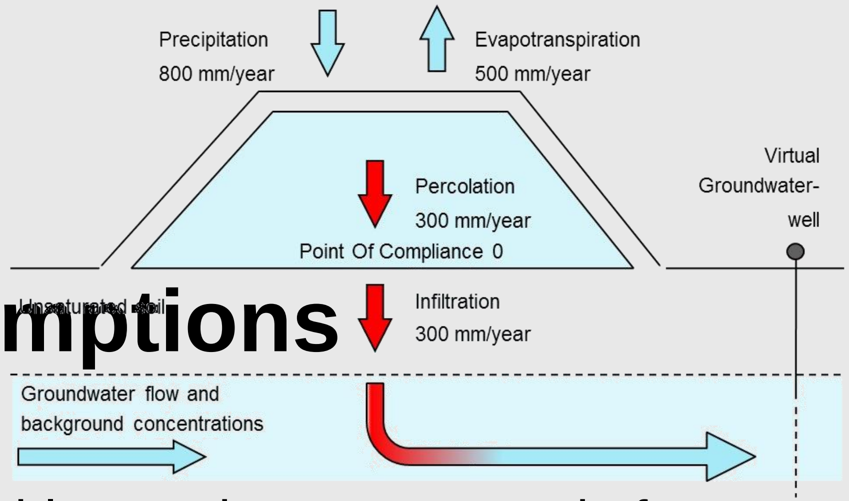

Conditions and assumptions

- Landfill gas will no longer be a problem at the moment end of aftercare can be considered with respect to leachate quality
- Groundwater needs to be protected in case of infiltration
- Surface water needs to be protected in case of seepage
- Infiltration is 300 mm/year (average Dutch conditions)
- Bottom liner has completely failed (worst case)
- Period to be considered is 500 years
- There is a constant source term (worst case)
- Target values for environmental protection are uniform
- Target values for leachte concentration can vary

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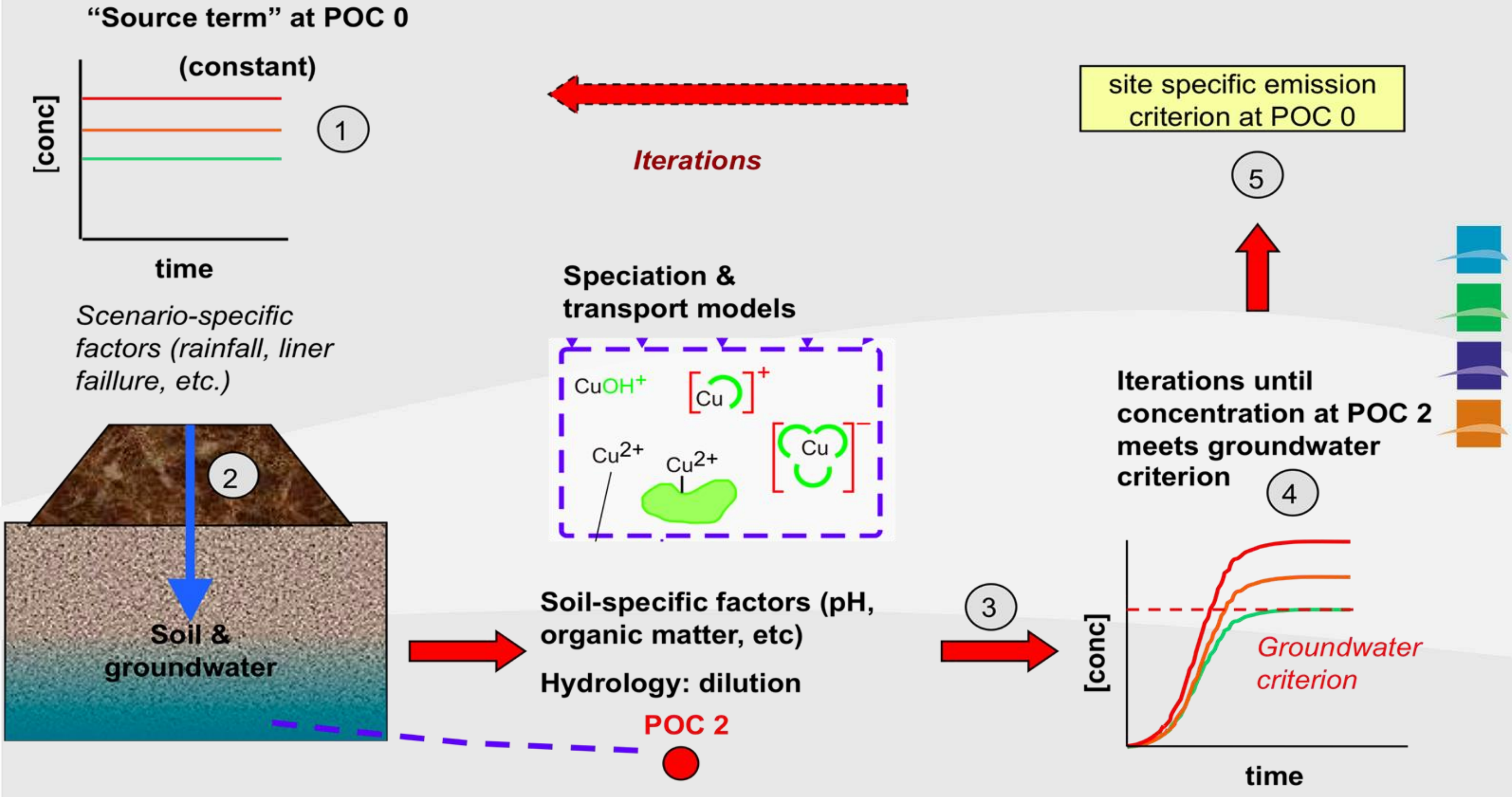
Conditions and assumptions (cont.)

- Sensitivity analysis:
  - No effect on compound mobility due to dissolution of soil iron oxides
  - Within expected range of phosphate in leachate no effect of phosphate on compound mobility
  - Within expected range of DOC in leachate a significant effect of DOC on compound mobility
- No emission criteria for Nkj, BOD, COD or DOC
- They are sum parameters: determining toxicity is impossible
- Realistic estimate for remaining DOC in leachate
- Considering the time horizon: dilution over the entire aquifer
- Gravitational flow is excluded

Calculations



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Emission criteria

Substances	Unit	Braam-bergen	Kragge	Wiering-ermeer
Arsenic	µg/l	190	100	190
Cadmium	µg/l	6,4	3,6	1,3
Chromium	µg/l	210	140	37
Copper	µg/l	50	64	19
Mercury	µg/l	5,8	4,1	1
Lead	µg/l	60.000	130	25.000
Nickel	µg/l	21	47	21
Zinc	µg/l	160	120	39
Cyanides	µg/l	61	6,8	35
Chloride	mg/l	450	160	2.400
Ammonium	mg/l	1,8	1,1	50
Sulphate	mg/l	700	200	1.400
Phosphate	mg/l	n.v.t.	n.v.t.	n.v.t.

- Calculated criteria have been ‘politically’ amended for lead and ammonium
- The ‘toughest’ criteria to meet will be those for chloride and ammonium
- An independent advisory board recommended aiming for significant Cl^- and NH_4 reduction

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Emission criteria

Substances	Unit	Braam-bergen	Kragge	Wiering-ermeer
Sum mineral oil C10-C40	µg/l	470	270	100
Vinylchloride	µg/l	0,047	0,014	0,01
Dichloromethane	µg/l	0,047	0,014	0,01
1,1 dichloroethane	µg/l	4,7	1,4	1
1,2 dichloroethane	µg/l	14	4,1	3
1,1 dichloroethene	µg/l	0,047	0,014	0,01
1,2 dichloroethene (cis,trans)	µg/l	0,047	0,014	0,01
Dichloropropane (1,2)	µg/l	3,8	1,1	0,8
Dichloropropane (1,3)	µg/l	3.8	1.1	0,8
Trichloromethane (chloroform)	µg/l	4,7	1,4	1
1,1,1 trichloroethane	µg/l	0,047	0,014	0,01
1,1,2 trichloroethane	µg/l	0,047	0,014	0,01
Trichloroethene (tri)	µg/l	47	14	10
Tetrachloromethane (tetra)	µg/l	0,047	0,014	0,01
Tetrachloroethene (per)	µg/l	0,047	0,014	0,01

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Emission criteria

Substances	Unit	Braam-bergen	Kragge	Wiering-ermeer
Naftalene	µg/l	0,047	0,014	0,01
Fenantrene	µg/l	0,028	0,016	0,006
Antracene	µg/l	0,0066	0,0038	0,0014
Fluoranthene	µg/l	0,056	0,033	0,006
Chrysene	µg/l	0,056	0,033	0,006
Benzo(a)antracene	µg/l	0,0019	0,0011	0,0002
Benzo(a)pyrene	µg/l	0,0094	0,0054	0,001
Benzo(k)-fluoranthene	µg/l	0,0075	0,0044	0,0008
Indeno(1,2,3cd)-pyrene	µg/l	0,0075	0,0044	0,0008
Benzo(ghi)perylene	µg/l	0,0056	0,0033	0,0006
Sum PAH-10	µg/l	1,9	1,1	0,2
Benzene	µg/l	0,94	0,27	0,2
Xylene	µg/l	0,94	0,27	0,2
Toluene	µg/l	4,7	1,4	1
Ethylbenzene	µg/l	4,7	1,4	1
Phenols	µg/l	0.94	0,27	0,2

- Independent experts consider compliance with all criteria on all landfill sites technically feasible

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Messages

- For three Dutch ‘pilot landfills’ site-specific emission criteria have been determined
- The method can also be applied to situations where the emission takes place in the surface water instead of the groundwater
- Through consideration of local conditions the method is applicable in many (not only landfill) situations
- The method can and will be further improved based on ongoing knowledge development regarding contaminant attenuation processes and ecotoxicity

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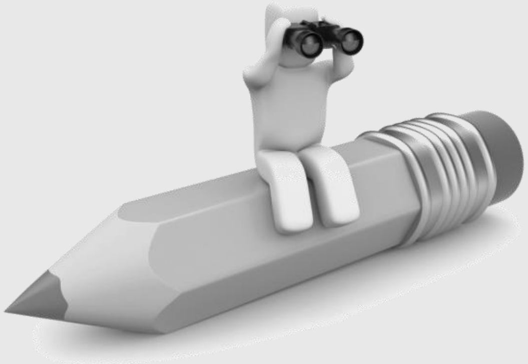
Outlook



- A covenant between national government, competent authorities and landfill operators was signed 6th October 2015
- Two ‘pilot agreements’ between competent authorities and landfill operators have been signed, the third follows soon
- Until spring 2016 legislation needs to enter into force and permits need to be amended
- Final design, contracting and construction can be carried out before the summer of 2016
- The pilot projects will start in 2016 an will be carried out for a duration of 10 years

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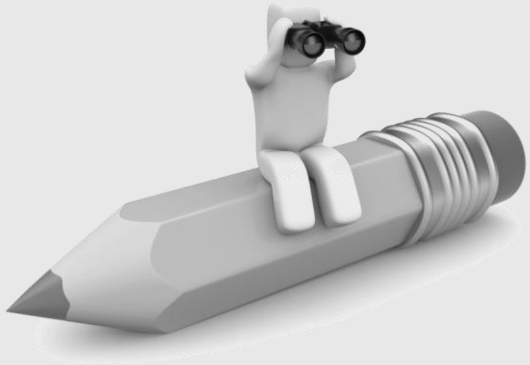

Challenges

- The technology has been shown effective in many projects
- Target values for nitrogen and chloride are probably harder to achieve than for heavy metals and organic compounds
- The main challenge is not to demonstrate that the target values are reached, but that they will not change in the far future
- Statements on the future can only be derived through modelling
- Modelling tools need to be combined, amended and improved
- In order to enable ‘reliable’ modelling, preferential flow and nitrogen attenuation require better understanding
- Research and development of measurement tools is needed

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Thank you very much for your attention

Nauerna landfill, November 2010