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Seminar on sustainable landfilling

Documentation

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Nordic co-operation

Nordic co-operation, one of the oldest and most wide-ranging regional partnerships in the world, involves Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland and Åland. Co-operation reinforces the sense of Nordic community while respecting national differences and similarities, makes it possible to uphold Nordic interests in the world at large and promotes positive relations between neighbouring peoples.

Co-operation was formalised in 1952 when *the Nordic Council* was set up as a forum for parliamentarians and governments. The Helsinki Treaty of 1962 has formed the framework for Nordic partnership ever since. The *Nordic Council of Ministers* was set up in 1971 as the formal forum for co-operation between the governments of the Nordic countries and the political leadership of the autonomous areas, i.e. the Faroe Islands, Greenland and Åland.

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1. Main General conclusions and recommendations

The participants in the Nordic Seminar on sustainable landfilling held in Holte, Denmark, on 18 and 19 June 2003 agreed on the following overall conclusions and recommendations:

A landfill is not an “island”, i.e. landfilling should be regarded and evaluated in a larger context, e.g. through life-cycle-analysis techniques, to avoid sub-optimisation.

The Landfill Directive and the associated Council Decision may accommodate a movement towards sustainability but they do not necessarily promote it.

Sustainability and final storage quality are useful concepts but they must be defined and interpreted.

Concerted efforts between and within sectors and nations are needed:

- to improve knowledge and exchange of information (all sectors); this would e.g. include the development of generic sampling protocols for some types of waste at EU level;
- to combine and co-ordinate research and development efforts;
- to carry out more comprehensive research and development and demonstration projects;
- to find common ground on regulatory issues (e.g. within the Technical Adaptation Committee (TAC) on the Landfill Directive);
- to provide feed-back from practical work to legislation and research and development.

The following actions were recommended with respect to collection, treatment, interpretation, exchange and dissemination of data on waste characterisation and monitoring in relation to landfilling:

- Determine which information is essential in terms of testing and monitoring and gather such data on a continuous basis.
- Encourage the production of such data.
- Ensure they are published under conditions acceptable to industry and operators (make single data sets anonymous if needed).
- Exchange data and data interpretation information.
- Make the data publicly available and useful, e.g. in databases coupled to expert systems.
- Educate the public and the politicians.

In addition to these more general statements, several more specific and detailed technical conclusions and recommendations were presented during the seminar and may be found in the reports from the group discussions or the summaries of these.

Background

The Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (the Landfill Directive) was published on 16 January 2003. It should be implemented into national legislation in all member states and associated countries before 16 July 20041. This means that all the Nordic countries have been faced with the substantial task of adjusting national landfill legislation and national landfill strategies to the Landfill Directive (LFD) and the new Council Decision (CD) within a relatively short period of time. In order to support and provide inspiration for this process, the Landfill Group under the Nordic Council of Ministers and the Centre for Waste Research (C-RES) decided to organise a joint seminar on sustainable landfill in view of the implementation of the EU Landfill Directive and the Council Decision on waste acceptance criteria.

It was a major objective of the seminar to provide a forum for exchange of information between legislators, operators, consultants and researchers on problems and issues associated with the implementation of the LFD and the CD into national legislation. The feasibility of sustainable landfilling within the framework of the LFD and the CD is of particular interest, and the invited participants were therefore asked to view the issues from the perspective of sustainability. It was intended for all participants to benefit from the seminar, but it was also a specific objective to provide input and inspiration to the national legislators in the Nordic Countries who were and still are faced with the task of implementation of the LFD and the CD.

The seminar took place on June 18 and 19, 2003, at the Comwell conference centre in Holte, Denmark. It was attended by 37 participants representing all the above mentioned sectors from the Nordic countries and a few specially invited persons from the United Kingdom and the Netherlands. The distribution of participants by nationality was: Denmark (12), Finland (3), Iceland (4), Norway (6), Sweden (7), the Netherlands (3) and the United Kingdom (2). A list of participants is included as Appendix B. The first day of the seminar was dedicated to the discussion of practical, conceptual, legal, environmental and economical problems (and solutions) associated with the implementation of the LFD and the CD, par-

[1] It has subsequently proven impossible for most EU Member States and associated countries to actually meet this deadline.

ticularly in the Nordic countries. The participants were asked to keep the concept of sustainability in mind, but to focus on the shorter-term problems of implementation and on problems met, anticipated and/or solved in this context. In terms of time, this would cover perhaps the next decade, but, of course, have long-term implications far beyond that. To inspire the discussions and provide some information on the situation in other European Member States, two speakers had been invited:

- Steve Gibbs, Atkins Environment, UK: Landfill Directive and Annex II Decision. Challenges for the UK.
- Rein Eikelboom, Ministry of Housing, Spatial Planning and the Environment, The Netherlands: Implementation of the Landfill Directive – Annex 2 and the horizontal approach to testing of waste and materials in Europe.

Abstracts and slides from the two presentations are included in Appendix D.

Each of the legislators responsible for the implementation of the LD and CD from each of the five Nordic countries gave a short presentation of the status of implementation in their own country and the major problems/challenges met or anticipated in their own countries:

- Jørgen G. Hansen, Danish Environmental Protection Agency: Implementation of the LD and CD and challenges in Denmark.
- Ari Seppänen, Finnish Ministry of the Environment: Impementation of the Landfill Directive and the Council Decision implementation and challenges in Finland.
- Cornelis Aart Meyles, Environmental and Food Agency in Iceland: Waste management and treatment in Iceland and implementation of the Landfill Directive, Council Decision and Annex II.
- Lise Kristin Jensen, Norwegian Pollution Control Authority: Implementation of the Landfill Directive in Norway.
- Stina Lundberg, Swedish Environmental Protection Agency: Landfilling in Sweden.

Abstracts and slides from the presentations of the situation in the Nordic countries are provided in Appendix E.

The participants were subsequently split into three groups, each with a pre-appointed chairperson and rapporteur. The groups were asked to discuss different issues related to the implementation of the LFD and the CD. They were also asked to identify urgent research needs. The issues were:

- Group 1: Acceptance criteria, exception clause, stricter national criteria, risk assessment.

- Group 2: Sampling, testing, standardisation, monitoring, risk assessment.
- Group 3: Environmental protection systems, gas management, risk assessment, financial security.

The results of the discussion in each group were presented and briefly discussed in plenum. The chairmen's and rapporteurs' reports on the group discussions are presented in Appendix G. The group reports do not necessarily represent all views expressed within the groups nor do they infer total agreement on the issues presented.

The second day was primarily dedicated to the pursuit of improved landfill solutions in the future, trying to ensure long-term sustainability in landfilling. Three speakers had been invited to provide inspiration for the subsequent group discussions:

- Thomas H. Christensen, Environment & Resources, DTU, Denmark: Sustainable landfill?
- Hans A. van der Sloot, ECN, The Netherlands: Development of new concepts for sustainable landfill.
- Keith Knox, Knox Associates Ltd, United Kingdom: Final storage quality criteria.

Abstracts and slides from the presentations are provided in Appendix F. The participants were again split into three (new) groups (A, B and C) and asked to discuss issues and research needs related to sustainable landfilling. All three groups were asked to address the following questions:

- What is sustainable landfilling in theory and practice?
- Can it be achieved within the framework of the Landfill Directive?
- What are the main obstacles to sustainable landfilling?
- Is final storage quality a useful concept and should it be based on leachate concentration or contaminant flux?
- What are the major research needs if sustainable landfilling is to be achieved?

The results of the discussion in each group were again presented and briefly discussed in plenum. The chairmen's and rapporteurs' reports on the group discussions are presented in Appendix G. The group reports do not necessarily represent all views expressed within the groups nor do they infer total agreement on the issues presented.

The participants finally agreed on some general conclusions and recommendations. They are listed in section 2 of this report.

The seminar was funded by the Nordic Council of Ministers and the Waste Research Centre (C-RES). It was organised by a project group consisting of:

- Ole Hjelmar, DHI – Water & Environment and C-RES (project leader)
- Jette Bjerre Hansen, Water & Environment and C-RES
- Dorthe Lærke Baun, Water & Environment and C-RES
- Bjørn Malmgren-Hansen, Danish Technological Institute and C-RES

The seminar was planned and carried out under the supervision of a Nordic Steering Group consisting of:

- Sofia Tingstorp, Swedish Environmental Protection Agency, Sweden (chairperson).
- Jørgen G. Hansen, Danish Environmental Protection Agency, Denmark.
- Ari Seppänen, Finnish Ministry of the Environment, Finland.
- Cornelis Aart Meyles, Environmental and Food Agency in Iceland, Iceland.
- Lise Kristin Jensen, Norwegian Pollution Control Authority, Norway.
- Stina Lundberg, Swedish Environmental Protection Agency, Sweden.

This report documents the seminar and the most important conclusions and recommendations resulting from the discussions.

2. Summary of discussions

The authorities' view of the implementation situation within the Nordic countries

The situation regarding the implementation of the Landfill Directive and the Council Decision in each of the Nordic countries as of mid-2003 is described in some detail in Appendix E by the representatives of the national authorities in charge of the implementation. Based on the presentations in Appendix E, table 3.1 shows the approximate numbers of existing landfills of various categories existing in the Nordic countries in 2003.

Table 3.1 Approximate numbers of landfills in the Nordic countries in 2003.

Types of landfills	Danmark	Finland	Iceland	Norway	Sweden
Current total number of landfills (2003)	144		41		316 (2002)
Inert waste landfills	26		10		47
Non-hazardous waste landfills	53	190	30	100-120	186
Industrial landfills (haz or non-haz waste)	65		1	50	30-50%
Hazardous waste landfills	1		0	3	44

Specific national goals or expectations by 2009/2010:

Denmark: Only 75 landfills expected to be in operation after July 2009.
Finland: Only 60 MSW landfills after 2010 (target), reducing landfilling of biodegradable MSW from 60 % to 20 %.
Iceland: Possibly fewer and larger landfills
Norway: A maximum of 25 % of the total quantity of waste generated should be delivered for final treatment/landfilling by 2010
Sweden: Fewer and larger landfills to be expected?

In *Denmark*, two sub-categories of non-hazardous waste are planned: Landfills for mineral waste (and stable, non-reactive hazardous waste) and landfixlls for mixed waste.

In *Finland*, subcategories of non-hazardous waste for mineral waste, mixed waste and stable, non-reactive hazardous waste are planned.

Table 3.2 summarises some of the plans and major concerns of the national authorities responsible for the implementation of the Landfill Directive and the Council Decision in the Nordic countries.

Table 3.2 Overview of some of the major concerns and some of the plans/expectations by mid-2003 of the authorities responsible for the implementation of the Landfill Directive and the Council Decision in the Nordic countries.

Issue	Danmark	Finland	Iceland	Norway	Sweden
Concerns about the implementation time schedule?	Yes		Yes	Yes	Yes
Concerns about fulfilling the criteria for landfilling of biodegradable waste?	No	Yes	Yes		No
Concerns about the availability of sampling and test methods	Yes	Yes			Yes
Specific concerns about the protection of surface water?	Yes, particularly seawater			Yes, surface water is the main source of drinking water	Yes
Will the “factor 3” rule be implemented?	Probably	Yes (not for Cd and Hg)			Yes, but with severe restrictions
Are acceptance criteria stricter than those of the Council Decision planned?	Depends on modelling				

In addition to the information in the table, it can be mentioned that:
Denmark is conducting model calculations similar to those performed by the TAC model group to develop acceptance criteria based on Danish conditions rather than average European conditions.

Finland sees a need for a method to test the biodegradability of a waste in view of the restrictions on landfilling of biodegradable waste. Finland also finds it important that testing for acceptance at landfills is seen in a broader context, e.g. with testing for utilisation.

Iceland has major problems with the poor quality of the landfill gas from smaller landfills and special problems with the slow degradation of slaughterhouse and fish processing waste under the prevailing climatic conditions (an average annual temperature of 4 °C).

Norway sees it as a challenge that many Norwegian landfills are situated in landscapes (bare rock) where the requirements for geological barriers and bottom sealing are not fulfilled and cannot be fulfilled. Requirements for leachate collection may be reduced if a thorough risk assessment shows that it is not necessary. Currently, it is mandatory for all municipal landfills to collect leachate.

Sweden would prefer acceptance criteria for landfills for all non-hazardous waste and not just for non-hazardous waste to be landfilled with stable, non-reactive hazardous waste. Sweden is also concerned about the fact that there are no acceptance criteria (except for total contents in inert waste) addressing the content/leaching of organics from waste to be landfilled.

It was mentioned during the seminar that a project has been initiated by the Nordic Council of Ministers to develop a common Nordic proposal for limit values for monolithic waste. The Council Decision requests each Member State to develop such criteria.

The concerns about the time schedule, i.e. the limited time available to implement the Landfill Directive and the Council Directive, which was expressed by practically all the representatives of the implementing authorities in the Nordic countries, were shared by the speakers from the United Kingdom and the Netherlands.

Summary of the discussions on implementation of the Landfill Directive and the Council Decision

This section provides a brief summary of the group discussions, which are reported in more detail in Appendix G (G1, G2 and G3). It should be noted that the three working groups discussed different subjects, and although the results were presented in plenum, time did not permit a thorough discussion of the reports of each group. The statements in this section and in Appendix G are believed to provide useful information but they may not necessarily be an expression of total agreement between all present. Only two of the three working groups discussing the implementation of the Landfill Directive and Council Decision found time to produce specific recommendations concerning urgent R&D needs. Those recommendations are listed at the end of this section.

The summary of the group discussions on the implementation of the Landfill Directive and Council Decision is split into the following main issues:

- Landfill classes, pre-treatment and exclusion of waste
- Landfill design and operation requirements and considerations
- Acceptance criteria and risk assessment
- Sampling and testing
- Monitoring
- Urgent research and development needs

2.1 Landfill classes, pre-treatment and exclusion of waste

It was stated that sub-categorisation of e.g. non-hazardous waste landfills could be useful, since this would make it easier to predict and control the behaviour of the landfilled waste. The main sub-categories of landfills for non-hazardous waste suggested were landfills for mixed inorganic and organic (biodegradable) waste and landfills for inorganic or mineral waste.

UK representatives felt that the requirements in the Council Decision for underground storage represent a major improvement. In Finland, difficulties were foreseen in combining the implementation of the requirements for underground storage with the requirements of the pending mining waste directive.

The Landfill Directive states that only waste that has been subject to treatment must be landfilled. It was discussed what degree of treatment is necessary to fulfil this requirement. It was suggested that sorting the waste prior to landfilling would be sufficient, but perhaps only if at least one stream of the waste is recycled rather than landfilled. It was also suggested that Best Possible Treatment (BPT) would be required. BPT is, however, still a fairly broadly defined concept. Mixing of waste materials prior to landfilling could be a form of pre-treatment, but it should be noted that article 5.4 in the Landfill Directive states that "The dilution or mixture of waste solely in order to meet the waste acceptance criteria is prohibited".

It was mentioned that some materials, e.g. air pollution control residues from the dry and semidry APC processes at MSW incinerators will require treatment in order to meet the leaching criteria for acceptance at a hazardous waste landfill.

The required reduction of the landfilling of biodegradable municipal waste will cause problems both in Iceland and in the UK. Liquid waste has hitherto been used to moisten other waste prior to landfilling in the UK. This may become problematic in the future since the landfilling of liquid waste is prohibited by the Landfill Directive.

Despite the general requirement and trend towards less biodegradable organic waste in the landfills, the waste in landfills that are not monofills for exclusively mineral industrial waste materials are still likely to contain a certain (lower) amount of organic material. There will always be some gas production, but it will be slower and produced over a prolonged period of time compared to a MSW landfill containing household waste, and it is impossible to predict the amount produced. Very little is known about gas production in and gas emissions from the newer, less organic landfills.

2.2 Landfill design and operation requirements and considerations

It was discussed that although it may be possible to meet the general requirements in Annex 1 to the Landfill Directive concerning top covers, bottom liners and geological barriers, this would not necessarily provide sufficient protection of the environment and it would often fit the landfill strategies badly. A top cover will for example prolong leaching and degradation processes and make the landfill less sustainable. The option of

reduced requirements (Annex 1, 3.4) should always rely on a site-specific environmental risk assessment. Two examples, where reduced geological barrier requirements may be in order, are landfills placed below the groundwater level or the sea level, where the gradient always will be directed towards the landfill, and landfills placed on rocks with sealed cracks. The properties of the leachate depend on the waste landfilled, and control of the type of waste accepted is crucial in controlling the risk to the environment and the possible reduced requirements of the bottom liner.

As already mentioned in section 3.1, only very few municipal landfills in Norway will meet the criteria for geological barriers and bottom sealing. For example, the geological structure is often fractured, and fissures may allow large amounts of leachate to leak into the local environment. As a result, almost all landfill owners are expected to apply for reduced requirements based on an environmental risk assessment.

In Sweden, more than 50 % of the landfill owners have not yet decided whether they will apply for exemptions from top cover, bottom lining and geological barrier requirements. It is a substantial challenge for the responsible authorities to ensure that exemption is given only if proper risk assessment shows that it is acceptable.

The possibilities of using waste materials instead of virgin soil materials for construction work within the landfill and for final cover. It was stressed that it is important to ensure that such materials remain functional, when they are used (e.g. that materials used in drainage systems are not compressed), and that they do not cause significant emissions or influence the surroundings. For the environmental authorities, the latter will be more important than the saving of virgin materials. Since the final top layer at a landfill is a barrier between the waste and the surroundings, this layer should never consist of waste materials.

It was mentioned that the landfilling taxes sometimes lead to creative thinking and solutions that from an environmental point of view may be less than optimal.

2.3 Acceptance criteria and risk assessment

It was discussed whether or not the acceptance criteria for granular waste in the Council Decision are strict enough. On one hand, it was argued that this is not so important since member states are allowed to implement more restrictive criteria, whereas on the other hand, it was argued that the limit values had been negotiated upwards from the values determined by the model calculations. It was also argued that the model assumptions were quite conservative. Most of the Nordic countries found the criteria for Cd and Hg rather high and expressed intentions to lower them nationally.

It was stated that several member states might not have agreed to the "upward" negotiation of the criteria if they had known that the "factor 3" clause (allowing member states on a case-by-case basis on certain conditions to allow limit values up to 3 times higher than those listed in the tables of the Council Decision) would be included. The factor 3 clause was regarded with limited enthusiasm and it was generally agreed that it should be used as little as possible. Several participants pointed to the difficulties involved in and the added burden of the performance and evaluation of the individual risk assessments required. It was felt that for some parameters, e.g. some metals, a 3 times higher limit value may not be very significant compared with the uncertainties involved in the testing and modelling. However, for other parameters, including Cd, Hg and the mobile constituents, including TDS, it might not be acceptable. Finland stated that it should not be possible to include Cd and Hg in the exemption. It was also felt that the significance of using a 3 times higher limit values would depend on the statistical approach used when determining compliance or non-compliance with the limit values.

The Council Decision does not provide any guidance on how to deal with the variability/uncertainty of test results when comparing them to the limit values. It was suggested that variations in test results over time could be dealt with by calculating averages over time periods appropriate to the risk under consideration for comparison with the limit values. This does, however, not address the uncertainty aspect, and there was agreement that development is much needed in this area.

It was found a little strange that there was no acceptance criteria set for the leaching of nitrogen species. The explanation is supposedly that the TAC had insufficient groundwater/drinking water criteria and/or insufficient leaching data on these components. Sweden was concerned about the lack of leaching criteria for organics other than DOC. The lack of acceptance criteria for monolithic waste was discussed, and it was mentioned that a Nordic project is being carried out with the purpose of developing such criteria and that some co-operation was also underway between the Nordic countries, the United Kingdom and the Netherlands. It was suggested that the model work if possible should be validated by field observations and that criteria to ensure the integrity of the monolithic material under realistic landfill conditions should also be developed. It may be problematic that the term "monolithic" is not defined in the Landfill Directive or the Council Decision. There were some concerns that no acceptance criteria have been set for non-hazardous waste in general.

The fact that the model calculations leading to the acceptance criteria in the Council Decision has taken only the risk to the groundwater into consideration was discussed, and it was agreed that there is a need to evaluated the criteria with respect to the risk of contaminating surface water bodies. A first step could be to review the sensitivity of fresh sur-

face water or seawater bodies to the parameters on the list and possibly model some typical scenarios where leachate contaminated groundwater is discharged into relevant surface water bodies.

2.4 Sampling and testing

The Council Decision states that sampling shall be carried out by independent and qualified persons and institutions. It was felt that this might cause problems in some Nordic countries, since only few people are proven qualified and independent. Nordtest is conducting a programme on certification of samplers, but it may take some time until certified samplers are available. Some participants found it important to get some sampling and testing done rather than wait for samplers to be educated. And there was some disagreement over the necessity of independent samplers since some of the most skilled samplers work for waste producers and contractors. There was agreement, however, that one of the most important steps in the development of a sampling plan would be communication with the people involved in the production of the waste to be sampled. It was also agreed that it should be possible to develop generic sampling protocols for some types of waste and to work out a common EU approach.

The advantages and disadvantages of sampling at the landfill gate (no cheating possible) or at the production site (more convenient and better for planning) were debated.

A sampling standard for waste is (still) being prepared by CEN/TC 292. This will include sampling plans for several typical waste sampling scenarios.

A full characterisation of a waste material should at least include a column leaching test and a pH-static leaching test with several parameters, including the ones for which criteria have been set. Any test to be used for compliance (e.g. a batch leaching test) must be included in the characterisation. There is a need for databases where characterisation data can be placed (possibly after being made anonymous) and made publicly available. Based on such data, a taskforce could identify classes of waste that could be treated as having common characteristics, making it possible to reduce the extent of basic characterisation work for certain waste streams in the future.

There still seems to be a need to study of the relationship between the quality of eluates from leaching tests and the quality of leachates from landfills. Information from old landfills is useful but cannot be used directly on newer landfills. Too little is known about the interactions between different wastes in inorganic landfills.

CEN/TC 292 is currently developing sampling and waste characterisation methods for the Landfill Directive and the Council Decision under a

mandate from the EU Commission. A need was identified for some test methods, which were not included in the mandate. Some of these methods were:

A test for hydrogen formation upon hydration (e.g. relevant for incinerator residues).

A test for characterisation of the nature of DOC (e.g. in relation to degradability, complexation).

A test to assess biodegradability. Some tests are already available, such as measurement of the biochemical methane potential (BMP) and the aerobic respiration test (AT). A Nordtest project comparing various bio tests is in progress as well as a Swedish project correlating VOC emissions to waste stability.

Monitoring

It was stated that there is a need for more detailed requirements/instructions than those in Annex 3 to the Landfill Directive with respect to how and where to monitor the gas in the surrounding areas. The gas production is highly influenced by factors like atmospheric pressure and heavy rains. As the requirements in the Landfill Directive are today, it is possible to choose a sampling time that ensures that no gas production will be detected (low pressure and wet weather/rain).

It was the general opinion that mass balance calculations carried out to supplement the groundwater monitoring as a potential indicator of leaks are very uncertain (± 20 to 30 %) and therefore useless for this purpose.

It was felt that the requirements in Annex 3, 4A with respect to groundwater monitoring (one upstream and two downstream monitoring wells) are inadequate and provide no security at all. It is very unlikely that the plume from a small leak should be detected by such a system. The possibility of using an electronic detection system was discussed. However, due to the limited experience with such systems it was recommended that the money should instead be spent on good liners and improved control of the waste.

It was agreed that liners do leak, and the more philosophical question of what actually should be done, when a leak is detected, was asked but not answered.

2.6 Urgent research and development needs

The following urgent research and development needs or development tasks were identified by two of the working groups (the group discussing sampling, testing waste characterisation and standardisation did not have time to discuss R&D needs):

Development tasks (should be performed by a task group, e.g. a Nordic group or a group like the TAC):

- Review of limit values
- Harmonisation of statistical approach
- Find out how to deal with mobiles such as chloride
- Consider surface water
- Define monolithic
- Harmonise monolithic limit values
- Agree on integrity parameters

Research and development issues:

- Pursue field data to confirm limit values
- Model additional parameters
- Conduct field studies of monolithic landfills
- Continue work on waste interactions
- Improve knowledge on the processes in the new type of landfills with low content of organic material. What would happen with the gas production and the leachate composition?
- Study gas production, how to avoid it or take care of it, and study the influence of the gas on the leachate quality.
- Develop methods to measure biodegradation, also in inhomogeneous materials like waste.
- Determine if there is a correlation between the composition of the produced leachate and the limit values in the acceptance criteria.
- Develop methods to establish limit values for discharge of leachate. These limit values should be related to site specific conditions.

2.7 Summary of the discussions on sustainable landfilling

This section provides a brief summary of the group discussions on sustainable landfilling, which are reported in more detail in Appendix G (G4, G5 and G6). In contrast to the first group discussions, all three groups discussed the same issues this time, and again, the results were presented and briefly discussed in plenum. Although it is felt that a substantial degree of consensus was achieved, it cannot be inferred that all participants present agreed with all the statements and conclusions. Most of the main conclusions and recommendations to which all participants agreed, have been listed in section 1.

2.8 Definition of sustainable landfilling

The Brundtland definition of sustainable development is "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Applied to landfilling this has in some countries lead to landfilling policies that require that each generation must take care of its own waste. Assuming that one generation corresponds to a period of 30 to 50 years, this implies that no active environmental measures should be necessary at a landfill after these 30 to 50 years. At that point in time, the impact of the unattended landfill on the environment should be acceptable, i.e. the waste should have reached "final storage quality" (see below). There was substantial agreement on this definition of sustainable landfilling, but it was also generally acknowledged that sustainability might be difficult to achieve within the above-mentioned timeframe. There was also agreement that the definition of an "acceptable" impact on the environment will be (and should be) subject to some discussion!

The location of the "point of compliance", i.e. the point downstream of the landfill where the environmental impact is assessed, was discussed, and there was some agreement that it might be necessary to "write off" a certain buffering zone closest to the landfill and allow a higher degree of contamination there.

It was mentioned that before discussing sustainability, it is necessary to discuss the objective of landfilling. It was suggested that the main objective of landfilling is to transfer matter from the society the environment. It was mentioned that the UK had the following sustainable landfill objectives:

- Landfills should be constructed with a beneficial afteruse;
- The input of reactive wastes should be reduced or measures should be provided to accelerate stabilisation;
- Resources should be used with care in design, construction and operation;
- Unacceptable adverse effects on the environment should be prevented both in the short and the long term;
- Costs and benefits should be balanced;
- Geotechnical stability should be ensured;
- Unnecessary burdens on future generations should be avoided (e.g. by using passive control measures).

It was stated that it is difficult to see any sustainability in landfills for hazardous waste since the environmental protection systems of hazardous waste landfills generally have a strong component of containment. This will prolong but not reduce the risk to the environment.

It was stated that merely setting aside funds for future generations to manage the waste landfilled today does not qualify as sustainable landfilling. The waste or the landfill must be treated and operated by the generation that has produced the waste in a manner that ensures an acceptable environmental impact within the appropriate timeframe.

Many participants agreed that sustainability of landfilling involves not only the landfill itself, but the whole waste management system. Landfilling should be viewed in a lifecycle analysis perspective, taking all impacts of pre-treatment, operation and aftercare into consideration, and all the resources spent to achieve a certain future impact level at a landfill should be evaluated. It was warned that a too rigid and general interpretation of sustainability may lead to excessive environmental burdens in meeting the criteria, and that the decision to pass from active to passive environmental protection measures should be based on site-specific impact assessments and on actual monitoring of the site.

2.9 Achievement of sustainable landfilling within the framework of the Landfill Directive

Several participants felt that the Landfill Directive does not promote nor provide guidance on sustainable landfilling and that it most certainly does not ensure that final storage quality is reached within a period of 30 to 50 years.

It was, on the other hand, felt that nothing in the Landfill Directive or the Council Decision will provide a direct obstacle to the achievement of sustainable landfilling by countries that want to take the measures necessary to do so.

2.10 Final storage quality

Final storage quality is generally defined as the state of the landfilled waste at the time when the emissions from the landfill to environment become (and remain) acceptable, and active environmental protection systems are no longer necessary. As seen above, final storage quality and the time at which it is achieved, play important roles in the discussion of sustainability of landfilling.

It was stated that final storage quality is a useful concept. It may, however be defined technically in different ways. The participants discussed whether final storage quality should be defined in terms of a flux of contaminants or in terms of leachate concentration. The latter is simplest and easiest to implement in regulation, but the first provides an extra “handle” (the water flow through the landfill) and may be more realistic, if final storage quality is to be reached within a reasonable timeframe. The defi-

nition based on flux is also more risky since it may depend on the long-term durability of infiltration-reducing systems.

Many participants felt that it would not be possible to reach final storage quality within 30 years unless the waste was treated extensively prior to and possibly also during landfilling. It was questioned whether it is actually optimal to achieve final storage quality within just one generation. One possible in-situ treatment of landfilled waste is flushing. It was discussed whether it is possible to reach final storage quality in landfills containing biodegradable waste. It was stated that it might be difficult to obtain complete degradation within a reasonable period of time, particularly in colder regions, and that landfilling of biodegradable waste should be avoided, if complete degradation cannot be ensured.

Landfilling of new and unknown compounds was mentioned as a potential threat to the achievement of final storage quality.

2.11 Major research and development needs and areas of attention

The following research and development needs and areas of attention were identified by the working groups as essential to the achievement of sustainable landfilling:

- Demonstration projects on sustainable landfill strategies should be established at EU or Nordic level.
- The final compartments or sinks for different waste components should be identified (e.g. “chloride to the sea” and “carbon to the soil”).
- Focus should be aimed at the sustainability of products in the production phase and not only in the landfilling phase.
- Focus should be aimed at new compounds that may constitute a threat to the achievement of final storage quality.
- Applications for environmental economics in waste management should be developed.
- Recipient-based studies should be carried out on reference objects.

Needs were also identified for more co-operation within Europe, development of decision support tools, more public communication and technology development.

Sammanfattning

Summary in Swedish

Ett nordiskt seminarium om hållbar deponering hölls i Holte, Danmark, den 18-19 juni 2003, med syfte att skapa ett forum för utväxling av information mellan myndigheter, operatörer, konsulter och forskare kring problem och utmaningar kopplat till implementeringen av EU's Deponeringsdirektiv 1999/31/EC samt EU-rådets beslut 2003/33/EG om kriterier och förfaranden för mottagning av avfall vid avfallsdeponier i enlighet med artikel 16i, och bilaga II till direktivet.

Deltagarne i seminariet kom överens om följande generella slutsatser och rekommendationer:

Deponering är inte en "ö", utan bör ses och evalueras i ett större sammanhang, t.ex. genom livscykelanalyser. Deponeringsdirektivet och EU-rådets beslut utgör möjligen ett steg mot hållbarhet, men gynnar den inte nödvändigtvis. Olika sektorer och länder borde samarbeta för att:

- förbättra kunskap och främja informationsutväxling (alla sektorer);
- kombinera och samordna insatser kring forsking och utveckling;
- genomföra mer övergripande forskning och utveckling samt demonstrationsprojekt;
- hitta en gemensam grund för regulering (t.ex. inom The Technical Adaptation Committee (TAC) för deponeringsdirektivet);
- ge feed-back från praktiska handlingar till lagstiftning och forskning och utveckling.

Följande insatser rekommenderades avseende insamling, behandling, tolkning, utväxling och spridning av data om avfallskarakterisering och monitoring i koppling till deponering:

- Identifiera vilken information som behövs avseende prövning och monitoring, samt att samla in sådan data löpande.
- Uppmuntra till framställning av denna data
- Säkra att data offentliggörs på ett sätt som gagnar industrin och operatörer
- Utväxla data och information om tolkning av denna
- Göra informationen offentligt tillgänglig och användbar, t.ex. i databaser
- Informera allmänhet och politiska fora

Utöver dessa mer generella påståenden, presenterades ett antal mer specifika och tekniskt detaljerade slutsatser och rekommendationer under seminariet. Dessa finns i rapporterna från seminarietes gruppdiskussioner eller i sammanfattningar från dessa.

3. Appendices

Appendix A: Seminar programme

Final programme for seminar on sustainable landfill 18 and 19 June 2003

Nordic Council of Ministers and Centre for Waste Research (C-RES)

Wednesday June 18	**Activity**	**Responsible/involved person(s)**
11.00 – 11.15	Welcome	Sofia Tingstorp
11.15 – 12.00	Introduction Presentation of participants	Ole Hjelmar All
12.00 – 13.30	Lunch	
13.30 –15.00	Implementation of the Landfill Directive and the Council Decision: Challenges in the UK Challenges in the Netherlands	 Steve Gibbs Rein Eikelboom
15.00 – 15.30	A short break for air, coffee and tea	
15.30 – 17.00	Introduction to group discussions by the members of the Nordic Landfill Group: Implementation and challenges in DK Implementation and challenges in F Implementation and challenges in IS Implementation and challenges in N Implementation and challenges in S Each introduction lasts up to 15 minutes and focuses on the specific problems experienced in each country. Among the issues to be addressed may be (see specific lists): Implementation vs. existing national strategies for sustainable landfilling Waste acceptance criteria, sampling and testing Environmental protection systems (e.g. liners) Risk assessments Conditioning plans Financial security Gas management	 Jørgen G. Hansen Ari Säppanen Cornelis Aart Meyles Lise Kristin Jensen/Gro Andersen Sofia Tingstorp/Stina Lundberg
17.00 – 17.15	Leg-stretching break	
17.15 – 19.00	Group discussions and coffee The participants will be split into 3 groups to discuss different subjects on the basis of the introductions and their own experience. The topics may possibly be those mentioned under the bullets above. A chairman and a rapporteur will be appointed beforehand for each group.	All – divided into 3 groups Chairpersons: Group 1: Steve Gibbs Group 2: Keith Knox Group 3: Henrik Wejdling
19.00 – 20.00	Break	
20 -	Dinner	

Thursday **June 19**	**Activity**	**Responsible/involved person(s)**
08.30 – 10.00	Presentation and discussion of the results of the group work	Group chairmen All
10.00 – 10.30	Coffee break	
10.30 – 12.00	Visions for the future: Sustainable landfilling What is sustainable landfilling? And how may it be attained? New concepts in landfilling (design/operation) How do we define final storage quality?	 Thomas Christensen Hans A. van der Sloot Keith Knox
12.00 – 13.00	Lunch	
13.00 – 14.30	Group discussions based on the presentation of visions before lunch	All – divided into groups – different from the previous groups Chairpersons: Group A: Peter Kjeldsen Group B: Anders Lagerkvist Group C: Ann-Marie Fällman
14.30 – 15.30	Presentation and discussion of the results of the group discussion	Group chairmen All
15.30 – 16.00	Summing up and ending of the meeting: Future actions Research needs Major problems to be managed	 The organisers

Appendix B: List of seminar patticipants

List of participants in Nordic Seminar on Sustainable Landfilling held at Cornwell Holte, Denmark, 18 to 19 June 2003
Organised by Nordic Council of Ministers and Centre for Waste Research (C-RES)

Name		Affiliation	Country
Dorthe Laerke	Baun	DHI/C-RES	Denmark
David	Bendz	Statens Geotekniska Institut, Malmö	Sweden
Helga	Bjarnadottir	Limnuhönnun	Iceland
Thomas H.	Christensen	Danmarks Tekniske Universitet	Denmark
Rein	Eikelboom	Ministry of the Environment	The Netherlands
Gunnlaug	Einarsdóttir	Environmental and Food Agency	Iceland
Ann-Marie	Fällman	Naturvårdsverket	Sweden
Steve	Gibbs	Atkins Environment	United Kingdom
Jørgen	Hansen	Miljøstyrelsen	Denmark
Jette Bjerre	Hansen	DHI/C-RES	Denmark
Jan	Hartlén	Lunds Tekniska Högskola	Sweden
Sacha	Heijblom	Ministry of the Environment	The Netherlands
Ole	Hjelmar	DHI/C-RES	Denmark
Tor	Holm	Norges Renholdsverks-forening	Norway
Ketil	Haarstad	Jordforsk, Ås	Norway
Jens Erling Frøiland	Jensen	Norconsult, Sandvika	Norway
Lise Kristin	Jensen	Statens Forurensningstilsyn	Norway
Peter	Kjeldsen	Danmarks Tekniske Universitet	Denmark
Keith	Knox	Knox Associates	United Kingdom
Anders	Lagerkvist	Luleå Tekniska Högskola	Sweden
Stina	Lundberg	Naturvårdsverket	Sweden
Bjørn	Malmlgren-Hansen	Teknologisk Insitut/C-RES	Denmark
Cornelis Aart	Meyles	Environmental and Food Agency	Iceland
Marianne	Munch	Miljøstyrelsen	Denmark
Jan August	Myhrstad	Det Norske Veritas, Høvik	Norway
Marcus	Müller	AV Miljø	Denmark
Gudmundur T.	Ólafsson	Landfill	Iceland
Thomas	Rihm	Svenska Renhållningsverksföreningen	Sweden
Ari	Seppänen	Environmental Ministry	Finland
Steen	Stentsøe	COWI	Denmark
Jan	Thrane	Odense Renovationsselskab	Denmark
Sofia	Tingstorp	Naturvårdsverket	Sweden
Marit	Torsvik	Fylkesmannen i Nordland	Norway
Hans A.	van der Sloot	ECN	The Netherlands
Kati	Vaajasaari	Regional Environmental Centre in Pirkanmaa	Finland
Margareta	Wahlström	VTT Processes	Finland
Henrik	Wejdling	DAKOFA	Denmark

Appendix C: Welcome presentation by Sofia Tingstorp, Naturvårdsverket, Sweden

I would like to welcome you all to this seminar on sustainable landfilling on behalf of the Nordic Network group on landfilling and our co-operation organisation Centre for Waste Research, C-RES.

The Nordic countries have a long-standing tradition of co-operation within the framework of the Nordic Council of Ministers (NCM). This co-operation covers numerous aspects of political, cultural, commercial and scientific life, including environmental protection issues. Under the auspices of the NCM Working Group on Products and Waste, representatives from the central environmental authorities being responsible for the landfilling policy in each of the Nordic countries have formed a small working group (the Nordic Network Landfill Group) and met regularly during the past 5-6 years to discuss issues of common interest. The Nordic network group on landfilling represents of participants from Miljöstyrelsen DK, Statens forurensningstilsyn N, Miljöministeriet, Fin, The environment and food agency Iceland and Naturvårdsverket S.

We discuss and exchange information regarding landfill issues. It could for example be implementation problem example establishing of criteria for monolithic waste, hot waste news and specific activities in our countries, we also run project in co-operation, leachate project, landfill-gas, characterisation of waste, …and this workshop. All our activities and project is financed by the Nordic council of ministers.

We hope that we with this seminar on sustainable landfilling, will provide a forum for exchange of information between legislators, operators, consultants and researchers on problems and issues associated with the implementation of the Landfill Directive (LD) and the Council Decision (CD) into national legislation.

The Landfill Directive was adopted in 1999. The directive establishes a set of rules meant to heighten the quality of landfilling and reduce the negative impacts on the environment caused by landfilling within the European Union and consequently also within the Nordic countries, including the non-EU Member States Norway and Iceland.

The directive did not solve the question of which landfill classes different waste are deemed to be landfill on. In Article 16 and Annex II of Directive 1999/31/EC on the landfill of waste it says that criteria and procedures for the acceptance of waste at landfills shall be established and adopted by a committee, Technical Adaptation Committee TAC.

The Technical Adaptation Committee (TAC) has worked intensively to establish concrete rules for acceptance of waste at the various classes

and subcategories of landfills. This work eventually resulted in the Council Decision of 19 December 2002.

The council decision includes rules about:

- Procedure for acceptance of waste, control and characterisation of waste
- Limit values for different landfill classes
- Test methods
- Criteria for underground storage

The objective of the seminar is to explore whether sustainable landfilling is possible within the Nordic countries and within the framework of the Council Decision and the directive 1999/31/EC on the landfill of waste.

It is a further objective to explore the possibilities for further development within the area of landfilling and how this development should and could proceed in view of the Council Decision.

This seminar is also intended to identify and suggest solutions to various other problems associated with the implementation of the Council Decision. We hope that that will be accomplished by bringing together legislators/administrators, experts/researchers, consultants and landfill operators to discuss the issues.

And once again very welcome and thank you.

Appendix D: Abstracts and slides from the presentations by Rein Eikelboom, NL, and Steve Gibbs, UK

Presentation: Recent developments in European legislation; challenges for recycling and horizontal standardisation of test methods. By ir. R.T. Eikelboom

Rein Eikelboom, Ministry of Housing, Spatial Planning and the Environment, The Hague, rein.eikelboom@minvrom.nl

Summary

This 5th WASCON conference on the safe reuse of waste materials coincides with a special moment in the history of reuse. In the 1980s, a small number of people started as pioneers in the field of reuse of waste materials. They focused on the development of test methods to better understand the behaviour of secondary and primary materials, such as the development of criteria, evaluation methods, scenarios and limit values for safe reuse, and the development of knowledge of new materials from waste materials. In these WASCON Conferences, information was exchanged and important information was provided to producers of waste, concerning the handling and reuse of waste, as well as to policy makers concerning legislation on waste. In many countries, developments on the proper reuse of waste started up and were developed further. Little by little, people have become more accustomed to reuse, but much resistance still remains.

WASCON started up with a small group of experts who were hard-working and motivated, but who were also rather modest and therefore not in the spotlight of public opinion.

The above-mentioned special moment in history concerns the fact that several developments in European legislation which directly or indirectly focus on the experiences and results of what has been discussed and exchanged in WASCON, have been tabled last year and this year.

A special mention should be made of the developments within the fields of the Construction Products Directive, the recent developments on Directives in the Environmental field (e.g. on land-filling, sewage sludge, bio-waste, monitoring of soil quality, water, waste), and the now well-recognised needs on both sides (environmental sector and construction sector), for a harmonised horizontal approach to development, and the use of test methods for the directives concerned. The pilot project 'Horizontal', which started in December 2002, will be of great importance to these developments concerning the harmonisation of test methods. This year, several important decisions will have to be taken in this field. The

EU will confirm its interest by giving some mandates to CEN. This contribution summarises a number of these relevant developments, ending with conclusions and remarks on some of the main points towards gaining optimal profit from these challenges. The expertise and results of the 'WASCON atmosphere' can be an important source for answering the needs of policy and legislative demands on the international EU-levels mentioned.

EU-Legislation

As mentioned in the summary, several types of development are relevant to the field of reuse of waste. It is often difficult to discuss the risks and challenges of these developments, as it is not always possible to get involved in each sector; information on these developments is not easily accessible. The major part of this paper is therefore devoted to giving a brief insight into each of the relevant developments.

EU-Construction Products Directive (CPD).

Structure and scope of the CPD

The CPD[1)] formulates the framework and procedures for the development of 'Technical Specifications' (TSs) for construction products. It is a 'New Approach' Directive. TSs are, in principle, developed by CEN-construction-TCs as 'Harmonised Standards'. The EOTA contributes to the development of Harmonised Standards for the attestation and certification aspects. The scope of the CPD concerns the phase of use in construction (houses, industrial buildings, road building, etc). Only the direct risks to users of the building and the direct environment are included. This means that risks to workers' safety, climate aspects, and second lifetime of materials are not included.

The TSs should cover six types of essential requirements. They were worked out further in 'interpretative documents'. Essential Requirement No. 3 concerns 'Hygiene, Health and Environment' [2)]. The other requirements concern 1) mechanical resistance and stability, 2) fire safety, 4) safety in use, 5) noise and 6) energy. After publishing a TS for a certain type of product, these products may only be brought onto the market with a CE-mark, which declares that the product has been produced according to the specifications of the TS.

A TS lists the parameters that are relevant for that product. Test methods are described with which these parameters should be tested. The producer should inform the client about the level he has measured. In general, no limit values are given in the TS itself. In the TS, classes of performance levels may be defined, so that the producer can declare that his product meets the requirements of, for instance, class 2, or class 3 of a certain parameter.

This means that the national legislators, local authorities, or the users of construction materials, can define their limit values for the parameters that fall within the scope of the CPD. But, as far as falling within the scope of the CPD is concerned, the current approach within the CPD-sector is that national legislation may only be made or maintained for the parameters that are included in the TSs, and only on the basis of test methods that are included in, or referred to in the TSs. So, in legislation, permits or in contracts, Member States may not ask information that should be produced with other methods than the methods included in the concerned TS.

The selections of parameters and test methods may be different per individual TS.

This approach of the CPD will limit the freedom of the national authorities to include environmental demands in their legislation. It means that current general environmental limit values should be differentiated from one (sub)product to another.

The preference in Essential Requirement 3 for 'release', will also mean that in many cases, the evaluation of construction products will have to change from 'content' to 'release'.

European Technical Approval

Within the CPD, eight levels of declaration of conformity are distinguished. In the TS for each parameter, it has been laid down which level of the declaration of conformity has to be followed before a CE-mark may be placed on the product. The subject of declarations of conformity is not further explained or discussed in this paper, but also still needs much attention.

Completion and introduction of Technical Specifications

Within the field of construction products, about 40 product families are distinguished (such as concrete products, road construction products, aggregates, doors, heating appliances, etc.).

TSs are developed for a product family, or more usually, only for sub-families. In total about 300-500 different TSs may be developed. Some dozens of these TSs were completed recently and have already, or will shortly come into force. The others will follow step by step.

In those TSs all essential requirements are included now, except the 'dangerous substances' of requirement 3. It turned out to be too complicated and too time-consuming for the construction sector to include these in the TSs, without causing further delay. Last year the Commission (DG-Enterprise) started a working program for completing the TSs with dangerous substances. The first step was an inventory of the national and European legislation, with limit values and test methods on dangerous substances, which covers construction products falling within the scope of the CPD. These substances are also called 'Regulated Substances'. The

next step will be to select the relevant substances and to define which kinds of test methods should be harmonised, and how a selection should or could be made for each Technical Specification. Based on this selection, a mandate will be given to harmonise these test methods and to include them in the next generation of Harmonised Standards. Obviously, it will still be difficult for the approximately 70 rather autonomous CEN-TCs concerned with these construction products to organise this standardisation in a proper and practical way. Initiatives were therefore taken to develop a horizontal standardisation within CEN for these test methods for the whole construction sector.

CPD; consequences and challenges

From this summary regarding the CPD and its developments, it may be clear that this Directive will become a strong driving force behind the further process of selecting and standardising the test methods for the environmental evaluation of substances. A major problem however, is that until now the knowledge of test methods, especially leaching tests, was developed in the environmental sector; in particular for the evaluation of waste to be land-filled or reused. CEN TC 292 (Waste) and WASCON were amongst the main driving forces for the development of these test methods, and for international communication on them, based on the results of a wide spectrum of research and test programs on leaching tests. However, there has been almost no communication between the construction sector in CEN and the environmental sector. The construction sector concentrated mainly on primary materials and experiences with primary materials when developing TSs, trying only to remove trade barriers for existing products. In several cases, representatives of these product sectors said that they would not like to mix this harmonisation for their primary products with developments in the waste sector, because their products should not be linked with waste. This point of view made it difficult to proceed with further communication. However it must be clear to everyone that recycled and reused materials in construction also fall within the scope of the CPD. The products we discuss at WASCON have to fit the specifications of the CPD, and can only be marketed with a CE-mark.

A great deal has changed in the last 10 years, since the publication of the CPD. Step by step re-use and recycling is becoming daily practice in research, industry and legislation. On the one hand, it is therefore relevant to realise that in developing the TSs, now the secondary materials should be taken into account. On the other hand, the secondary materials should fit the TSs, and can therefore only be brought onto the market with a CE-mark in the near future.

EU-Directive on waste

The Framework Directive on Waste [3)] explicitly takes reuse of waste into account.

In this Framework Directive on waste, it is considered desirable to encourage the recycling of waste and re-use of waste as raw materials, and that it may be necessary to adopt specific rules for re-usable waste.
Member states shall (Article 3) take appropriate measures to encourage prevention and reduction of waste production and its harmfulness, in particular by:

- Development of clean technologies,
- Prevention, or reduction to the smallest possible contribution to the harmful effects of products that have become waste,
- Development of appropriate techniques for the final disposal of dangerous substances contained in waste destined for recovery,
- Recovery of waste by means of recycling, re-use or reclamation, or any other process, with a view to extracting secondary raw materials.

Article 4 says that Member States shall take the necessary measures to ensure that waste is recovered or disposed of without endangering human health, without using processes or methods which could harm the environment, and in particular, without risk to water, air, soil, plants and animals, etc. According to Article 6, Member States shall establish or designate the competent authority or authorities to be responsible for the implementation of this Directive.

For the purposes of implementing Articles 4, etc, any establishment or undertaking that carries out such operations must obtain a permit from the competent authority. Activities concerning waste recovery may be exempted from the permit requirements if the competent authorities have adopted general rules for each type of activity laying down the types and quantities of waste, and the conditions under which the activity in question may be exempted from the permit requirements.

Landfill Directive

The Landfill Directive [4)] was finally completed in 1999. The Directive made a general distinction between three types of Landfill; landfills for ‘Inert waste’, for ‘Non-hazardous waste’, and for ‘Hazardous waste’. Annex 2, with acceptance criteria and limit values, was completed in December 2002, and published as Decision 2003/33/EC [5)]. This document gives acceptance values for waste that is landfilled regarding certain types or sub-types of landfill. Member States may set stricter limit values. (In individual cases, higher limit values may be accepted for some parameters if specific situations should make this necessary). Limit values are given for ‘Inert waste’ landfilled on ‘landfills for inert waste’, landfilling

non-hazardous waste in cells with hazardous waste, hazardous waste in landfills for non-hazardous waste, and hazardous waste in landfills for hazardous waste. Member States may make further subdivisions. They should define the criteria and limit values where this Annex does not yet contain completed limit values for such landfills; e.g. for landfills for stabilised waste, if such landfills were to be developed.

These acceptance criteria and limit values have to be implemented in July 2004, and must come into force in July 2005. The Decision gives a list of test methods that are under development in CEN-TC292 and which will be selected after they have been finalised. Member States have to select their own test methods and criteria as long as CEN-test methods are not yet available, or as long as EU-criteria have not yet been developed for certain classes or subclasses.

The Commission (DG-Environment) recently gave a mandate to CEN for the development of these test methods, underlining the need for adequate test methods. This concerns test methods developed by CEN-TC-292 on Waste, i.e. test methods for leaching (batch tests and percolation tests especially for inorganics) and tests on content (especially on a number of organics, and some generic parameters).

Annex 2 distinguishes different levels of testing: 1) characterisation, 2) compliance, and 3) acceptance testing.

The limit values are based on a mix of source-based approach (what is possible) and effect-oriented approach. For the effect-oriented approach, limit values were developed and checked for their effect in different scenario evaluations.

Initiatives concerning soil

The EU-Commission (DG-Environment) took some initiatives during the last few years concerning the use of waste products as soil ‘fertilisers’. These initiatives led to the conclusion that adequate test methods are needed. After some time however, it became clear that in different committees often the same tests were developed for the same parameters, but in each committee for its own scope and for its ‘own' area of legislation. It was concluded that this duplication in developing tests, as well as the use of different tests for the same kind of materials, should be avoided. A horizontal approach could possibly offer a practical solution.

The most important sources for this development were draft directives on sludge and bio-waste, and initiatives for a strategy on soil protection.

Sludge Directive

Discussions were started on the revision [6)] of Sewage Sludge Directive 86/278/EEC. The revised directive will deal with Sewage sludge, Septic tank sludge and Industrial sludge from the treatment of industrial wastewater from a listed number of industrial sectors. The proposals in the

Commission's working document on sludge concern the quality of the sludge as well as the quality of the soil on which the sludge will be used. The soil should be tested for heavy metals, P, pH, etc. The sludge should be tested for heavy metals, P, N, pH, dry matter, organic matter and organics, etc. This Directive therefore not only requires test methods for testing sludge to be developed, but it implicitly also makes the development of uniform test procedures for testing soil quality obligatory.

Bio-waste

The working document on Bio-waste [7] determines the outlines for the directive. The transition to a Directive requires more time, but from this draft it was concluded that a number of tests should be done on bio-waste, before bringing it on the market. The tests concern hygienic aspects, general parameters (such as dry matter, organic matter, pH, etc), heavy metals, PAH, PCB's and substances such as N, P, K and Ca; only the 'content', not 'leaching'. Based on the test results, compost and stabilised biodegradable waste should be classified in one of the quality classes to be distinguished.

Soil Protection / Monitoring

In the document 'Towards a Thematic Strategy for Soil Protection' (16-4-2000) [8)], the Commission presented outlines and specific points for further discussion and investigation. The purpose of this Communication Document is to build on the political commitment to soil protection in order that it may be achieved more fully and systematically in coming years. One of the practical topics is information on the quality of the soil in Europe. In a special project of the Commission's Joint Research Centre (in co-operation with a network of soil science institutions) scientific and technical work programmes are being carried out to collect, harmonise and distribute soil information. This information is relevant to the Community and to national policies. During the work on this project, it emerged that information about the soil quality often cannot be compared between Member States, due to the use of different test methods. This is a major bottleneck for the further assessment of soil conditions in Europe. The Commission is now preparing a project for the further monitoring of soil quality in Europe. One of the major starting points for such a monitoring system is the use of uniform test methods throughout Europe. The specifications of a Community monitoring and information system will be the subject of a proposal for soil monitoring legislation. It will aim to ensure that a number of measurements on the identified threads in the relevant areas are carried out in a harmonised and coherent way, and that its results are relevant and accessible to policy makers, as well as to early warning systems

Water Framework Directive

The Water Framework Directive [9) 10)] provided a fresh impetus towards improving surface and ground water, to avoid the long-term deterioration of freshwater quality and quantity. It aims at a progressive reduction of pollution. It includes the development of programmes and actions, as well as several deadlines. Along list of relevant and priority substances, which need extra attention, are presented in two annexes. Member States are to identify individual river basins. Programmes will be drawn up for these river basins. The MS will identify the competent authorities for these river basins. Member States may give general rules and limit values. They can also mandate this to authorities that issue regional regulations or individual permits.

Primary and secondary construction materials may affect the water quality. Therefore the national general rules and individual approaches applied by competent authorities should also include construction products, secondary as well as primary material and products

Other Environmental, health and hygiene legislation

This paragraph does not give an outline of all legislation that may be relevant to construction products. It shows only some of the main examples of EU-legislation concerning criteria and limit values for substances. These EU-Directives and EU-Decisions should be included in national legislation. It may often be the case that national legislation is stricter. In general, national legislation may also concern substances for which EU-legislation has not yet given instructions. On the other hand, in certain cases, the EU-Commission may conclude that national legislation conflicts with general rules designed to prevent unnecessary trade barriers. Some of the main European Directives related directly or indirectly to substances, are as follows:

Substances

- Council Directive 76/769/EEC, on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations.
- More than 20 amendments to this directive, each including special criteria and restrictions regarding one or more substances (e.g. asbestos, PCP's, arsenic).
- Council Directive 91/414/EEC concerning the marketing of plant protection products
- Council Regulation (EC) No 3093/94 on substances that deplete the ozone layer.

These EU-legislations sometimes relate specifically to the construction products in use; in these cases the subject also falls directly within the scope of the CPD. However, these regulations often only concern the use of substances in general. They may include a total ban or the strict limit value on the content of substances in these products. Usually, they only concern content of substances in materials or products and they are not concerned with the substances released by products.

Drinking water

- *Directive 80/778/EEC, relating to the quality of water intended for human consumption.*

Construction products used for the production and transport of drinking water must meet the criteria on substances, to protect the users of drinking water. These products generally fall within the scope of the CPD. Some years ago, a special project was started within the scope of the CPD, in which a specific approach was established for setting criteria and evaluating the quality, as well as a system of approval for this family of construction products.

Radiation

- Council Directive 96/29/Euratom, which lays down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation

Radiation may be relevant to a small number of materials. In some Member States, legislation is under development or already available. In relevant cases, materials and products should be tested.

Worker safety legislation

There are several Directives, etc. on a European level, e.g.:

- Council Directive 80/1107/EEC, on the protection of workers from the risks related to exposure to chemical, physical and biological agents at work
- Council Directive 83/477/EEC of 19 September 1983, on the protection of workers from the risks related to exposure to asbestos at work (second individual Directive within the meaning of Article 8 of Directive 80/1107/EEC)

Workers safety legislation is primarily directed at exposure to workers. In each situation the amount of exposure should be determined. From such an evaluation, it follows whether the product can or cannot be used, or whether special preventive measures should be taken for the workers. These directives give no direct criteria or limit values for construction products. However, these directives often forbid the use of dangerous substances, such as asbestos or other substances that can cause cancer, in

cases where alternative materials or products are available. These regulations generally only concern the manufacture of products, or the production phase of construction, which does not fall within the scope of the CPD. They only fall within the scope of the CPD in cases where they concern buildings in which people will work, such as offices, shops, workshops, etc.

LCA

Several kinds of activity are being carried out regarding Life Cycle Analyses (LCA), often on the basis of experiments or special activities in specific sectors. In some cases the role of legislation is considered or prepared. On a European level, discussions are also on-going, including activities concerning the atmosphere of construction products.

In these approaches, the main purpose is not the setting of limit values for individual substances. Most of the systems are currently aimed at comparing different products. These approaches take into account all the phases a product undergoes during its life. These activities will not fall directly within the scope of the CPD.

The main point of concern in this field is that adequate information about products becomes available. This means that it is important to agree on the information that is needed, and to produce this information using harmonised test methods.

Environmental directives and the CPD

It is clear that a large number of environmental EU-directives set restrictions on dangerous substances in construction products. In some cases, as with the CPD, their scope centres on ‘products in use’. However, in many cases the environmental directives are concerned with other phases during the lifetime of products. In these instances, the CPD will not take such directives (or such national legislation) into account.

If the process of harmonising test methods were to continue under the CPD without taking these other directives into account, it would still affect these other directives (and national legislations). In many Environmental Directives and national legislation on dangerous substances, no test methods are specifically selected or formally designated. For daily practice one has chosen their own test methods or Member States have sometimes chosen specific test methods. It must be realised that the selection and harmonisation of test methods within the scope of the CPD will lead to CEN-standards, which producers of construction products are obliged to comply with, as far as the CPD is concerned. Predictably, they will not be happy with other test methods in other legislative obligations for testing the same parameters. These contradictions will lead to further discussions on selection of test methods in other legislative area and at

the end of the day often in obligations to use the same test methods as selected under the scope of the CPD.

Another point deserving attention is the difference in procedures between the CPD and e.g. the directives on waste and water. The CPD wants to set general standards, and it is aimed to include only rather limited groups of substances in Technical Specifications of product subfamilies. However, the Directives on waste (including re-use) and water, consider that all types of substances may be part of primary or secondary products. This cannot be covered by short lists of substances only, but requires instead attention to all possible substances and to the possibility of individual approaches. (These individual approaches may be combined with general criteria contained in the national legislation if required). These contradictions between CPD-approach and other approaches need serious attention.

In the environmental sector, individual licensing is not the only alternative. Covenants and other types of agreement dealing with the use of substances are also applied, without them being included in national legislation. It is not intended to take these individual approaches into account in the present CPD's proposed approach.

Next, the CPD approach on dangerous substances is aimed at 'release' of substances. If this approach is followed strictly, it will conflict with several existing national legislations and EU-directives both within and beyond the scope of the CPD. In many of the cases that are beyond the scope of the CPD, there are good reasons for setting limit values on content, or even for defining total bans on substances. In those cases, it should be considered whether it is efficient to also set limit values for release.

Finally, it must be considered that the CPD's approach is product oriented; each product (each product family of product subfamily) will receive its own Technical Specification, with its own selection of parameters. Environmental legislation is mainly focused on substances or materials, or combinations of both. This, for instance, leads to general bans on asbestos or general restrictions on cadmium in plastics. It is not always possible to select beforehand in which product sub-families asbestos or plastics could be used. Often it is also not possible to determine on beforehand if in a specific product family this asbestos or cadmium would never be applied, in Europe or in imported products. So, when drawing up TSs, it is not possible to conclusively determine under which environmental directives and legislation the TS's will fall and so to determine that some substances are not relevant for that product sub family.

From these examples it may be concluded that it is rather important to consider these points in detail, and to solve these problems before giving a mandate to CEN to harmonise test methods for the technical specifications of the CPD.

On the other hand, it is obviously important for all parties concerned to harmonise test methods, as the same parameters are included in several legislations and directives, and in several working fields that overlap each other in different ways.

Project Horizontal

The above-mentioned overlaps between soil, sludge and bio-waste directives were the basis for a workshop on the harmonisation of test methods held in Stresa (Joint Research Centre, JRC) in February 2001, with participants from a wide range of CEN TCs. It was concluded that horizontal standardisation is very much needed to avoid unnecessary duplication of work. Initiatives were taken to start a project that is aimed at developing Horizontal Standards for the new EU Directives on Sludge, Soil and Treated Bio-waste

The 'Horizontal' project [11)] phases the work into a desk study, and the further development and validation of the test methods. The project is aimed at all test methods that are required in the directives mentioned. In the desk study, all information regarding the testing of these parameters will be investigated and compared. Information concerning similar test methods used in other fields, and used for other directives or national legislation, will be included in the investigations. One or more test procedures for each parameter will be selected from this information and elaborated into a draft standard.

About 40 institutes in Europe are involved in this project. Co-ordination is carried out by ECN (Netherlands). The JRC and CEN are also closely involved with the co-ordination. It is estimated that approximately 4.5 million Euros would be needed for the entire project. However, it was not possible to obtain a financial contribution from DG-Research at the beginning of the project so that it could be started in one step. The project has now been divided into several phases. The first phase includes most of the desk studies and some of the further investigations and validations on inorganics. One and a half million Euros are needed for this first phase. At the end of 2002, it was decided that DG-Environment and JRC will jointly contribute about 40% of this amount. The rest will be financed by contributions from Member States. All Member States promised to contribute, stressing their interest in this project. The second phase is currently being prepared. It is assumed that DG-research will contribute to the next phases.

The desk studies will be completed during the summer of 2003. They will be discussed in all the relevant CEN-committees as well as other relevant groups in autumn. The entire project will take about 3 years. Within CEN-Environment, a procedure has been agreed regarding where and how to discuss the results of each step of the project, how to decide on the selection of tests, and the further implementation of the results of

the project. The procedure will be co-ordinated by the Co-ordination Group of CEN Environmental Technical Committees (ENV-TC-CG). The Commission (DG-Environment) is preparing a mandate for CEN regarding this work for Horizontal.

However, the primary scope of the Horizontal project appears to fall outside the scope of reuse of secondary materials, although it is rather relevant to this work. The Commission now strongly promotes and demands the effective and horizontal further development of test methods. Information from different sectors must be made as accessible as possible, since working areas are rather close, and the same materials and products can often be involved in different areas. It is therefore not practical if these materials frequently have to be tested using different test procedures for the same parameters. The commission tends to cover these demands with formal mandates. It must be considered that soil matrices are closely related to construction materials and their matrices. So from a practical point of view, it would be preferable if test methods for construction and soil materials were more similar.

As this project has already started, it will now also become relevant to further horizontal developments in the construction sector (CPD), because of these similarities with soil materials. It is relevant to exchange information on the results with the construction sector, and to discuss the results before reaching final conclusions.

Environmental criteria for the development of test methods

Decisions concerning which methods will be chosen for further horizontal approaches have to be considered carefully. What information is needed for each parameter from the relevant regulations and the relevant environmental sectors? What information is needed from these test methods to serve the risk assessment in these sectors adequately? What other requirements are there, for instance from the construction sector?
In each case it should carefully be decided if priority should be given to ‘content’, ‘release’, or both. For content approaches, one type of extraction should be selected. For release approaches, release test methods should include aspects such as development of leaching in time; type of release such as percolation, diffusion, evaporation or combinations of these; influences of pH, redox DOC; mutual influence of different substances; limited solubility; changes of material quality in time; etc. Leaching is a complex process. Leaching tests and risk assessment should be based on scenario approaches. With an adequate selection of test methods, many materials can be characterised and evaluated effectively. So, for general characterisation and evaluation test methods should be selected with great care.

In daily practice, a selection of test methods can often be used after the material has been completely characterised.

It is important to agree on these points (what is needed and what should be taken into account?), before CEN is mandated to standardise test methods for legislation or other purposes.

Horizontal development of test methods

What is meant by the 'horizontal' development of test methods is a system in which test methods can be used for a wide range of materials or products. Horizontal development of test methods requires a 'modular' approach.

Modules (CEN-standards) should be developed on the following levels: 1) Testing plan (including the sampling plan); 2) Sampling techniques and strategy; 3) Sample pre-treatment; 4; Specific handling, such as extraction, release / leaching, other handling; 5) Analyses; 6) Report on the testing procedure and the final results; 7) supporting procedures for transport and storage of samples. A number of modules can be developed for each level, only as far as strictly needed.

Further developments

As shown above, it is clear that it is necessary to harmonise test methods. This requires a great deal of creativity and co-operation from all parties concerned.

In the short term some of the main milestones will be:

- The following steps within the scope of the general mandate of the Landfill Directive to CEN; the planned mandates on regulated substances for the CPD, and on the 'Horizontal' project.
- The results of the desk studies of the 'Horizontal' project
- Discussions within the relevant committees of CEN-Environment and ISO regarding the co-ordination of these new developments.
- Similar discussions within the CEN-Construction sector regarding this horizontal approach and a mandate to the CEN-Construction sector
- The CEN workshop on 29 and 30 September 2003 concerning the further demands on, and organisation of standardisation, especially within the CEN-Construction sector and the co-operation with the CEN-environmental sector. Representatives from all relevant committees, Member States and EU are invited to exchange ideas and requirements at this workshop.

It is important for these short-term activities, as well as for future work, that the available knowledge on characterisation of construction products, waste, soil, etc, is put forward. It is also important to clearly determine

what the real demands are from the environmental and health risk assessment point of view.

Conclusions

1. Reuse of waste is strongly stimulated by the EU-framework directive on waste; according to this directive, the reused waste must meet environmental criteria as formulated in other European directives and national legislation, guidelines and permits.
2. In the near future construction products containing secondary materials and reused waste should meet the CPD-Technical Specifications, the same as primary products.
3. A large number of environmental directives set direct or indirect criteria (via licensing) and limit values that have to be met by construction materials containing primary, secondary and waste materials.
4. 'Release' approaches are most relevant for the evaluation of products in use. However, in other phases of lifetime, environmental approaches often concentrate on 'content' approaches, because that is more effective within their scope.
5. In general, only a limited number of substances (150-200) are relevant. For most construction products, less than 5 to 10 substances may be really relevant. However, in special products and in reuse of waste, other substances may be present which fall within the scope of one or more environmental, hygiene and workers safety legislations.
6. Adequate test methods are needed for approval of the quality of all types of products. Only a 'horizontal' and 'modular' development of test standards can serve these needs efficiently.
7. Recent EU-Commission initiatives stress the relevance of adequate horizontal standardisation of test standards for 'dangerous' substances; EU-mandates to CEN will provide guidance regarding further developments.
8. Completing this horizontal standardisation requires the co-operation of the environmental sector and the construction sector.
9. The 'Horizontal' project which concentrates on 'content tests' for a number of environmental EU-Directives, is an important step towards horizontal standardisation of test methods in Europe. A similar step on leaching should be taken soon for tests on release, serving several environmental directives and the CPD.
10. During the past 12 'WASCON-years', it has became evident that leaching is mostly a rather systematic event that can be characterised and described in rather the same way for different types of materials and products. This knowledge can provide the basis for further horizontal approaches.

11. These actual demands of the CPD and the environmental EU-Directives are a big challenge for implementing developments that were presented and discussed in earlier WASCON conferences as well as this one.

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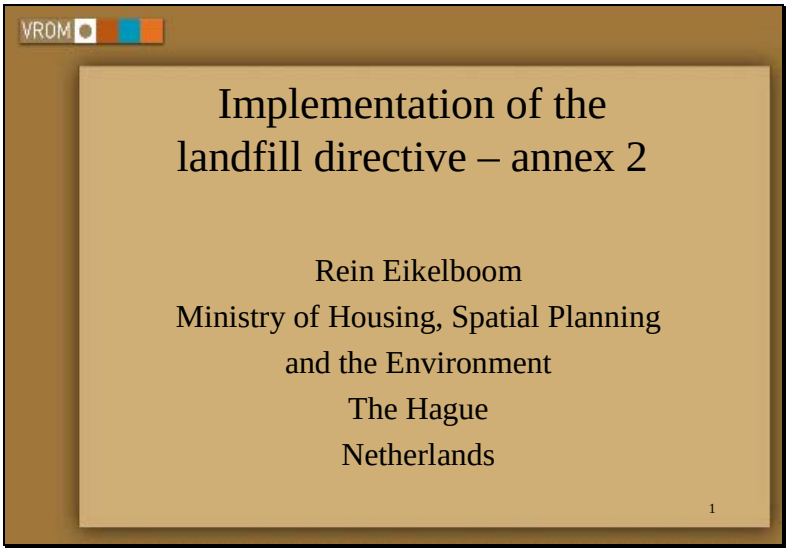

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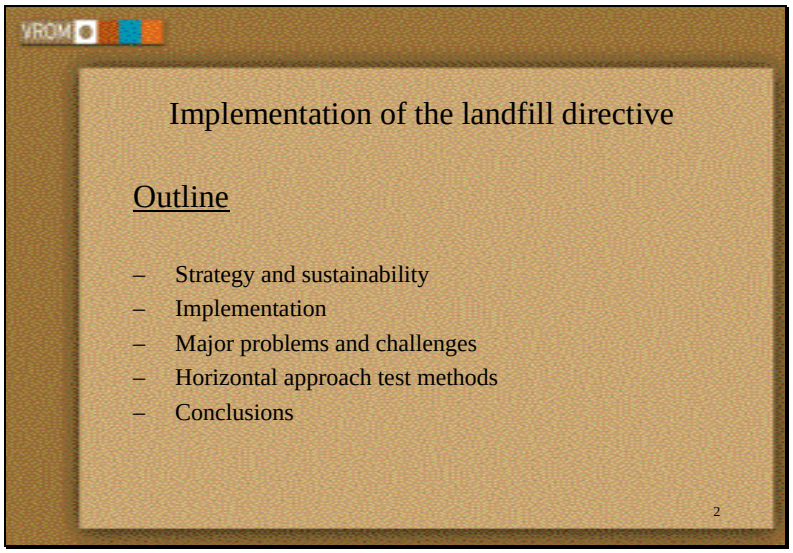

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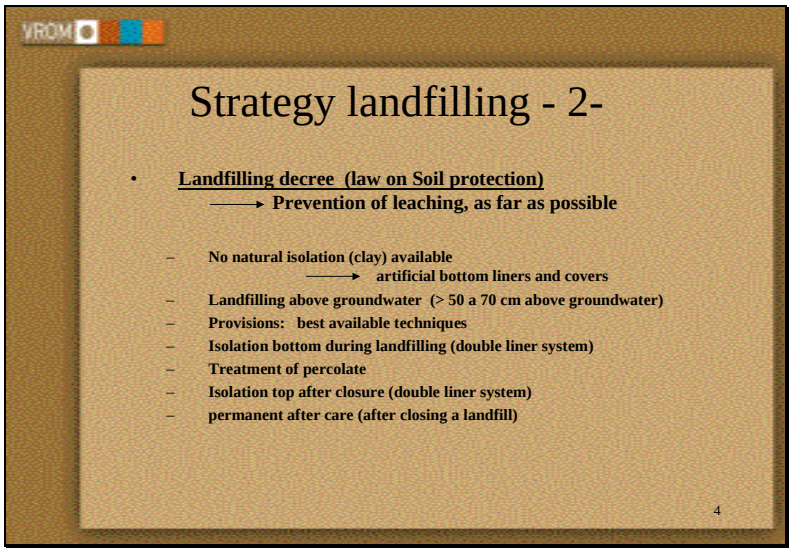

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VROM

Types of landfill sites
landfill directive - Netherlands

Landfill Directive	Netherlands policy
1. Inert waste	------
2. NH waste (Domestic waste)	------
2a. NH waste mixed with HW (LV: Ann.2)	------
(+ subclasses)	NH-waste (Mixed inorganic) (LV: = Ann.2)
	NH-waste (Mono landfilling) (LV: =Ann.2) (e.g. dredging sludge, industrial waste)
3. H waste (LV: Ann.2)	-------
(+ subclasses)	H-Waste (LV: < Ann.2)
	Stabilized H-waste (LV: 'Conditioned waste')
	H-Waste (LV: Ann.2) *(concrete landfill basin)*

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Slide 8

VROM

Implementation Annex 2
Problems

- Selection of test methods
- Sampling; quality parameters (producers and enforcement)
- Changes in test methods next few years
- Uniformity of test methods with test methods for reuse, treatment, etc.
- Position of different groups Haz. waste (C2 and C3); can they be included in criteria Annex 2 for HW?
- Use of the factor 3

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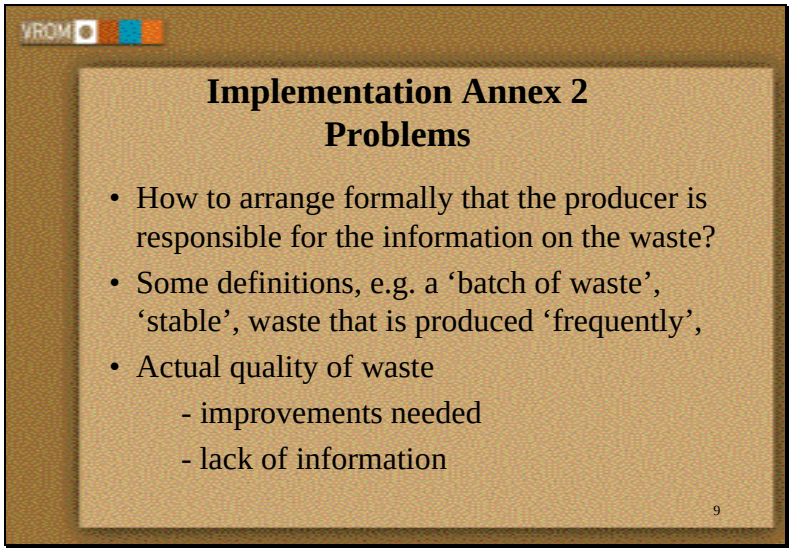

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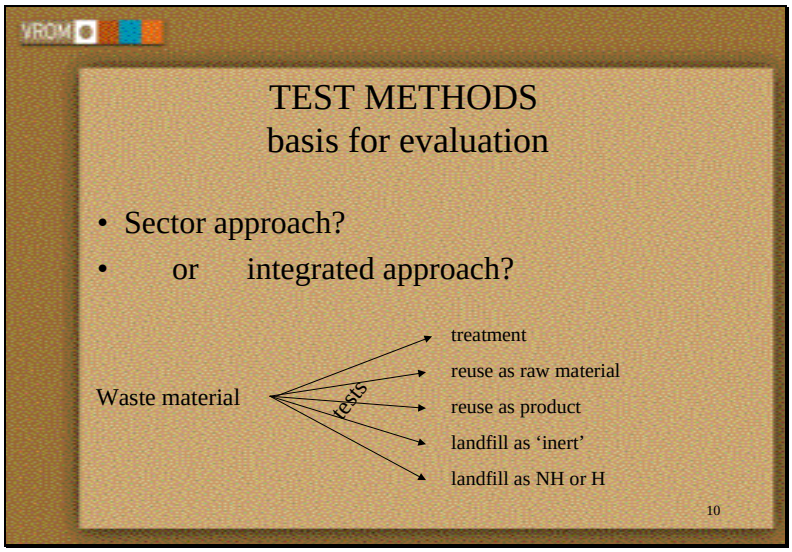

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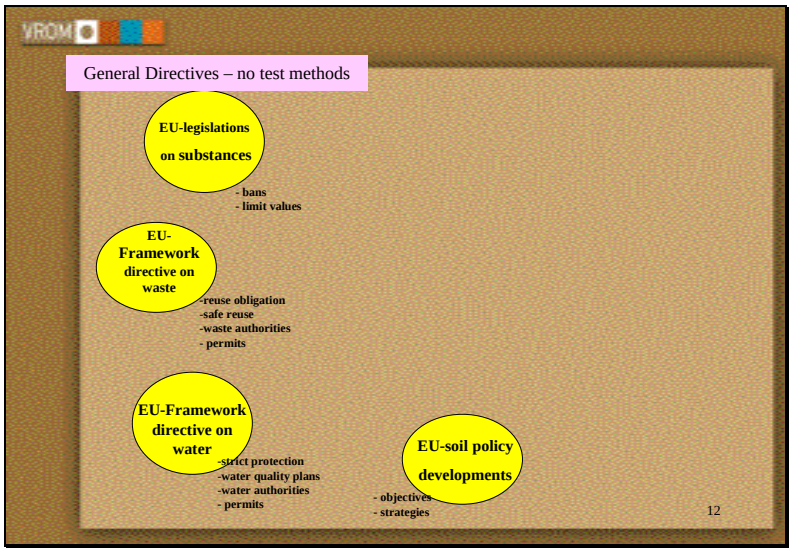

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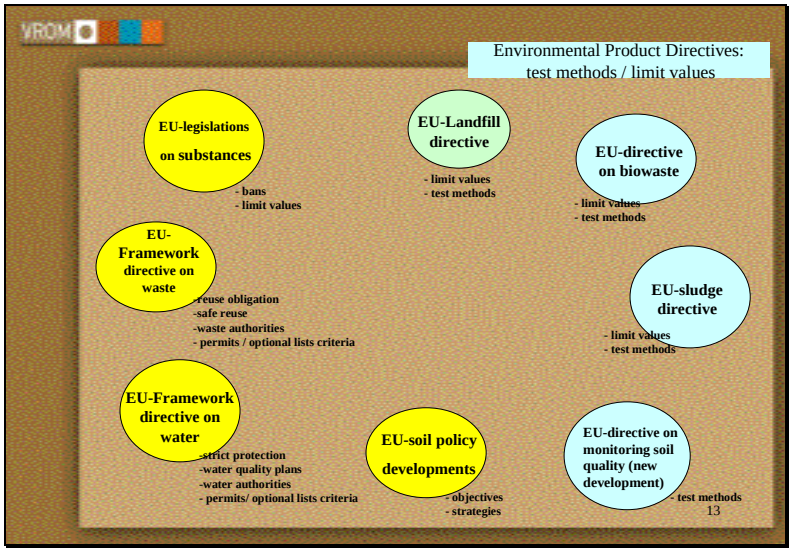

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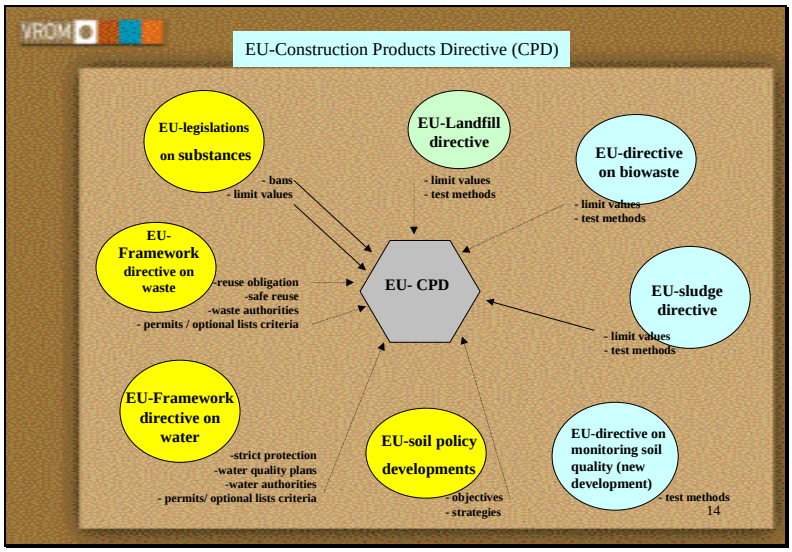

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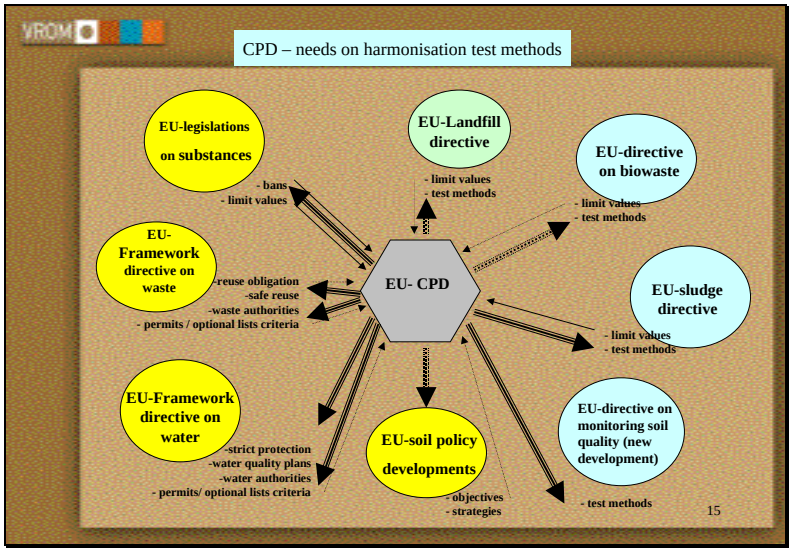

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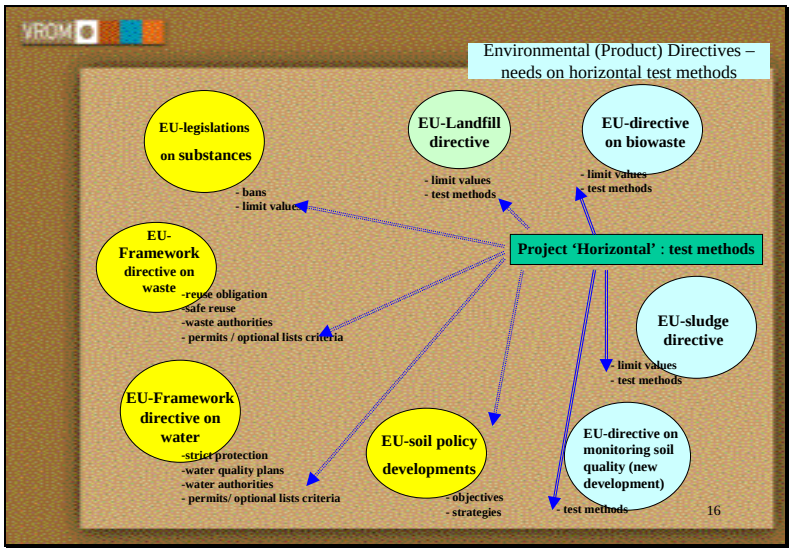

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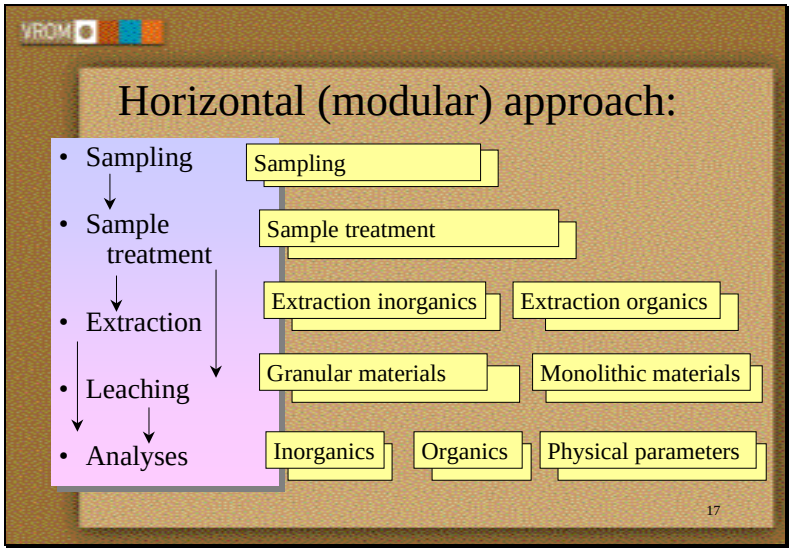

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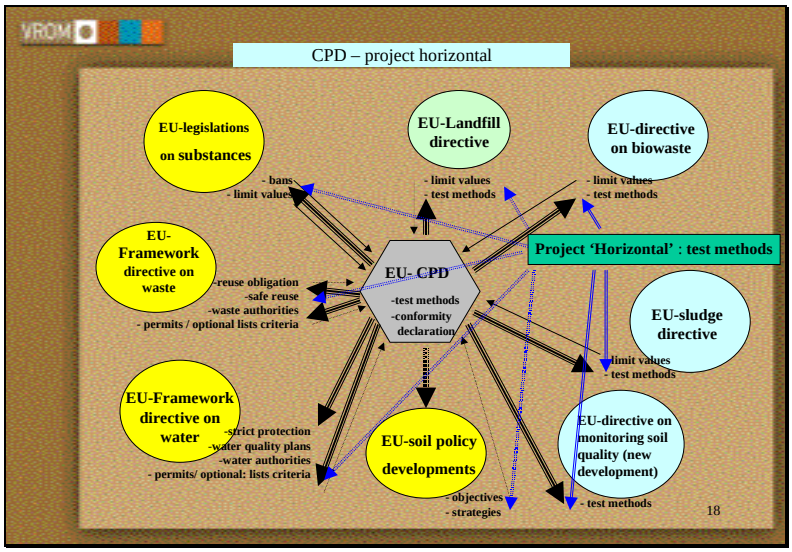

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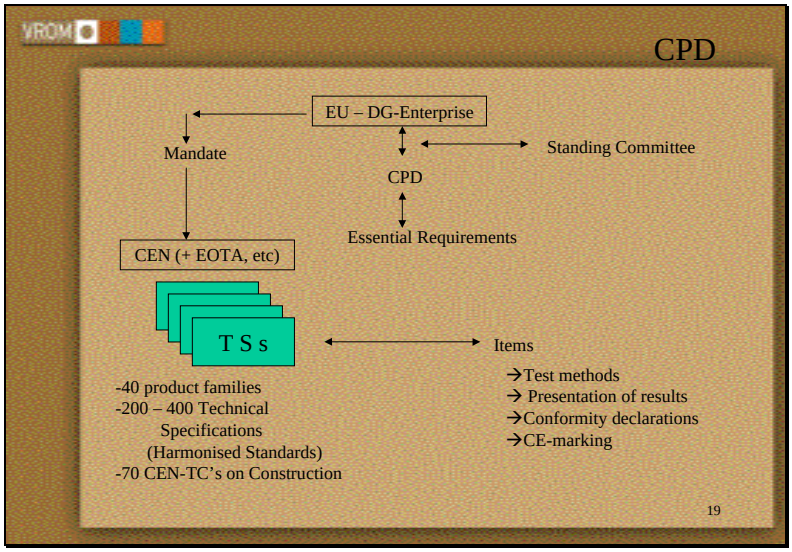

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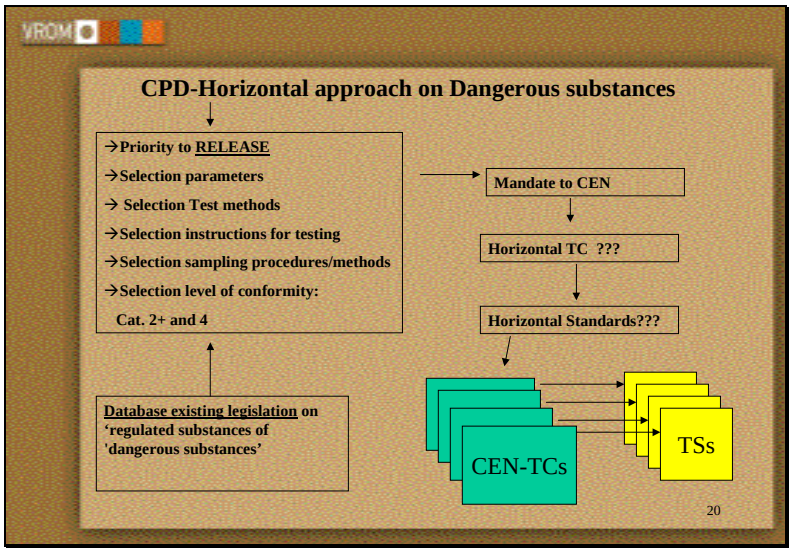

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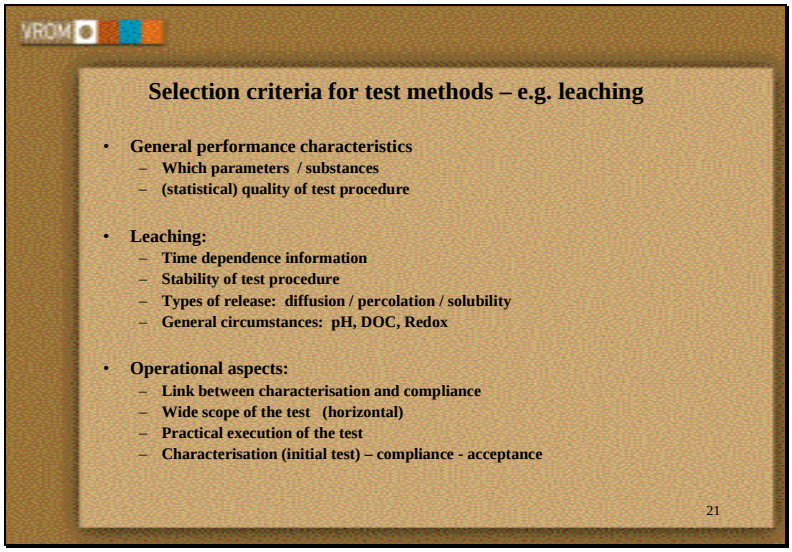

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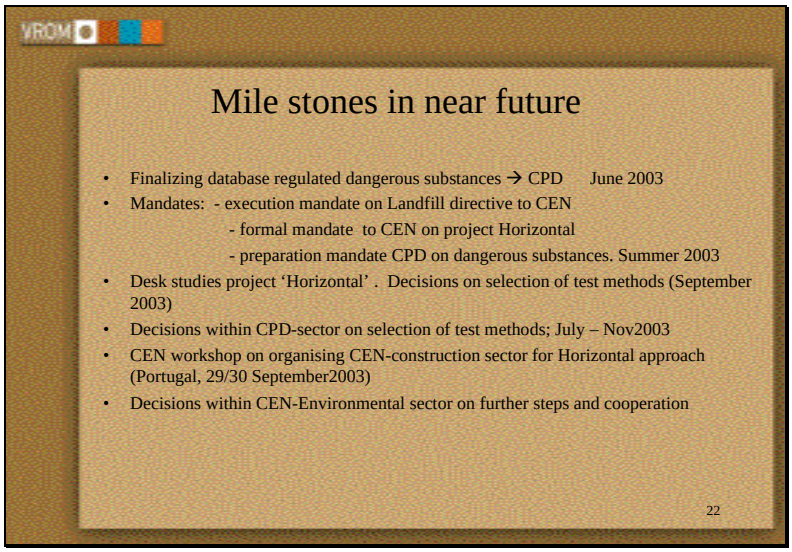

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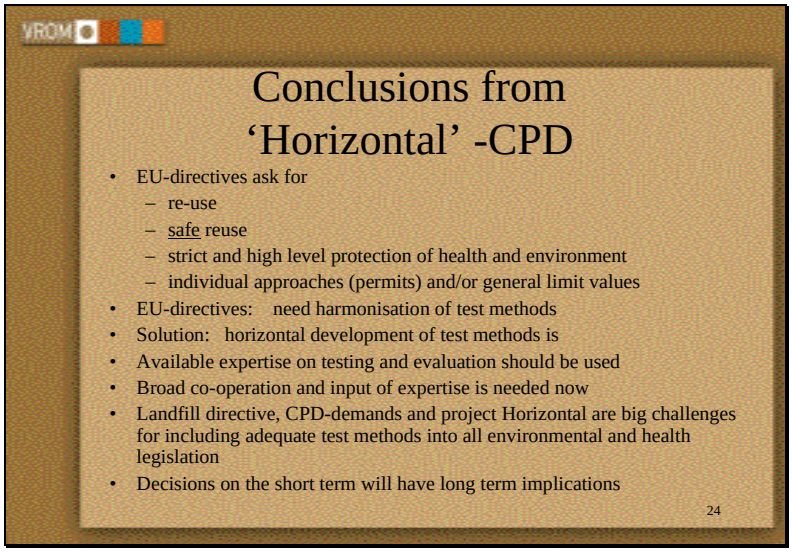

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Presentation: The Landfill Directive and Council Decision on Annex II – Challenges for the UK. By Steve Gibbs

Steve Gibbs, Principal Consultant, Waste Management, Atkins Environment

The interpretation of "sustainable landfill" in the UK has been controversial, with resistance in many quarters to the notion that a landfill should place no significant management or monitoring burden on the next generation. This resistance is rooted in the view that companies should be regarded as ongoing businesses, that will continue to carry the burden of their operations.

The approaches explored most fully in the UK are:

- the technical approach of seeking to achieve accelerated stabilisation, by managing landfill processes; and
- the administrative approach, of seeking financial provisions during the active life of the landfill, available to the competent authorities if the operating company fails to manage the liabilities.

The Landfill Directive both modifies these ideas, and brings new challenges for the UK.

The main challenges presented by the Directive are:

- The loss of co-disposal landfill as the main disposal option for hazardous waste. Associated with this are concerns about the sustainability of landfill for treated hazardous waste alone. In addition, operators of co-disposal landfill are mainly seeking classification for non-hazardous waste, so that less than 20 landfills will be available on a merchant basis.
- The provision of treatment capacity, both to achieve diversion of biodegradable municipal wastes, and to comply with Article 6(a) and to attain Annex II waste acceptance criteria (WAC). Provision of this capacity will take both time and investment. The UK private sector has been reluctant to provide the investment without certainty as to the Directive requirements such as limit values.

The Council Decision on Annex II provides some solutions, and leaves some residual problems.

On the positive side, the Environment Agency welcomes the waste characterisation procedures and the requirements for underground storage. The limit values, based on the work of the modelling sub-group, provide some soundly-based certainty for the industry.

Two areas of concern are:

- The provision that some limit values may be varied by risk assessment. This is resisted by the waste industry, because it re-introduces uncertainty, and supported by waste producers, who see the potential for reduced costs.
- The year-long gap between 2004, when landfills for hazardous waste may only accept treated waste and may not accept non-hazardous wastes, and 2005, when the Annex II limit values apply. The Agency and the waste industry would like the limit values to apply earlier, in order to limit any environmental impact of wastes that do not comply with WAC. At the same time, there is a recognition that treatment capacity to achieve WAC may not be available in time.

The UK government is about to consult on options for dealing with these two concerns.

The Environment Agency is seeking to apply the Annex II limit values now to landfills for inert waste, to proposals to accept hazardous wastes in non-hazardous landfills under Article 6(c)(iii), and to new landfills for hazardous wastes. For landfills for non-hazardous wastes, the Agency will require site-specific risk assessments, and will require operators to justify the leachate source term used. It may be necessary to control loading rates of parameters such as heavy metals.

There are some unknowns as to the extent of treatment that will be necessary, for example to comply with WAC for stable, non-reactive hazardous wastes. For example, will it be necessary to use solidification processes to comply? There are also concerns about the use of “bogus” treatment processes, involving mixing of waste materials. If such proposals are allowed, it will further reduce the certainty needed if the waste industry is to provide the treatment capacity required by the UK.

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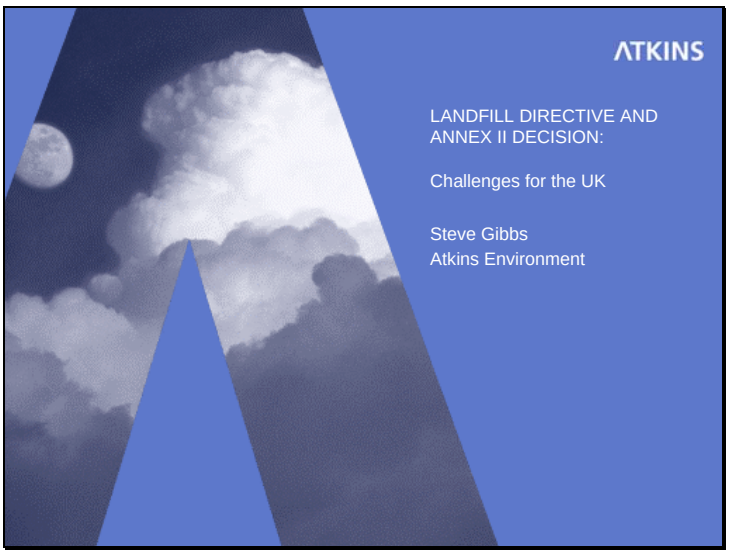

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SUSTAINABLE LANDFILL OBJECTIVES

ATKINS

- Circa 1995
  - Promote landfill practices which will achieve stabilisation of landfill sites within one generation
- Circa 1998
  - Manage the contents of the landfill so that the outputs are released to the environment in a controlled and acceptable way
  - Residues left in the site should not pose an unacceptable risk to the environment, and the need for aftercare and monitoring should not be passed on to the next generation
  - Future use of groundwater and other resources should not be compromised

Slide 4

SUSTAINABLE LANDFILL OBJECTIVES

ATKINS

- CURRENT DRAFT
- construct a landform with a beneficial after use
- reduce input of reactive wastes/provide measures to accelerate stabilisation
- careful resource use in design, construction and operation
- prevent unacceptable adverse effects on the environment in both the short and the long term
- balance costs and benefits
- ensure geotechnical stability
- no unnecessary burdens on future generations, e.g. use passive control measures

Slide 5

FLUSHING BIOREACTORS

ATKINS

- Key problems
- Water management
  - Flushing rates eg 10m/annum for 30yrs (60m landfill)
  - Source of water
  - Containment of water
  - Treatment/Disposal of water
- The time value of money
  - £10,000 yr 50= £35 NPV @ discount rate 12%
  - Leachate and gas management costs met earlier

Slide 6

DRAFT WMP26F

ATKINS

- Intended to codify management of codisposal operations
- Specify minimum requirements for reactive zone
- Define suitable and unsuitable wastes
- Define loading rates
- Specify testing requirements etc

Slide 7

DIRECTIVE CHALLENGES

ATKINS

- DIVERSION OF BMW
- PROHIBITED WASTES
- END OF CO-DISPOSAL
- PRE-TREATMENT (ART 6A)
- COMPLEX TIMETABLE - FAIRNESS

Slide 8

DIVERSION OF BMW

ATKINS

- Mass burn unpopular
- Suspicion of pyrolysis, gasification, AD
- Market issues re use of compost
- Therefore:
  - Maximise source segregation, recycling, composting
  - Defer EfW decision post-2013
  - Falling biodegradable content in landfill
  - Gas management problems?

Slide 9

PROHIBITED WASTES

ATKINS

- LIQUIDS
- Difficult to operate flushing bioreactor concept, unless alternative water sources used eg "grey" water
- H8 CORROSIVE
- Solid alkaline wastes such as APC residues

Slide 10

END OF CO-DISPOSAL

ATKINS

- Concerns about sustainability of landfills for hazardous wastes
  - cf Repositories for radioactive wastes
- Economics for operators who rely on local authority MSW contracts
  - Opting for "non-hazardous": 20 for hazardous wastes post 2004
- Timescale for provision of treatment capacity

Slide 11

PRE-TREATMENT- ART 6A

ATKINS

- Compliance?
  - The “three point test”
- Achieve WAC?
- Achieve sustainability/FSQ?
- Consider BPEO?
- Issues:
  - “Bogus treatments”
  - “Gold-plating”

Slide 12

COMPLEX TIMETABLE

ATKINS

- Existing landfills/New landfills
- Hazardous /Non-hazardous
- Interim WAC/ Annex II
- Tyres
- Fairness:
  - Treatment requirements for new/existing non-haz
  - Ban on liquids for new/existing non-haz
  - National date, or as permitted?

Slide 13

TIMETABLE

ATKINS

REQUIREMENT	EXISTING SITE	NEW SITE
Classification of landfills for hazardous waste (HW)	16.07.2002	NOW
Banned wastes, including liquid wastes, apply at landfills for HW (see Summary Note 2)	16.07.2002 Tyres as dates in Regulation 9(e) and (f)	NOW Tyres as dates in Regulation 9(e) and(f)
Waste acceptance criteria apply to HW landfills	Schedule 1 paragraph 1 NOW, otherwise 16.07.2004	NOW
Stable, non-reactive, low-leaching hazardous waste may be deposited in landfills for non-hazardous waste in cells separate from biodegradable waste.	NOW	NOW
No more non-hazardous waste allowed at landfills for HW	16.07.2004	NOW
Waste must be pre-treated before entering landfills for HW	16.07.2004	NOW
Final European waste acceptance procedures apply	16.07.2005	16.07.2005
Liquid waste banned from landfills for non-hazardous waste	Single national date expected to be announced by DEFRA	NOW
Waste must be pre-treated before entering landfills for non-hazardous waste	Single national date expected to be announced by DEFRA	NOW
PPC permits applications required	As notified by Agency on the basis of risk assessment using Conditioning Plans	NOW
Other requirements of the Regulations	As permits are granted	NOW

Slide 14

COUNCIL DECISION: THE GOOD!

ATKINS

- Certainty for inerts, hazardous
- Limits on organics
- Other limits derived by sound science – modelling sub-group
- Flexibility for non-hazardous
- Underground storage requirements
- Characterisation and testing

Slide 15

COUNCIL DECISION: THE BAD

ATKINS

- RISK ASSESSMENT – 3X OR 2X LIMITS
  - Erodes certainty for the waste industry
  - Regulatory burden of risk assessments
- "GAP YEAR" 2004 – 2005
  - Treatment, no co-disposal, but no Annex II WAC
- STILL LOTS TO DO!
  - Monolithic wastes
  - Statistical approach
  - Use of TDS, definitions, limit values eg PAHs

Slide 16

COUNCIL DECISION: UNCERTAINTIES

ATKINS

- SUSTAINABILITY
  - Modelling work assumes long-term leachate removal
  - How long to flush out dry granular wastes eg APCs?
- TREATMENT IMPLICATIONS
  - What wastes will fail?
  - Will solidification be required?
  - What other options eg APCs: chloride, pH

Slide 17

UK SITUATION: Main technical issues

ATKINS

- Risk assessment – government to consult on options
  - Do nothing
  - No risk assessment
  - Risk assessment
  - Risk assessment for mobile constituents
- Monolithic wastes
  - Definition – deliberately solidified wastes; limited additions
  - Modelling output awaited
- Sampling and testing
  - Draft guidance produced – includes statistical approach
- Extent of treatment
  - Looking to Europe
  - Commercial secrecy

Slide 18

UK SITUATION : Landfills

ATKINS

- Landfill for inert – restricted definition, fewer landfills
- Landfill for non-hazardous
  - Site specific risk assessment
  - Justification of leachate source term
  - Control of loading rates
- Landfill for hazardous
  - Few sites (20?)
  - Gap year – use “spare” loading capacity; separate later wastes?
  - Sustainable?
  - Will proposals for new sites come forward?
- Expect many haz in non-haz (Article 6(c)(iii)

Slide 19

UK SITUATION: Landfill permitting

ATKINS

- All landfills being permitted under IPPC
- Specific application form for landfills
- Application requires a number of risk assessments
- Guidance and templates produced
- About 970 submitted conditioning plans
- Being processed in tranches up to 2007
- Uncertainties have greatest effect on early tranches: hazardous

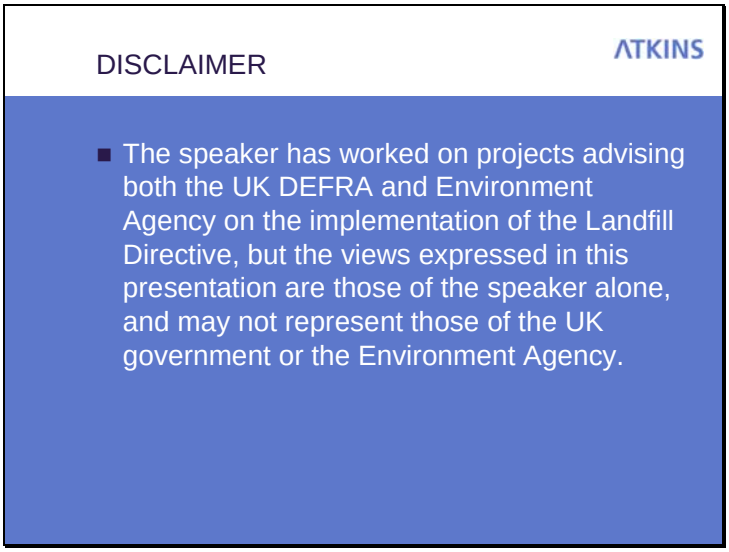
Slide 20

UK SITUATION: Treatment

ATKINS

- Compliance option pursued
- Guidance produced
- Concern re bogus treatments – Article 5(4)
- Possible use of BAT for IPPC waste production processes
- Application of BPEO via land use control system
- Uncertainty over Annex II etc means the waste industry is reluctant to invest in new treatment capacity

Slide 21


DISCLAIMER
ATKINS
The speaker has worked on projects advising both the UK DEFRA and Environment Agency on the implementation of the Landfill Directive, but the views expressed in this presentation are those of the speaker alone, and may not represent those of the UK government or the Environment Agency.

Appendix E: Introductions on implementation and challenges in the Nordic countries

Denmark

Seminar on Sustainable Landfilling
Holte/Copenhagen, 18-19 June 2003

By Jørgen G. Hansen, Danish EPA

Landfilling of waste since 1970

During the seventies and the first half of the eighties round 60 percent of all waste were disposed off at landfills.

In 1985 the Danish Government introduced a tax on waste going to incineration and landfills.

From 1985 to 1995 the total amount of waste disposed off at landfills decreased from 5.2 million tonnes (57% of the waste production in 1995) to 2.0 million tonnes (17% of the total waste production in 1995).

The amount of waste disposed off at landfills have continued decreasing and today (2001/2002) only 10% (equivalent to 1.4 million tonnes) of the total waste production in Denmark are landfilled.

Paralleled with the decreasing amount of waste disposed off at landfills the numbers of Municipal Solid Waste (MSW) Landfills have declined – from approximately 915 landfills (inclusive uncontrolled dumps) in 1973 to 79 (MSW and dumps) landfills in 2003.

Danish Implementation of the Landfill Directive (99/31/EC)

The implementation of the EU Landfill Directive in Danish legislation covers:

- Amendments to the "Environmental Protection Act" and to the "Soil Protection Act". (Passed 7th June, 2001)
- New Statutory Orders (passed 29th June, 2001):
  - Statutory Order (no. 650) on Landfills
  - Statutory Order (no. 647) on Education of Landfill Operators and Staff
- Amendments to existing Statutory Orders (passed 29th June 2001):
  - Statutory Order (no. 648) on Waste
  - Statutory Order (no. 646) on Licensing of Polluting Activities
- The Danish EPA issued Guidelines (no. 5/2002): Preparing of Conditioning Plans for Existing Landfills.

Implementation of the Council Decision (2003/33/EC)

The expected time schedule for the Danish implementation of the Council Decision (CD) of 19th December 2002 *"Establishing criteria and procedures for the acceptance of waste at landfills"* is as follows:

Time:

1. Danish EPA starts the "hard work" with the implementation of the CD	August 2003
2. Reference Group to be appointed	Autumn 2003
3. Statutory Order (Draft) in external hearing (Statutory Order 650 to be revised)	January 2004
4. Process remarks/complaints from the external Hearing	March 2004
5. New Statutory Order (Final Draft) to be approved by the Minister	May 2004
6. New Statutory Order to be passed	June 2004
7. New Danish Guidelines "Landfilling of Waste" to be issued	2005

Important matters of concern due to the Danish implementation

From a National Legislators point of view the Danish implementation of the Council Decision covers the following matters of concern:

1. Very short time for the implementation!
2. A correction of the Danish translation of the CD is strongly needed. (Correction notified 20th May 2003!)
3. When are the new CEN-Standards completed? – Does Denmark have to evaluate & address other relevant (non-CEN) standards?
4. Are the EU-limit values too gently? – If so: What should the basis be for setting stricter criteria and limit values in Denmark? (Answer: Comparison between the results from the Modelling Work (Danish contribution) and the limit values laid down in the CD is needed!)
5. Does Denmark wants to include other components or parameters for analysing?
6. Is Denmark going to establish national criteria and limit values for non-hazardous waste?
7. Which waste types could/should be exempted from characterisation?
8. Will the EU limit values for hazardous waste course any problems in Denmark?
9. Is there a need in Denmark to define other types (sub-categories) of landfills?

Conditioning Plans

With reference to the conditioning plans put forward to the local authorities (The Councils) by July 2002 the total numbers of landfills in Denmark is 144.

In the figure (below) one can see the distribution of the 144 existing landfills in 3 different landfill categories (MSW-landfills, Mono-landfills and Dumps) and furthermore the figure shows how many of the existing landfills are expected (by the owner of the landfills!) to be in operation after July 2009.

Landfill category	In Operation (after July 2009)	Don´t know	Closed down (Before July 2009)	Total
Landfill (MSW)	33	8	12	53
Mono Landfill	33	12	20	65
Dump	9	8	9	26
Total	75	28	41	144

Slide 1

Seminar on Sustainable Landfilling
(Copenhagen/Holte, 18-19 June 2003)

Implementation of the LD & CD and challenges in Denmark

Jørgen G. Hansen, Danish EPA

Slide 2

Waste Treatment in Denmark

2001: 13.6 million tonnes

≈ 2.5 tonnes pro inh./year
≈ 7 kg. pro inh./day

Slide 3

Landfilling of Waste since 1973

Year	Landfilling of Waste	% of Total Waste
1973	??????	59%
1985	5.2 million tonnes	57%
1993	2.5 million tonnes	26%
1995	2.0 million tonnes	17%
1997	2.1 million tonnes	16%
2000	1.5 million tonnes	11%
2001	1.4 million tonnes	10%

Slide 4

Numbers of (MSW) Landfills in DK

Year	Landfills
1973	915
1989	~ 200
1992	130
1995	113
2003	79

(2003: one Landfill per 70.000 inhabitants)

Slide 5

Existing Landfills - Total: 144 sites

(Ref.: Conditioning plans)

Landfill Type	In Operation (After 2009)	Don´t know	Closed down (Before 2009)
Landfill (MSW)	33	8	12
Mono Landfill	33	12	20
Dump	9	8	9
TOTAL	75	28	41

Slide 6

Danish Implementation of the EU Landfill Directive (99/31/EC)

- Amendments to ”Environmental Protection Act” and ”Soil Protection Act” (7. June 2001)
- New Statutory Orders (29. June 2001)
  - — on Landfills
  - — on education of Landfill Operators and Staff
- Amendments to existing Statutory Orders
  - — on Waste
  - — on Licensing of Polluting Activities
- Danish EPA Guidelines (5/2002): Preparing of Conditioning Plans for Existing Landfills

Slide 7

Time Schedule for the implementation of the CD (1)

Timescale:

- **DEPA ”relax”...…….. Spring ´03**
- **DEPA starts the ”hard work” with the implementation of the CD…….. August ´03**
- **Reference Group to be appointed……. Autumn ´03**
- **Statutory Order (Draft) in external hearing (”650” to be revised?) …….. January ´04**

Slide 8

Time Schedule for the implementation of the CD (2)

Timescale:

- **Process remarks/complaints from the external hearing……... March ´04**
- **New Statutory Order - Final Draft to be passed to the Minister……...……... May ´04**
- **New Statutory Order to be issued……..…. June ´04**
- **New DK-Guidelines: Landfilling of waste (revision of the 1997-Guidelines)…….. 2005**

Slide 9

Implementation of the CD (1)

- Very short time for implementation!
- A correction of the Danish translation of the CD is strongly needed. (Correction notified 20. May 2003 !!!)
- When are the CEN-standards completed?
- Evaluation of other relevant standards, norms etc. to be adressed. (non-CEN)

Slide 10

Implementation of the CD (2)

- Is the EU-limit values too gently?
  - If so: What should the basis be in DK for setting stricter criteria and limit values?
- Comparison between the results from the Danish Modelling work and the limit values laid down in the CD. (Stricter values? ⇒ YES!)
- Does DK wants to include other components or parameters for analyzing?

Slide 11

Implementation of the CD (3)

- Is DK going to establish national criteria and limit values for non-hazardous waste?
- Which waste types could/shall be exempted from characterization (Mixed waste?)
- Will the EU limit values for hazardous waste cource any problems in DK?
- Is there a need in DK for definition of other types of landfills?

Finland

Nordic Council of Ministers and Centre of Waste Research
Seminar on sustainable landfilling 18-19 june 2003
Holte Denmark

18 june 2003
Ari seppänen

Status

- Implementation of landfill directive at 1997, amendments at 1999
- Implementation of Council Decision is running actively in autum 2003.

Landfilling

- At the moment for mixed non-hazardous waste about100 landfills operated by companies owned by municipalities and 90 private non-hazardous landfills owned by industrial plants.
- New permit round is running for year 2007. Targets at 2010:
    - 60 municipal landfills,
    - enhancement of incineration, composting, rotting and biomechanical treatment of municipal waste,
    - reducing landfilling of biodegradable municipal waste from 60% to 20%.

National Points

- Preliminary lines for implementation of national parts of criteria are in first discussion at the moment:
- Subtypes of non hazardous landfills proposed for mineral, mixed and stabilized hazardous waste
- Equal testing criteria for all mineral non hazardous granular waste sites excluding inert waste sites.
- Factor 3 will be open with case by case procedure with assessment of risks of impacts, waste and landfill and surroundings including permits of operator and producer. Hg and Cd will be outside of factor 3 openings.
- Monolithic waste is open question because of lack of definition and also methods for eluate testing and calculation.

- Because of the restrictions for biowaste in landfill, something must be said about testing of biodegradability and also more general about accepted pre-treatment.

Other

- There are as well juridical difficulties to transform round written-annex text for underground landfills in old mines to compact articles to national decision and at the same time restrict or take account the proposed mining waste directive.
- Landfill acceptance testing should have connection to other waste testing such as acceptance testing for recovery purposes and also broader sense to testing in the world of products.

Iceland

*Cornelis Aart Meyles,*Environmental and Food Agency in Iceland

In Iceland there are 30 landfills operational for non-hazardous waste, around 10 for inert waste and 1 for industrial waste. No landfills are operational for hazardous waste as contaminated soil, but one such landfill is planned for the near future.

The biggest landfill for non-hazardous waste in Iceland is in the vicinity of Reykjavik and handles around 110.000 tonnes yearly. There are four landfills for non hazardous waste that are handling from 10-20.000 tonnes a year. All other landfills handle less than 5000 tonnes a year, with 10 handling less then 500 tonnes a year.

In Iceland, around 2/3 of all municipal waste is landfilled, ca. 172.000 tonnes a year. Around 81000 tonnes of waste are recovered whereof 7000 tonnes of household and similar waste is being incinerated with energy recovery. Most of the hazardous waste produced in the country is being sent abroad (ca. 1000 tonnes a year) for further treatment, but waste oil is incinerated with energy recovery (around 6000 tonnes a year).

The trend during the last decade has been fewer and bigger landfills as in other EU/EC countries, with more and more municipalities cooperating in their waste treatment. However, due to harsh weather conditions some isolated settlements have not such an option. Municipalities that are operating a co-operative waste treatment facility, usually operate a small landfill for inert waste for themselves.

No landfill or incineration taxes are posed in Iceland. Instead, there has been adopted a new law on the treatment of waste committee, creating a financial frame for boosting re-use, recycling and recovery of waste materials. The main reason for choosing this option in waste management policy can be found in the fact that waste for re-use, recycling and/or recovery has to be transported over long distances which can be problematical during a great part of the year because of wheather conditions. Also the amounts of waste are too small to make re-use, recycling and/or recovery not a feasible option in most cases. Taxes for landfilling or incineration would therefore merely higher the cost for waste treatment in the municipalities, without being a useful instrument of increasing re-use, recycling and/or recovery.

In practice there is being set a fee on some specific products (beverage-containers, composites, tyres, silage wraps, fishing nets, cars) to pay for collection, transport and treatment of these wastes. In two cases there is also set a return fee: beverage-containers and cars.

Iceland is facing three main problems in waste management today (as I see it):

- biodegradable municipal waste. No reliable data are available on the amount of this waste for 1995. It has been estimated that around 60% of municipal waste is biodegradable, but a final agreement on this has not been reached. This makes it difficult to complete the national waste management plan that is under construction.
- Landfill gas was first measured in Iceland in 2002 on 4 –bigger-landfill sites. A further research is being performed this summer, including most of the landfill sites that are operational in Iceland today. The report is due to come out in the autumn of 2003, but the first results give way to assume that only on a few bigger landfill sites it may be useful to collect landfill gas, as concentrations of methane gas prove to be very low on smaller landfills. The results of the research may lead to the necessity of applying for a further exemption from gas collection for isolated settlements (less then 500 inhabitants/km2) in the LD.
- Slaughterhouse- and fish waste. The major waste problem in Iceland could well be the problem of slaughterhouse- and fish waste. It has become clear that slaughterhouse waste is degrading very slowly under the Icelandic climatic conditions (a comparison with a good refrigerator is applicable, as the average temperature is 4°C over the year). Investigations have been carried out that show that landfilled slaughterhouse waste has not significantly changed over a period of 25-30 years. Biological, physical and chemical processes seem to be totally absent on the landfill sites observed. This makes a revision of treatment of this waste necessary. Unfortunately slaughterhouse waste is not included in biodegradable municipal waste, making incineration of this waste not a financial option, unless a total ban on landfilling is set.

Implementation of the Landfill Directive, Council Decision and Annex II

In March 2003 a new law on the treatment of waste came into force in Iceland, implementing the Landfill Directive in general terms. 2 Regulations, one on waste treatment in general and the other on landfill of waste, containing a further and more detailed and practical implementation of the LD, are under construction and are due to be set somewhere during the summer of 2003.

The translation of the Council Decision and Annex were recently finished and the work of implementing them has started. It is however unlikely that they will be fully taken into account within the frame of the two new regulations mentioned above, as the implementation of the LD has already proved to cause a major change in waste management in Iceland in general, especially in respect to financial, political and practical issues.

Norway

Lise Kristin Jensen

There are about 105 municipal landfills, 3 hazardous waste landfills and about 50 industrial landfills in Norway. The industrial landfills receive non-hazardous and hazardous waste.

As part of Norway's strategy for sustainable waste management, a national target has been introduced on final treatment:

Maximum 25% of the total quantity of waste generated is to be delivered for final treatment by 2010.

Final treatment includes both landfilling and incineration without energy recovery.

The Landfill Directive (LFD) was implemented in Norway through the Landfill Regulations of 1 May 2002. Landfill owners were required to send in a provisional application by 1 May 2003. As the Norwegian Pollution Control Authority (Statens Forurensningstilsyn, SFT) is still in the process of drafting specific guidelines, the deadline for landfill owners to send in a complete application has been extended to 1 May 2004.

For existing landfills, the requirements of the Regulation will come into effect when the landfill owner receives a new permit. The new permit will cover all the requirements of the Regulations. Unlike existing landfills which have a transitional period until 2009, new landfills cannot start operations before all requirements are met.

In view of the complex and technical requirements in the Regulations, SFT finds it necessary to draw up specific guidelines. It is important that the landfill owners and the environmental advisors working for the regulators have a common understanding of the Regulations. The new guidelines that are due this autumn/winter will be on environmental risk assessment, financial security and leachate monitoring and management.

Only a very few municipal landfills in Norway will meet the requirements for geological barrier and bottom sealing. For example, the geological structure is often fractured and fissures can lead large amounts of water out into the local environment. As a result of this almost all landfill owners will apply for reduced requirements via an environmental risk assessment.

The Landfill Directive bases its requirements on protection of soil and water on the Groundwater Directive. In Europe many countries take their drinking water from groundwater resources. In Norway, however, only 13% of the population receive drinking water from groundwater sources. Another aspect is that in Norway, the groundwater aquifers are small and isolated. Protection of surface water is therefore just as or even more important for Norway than protection of groundwater.

When it comes to leachate control and management, Norway's regulations are stricter than the LFD. There is an absolute requirement for collecting leachate from municipal leachate today.

As a basis for the guidelines on environmental risk assessment, SFT will combine other relevant National strategies with the objectives of the Landfill Directive. Norway has a National strategy for reducing the discharge of hazardous substances. For example, there are actions plans for brominated flame retardants and PCBs. Both substances have been found in leachate and sediments downstream landfills. Norway has set aside 50 million kroner in the national budget this year to clean up and tidy up contaminated sediments in harbours and fjords. It is important for Norway to avoid such big clean up operations again.

In conclusion, steady progress on the implementation of the LFD and drafting guidelines are made, but a considerable amount of work still remains.

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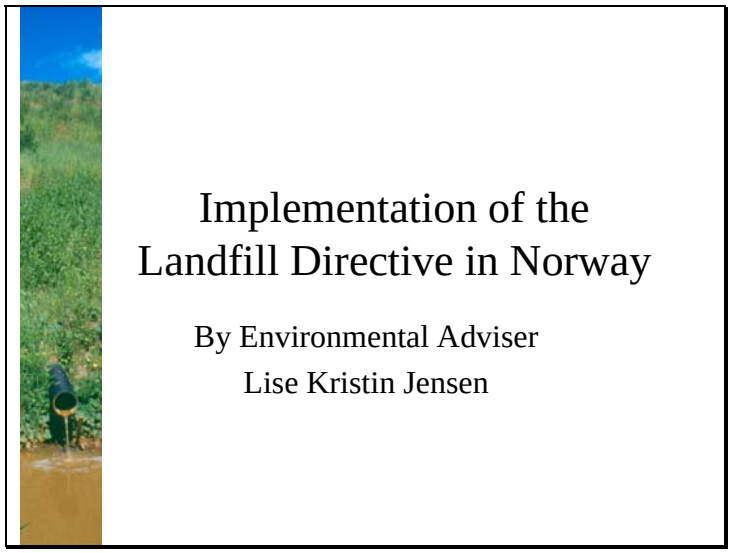

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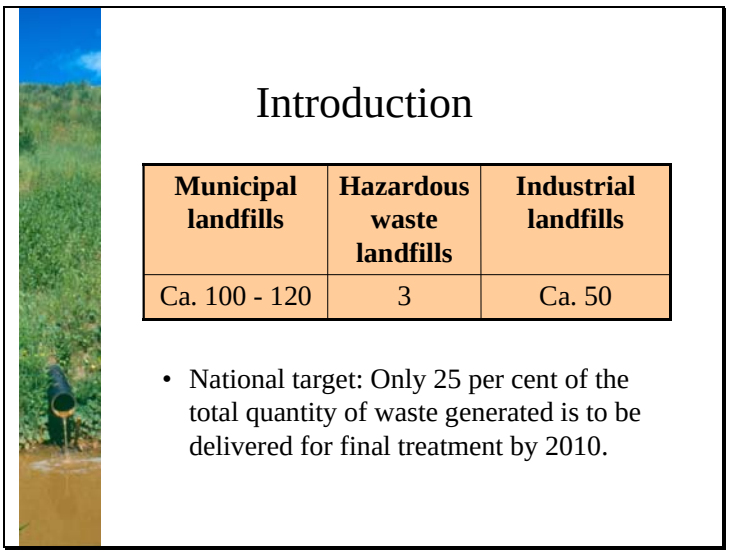

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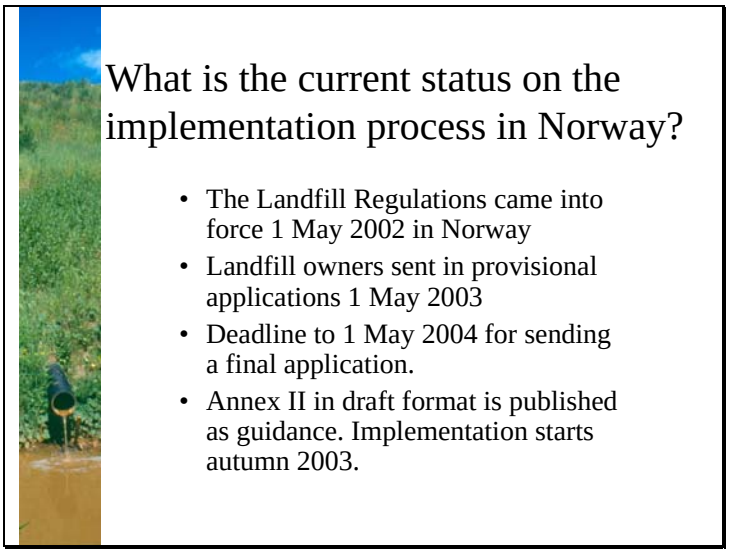

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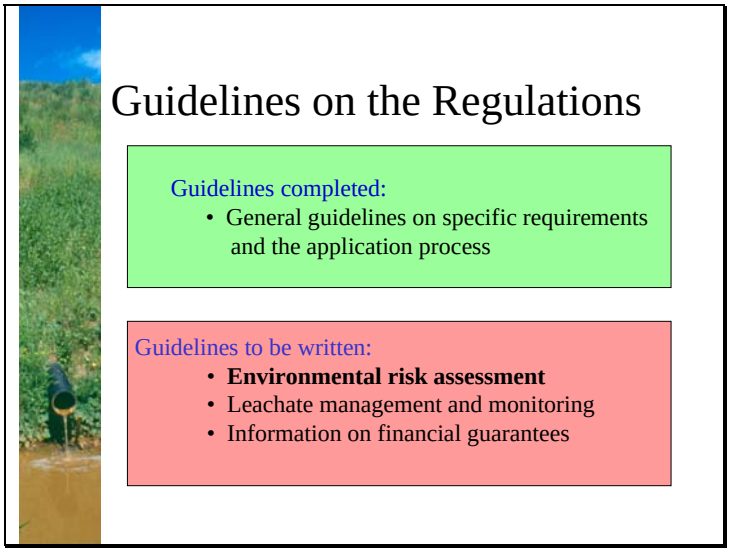

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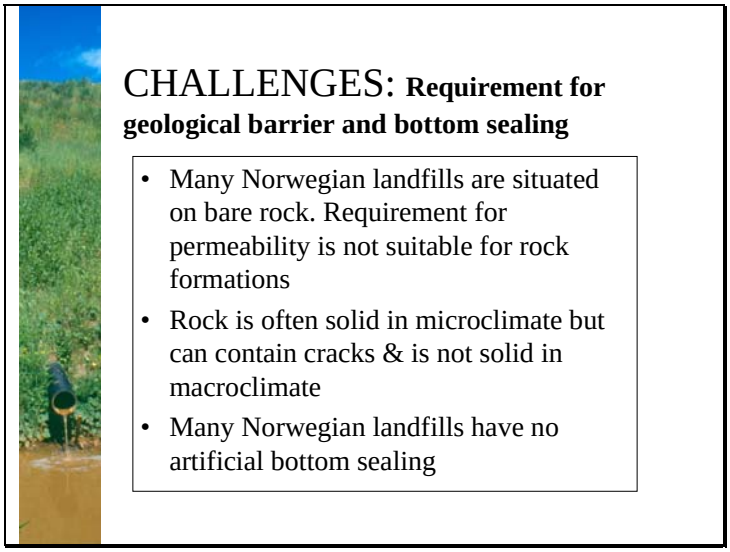

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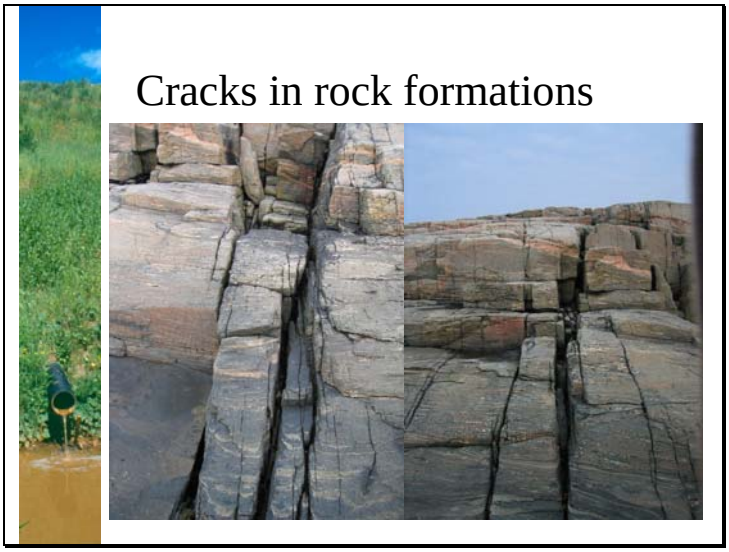

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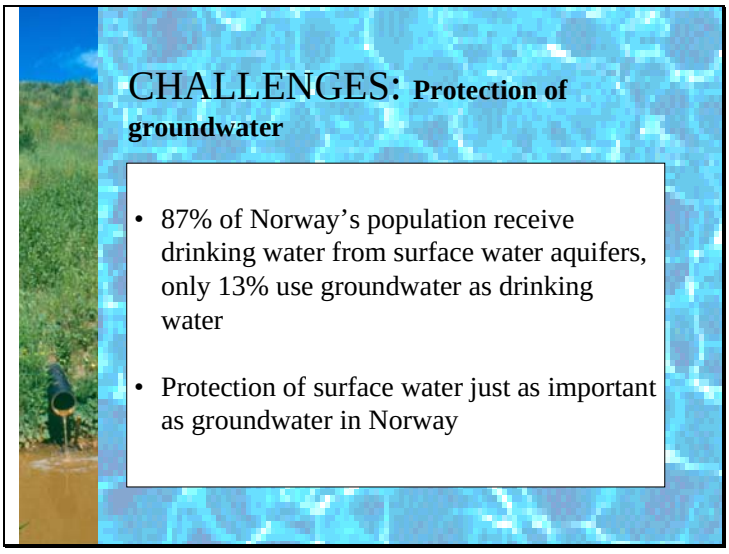


Slide 8

CHALLENGES: **Requirements for leachate collection**

Requirements for leachate collection may be reduced if not seen as necessary:

– Mandatory for municipal landfills to collect leachate since mid 1990s

Slide 9

Environmental risk assessment guidelines

- National strategies underpinning the ERA
  - Norway's strategy on chemicals
  - Norway's work on polluted soil/sediments,
  - Other Directives: Water Framework Directive and Groundwater Directive
- Method
  - Source – Release – Exposure assessment

Sweden

Stina Lundberg

A brief presentation regarding the situation for landfilling in Sweden today. What has the landfill directive meant for Sweden? How is the implementation going? What kind of problems do we have? And also, what more needs to be done? As many other countries Sweden is not fully satisfied with the landfill directive and the new Council decision.

339 landfills are covered by the landfill directive in Sweden today. Nearly 50 % are landfills for production waste. Three years ago the situation was different. Many landfill sites closed down before the landfill directive came into force and there was a very rapid decrease from 1999 to 2001. These landfills have closed down the way required in their permit, that is not as strict as the landfill directive.

The landfill directive is implemented in Sweden with an ordinance and regulations from the Swedish EPA. But despite all the work that has already been done there is still more work to be done. Further guidance regarding financial security is needed, this issue is discussed intensively and clarifications are needed. And the new Council decision needs to be implemented.

One important difference between Sweden and many countries in Europe is that Sweden has a big amount of lakes that need protection. This has to be taken into account while implementing the landfill directive and the Council decision. The article regarding bottom lining and geological barriers in the landfill directive have been supplemented with an extra paragraph in Sweden and we require a side barrier as well as an geological barrier under the landfill in the Swedish ordinance. Surface water also needs to be considered while we implement the Council decision in Sweden.

Sweden is in general positive to the decision but in some cases we are in favor of stricter criteria. Sweden is especially concerned about:

1. The limit values for Cd, Hg and As
2. That we do not have limit values for non-hazardous waste
3. The requirements for organic parameters

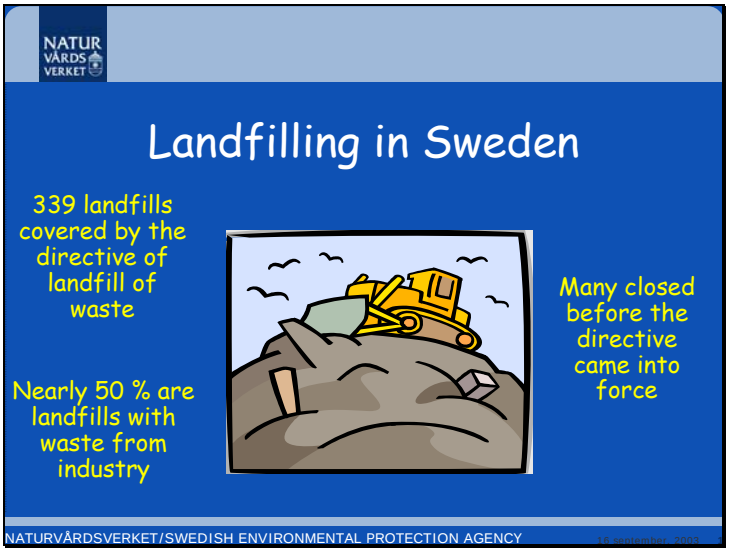
The use of the exemption clause, both in the landfill directive and in the new decision must be limited. We have recently carried out an evaluation of the landfill directive of waste, a report was presented to the government in March this year. The evaluation we have made show that the uncertainty how to tackle the new legislation is big. The condition plans that have been handed in to the authorities show that more than 50 % do

not know yet if they will apply for exemption from top cover, bottom lining and geological barrier. It is a big challenge for responsible authorities to make sure that exemption is given only if a proper risk assessment shows that this is acceptable. The same procedure is needed if using the exemption clause in the Council decision.

It is clearly stated in the Council decision that member states may set stricter limit values.

For Sweden it is a question of reliability, our environmental policy requires stricter criteria, especially for heavy metals such as mercury. But it is very important to explain the reasons if we chose to set stricter criteria. Regarding limit values for mercury, cadmium and arsenic it is not difficult, the modelling work shows that the limit values should be stricter, the values in the decision is a result of negotiation between the member states.

Slide 1



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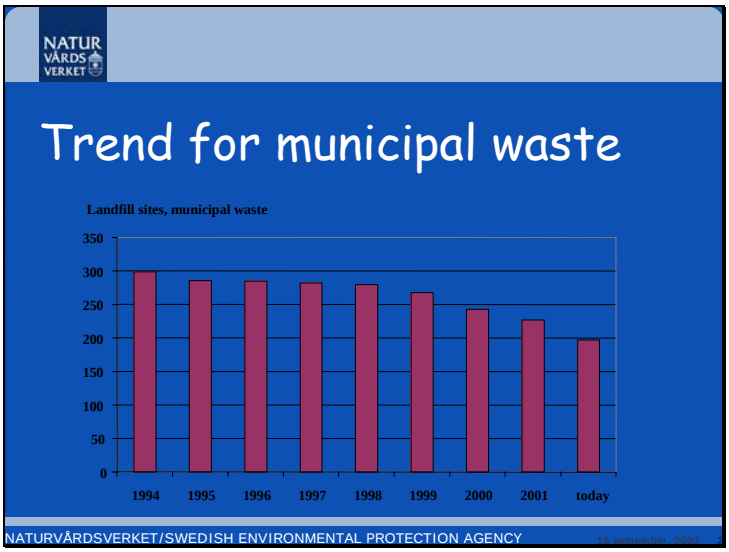

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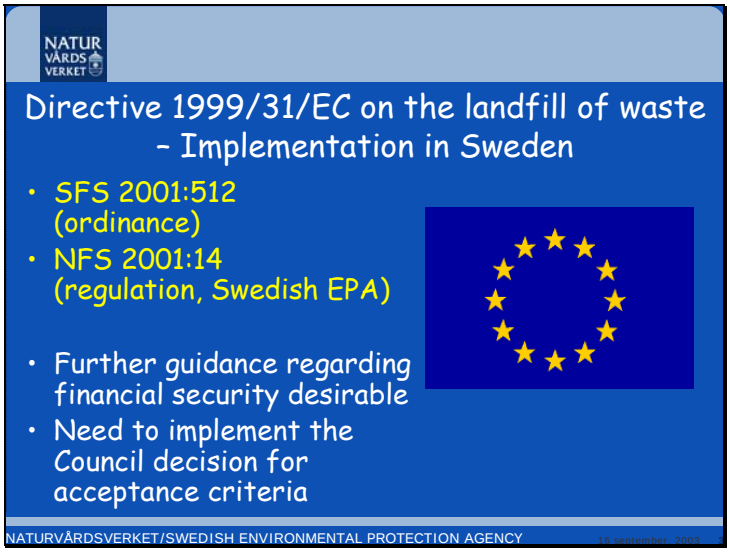

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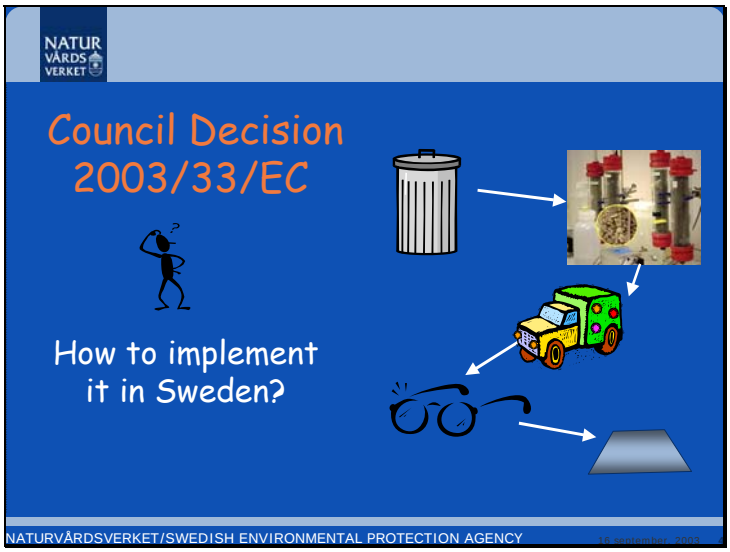

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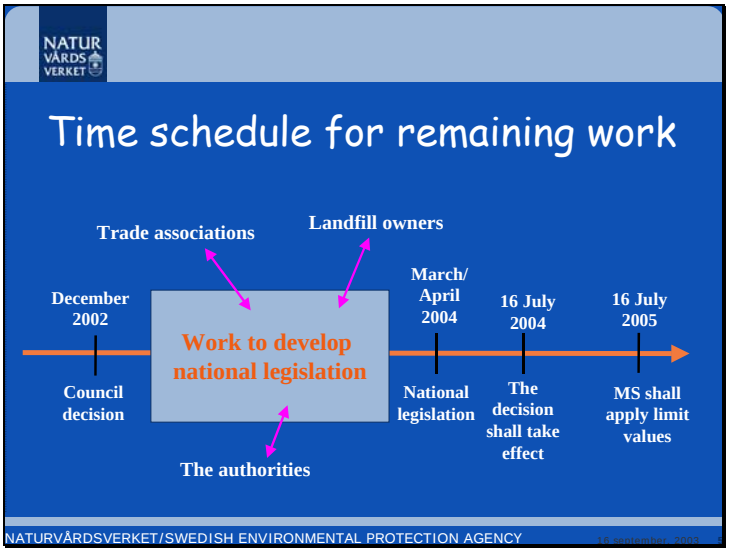

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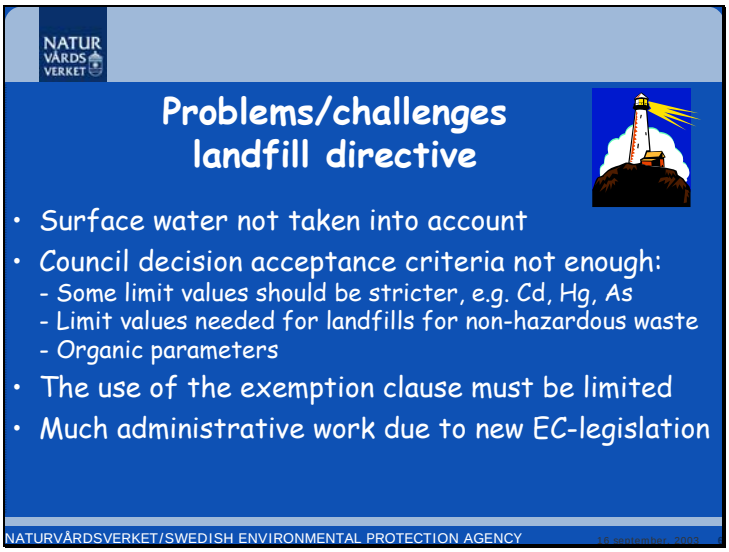

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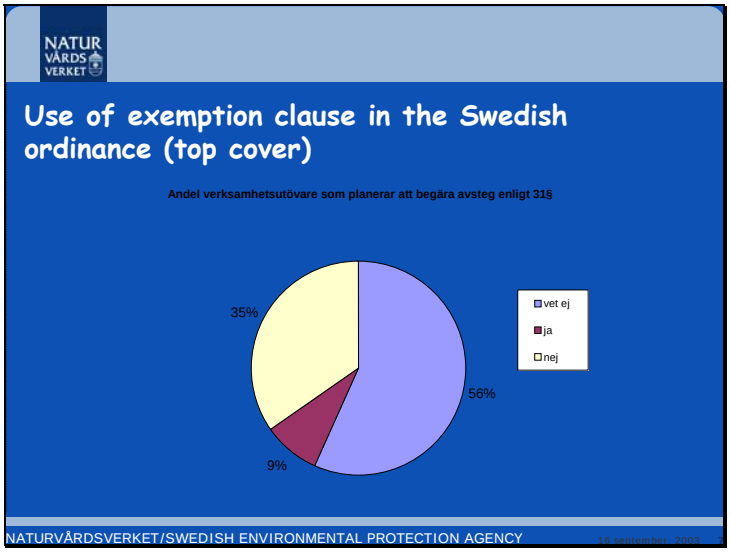

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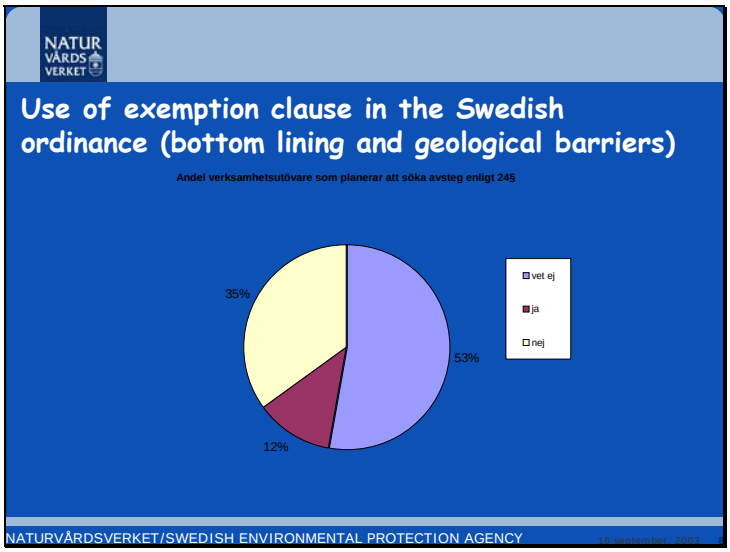

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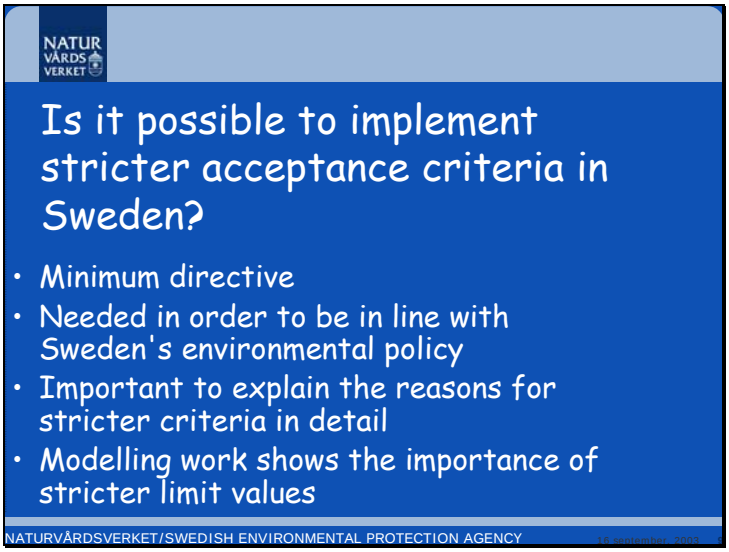

Slide 10

Appendix F: Abstracts and slides for the speakers on future and sustainable landfilling: Thomas H. Christensen, DK, Hans A. van der Sloot, NL ,and Keith Knox, UK

Abstract: Sustainability in the context of landfilling

Thomas H. Christensen, Environment & Resources DTU, Technical University of Denmark, thc@er.dtu.dk

The concept of sustainability was first introduced by the World Commission on Environment and Development, 1987 (The Brundtland-report: *Our Common Future*) defining: *Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. Not many directions as to its interpretations were provided, but suggestions have been made, e.g.: long term issues should receive more attention, each generation solves its own problems, local responsibility for own problems, etc.

It the context of landfilling sustainability has been interpreted as the landfill after a certain time frame (one generation: 30 years?) should have no significant effects on the environment (groundwater, surface water, local air, global air, vegetation, regional ecology, etc.) and pose no significant limitations on land use and there should be no active measures (no man power, no energy) spent on leachate treament, gas flairing or landscape maintenance in excess of ordinary landscape maintenance. These interpretations are very rigoristic compared to the original defining statement: Will some maintenance and energy use really "*compromise the ability of future generations to meet their own needs*"? Since we know that the emissions in a traditional landfill may be supported for centuries, this rigoristic interpretation may lead to intense use of technology to treat the waste by flushing, aeration, pre-treatment etc. in order to render the emissions acceptable after 30 years. This is problematic since it may in some cases lead to an increased environmental burden: Environmental cost of all the technical measures we introduce in the first 30 years in order to reduce the environmental burdens from the landfill after 30 years.

In a technical sense it must in all cases be determined what an acceptable impact is: Where does the criteria apply (point of compatibility), what is the corresponding emission and what is the characteristic of the waste not exceeding this emission? If such a sequence of considerations does not pay attention to local conditions as the local hydrological regime, attenuation in aquifer (dilution, degradation, sorption),

local quality criteria and background levels as well as the landfill hydrology, a rigid interpretation of sustainability will be very strict and may in many cases lead to excessive environmental burdens in meeting the criteria.

It is suggested that landfills should be approved in accordance with the concepts of sustainability on a site specific basis paying attention to over-all environmental impacts from the full operation incl. pretreatment, on-site enhancement and after-care using an LCA approach and that the time where active measures change to passive measures be determined on actual monitoring of the site.

Slides

Slide 1

Sustainable Landfilling?

Thomas H. Christensen

Environment & Resources DTU, Technical University of Denmark

Building 115, DK-2800 Lyngby, Denmark

Environment & Resources DTU
Technical University of Denmark

Slide 2

Outline

- **Define sustainability**
- **Interpret sustanaibility**
- **Sustainability in a context**
- **Approaches to sustainability**
- **Pittfals and musts in sustainability**

I will wake you up when I have finished

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Slide 3

Sustaina… WHAT?

- **Sustainability: World Commission on Environment and Development, 1987(The Brundtland-report: *Our Common Future*) defines: *Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*.**
- **Not many direct suggestions, but a way of thinking: long term issues should receive more attention, each generation solves its own problems, local responsibility, etc.**

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Slide 4

Sustainability interpreted

- **No active measures (no man, no energy): No leachate treament, no gas flairing, no differential settlements**
- **No significant effects on the environment: groundwater, surface water, local air, global air, vegetation, regional ecology**
- **No significant limitations on land use?**
- **Time frame defined**

But…

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Slide 5

Sustainability interpreted

- **These interpretations are very rigorist compared to the original defining statement: Will some maintenance and energy use really " *compromise the ability of future generations to meet their own needs"***
- **My feeling: " Waste tends to become the carrier of our bad environmental consciousness, there may be a risk for overdoing the issues"**
- **This is problematic; it may in some cases lead to an increased environmental burden: Environmental cost of all the technical measures we introduce in order to reduce the environmental burdens from the landfill**

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Slide 6

Sustainability in competition

- **Sustainability is being pioneered in the area of landfilling**
- **Alternative approaches:**
  - Environmental economics: Completely different wrt to time
  - Life-cycles-assessment: + indirect emissions in a broad context

Landfill as C-sink

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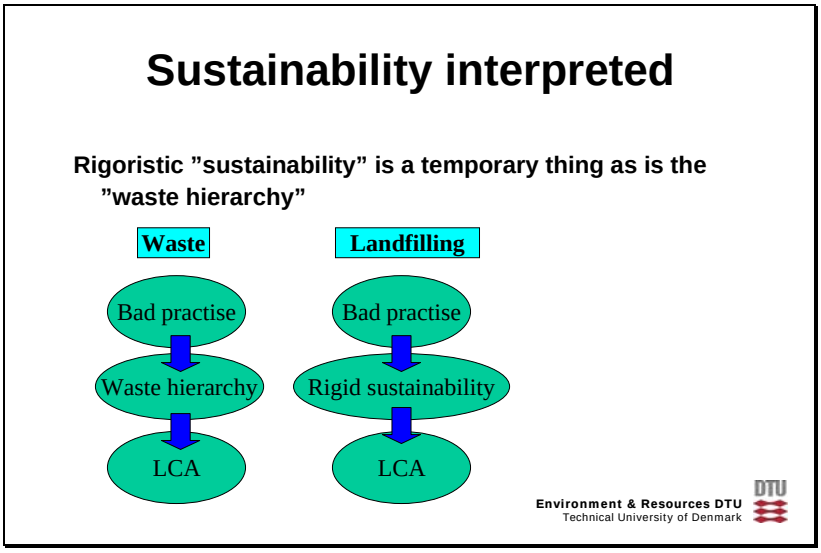
Slide 7



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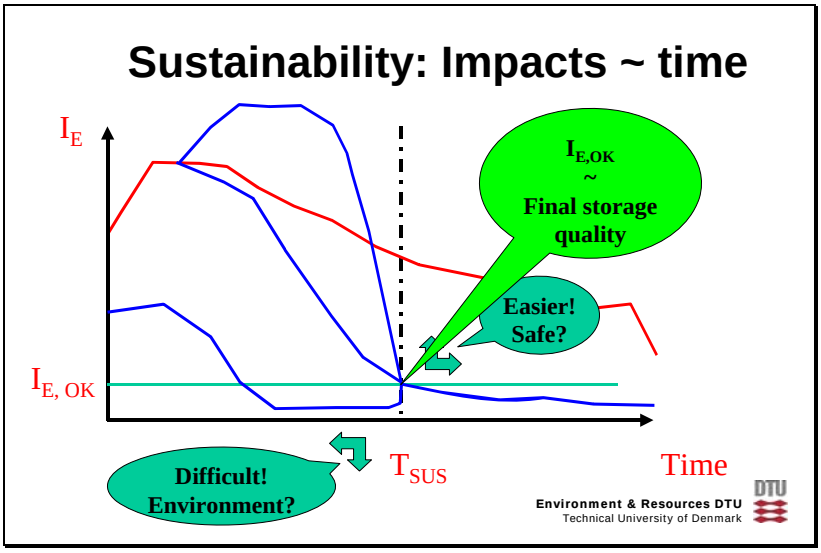

Slide 9

Sustainability in a context

- **Construction products**
- **Other land uses (example: fluxes)**
- **De-icing (example: concentrations)**
- **Soils (example: leaching test ???)**

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Slide 10

Fluxes from other land uses

Flux ton/year	Area ha	N	P	K	Mg	Ca	Na	S	Cl
Rain	**800**	**12**	**0**	**1**	**3**	**2**	**23**	**11**	**41**
Agriculture	**624**	**32**	**0**	**19**	**9**	**66**	**20**	**13**	**64**
Soil decay	**800**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**
De-icing	**4**	**0**	**0**	**0**	**0**	**0**	**7**	**0**	**15**
Landfill	**7**	**2**	**0**	**2**	**1**	**3**	**5**	**1**	**8**
Total	**800**	**46**	**0**	**23**	**13**	**71**	**55**	**25**	**128**

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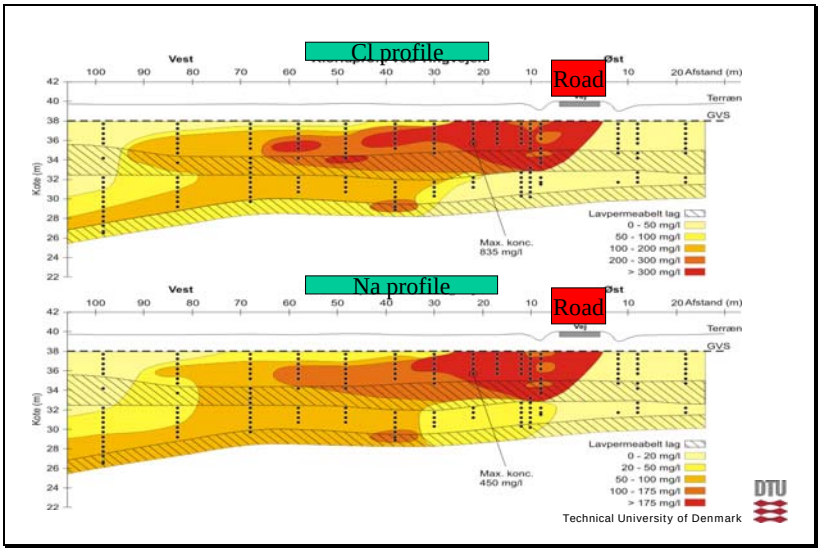
Slide 11



Slide 12

Approaches to sustainability

What is acceptable:

- **At point of compliance (e.g. defined well in aquifer)**
- **As emission**
- **As waste characteristic**

What to include (groundwater + surface water/ gas also):

- **Attenuation in aquifer (dilution, degradation, sorption)**
- **Hydrological regime**
- **Local quality criteria and background**
- **Landfill hydrology** **+ waste (type and amount)**

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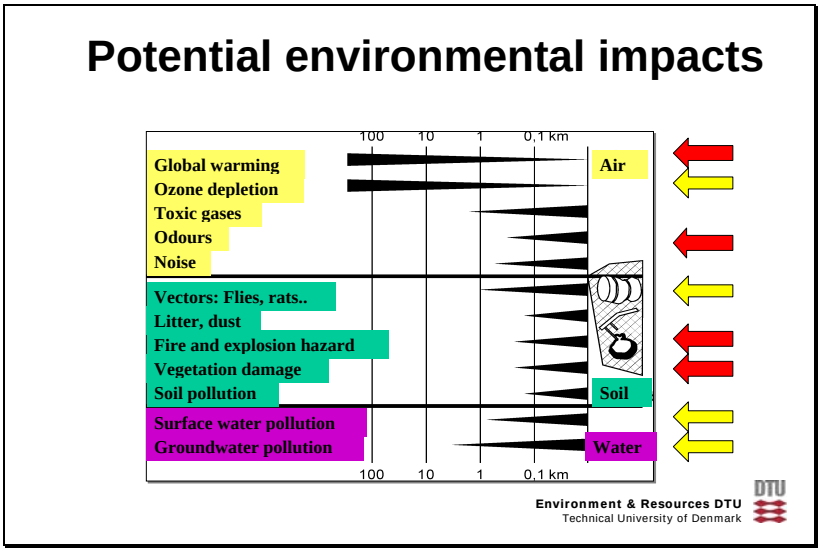
Slide 13



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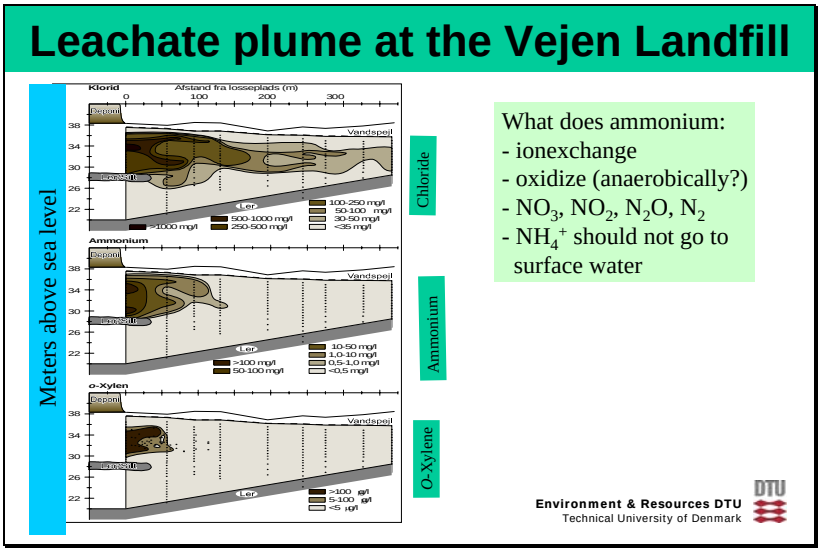

Slide 15

Approaches to sustainability

What is possible:

- **Organic containing waste:**
  - **MBP (mechanical-biological pretreatment)**
  - **Incineration**
- **Inorganic incl residues:**
  - **Chemical stabilization**
  - **Physical stabilization**
- **Enhancement of landfill stabilization:**
  - **Design and operation**
  - **Post-treatment (In-situ-aeration)**
  - **Post hydraulic controls**

Often increase emissions and environmental burden

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Slide 16

Pitfalls and musts in sustainability

- **Rigid sustainability criteria (time, level) may lead to excessive environmental burdens in meeting the criteria**
- **General waste related criteria may become very strict to be able to accommodate all scenarios wrt geology, hydrology and landfill design, even if criteria are related to time of closure**
- **General waste related criteria may not adequately reflect regional conditions and priorities**
- **Rigid sustainability criteria moves the focus from being environmental sustainable to meeting the criteria and increase the role of lawyers in landfilling**

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Slide 17

Pitfalls and musts in sustainability

- **Must pay attention to attenuation**
- **Most likely based on fluxes**
- **Must pay attention to local conditions**
- **Prediction not very precise, monitoring must decide when active measures change to passive**
- **Follow-up monitoring necessary until we have build the experience**
- **Must pay attention to environmental burdens from ”pre-treatment” and ”enhancement”**

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Slide 18

Sustain WHAT!

Approve landfills in accordance with the concepts of sustainability on a site specific basis (at least for small countries) paying attention to over all environmental impacts from the full operation incl. pretreatment, on-site enhancement and after-care using an LCA approach

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Slide 19

Abstract: Development of New Concepts for Sustainable Landfill With Emphasis on the Predominantly Inorganic Waste Concept

H.A. van der Sloot, ECN, Department Clean fossil fuels, Environmental Risk Assessment, P.O. Box 1, 1755 ZG Petten, The Netherlands (vandersloot@ecn.nl)

In landfilling of waste today a lot of emphasis is given to isolation. Several isolation technologies, however, are generally not guaranteed for longer than 50 years. The leachate quality of landfills, in particular modern large-scale landfills, is not expected to be harmless beyond that time scale. Therefore, in recent years more emphasis has been placed on processes within the landfill as the mutual interaction of individual wastes determines the long-term quality of the leachate. This understanding is needed for setting proper criteria on wastes to be landfilled. Although current waste acceptance is based on a judgement of the individual wastes delivered for disposal, the quality of individual wastes disposed in a site are not of major relevance. More important is how these wastes mutually interact leading to concentrations in leachate from an entire cell or landfill site as a function of time. The latter is important from the operator's perspective in relation to the necessary aftercare. The key question being: "Is leachate treatment required in the long-term?" And if the answer is yes, what level of leachate treatment would be required, or can measures in waste acceptance and waste treatment be taken prior to landfilling to eliminate the need for leachate treatment after closure?

In 1995 this question has been addressed by the Dutch waste management industry organisation (VvAV). Five Dutch landfill operators have organised themselves in the Dutch Sustainable Landfill Foundation and showed interest in innovative techniques of waste processing. The main motivation for research into sustainable landfill concepts originates in concerns about long-term processes and aftercare. It was realised that the wide variety of waste types will most likely lead to segregation and/or more active processing of wastes prior to landfilling. Four pilot projects in the vicinity of the different sustainable landfill concepts were initiated by the Sustainable Landfill Foundation, with a duration of 5 years. These four projects are able to cover almost the entire range of waste originating in The Netherlands nowadays. The four different sustainable landfill projects are:

- Bioreactor (completed)
- MSW with leachate recirculation (in progress)
- Stabilized waste landfill (started October 2002)
- Predominantly inorganic waste landfill (in progress)

The study of the Sustainable landfill concept for predominantly inorganic waste has been addressed at previous conferences (van der Sloot et al, 2001; Van der Sloot et al, 1999a). The study integrates testing at laboratory-, lysimeter- and pilot scale with modelling of long term release (vanderSloot et al, 2003). Emphasis has been placed on understanding the processes within the landfill as the mutual interaction of individual wastes determines the ultimate long-term quality of the leachate (Van der Sloot et al, 1999b). The anticipated outcome is a disposal practice through waste acceptance that will reduce the contaminant emissions to acceptable levels on the long-term; thus reducing long-term aftercare.

The mutual consistency of the data at different scales (not only for DOC, Pb, Cl and PAH, but for several other parameters also) as visualized by a specific data representation, i.e. release as a function of pH and release as a function of L/S (liquid/solid ratio), has been reconfirmed with more data and forms a very promising approach to tackle the issue of assessing long-term leachate quality and the means to control it by a new waste acceptance policy. Monitoring is continued to obtain a more extended overlap between testing at different levels.

It is striking to note the agreement between the leaching behaviour of the constituted waste mix and the leachate as obtained from the full-scale demonstration. This indicates that in spite of an apparently very heterogeneous mix of materials, leaching is governed by well-defined solubility controls for many constituents. The key aspect is to identify, which waste streams or external stresses can affect this balance in such a way that control is lost.

Key controlling factors for this predominantly inorganic waste disposal are controls on the individual waste DOC levels (as shown with geochemical modelling), mobile inorganic (e.g. Cl, sulfate) and water-soluble organic contaminant levels.

The behaviour of organic contaminants has been evaluated and shows a very consistent behaviour as well, in a similar data representation as used for inorganic constituents. In view of excessive DOC and colloid mobilization, a percolation test would seem more appropriate to assess organic contaminant release from a landfill than a single step batch leaching test (L/S=10).

The geochemical speciation modelling allowing a direct comparison of solubility control at a wide range of pH and a wide range in L/S as well as in field leachate, provides a means of gaining more understanding and subsequently more control over long-term release.

The comparison of the cumulative release of mobile species in lysimeter and field situations with the laboratory characterisation of the mixed waste entering the landfill, gives an indication of preferential flow. Based on the present data, this may imply that only about 20 % of the cell is engaged in the leaching process.

A comparison of release as observed on the integral waste mix of pilot Nauerna shows that for all critical parameters the inert EU landfill criteria are met (Table 1). An exception is formed by Cl and sulphate, while Sb is just on the limit. This observation indicates that already an important goal has been achieved. As inert waste does not require any form of lining, the conditions for minimum aftercare are approached.

Table 1. Comparison of measured release at L/S=10 for the pilot Nauerna with inert waste criteria (EU LFD, 1999; 2003). (* Corrected for preferential flow; ** At L/S=0.1).

Element/ parameter	Measured release in mg/kg at L/S=10	EU LFD Inert in mg/kg at L/S=10	Element/ parameter	Measured release mg/kg at L/S=10	EU LFD Inert in mg/kg at L/S=10
pH	7.2	> 6	Hg	0.000007 **	
As	0.13	0.5	Mo	0.12	0.5
Ba	0.5	10	Ni	0.14	0.4
Cd	0.02	0.04	Pb	0.35	0.5
Cl	*3300 (1100)**	*800*	*SO4*	*11170 (3700)**	1000
Cr	*0.019*	*0.5*	*Sb*	*0.06*	0.06
Cu	0.038	2	Se	0.05	0.1
DOC	350	500	Zn	0.8	4

The systematic approach to evaluate the sustainable landfill concept for predominantly inorganic waste by comparing release at different scales of testing (lab, lysimeter and field) gives a clear insight in the release controlling factors and the long term leaching behaviour. The relationships found and the conclusions that can be drawn for important inorganic and organic parameters imply an important step forward. The realisation, that a waste mix behaves more consistently than an observation of the visual heterogeneity would indicate, is striking and hold promise for

future control of leachate quality. For the sustainable landfill concept of predominantly inorganic waste, it is already clear that for a large number of parameters, inert waste criteria as specified in the EU Landfill Directive can be met (table 1).

Acknowledgements

This project is part of the Sustainable Landfill project that is financed by VVAV (Dutch Waste Processing Association) and the landfill operators Afvalzorg Deponie, Essent, and VBM. In addition we acknowledge the Provinciaal Afvalstoffen Fonds of the province of Noord-Holland for their financial support.

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Slides

Slide 1

DEVELOPMENT OF NEW CONCEPTS FOR SUSTAINABLE LANDFILL

Hans A. van der Sloot
ECN, The Netherlands

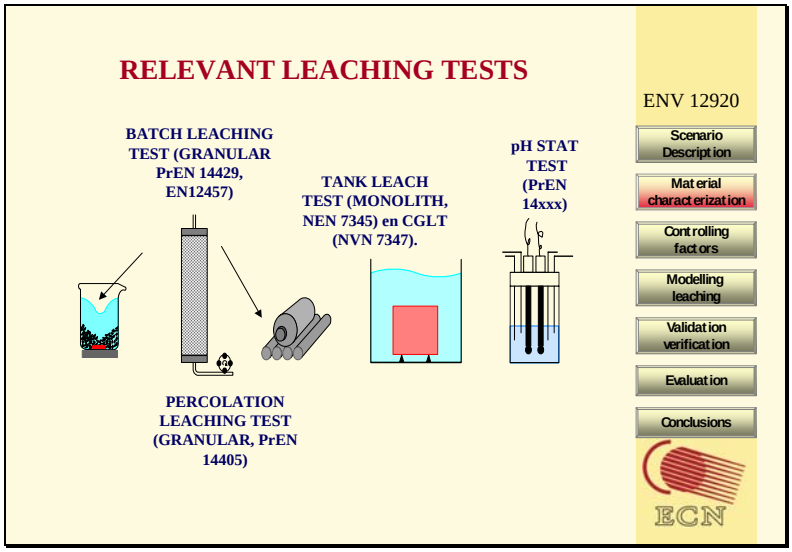
Workshop EU LFD, Holte, Denmark June 19, 2003

Slide 2

Sustainable Landfill Project (VVAV)

- VVAV - branche organization with most of the landfill owners in the Netherlands
- Motivation: concerns about long-term aftercare
- Pilot projects on sustainable landfill concepts
  - Predominantly inorganic waste landfill (in progress)
  - Stabilized waste landfill (started October 2002)
  - Bioreactor (completed)
  - MSW with leachate recirculation (in progress)
  - Waste recycling landfill (dropped)
- Testing at different scales with modelling to allow long-term predictions

Slide 3



Slide 4

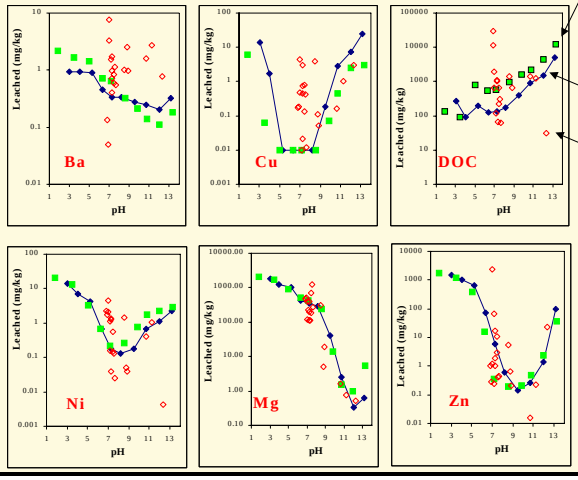
Slide 5

PRIMARY OBJECTIVES

- Create a sustainable landfill concept for predominantly inorganic waste by focusing waste acceptance criteria on reaching long-term stable equilibrium conditions in terms of pH (neutral), dissolved organic carbon (DOC) level and other complexants.
- Reduction of leachate concentrations to levels as close as possible to levels in the natural surroundings, thus reducing the requirement for long-term aftercare.
- Avoid minor waste streams with an disproportionately high impact on overall leachate quality.
- Provide better understanding of landfilled waste behaviour in the long term, as isolation measures have a limited life span.

Slide 6

INDIVIDUAL WASTES VERSUS INTEGRAL WASTE MIX



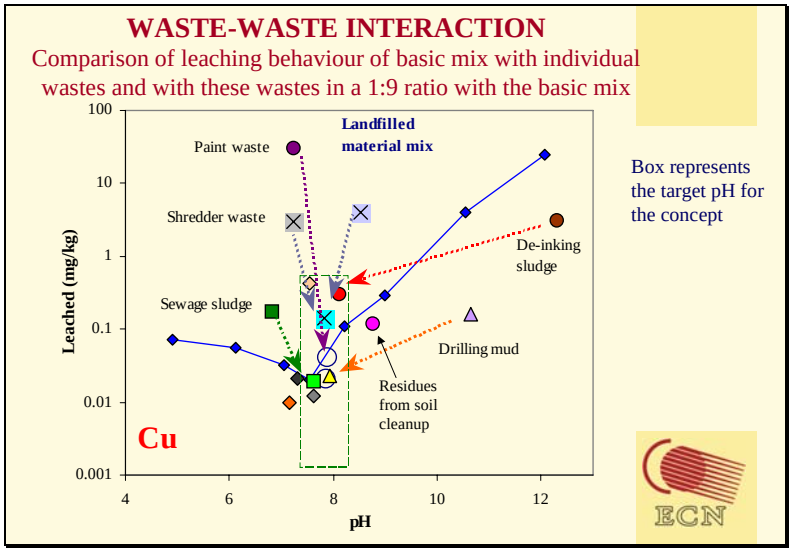
Integral waste mix enriched with organic rich waste

Integral waste mix

Individual wastes

A waste mixture behaves quite systematic

Slide 7



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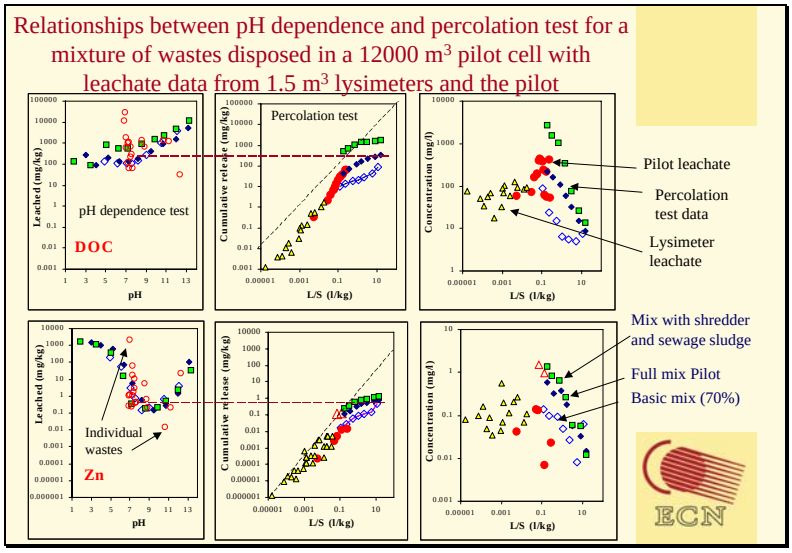

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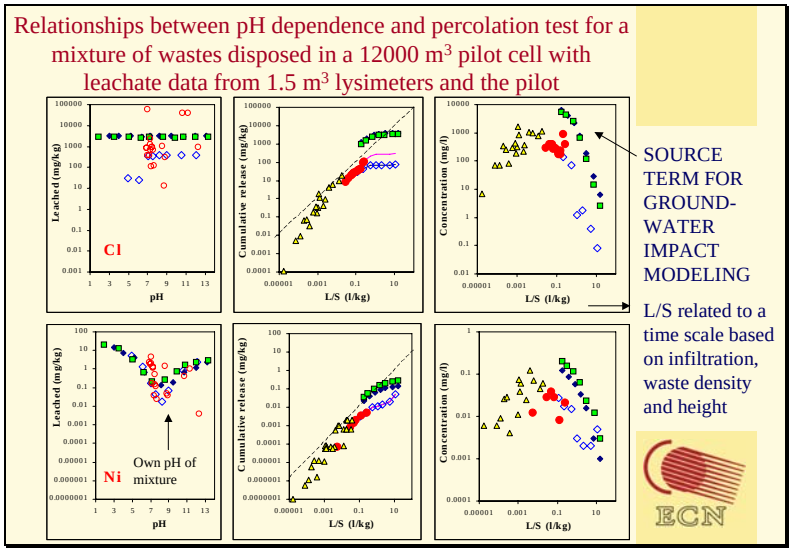

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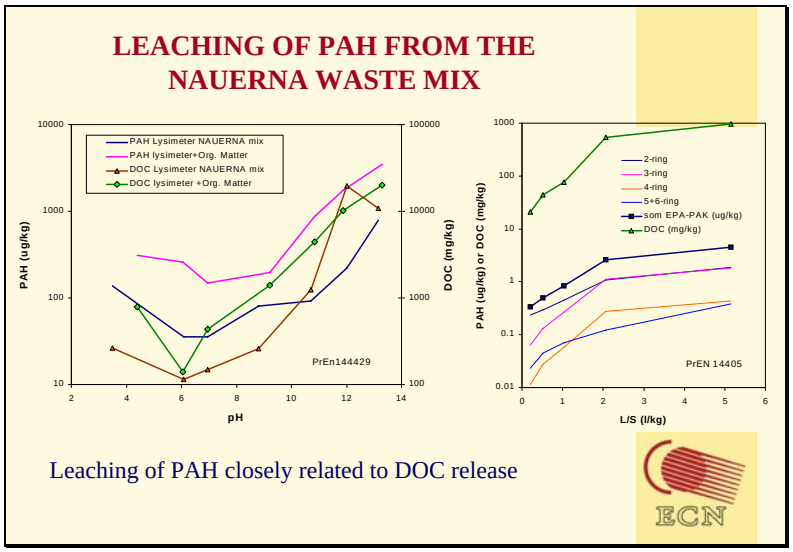
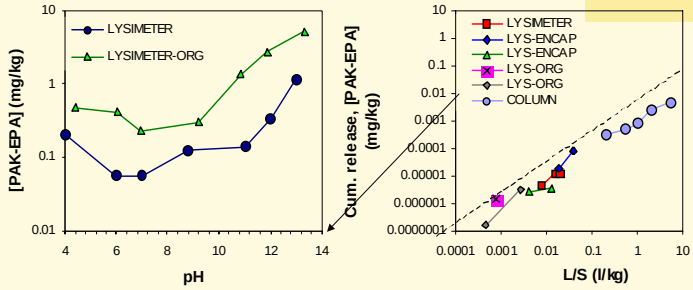


Slide 11

LEACHING OF PAK FROM NAUERNA WASTE MIX



Batch tests lead to higher released amounts than a column test

Consistency between different scales of testing very promising indeed

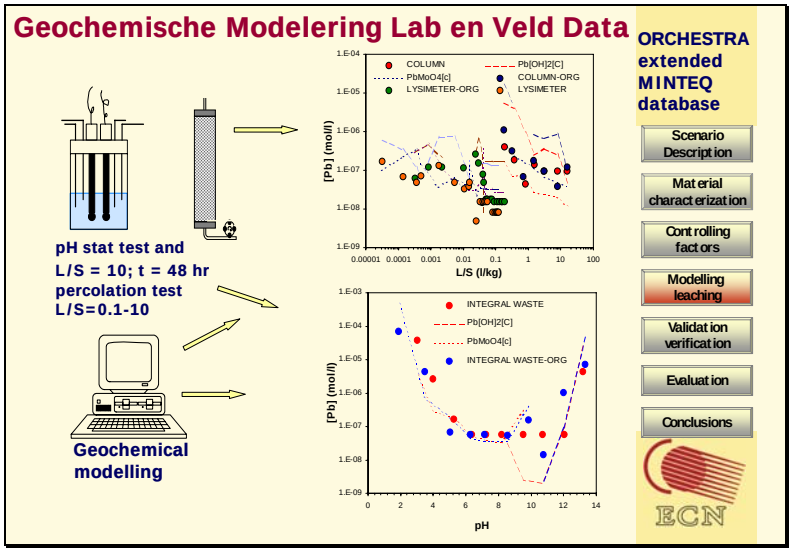
Slide 12

CALCULATED RELEASE RELATIVE TO COLUMN TEST ON NAUERNA WASTE MIX

Experiment	Na %	K %	Cl %
Nauerna Pilot	46	36	28
LYSIMETER	23	16	22
LYS + Shredder en RWZI	33	23	21
LYS met afval insluiting	38	33	36

These data indicate that preferential flow with around 30 % of the waste affected by leaching

Slide 13



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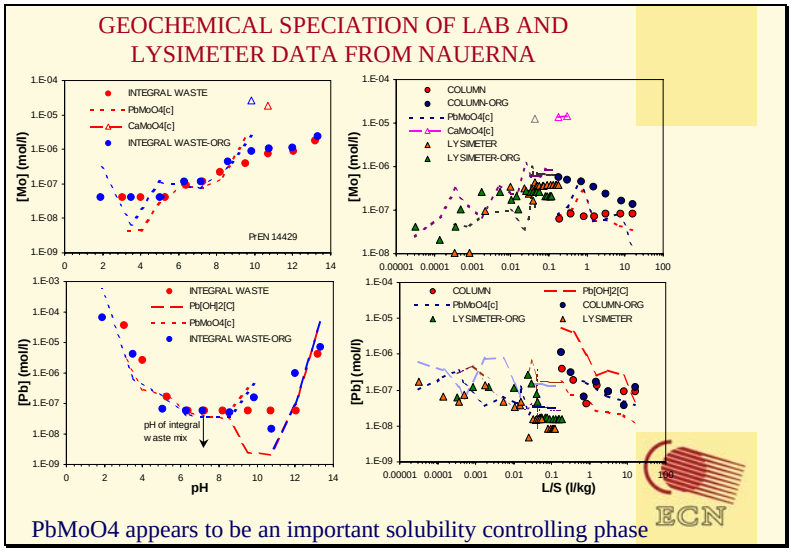

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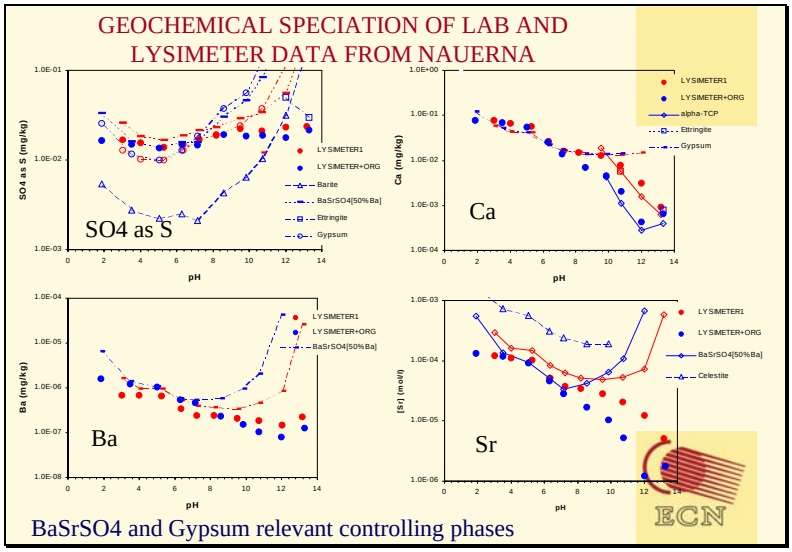

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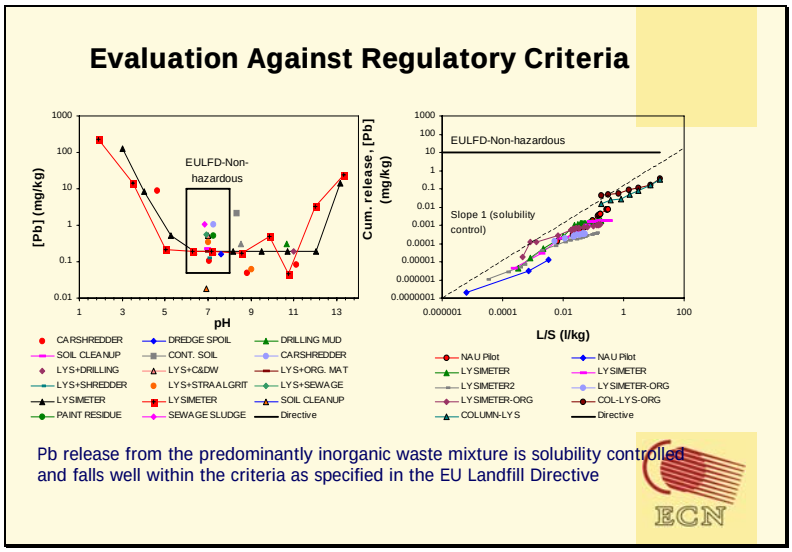

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COMPARISON OF MEASURED RELEASE AT L/S=10 FOR THE PILOT NAUERNA WITH INERT WASTE CRITERIA EU LFD.

Element/ parameter	Measured release in mg/kg at L/S=10	EU LFD Inert in mg/kg at L/S=10	Element/ parameter	Measured release mg/kg at L/S=10	EU LFD Inert in mg/kg at L/S=10
pH	7.2	> 6	Hg	0.000007 **	
As	0.13	0.5	Mo	0.12	0.5
Ba	0.5	10	Ni	0.14	0.4
Cd	0.02	0.04	Pb	0.35	0.5
Cl	*3300 (1100)**	*800*	*SO4*	*11170 (3700)**	1000
Cr	*0.019*	*0.5*	*Sb*	*0.06*	0.06
Cu	0.038	2	Se	0.05	0.1
DOC	350	500	Zn	0.8	4

* Corrected for preferential flow; ** At L/S=0.1

With the exception of Cl and sulphate (Sb border line) Nauerna meets inert landfill criteria

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CONCLUSIONS

- Comparison between laboratory scale leaching tests and pilot cell (12,000 m^3) results are quite promising.
- The mixture of wastes is exhibiting far more consistent leaching behaviour than anticipated. Determination of controlling mineral phases and organic matter interactions provides useful insights for release controlling factors.
- A limited number of leaching tests can provide the crucial answers needed to assess impact.
- Reduction of DOC levels in leachate by proper acceptance criteria will lead to significantly decreased concentrations of contaminants in the leachate.

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CONCLUSIONS

- Leaching characterization of wastes will allow identification of relatively small waste streams that disproportionately affect the quality of the leachate from the entire cell. Such waste requires either pretreatment or alternative disposal.
- Leaching of organic contaminants can be addressed in a similar manner as done for inorganic contaminants. This also relates to the judgement of acceptability and criteria development.
- The comparison of release from Pilot Nauerna indicate that many parameters already meet the criteria for Inert waste of the landfill Directive (exceptions Cl and sulphate, Sb borderline)

Slide 20

DATABASE / EXPERT SYSTEM OF CHARACTERIZATION DATA FOR WASTE, SOILS, CONSTRUCTION MATERIALS

- Reference for compliance test data
- Basis for regulatory development
- Limit unnecessary duplication of work
- Avoid generation of useless data at great cost
- Focus on key parameters for specific materials
- Identify controlling factors for guiding the choice of treatment options/ recipes

Slide 21

MATERIALS FOR WHICH MORE EXTENDED LEACHING INFORMATION IS AVAILABLE

Sources: Mammoet project, RIVM studies, EU Harmonisation work (ECN, DHI, INSA, WRc, IBAC,NNI,UB), ECN research, Building Materials Decree certification, others.

Synthetic Aggregates (coal fly ash, mining waste, etc)	Expanded clay pellets	Lava stone
Alkaline batteries	Fe-Cr catalyst residue	Lime stone
Al-production ash	Fe-norit waste from phamarceutic industry)	Light weight concrete
Asphalt	FeOH sludge needle factory	Lime silicate bricks
Asphalt rubble	Filter cake MSWI	Metallurgical sludge (Cao-type)
Basalt	Filter dust (ceramic industry)	Metalugical slag
Biomass ash	Flotation concentrate/sand blasting waste purific.	Milling residues
Bioreactor residue (after degradation)	Fluor cont. dust from primary Al production	Mine stone (coal)
Blast furnace slag	Flourescent Powder	Waste mixture (70% of landfilled waste largely inorg.)
Bottom ash (coal)	Fly ash from isolation material prod.	MSWI residues (bottom ash, fly ash APC residues)
Brown coal ash	Fly ash industrial waste and RDF incineration	Municipal Solid Waste, fly ash
Bricks (ceramic)	Foundary sand (waste material)	Natural gas production sludge
Cat. Cracker, Cat. ox. RVC	Foundry Oven Dust	Ni sludge
Chemical sludge (Electroplating Ni)	Galvanic sludge	Non-purificable sand blasting dust
Clay bricks	Glass-oven rubble formglass production	Oven waste from primary Al production
Coal fly ash	Glaze/enamel sludge	PAH, PCB and metal polluted soil
Compost	Gravitational concentrate/sand blasting waste	Paper sludge
Concrete	HCH soil purific. res. (physical purification)	Pb/Zn slag
Concrete with coal fly ash	Incinerated sewage sludge	Phosphate slag
Construction debris	Jarosite	Phosphating Sludge
Contaminated soil	Sand blasting waste	Phosphogypsum
Crushing waste	Sediments (river, lake, canal)	Pigment Sludge
Cryolite waste (Zeolite production)	Sewage sludge	Plastic waste material
Detox., neutralized dewatering sludge(filter cake)	Shredder waste	Preserved wood
Dredging sludge	Sieve sand from demolition breaker	Purification sludge from industrial purification
Drinking water pipes	Soil (various types of natural soil: sand, loam, clay)	Purification sludge from textile paint product.
Drinking water product. sludge (ground water)	Soil amended with sewage sludge	Purification Sludge polymer prod.
Dust form a sand blasting unit	Soil purific. extract. Residue	Refuse derived fuel ash
Tannery Sludge	Spent Catatalyst (activated Al)	Vitrified MSWI fly ash
TBBA recovery sludge from production of te	Stabilized galvanic sludge	Zn-Fe-salt residue from Zn-varnish installation
Tiles (ceramic)	Stabilized waste (various)	Zn-MnO- batteries
Sb containing sludge	Steel slag	

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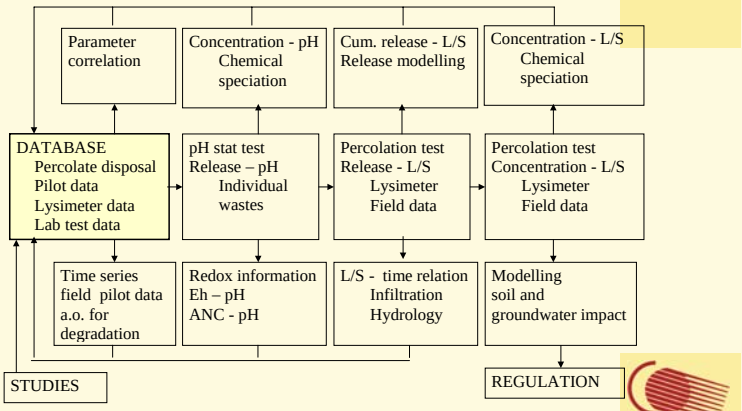
DATABASE/EXPERT SYSTEM - LANDFILL Granular waste



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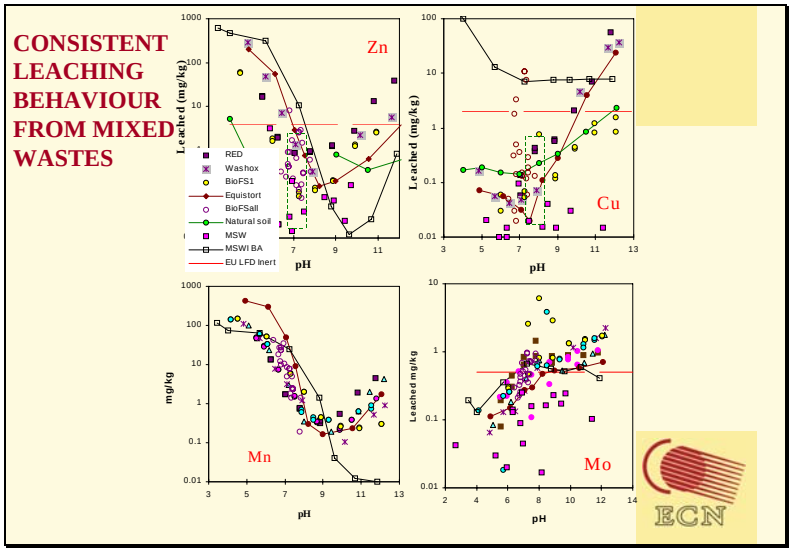

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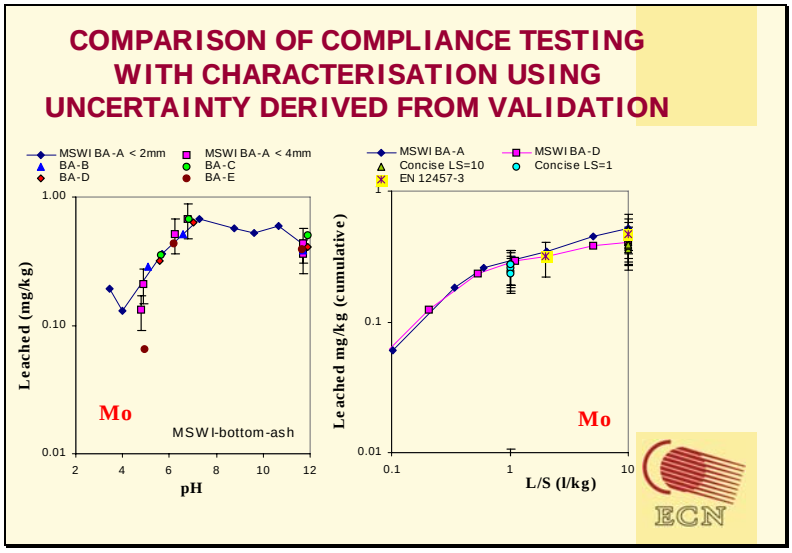

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CONCLUSIONS

- If within the current expense on testing a more appropriate selection is made, the cost of implementing the three levels of testing will not be excessive and provide the possibility to focus on key aspects rather than measure irrelevant parameters
- Branche wise organisation of characterization testing will prove very beneficial for industry as it reduces cost and at the same time highlights the key issues to be resolved in the branche.
- A European database of characterization data would be very beneficial for all parties. Many materials have the same basic characteristics, yet often different compliance test results.

ECN

Abstract: How do we define final storage quality criteria? By Keith Knox

A suitable basis for defining and deriving FSQ criteria can be found in Swiss, Austrian and Danish policies from 1986, 1990 and 1992 respectively: these stated that any emissions to the environment should be acceptable without further treatment and that no active management or monitoring should be needed. For sustainability, this condition should be reached within one generation. Similar policy statements were contained in UK government guidance documents from 1993 and 1995.

These conceptual definitions imply that pollutant flux is the key factor. This would be site-specific and would take into account the dilution and attenuation that might occur in the receiving environment. This presentation also discusses the case for setting some absolute criteria for leachate quality and for solid material characteristics, because of the difficulty of assessing the local hydrogeology well enough and the uncertainty over long term performance of engineered barrier layers. The presentation argues that if flux were the sole criterion, then a well-engineered landfill would be at FSQ on day one, because the liners are designed to ensure that flux to the environment is kept to an acceptable level, even for materials that have the potential to pollute.

Absolute criteria could be based on a variety of standards, such as Waste Acceptance criteria for inert wastes, surface water discharge consent limits, or (more extreme) drinking water standards. The presentation compares concentrations of key leachate components against examples of these absolute standards, for leachates from:

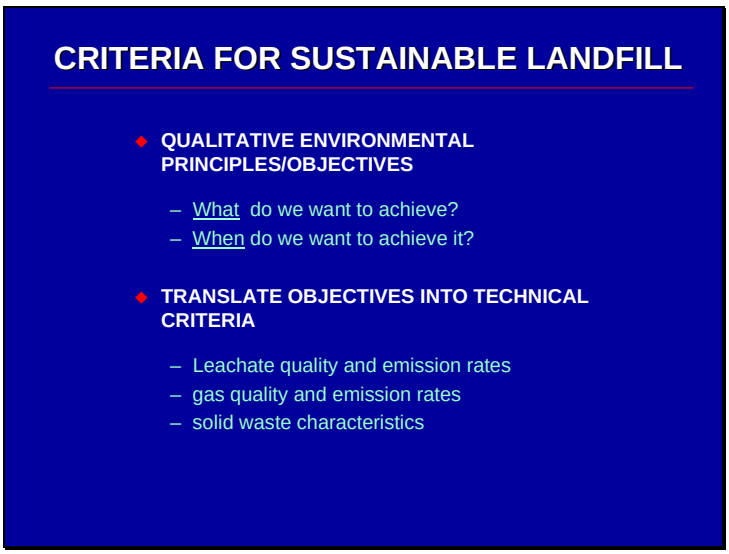
- MSW,
- mechanically separated organic residue (MSOR),
- composted MSOR,
- MSW incineration APC residues and
- treated hazardous wastes.

The dilution necessary to reach tentative FSQ standards derived in this way is typically 20 to 200 times. The need to either pre-treat to reach these standards before landfilling , or to flush the landfill with large volumes of water is discussed.

Slides

Slide 1

Slide 2



Slide 3

Broad principles/objectives

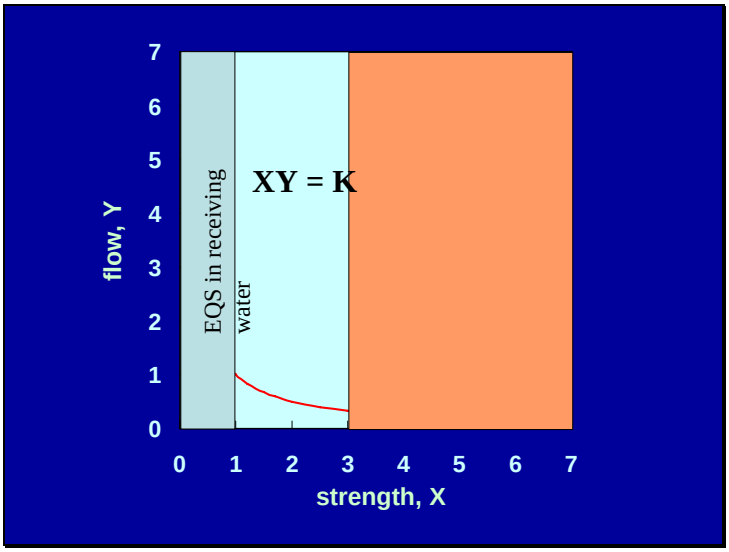
- **BRUNDTLAND (1987):**
  - "….meets the needs of the present without compromising the ability of future generations to meet their own needs."
- **SWITZERLAND (1986) [also Austria, 1990]**
  - Each generation should manage its wastes to a status of Final Storage Quality.
  - Final Storage Quality: any emissions to the environment to be acceptable without further treatment..
  - One generation = 30 years
- **DENMARK (1992)**
  - Each generation must take care of its own wastes.
  - No active management or monitoring should be needed after 30 years
- **UK, WMP26A & 26B (1993 & 1995)**
  - "…stabilised physically, chemically and biologically to such a degree that…..post-closure controls, leachate management and gas removal systems are no longer required."
  - "…in equilibrium with its environment 30 - 50 years after cessation of filling…."

Slide 4

Flux to environment *or* in situ quality?

- **Swiss definition implies flux is the key factor**
- **This leads to two further considerations:**
  - **acceptability of a given flux, of pollutant X, is site-specific**
    (potential for huge variation between different hydrogeological settings)
  - **flux of pollutant X = f(in situ quality, volumetric flow)**

Slide 5



Slide 6

Could we avoid having any absolute standards for in situ quality?

- Can we characterise most landfills' hydrogeological settings well enough to assess what the acceptable flux will be?
- Can we be sure enough of how barrier systems will perform over decades/centuries/millenia?
- Does this approach really fulfil our obligation to future generations?

Slide 7

TECHNICAL CRITERIA for FSQ

- **DEFINE FINAL STORAGE CRITERIA**
  - Gas quality and emission rate
  - Potential for further degradation/reaction
  - Leachate quality (and emission rate?)
  - Potential for further leaching of pollutants from solids
- **STATISTICS OF SAMPLING AND DATA INTERPRETATION**
  - Heterogeneity of waste, leachate and gas
  - What is an appropriate degree of confidence?

Slide 8

Gas quality and emission rates

- UK WMP 26A values (now withdrawn)
  - less than specified trigger levels for at least 2 years
    - CH4 < 1%
    - CO2 < 1.5%
  - less than specified rate from any borehole, for at least 2 years
    - CH4 < 15 litres/hour
    - CO2 < 22 litres/hour
    - (roughly equivalent to << 0.1m3 LFG/t.a, for typical well spacing and landfill depth)
- UK Emission Limit Values for methane from capped landfills, based on minimising global warming emissions
  - 1×10^{-3} $mg.m^{-2}.s^{-1}$ equivalent to 1.2 m^3.ha.d, or,
  - 0.004 m^3 CH_4 per tonne per year, for 10m deep at 1 t/m^3

Slide 9

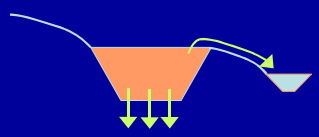
Potential for further degradation

- **WHICH PARAMETERS FOR BIOWASTES & MBP WASTES?**
  - Measure degradable materials
    - *cellulose, hemicellulose [= acid digestible fibre]*
  - Measure surrogate parameters
    - *Loss on Ignition, COD, TOC [will include non-degradables]*
  - Measure gas emission under optimised conditions in laboratory
    - *Biochemical Methane Potential test [BMP test]*
    - *Respiration test, AT_4, AT_7 etc.*
  - Measure biochemical nitrogen potential *[BNP test]*
- **WHAT LEVELS SHOULD BE SET FOR FSQ?**
  - UK had BMP < 0.1 m^3CH_4 per dry tonne [=>99.9% degradation]
  - Now adopting site-specific risk assessment approach
  - compare with landfill acceptance criteria e.g. EC Draft proposal on biowaste treatment:
    - *AT_4 10mgO_2/g dm [~30 m^3 gas/t dm; I.e.~85% degraded]*

Slide 10

Leachate quality criteria

- WAC for inert wastes
  - C_o values for wastes that need no leachate management
  - missing important parameters
  - based on generic risk assessment for groundwater
- Surface water discharge criteria



Slide 11

Leaching criteria for Inert Wastes

(from Council Decision14473/02)

Component	mg/kg at L/S 2	mg/kg at L/S 10	C_o mg/l
As	0.1	0.5	0.06
Ba	7	20	4
Cd	0.03	0.04	0.02
Cr	0.2	0.5	0.1
Cu	0.9	2	0.60
Hg	0.003	0.01	0.002
Mo	0.3	0.5	0.2
Ni	0.2	0.4	0.12
Pb	0.2	0.5	0.15
Sb	0.02	0.06	0.1
Se	0.06	0.1	0.04
Zn	2	4	1.2
Chloride	550	800	460
Fluoride	4	10	2.5
Sulphate	560	1000	1500
DOC	240	500	160
TDS	2500	4000	

Slide 12

Leachate dilution requirements for biowaste

Source and components	units	Typical leachate concentration	Typical discharge limit (inland watercourse)	Dilution/ reduction needed
MSW				
NH_4-N	mg/l	1,000	10	100
hard COD	mg/l	1,000	125	8
MSOR				
NH_4-N	mg/l	4,000	10	400
hard COD	mg/l	3,000	125	24
MBP residues				
NH_4-N	mg/l	1,000	10	100
hard COD	mg/l	3,000	125	24

Slide 13

Leachate dilution requirements for MSWI and hazardous wastes

Source and components	units	Typical leachate concentration	WAC C_o value for inert waste	Dilution/ reduction needed
APC residue from MSWI				
Cl^-	mg/l	100,000	460	217
Pb	mg/l	100	0.15	666
Cd	µg/l	500	20	25
Carbonated APC residue from MSWI				
Cl^-	mg/l	100,000	460	217
Pb	µg/l	500	150	3.3
Cd	µg/l	900	20	45
Treated hazardous waste				
Cl	mg/l	20,000	460	43
NH_4-N	mg/l	200	10	20
Cd	µg/l	100	20	5
Heavy metal X	mg/l	5	0.2	25

Slide 14

Solid waste characteristics

- **PARAMETERS FOR INORGANIC & HAZARDOUS WASTES**
  - Leachable inorganic ions (*e.g. Cl, SO_4*)
  - Leachable heavy metals
  - Leachable organics (DOC)
  - Others?
    - eluate pH
    - readily soluble content?
    - organic content/Loss on ignition?

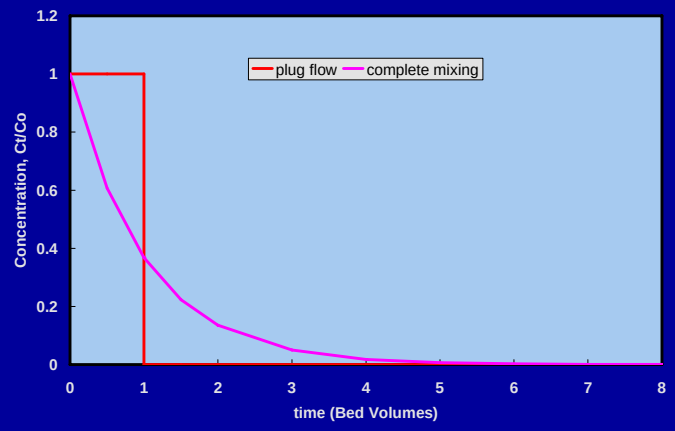
Slide 15

Main thesis

- Wastes must either be treated to Final Storage Quality (FSQ) before landfilling, **or**
- The landfill must be designed and operated to achieve FSQ
- for sustainability, it must do this within the lifetime of those who produced the waste.

Slide 16

How much water does it take to flush a lan



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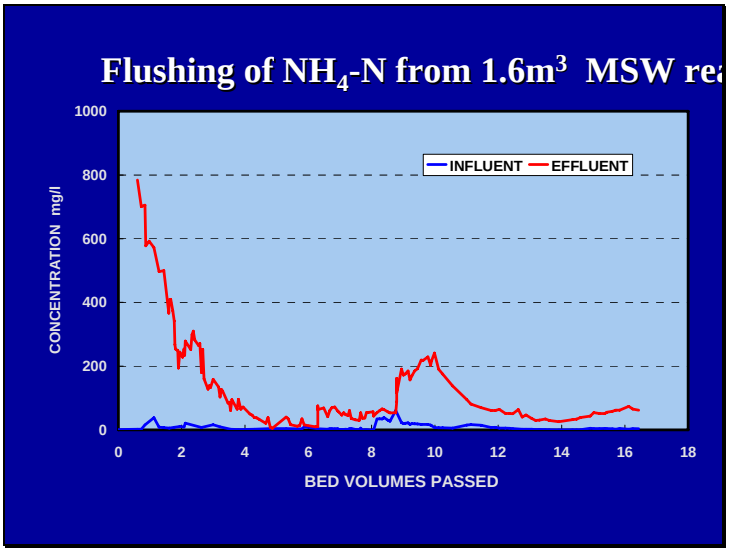

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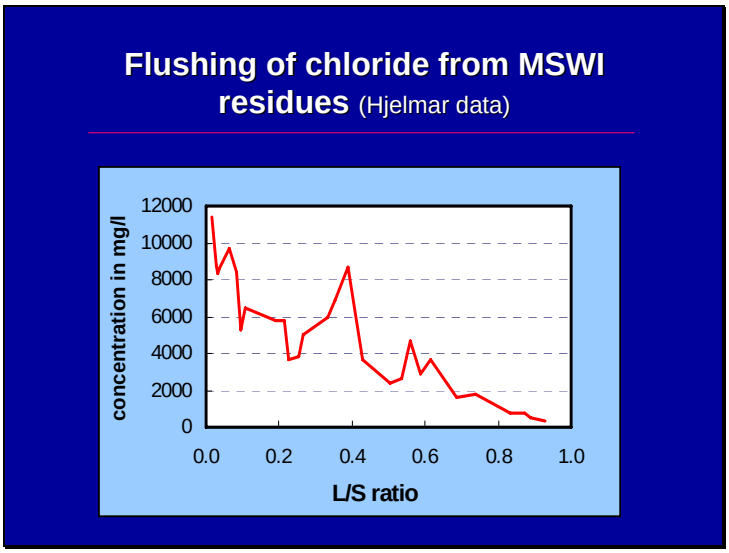

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Barriers and needs

- failure to face up to the concept of FSQ as an inevitable consequence of legislation e.g. LFD
- failure to embrace the challenge of achieving FSQ within one generation, despite politicians fine words
- unwillingness to spend money on landfill research, when landfill is seen as a thing of the past
- need to develop agreed procedures for deriving site-specific technical criteria for a given landfill
- need full-scale demonstration trials to achieve FSQ for the major classes of waste (MSW, MSOR, MBP, MSWI, hazardous).
  - e.g. UK cost estimate of £2M for a 5 year flushing trial on a 1ha MSW cell. [www.soton.ac.uk/~sunrise/knox.htm]

Appendix G: Summaries of group discussions

Group 1:Acceptance criteria, exemption clause, sub-categories of landfills, risk assessment

Group 1: Group members:

Steve Gibbs	Atkins Environment	UK (Chairperson)
Bjørn Malmgren-Hansen	Tek. Institut/C-RES	DK (Rapporteur)
Helga Bjarnadóttir	Linnuhönnun	IS
Gunnlaug Einarsdóttir	Environmental and Food Agency	IS
Ann-Marie Fällman	Naturvårdsverket	S
Jørgen G. Hansen	Miljøstyrelsen	DK
Jan Hartlén	Lunds Tekniska Högskola	S
Sacha Heijblom	Ministry of the Environment	NL
Ari Seppänen	Environmental Ministry	F
Stina Lundberg	Naturvårdsverket	S
Marit Torsvik	Fylkesmannen i Nordland	N
Hans A. van der Sloot	ECN	NL

- *Issue: Are the criteria for granular waste strict enough or should they be implemented in a stricter form? Why? Or why not?*

This seemed to be a concern only in relation to hazardous wastes, and not to inert wastes. It was questioned whether it is an important question, given that member states may set stricter values, and it was felt that it is easier to justify the limit values to legislators if they are harmonised with other MSs. There was a view that the values are not strict enough; this view was based upon the selection of the scenario from which the values were derived, and also that most of the values were then negotiated upwards from the model output. However, a counter-view was put that some of the model assumptions were quite conservative. It was suggested that ideally field data should be obtained to validate the model output. This would necessitate finding suitable landfills. The group agreed that it would be desirable to keep the limit values under review, but that this should not be done in a way that may undermine the authority of the limit values.

The group felt that there is an important relationship with the “Factor 3” exemption clause. Members might have sought stricter values had they known that the exemption would be inserted.

There is also an important link with the approach adopted to compliance with the values (ie, the statistical approach), as this may again make the values seem more or less difficult to comply with. It was agreed that it would be desirable to harmonise the statistical approach: this was left to MSs primarily because the modelling group had no time to consider it.

Some members of the discussion group found it hard to contribute without knowing the modelling work. Although there are published papers on the work, it was agreed that it would be desirable for the record of the modelling to be completed and freely available.

- *Issue: The criteria are based primarily on assessment of the risk of groundwater pollution. Should other risks be considered, perhaps leading to additional or stricter criteria? If other risks are taken into consideration, could the associated criteria also be based on risk assessments – and if they could, how should the risk assessment be coupled to criteria/limit values?*

The group saw no need to address occupational exposure. Dust and odour might be issues during operations, but would afterwards be controlled by the top cover.

Protection of surface water was therefore seen as the main possible concern. Migration to surface water might be direct, in which case engineering controls would be required, and these would have to be site-specific. Migration might be via groundwater, and the question then is whether the limit values derived for groundwater protection (based on drinking water standards) are suitable for surface water protection. There may be some parameters for which surface water is more sensitive (though the model output was modified to reflect this for some parameters). There may also be cases where only surface water is at risk, and some members felt that less strict values could be applied. The model scenarios did not consider, for example, hard rock geology with fissure-flow, or discharge to a large water-body or to the sea.

It was felt that the necessary first steps might be to review the parameters to determine those to which surface water might be more or less sensitive, and perhaps to model a typical scenario for distance to a surface receptor.

- *Issue: Do we need additional, national acceptance criteria for total or "partial" contents of inorganics and organics? Do we need additional criteria based on leaching of organics?*

For organic parameters, the group felt it was necessary to distinguish between total and leachable. Total might be useful as a cheaper indicator for the presence of leachable organics, but it was felt that this relationship is not always reliable. It was felt that the limit value for DOC should control leachable organics. The point was made that the DOC limit value may conceal particularly hazardous organics, or chelating agents such as EDTA.

Members felt that there are obvious omissions such as NH4-N and CN, that have been questioned, and for the criteria to be credible there needs to be an explanation for there absence.

It was felt that the modelling could now accommodate additional parameters, but there may be issues with regard to availability of suitable test methods.

It was therefore felt that a mechanism to consider the question further is needed before any research or modelling is undertaken.

- *Issue: How do we go about the setting of acceptance criteria for monolithic2 waste to be landfilled at non-hazardous and hazardous landfills?*

It was noted that modelling work to produce leaching limit values is in progress by the Nordic group, Netherlands, France and UK. It would be desirable for the outputs to be discussed before limit values are adopted, with a view to harmonisation. Discussion would allow review of modelling assumptions and implications of the limit values.

It was felt that it is also desirable to set criteria to ensure the integrity of the monolith in the short and long-term, under the conditions of a realistic landfill scenario.

It was felt that field work is desirable on real monolithic landfills, to confirm the "hydrogeological" behaviour assumed in the modelling.

- *Issue: Do we need to use the exemption clause at the beginning of section 2 of the Council Decision (that allows Member States to raise the limit values by a factor of 3)? How do we prevent misuse of the clause? What should the required case-by-case evaluation preceding a possible permit include?*

There was no desire expressed in the group for the use of the exemption. It was felt that the only case for using it would be if stricter protection measures are in place than assumed in the Directive. The Decision makes it clear that the risk assessment must be thorough. The risk assessment must take full consideration of pathways, receptors and potential impacts, as well as the waste mix.

Risk assessment may be feasible for operators intending to accept one or a few wastes, but will be progressively more difficult for both operators and regulators if there are many wastes. It may, however, be possible to model on the assumption that all the waste in the landfill is at three times the limit values, thus providing a generic view of the suitability of the landfill for the exemption.

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[2] monolithic waste = waste in large pieces or blocks, e.g. chunks or blocks of concrete or solidified waste – the leaching mechanism is different from that for granular waste.

It was felt that for some parameters, for example, some metals, 3x may not be very significant compared with the uncertainties in the modelling and in the leach testing. However, for some parameters, particularly cadmium and mercury and the mobile parameters, including TDS, it might be very significant.

It was felt that we all need solution(s) to the problem of wastes high in mobile constituents, such as APC residues. These must be addressed either by a good location (implying a need to be flexible on risk assessment) or by treatment such as washing.

- *Issue: Which sub-categories of non-hazardous waste landfills are likely to be needed? Do we need additional or different waste acceptance criteria for such sub-categories of landfills? Is it possible to set meaningful waste acceptance criteria/limit values for mixed waste?*

The group felt that it is desirable to be able to predict and control the behaviour of the landfill. It was felt that this is easier if similar wastes are landfilled together, and the main sub-categories proposed are for mixed waste (including biodegradable waste,) and inorganic or mineral waste.
It was felt that research shows that leachate from mixed landfills is very similar (though it was later questioned as to whether this is confirmed by toxicological testing or analysis of trace organics). Limit values can only really be set in relation to leachate composition. Therefore criteria might be set as to what is the normal range of waste components in a mixed waste landfill; in other words, when does it stop being a normal mixed waste landfill and have a leachate influenced by specific waste inputs.

It was felt that research should continue on waste interactions. The criteria assume all the waste in the landfill is the same. Some loads exceeding the values may not change the overall equilibrium, whilst others might and should be further treated. It is important to be confident that the equilibrium will not change adversely in the long-term, for example by leaching out of some constituents.

- *Issue: Are there any urgent R&D needs?*

It was felt that the needs for further work could be distinguished as tasks for further expert review and discussion (continuing the work of the modelling group, either in the Nordic Group or more widely) and research tasks. These are shown in the following table:

R&S issue		
Review of limit values	G	
Field data to confirm limit values		R
Harmonise statistical approach	G	
How to deal with mobiles eg Cl?	G	
Consider surface water	G	
Model additional parameters		R
Define monolithic	G	
Harmonise monolithic LVs	G	
Agree integrity parameters	G	
Field investigation of monolithic landfills		R
Continue work on waste interactions		R

Notes: G= Working group, R= Research

Group 2: Sampling, testing, waste characterisation, standardisation, risk assessment

Group 2: Group members:

Keith Knox	Knox Associates	UK (Chairperson)
Jette Bjerre Hansen	DHI/C-RES	DK (Rapporteur)
David Bendz	SGI, Malmö	S
Rein Eikelboom	Ministry of the Environment	NL
Ketil Haarstad	Jordforsk, Ås	N
Jens Erling Frøiland Jensen	Norconsult, Sandvika	N
Marianne Munch	Miljøstyrelsen	DK
Jan August Myhrstad	Det Norske Veritas, Høvik	N
Kati Vaajasaari	Regional Env. Centre in Pirkanma	F
Margareta Wahlström	VTT Processes	F
Helga Bjarnadottir	Linnuhönnun	IS

A group member requested that we also looked at the need for other tests and parameters than those mentioned in LD and CD.

- *Issues: In terms of testing, what should be the extent of a full basic characterisation of a particular waste stream? Should column leaching tests e.g. always be required at basic characterisation level for granular wastes for which to be tested at compliance level using EN 12457 (batch leaching test)? How many different samples should be tested, and which tests should be performed (see e.g. section 1.1.3 in the Council Decision)?*

Objectives of testing?

Where acceptance criteria are set the objectives of testing is clear. Compliance tests are performed to document that the waste behaves as observed by a basic characterisation of the waste.

However, there was a general feeling that we need to know a lot more about the leaching behaviour of different kinds of waste material. For some specific waste streams there already exist a lot of information on the behaviour but it is not necessarily collated or publicly available and there are still many waste streams where we not know enough. Thus, already from the beginning of the implementation of the LD the basic characterisation of a waste stream should include data from a column test and a pH-static test for at least parameters from a full ICP run and pH value. The tests used for basic characterisation must always include those to be used for compliance testing (CD: 1.1.3).

We found that there is a need for a public databases where all these data can be gathered and available. If data could be made anonymous we think that data owners will be willing to share their data in a database and in return they will be able to compare their data with similar data from other waste producers.

Based on data from basic characterisations a taskforce could identify/develop classes of waste that can be treated as having common characteristics, and in the future it might be possible to cut down the extent of basic characterisation for certain waste streams.

The group stated that there is still a need for investigations focusing on the relation between the quality of the eluates from leaching tests and the quality of the leachate from the landfills. Knowledge from the older landfills is very useful but care must be taken transferring that knowledge directly onto these new landfills. For example very little is known about the interactions between wastes on inorganic landfills.

The group discussed whether basic characterisation was necessary for single batch of wastes and concluded that they should be judged case by case, depending on knowledge of the source. For waste that might have a serious impact from a singly batch, a full characterisation should be required but for waste that is expected to be inert waste a smaller basic characterisation program could be enough. (who will judge??)

- *Issue: What does it take to be exempted from testing according to section 1.1.4 in the Council Decision?*

This issue was only discussed briefly. It might be possible to derive a list of waste materials where all the necessary information is available. However the group agreed that compliance testing for these materials should be claimed. In the CD it is written that wastes that are exempted from testing requirements for basic characterisation are also exempted from compliance testing. A common European approach would be useful.

- *Issue: Section 3 in the Council Decision prescribes the use of CEN methods for sampling and testing. At present, only a few of these methods have been provided by CEN (primarily CEN/TC 292: Waste Characterisation). In the meantime, national standards or procedures or draft CEN standards should be used. Are all the necessary methods available one way or another? If not, what do we then do? Is there a need to carry out a comparison of national standards or methods that may be used? Are the CEN tests specified in section 3 of the Council Directive appropriate?*

This issue was not discussed.

- *Issue: Sampling is a particularly critical issue in relation to waste characterisation and testing. CEN/TC 292 is preparing a list of examples on how to prepare a sampling plan. Which sampling scenarios are most relevant and/or critical?*

This question is closely related to the first question about testing. The group discussed who would be responsible for the testing of wastes. Ice-

land, Norway and Finland described systems where the waste producers have operating permits that include a description of the wastes they produce and stipulate the analysis to be done. This could be the mechanism to get the basic characterisation done. However, this type of permit would only be applicable to manufacturing and would be harder to apply to some other sectors such as construction and demolition etc.

The CD says that sampling shall be carried out by independent and qualified persons and institutions. The group felt that this might cause problems in some Nordic countries, as only few people are proven qualified and independent. Nordtest is working on a programme concerning certification of samplers. It can take a while until certified samplers are available and in the meantime it was mentioned from some group members that it is more important to get some sampling and testing under way than to wait for samplers to be educated. The group did not agree on the necessity of having independent samplers, as some of the most skilled people in this area work for waste producers and waste contractors.

However, the group agreed that communication with the people involved with the production of the waste was one of the most important steps in preparing a sampling plan. A sampling plan must also contain information on the stability of the waste and identification of sources of variation (temporary variation, seasonal variation, long-term variation etc.). For some types of waste it may be possible to develop generic protocols and a common EU approach should be worked out.

The group discussed where samples for compliance testing should be taken – at the waste production site or at the landfill gate. Different opinions were expressed.

The advantages of sampling at the waste production site would be that the producer knows if the batch will fulfil the criteria before the waste has been disposed and it will be possible to landfill it in an appropriated landfill. On the other hand it was mentioned that things could happen to the waste on the way from the producer to the landfill and not all producers are equally trustworthy. Thus, the landfill operator may want to do his own sampling and testing at the landfill gate. The landfill operator will be responsible to the regulator.

It was not discussed which sampling scenarios that is most relevant to include in the CEN TC-292 standard on sampling.

- *Issue: How do we ensure sufficient consistency between testing at basic characterisation level and compliance testing?*

This issue was not discussed.

- *Issue: The Landfill Directive restricts the landfilling of "biodegradable waste". How do we define biodegradability and do we need a*

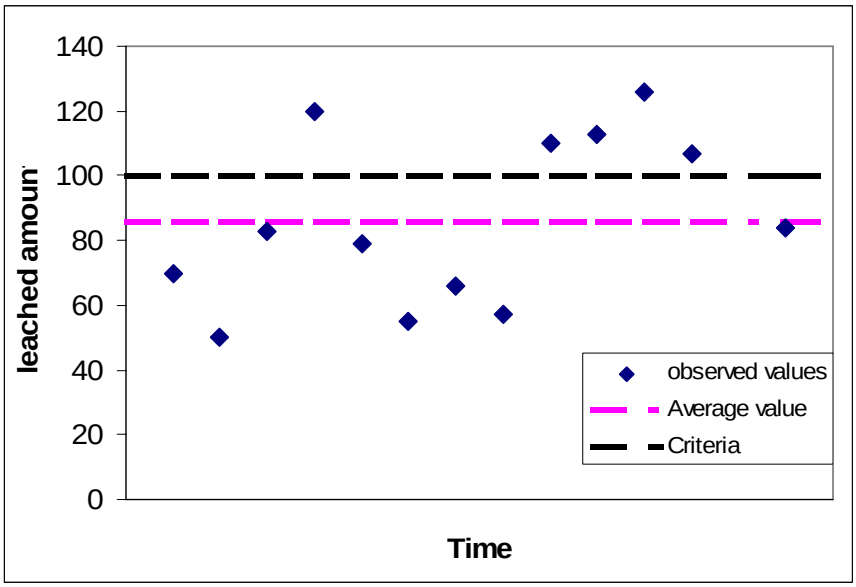
test for biodegradability? If we do, which tests are available for this purpose?

A view expressed was that the LD only restricts biodegradable *municipal* waste, so there may be no need for a test for waste acceptance. However, a test to assess progress within the landfill towards stabilisation (Final Storage Quality) is needed. Several tests are already available, such as biochemical methane potential (BMP) tests and aerobic respiration tests (AT) which are much quicker than BMP.

Several projects concerning tests for biodegradability are running at the moment. A Nordtest project comparing various bio tests is running, a Swedish project correlating VOC emissions to stability is also in progress and in Horizontal standardisation this issue is also addressed (Netherlands?).

- *Issue: How can the uncertainty of sampling and test results be taken into account when comparing test results to limit values and/or performing risk assessments?*

Concerning risk assessments it was discussed whether protection of surface water should be included. Most group members had no concern with regards to rapid escapes to surface water. However some concerns were expressed regarding spilling into surface water and long term risks from filling up of landfills when pumping of leachate stops.



One way of dealing with variability of compliance test results could be to survey the quality of the waste using a time scale appropriate to the risk being considered (see figure below). For groundwater risks, the timescales are long and a rolling average over a period of one year might be sui-

table. If for example one or two tests show leached amounts exceeding the criteria a more frequent testing would be needed. As long as the average value over a certain period is below the criteria, the waste stream for that period would be regarded as compliant.

However the uncertainties of sampling is not dealt with in that procedure. For the time being not much information exists concerning uncertainties related to sampling of wastes and that information would be useful and a potential research area.

- *Issue: All the tests currently listed in section 3 of the Council Decision refer to granular waste materials. There is an obligation to develop criteria for monolithic waste, which provide the same degree of environmental protection as criteria for granular waste. Which test methods are appropriate for monolithic waste? Is it necessary to ensure the short and long term physical stability and integrity of a monolithic material? If yes, how can this be done?*

This issue was not discussed.

- *Issue: Additional test and test-parameters needed*

Several suggestions of additional tests that might be needed for characterisation of wastes came up:

- Test for hydrogen formation upon hydration (e.g. incinerator residues)
- Test for acid neutralisation capacity (being prepared by CEN/C 292)
- Test for characterisation of the nature of DOC (e.g. degradability, complexing capacity)
- Ecotox test (being prepared by CEN/TC 292).

The group wondered why no acceptance criteria were set for Nitrogen species.

It was mentioned that in the TAC work on setting acceptance criteria several elements were left out due to the lack of criteria that could be used in the point of compliance (EU drinking water criteria were used).

- *Issue: Are there any urgent R&D needs?*

Unfortunately the group did not have time to address this issue.

Group 3: Environmental protection systems, gas and leachate monitoring and management, financial security, risk assessment

Group 3: Group members:

Henrik Wejdling	DAKOFA	DK (Chairperson)
Dorthe Lærke Baun	DHI/C-RES	DK (Rapporteur)
Tor Holm	Norges Renholdsverks-forening	N
Lise Kristin Jensen	Statens Forurensningstilsyn	N
Peter Kjeldsen	Danmarks Tekniske Universitet	DK
Anders Lagerkvist	Luleå Tekniske Högskola	S
Sofia Tingstorp	Naturvårdsverket	S
Cornelis Aart Meyles	Environmental and Food Agency	IS
Marcus Müller	AV Miljø	DK
Gudmundur T. Ólafsson	Landfill	IS
Thomas Rihm	Svenska Renhållningsverksfören.	S
Steen Stentsøe	COWI	DK
Jan Thrane	Odense Renovationsselskab	DK

- *Issue: Is it always possible to meet the requirements of the Landfill Directive (Annex I) for top covers, bottom liners, and geological barriers? Do they provide sufficient protection? How do these requirements fit various landfill strategies, particularly those based on high or increased water flows (e.g. flushing)?*

The short answers to these questions are yes (it is always possible to meet the requirements of the Landfill Directive (LD) for top covers, bottom liners and geological barriers), no (they do not provide sufficient protection), and badly (the requirements fit various landfill strategies badly).

The requirements in LD, Annex I, are not necessarily requirements but can also be seen as guidelines according to Annex I, 3.4. However, the group felt that reduced requirements always should rely on a site-specific environmental risk assessment. Two examples where the requirements for geological barriers probably can be reduced were given:

- Landfills placed below groundwater level on the coastline, where the gradient will always be inwards to the landfill
- Landfills placed on rocks with sealed cracks

It was stressed out that the composition of the leachate totally depends on the type of waste that is landfilled. By controlling the type of waste that is accepted on the landfill it is possible to a large extent to control the composition of the leachate and thereby the potential risk to the environment and subsequent the requirement to e.g. the bottom sealing.

The group agreed that top-cover is a bad idea from a sustainable point of view since all processes (e.g. degradation, ageing) inside the landfill is stopped.

- *Issue: What should be required in terms of risk assessment (on a case-by-case basis) if the competent authorities are to allow less stringent requirements for bottom liners and geological barriers than those specified in sections 3.2 and 3.2 in Annex I to the Landfill Directive (see section 3.4 in Annex I)?*

This issue was not discussed.

- *Issue: To what extent will it be possible to use waste materials/alternative raw materials instead of virgin soil materials for construction work within a landfill and for the final cover after completion of the operation period?*

According to LD it is possible to use waste materials/alternative raw materials instead of virgin soil materials both for the bottom layers and for the final top covers. What is important in this context is to focus on what kind of materials/wastes that are actually suitable for being used in construction work at landfills. Possible types of waste could be tyres, broken glass, bottom ash from incineration, and contaminated soil. Still, these types of waste materials will not be suitable for all applications. An example is tyres, which at a first look might be very suitable for bottom drainage layer. However, when tonnes of waste is placed on top of the tyres they will be compressed and will no longer have any draining effect.

The difficulties with comparing saving of virgin materials with higher emissions due to the use of waste materials where pointed out.

Another important aspects is that it is very important that the material used for top cover do not cause any emissions to and have any influence on the surroundings. For the environmental authorities this is more important than the saving of virgin materials.

The group agreed that it is important to remember, that top-cover should be seen as a barrier between the waste and the surroundings (e.g. playing children). Therefore, at least the upper part of the top layer should not be decidedly waste.

- *Issue: The precautions prescribed in the Landfill Directive and in particular the waste acceptance criteria in the Council Decision are very much focused on protection of groundwater. Are further precautions or stricter limit values required to ensure protection of e.g. surface water quality (both fresh water and seawater)?*

This issue was not discussed.

- *Issue: There is a general trend towards exclusion of organic, biodegradable or combustible waste from landfilling. What are the*

implications of this on gas and leachate formation, quality and management (treatment/utilisation/discharge)?

The general opinion was that organic materials can not be avoid in any type of landfills. Therefore, there will always be some gas production regardless of the type of waste landfilled, and the questions are more if the gas production will be significant and how do we collect or treat the produced gas?

The group agreed that if the amount of landfilled organic household waste is reduced then the gas production will be slower and the gas will be produced over a prolonged period, but as mentioned above it will still be produced. Furthermore, it was felt that it is impossible to predict the amount of produced gas.

With respect to the emissions a general problem is that we know very little about the redox-processes in the new types of landfills that is outlined in LD. This implies that we also know very little about the produced leachate and the fate of contaminants in the landfills.

The group felt that another important aspect is the shape of the landfill. Together with the actual landfill technology the shape of the landfill has large influence on the conditions inside the landfill and thereby on the leachate and other effluents/emissions from the landfill. An example was a landfill construction with a total height of the landfilled waste of only 2 m. Inside such a landfill there would probably be aerobic conditions and much higher activity than in a landfill with 10-15 m of landfilled waste. However, such a landfill would take up a lot of area and would therefore not be a realistic possibility on many locations. Furthermore, a landfill with a little fill height would be much more expensive to construct per tonnes of waste.

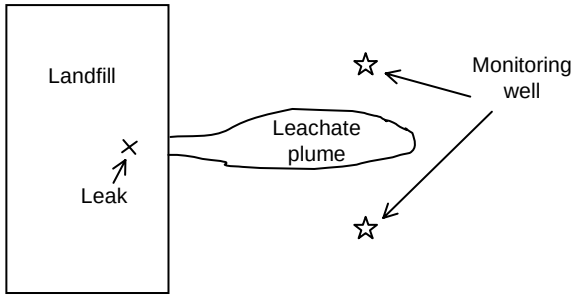
- *Issue: Do the requirements for monitoring of gas and leachate quality and quantity in Annex III of the Landfill Directive give rise to concerns or problems? Is the quality of such monitoring data generally satisfactory or should it be improved?*

The group felt that there was a need for more detailed requirements with respect to how and where to monitor the gas in the surrounding areas. The gas production is highly dependent on factors like atmospheric pressure and heavy rains. Therefore, as the LD-requirements are today, it is possible to choose the sampling time, so no gas production will be detected (e.g. low pressure and wet weather/rain).

- *Issue: Is it useful to do water balance calculations for a landfill to supplement the groundwater or surface water monitoring programme (as an indicator of leakages)? If yes, which methods are preferable?*

The general opinion was that mass balance calculations are very uncertain. Experiences at a Danish landfill since 1994 was that the uncertainties on such mass balance calculations would be up to +/- 30 % and use of different equipment for measurements could result in uncertainties up to +/- 20 %.

The requirements in LD (Annex III, 4A) with respect to groundwater monitoring are one measuring point upstream and two measuring points downstream. The group felt that this will give no security at all, since it is very unlikely that a smaller leak would be detected in one of the measuring points (se figure below).



Another possibility that was discussed was the use of electronic detection systems. The experiences with these systems are still very limited and the group felt that they might give some security but probably only for some years.

The group agreed on that liners do leak and a large problem is what we actually do if we find a leak?

All in all it was felt that the money are better used on good liners, improved control of the incoming waste etc. than on more or less unreliable monitoring/control systems.

- *Issue: How is the required financial security (LD Article 8 (a) (iv)) handled? Does it give rise to problems or conflicts with existing laws?*

This issue was not discussed.

- *Issue: Are there any urgent R&D needs?*

The group felt that there were several urgent R&D needs. The identified R&D needs are listed below.

- Better knowledge on the processes in the new type of landfills with low content of organic material. What would happen with the gas production and the leachate composition?
- More focus on the gas production, on how to avoid it or take care of it, and on the influence of the gas on the leachate quality?
- Developments of methods to determine biodegradation also in inhomogeneous materials like waste.
- Determine or define the/a correlation between the composition of the produced leachate and the limit values in the acceptance criteria.
- Developments of methods to establish limit values for discharge of leachate. These limit values should be related to site specific conditions.

Group A:Visions for the future: Sustainable landfilling

Group A: Group members:

Peter Kjeldsen	Danmarks Tekniske Universitet	DK (Chairman)
Dorthe Lærke Baun	DHI/C-RES	DK (Rapporteur)
Steve Gibbs	Atkins Environment	UK
Sacha Heijblom	Ministry of the Environment	NL
Ari Seppänen	Environmental Ministry	F
Hans A. van der Sloot	ECN	NL
David Bendz	SGI, Malmö	S
Ketil Haarstad	Jordforsk, Ås	N
Jan August Myhrstad	Det Norske Veritas, Høvik	N
Cornelis Aart Meyles	Environmental and Food Agency	IS
Thomas Rihm	Svenska Renhållningsverksfören.	S
Henrik Wejdling	DAKOFA	DK

- *Issue: What is sustainable landfilling in theory and in practice?*

The group agreed on that sustainable landfilling is landfilling in a way so no harmful effects on the environment was taken place at least not after eg. 30 years.

It was also stressed that there are some examples of old landfills (without liners) that might be defined as sustainable landfills since no pollution can be detected 50-100 meters downgradient these landfills. However, it depends on what we would accept – would we accept a kind of a buffer zone, meaning that the groundwater can be polluted in a limited distance downgradient landfills? The group felt that this was probably necessary. There will always be some effects on the environment and sustainability is therefore more to minimise and control these environmental impacts.

It was also discussed if leaving money to the next generation for treating the waste was sustainable. The general opinion was that leaving money to the next generation was not sustainable.

The problems with environmental burden were also briefly discussed. It was mentioned that there is a risk of using a lot of and maybe to many resources today to obtain sustainability in the future. However, the group did not come to any agreement on how to tackle the possibilities for environmental burden.

Theoretically sustainable landfilling is the best solution, however in practice it will often be the second or third best solution.

- *Issue: Can it be achieved within the framework of the Landfill Directive?*

The short answer on this is no, not as it is today! However, the LD do not prevent sustainability but to obtain sustainability we have to go beyond the requirements in the LD.

The group felt that regulated landfills as they are today will not be able to be sustainable within 30-40 years. Generally mixed landfills can probably be sustainable, but it depends to a very large extent on the type of waste that is landfilled.

The group felt that to be able to obtain sustainable landfilling it has to be integrated in the legislation. As it is today, there are things that are right to due with respect to sustainability but these things might not be possible to do due to the legislation. Examples of things that possibly could be integrated in the legislation for making sustainability easier to reach was:

- Aquifer treatment zones / buffer zones?
- Discharge to sea of leachate with a high salt content.

However there was agreement on that acceptance of things like the ones mentioned above requires site specific risk assessments. Therefore, it is necessary to have the possibilities for doing site specific risk assessments but it should not be a demand.

- *Issue: What are the main obstacles to sustainable landfilling?*

This issue was not addressed.

- *Issue: Is final storage quality a useful concept?*

The group felt the final storage quality (FSQ) is a useful concept. However, before using it, we have to decide when to use it. Is it before landfilling the waste or is it when going from the active to the passive phase?

There was a discussion about whether FSQ should be based on concentrations (leachate quality) or fluxes (of contaminants). The possibility of using both was mentioned, where the fluxes were used for evaluation and the concentrations were used for regulation. It was also mentioned that it is difficult to regulate on the fluxes and to do it the regulation has to be done on another way than was it the general practice today. The group did not come to any agreement besides that using concentrations is more simple.

The possibility for passing on money to the next generation was discussed. Generally the group did not like this concept. It was mentioned that if it is possible, then it is more sustainable to use the money for a treatment that will last for more than 30 years and that will not require any active effort than just passing on some money.

General the group felt that is will be very difficult to reach FSQ within 30 years. This will require some treatment and before doing this it could be an idea to use LCA and to take a closer look both on both the cost of the treatment and on the impacts (both due to the treatment and if no treatment is done).

- *Issue: What are the major research needs if sustainable landfilling is to be achieved?*

This issue was not addressed.

Group B: Visions for the future: Sustainable landfilling

Group B: Group members:

Anders Lagerkvist	Luleå Tekniske Hogskola	S (Chairman)
Bjørn Malmgren-Hansen	Teknologisk Institut/C-RES	DK (Rapporteur)
Gunnlaug Einarsdóttir	Environmental and Food Agency	IS
Jørgen G. Hansen	Miljøstyrelsen	DK
Stina Lundberg	Naturvårdsverket	S
Thomas H. Christensen	Danmarks Tekniske Universitet	DK
Rein Eikelboom	Ministry of the Environment	NL
Jens Erling Frøiland Jensen	Norconsult, Sandvika	N
Kati Vaajasaari	Regional Env. Centre in Pirkanma	F
Tor Holm	Norges Renholdsverks-forening	N
Marcus Müller	A V Miljø	DK
Steen Stentsøe	COWI	DK

Issues:

- *What is sustainable landfill in theory and in practice?*
- *Can it be achieved within the framework of the Landfill Directive?*
- *What are the main obstacles to sustainable landfilling?*
- *Is final storage quality a usefull concept?*
- *What are the major research needs if sustainable landfilling is to be achieved?*

Before starting the discussion of the 5 issues to be discussed a number of subjects within the scope for discussion were formulated around the table from the participants to be included in the discussion.

When discussing sustainable landfilling a definition the purpose of landfilling was first defined: The purpose of landfilling is the transfer of matter from the society to the environment.

When looking at the Brundtland definition of sustainability: “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" this may be reached in different ways when looking at landfilling. Looking at the present situation in Europe some countries landfill a large part of their waste and some recycle a large part.

This leads to a discussion regarding what should be taken into account when assessments of sustainable landfilling are performed. Assessments of sustainable landfilling must not only be based on waste acceptance

criteria for the landfill but also include an analysis of the whole waste management system. Looking at landfilling alone and thereby not including an analysis of the effects of alternative treatments like combustion, recycling of the waste etc. may lead to a sub-optimisation. The assessment must be based on environmental effect, i.e. recipient-based.

A question discussed was whether it is possible to obtain sustainable landfilling in one generation and should the limit be only one generation if other solutions are better?

There was common agreement that one generation ie 30 years may not be an optimum period when performing a total assessment- but if a longer period is chosen then funds must be set aside for the hole treatment period to avoid compromising future generations ability to meet their own needs.

In order to perform proper environmental and economic assessments of the effects of sustainable landfilling there was expressed a need for case-studies of deposits including the surroundings and the total waste management system to obtain sufficient data. The study of such reference objects should be performed on an inter European level and in general it was agreed upon that a strong inter-European co-operation is needed to obtain the best results in the development of sustainable landfilling.

The concept of sustainable landfilling may lead to wishes for new demands and changes in regulations and it was felt that tools for decision support should be developed to help promote awareness of these needs for politicians and decision makers and to avoid confusion.

There was expressed a wish for more public communication about ongoing work, like fx. the data background for calculation of the acceptance criteria.

It was felt that there is no apparent obstacles in the EU directives for obtaining sustainable landfilling, but the directive does not necessarily promote sustainable landfilling and supplementary regulation may be needed.

Major research needs identified:

- Development of applications for environmental economics in waste management
- Recipient based studies on reference objects
- More co-operation within Europe
- Development of decision support tools
- More public communication
- Technology development

Group C:Visions for the future: Sustainable landfilling

Group C: Group members:

Ann-Marie Fällman	Naturvårdsverket	S (Chairperson)
Jette Bjerre Hansen	DHI/C-RES	DK (Rapporteur)
Helga Bjarnadottir	Linnuhönnun	IS
Marit Torsvik	Fylkesmannen i Nordland	N
Keith Knox	Knox Associates	UK
Marianne Munch	Miljøstyrelsen	DK
Margareta Wahlström	VTT Processes	F
Lise Kristin Jensen	Statens Forurensningstilsyn	N
Sofia Tingstorp	Naturvårdsverket	S
Gudmundur T. Òlafsson	Landfill	IS
Jan Thrane	Odense Renovationsselskab	DK

- *Issue: What is sustainable landfilling in theory and in practice?*

The objective of sustainability was defined, as no harmful impact on the environment must take place. Sustainability must be seen in a broad perspective and focus must not only be on the fact of fulfilling waste acceptance criteria.

It was discussed in the group what the sustainability level for ground water, air ect is. For example, is it sustainable that the future use of the land might be restricted? No one really had the answer.

Thus, one of the major questions that have to be discussed on both National and EU-level is “What is good enough?” A definition of sustainability is needed and it should be concretised in order to be able to answer that question.

There is a conflict between economy and the idea that sustainable landfills are small landfills.

To obtain sustainable landfill strategies it will be very useful to have demonstration projects where different landfilling strategies (operations) could be tested in order to try and meet sustainability. Projects like these should be performed on EU or Nordic-level in order to be sufficiently funded, as it will be necessary to run the projects for a long period (more than 5 years).

- *Issue: Can it be achieved within the framework of the Landfill Directive?*

This issue was not really addressed.

- *Issue: What are the main obstacles to sustainable landfilling?*

The group discussed if it should be avoided to have biodegradable waste on landfills in order to be able to obtain sustainability. The problem is

that it might be very difficult to have a complete degradation of the organic waste and also in areas with low temperatures the degradation will go on for very long time.

It was mentioned in the group that if it is not possible to obtain complete degradation, biodegradable waste should be avoided on landfills in order to be able to obtain sustainability.

New and unknown compounds were seen as one of the main threats to sustainability evaluation.

- *Issue: Is final storage quality a useful concept?*

Overall the group liked the idea of Final Storage Quality (FSQ) within one generation but the waste produced today may require more effort to reach FSQ. Thirty years is not enough for sure. The impact of reaching FSQ on the environment should however be seen in a broader perspective so that the efforts / activities to get to FSQ will not be harmful to the environment.

- Some limits for reaching FSQ
- Biodegradability:
- Time
- knowledge
- temperature
- final degradation (last 10% of biodegradable waste)
- New unknown problematic constituents.

- Inorganic – organic compounds
- New / unknown components

- *Issue: What are the major research needs if sustainable landfilling is to be achieved?*

The following statements were made:

- Demonstration projects on sustainable landfilling strategies on EU-level and/or Nordic-level.
- Identification of the “final room” for different substances / specific compounds. For example “chloride to the sea” and “carbon to the soil”.
- Focus on sustainability of products and not only at the end of the line where the products are becoming wastes for landfilling.
- Focus on new compounds that might be a threat to sustainability evaluation.