

Landfill Aftercare

Shredder waste and mixed waste



Aftercare

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July 2011

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Project Landfill Aftercare	Project No 11700096
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	Draft Final Report	MTA/OH	OH/JHY	SL	29/07/11
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Revision	Description	By	Checked	Approved	Date
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Key words Landfill, Aftercare, Leachate, Mixed waste, Shredder waste, Estimation of aftercare duration, Characterisation, Leaching tests, Lysimeter tests, Full scale landfills	Classification <input type="checkbox"/> Open <input type="checkbox"/> Internal <input checked="" type="checkbox"/> Proprietary
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Distribution	
AV Miljø DHI:	Per Wellendorph, Jonas Nedenskov, Finn Reinholdt Jensen MTA, JHY, JBH, OH
Data suppliers :	FASAN, SYSAV, BOFA, REFA, Odense Renovation, KARA/NOVEREN



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1 INTRODUCTION

1.1 Background

Landfilling is generally based on the assumption that the landfilled waste will achieve “final storage quality” within a reasonable period of time. Final storage quality represents a condition at which the leachate from the landfill has become acceptable in the surrounding environment, allowing the site to be safely abandoned without active environmental protection measures. Final storage quality is not a very well defined concept and due to the lack of reliable data and research, little is known about the time needed to reach final storage quality. For a Danish landfill, the supervising authorities must determine if and when final storage quality has been achieved and the operator can stop the leachate pumping system at the landfill.

The costs associated with the management of leachate and monitoring of groundwater/surface water and leachate during the aftercare period, i.e. the period from the completion of landfilling until the achievement of final storage quality, should be incorporated into the gate fee paid by the waste producers. The total costs of landfilling thus depend on the duration of the aftercare period. At present, EU and Danish landfill regulation prescribes the use of an aftercare period of at least 30 years as the basis for the calculation of the gate fee. If a 30 year aftercare period is used as the basis for calculation of the gate fee and this period eventually must be extended beyond the 30 years, the landfill owners themselves or society will have to cover the additional costs associated with the extension of the aftercare. For AV Miljø the aftercare costs are estimated at approx. 1.4 million DKK/year for the first 70 years. After 70 years additional expenses for renewal of pumps and more thorough renovation of leachate collection systems may be expected.

A landfill owner therefore needs the best possible estimate of the duration of the aftercare period to be able to calculate a proper gate fee which includes all operation and aftercare costs. In response to this need DHI has carried out a project for AV Miljø with the aim of collecting data and developing tools and methodologies that can contribute to the improvement of the estimates of the duration of the aftercare period at landfills under various design and operation conditions, particularly under conditions relevant to AV Miljø. This report describes the project activities and the results of the project which was carried out during the period 2007 to 2010.

1.2 Objectives

The main objective of the project has been to establish and validate tools which can be used to predict and possibly also influence (reduce) the duration of the aftercare period for modern landfills, especially the AV Miljø landfill cells at Avedøre Holme containing mixed waste and shredder waste.



1.3 Activities

The study has included the following activities:

- A: Collection and compilation of data from laboratory characterisation and lysimeter leaching tests carried out on shredder waste and mixed waste from AV Miljø
- B: Collection and compilation of data from existing landfills, including AV Miljø
- C: Development of a tool for improved prediction of the duration of the aftercare period.

An overview of the project activities is shown in table 1.1.

Table 1.1 Overview of project activities

ID	Activity	Comments
A	<p>Collection and compilation of laboratory and lysimeter data</p> <ul style="list-style-type: none"> • Collection of samples of shredder waste and mixed waste from AV Miljø • Laboratory characterisation of the two waste types • Lysimeter tests carried out on the two waste types 	<p>The sampling was performed by AV Miljø and DHI</p> <p>The laboratory characterisation was performed by DHI</p> <p>The lysimeter leaching tests are carried out by DHI in co-operation with KMC, AV Miljø and Danwaste. The lysimeter tests will continue.</p>
B	<p>Collection and compilation of data from existing landfills</p> <p>Collection of data and information from other landfills</p> <p>Collection of data and information from AV Miljø</p> <p>Comparison of data from laboratory tests, lysimeter tests and landfill sites</p>	<p>It was difficult (and generally impossible) to get data and information of the desired quality. The data collected represent the best possible information available and may be useful in relation to other projects.</p>
C	<p>Development of a tool for prediction of the duration of the aftercare period</p>	<p>Attempts at geochemical speciation modelling of the leaching from shredder waste did not fully succeed. The application of a simplified model for prediction of the duration of the aftercare period for cells for shredder waste at AV Miljø demonstrated the many uncertainties involved.</p>



1.4 Approach

The approach has been to collect data on the quantity and quality of leachate from land-filled shredder waste and mixed waste as a function of time and L/S from old and existing landfills, including AV Miljø, on the one hand and produce such data from laboratory and large scale lysimeter leaching test on the other hand.

Based on speciation, source and transport modelling, and using the insight gained from the studies of the full scale landfills and the laboratory and lysimeter leaching tests, and using primarily laboratory characterisation leaching data as input to the source model, it was the intention to develop a reliable tool for prediction of the quantity and quality of leachate from shredder and mixed waste landfills and apply the model to scenarios relevant to AV Miljø in order to predict the duration of the aftercare period and, if possible, to assess various possibilities for reducing this period.

The final step should be to validate the model by applying it to some of the existing landfills for which information and data have been collected and compare the results to the observed leachate behaviour at the landfill.

2 **LABORATORY CHARACTERISATION AND LYSIMETER TESTING**

2.1 **Sampling of waste materials**

Shredder waste and in particular mixed waste are very inhomogeneous waste materials, and the collection and subsequent testing of representative samples of these wastes from a landfill represents a major challenge. In the project, it has been the intention to collect representative samples of shredder waste and mixed waste which had recently been landfilled in separate cells at the AV Miljø landfill to be used in the lysimeter tests and in the laboratory characterisation.

The shredder waste was collected from the landfill cell shown in figure 2.1 (see map in Appendix 1). At each of 11 different sites spread out across the cell, approximately 1 tonne of shredder waste was dug out from a depth of up to several meters with an excavator, loaded onto the shovel of a larger excavator and placed in a container from where it was later collected and placed in two of the lysimeters. A total of 11.5 tonnes of shredder waste was collected. Each time the waste was transferred from the smaller excavator shovel to the larger one, an increment sample was collected with a hand shovel and placed in a plastic barrel. The combined sample in the barrel was subsequently homogenised and sub-sampled to be used in the laboratory characterisation. Figure 2.2 provides a closer look at the surface of the shredder waste in the landfill cell.



Figure 2.1 Landfill cell with shredder waste.



Figure 2.2 Surface of shredder waste in landfill.

The even more inhomogeneous mixed waste was collected from the landfill cell shown in figure 2.3. From each of 9 different locations at the active tipping edge within the landfill cell, 3 shovel-loads of mixed waste were dug out with an excavator. All the material was placed in one heap, which was mixed with an excavator and crushed with a compactor. Figure 2.4 shows the heap after crushing.

A smaller excavator was used to transfer mixed waste from the crushed heap to the shovel of a larger excavator (see figure 2.5), which then transported the waste to a container. A total of 17.5 tonnes of mixed waste was collected in the container from where it was later collected and used in two lysimeters. Each time a shovel-load was trans-

ferred from the smaller to the larger excavator, parallel increment samples were taken with a hand shovel and placed in two plastic barrels (see figure 2.6) for subsequent laboratory characterisation. In principle, the samples A and B in the two barrels were “identical”.



Figure 2.3 Landfill cell with mixed waste.



Figure 2.4 Heap of mixed waste after crushing.



Figure 2.5 Loading of the larger excavator with mixed waste.



Figure 2.6 Sampling of mixed waste.

The sampling procedures are further described in Appendices A (shredder waste) and B (mixed waste). The samples in the plastic drums were transported to DHI for pretreatment and characterisation. The containers with the larger amounts of waste were transported to KMC, covered up and stored until the waste was placed in the lysimeters in June 2007.

2.2 Pretreatment of waste samples for laboratory characterisation

At DHI the 226 kg of shredder waste collected were sieved, mixed and subdivided to reduce the sample size. Material larger than 10 mm was crushed, and material that could not be crushed (metal and stones) was rejected. After further pretreatment (as prescribed by the individual test methods), representative subsamples were subjected to chemical analysis and a number of characterisation tests. Further details of the pretreatment may



be found in Appendix A. The sample of shredder waste was registered as R-094-06 in DHI's database system.

The two drums with mixed waste (78.6 kg (sample A) and 70.1 kg (sample B), respectively) received at DHI were sieved and sample size reduced separately. Material larger than 10 mm was crushed or cut into smaller pieces, and material that could not be crushed or cut (metal and stones), was rejected. After further pretreatment in accordance with the applied test methods, sample B (registered as R-094-06) was subjected to chemical analysis and a number of characterisation tests. From the other drum (sample A), three subsamples corresponding to the sample from drum B were collected. These three subsamples and a subsample from drum A were subjected to a batch leaching test to assess the relative influence of the sampling and pretreatment procedures on the results of a leaching test. Further details of the pretreatment of the mixed waste samples are given in Appendix B.

2.3 Laboratory characterisation

2.3.1 Overview of characterisation programme

Table 2.1 shows an overview of the basic characterisation testing programme to which the samples of shredder waste and mixed waste were subjected.

Table 2.1 Overview of laboratory characterisation programme for shredder waste and mixed waste.

Tests/analyses	Chemical analytical programme for eluates
Total content of inorganic substances	
Content of total organic carbon (TOC)	
Content of hydrocarbons, PAH, BTEX og PCB	
Column leaching test CEN/TS 14405	Inorganic substances og DOC
Batch leaching test EN 12457-1	Inorganic substances og DOC
pH dependence leaching test CEN/TS 14997	Inorganic substances og DOC
Equilibrium column test for organic substances	Non-volatile organic substances

2.3.2 Chemical analysis for content of inorganic and organic substances

A representative subsample of each type of waste was sent to ECN in the Netherlands for total digestion and subsequent analysis for total content of Si, Al, Ca, Mg, Ti, Na, K, Fe, S, P, As, B, Ba, Br, Cd, Cl, Co, Cr, Cu, Hg, Mn, No, Ni, Pb, Sb, Se, Sr, V, W, Zn.

Another representative subsample of each type of waste was sent to Pirkanmaa Regional Environment Centre Laboratory in Finland for analysis of the content of total organic carbon, TOC.

A third representative subsample of each type of waste was sent to Eurofins (Denmark) for analysis of the content of hydrocarbons, PAH, BTEX and PCB.



The results are shown in Appendices A and B.

2.3.3 Performance of column leaching test for inorganic substances and DOC

A representative subsample of each type of waste was size reduced to approximately < 4 mm and subjected to a column leaching test with demineralised water in accordance with CEN/TS 14405 (10 cm column diameter). Seven eluate fractions were collected under nitrogen in the range L/S = 0 to 10 l/kg and filtered through a 0.45 µm filter after measurement of pH and conductivity. The eluates were subsequently sent to Analytica in Sweden for analysis for chloride, fluoride, sulphate, HCO₃⁻, Si, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se and Zn. Parallel samples were sent to ECN for analysis for dissolved organic carbon, DOC.

The results are shown in Appendices 1 and 2, both as concentrations in the eluates (mg/l) and as accumulated leached amounts (mg/kg) as a function of the liquid to solid ratios L/S. The accumulated leached amounts are further shown graphically as a function of L/S.

2.3.4 Performance of batch leaching tests for inorganic substances and DOC

One representative subsample of the shredder waste was size reduced to < 4 mm and subjected to a batch leaching test with demineralised water at L/S = 2 l/kg in accordance with EN 12457-1. As described above, 3 subsamples of mixed waste from drum A and one subsample from drum B were subjected to the same batch leaching test. The filtered eluates were subsequently sent to Analytica in Sweden for analysis for chloride, fluoride, sulphate, HCO₃⁻, Si, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se and Zn. Parallel sub-samples of the eluates were sent to ECN for analysis for dissolved organic carbon, DOC.

The results are shown in Appendices 1 and 2. The leached amounts of substances are shown graphically together with the results of the column leaching test.

2.3.5 Performance of pH dependence leaching test for inorganic substances and DOC

Representative subsamples of shredder waste and of mixed waste (from drum B) were sized reduced to < 2 mm and subjected to a pH dependence leaching test with demineralised water at L/S = 10 l/kg with pH fixed for 48 hours in accordance with CEN/TS 14997 (pH-stat test). pH is kept constant by means of feed-back computer controlled addition of HNO₃ or NaOH. The test was carried out at 8 different pH values: Shredder waste: 2, 4, 6, 7, 8.1 (own pH), 9.1, 10.1 and 12.1, Mixed waste: 2, 3.8, 6.1, 7.4 (own pH), 8.2, 8.9, 9.8 and 11.8. After filtration through a 0.45 µm filter the eluates were sent to Analytica in Sweden for analysis for chloride, fluoride, sulphate, Si, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se and Zn. Parallel sub-samples of the eluates were sent to ECN for analysis for dissolved organic carbon, DOC.

The results are shown in Appendices 1 and 2, both as concentrations in the eluates (mg/l) and as leached amounts (mg/kg). The results are further shown graphically as concentrations as a function of pH. Based on the consumption of acid and base in the test, the acid/base neutralisation capacity is also shown graphically in Appendices 1 and 2.

2.3.6 Performance of equilibrium column test for non-volatile organic substances

The equilibrium column leaching test was developed by DHI and DTU for the Danish EPA for determination of the leachability of non-volatile organic substances (see e.g. Hansen et al., 2005). Two column leaching tests were performed on representative samples of shredder waste and mixed waste (from drum B), respectively, in glass columns (size: ~15 cm length and ~6 cm diameter, ~425 cm³) at a fixed L/S depending on the properties of the test material (for the shredder waste L/S was 1.87 l/kg, for the mixed waste L/S was 1.40 l/kg). A continuous vertical up-flow was used, so that the column was water-saturated, see figure 2.7. The eluent, which was demineralised water with 0.5 g/l NaN₃ added (to prevent degradation) was recirculated in the test system for 7 days to ensure equilibrium. The flow velocity was approximately 0.7cm/h (Darcy velocity). The eluate was collected as one single fraction after 7 days of recirculation. The eluate, which was neither treated by centrifugation nor filtration after being collected, was subsequently characterised physically and chemically. For analysis of organic compounds the extraction was performed directly in the receiving vessel from the test system. The eluates were sent to Eurofins (Denmark) for analysis for hydrocarbons and PAH. The results are shown Appendices 1 and 2.

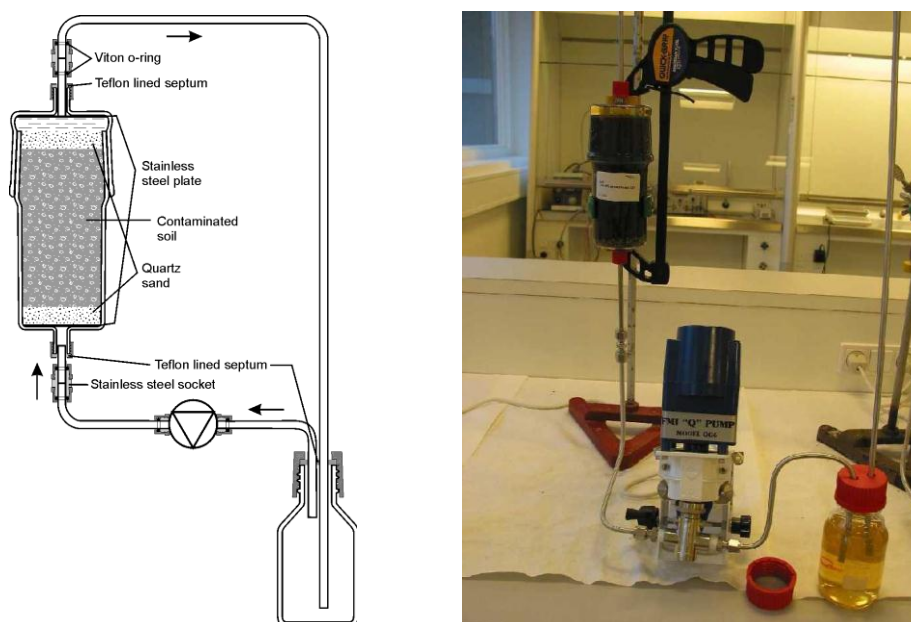


Figure 2.7 The equilibrium column leaching test for non-volatile organics, with recirculation of eluate.

2.3.7 Results of the laboratory characterisation of the waste

Shredder waste

The results of the characterisation of the shredder waste are shown in Appendix 1. In Denmark, shredder waste is currently characterised as hazardous waste. This characterisation is related to landfilling and, and an actual classification will require further testing and analysis. The measured contents of various substances alone do not seem to indicate hazardous properties of the waste. For certain substances, such as Cd and Hg, the



content alone, regardless of the form in which they are present, is sufficient for an evaluation. The lowest limit value for classification as a hazardous waste for these substances is 1000 mg/kg, and since the contents of Cd and Hg are 33 mg/kg and 1.8 mg/kg, respectively, this does not classify the shredder waste as hazardous waste. The content of hydrocarbons (C6-C35) is 8,600 mg/kg (limit value for hazardous waste 10,000 mg/kg) and the content of PCB (the results for 7 congeners summed and multiplied by 5) is 28 mg/kg (limit value for hazardous waste 50 mg/kg). One property that might render shredder waste hazardous could be the risk of spontaneous ignition (H3-A in the Waste Framework Directive, 2008/98/EC). This property was, however, not investigated in this study.

Compared to the waste acceptance criteria (WAC) at landfills for hazardous waste in the Danish Statutory Order on landfills (BEK no. 719/2011), the measured content of TOC (18 % w/w) by far exceeds the limit value of 6 % (w/w). The DOC in the eluate from the column test (1500 mg/kg at L/S = 10 l/kg) also exceeds the WAC (1000 mg/kg) for all hazardous waste landfills. The column leaching results for Ni (0.69 mg/kg) also exceeds the limit value for non-near coastal hazardous waste landfills (FA0) at L/S = 10 l/kg (0.53 mg/kg). Ni complies with the leaching WAC for hazardous waste landfills of type FA1 and FA2.

Mixed waste

The results of the characterisation of the mixed waste are shown in Appendix B. Table 2.2 shows the results of the triplicate batch test on sub-samples from drum A and the single batch test on the sub-sample from drum B. As seen in table 2.2, the relative standard deviation is relative small within the same sample (A) and for many parameters somewhat larger when the (single) test result for sample B is included. The results indicate that the influence of the sampling on the results of the leaching test is significantly larger than the effect of the pretreatment.

Table 2.2 Results of batch leaching tests (EN 12457-1) at L/S = 2 l/kg.

Parameter	Sample A (N = 3)		Sample B (N = 1)	Sample A + Sample B (N=4)
	Average mg/kg	Relative standard deviation %	Result mg/kg	Relative standard deviation (%)
As	0.13	15	0.20	28
Ba	0.21	6.5	0.53	56
Cd	0.0031	11	0.0029	9.4
Cr	0.073	17	0.19	58
Cu	0.61	18	2.1	74
Hg	0.0013	21	0.00062	36
Mo	0.044	2.5	0.025	24
Ni	0.10	10	0.11	7.8
Pb	0.044	23	0.031	26
Sb	0.034	4.4	0.033	3.9
Se	0.0014	9.3	0.0018	17
Zn	2.5	19	1.5	29
Chloride	710	0.71	720	1.1
Sulphate	3900	0.59	4000	0.97
TDS	9500	4.7	9700	3.9
DOC	590	13	1200	43
pH	7.89 – 8.01	-	8.09	-

From the results in Appendix B it appears that the mixed waste from AV Miljø seems to fit the definition of mixed waste as given in BEK no. 719/2011: “A subcategory of non-hazardous waste consisting of a mixture of organic and inorganic material with a content of total organic carbon (TOC) of 50 g or more per kg of dry matter.” None of the analyses or tests carried out indicate that the waste should be hazardous, and the measured content of TOC of 230 g/kg clearly exceeds the limit value of 50 g/kg which qualifies the waste as mixed waste.

Both the visual impression and the observations during the pretreatment indicated that the mixed waste had a very high volume content of plastics (no distinction was made between PVC and other types of plastic), wood, roofing felt and similar materials which to a large extent probably would have been suitable for combustion if it had or could have been separated by sorting. Because of the large content of slowly degradable organic material it may be expected that the observed leaching properties will change over time as a result of biological activity.

2.4 Lysimeter leaching tests

2.4.1 Design of lysimeters and leachate collection systems

The lysimeter leaching tests were carried out at the KMC test site near Copenhagen in cooperation between KMC (City of Copenhagen), AV Miljø, Danwaste and DHI. The shredder waste and mixed waste occupies 4 out of 16 lysimeters at the KMC test facility. The design of the lysimeters is shown in figure 2.8. Each lysimeter is a 1.8 m high tube, made of HDPE, with an inner diameter of 2.00 m.

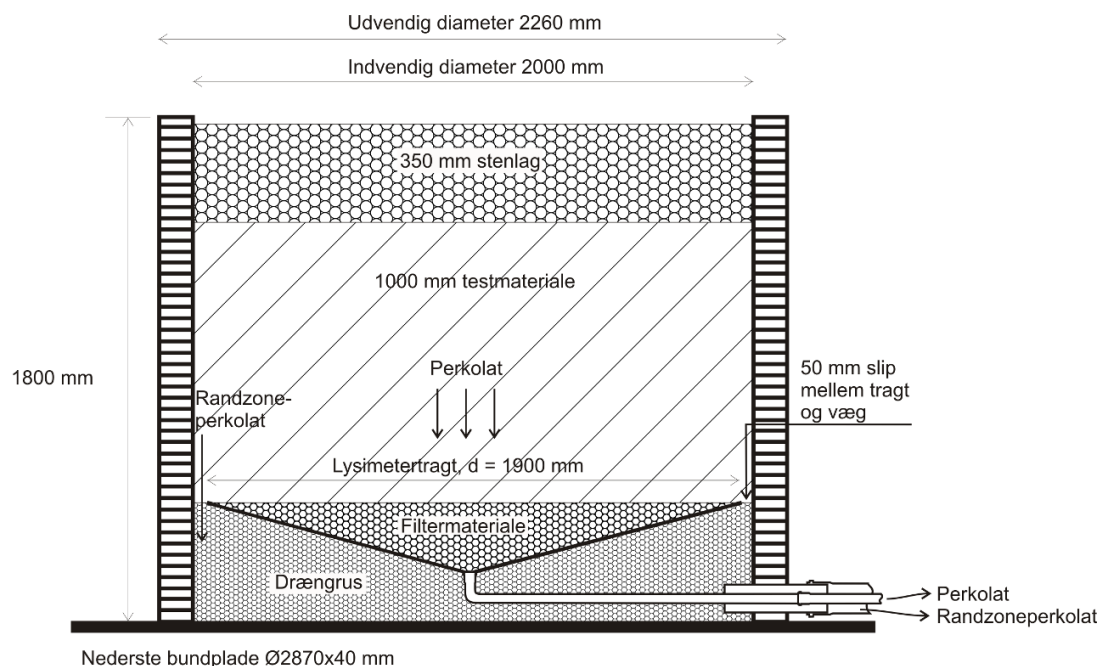


Figure 2.8 Cross-section of lysimeter.

The lysimeters are designed in such a way that rainwater percolating through the test material (and becoming leachate) is collected in a funnel at the bottom of the lysimeter and led to the leachate collection tank that is placed in a buried shipping container. The funnel which has a diameter of 1.90 m is supported by drainage gravel and it is placed in the middle of the lysimeter, leaving a distance between the edge of the funnel and the wall of the lysimeter of 5 cm. This means that leachate traveling along the wall of the lysimeter will pass by the funnel into the underlying drainage gravel from where it is led to the leachate collection container and collected in a tank, separated from the tank in which the leachate from the middle or main body of the waste is collected. Figure 2.9 shows the relative placement of the lysimeters and the shipping container.

To facilitate analysis for both inorganic and organic substances, the funnels in two of the lysimeters (one with shredder waste and one with mixed waste) and the associated tubing are made of stainless steel (for analysis of organic substances) and the funnels and tubing in the two other lysimeters are made of HDPE (for analysis of inorganic substances).

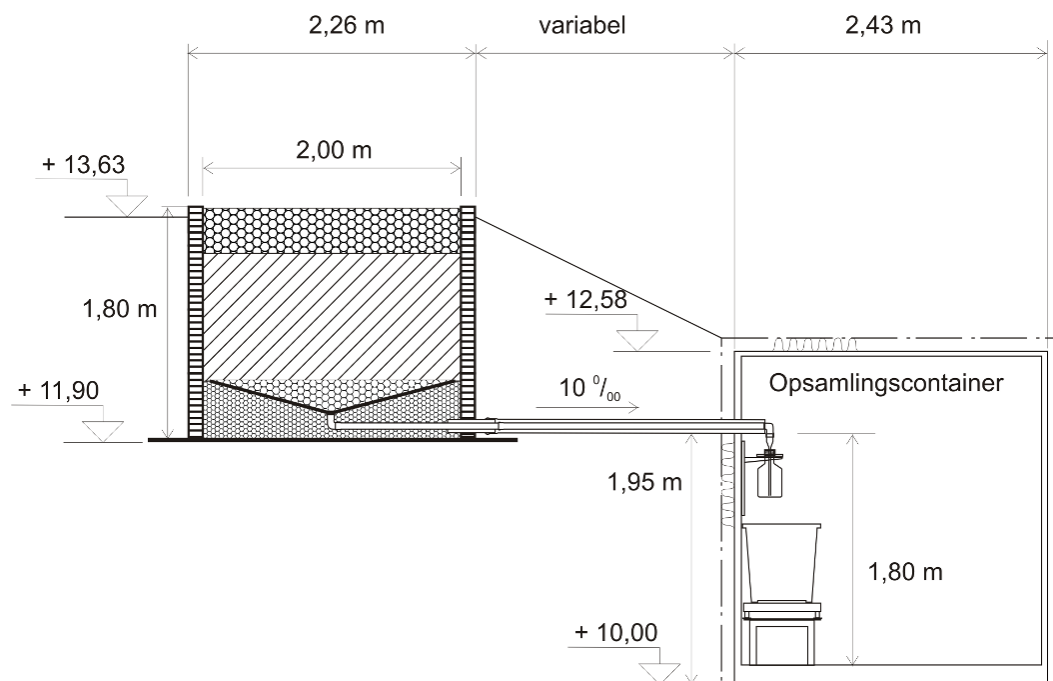


Figure 2.9 Cross-section of lysimeter and leachate collection container. The levels shown are relative. Level +13.63 is ground level.

As mentioned above, the leachates from the middle and wall sections of a lysimeter are led to separate leachate collection tanks. The tanks collecting leachate from the middle sections are placed on scales that register the mass of leachate produced electronically when a tank is emptied. The volumes of the leachate collected from the wall sections are registered manually when those tanks are emptied. The setup inside the shipping container is shown in figure 2.10. On its way to the leachate collection tank, the leachate from the middle section passes through a cleaned 5 l glass bottle which can be removed at intervals with its content of water and sent to DHI where subsamples are taken and shipped to laboratories for analysis for inorganic substances (Analytica, Sweden), or-

ganic analysis (Eurofins, DK) and DOC (ECN, The Netherlands). The full bottle is replaced by a cleaned, empty bottle filled with argon to prevent or delay in particular re-dox reactions between the leachate and the atmosphere. The leachate sampling setup is shown in figure 2.11.



2.10 View of the leachate collection and sampling systems in the shipping container.

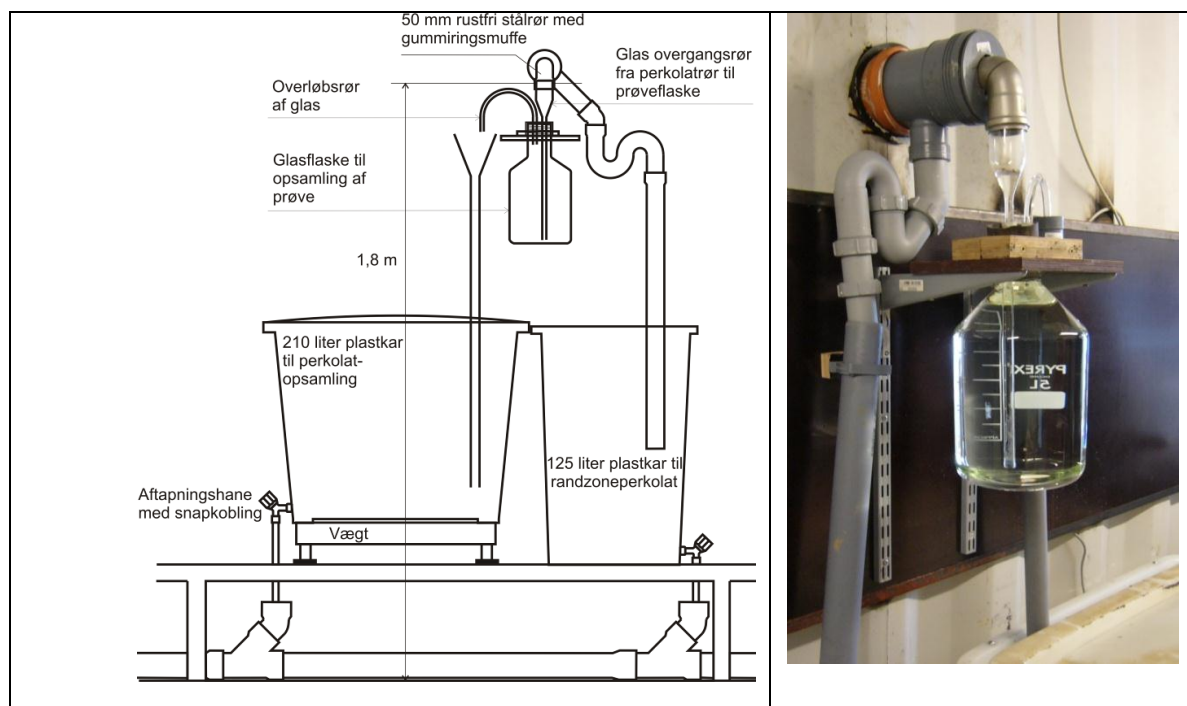


Figure 2.11 The leachate collection and sampling system for a lysimeter.

The precipitation at the lysimeter test site is measured continuously and registered electronically by means of a “Rain-O-Matic” rain gauge which has been installed next to the lysimeters.

Further details on the design of the lysimeters may be obtained from Hjelmar et al. (2010).

2.4.2 The waste in the lysimeters

The waste was filled into the lysimeters on 7 June 2007 and left there under cover until 11 May 2009 when the covers were removed and the leaching tests started. Smaller amounts of water had, however, found its way into the lysimeters despite the covers. The delay time between the filling of the lysimeters and the start of the tests was due to difficulties with and delays of the installation of the leachate collection and registration systems, in particular the establishment of access to the electronically stored data. Figure 2.12 shows some pictures of the filling of the lysimeters, and tables 2.3 and 2.4 provide some information on the individual lysimeters and their content of waste.



Figure 2.12 Pictures of the filling of the lysimeters on 7 June 2007.

Table 2.3 Information on the lysimeters and the waste materials in them.

Lysimeter	Type of waste	Amount of waste (wet)	Waste placed in lysimeters	Start of test	Funnel material
1	Shredder waste	2840 kg	07-06-2007	11-05-2009	HDPE
2	Shredder waste	2780 kg	07-06-2007	11-05-2009	Stainless steel
3	Mixed waste	1600 kg	07-06-2007	11-05-2009	HDPE
4	Mixed waste	1880 kg	07-06-2007	11-05-2009	Stainless steel



Table 2.4 Data on the waste in the lysimeters.

Lysimeter	Type of waste	Depth empty (m)	Depth full (m)	Volume (m ³)	Bulk density in lysimeter (tonnes/m ³)	Comment
1	Shredder	1,40	0,36	3,267	0,869	Dry and dusty
2	Shredder	1,47	0,43	3,267	0,851	Coarser than in lysimeter 1
3	Mixed	1,46	0,46	3,142	0,509	-
4	Mixed	1,50	0,45	3,299	0,570	-

2.4.3 Overview of leachate samples

Tables 2.5 shows an overview of the amounts of leachate collected from the middle sections and wall sections, respectively, of the lysimeters as well as the average L/S values obtained in total for each lysimeter by February and April, 2011. The tables 2.6, 2.7, 2.8 and 2.9 further provide an overview of the leachate samples collected from each of the four lysimeters.

Further information on the amounts of leachate produced by each lysimeter is given in Appendix C.

Table 2.5 Overview of the amounts of leachate produced by the four lysimeters.

Lysimeter	Material	Weight of material		Date	Accumulated volume of leachate produced (litres)			L/S l/kg
		Wet (kg)	Dry (kg)		Middle	Wall section	Total	
1	Shredderaffald	2840	2357	24-02-2011	1777,8	120	1897,8	0,805
2	Shredderaffald	2780	2307	07-03-2011	1883,8	475	2358,8	1,022
3	Blandet affald	1600	1392	12-04-2011	1289,6	1140,5	2430,1	1,746
4	Blandet affald	1880	1636	12-04-2011	2349,0	510,0	2859,0	1,748

Table 2.6 Overview of leachate samples collected from lysimeter 1 (shredder waste).

Lysimeter	Material	Leachate sample		Date collected
		KMC-ID	DHI-ID	
1	Shredder waste (R-94-06)	1.1	E-055-09	23-06-2009
1	Shredder waste (R-94-06)	1.2	E-092-09	15-09-2009
1	Shredder waste (R-94-06)	1.3	E-030-10	19-03-2010
1	Shredder waste (R-94-06)	1.4	E-042-10	19-05-2010
1	Shredder waste (R-94-06)	1.5	E-082-10	19-09-2010
1	Shredder waste (R-94-06)	1.6	E-092-10	08-09-2010
1	Shredder waste (R-94-06)	1.7	E-100-10	15-10-2020
1	Shredder waste (R-94-06)	1.8	E-130-10	25-11-2010
1	Shredder waste (R-94-06)	1.9	E-139-10	08-12-2010
1	Shredder waste (R-94-06)	1.10	-	29-12-2010
1	Shredder waste (R-94-06)	1.11A	E-035-11	26-01-2010
1	Shredder waste (R-94-06)	1.12	E-045-11	24-02-2010



Table 2.7 Overview of leachate samples collected from lysimeter 2 (shredder waste).

Lysimeter	Material	Leachate sample		Date collected
		KMC-ID	DHI-ID	
2	Shredder waste (R-94-06)	2.1	E-056-09	22-06-2009
2	Shredder waste (R-94-06)	2.2a	E-084-09	21-08-2009
2	Shredder waste (R-94-06)	2.2b	E-101-09	03-11-2009
2	Shredder waste (R-94-06)	2.3	E-036-10	06-04-2010
2	Shredder waste (R-94-06)	2.4	E-049-10	09-06-2010
2	Shredder waste (R-94-06)	2.5	E-051-10	22-06-2010
2	Shredder waste (R-94-06)	2.6	E-057-10	11-08-2010
2	Shredder waste (R-94-06)	2.7	E-084-10	20-08-2010
2	Shredder waste (R-94-06)	2.8	E-093-10	08-09-2020
2	Shredder waste (R-94-06)	2.9	E-103-10	28-10-2020
2	Shredder waste (R-94-06)	2.10	E-129-10	09-11-2010
2	Shredder waste (R-94-06)	2.11	E-134-10	01-12-2010
2	Shredder waste (R-94-06)	2.12	E-024-11	29-11-2010
2	Shredder waste (R-94-06)	2.13	-	14-01-2010
2	Shredder waste (R-94-06)	2.14	E-043-10	07-03-2010

Table 2.8 Overview of leachate samples collected from lysimeter 3 (mixed waste).

Lysimeter	Material	Leachate sample		Date collected
		KMC-ID	DHI-ID	
3	Mixed waste (R-096-06)	3.1	E-048-09	04-06-2009
3	Mixed waste (R-096-06)	3.2	E-058-09	23-06-2009
3	Mixed waste (R-096-06)	3.3	E-093-09	15-09-2009
3	Mixed waste (R-096-06)	3.4	E-102-09	03-11-2009
3	Mixed waste (R-096-06)	3.5	E-108-09	16-11-2009
3	Mixed waste (R-096-06)	3.6	E-111-09	11-12-2009
3	Mixed waste (R-096-06)	3.7	E-026-10	09-03-2010
3	Mixed waste (R-096-06)	3.8	E-031-10	24-03-2010
3	Mixed waste (R-096-06)	3.9	E-094-10	08-09-2010
3	Mixed waste (R-096-06)	3.10	E-101-10	15-10-2010
3	Mixed waste (R-096-06)	3.11	E-104-10	28-10-2010
3	Mixed waste (R-096-06)	3.12	E-140-10	14-12-2010
3	Mixed waste (R-096-06)	3.13	E-025-11	14-01-2011
3	Mixed waste (R-096-06)	3.14	E-044-11	07-03-2011
3	Mixed waste (R-096-06)	3.15	E-047-11	12-04-2011

Table 2.9 Overview of leachate samples collected from lysimeter 3 (mixed waste).

Lysimeter	Material	Leachate sample		Date collected
		KMC-ID	DHI-ID	
4	Mixed waste (R-096-06)	4.1	E-049-09	04-06-2009
4	Mixed waste (R-096-06)	4.2	E-060-09	23-06-2009
4	Mixed waste (R-096-06)	4.3	E-037-09	29-03-2010
4	Mixed waste (R-096-06)	4.4	E039-10	22-04-2010
4	Mixed waste (R-096-06)	4.5	E-043-10	19-05-2010
4	Mixed waste (R-096-06)	4.6	E-052-10	22-06-2010
4	Mixed waste (R-096-06)	4.7	E-056-10	16-07-2010
4	Mixed waste (R-096-06)	4.8	E-058-10	11-08-2010
4	Mixed waste (R-096-06)	4.9	E-095-10	08-09-2010
4	Mixed waste (R-096-06)	4.10	E-131-10	25-11-2010
4	Mixed waste (R-096-06)	4.11	E-141-10	14-12-2010
4	Mixed waste (R-096-06)	4.12	E-026-11	14-01-2011
4	Mixed waste (R-096-06)	4.13	E-042-11	24-02-2010
4	Mixed waste (R-096-06)	4.14	E-048-11	12-04-2010



2.4.4 Leachate volumes and water balances

In figure 2.13 the total leachate production from each of the four lysimeters has been expressed in mm and compared to the precipitation registered by the rain gauge. Figures 2.14, 2.15, 2.16 and 2.17 compares the amounts of leachate collected from the middle section and the wall section of each of the four lysimeters.

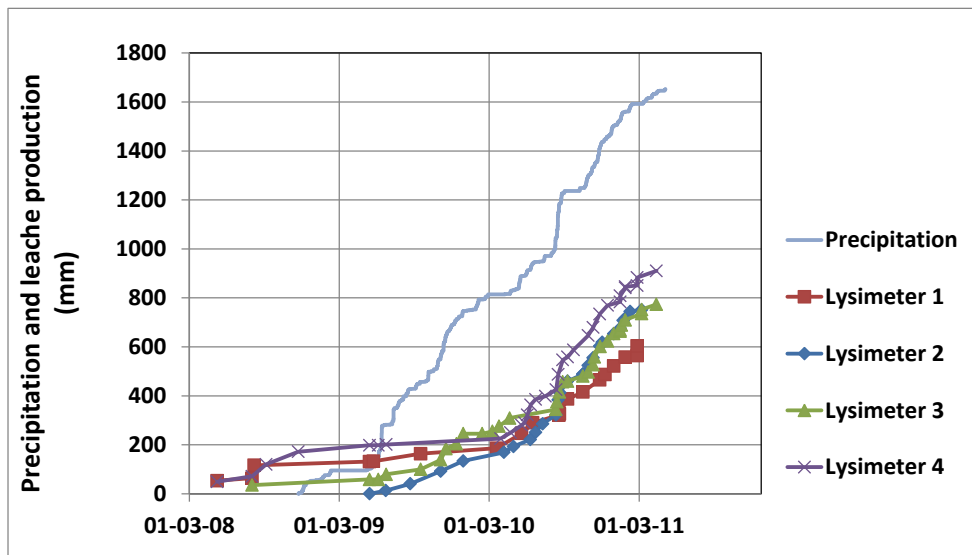


Figure 2.13 Accumulated total leachate production from lysimeters compared to the precipitation.

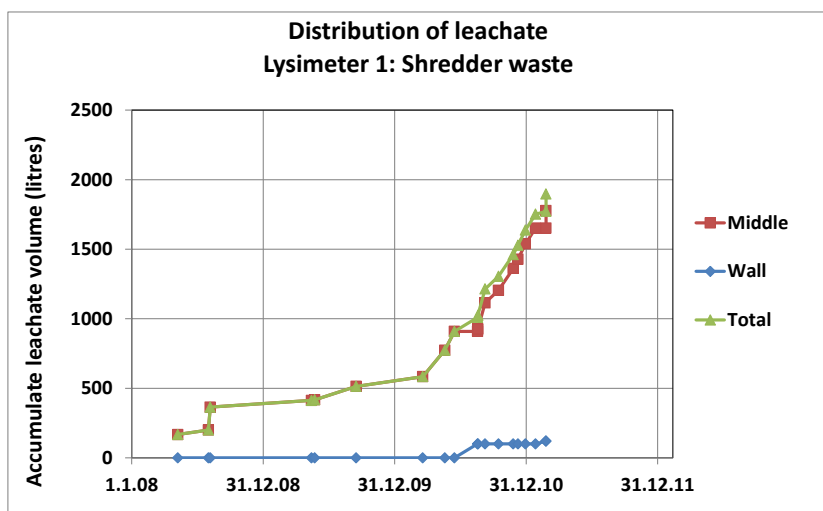


Figure 2.14 Distribution of collected leachate between middle and wall section for lysimeter 1.

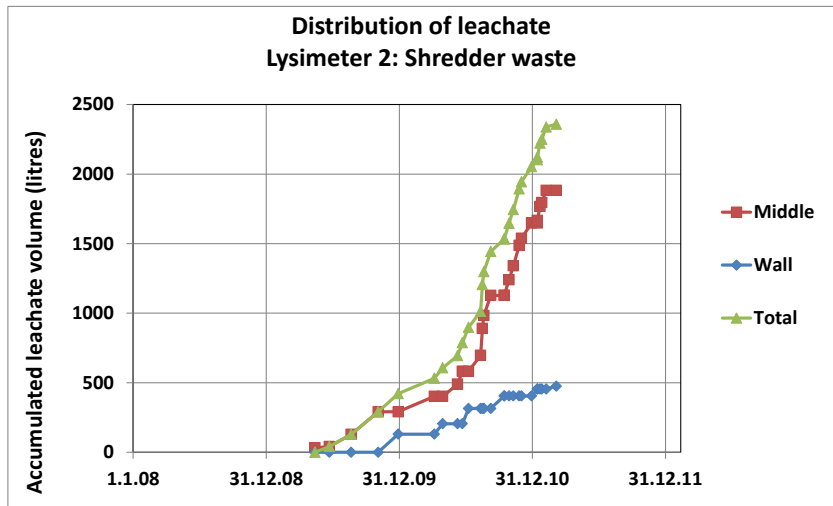


Figure 2.15 Distribution of collected leachate between middle and wall section for lysimeter 2.

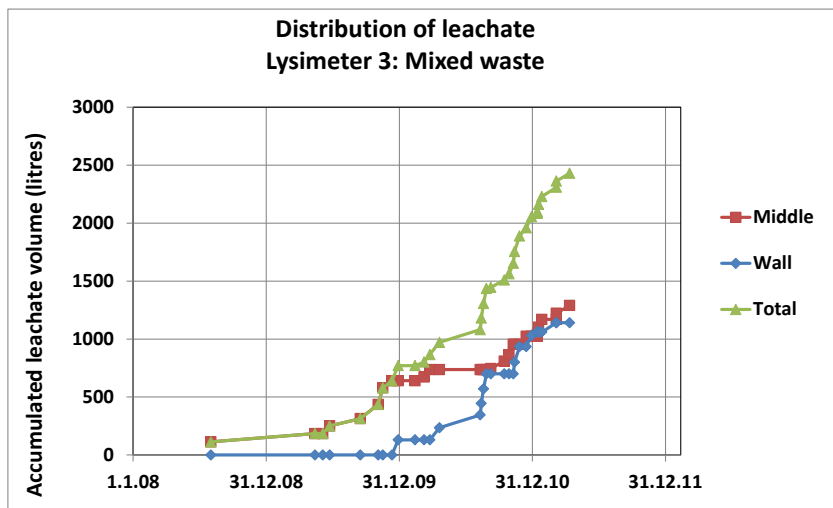


Figure 2.16 Distribution of collected leachate between middle and wall section for lysimeter 3.

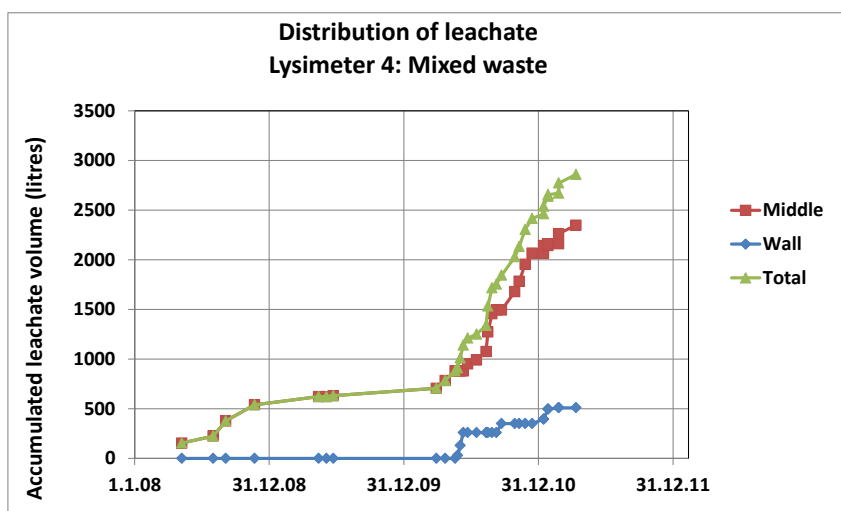


Figure 2.17 Distribution of collected leachate between middle and wall section for lysimeter 3.



Table 2.10 shows the total leachate production from each of the lysimeters over a period of almost 2 years as percentages of the precipitation. It is noticed that almost 50 % of the precipitation is infiltrating into the lysimeters, except for lysimeter 1. This lysimeter differs from the others by producing the highest percentage of the leachate (92 to 94 %, see figure 2.14 and table 2.11) from the middle section. This may provide a higher capacity for (temporary) absorption of water.

Table 2.11 shows the distribution between the middle and wall sections of the accumulated amount of leachate collected from each lysimeter in the summer of 2010 and the spring of 2011. It also shows the distribution as it would be if the flow was even across the lysimeters (90 %/10 %). It can be seen that the flow is particularly uneven in lysimeter 3 with mixed waste where almost equal amounts of leachate are produced from the middle section and the wall section even though the former has a surface area that is 9 times larger than the latter. The reason for this must be the extreme heterogeneity of mixed waste and the large content of plastic bags and plastic sheets.

Table 2.10 The leachate production from the lysimeters as percentages of the precipitation.

Lysimeter	Material	Period	Percentage of precipitation infiltrated
1	Shredder waste	14-05-2009 – 24-02-2011	31,7
2	Shredder waste	14-05-2009 – 07-03-2011	49,7
3	Mixed waste	14-05-2009 – 12-04-2011	46,6
4	Mixed waste	14-05-2009 – 12-04-2011	46,4

Table 2.11 Distribution of leachate production between the middle and wall sections.

Lysimeter	Material	Leachate from middle section (%)		Leachate from wall section (%)	
		Summer 2010	Spring 2011	Summer 2010	Spring 2011
1	Shredder waste	92	94	8	6
2	Shredder waste	78	80	22	20
3	Mixed waste	52	52	48	48
4	Mixed waste	81	82	19	18
Evenly distributed flow		90	90	10	10

2.4.5 Lysimeter leaching results for shredder waste

Appendix D shows the results of the chemical analysis of the leachate samples collected from lysimeters 1 and 2 containing shredder waste.

In figures 2.18a – 2.18d the leaching of a number of inorganic substances and DOC from the shredder waste are shown as a function of L/S. For comparison, the results of the column leaching test performed in the laboratory are also shown.



Figures 2.19a – 2.19d show the leaching of the same substances in terms of accumulated leached amounts as a function of L/S both for lysimeters and the column test. The accumulated leached amounts are estimated on the basis of the amounts of leachate collected prior to the collection of each sampling and the concentration of substances in that sample. Since the concentration level of several substances decreases with increasing L/S, this method is likely to underestimate the release of these substances (and overestimate the release of substances for which the concentration may increase with increasing L/S). This could possibly be evaluated at a later time by carrying out a calculation which uses the concentration of a substance in a preceding sample to estimate concentration in a given L/S interval.

The results in Appendix D show that almost no measurable amounts of specific organic substances and groups (BTEX, hydrocarbons and PAH) can be detected in the leachate samples collected and analysed. Small amounts of hydrocarbons (C10-C25) have, however, been observed at concentration levels of 9 – 13 µg/l in all samples from lysimeter 2 and small amounts of anthracene (0.014 – 0.015 µg/l) and acenaphthylene (0.015 µg/l) in a few samples from lysimeter 2. In a few samples of the leachate from lysimeter 1, hydrocarbons (6 µg/l of C6-C10, 55 µg/l of C10-C25, 19 µg/l of C15-C20, and 36 µg/l of C20-C25) have been measured as well as PAHs (0.010 µg/l of naphthalene, 0.041 µg/l of fluorene, and 0.020 to 0.027 µg/l of anthracene). Because of these low levels of organic substances it was decided in the fall of 2010 not to go on analysing for specific organic substances on a regular basis. Once a year, a single sample from each lysimeter may be analysed for these substances.

From figures 4.18a to 4.18d it can be seen that – with a few exemptions including Co, Cu, Ni and Zn – in general there is good agreement between the results from the two lysimeters with shredder waste which, except for the funnel at the bottom, in principle are similar and contain the same waste (the funnel in lysimeter 1 is made of HDPE while the funnel in lysimeter 2 is made of stainless steel). There is, however, less agreement between the results from the lysimeters and the results of the column leaching tests carried out on the same material. From field experiments it is known that the flow pattern of the percolating rainwater through the very heterogeneous shredder waste can be very unevenly distributed. From section 2.5.4 this is also seen to be the case here, the flow distribution between the middle and wall sections differ substantially between the two lysimeters and this may contribute to the observed differences from the column tests where the flow is assumed to be more even due to the application of up-flow.

In an assessment of the results of the first year of operation of the lysimeters it was shown that a better agreement between lysimeter and column test results (particularly for the salts) could be obtained if the L/S in the lysimeter tests was calculated on the basis of the assumption that only 40% of the waste in the lysimeters actually is in contact with the percolating water. However, later results as shown here seem to indicate that this situation has changed somewhat and a larger fraction of the waste actually participates in the leaching process.

In general, higher amounts of leached substances are observed from the column leaching test than from the lysimeters. It may possibly be explained by the heterogeneity of the shredder waste, occurrence of biological processes in the waste in the lysimeters, small differences in pH. A difference in redox potential could also be expected, but has not been observed (e.g. by release of ferrous iron).

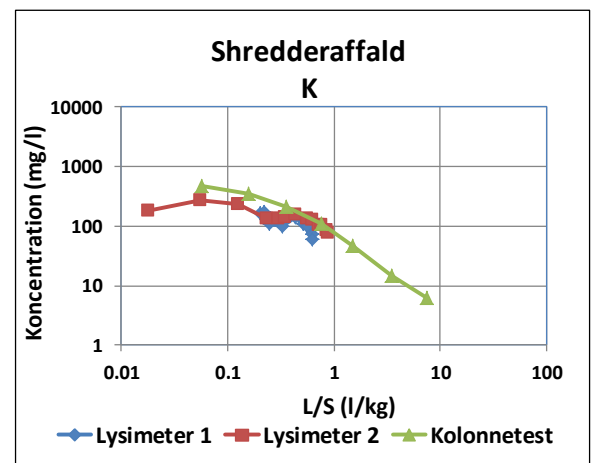
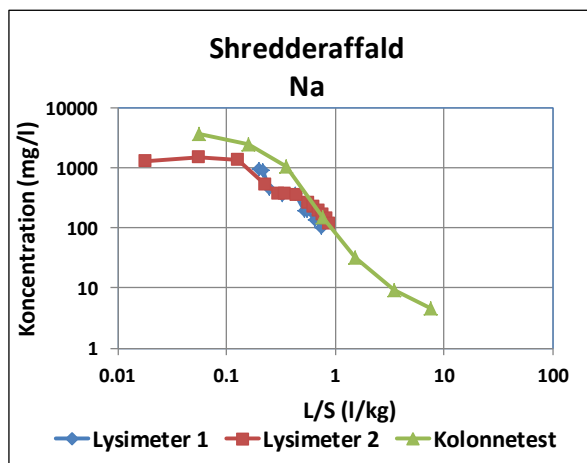
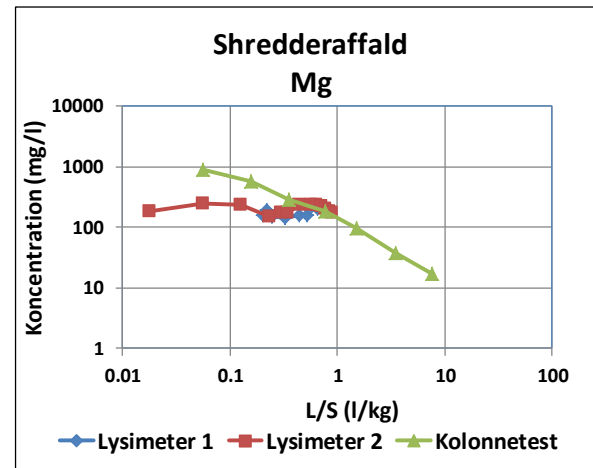
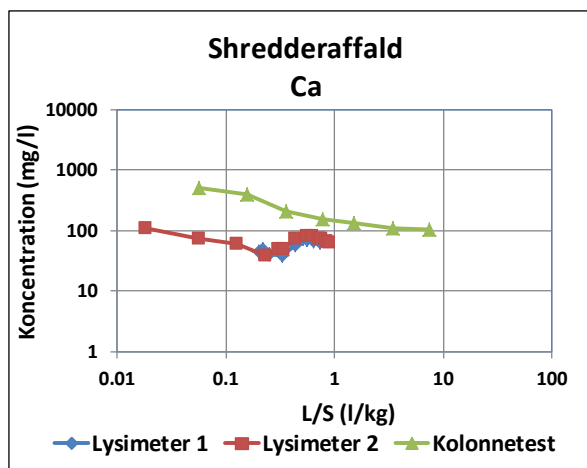
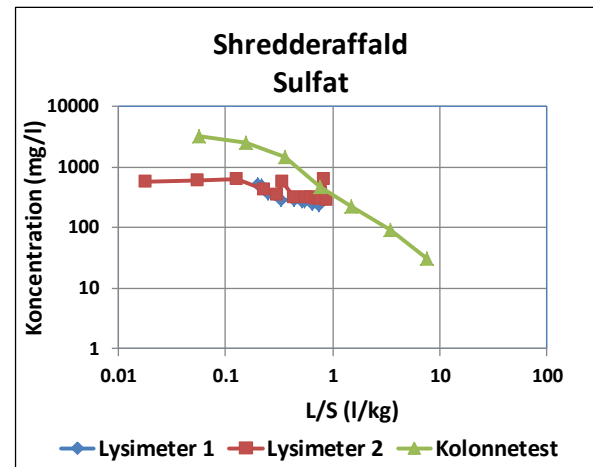
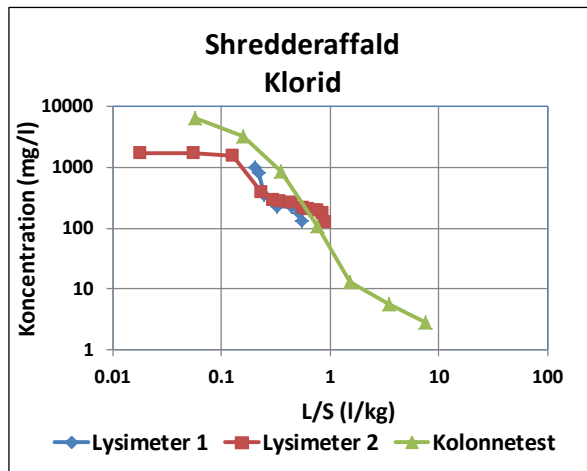


Figure 2.18a Leaching from lysimeters 1 and 2 and from column test (concentrations as a function of L/S).

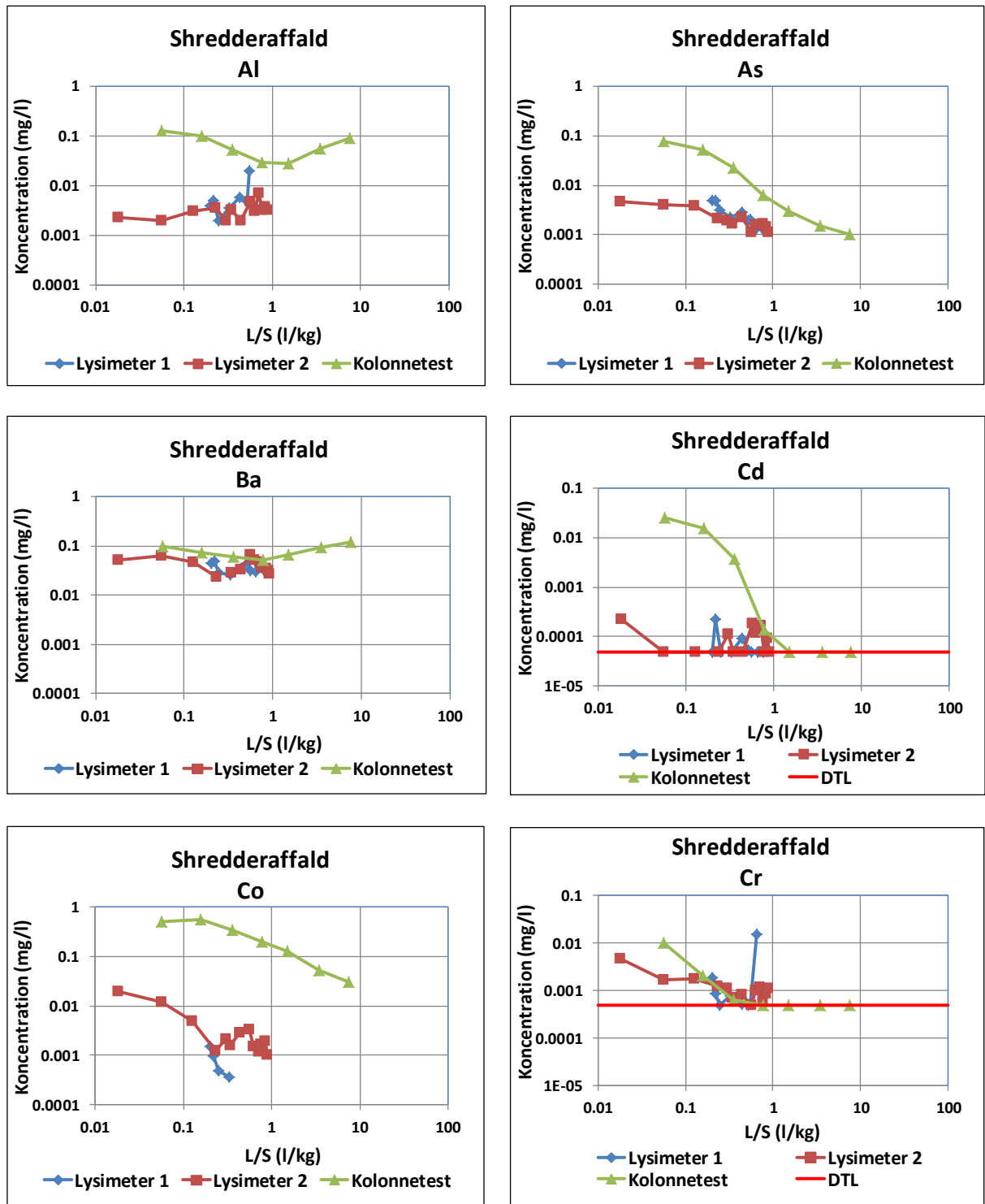


Figure 2.18b Leaching from lysimeters 1 and 2 and from column test (concentrations as a function of L/S).

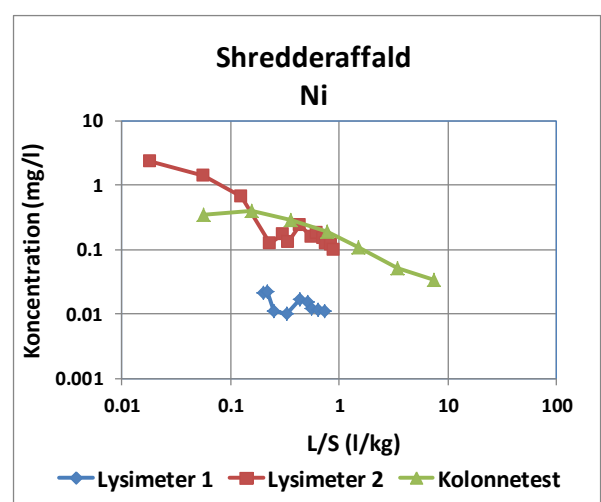
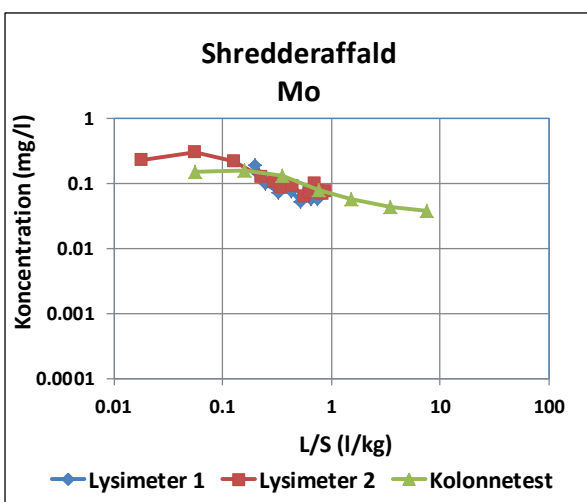
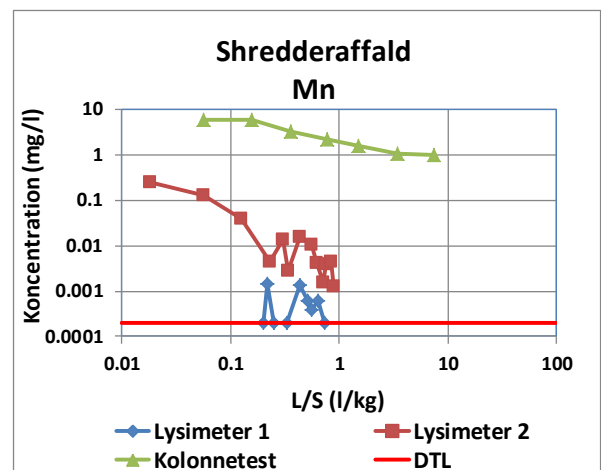
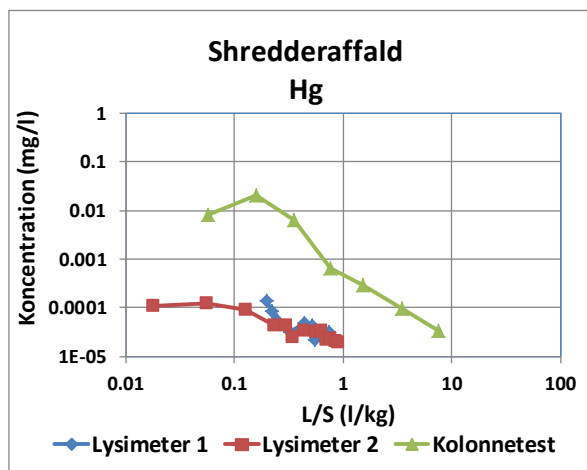
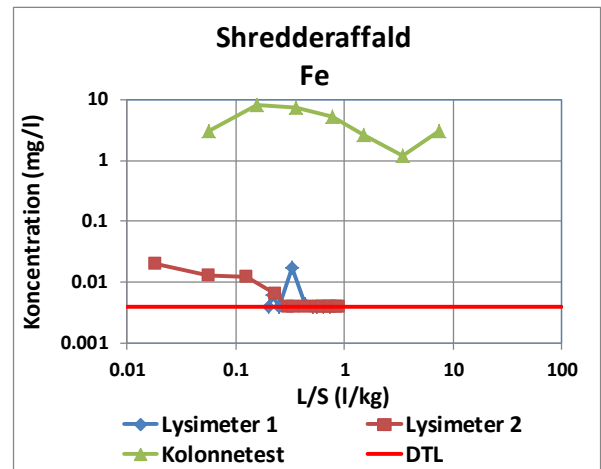
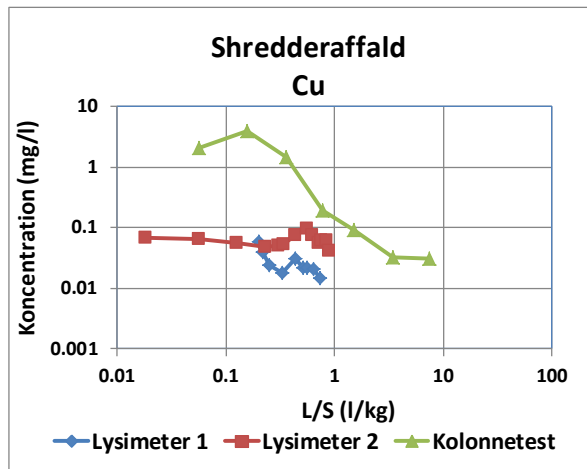


Figure 2.18c Leaching from lysimeters 1 and 2 and from column test (concentrations as a function of L/S).

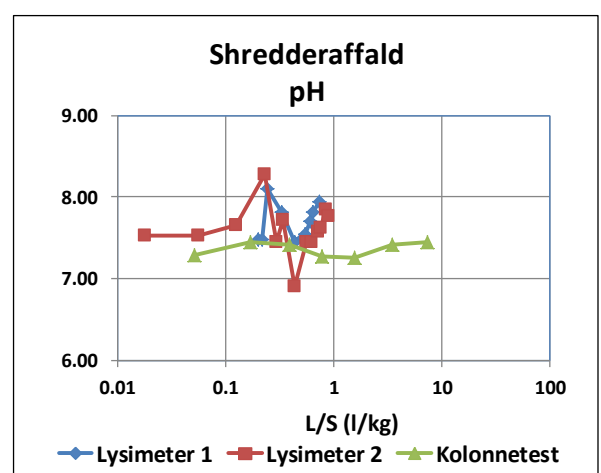
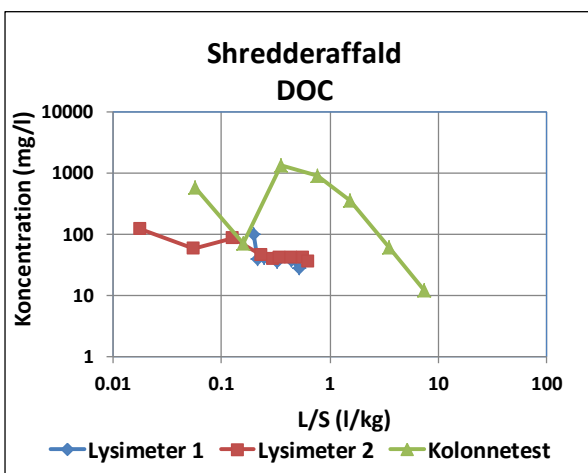
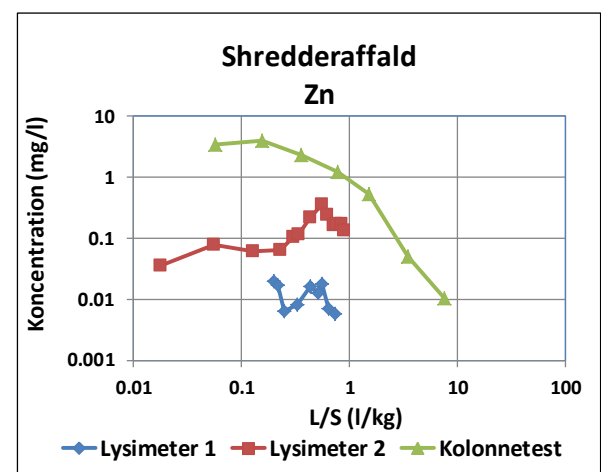
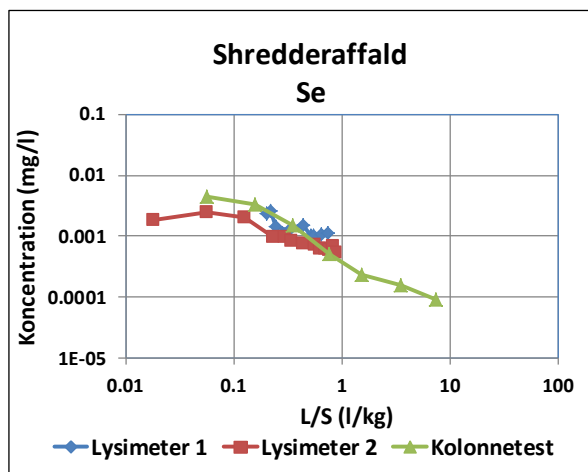
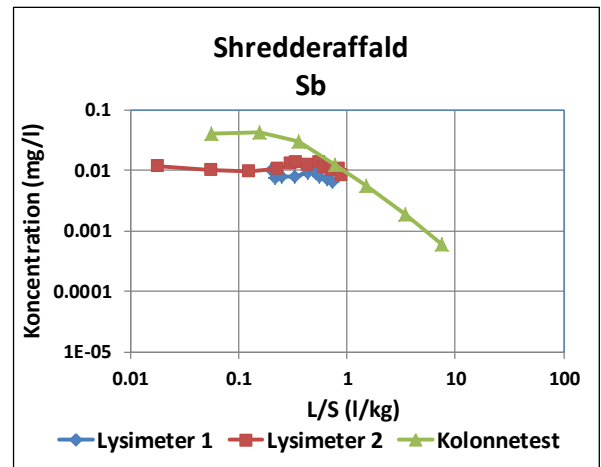
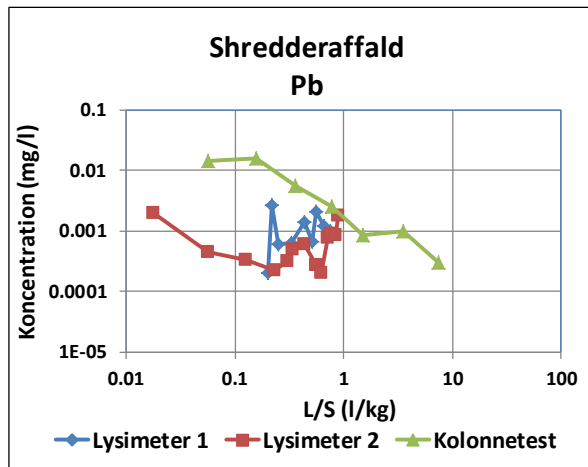


Figure 2.18d Leaching from lysimeters 1 and 2 and from column test (concentrations as a function of L/S).

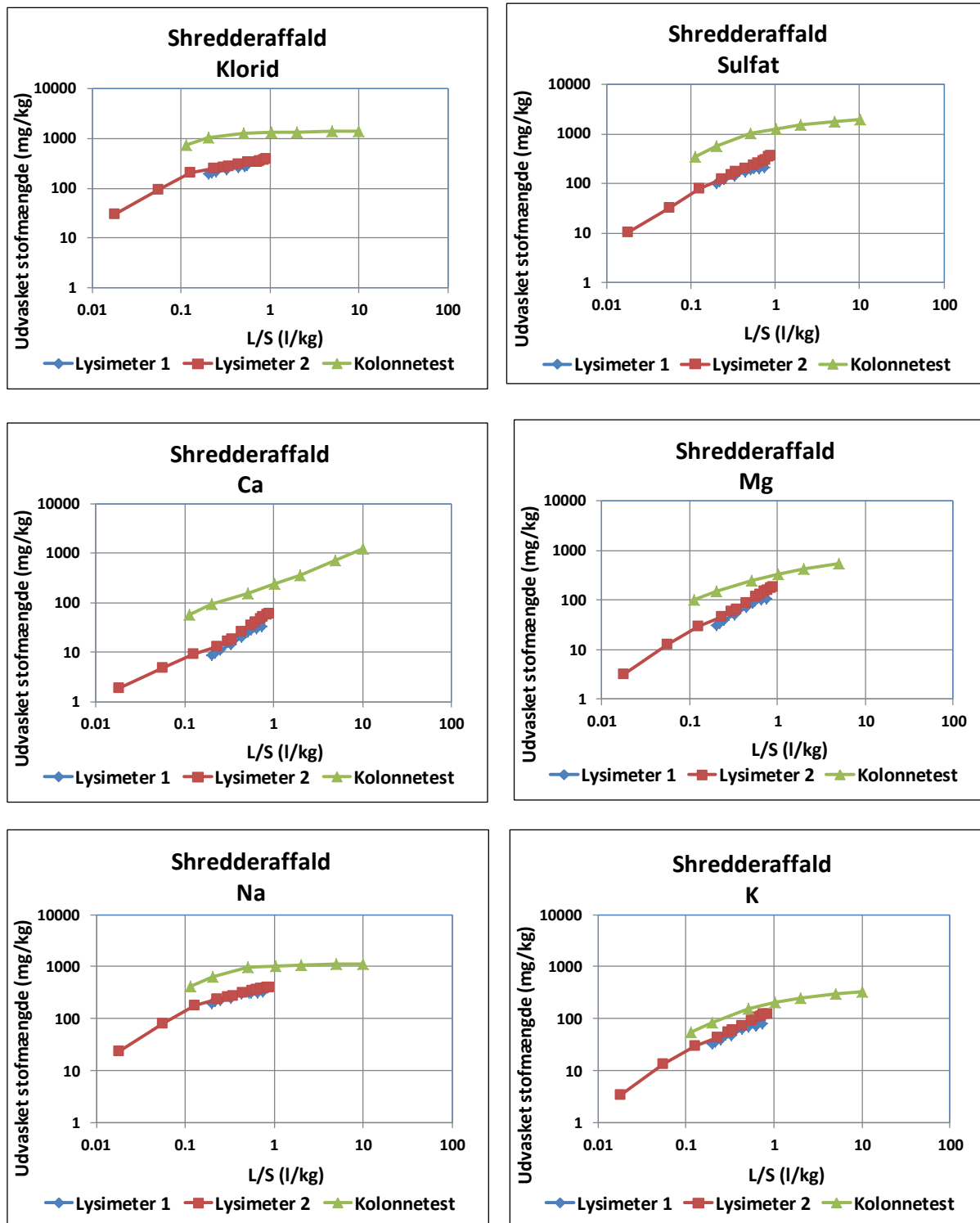


Figure 2.19a Leaching from lysimeters 1 and 2 and from column test (release as a function of L/S).

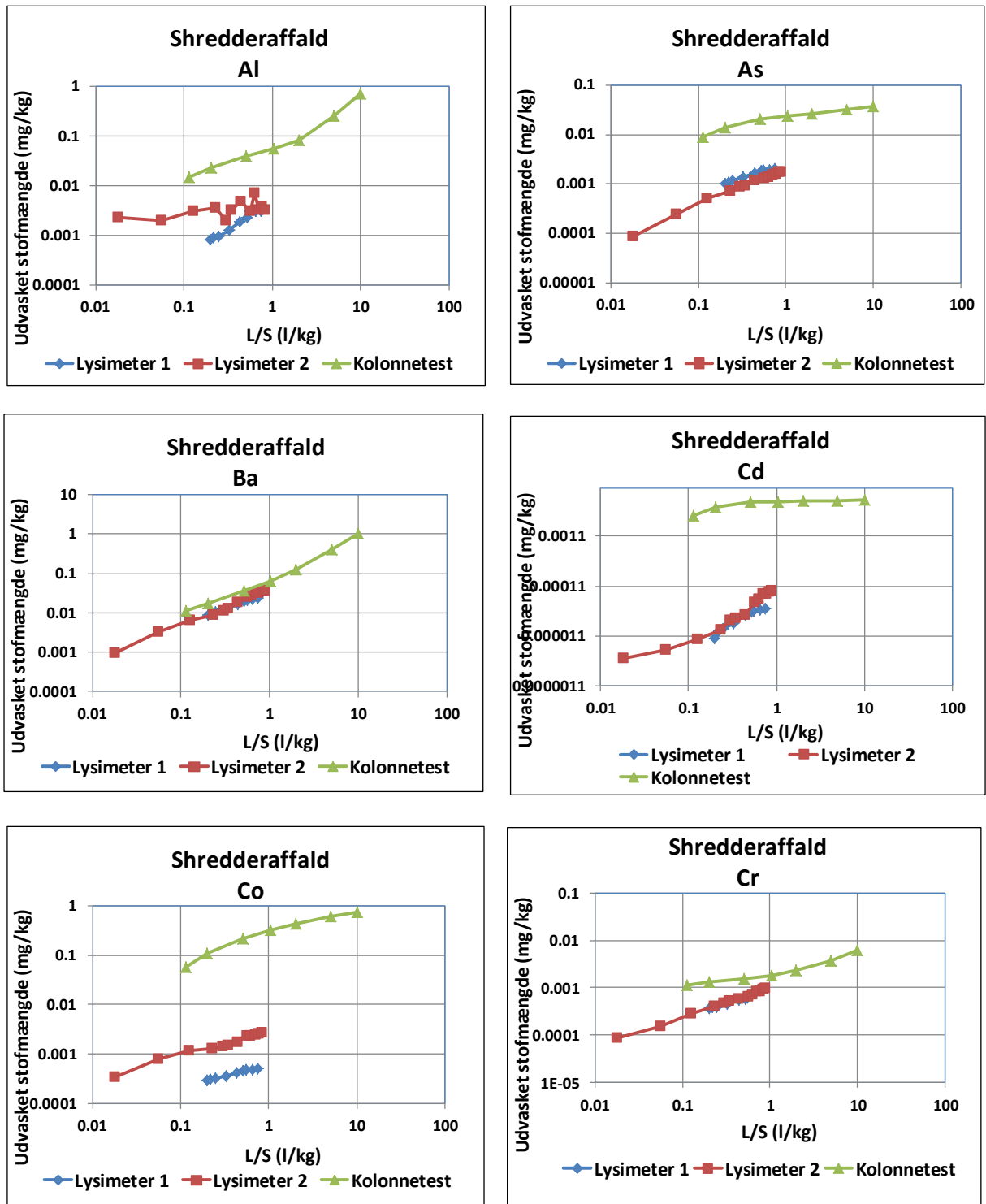


Figure 2.19b Leaching from lysimeters 1 and 2 and from column test (release as a function of L/S).

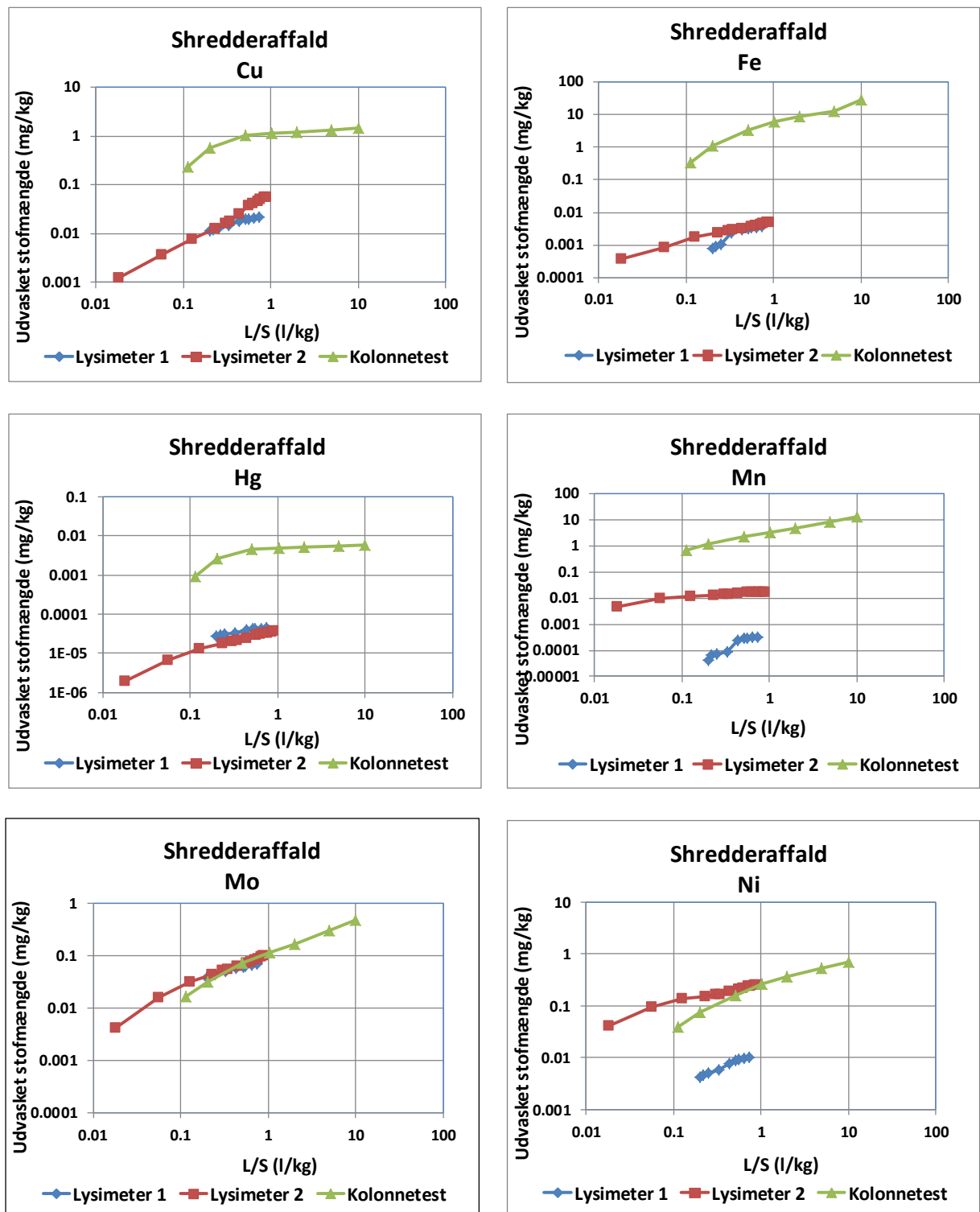


Figure 2.19c Leaching from lysimeters 1 and 2 and from column test (release as a function of L/S).

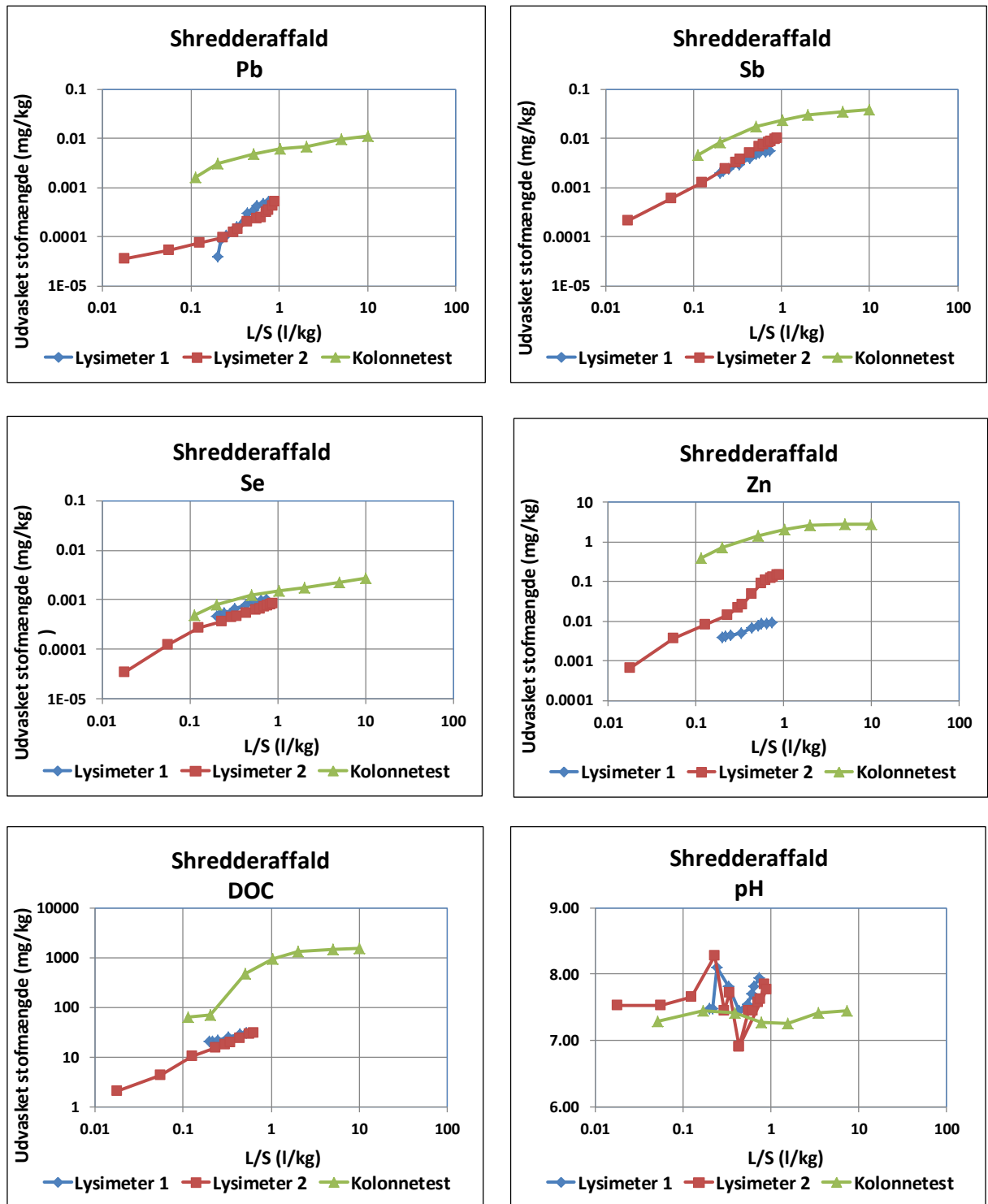


Figure 2.19d Leaching from lysimeters 1 and 2 and from column test (release as a function of L/S).



2.4.6 *Lysimeter leaching results for mixed waste*

Appendix D shows the results of the chemical analysis of the leachate samples collected from lysimeters 3 and 4 containing mixed waste.

In figure 2.20a – 2.20d the leaching of a number of inorganic substances and DOC from the shredder waste are shown as a function of L/S. For comparison, the results of the column test performed in the laboratory are also shown.

Figures 2.21a – 2.21d show the leaching of the same substances in terms of accumulated leached amounts as a function of L/S both for lysimeters and the column test. The accumulated leached amounts are estimated on the basis of the amounts of leachate collected prior to the collection of each sampling and the concentration of substances in that sample. Since the concentration level of several substances decreases with increasing L/S, this method is likely to underestimate the release of these substances (and overestimate the release of substances for which the concentration may increase with increasing L/S). This could possibly be evaluated at a later time by carrying out a calculation which uses the concentration of a substance in a preceding sample to estimate concentration in a given L/S interval.

The results in Appendix D show that almost no measurable amounts of specific organic substances and groups (BTEX, hydrocarbons and PAH) can be detected in the leachate samples collected and analysed. However, small amounts of anthracene (0.068 – 0.53 µg/l) have been measured in most samples, and naphthalene has been observed in a single sample (0.015 µg/l). Because of these low levels of organic substances it was decided in the fall of 2010 not to keep on analysing for specific organic substances on a regular basis. Once a year, a single sample from each lysimeter may be analysed for these substances.

From figures 4.20a to 4.20d it can be seen that in general there is good agreement between the results from the two lysimeters with mixed waste which, except for the funnel at the bottom, in principle are similar and contain the same waste material (the funnel in lysimeter 1 is made of HDPE while the funnel in lysimeter 2 is made of stainless steel). For the salts and some of the trace elements that are not overly sensitive to changes in pH or redox potential there is a very good agreement between the results of the lysimeter tests and the column leaching results. The horizontal concentration curve for Ca is a clear indication of solubility control, probably due to the presence of calcium sulphate (gypsum). For some of the trace elements that are sensitive to changes in pH and redox potential the agreement is not so good.

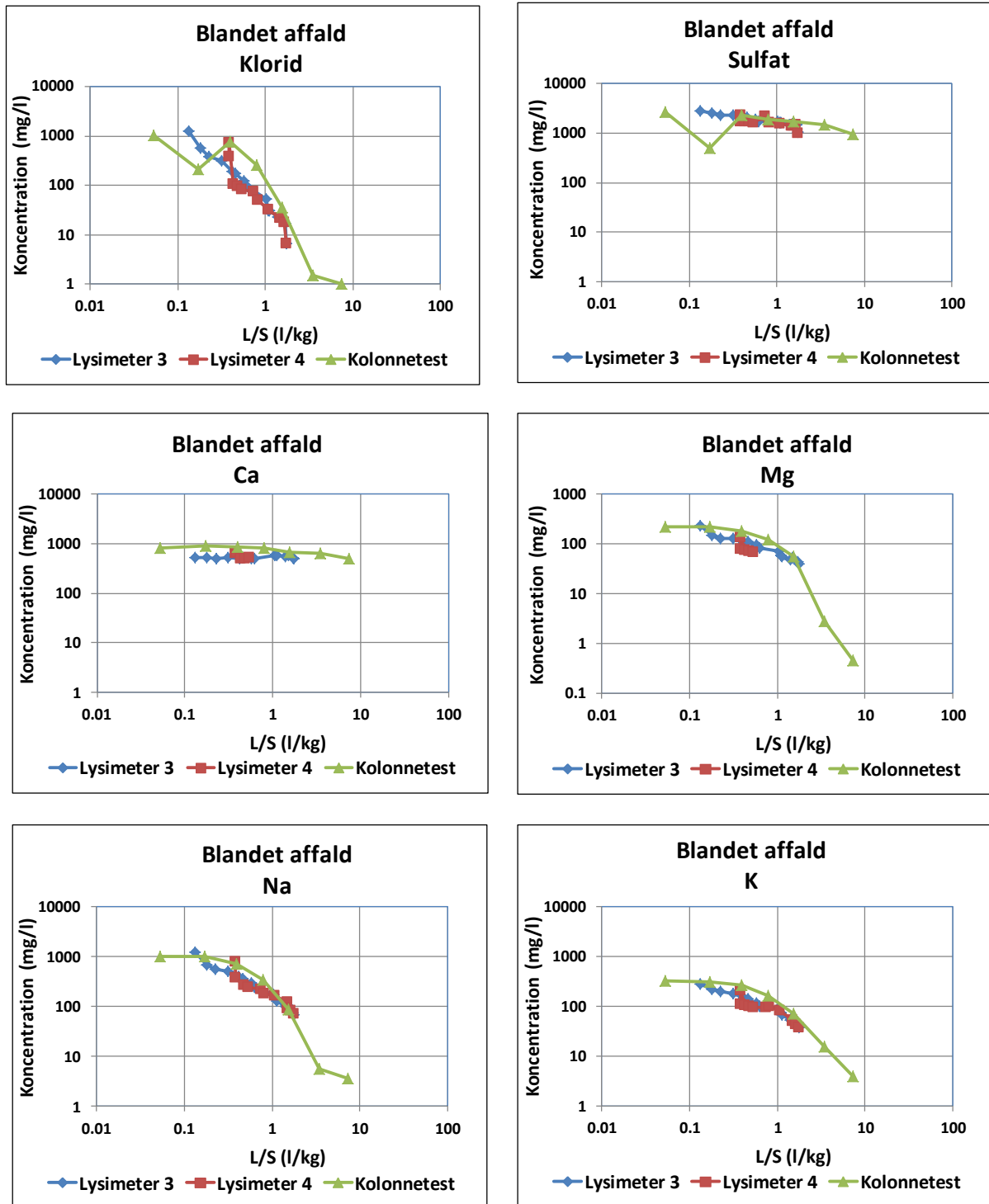


Figure 2.20a Leaching from lysimeters 1 and 2 and from column test (concentrations as a function of L/S).

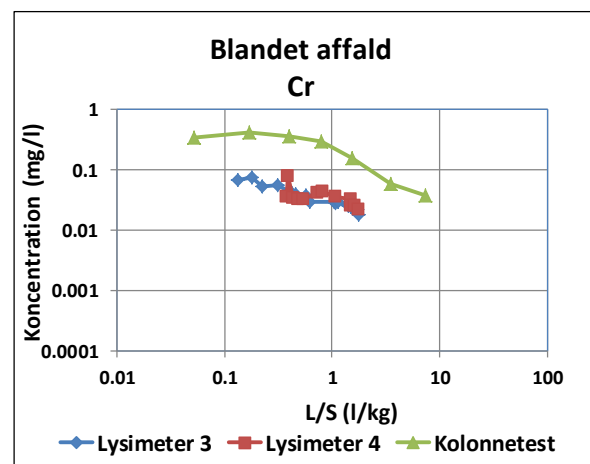
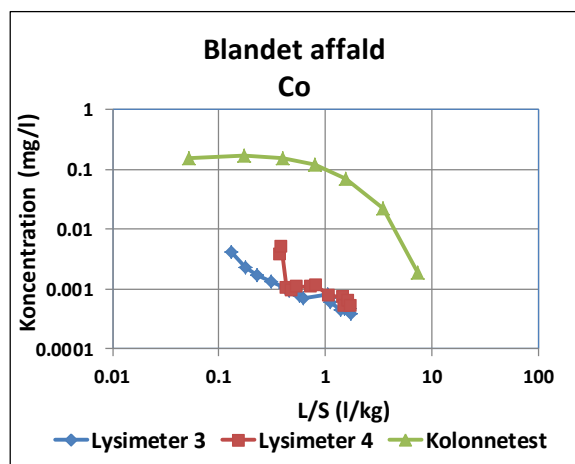
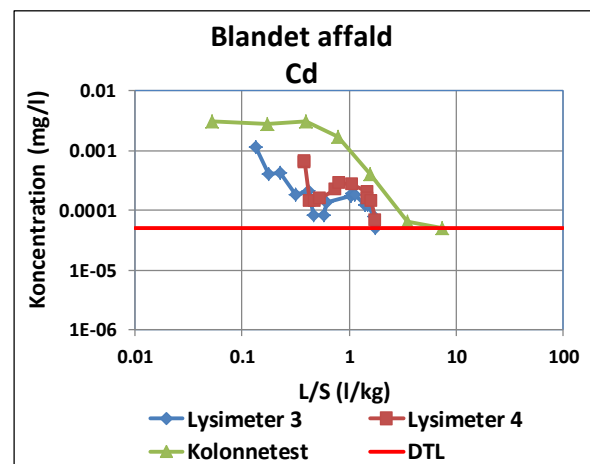
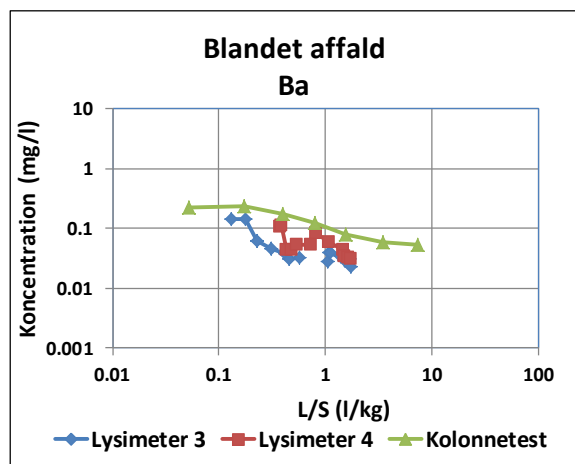
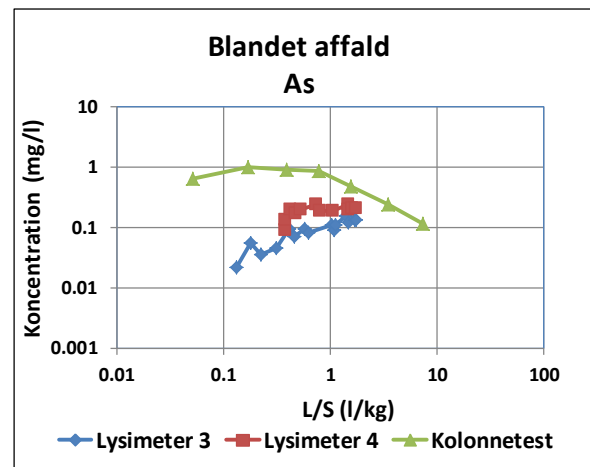
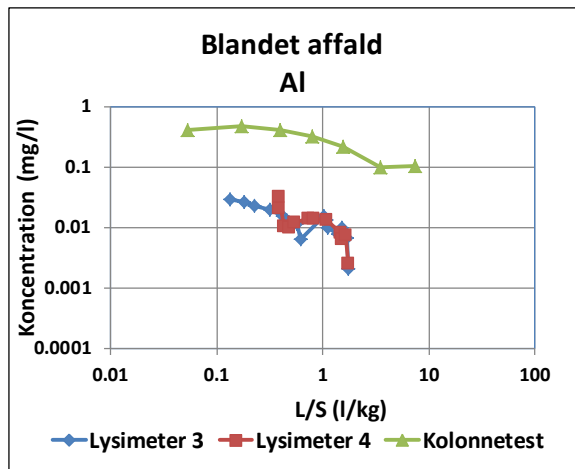


Figure 2.20b Leaching from lysimeters 1 and 2 and from column test (concentrations as a function of L/S).

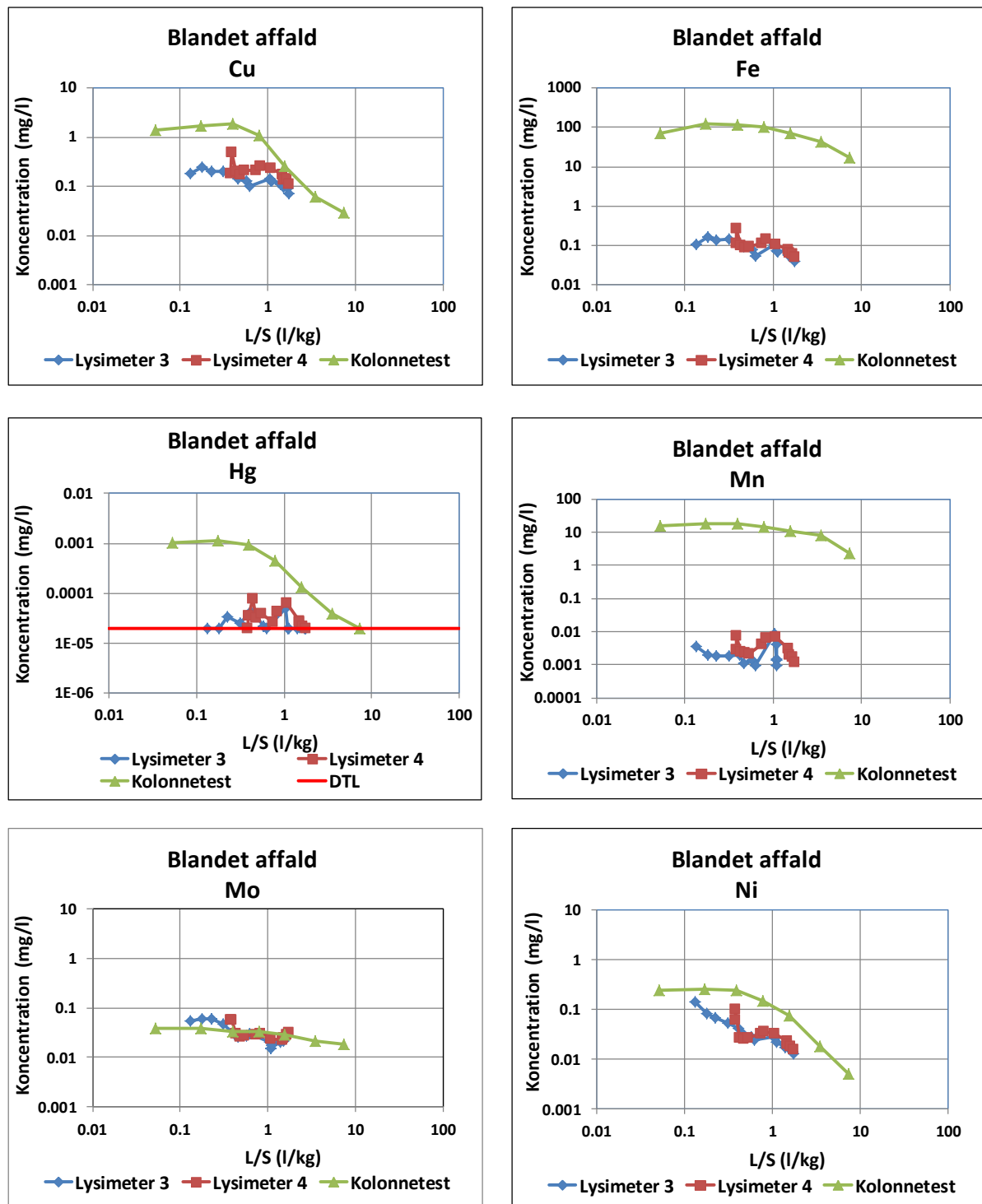


Figure 2.20c Leaching from lysimeters 1 and 2 and from column test (concentrations as a function of L/S).

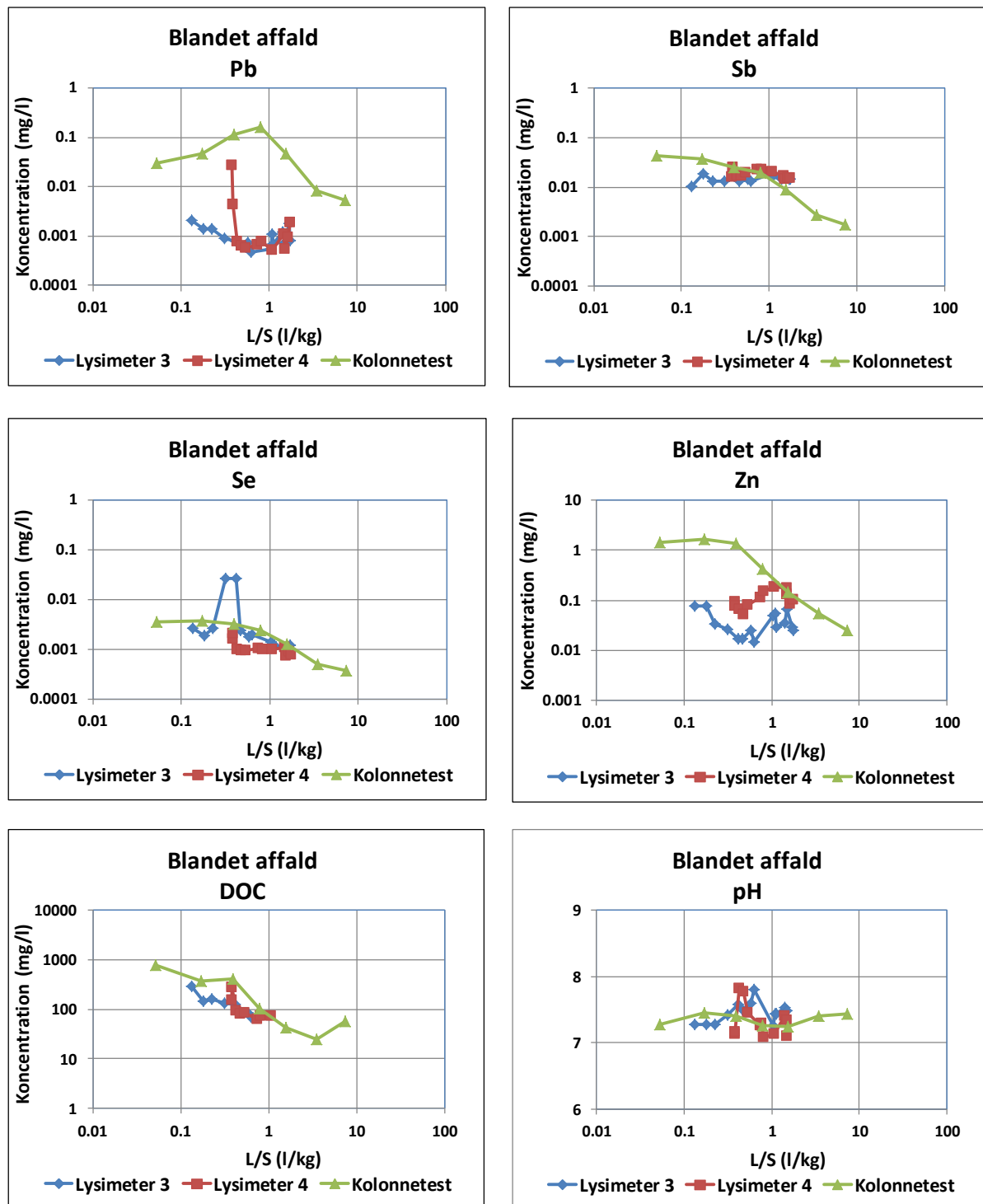


Figure 2.20d Leaching from lysimeters 1 and 2 and from column test (concentrations as a function of L/S).

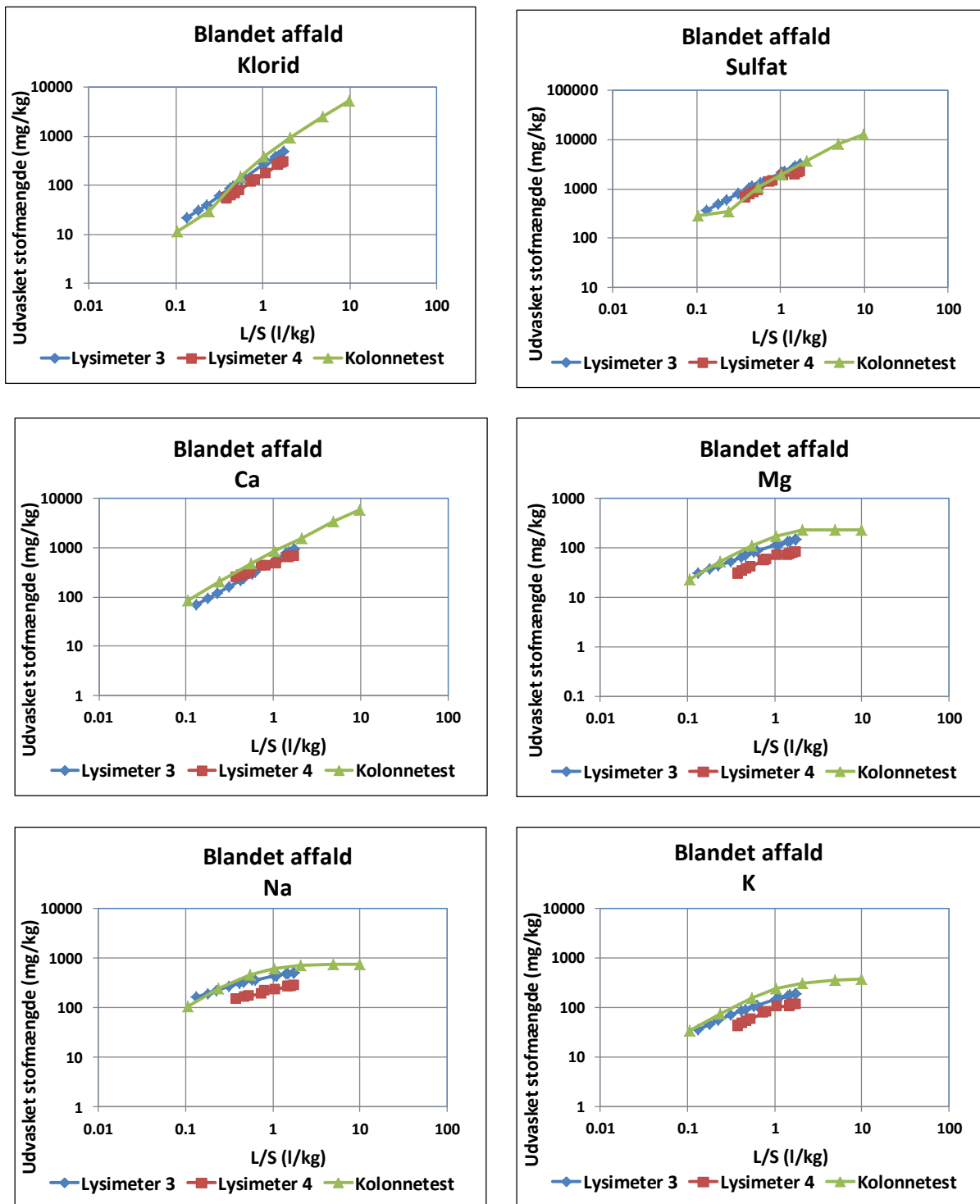


Figure 2.21a Leaching from lysimeters 1 and 2 and from column test (release as a function of L/S).

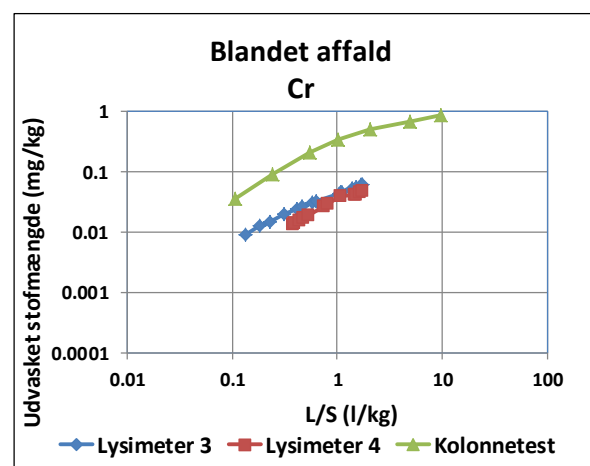
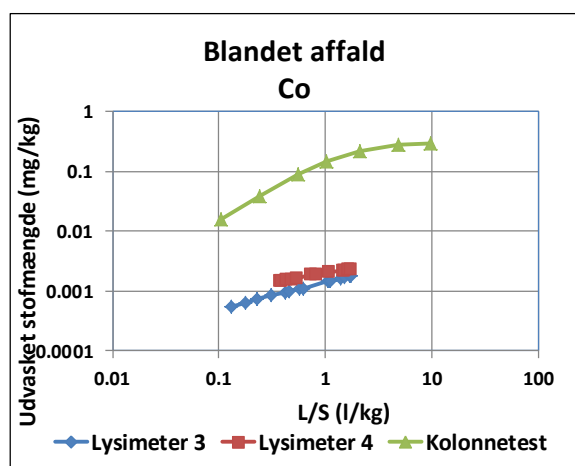
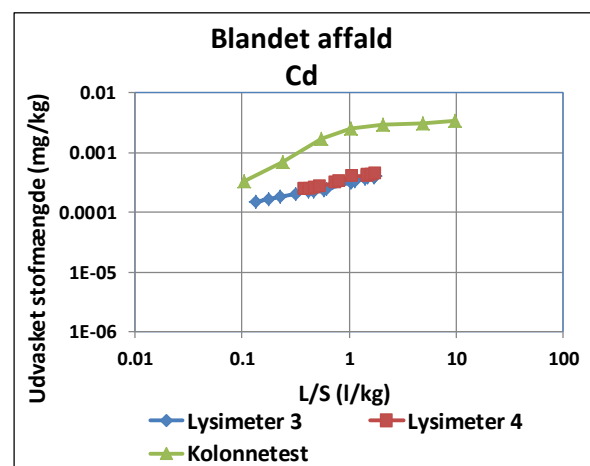
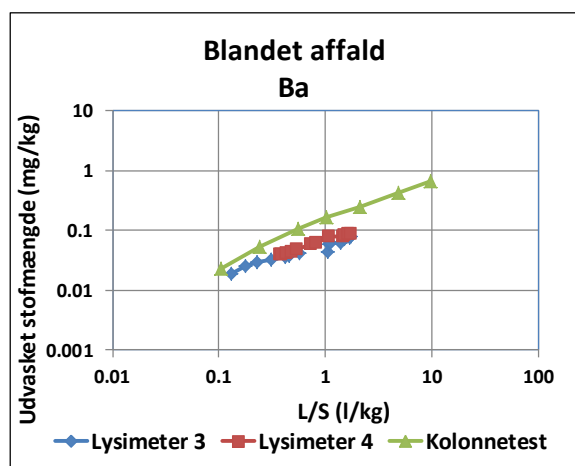
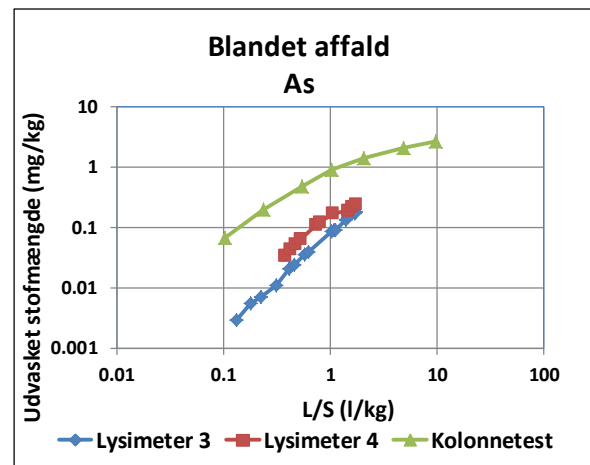
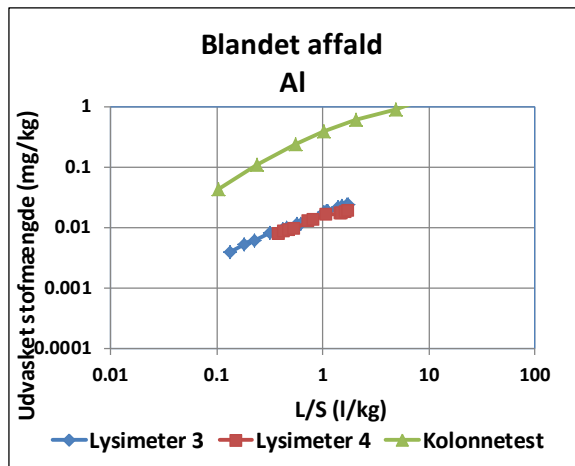


Figure 2.21b Leaching from lysimeters 1 and 2 and from column test (release as a function of L/S).

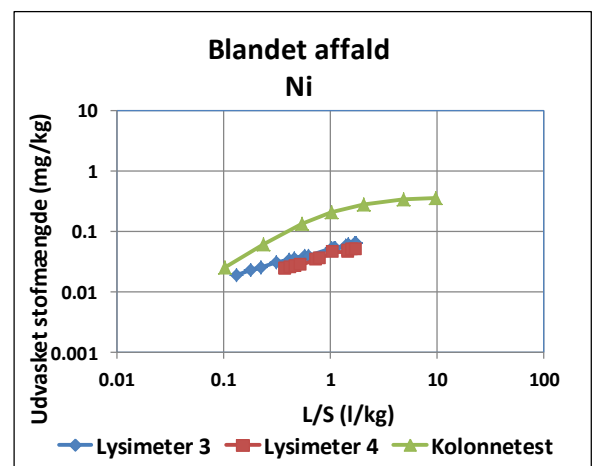
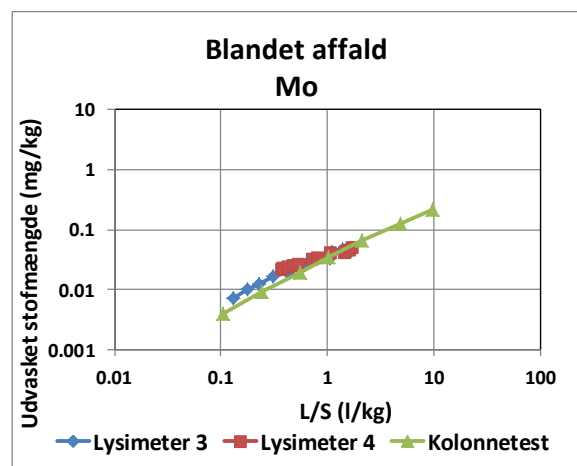
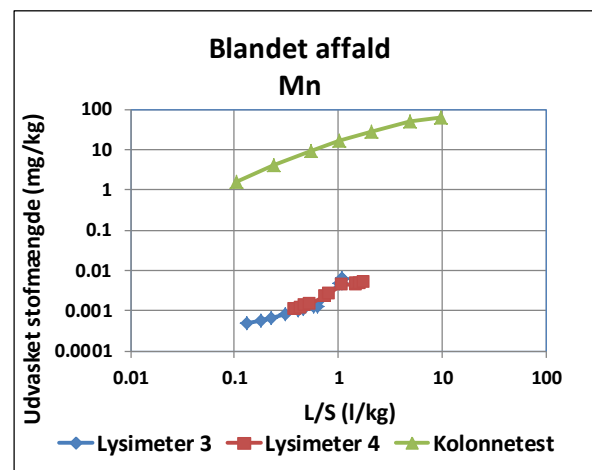
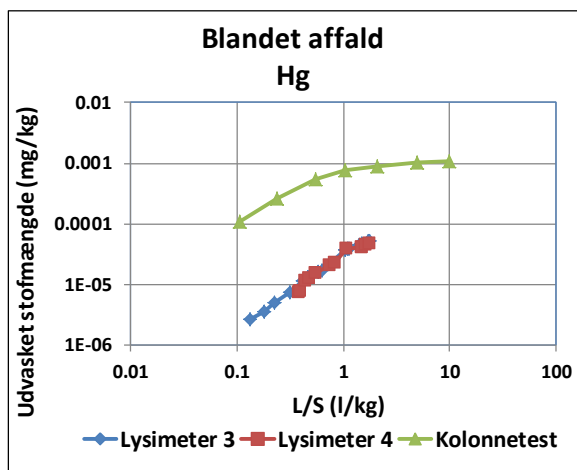
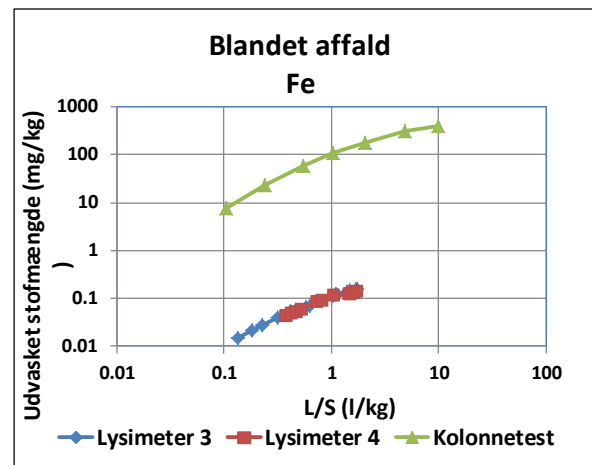
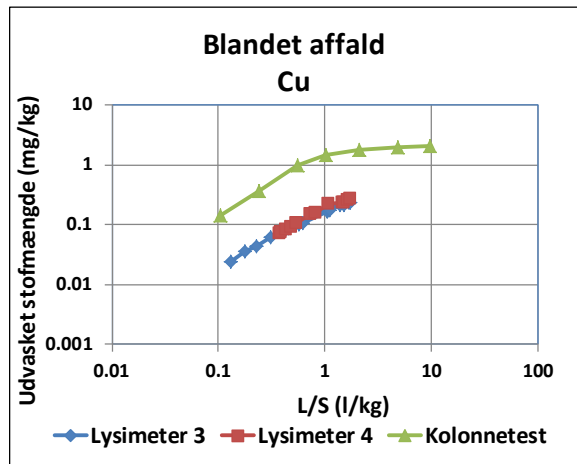


Figure 2.21c Leaching from lysimeters 1 and 2 and from column test (release as a function of L/S).

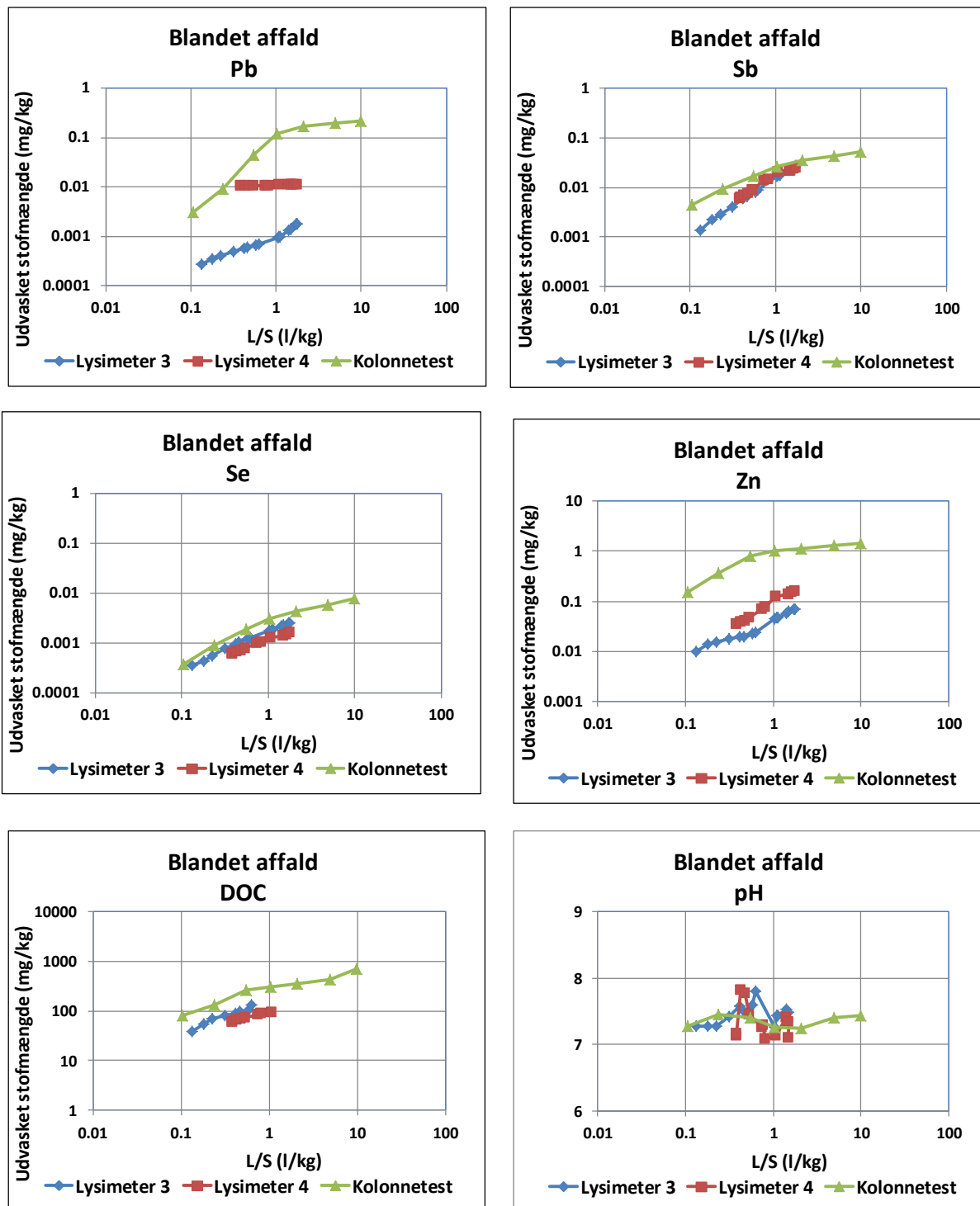


Figure 2.21d Leaching from lysimeters 1 and 2 and from column test (release as a function of L/S).



3 COLLECTION OF DATA FROM LANDFILLS

3.1 Criteria for selection of landfills for the study

The collection of leachate data from landfills was performed in a stepwise manner. Initially, a large number of selected landfills were contacted by mail to inquire about the existence of relevant data, their willingness and ability to provide data to the project and requesting some overall information on the landfill in the form of a small questionnaire. Their main criteria for selection of landfills to participate were:

- The existence of landfill cells with shredder waste or mixed waste
- Existing measurements of leachate volumes/water balances
- Analyses of leachate from cells containing only mixed waste or shredder waste
- No intrusion of water in the leachate from other sources than rainfall

Secondly, relevant landfills (selected on the basis of the returned questionnaires and the above criteria) were contacted to gain all relevant information.

Some landfills were contacted directly, since they had formerly exchanged leachate data with AV Miljø. In addition, RenoSam helped by sending out an email to its members with a request to participate; however, this did not result in any new contacts.

3.2 Landfills contacted

The landfills that responded to the first letter or were contacted directly are listed alphabetically below. For each landfill, a comment is included on whether or not they were considered suitable for the project and were participating in the extensive data collection. Names of suitable landfills are underlined; their geographical location is shown in Figure 2.1.

Audebo landfill, KARA / NOVEREN had cells with mixed waste that were of interest.

AV Miljø (Avedøre Holme) had cells with mixed waste as well as cells with shredder waste that were of interest.

AVV stated that they had no relevant information.

BOFA has cell with mixed waste, that were of interest.

Edslev Landfill only had analyses of leachate from cells containing household waste. This was not found irrelevant.

ESØ 90 did not want to participate.

Fakse Landfill, FASAN had cells with mixed waste that were of interest.

Feltengård Landfill had measurements and analyses of the total leachate volume (i.e. not for separate cells). The data was therefore not as detailed as required.



Fladså Landfill, FASAN had cells with mixed waste that were of interest.

Frederiksværk Landfill had a leachate collection system that took in water from the nearby lake Arresø. Therefore, it is not possible to quantify the volume of actual leachate that passes through the waste and the landfill was therefore not relevant.

Ganløse Landfill is a special site for slag and fly ash and therefore not relevant. However, a relatively large amount of household waste is deposited in one cell.

Hassel Nor Landfill, REFA is a site with mainly cells for slag and temporarily deposited combustible waste. Interesting for this project was a cell with shredder waste.

Hvalsø Landfill is a site for lighter polluted soil and was therefore not relevant.

Lystrupvej Landfill is a deposit for waste suitable for incineration and was therefore not relevant.

Odense Nord Landfill, Odense Renovation had cells with mixed waste as well as cells with shredder waste that were of interest.

Reno Djurs stated in the questionnaire that they had no relevant information.

REVAS Landfill stated in the questionnaire that they had no relevant information.

Rærup Landfill, Reno-Nord stated in the questionnaire that they only had measurements on the total leachate volume, and not on separate cells.

Sengeløse Landfill had a single cell of mixed waste which would classify the site as relevant. However, they did not want to participate.

Skibstrup Landfill is located at the location of an old lake. The landfill was found not relevant due to its leachate collection system.

Skive Renovation 4-S had deposited shredder waste, but did not have separate leachate analyses for the shredder waste cell. Therefore the landfill was not found relevant.

Spillepeng Landfill in Malmö had cells containing mixed waste that were of interest.

Uggeløse Landfill, AV Miljø had cells with mixed waste that were of interest.

Vestskoven, Vestforbrænding is a special site for slag and fly ash and therefore not relevant.

Each of the 9 landfills of interest is described in more detail in section 3.3.

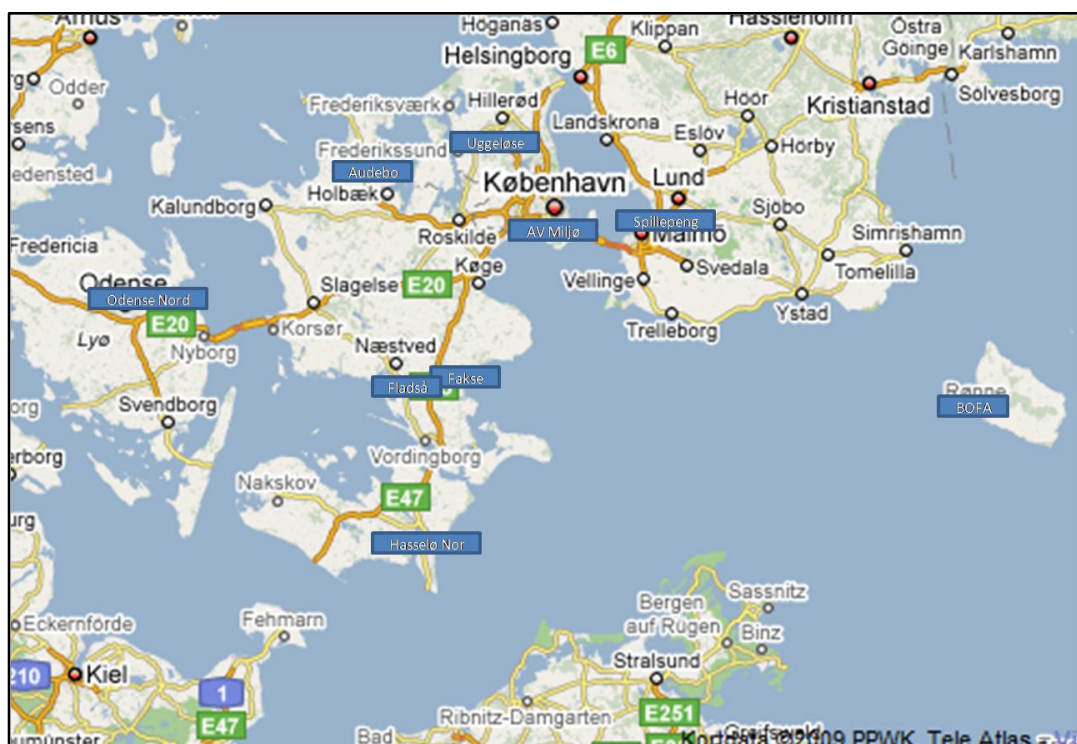


Figure 3.1 Geographical location of the landfills included in this project.

3.3 Description of the landfills selected for the study

3.3.1 Audebo Landfill

Summarised description of Audebo Landfill with focus on cells relevant for this project is given in table 3.1 and an overview of the site is presented in figures 3.2 and 3.3.

Table 3.1 Description of Audebo Landfill.

Site	Audebo Landfill
Owner	KARA / NOVEREN
Short general description	The site was opened in 1990. It covers an area of approx. 18 hectares and has a volume of approx. 2 million m ³ , with a maximum waste height of 25 m. The site is used for disposal of mixed waste including soil and asbestos. The waste comes from various places, but mostly from waste separation plants. The waste is deposited in layers with a compactor.
Description of relevant cells incl. waste type and operating period	The landfill is designed to consist of 12 deposit cells of which 3 cells (1,2,4) were of interest. Cells 1, 2 and 4 were taken into operation in 1990 and 1997 respectively. Today, Cell 1 has little volume left; this is saved for asbestos waste. Cell 2 is full. Cell 4 is almost full. Seasonal deposit of combustible waste has taken place in Cell 4 since 2000. The waste has not been covered. Gas extraction has taken place since 2000 from cells 1 and 2.

Site	Audebo Landfill
	At the bottom of all cells 1 m household of waste has been placed as a driving pad. It is assumed that cells 1 and 2 contain even more household waste.
Site and cell geometry	Approximate areas and fill heights of the relevant cells are: Cell 1: 17,000 m ² , 10.0 m Cell 2: 17,000 m ² , 12.0 m Cell 4: 20,000 m ² , 11.5 m
Bottom liner	There is a "double liner" consisting of a composite membrane of 1 mm HDPE on 0.2 m clay. Further, there is a natural clay membrane of 50 m thickness. Gravel is placed on top of and in between the two liners.
Top cover	None of the cells are closed and they are therefore not covered.
Design of leachate collection system	Each cell has a separate drainage system.
General information on leachate volumes	Since 2006 the amounts of leachate from each cell have been registered.
Extent of leachate sampling and analysis	Sampling is performed 4 times per year; data were only obtained for a period of 2006-2007. The general analysis programme includes pH, conductivity, COD, NH ₄ -N, N, P and chloride. In addition, AOX, NVOC, sulphate/sulphide, heavy metals, Na, Ca, Fe, K, THC, phenols are measured once or twice a year.
Rainfall measurements	Local measurements of rainfall and temperature are collected. Recirculation of leachate or watering of the waste have never taken place.
Performing water balance	No estimates have been made.
Guidelines for aftercare	None yet.

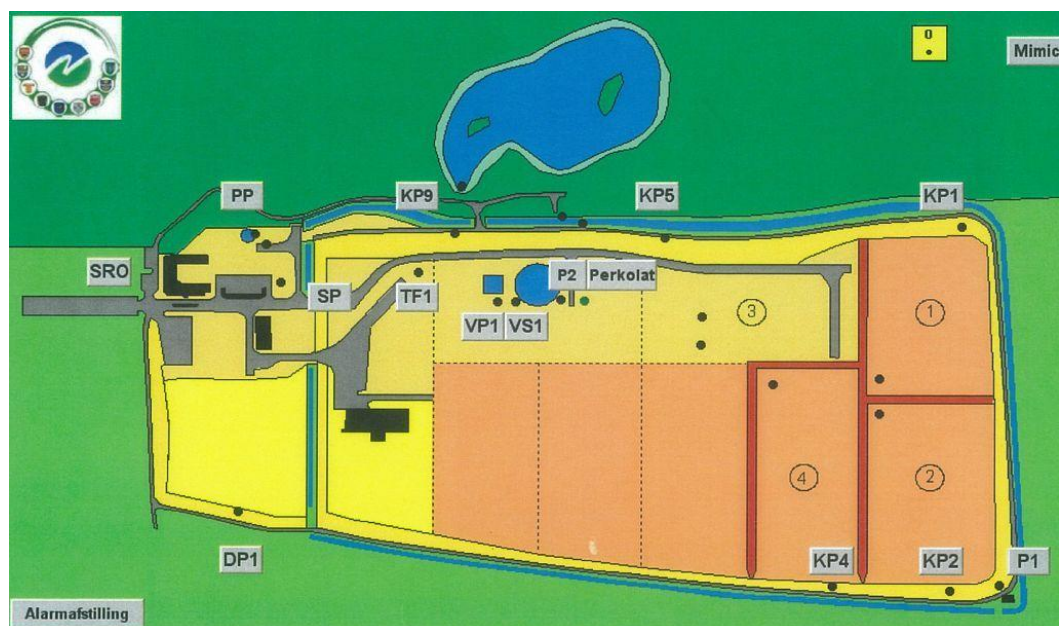


Figure 3.1 Overview of cells at Audebo Landfill.

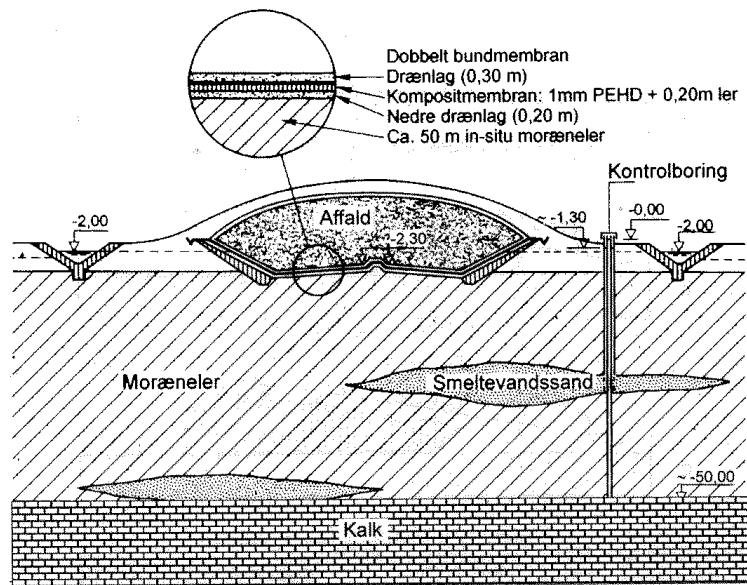


Figure 3.2 Section of Audebo Landfill. Only available in Danish (Christensen, T. 1998).

3.3.2 AV Miljø

A short summarised description of AV Miljø with focus on cells/units relevant for this project is given in table 3.2 and an overview of the site is seen in figure 3.4.

Table 3.2 Description of AV Miljø.

Site	AV Miljø
Owner	I/S Amagerforbrænding and I/S Vestforbrænding
Short general description	The site was opened in 1989. It covers an area of approx. 40 hectares and has a volume of approx. 2 million m ³ . The site is used for disposal of shredder waste, slag, coal combustion products, asbestos and mixed waste. Furthermore, crushed combustible waste is temporarily deposited here. This waste is covered with plastic membranes and the surface water is collected. Previously, flue gas cleaning residues have been deposited temporarily, but they have now been removed. In connection with the new environmental approval (2006), some cells have been merged, and the site has been divided in units. Each unit contains one or more former cells. Future sampling is only required from each unit. The shredder waste (\pm 50,000 ton/year) comes from one main producer, Stena Jern og Metal. The mixed waste comes from various places, especially from waste separation plants.
Description of relevant cells incl. waste type and operating period	There are several cells where flue gas cleaning agents have been originally deposited which today contain shredder waste. Similarly, many cells have been used for intermediate depositing of waste suitable for incineration. Leachate quality from these cells is influenced by this practice and cannot be used, at least not for the periods where intermediate deposition is taking place. One cell (cell 1.5.1) containing shredder waste as well as industrial waste and sludge incineration ash is included for comparison. Suitable cells/units containing shredder waste are: cell 2.1.3 (operation from 2000-2004), cell 2.1.4 (2002-2005), cell 1.5.1 (1989-



Site	AV Miljø
	<p>2000).</p> <p>Suitable cells/units containing mixed waste are: Unit 1E (cell 2.1.2.2, 2.1.2.3 and 2.2.2). Operation of the oldest cell (cell 2.2.2) started in 1992. The unit is still in operation.</p> <p>These cells have previously contained waste suitable for incineration, though today they are all containing mixed waste.</p> <p>Previously, the waste was deposited in one layer only, but now in several layers, with an optimal layer of ½ m only.</p>
Site and cell geometry	<p>AV Miljø has estimated the following areas:</p> <p>Cell 2.1.3: 5,600 m²</p> <p>Cell 2.1.4: 11,600 m²</p> <p>Cell 1.5.1: 8,100 m²</p> <p>Unit 1E: 39,250 m²</p> <p>The average filling height is 5.5 m.</p>
Bottom liner	<p>There is no bottom liner in the cells except for the natural clay layer.</p>
Top cover	<p>None of the relevant cells are fully covered. The general design of top covering on the site is 0.2 m root seal (gravel), 1 m of clayey soil and 0.2 m topsoil.</p>
Design of leachate collection system	<p>Each cell has a separate drainage system. Leachate is lead from here to the pump station.</p>
General information on leachate volumes	<p>The pump station includes a flow meter, however, there is no separate measuring of leachate volumes from each cell. The site is located on former sea area, meaning minor volumes of sea and groundwater are infiltrating and collected with the leachate (AV Miljø 2008).</p>
Extent of leachate sampling and analysing	<p>Until 2006, 4 to 6 samples have been extracted in selected cell every year. From 2007 samples are extracted from each unit. This means that cells 2.1.3 and 2.1.4 are sampled together with the cells 2.1, 2.1.1, 2.2 and 2.2.1 (unit 1D). For cell 1.5.1 samples are still taken separately. Thus, analyses from unit 1D cannot be used as only cells 2.1.3 and 2.1.4 contain shredder waste; for these cells only data from start of the operation until 2006 could be used. Today, samples are taken once a year from units with mixed waste, while for units with hazardous waste 4 samples are taken every year.</p> <p>Originally, leachates were sampled in wells using bucket or pump. Today leachates are extracted directly from a pipe branch in the pump housing. The sampler is Milana, while previously Eurofins, COWI and the Environmental Lab of Copenhagen have performed sampling/analysis. The analytical programme for the shredder cells includes pH, heavy metals/trace elements and oil. Unit 1E is analysed for the same parameters except oil. In addition, conductivity, dry matter, chloride, COD, BOD and N are determined.</p>
Rainfall measurements	<p>Local rainfall measurements are available from 2002 . The shredder waste is sprinkled; however, specifications of these water volumes have only been available since October 2007.</p>
Performing water balance	<p>In connection with Green Accounts an estimate of a water balance has been made.</p>
Guidelines for aftercare	<p>Guidelines and limit values are described in the environmental approval from 2006, enclosure 16.</p>

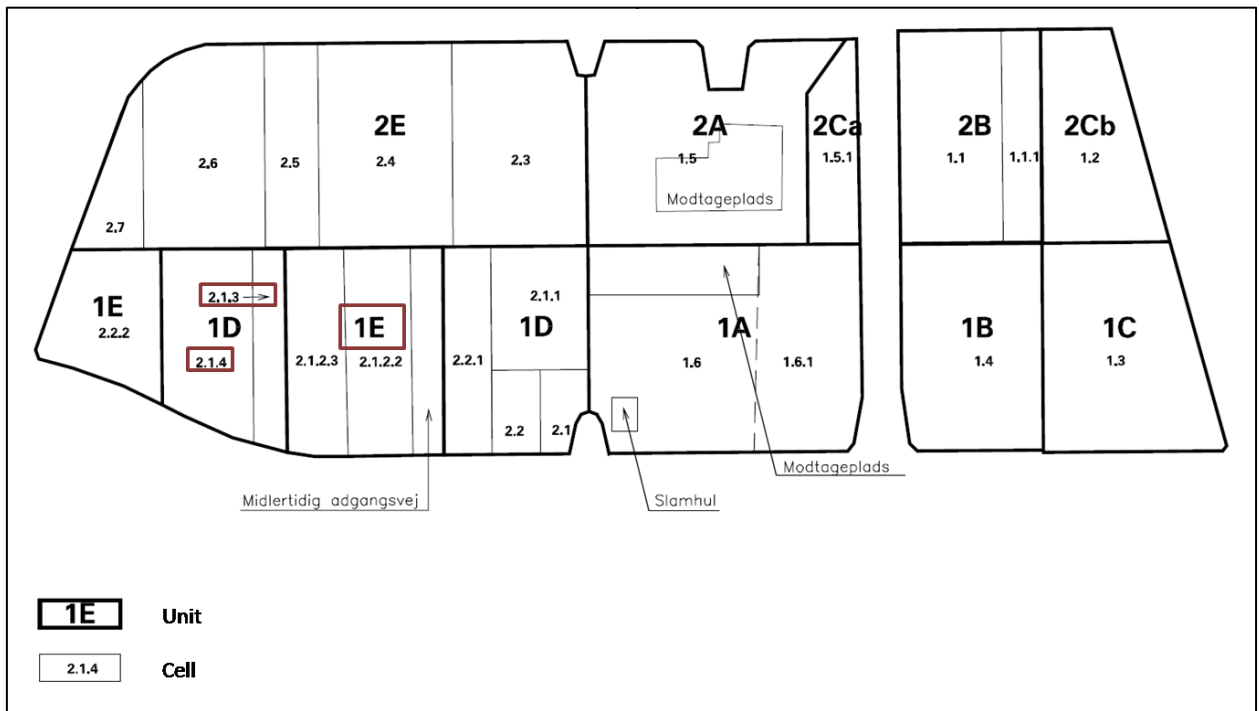


Figure 3.3 Overview of landfill cells and units at AV Miljø.

3.3.3 BOFA Landfill

A summarised description of the BOFA Landfill with focus on cells relevant for this project is given in table 3.3 and an overview of the site is seen in figure 3.5.

Table 3.3 Description of BOFA Landfill.

Site	BOFA Landfill
Owner	BOFA
Short general description	The site was opened in 1973 and consists of two major cells. An old cell which was in use from 1973 has been filled completely and covered. From 1999 a new cell with capacity of 62,500 m ³ was taken into use for mixed waste. In addition, there are two minor cells with mineral waste (polluted soil) and asbestos. The waste originates mostly from waste separation plants (65 %) and local industry. Depositing of PVC, preserved wood, fishing nets and trawls have taken place periodically.
Description of relevant cells incl. waste type and operating period	The cell with mixed waste has been in use throughout the operation period. In waste is deposited 5,000 ton/year. The waste is deposited in layers with a compactor.
Site and cell geometry	Approximate area and fill height of the relevant cell is: 10,000 m ² , 5 m
Bottom liner	The site is located on rock which is covered with 150 mm sand drainage layer followed by 1 mm HDPE membrane and another 200 mm of sand layer. Finally, 300 mm of waste incineration slag is added on the top of the second sand layer.
Top cover	The cell is still in operation and is therefore not covered.
Design of leachate collec-	The cell has separate drainage system.

Site	BOFA Landfill
tion system	
General information on leachate volumes	No data on collected volumes of leachate. Estimates have been made based on rainfall, pump capacity and operation time. A leak in the membrane caused by penetration has been discovered.
Extent of leachate sampling and analysing	Sampling is performed 4 times per year, if there is water in the well. This was the case in 25 % of the sampling campaigns. The general analysis program includes pH, conductivity, COD, BOD, DM, NVOC, NH ₄ -N, P, Fe, oil and hydrocarbons, phenols, chloride, sulphate, AOX and heavy metals.
Rainfall measurements	Local measurements of rainfall and temperature are not collected.
Performing water balance	No estimates have been made.
Guidelines for aftercare	None yet.



Figure 3.4 Overview of BOFA Landfill.

3.3.4 Fakse Landfill

A summarised description of Fakse Landfill with focus on the cells/parts relevant for this project is given in table 3.4 and an overview of the site is seen in Figure 3.5figure 3.6.

Table 3.4 Description of Fakse Landfill.

Site	Fakse Landfill
Owner	FASAN I/S
Short general description	Fakse waste disposal site was opened in 1981. It covers an area of approx. 28 hectares and has a volume of approx. 2.5 million m ³ . It includes two sections. The older section was in operation between 1981 and 1998. Parts of the section were covered in 1996, 2003 and 2009. New section was opened in 1997 and is still in operation. The site receives mixed waste and asbestos and previously also



Site	Fakse Landfill
	<p>household rubbish. Combustible waste has been intermediately deposited on the site. It has been placed on top of repository waste. A section of the old part of the site was used as composting site for 15 years and was filled up in 2007. Oily soil has been treated (in pajab pit). Water collection and a membrane has been applied, and has presumably not had any impact on the leachate in the individual cells.</p> <p>The waste is a good mixture of industrial waste, a lot of it from recycling centres. No particularly large customers.</p>
Description of relevant cells incl. waste type and operating period	<p>In the <u>old part</u> of the site the cells are called parts. Half of the area of parts 5 and 6 half was used for composting; this makes them irrelevant for this project. Parts 4 and 7 contain household refuse (approx. 5-10% and 15-20% respectively). The remaining parts are:</p> <p>Part 1: In use 1982-1984, covered in 1996. Contains a few percentages of refuse.</p> <p>Part 2: In use 1985-86 incl. a hole for asbestos waste. In 1998 a "sludge hole" filled with burnt waste (after fire in intermediary deposit of combustible waste), partly covered in 1996 and finally covered in 2003.</p> <p>The <u>new part</u> includes 14 cells of which 9 have been established. Two of these cells contain mixed waste (cells 1 and 2). In some of cells combustible waste, sludge and garden refuse are intermediately deposited while in others is deposited inert waste. Cell 1 was taken into use in 1997, cell 2 in 1999.</p> <p>The waste has been deposited in several horizontal layers.</p>
Site and cell geometry	<p>The bottom areas in the relevant cells are: Part 1: 22,000 m², part 2: 11,000 m², part 3: 11,000 m², cell 1: 15,000 m², cell 2: 15,000 m². Top areas are estimated to be approx. 5% larger than the bottom areas. The old section has a total area of 121,000 m², the new section 159,000 m². The fill height is 9 metres in average, though can be estimated for each cell/part.</p>
Bottom liner	Composite membrane of 1 mm HDPE on 0.80 to 1 metre spread clay.
Top cover	Subsoil and if required a gravel layer under it.
Design of leachate collection system	Drainage gravel with drain pipes. Leachate from the old section is collected in pump P1-3; from the new section it is lead to pump P4.
General information on leachate volumes	There are no leachate volumes for each individual cell. They must be estimated based on occupied areas and total leachate volumes. Flow meters are installed at P1-3, P4 and one for the whole site, however, the last-mentioned was not established until 2006.
Extent of leachate sampling and analysing	Analyses from each individual cell varying from 2 to 11 times per year. In 1994 and 1995 as well as autumn 2001 there was unfortunately no water to sample from in state 1. Furthermore, analyses of the total volume of discharged leachate from the old section and from the whole site have been made. Samples are extracted and analysed by Rovesta. They are taken from a pipe branch in the pump stations. The analysis program includes COD, BOD, pH, and chloride, some analyses have included NH ₄ ³⁺ , and DM. For the new cells is also included N, P, Ca, Na, Fe, AOX, NVOC, phenol, BTEX, heavy metals and sulphide/sulphate.
Rainfall measurements	A weather station was installed on the site around 2004. The data are unfortunately of low quality and couldn't be used here.

Site	Fakse Landfill
Performing water balance	The annual report includes some thoughts on water balance.
Guidelines for aftercare	None yet.

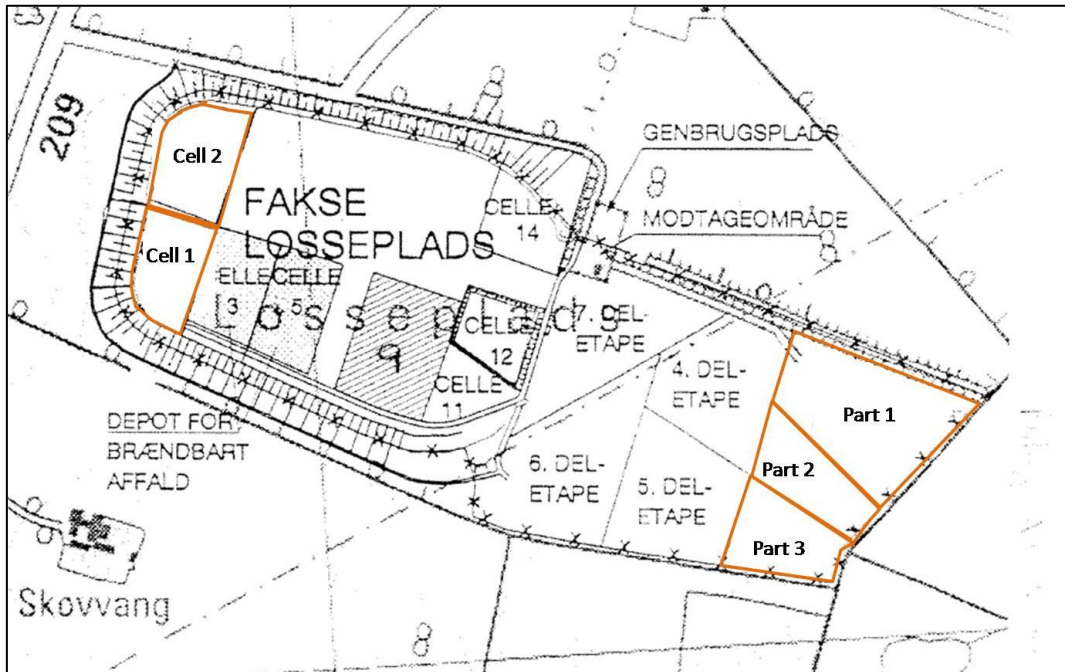


Figure 3.5 Overview of cells and parts at Fakse Landfill.

3.3.5 Fladså Landfill

A summarised description of Fladså Landfill with focus on the cells relevant for this project is given in table 3.5 and an overview of the site is seen in figure 3.7. A cross-section of the site is shown in figure 3.8.

Table 3.5 Description of Fladså Landfill.

Site	Fladså Landfill
Owner	FASAN I/S
Short general description	Fladså Waste Disposal Site was opened in 1984 on the place of an old pit. The area is approx. 4 hectares and it has a disposal volume of approx. 0.8 mill. m ³ , with a max. disposal height of 25 metres. The site has been in operation until now and will be closed during the spring of 2009. The site has received mixed waste, slags and fly ash, the latter two are deposited in a separate cell. Combustible waste and garden refuse have been intermediately deposited on the site. It has been placed on top of repository waste. The waste is a good mixture of industrial waste, a lot of it from recycling centres. There are no particularly large customers.
Description of relevant cells incl. waste type and operating period	The site has 3 cells with mixed waste named A1, A2 and A3. The specific weight of the mixed waste is estimated by FASAN to 1.3 ton/m ³ . The waste has been deposited in two horizontal layers,

Site	Fladså Landfill
	starting in A1, continuing to A2 and A3 and back.
Site and cell geometry	The bottom areas in the cells are: A1: 17,000 m ² , A2: 15,000 m ² , A3: 24,000 m ² . Top areas are estimated to be approx. 30% larger than the bottom areas. Fill height is 15-20 metres and max. 25 metres.
Bottom liner	Double membrane (figure 2.8). On top a composite membrane of 1 mm HDPE on 0.20 m clay/bentonite, in the bottom 0.80-1 m clay. On some slopes clay membrane 1 m thick is laid out.
Top cover	Subsoil and if required a gravel layer under it. Covering has started and will be finalized in 2009.
Design of leachate collection system	Upper drainage layer consists of 0.3 m gravel (corn size 1-8 mm) with a gradient of 0.5% and drain pipes in PVC and PE with a typical distance between the pipes of 10-15 m. The bottom drainage layer is 0.20 m.
General information on leachate volumes	The volumes pumped away from the lower drainage layer are quite limited, approx. 40 m ³ every month. In this project only data for the upper drainage layers were taken into account. These volumes are in the order of 2,000 m ³ /month. Leachate is pumped from each individual cell. Relevant pumps are A1: pump 1.2, A2: pump 1.3, A3: pump 1.4. Furthermore, a flow meter is installed which measures the total volume of leachate. Pump P1 pumps the total volume of leachate onwards. The pumping volumes of P1 should equal the specification of the flow meter.
Extent of leachate sampling and analysing	Leachates were sampled and analysed by Rovesta. Samples were taken from a pipe branch in the pump stations. Typically, individual cells were sampled once a year; in some years two samples were taken. In addition, samples of the total discharged leachate were taken annually (in 2007 and 2008 4 samples were analysed). The analysis program includes conductivity, DM, COD, BOD, pH, NH ₄ ³⁺ , P, N, chloride, sulphide, sulphate, Na, K, Ca, Mg, Pb and phenols.
Rainfall measurements	A weather station was installed on the site in 2004.
Performing water balance	The annual report includes some thoughts on water balance.
Guidelines for aftercare	None yet.

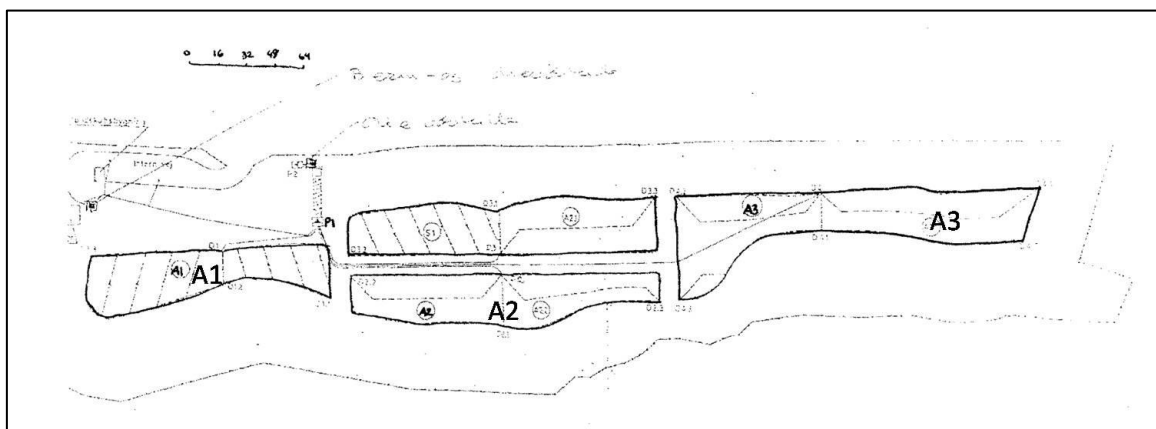


Figure 3.7 Overview of cells at Fladså Landfill.

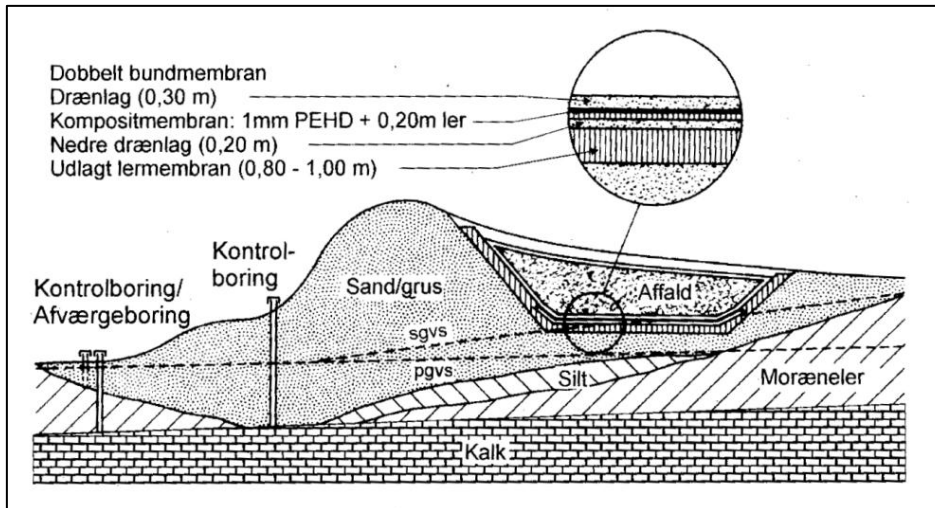


Figure 3.6 Cross-section of Fladså Landfill. Only available in Danish (Christensen, T. 1998)

3.3.6 Hasselø Nor Landfill

A short summarised description of Hasselø Nor Landfill with focus on the shredder waste cell relevant for this project is shown in table 3.6 and an overview of the site is seen in figure 3.9.

Table 3.6 Description of Hasselø Nor Landfill.

Site	Hasselø Nor Landfill
Owner	REFA
Short general description	The site was opened in 1984 and has an expected lifetime of more than 80 years from now. The site has cells with industrial waste, waste water sludge, slightly polluted soil, slag as well as shredder waste. The shredder waste comes from Dansk Kabelskrot.
Description of relevant cells incl. waste type and operating period	One cell containing shredder waste is relevant for this project. The cell is named E1. Shredder waste and stones with cables was deposited in the cell in the period 1991-1994. It was planned to deposit the waste in 1 m thick layer. Leachate test and analyses of the waste were performed before depositing started.
Site and cell geometry	Approximate area of the cell is 2,000 m ² .
Bottom liner	The membrane is a clay membrane consisting of 1 m laid out clay on top of a natural clay layer. The added clay has a permeability of 10^{-10}. The area has an upward water pressure. Gravel with drain is on top of the clay membrane.
Top cover	In 1994 the cell was covered in with approximately 1 m clay membrane.
Design of leachate collection system	Cell has a separate drainage system. Leachate is drained to a joint well for several cell.
General information on leachate volumes	There is no separate measurement on leachate volumes from cell E1. Suggested in the permission from 1991 is a two-layer clay membrane. This was estimated to reduce the infiltrated water volume from 200 mm/year to 10 mm/year, corresponding to 20 m ³ /year for this site of 2,000 m ² .

Site	Hasselø Nor Landfill
Extent of leachate sampling and analysing	Sampling of leachate from Cell E1 has been performed since 1993 either quarterly or half-yearly. The general analysis program at the moment includes pH, TOC, VOC, NVOC, BOD ₅ , heavy metals, and oil. Recently, a few more heavy metals as well as DM, chloride, sulphate and conductivity have been added to the program. Sampling and performing of analyses is taken care of by Miljølaboratoriet.
Rainfall measurements	Measurements of rainfall are collected from where?. Data received from 1997 and onwards.
Performing water balance	No
Guidelines for aftercare	None yet.

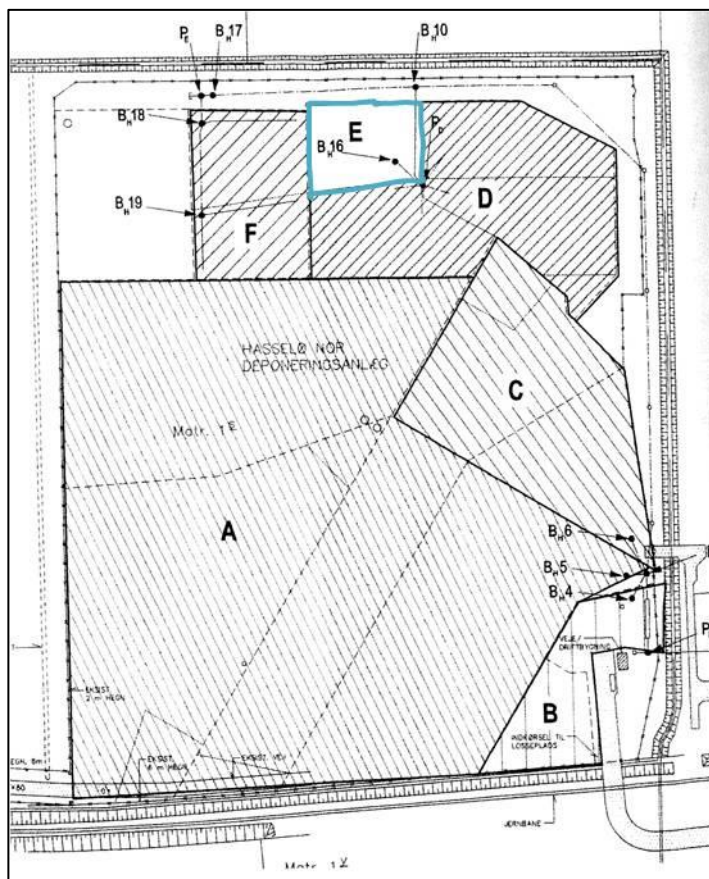


Figure 3.9 Overview of Hasselø Nor Landfill.



3.3.7 Odense Nord Landfill

A short summarised description of Odense Nord Landfill with focus on cells relevant for this project is given in table 3.7 and an overview of the site is seen in figure 3.7.

Table 3.6 Description of Odense North Landfill.

Site	Odense Nord Landfill
Owner	Odense Renovation
Short general description	The site was opened in 1994 and has an expected lifetime of more than 100 years. It covers an area of approx. 110 hectares and has a volume of approx. 10 million m ³ . The site has cells for mixed waste, shredder waste as well as other waste types. The mixed waste comes from various places, especially from waste separation plants. The shredder waste comes from HJ Hansen regaining industry.
Description of relevant cells incl. waste type and operating period	Two cells have been pointed out as relevant for this project. Cell 1c contains mixed waste and Cell 7a contains shredder waste. These cells were taken into use in 1998/99 and 2000/01 respectively. The waste is deposited in layers of maximum 50 cm with a 20/30 ton compactor.
Site and cell geometry	Approximate areas and fill height of the relevant cells are: Cell 1c: 41,000 m ² , 13 m Cell 7a: 35,000 m ² , 15 m At the bottom of the cells there is 1 m of household waste and/or 0.75 m bio-compost for driving pad.
Bottom liner	The membrane is a composite membrane of 1 mm polymer membrane on top of 3 m clay. Gravel is on top of the membranes.
Top cover	The two cells are still in operation and are therefore not covered.
Design of leachate collection system	Each cell has a separate drainage system.
General information on leachate volumes	Separate registration of the leachate volumes from each cell has been done on a yearly basis since start of operation and on a monthly basis since 2004.
Extent of leachate sampling and analysing	Sampling of leachate from Cell 1c and Cell 7a is performed 4 times per year using one and three wells, respectively. The general analysis program at the moment includes pH, conductivity, DM, SS, NH ₄ -NH ₃ - N, N, P, chloride, sulphate, TOC, VOC, NVOC, BOD ₅ , COD and Fe. Heavy metals, oil and phenols are measured once a year. Sampling is performed by Miljølaboratoriet; Eurofins is performing the analyses.
Rainfall measurements	Measurements of rainfall and temperature are collected from Beldringe Airport 4 kms away. Sprinkling with sea water has taken place.
Performing water balance	Estimation on leachate creation has been performed based on historical leachate creation and recent rainfall data.
Guidelines for aftercare	None yet awaiting new waste guideline from the Danish authorities.

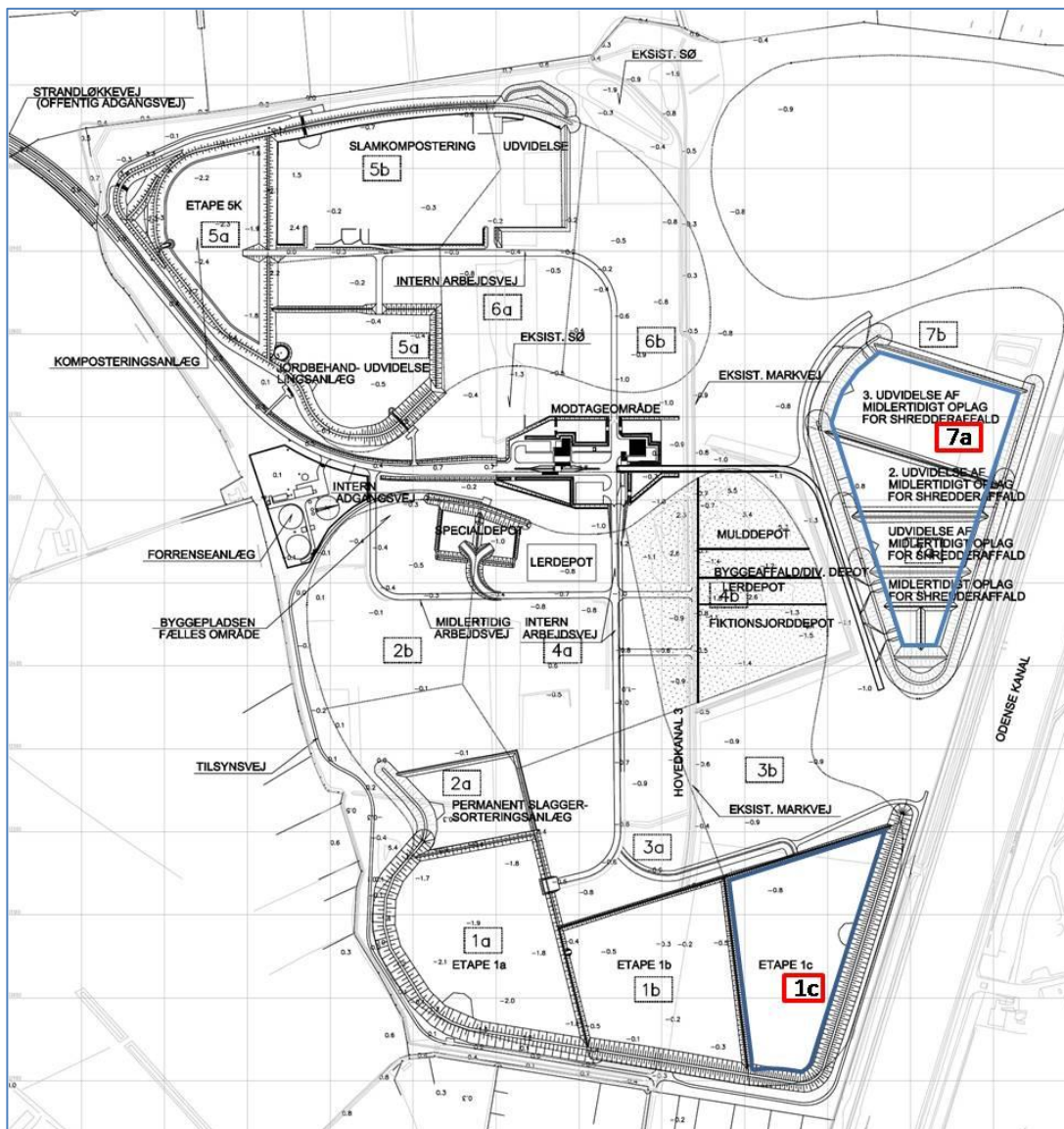


Figure 3.10 Overview of the cells at Odense Nord Landfill.



3.3.8 Spillepeng Landfill

A short summarised description of Spillepeng Landfill (located north of Malmö, Sweden) with focus on cells relevant for this project is given in table 3.8 and an overview of the site can be seen in figure 3.11 and figure 3.12.

Table 3.7 Description of Spillepeng Landfill.

Site	Spillepeng Landfill
Owner	SYSAV
Short general description	<p>The site is split in two parts: old and new. The old part was in use between 1940 - 1990 and is today covered and used as a recreational area. The new part is dammed land which is separated into 3 units. The unit 1 was taken into use in 1991 and was filled by 1994. Unit 2 and 3 were taken into use in 1993 and 2001, respectively. The landfill is expected to still having a lifetime of 30-40 years. The three units in the new part cover an area of approx. 55 hectares and have a capacity of approx. 6.5 million m³. The final height of the waste will be from a few meters above sea level near the dam walls up to 32 m above sea level.</p> <p>The site is today used for disposal of mixed waste and hazardous waste, and a volume of combustible waste is intermediately deposited. Unit 1 also includes cells for organic waste where fermentation processes and gas production are taking place.</p> <p>The waste comes from various places, especially from waste separation plants. The site also has waste sorting facilities</p>
Description of relevant cells incl. waste type and operating period	Unit 3 contains cells R9 and R10 which were found relevant for this project (herein used as one cell R9-10). These cells were taken into operation in 2001 and contain mixed waste. Until 2004 also organic and combustible waste was deposited in the cells. The content of organic waste is therefore relatively high compared to Danish conditions. The cells are still in use today.
Site and cell geometry	Approximate areas and fill height of the cell today is: Cell R9-10: 50-60,000 m ² , 4-7 m
Bottom liner	The membrane is a natural moraine clay membrane of 11 m. The first meter is seen as the tight layer and the next 10 m as a geological barrier. The moraine has a hydraulic conductivity of 5*10 ⁻⁹ m/s. The drainage layer consists of crushed construction waste.
Top cover	The R9-10 cell is still in use is therefore not covered.
Design of leachate collection system	<p>The drainage system is designed with several pumps in each unit (Figure 2.12). The well P8(b) is collecting leachate from the cells R9-10. The same well is also collecting leachate from a minor area where combustible waste is intermediately deposited as well as a small paved area where sorting of wood is taking place.</p> <p>The water level is kept below the sea level and there is evidence that sea water is coming into the drainage system (SYSAV 2007). The concentrations from well P8b are not noticed to be significantly higher, that the chloride concentrations in many of the other landfills.</p>
General information on leachate volumes	The leachate volumes in P8b have been monitored since start of deposition.
Extent of leachate sampling and analysing	Intensive sampling is performed during the year. A flow proportional sample is taken out every month, while spot test are taken 4-11 times per year. The general analysis program includes pH, conductivity, COD, BOD ₇ , TOC, N, NH ₄ -N, NO ₂ -NO ₃ -N, P, chloride, SS, Fe, Mn and heavy metals.

Site	Spillepeng Landfill
Rainfall measurements	Local measurements of rainfall has been collected since 20003. Recirculation of leachate or watering of the waste have never taken place.
Performing water balance	No estimates have been made.
Guidelines for aftercare	None yet.



Figure 3.11 Overview of new landfill area at Spillepeng Landfill.

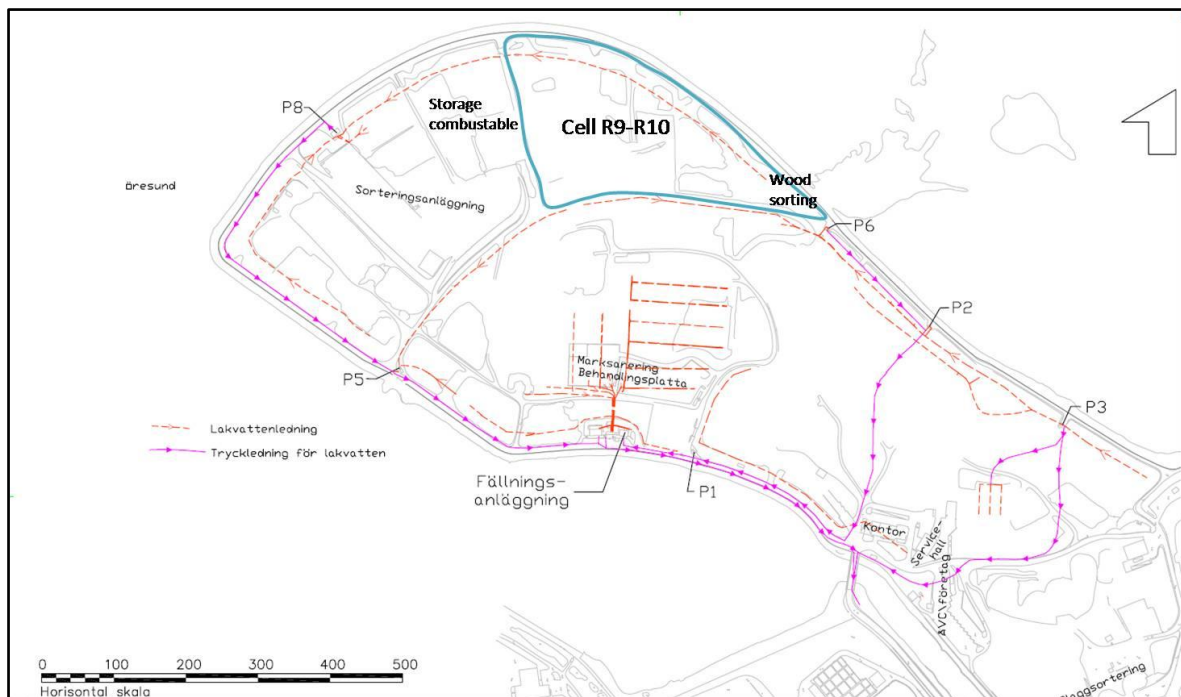


Figure 3.12 Overview of drainage system at Spillepeng Landfill.



3.3.9 Uggeløse Landfill

A short summarised description of Uggeløse Landfill, with focus on cells relevant for this project, is given in table 3.9 and an overview of the site is seen in figure 3.13.

Table 3.8 Description of Uggeløse Landfill II & III.

Site	Uggeløse Landfill
Owner	Amagerforbrænding
Short general description	Uggeløse Site (here only including Cell II and III) was established in an old gravel pit. Legal deposit has taken place between 1977 and 1989. The site was closed and covered in 1987/1989. Today, the area is used for farming as well as recreational area. At the site 1 mill. m ³ waste is deposited. A gas extraction system is established, but today it is not in use due to lack of gas. In the first years of operation the leachate was recirculated; this was stopped in 1990. The waste is construction waste, industrial waste, garden refuse, bulky refuse, polluted soil, sludge, asbestos, slag and sludge melting of cast iron (cupola oven), see details on the sludge later. Cell II contains 250,000 m ³ waste (in operation 1977 – 1979), Cell III contains 735,000 m ³ (in operation 1979 – 1989). Asbestos and contaminated soil are mainly deposited in Cell III.
Description of relevant cells incl. waste type and operating period	In early 1970's sludge from melting of cast iron (cupola oven) was deposited on bare soil and covered by a composite membrane in 1977. Hereafter, a landfill with clay membrane and drainage was established. Leachate from the sludge is therefore not collected in leachate collection system under Cell II.
Site and cell geometry	The areas are: Cell II: 30,300 m ² and Cell III: 82,000 m ² . Deposit height is 7-11 m for Cell III.
Bottom liner	Membrane of 1 meter clay. Surface of Cell III is specified to be treated with bentonite.
Top cover	Covered with ½-1 m soil in 1987/1989.
Design of leachate collection system	Leachate from the two cells is pumped to a joint pumping station (well G). A well H is located in Cell II.
General information on leachate volumes	The volume of leachate created in both cells is measured jointly at well G. For Cell III the leachate has been collected since 1981 (2 years after start of operation). For Cell II leachate has been collected approximately since 1987 (10 years after start of operation) after it was shown (in 1984 and 1986) that accumulation of leachate in the waste took place. Between 1983 and 1990 leachate has been recirculated in parts of Cell III. The system has several times been partly blocked. Remarks have been done for both cells on risk of rain / groundwater oozing into the cell and leachate collection basin as well as possible leakage from the leachate collection basin. These issues can cause impact on the collected leachate volumes.
Extent of leachate sampling and analysing	Samples from well G were analysed monthly from 1980-84, quarterly in 1984-2004, and semi-annually from 2004. A few samples were also taken from Cell II separately. Sampling is at the moment performed by Milana. The analyses are covering conductivity, COD, BOD ₅ , pH, heavy metals, Fe, N, sulphate, chloride, NH ₄ ³⁺ . Recently, CH ₄ , NVOC, Mn, NO ₃ , hydrocarbons, BTEX and chlorinated solvents have also been included. Analyses exist for leachate both before and after recirculation.
Rainfall measurements	No local measurements; however, rainfall measurements from nearby national measuring station from 1965 to 1991 are available.
Performing water balance	Water balance has been performed for Cell III: leachate volume of 22 % of

Site	Uggeløse Landfill
	rainfall is estimated (Vandkvalitetsinstituttet ATV 1986). For Cell II leachate production of max 20 % of rainfall is estimated due to gradient on top cover (Enviroplan 1985).
Guidelines for aftercare	None yet.

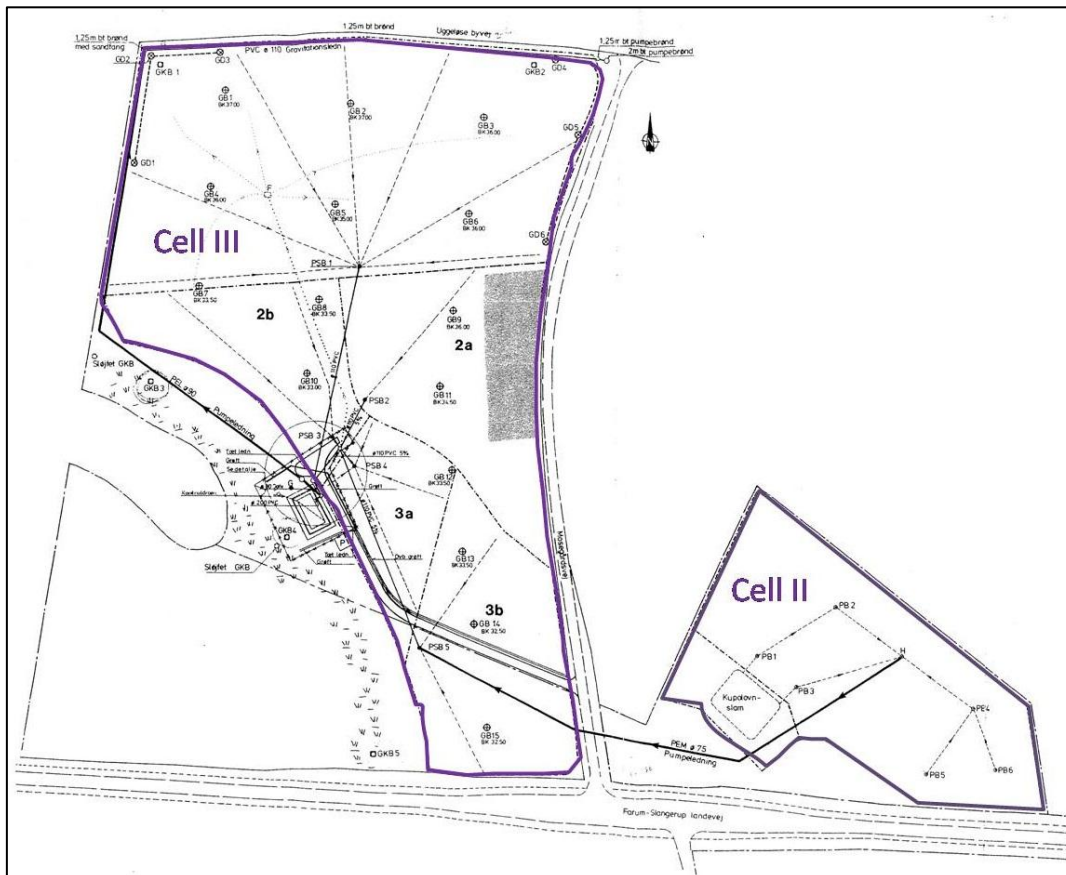


Figure 3.13 Overview of Uggeløse Landfill II & III.



3.4 Data quality and summary

3.4.1 Overview

In total, data from 21 landfill cells were collected. This dataset includes just above 1000 leachate analyses, which are collected in a spreadsheet database. A summary of the cells is given in table 3.10

The liquid/solid ratio (L/S) is estimated simply by dividing the total mass of waste in a landfill cell/site by the total amount of leachate collected from that cell/site..

Table 3.10 Overview of landfill cell where data has been collected. *Layer of different waste material than cell main waste type placed in bottom of cell as protection of drainage system.

Site	Fladså	Fakse	Odense Nord	AV Miljø	Audebo	Hasselø Nor	Uggeløse	BOFA	Spillepeng
No. cells	3	5	2	3-4	3	1	1 (2)	1	"1"
Shredder waste			X	X		X			
Mixed waste	X	X	X	X	X		X	X	X
Start operation	1988	1982	1998	1989	1990	1991	1977	1999	2001
End operation	2009	2007	-	2005	(2009)	1994	1989	-	-
Volume in included cells end 2008 (t m ³)	735	541	1058	329	604	20	985	~ 62.5	465
Leachate measurement	Cell	Site	Cell	Site	Cell	Site	Site	Site	Cell +
Accum. L/S (approx. 2008)	0.34-0.64	0.26-1.6	0.054-0.51	0.42-0.64	-	0.37	0.37	0.54	0.18
Bottom cover of drainage*			X		X			X	
Top liner						X			

The liquid/solid ratio (L/S) is estimated simply by dividing the total mass of waste in a landfill cell/site by the total amount of leachate collected from that cell/site.

3.4.2 Data quality

Ideally, the following criteria should be fulfilled for a cell/unit to be relevant for this project:

- Contain only one waste type, e.g. not special material in bottom of cell for covering of drainage system
- Mixed waste contains a minimum of organic content
- Volumes of leachate are measured for the single cell
- Analyses are performed for the single cell
- Top liner should be omitted to maximise the infiltration of precipitation

Unfortunately, hardly any of the cells included in this project fulfil all of these criteria. The cells at Odense Nord, Audebo and BOFA all have a bottom layer of a different waste type (e.g. combustible waste, bio-compost, waste incineration slag), while the contents of organic or combustible waste in the old Danish landfills (Fakse, Fladså, Uggeløse) as well as the Swedish landfill Spillepeng is uncertain yet expected to be higher than in today's standard cell for mixed waste.



Only at Fladså, Odense Nord, Audebo and Spillepeng are leachate volumes measured per cell. However, at Odense Nord the leachate formation is minimal due to very hard compacting of the waste. At Audebo, the system was established recently and the full history of leachate volumes does not exist. At Spillepeng, the leachate collection covers an area slightly larger than the relevant cell; the extra area contains an intermediate deposit of combustible waste which affects the leachate quality.

Leachate analyses of the specific cells exist for nearly all cells. At Uggeløse there are two cells from which leachate is mixed and so volumes and concentrations are measured on the mixed leachate.

Cell E1 at Hasselø Nor containing shredder waste is equipped with a 1 m clay top liner. This will influence the infiltration through the waste and reduce leachate generation.

All these uncertainties have present significant complication for the planned modelling of leaching data which was not very successful. The collected data needs to be thoroughly evaluated prior to any modelling exercise in order to ensure realistic outcome based on the available data.

3.4.3 Data summary

In total, results from analyses of 1074 samples were collected. These samples were analysed for a variety of almost 100 different parameters. A summary of the parameters and their frequency in the dataset is given in table 3.11 and table 3.12.

Table 3.11 Overview of collected data and selected analysed parameters, part 1. Notes 1: BOD7 instead of BOD5 is measured, 2: First measured from 2005, 3: Only measured in 1999-2000, 4: First measured from 2007, 5: For some samples either TOC or NVOC is measured, 6: First measured from 2002, 7: First measured from 2006, 8: First measured from 2000, 9: Significant part of results below detection limit, 10: Only few samples analysed, 11: Only one cell and first from 2007, 12: Some result as mg/l some as %, 13: Sampling in single cells started in 2006, 14: Only sampled as single unit since 2008.

	Start of operation	Temperature	pH	pH (in field)	Conductivity	COD	BOD	DM	SS	NH ₄ -N	NH ₃ -N+H ₄ -N (flit.)	N	P	Chloride
No. of analyses (n)		162	862	138	396	690	764	288	138	324	95	338	276	658
% below detection limit		-	-	-	-	0	1	0	1	0	0	0	0	0
Audebo 13	1990, 1997		x		x	x				x		x	x	x
AV Miljø, shredder waste	1989, 2000-1	x 10												
AV Miljø, Mixed waste 14	1992				x	x	x	x				x		x
BOFA	1999				x	x	x	x		x			x	x
Fakse, old parts	1982-85		x		x 2	x	x	x		x 2				x
Fakse, new cells	1997-99		x		x	x	x	x 12		x		x	x	x
Fladså	1988-91		x		x	x	x	x 12		x		x	x	x
Hasselø Nor	1991		x	X	x 4		x	x 4						x 4
Odense Nord, shredder waste	2002	x	x	X	x	x	x	x	x		x	x	x	x
Odense Nord, mixed waste	1998	x	x	X	x	x	x	x	x	x 3	x 6	x	x	x
Spillepeng	2001	x 10	x	x 10	x	x	x 1		x	x		x	x	x
Uggeløse	1977		x	x 10	x	x	x			x		x		x



Table 3.12 Overview of collected data and selected analysed parameters, part 2. Notes 1: BOD7 instead of BOD5 is measured, 2: First measured from 2005, 3: Only measured in 1999-2000, 4: First measured from 2007, 5: For some samples either TOC or NVOC is measured, 6: First measured from 2002, 7: First measured from 2006, 8: First measured from 2000, 9: Significant part of results below detection limit, 10: Only few samples analysed, 11: Only one cell and first from 2007, 12: Some result as mg/l some as %, 13: Sampling in single cells started in 2006, 14: Only sampled as single unit since 2008.

	Start of operation	SO ₄ ²⁻	HS ⁻	Na	Ca	Fe	K	Mg	Mn	AOX	NVOC	TOC	VOC	Hydrocarbons	Oil
No. of analyses (n)		225	81	95	288	235	69	56	184	85	205	172	94	37	268
%below detection limit		4	46	0	0	0	0	0	1	1	0	0	28	41	65
Audebo 13	1990, 1997	x	x 9	x	x	x	x			x	x			x	
AV Miljø, shredder waste	1989, 2000-1														x 9
AV Miljø, Mixed waste 14	1992														x 9
BOFA	1999	x				x				x	x			x 9	x 9
Fakse, old parts	1982-85														
Fakse, new cells	1997-99	x	x 9	x 10	x	x 10				x	x				
Fladså	1988-91	x	x 9	x	x		x	x							
Hasselø Nor	1991	x 4									x 5	x 5	x 8		x 9
Odense Nord, shredder waste	2002	x				x			x		x 6	x	x 6	x 10	x 9
Odense Nord, mixed waste	1998	x				x			x		x 6	x	x 6	x 10	x 9
Spillepeng	2001					x			x			x			
Uggeløse	1977	x				x			x 10		x 7			x 10	

	Start operation	Phenols	Phenol	Chlor. phenols	Al	As	Cd	Co	Cr	Cu	Hg	Ni	Pb	Zn
No. of analyses (n)		144	85	57	84	124	428	131	368	354	350	371	411	245
% below detection limit		18	5	0	26	2	29	1	8	5	58	2	26	4
Audebo 13	1990, 1997	x	x 9				x 9		x	x	x 9	x	x	
AV Miljø, shredder waste	1989, 2000-1						x 9		x	x	x 9	x	x 9	x 11
AV Miljø, Mixed waste 14	1992				x		x 9	x 10	x	x	x 9	x	x	
BOFA	1999	x 9					x	x	x	x	x 9	x		x
Fakse, old parts	1982-85		x 10											
Fakse, new cells	1997-99		x 10				x 9		x 10	x 10		x 10	x 9	x
Fladså	1988-91	x 9	x										x 9	
Hasselø Nor	1991				x	x 4	x 9		x 4 9	x	x 9	x 4	x 9	x 4
Odense Nord, shredder waste	2002	x	x	x	x 9		x 9		x 9	x	x 9	x	x 9	x
Odense Nord, mixed waste	1998	x	x	x			x 9							x
Spillepeng	2001				x	x	x	x	x	x	x 9	x		x
Uggeløse	1977						x 9		x			x		



An overview of some of the parameters that have been measured less frequently but which are still included in the database is shown in table 3.13. For these parameters only a few leachate samples have been analysed (from 1 to 28); this number is not sufficient for detailed statistics.

Table 3.13 Parameters with limited number of analyses performed. DL: Detection limit.

Parameter	No.	% below DL	Parameter	No.	% below DL
Redox potential	2	0	Sn	6	0
NH ₄ -N (filtrated)	7	0	V	4	0
NO ₂ -NO ₃ -N	16	0	PAH (EPA - 16)	12	50
P (filtrated)	2	0	PAH (9)	6	100
HCO ₃ ⁻	3	0	Naphthalene	17	41
Fluoride	2	0	DOC	2	0
S	1	0	Petroleum (OM)	4	0
B	28	0	Diesel oil (OM)	3	67
Ba	2	0	BTEX	24	~ 40
Si	2	0	Nonyl phenols	4	100
Fe (filtrated)	2	0	DEHP	4	0
Ag	6	100	Chlorinated hydrocarbons	6	67
Mo	2	0	LAS	4	100
Pb (filtrated)	6	17	Phthalates	1	0
Sb	2	100	CN-total	2	50
Se	2	0	Volatile acids	2	0

As seen from tables 3.11-3.13, extensive data are available for some parameters while for others the number of analyses is rather limited. For further evaluation of the data, a few parameters especially relevant with regards to landfills (“model parameters”) have been selected. These parameters are listed in table 3.14 together with the reasons for choosing them.

Table 3.14 Selection of model parameters. DL: Detection limit. * For leachate from TOC and NVOC give very alike results, therefore often only of them is analysed. To give a more complete dataset they are here combined.

Group	Parameters in group	Chosen model parameter	Others parameters with sufficient data for analyses	Reason for choosing model parameter
Anions	Chloride, SO ₄ ²⁻ , HS ⁻ , fluoride, HCO ₃ ⁻	Chloride	SO ₄ ²⁻	Chloride is the substance which has been measured in most eluates and it is a good representative of mobile substances
Heavy metals and trace elements	Al, As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Zn, Fe, Mg, Mn, S, B, Ba, Si, Ag, Mo, Sb, Se, Sn, V	Cu	As, Co, Cr, Ni, Zn, Fe, Mn	For Cu there are many results from many cells. Only 5% of the results are below detection limit. Cu is interesting because it is subject to complexing and increased leaching in the presence of DOC
Organic carbon	TOC, NVOC, VOC, DOC	TOC/NVOC*	VOC	TOC and NVOC combined cover many samples. For inorganic and older landfills they will often be almost identical to DOC.
Cations	Ca, K, Na, NH ₄ ⁺ -N, NH ₄ ⁺ -NH ₃ ⁺ -N,	Ca	Na, (K), NH ₄ ⁺ -N, (NH ₄ ⁺ -NH ₃ ⁺ -N),	Ca is best represented in the data set.
Oxygen demand	COD, BOD ₇	BOD ₅	COD	Many leachates have been analysed for BOD ₅ which provides information on the biodegradability of the substances in the leachate

4 STUDIES ON THE WASTE AND LEACHATE FROM AV MILJØ

4.1 Characterisation of waste

Two of the waste materials from AV Miljø, shredder waste and mixed waste, have been subjected to basic characterisation in terms of environmental properties (content and leaching of substances) and used in lysimeter experiments as described in chapter 2 and Appendices A and B for the purpose of gaining a better understanding of the relationship between the leaching processes at different scales and eventually to be able to predict the duration of the aftercare period based on such results.

4.1.1 Shredder waste

Leaching data obtained for the shredder waste from AV Miljø were added to a LeachXS database developed in this study. Here they were compared with leaching data from shredder waste sample taken from Odense Nord in 2005 (DHI 2006), a shredder waste sample from the Netherlands and shredder waste taken from 3 different shredder plants in Norway (Hjellnes Consult (2008a and 2008b)). For two of the Norwegian plants the waste has been divided into a coarse and a fine fraction. An overview of the leaching tests performed is shown in table 2.1. Note that fully comparable column leaching data was only available for the other Danish landfill (Odense Nord).

Table 4.1 Overview of leaching tests performed on shredder wastes from different locations.

Test methods	AV Miljø	Odense Nord	The Netherlands	Norway
Inorganic parameters				
Batch test at L/S 2 l/kg	X	X		
Batch test at L/S 10 l/kg			X	X
Column leaching test	X	X		
pH-static leaching test	X			
Organic parameters				
Batch test at L/S 2 l/kg		X		
Equilibrium column test	X	X		

Leaching as a function of L/S

A few graphs comparing the results of column and batch tests are shown in figure 4.1 to figure 4.4 for the model parameters chosen for the field data in table 3.14: calcium, chloride, copper and organic carbon (TOC/DOC).

The leaching of the anion calcium is fairly similar for all tested samples. A good agreement between batch and column test performed on the same test material is also seen.

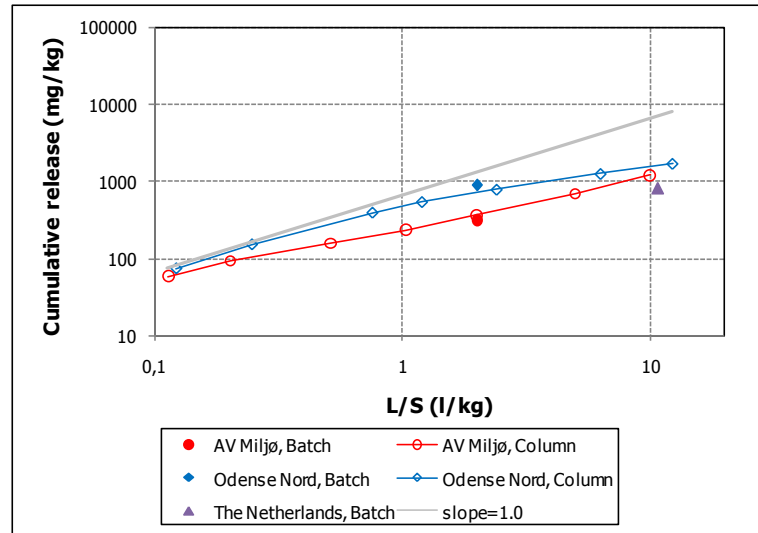


Figure 4.1 Comparison of calcium leaching from different shredder wastes.

The grey line in the figure has a slope of 1 corresponding to the leaching curve of a substance for which the leachability is solubility controlled. As seen the leaching of Ca from the Odense Nord shredder waste is solubility controlled at low L/S, probably controlled by sulphate.

The leaching profiles for chloride from the waste samples are fairly identical, but the released amounts from the AV Miljø shredder waste is slightly higher, than the released amounts from Odense Nord and the Netherlands.

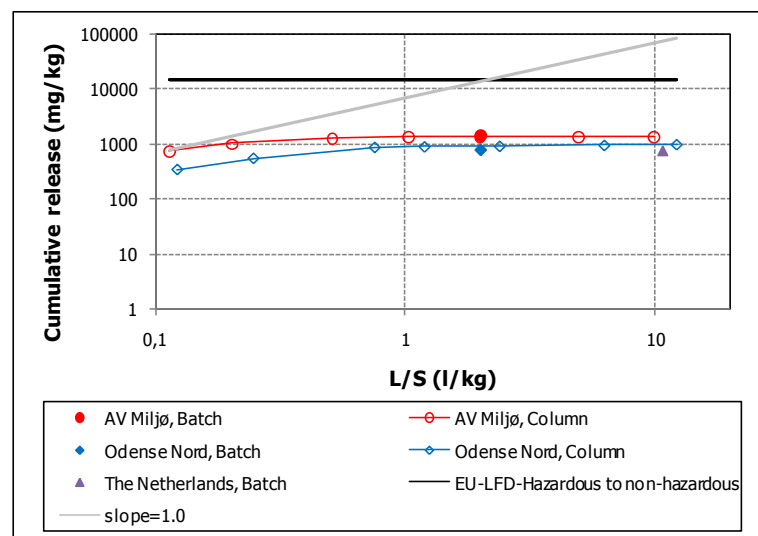


Figure 4.2 Comparison of chloride leaching from different shredder wastes.

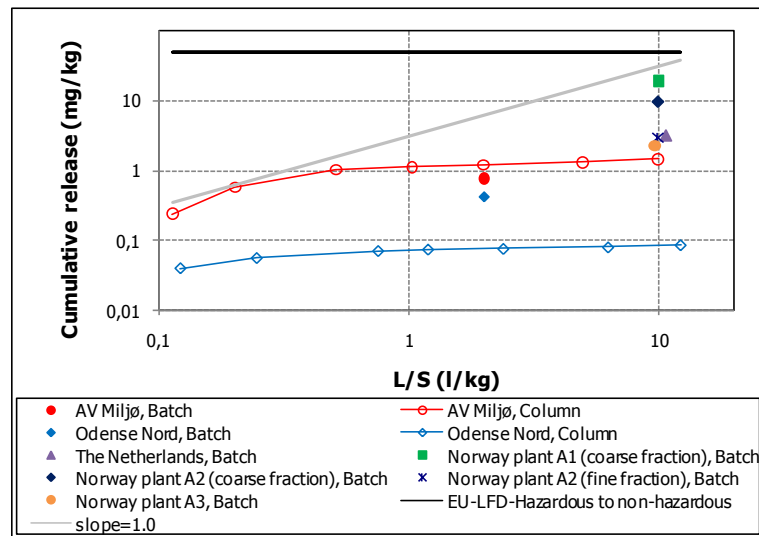


Figure 4.3 Comparison of copper leaching from different shredder wastes. The Norwegian waste from plant A1 and A2 are separated into fine fraction (f) and coarse fraction (c). For A1 leaching test was only performed on coarse fraction.

As for chloride the profiles from leaching test on AV Miljø and Odense Nord are equally shaped, but the released amounts of copper from the AV Miljø shredder waste are significantly higher than the released amounts from shredder waste from Odense Nord. The shredder wastes from other locations are seen to behave mostly like shredder waste from AV Miljø. The reason for the differences between the leaching of Cu from the shredder waste from AV Miljø and from Odense Nord is not immediately obvious, particularly because there are no great differences between the leaching of DOC from the two waste types (see figure 4.4).

The initial leaching of Cu from the AV Miljø shredder waste appears to be solubility controlled. It is noticed that the two samples of coarse fractions from the Norwegian shredder plants leached significantly higher amounts of copper than the other tested shredder wastes.

The batch test result for shredder waste from Odense Nord is seen not to match with the corresponding column test. The setups of two test types are very different, meaning that the conditions for interactions between waste, water and atmospheric air are different. E.g. a change in pH can affect the leaching of elements as copper, this is visualised later for shredder waste from AV Miljø in figure 4.6. The conditions in the column test can be regarded as closer to the situation in the landfill than the conditions in the batch test where the exposure to air is much greater. Copper is sensitive to the redox potential in the sense that it will form precipitates of sulphide with low solubility if the sulphate in the column is reduced to sulphide due to biological activity. This could cause low Cu release from the column and a higher release in the batch test where the material is agitated and exposed to oxidised conditions. However, the leaching results for sulphate in DHI (2006) shows no indication of sulphate reduction.

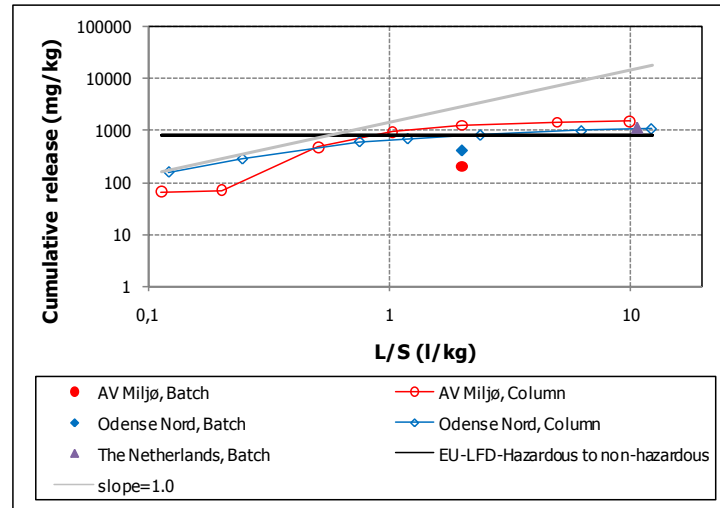


Figure 4.4 Comparison of dissolved organic carbon (DOC) leaching from different shredder wastes.

The leaching of DOC from shredder waste from AV Miljø and Odense Nord are seen to be nearly the same, and the leaching from the Dutch sample corresponds well to the others.

The corresponding batch test result and column test, are seen not to correspond so well, especially not for the sample from AV Miljø. As mentioned regarding copper, the test setups are very different, and in this case the batch test seems to underestimate the leaching potential of DOC from the shredder waste, especially for AV Miljø shredder waste.

Leaching as a function of pH

A pH dependence leaching test has been performed on the shredder waste from AV Miljø. Some results are shown in figure 4.5 for the same model parameters as chosen for the field data, calcium, chloride, copper and organic carbon (TOC/DOC).

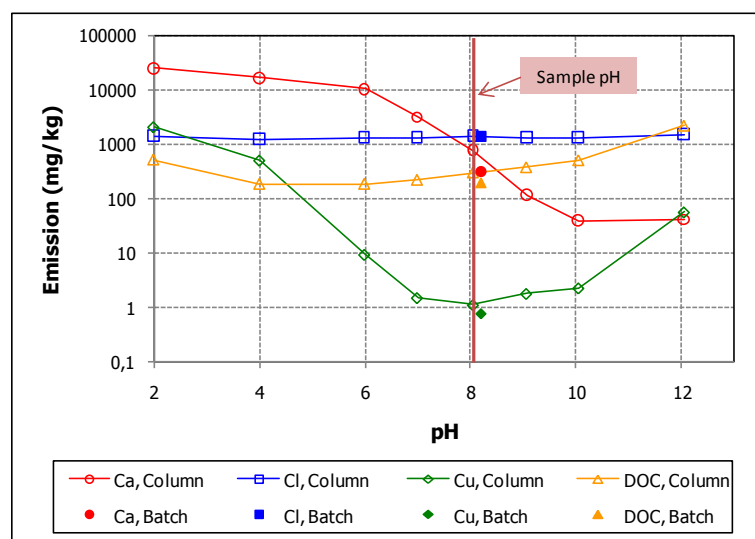


Figure 4.5 pH dependent leaching of selected substances from AV Miljø shredder waste. 'Sample pH' is the original pH value of the column test sample.



For comparison the pH value of the sample is included in the graph in Figure 4.5. A change in pH of one unit to pH 7 or pH 9 is seen not to affect the leachability of copper, chloride and DOC significantly, while the leaching of calcium will be a factor of 4 higher if pH is lowered to 7 and a factor of almost 7 lower if the pH is raised to 9. A decrease of pH to 6 will increase the leachability of Cu by a factor of 10.

Further results of the testing of the pH dependency of the leaching of various trace elements from the shredder waste from AV Miljø (Appendix A) are shown graphically in figure 4.6.

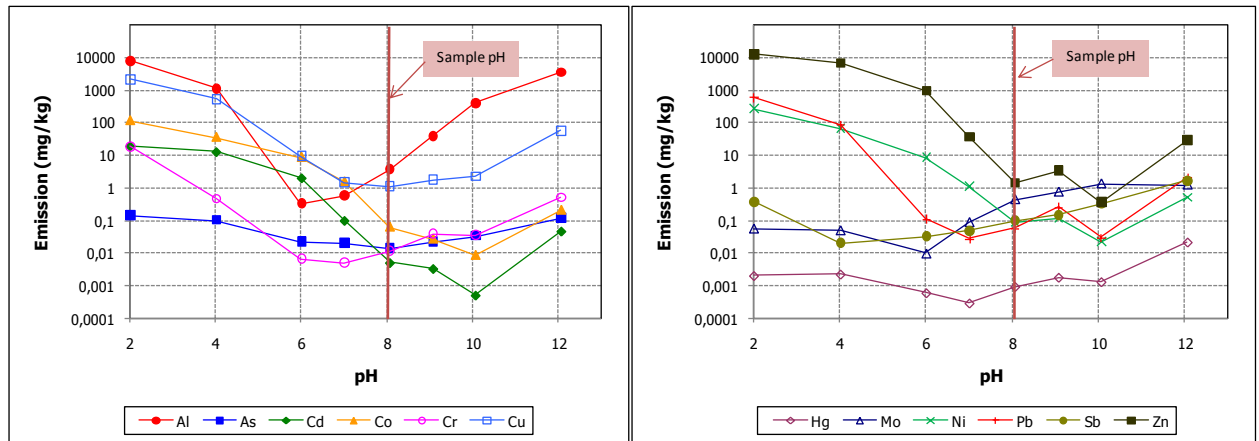


Figure 4.6 pH dependent leaching of trace elements from AV Miljø shredder waste. 'Sample pH' is the original pH value of the column test sample.

A decrease of pH to 7 will cause significant additional leachate of especially cadmium, cobalt, nickel and zinc, while it will cause a decrease of the leaching of aluminium, chromium, mercury, molybdenum, lead and antimony.

An increase of pH to 9 will, on the other hand, cause significant additional leachate of aluminium, and to some extent of arsenic, chromium, lead and zinc, while it will cause a slight decrease of the leaching of cobalt and cadmium.

Generally, a decrease to pH 7 will cause larger changes in leaching behaviour than an increase to pH 9. Based on the conditions in the landfill and the surroundings, an increase in pH is not likely to occur.

The pH of each of the L/S fractions of eluate collected in the column test is measured. The development in pH during the column test is shown in figure 4.7.

The pH changes during the leaching are very small and are not seen as significant. It is noticed that the pH measured in the batch test is slightly higher than the pH range of the column test. This can give deviations when trying to compare results from column tests and batch test, bearing in mind the large variations in leaching as a function of pH seen in figure 4.6.

Included in the graph are also the actual measured pH levels in the 3 shredder waste cells studied at AV Miljø. As seen, they correspond very well with the pH obtained in the column testing.

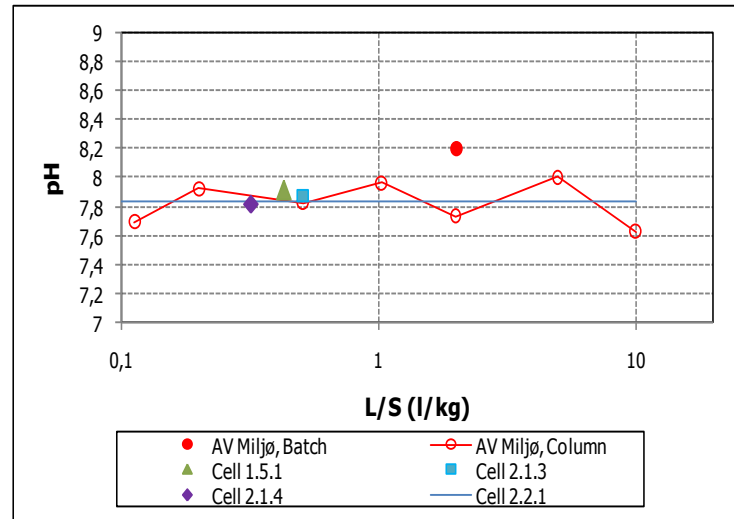


Figure 4.7 pH development in the column test as a function of L/S for AV Miljø shredder waste. Field measurements from AV Miljø cell 1.5.1, 2.1.3 and 2.1.4 are included. L/S for these is based on assumptions of percolation and waste volumes in cells in 2006 (which is last year where regular sampling was performed in cell 2.1.3 and 2.1.4). The field measurement from AV Miljø cell 2.2.1 on sample taken in May 2009.

4.1.2 Mixed waste

The laboratory leaching tests carried out on mixed waste from cell 2.4 at AV Miljø are described in chapter 2 and Appendix B. Since no other leaching tests on mixed waste are available and the column (and lysimeter) leaching results have already been presented in section 2.4.6, only the results of the pH dependence leaching tests will be discussed here.

Leaching as a function of pH

Some results of the pH dependence test on mixed waste from AV Miljø are shown in figure 4.8 for the same model parameters as chosen for the field data, calcium, chloride, copper and organic carbon (TOC/DOC).

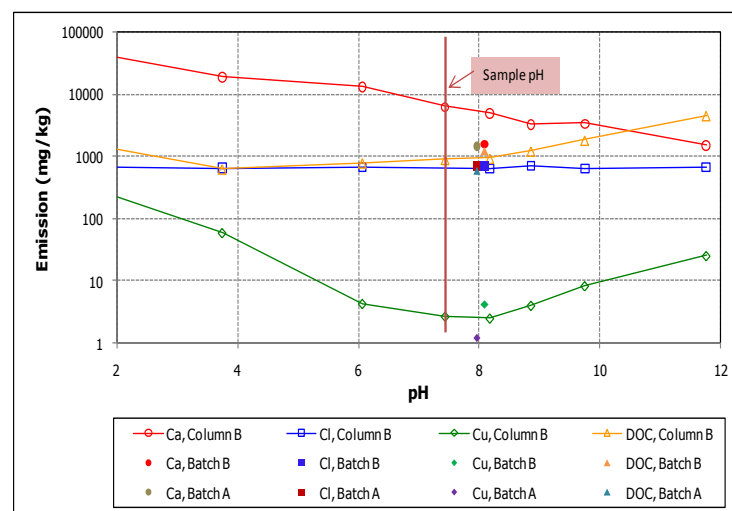


Figure 4.8 pH dependent leaching of selected substances mixed waste from AV Miljø. Batch A is average of the results from batch test on the samples from drum A (see section 2.3.7). 'Sample pH' is the original pH value column test sample.

For comparison the average pH value of the samples (own pH) is included in the graph in figure 4.8. A change in pH of one unit is seen not to affect the leachability of any of the parameters significantly, the largest effect is seen for calcium, where an decrease in pH from 7.4 to 6.4 causes a rise in the amount of calcium leached of a factor of almost 2.

Further results of the testing of the pH dependency of the leaching of various trace elements from the mixed waste from AV Miljø (Appendix B) are shown graphically in figure 4.9. A

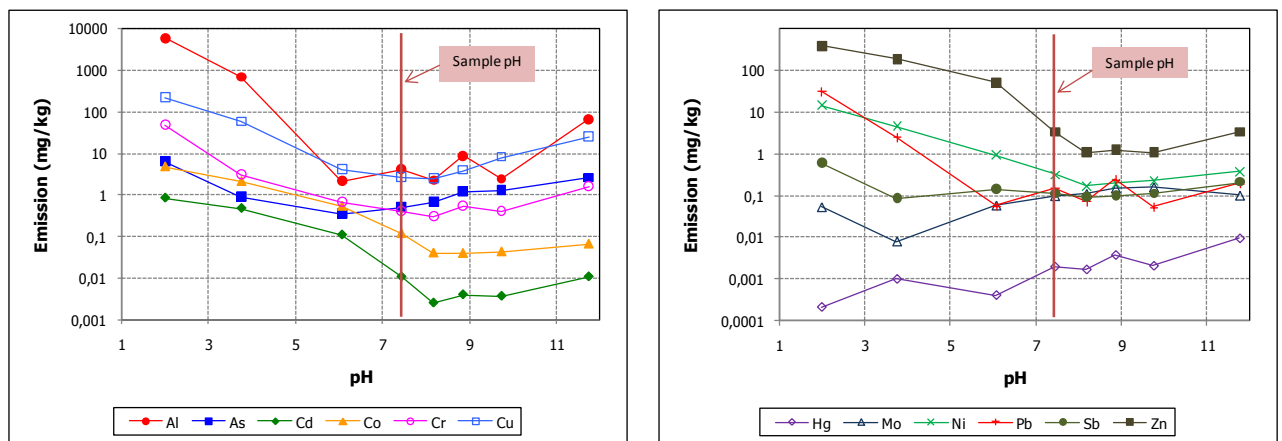


Figure 4.9 pH dependent leaching of trace elements from mixed waste from AV Miljø. 'Sample pH' is the original pH value of the column test sample.

A decrease of pH to 6.4 will cause significant additional leachate of zinc, but also of cadmium, cobalt, chromium and nickel, while it will decrease leaching of aluminium, mercury and lead.

An increase of pH to 8.4 will, on the other hand, cause some additional leaching of arsenic, while it will decrease leaching of cadmium, cobalt, nickel and zinc.

Generally is a decrease to pH 6.4 causing larger changes in leaching behaviour than an increase to pH 8.4.

Compared to the similar graphs for shredder waste in figure 4.6 is noticed that changes in pH generally have much more effect on shredder waste than it has on mixed waste.

The pH of each of the L/S fractions of eluate collected in the column test was measured. The development in pH during the column test is shown in figure 4.10 together with the pH values measured in the batch leaching tests.

From this figure is can be seen that the pH of the batch samples is slightly higher than for the column test sample (0.3 to 0.4 pH units). A similar difference was seen for the shredder waste samples, see figure 4.7.

The leachate sample taken in the field in 2009 from cell 2.4 is seen to be very alike the result from the column test, while pH in unit 1E is slightly lower.

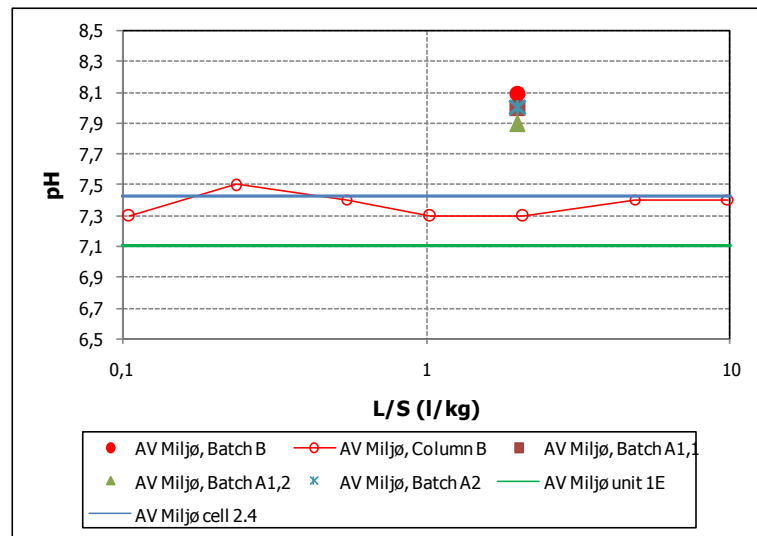


Figure 4.10 pH development in eluate from the column and batch tests on mixed waste from AV Miljø shown as a function of L/S. Field measurements from AV Miljø unit 1E from 2008 and cell 2.4 from 2009 are included.

4.2 Detailed chemical analyses of leachate from AV Miljø

4.2.1 Expansion of the leachate monitoring programme

Leachate from the cells and sections at AV Miljø is sampled and analysed chemically on a regular basis at. The sampling programme and corresponding programme of analyses were expanded during the sampling campaigns in November 2008 and May 2009. The main purposes of the expanded leachate monitoring programme were:

- To study the influence of filtration on the chemical compositions of leachate samples
- To supplement the normal analytical programme for the leachate from hazardous waste (shredder waste) which is very much focused on heavy metals and trace elements and oil with some additional parameters
- To enable the calculation of an ion-balance for the leachate
- To get information on redox potential
- To get information on the parameter DOC (included in the leachate monitoring programme for landfills with permits from 2009 and later)
- To get information on leachate from cells where waste for characterisation has been sampled (cell 2.2.1 and cell 2.4)

The sampling and the analyses were performed by Milana A/S.

In November 2008 the regular sampling program was expanded for the following samples:

- Joint leachate, flow proportional sample
- Joint leachate, random sample
- Leachate from non-hazardous waste, Tap 1E (unit 1E)
- Leachate from non-hazardous waste, well S 1.2 (cell 1.2)
- Leachate from hazardous waste, Tap 1D
- Leachate from non-hazardous waste, well S 1.5.1 (cell 1.5.1)



In connection with the regular leachate monitoring programme in May 2009, samples were taken from the following additional cells:

- Leachate from hazardous waste (shredder waste), well S 2.2.1 (cell 2.2.1)
- Leachate from hazardous waste (shredder waste), Tap 1D
- Leachate from non-hazardous waste (mixed waste), well S 2.4 (cell 2.4)

The results from these additional sampling activities are shown in Appendix C.

4.2.2 Filtered and unfiltered samples

Leachate monitoring programmes are primarily designed to protect the leachate treatment systems (e.g. the wastewater treatment plant receiving the leachate) against hazardous or undesired substances that may be present in the leachate and constitute a potential risk to the treatment systems, depending on the concentration level. The risk is generally considered the same whether the substances are dissolved or present in suspended matter in the leachate, and monitoring samples of leachate are therefore in most cases not filtered prior to chemical analysis. However, from the point of view of understanding the chemistry of the leachate based on the chemical analysis, filtered leachate samples are strongly preferred, and the results are generally interpreted as if all measured substances are dissolved in the aqueous phase. If the leachate is reduced and e.g. contains iron dissolved as Fe(II), exposure to atmospheric air may cause oxidation of the Fe(II) to Fe(III) which is less soluble and forms a precipitate and several trace elements may co-precipitate. If this happens before a sample is filtered, there could be a substantial difference between the composition of a sample before and after filtration.

During regular sampling at AV Miljø the leachate samples are not filtered prior to chemical analysis. For samples taken in November 2008 and May 2009 several parameters were analysed on both filtered and unfiltered leachate samples for comparison (0.45 µm membrane filters were used). Table 4.2 shows an evaluation of the results where the substances are split into three groups: One group for which the concentration decreases significantly due to filtration, another group for which there is a possible or minor decrease due to filtration, and a third group which seems unaffected by the infiltration. The results will, of course, depend very much on the nature of the specific leachates tested, in particular on the content of suspended solids.

The parameters phosphate, iron, lead, cadmium, copper, zinc and aluminium are seen to give very different results depending on whether the samples are filtered before analyses or not. For one sample the concentration of aluminium in the unfiltered leachate was a factor of 85 higher than it was in the filtered sample, possibly due to the very high sensitivity of Al to changes in pH (a slight, but consistent increase in pH as a result of the filtration was observed). For these substances and probably also for chromium, arsenic, barium, molybdenum and antimony, a filtration of samples containing suspended matter prior to analysis might be appropriate if the aim is to evaluate the water chemistry based on dissolved substances. The filtration should take place immediately after or during the sampling to avoid precipitation caused by exposure to atmospheric carbon dioxide or oxygen, release of gasses and resulting changes in pH and redox potential induced by the sampling and storage procedures. The pH and redox potential reported should be measured immediately after sampling, prior to filtration.



The results in table 3.2 also indicate that when field results based on normal leachate monitoring procedures (as the field data collected in this project) where samples seldom or never are filtered prior to chemical analysis, the reported concentrations of some substances in the leachate may include the content of the substances in any suspended matter present in the sample and lead to an overestimation of the concentration of dissolved substances in the aqueous phase. This should be kept in mind when evaluating such data. It could be recommended to report the content of suspended solids and perhaps even the turbidity of the leachate samples in order to facilitate the interpretation.

Table 4.2 Evaluation of the effect of filtration of leachate samples prior to chemical analyses. NA: Not applicable.

Evaluation	Parameters	Factor between pairs where both are above limit of detection	Pairs of results above limit of detection	Pairs of results where only unfiltered sample is above limit of detection
Increase in result due to filtration	pH	1-0,92	NA	NA
Decrease in result due to filtration	P-total	1-7	7	0
	Fe	2-24	7	0
	Pb	4-15	2	0
	Cd	1-25	5	0
	Cu	1-7	2	2
	Zn	3-7	3	2
	Al	24-85	2	0
Possible/minor decrease in result due to filtration	Cr-total	1.0-1.6	3	1
	As	1.0-3.5	7	0
	Ba	1.1-2.0	7	0
	Mo	1.0-2.1	7	0
	Sb	1.3-2.1	2	0
Filtration causes no effect	Sn	0.9-1.8	4	0
	Conductivity	1.0	6	0
	Dry matter	1.0	5	0
	NH4-N	1.0	5	0
	N-total	0.9-1.0	5	0
	Mn	1.0-1.1	5	0
	Chloride	1.0	5	0
	Sulphate	1.0	5	0
	Ni	1.0-1.5	4	0
	HCO3	0.8-1.1	5	0
	Fluoride	1.0-1.1	5	0
	Si	1.0-1.1	5	0
	Ca	1.0	5	0
	Na	1.0	5	0
	K	1.0	5	0
	Co	1.0	5	0
	Se	1.0	5	0
NVOC	0.9-1.2	7	0	
Redox potential	1.0	5	0	
Not possible to evaluate	CN-total	1.0	1	0
	Ag	NA	0	0
	Hg	NA	0	0



When leachate quality data are used in contexts related to assessments of the duration of the aftercare period and achievement of final storage quality, it will generally be the concentrations of substances in the aqueous phase that are of primary interest, since these assessments in most cases involves (modelling of the) transport of the leachate and the dissolved substances through soil and/or groundwater where any suspended matter will be filtered off.

4.2.3 Leachate from hazardous and non-hazardous waste

The leachate samples taken from unit 1E and cell 1.5.1 in November 2008 and from well 2.2.1 and well 2.4 in May 2009 are here of special interest. Unit 1E and especially cell 1.5.1 are selected as representative unit/cells for respectively mixed waste and shredder waste. These cells are to the extent possible used in the comparison with cells from other landfills containing similar waste types. The cell 2.2.1 and 2.4 are interesting because it was from these cells that the samples for characterisation of respectively shredder waste and mixed waste were taken in 2006. A few characteristics of the leachate from these cells are shown in table

Table 4.3 General chemistry for leachate from cell 2.2.1, 1.5.1, 2.4 and unit 1E. The determination of ionic strength and the ionic charge balance are based on measurement the analysis of the filtrated samples.

Unit:	Cell 2.2.1	Cell 1.5.1	Unit 1E	Cell 2.4
Waste type:	Shredder	Shredder	Mixed	Mixed
<i>Water chemistry</i>				
pH (-)	7.84	7.5	7.2	7.43
Redox potential (mV)	-202*	197	95	-105*
Conductivity (mS/m)	1732	530	1230	1063
Ionic strength (mol/l)	0.19	0.06	0.13	0.13
Ionic charge balance**	-5.2 %	13 %	7.0%	-9,4 %

* : As measured in the field and therefore (probably) not corrected for the hydrogen standard electrode potential by adding approximately 210 mV.

** : Based on the expression $(C-A)/(C+A)/2$, where A is the sum of cationic charges and C is the sum of cationic charges of sodium, potassium, calcium, magnesium and ammonia, and A is the sum of the anionic charges of chloride, sulphate and bicarbonate.

Redox potentials as seen here of ± 200 mV are indications that nitrate reduction and iron(III) reduction is taking place in the landfill cells. Reduction of sulphate to sulphide should not take place (provided the measured redox potentials from cells 2.2.1 and 2.4 have not been corrected).

pH is seen to be near neutral and is very similar for all cells/units.

The conductivities correspond reasonably well with the values that could be expected on the basis of the column leaching results. The high value of the conductivity of the leachate from cell 2.2.1 could be somewhat influenced by the fact that the cell was used for MSWI acid gas cleaning residues before it was filled up with shredder waste.

The ion charge balance indicates that the main composition of the leachate is reasonably well described by the chosen analytical programme.



4.3 Details on cell 2.1.3, 2.1.4, 1.5.1 and unit 1E

Four cells/units were selected for further studies. The selection of cells/units focused on the cell history and it was high priority that the cells should only have received either shredder waste or mixed waste.

Some of the cells that now contain shredder waste have earlier contained MSWI air pollution control (APC) residues, hence these cells cannot be included, since the leachate may be expected still to be affected by the APC residues. For cells containing hazardous waste, e.g. shredder waste, regular sampling has been performed until 2006. The selected cells, 2.1.3, 2.1.4 and 1.5.1 have not contained APC residues and the leachate has been sampled and analysed from start of operation until 2006. Cell 1.5.1, though, contains other types of hazardous waste than shredder waste.

In 2006 the sampling procedure was changed and leachate from several cells containing hazardous waste is now mixed before sampling. For two cells regular sampling has continued after 2006. One of these cells is the selected shredder cell 1.5.1.

Before 2006, no regular sampling was performed on cells containing mixed waste, except for cell 1.6, where a hole for depositing of sludge has been placed. However, today (2010) that cell contains temporarily stored combustible waste and it is therefore not relevant for the study.

The leachate from several cells is now mixed before sampling. Unit 1E is seen as a regular unit with mixed waste. The unit consists of the cells 2.1.2.2, 2.1.2.3 and 2.2.2. The two latter have been filled up and final covering has started, whereas cell 2.1.2.2 is still in operation (2010). Earlier some temporarily deposited combustible waste has been placed in these cells during operation, but today they are expected only to contain mixed waste. Details on the content of the selected cells

Details on the types and amount of waste in the selected cells/units have been obtained as excel files from AV Miljø. The excel sheets are not suitable for printing and have therefore not been included in the report. They can be obtained as excel files from DHI upon request. An overview of the main fractions in the cells/units is given in figure 4.11. From the figure it can, as mentioned, be seen that cell 1.5.1 contains other waste types than shredder waste, whereas cell 2.1.3 and 2.1.4 have high shredder waste fractions.

The various operation periods for the cells/units are listed in table 4.4, which also shows when the cells have been covered by plastic liners and therefore not producing leachate. The cells selected for this study has never been covered by plastic liners. Further details are shown in Appendix F.

Table 4.1 Operation period for cell 1.5.1, cell 2.1.3, cell 2.1.4 and unit 1E.

	Cell	Waste type	Start operation	End operation	Start covering	End covering
	1.5.1	Shredder	1989	2000	2001	Not ended
	2.1.3	Shredder	2000	2004	2005	Not ended
	2.1.4	Shredder	2001	2005	2006	Not ended
Unit 1E	2.1.2.2	Mixed	2002	Not ended	N/A	N/A
	2.1.2.3	Mixed	2001	2004	2008	Not ended
	2.2.2	Mixed	1992	2000	2008	Not ended

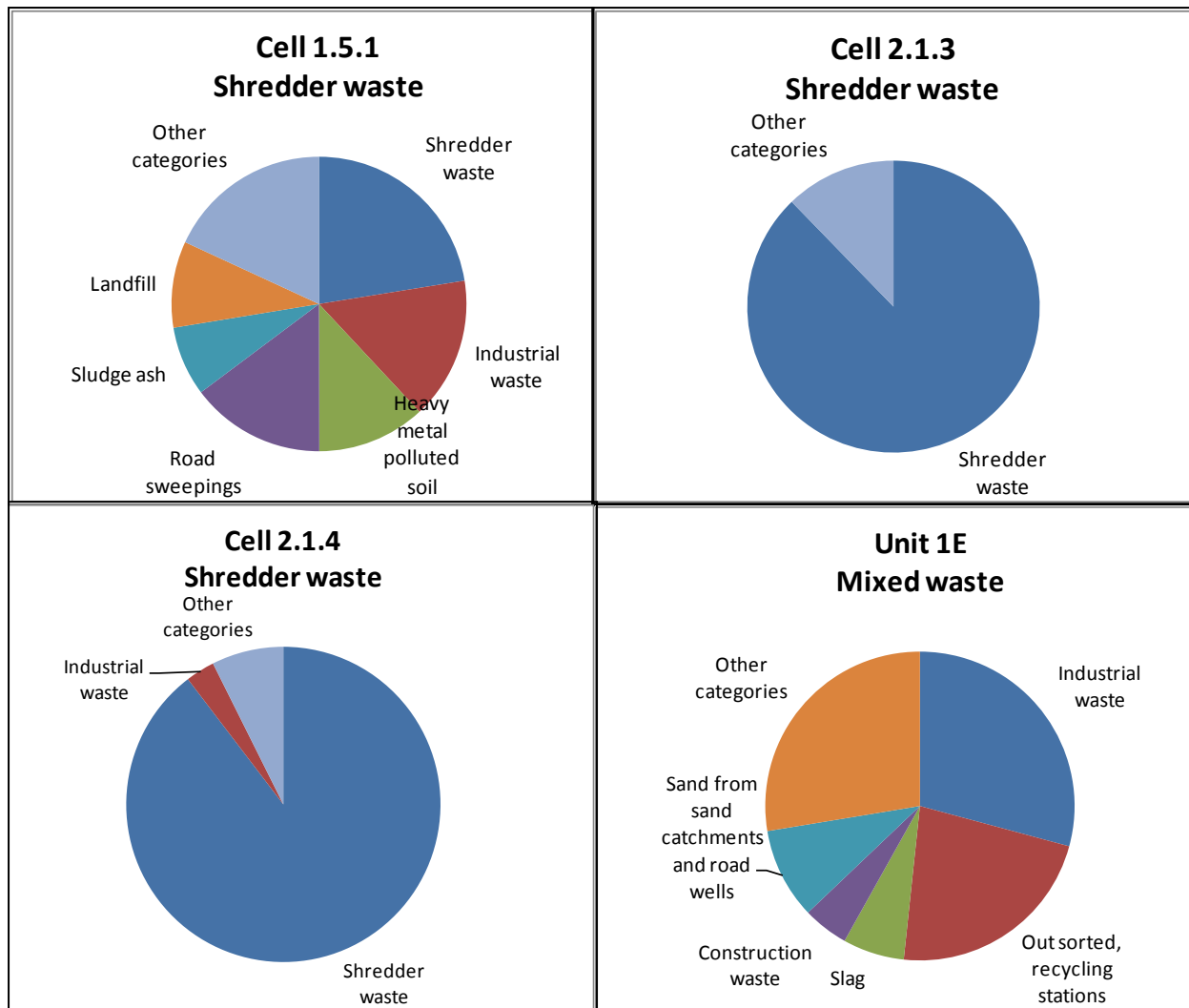


Figure 4.11 Distribution of the main waste types in cell 1.5.1, cell 2.1.3, cell 2.1.4 and Unit 1E.

4.4 Leached amounts over time

The leaching of the pollutants from the waste at AV Miljø over time has been calculated based on data collected from the cells for which water balances (produced volumes of leachate) have been measured regularly and where reasonably frequent chemical analyses of the leachate from each cell are available. In addition, if the results are to be expressed relative to the amount of waste in the cell (in mg/kg or g/tonne of waste) as a function of time, the approximate amount of waste deposited per year should also be known. There are only sufficient data available for such calculations for the substances copper, chromium and nickel from the shredder cells 1.5.1, 2.1.3 and 2.1.4.

From the information on the actual leachate production and the concentration of the three substances the leached amounts of the substances were calculated for every year since the start of depositing at the cells. The leached amounts of the substances are accumulated over the years and related to the corresponding amount accumulated of waste

landfilled at the site. The results for shredder waste from AV Miljø are shown in figure 4.12 as a function of time.

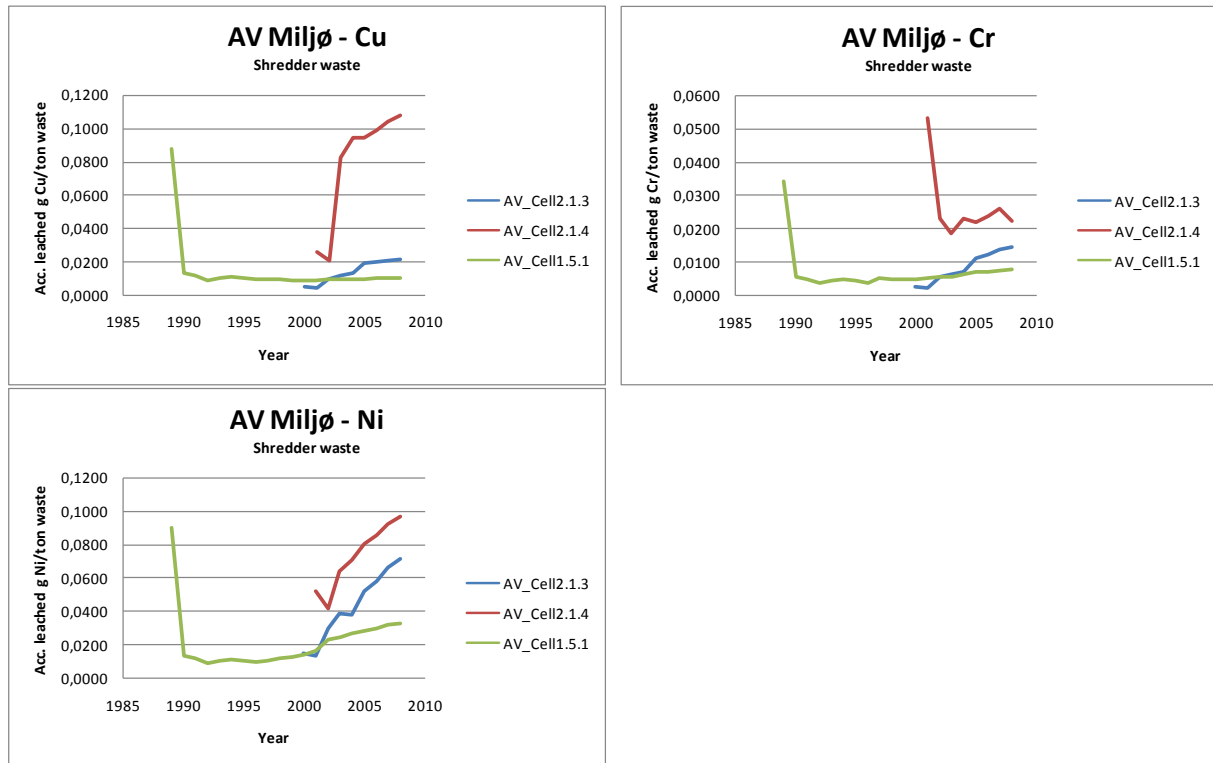


Figure 4.12 Accumulated leached amounts of copper, chromium and nickel per ton waste from the AV Miljø shredder cells 2.1.3, 2.1.4 and 1.5.1.

The accumulated amount of substances leached at start of the depositing period is heavily influenced by the waste amounts and is seen to actually show an initial decrease. This effect occurs when the cell is filled up relatively quickly with waste or with relatively large annual amounts of waste when the annual infiltration of precipitation does not increase or even decreases due to absorption in new layers of waste. This effect disappears with time, if not before then when the cell is filled up. In addition, analyses of the leachates are sometimes missing for the first year(s) for the cells shown on figure 4.12, which makes the curves less reliable for the initial period.

For the AV Miljø shredder cells it is noticed that the leached amount of the heavy metals, especially copper, is significantly higher from cell 2.1.4 than from the two other shredder cells.

The leaching from the waste in cell 1.5.1 could be expected to be somewhat different from the other cells since it contains much less shredder waste than the others, see figure 4.11. The leaching of the three substances is, in fact, consistently lower from this cell than from the two cells dominated by shredder waste.



5 COMPARISON OF LEACHATES FROM DIFFERENT LANDFILLS

5.1 Factors that influence the comparability of the landfills

As mentioned before, the quality of the data material collected from the different landfills differs significantly from site to site, which complicates or renders comparisons impossible.

At some sites leachate analyses have been performed once a month, at others once a year. For some sites an extensive analytical programme has been performed, while at other locations only few parameters have been measured. Some of the analytical laboratories involved operate with high detection limits and have many values below detection limits, while others operate with low detection limit and a minimum of results below limit of detection.

There is a similar variation in the quality of the data on water balances and produced volumes of leachate. At some sites leachate is collected from a single cell, and at other sites it is collected for all cells at one location. Some sites have registered leachate volumes per month while others only register the volume once per year. For the older sites, leachate volumes are often determined on a monthly basis today, while leachate volumes were not registered or only registered on an annual basis during the first period of operation of the landfills. Finally, the data on landfilled waste can also vary widely in detail. In some cases is a detailed list of yearly amounts and waste types given, while in other cases only the final amount and the years of operation are given.

Other factors that may prevent or disturb a comparison between different landfill sites and different cells or strongly reduce the production of leachate include the placement of a bottom layer of e.g. household waste or slag or covering with a top liner. Some examples of such issues are listed below for the landfills included in the study:

- Audebo Landfill: 2->2 m combustible waste is placed as bottom layer
- BOFA Landfill: 0.3 m slag is placed as bottom layer
- Haseelø Nor Landfill: Shredder cell is covered with a topmembrane
- Odense North Landfill: In mixed waste cell is a bottom layer of 1 m household waste. In shredder waste cell is a bottom layer of 0.75 m bio-compost.
- Spillepeng Landfill: Swedish waste generally contains more organic waste than Danish waste
- Uggeløse Landfill: The landfill operations started here in 1977 and some organic waste must be expected there.



5.2 Comparison of accumulated release from different landfills

In an attempt to compare the release of the “model” substances (chloride, Ca, Cu and DOC/NVOC, see section 3.4.3) from the different landfills, the accumulated release as a function of time of those of the model substances for which data were available have been calculated similarly to the calculations carried out for AV Miljø in section 4.4 on the basis of the annual volume of leachate produced, the accumulated amount of waste placed in the landfill cell and average concentrations of the substances included.

Table 5.1 provides an overview of the background information for estimation of the annual leachate volumes produced.

Table 5.1 Basis for estimation of leachate volumes.

Landfill	No. of cells	Waste type	Leachate measurement	Comment
Audebo	3	Mixed	Cell, since 2006	Only leachate data from 2006-2008 is obtained, the cells have been operation since 1990/1997. Accumulated amount can therefore not be estimated.
AV Miljø	4	Mixed and shredder	Site	Based on information on area and plastic covering of cell is leachate estimated per area unit in included cells.
BOFA	1	Mixed	Site	Only leachate volume for 2008 has been estimated by BOFA. BOFA have seen good correlation to rainfall. 45% of yearly rainfall is estimated to end as leachate.
Fakse	5	Mixed	Site	Based on information on area leachate is estimated per area unit in included cells.
Fladså	3	Mixed	Cell	Actual pump data for cell
Hasselø Nor	1	Shredder	Site	During operation estimates of leachate volumes are based on area information and leached is estimated per area unit in cell. After covering with top membrane 10 mm of rainfall per year is expected to penetrate the cell.
Odense North	2	Mixed and shredder	Cell	Actual pump data for cell
Spillepeng	1	Mixed	Site	Actual pump data for cell. The pumping area is known not to fully match the cell boundaries.
Uggeløse	1	Mixed	Site	Uggeløse consists of two cells, but leachate from one cell is lead to the other cell, meaning that leachate volumes and analyses performed in the latter cell can be seen as results from one big cell. Leachate volumes is measured since 1981 in one cell, while the second was connected to the system in 1987. The cells have been in operation from respectively 1977 and 1979.

The other input needed is an average annual concentration of the substances in question in the leachate, which often is easy to calculate. If data were missing for some measurements, there are estimated based on relevant data. E.g. if the concentration of chloride has not been measured in 2004, it is estimated based on the concentrations measured in 2003 and 2005.

The leaching of the model parameters copper, chloride, TOC/NVOC and calcium, has been calculated based on data collected from the different sites. The results are shown in figure 5.1.

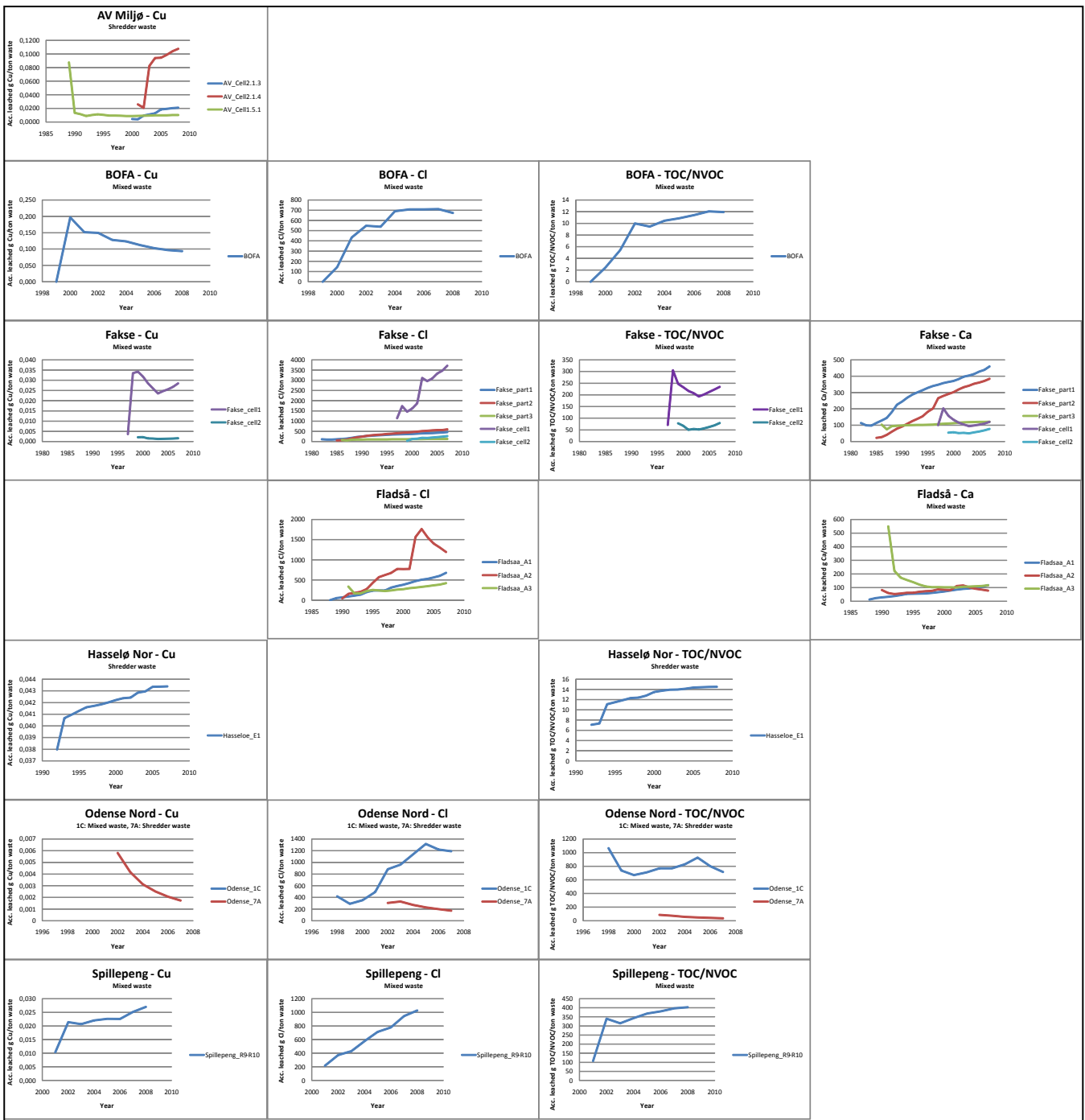


Figure 5.1 Accumulated leached amount of model parameters per ton waste (mixed waste and shredder waste) from AV Miljø, BOFA, Fakse, Fladså, Hasselø Nor, Odense Nord and Spillepeng.

It is difficult to see a general trend in the results in figure 5.1. A sudden decrease in the accumulated leached amount of a substance per tonne of waste is probably an indication that new waste has been added to the site. The decreasing curves for Cell 7A from Odense is probably caused by the very low or lacking production of leachate due to a

high degree of compaction (and a high filling height) of the shredder waste landfilled there. It is interesting to see the high level of release of chloride and DOC (or TOC/NVOC) from Cell 1 at Fakse Landfill, it is significantly higher than it is in the leachates from BOFA and Fladså. When the leachate quality approaches final storage quality, i.e. the end of the aftercare period, the curves in figure 5.1 may be expected to be almost horizontal or exhibit only a very slight increase.

5.3 Relation between field leaching and laboratory testing

5.3.1 Shredder waste

The estimated L/S and cumulative release of three of the four modelling parameters have been expressed as a function of L/S and compared to the results of the laboratory column and batch testing on AV Miljø shredder waste (see chapter 2). Only copper, chloride and organic carbon have been measured in the field. The results are shown in figure 5.2.

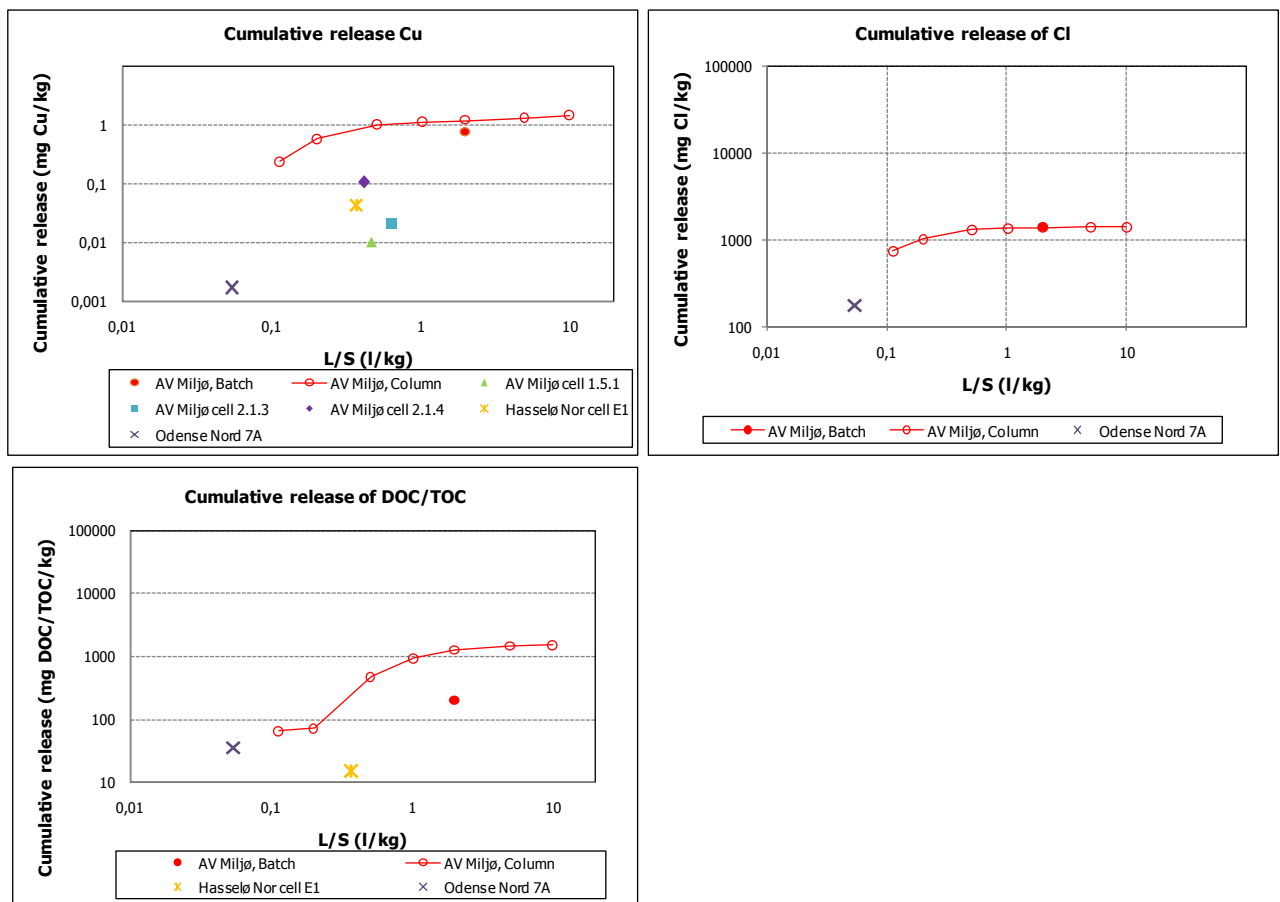


Figure 5.2 Comparison of copper, chloride and organic carbon (DOC in laboratory test and TOC or NVOC in landfill leachate) leaching from laboratory column and batch test and landfill leachate from shredder waste cells at AV Miljø, Hasselø Nor and Odense Nord. The data for landfills are including leachate volumes and waste amounts until 2008 (inclusive).

For all parameters is seen that the release in the laboratory column test is larger than estimated for the landfill leachate at AV Miljø, Hasselø Nor and Odense Nord, particularly for copper. The results for Odense Nord for chloride and DOC could actually be interpreted as fitting an extension of the column data to low values of L/S.

The shredder wastes at AV Miljø and Hasselø Nor originates from different waste producers. Due to the very limited number of results shown and the uncertainties involved, it is difficult to draw any firm conclusions from figure 5.2. The fit between laboratory and field data is worst for Cu. This would be consistent with the assumption that there would be a low redox potential in the field but not in the column test, and the reduction of sulphate to sulphide in the field would then precipitate copper. This is also consistent with observations made in recent studies e.g. at Reno Djurs.

5.3.2 Mixed waste

The estimated L/S and cumulative releases of the four modelling parameters from four landfills with mixed waste have been compared to the results of the laboratory column and batch testing on mixed waste from AV Miljø. The results are shown in figure 5.3.

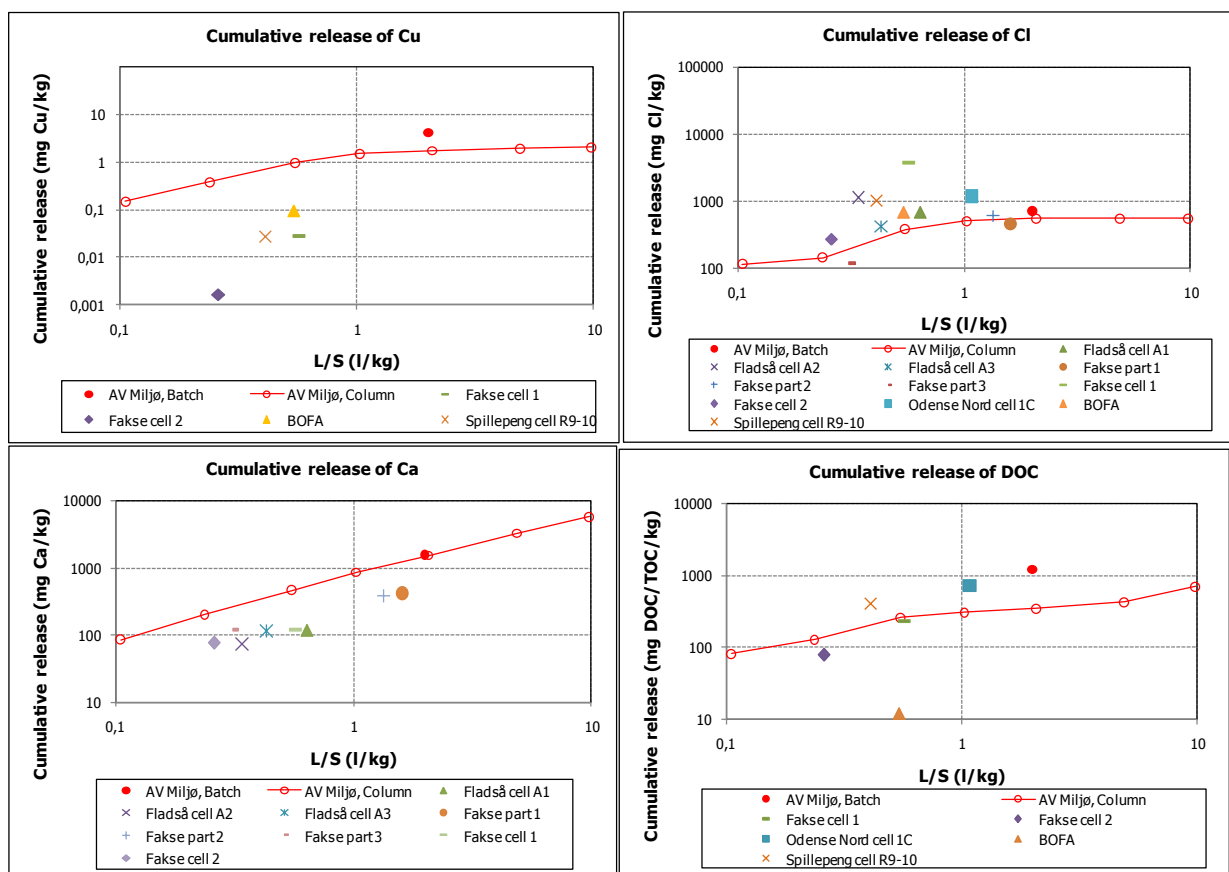


Figure 5.3 Comparison of copper, chloride, organic carbon (DOC in laboratory test and TOC or NVOC in landfill leachate) and calcium leaching from laboratory column and batch test with landfill leachate from mixed waste cells at AV Miljø, Fakse, Fladså, Spillepeng, BOFA and Odense Nord. Numbers for landfills are including leachate volumes and waste amounts until and including 2008.



For copper and calcium it is seen that the artificial leaching in the column test is larger than estimated for the landfill leachate from cells with mixed waste. The behaviour of copper resembles that observed for leachate from shredder waste (figure 5.2).

For chloride, calcium and DOC most of the results are of the same order of magnitude for the column test and the landfills. The results for Ca appear to be solubility controlled in both cases (a slope of approximately 1), and the moderate difference between laboratory and field results may possibly be explained by differences in sulphate concentration and/or ionic strength, but the uncertainty of the calculation of L/S for the landfills could also contribute.



6 MODELLING OF LEACHATE BEHAVIOUS

6.1 Brief review of leachate models

A brief literature survey of models relevant for predicting the quality (and quantity) of leachate from landfills has been carried out. The aim was to review some examples of models that might be applicable to assessments of the quality and quantity of leachate from landfills.

Many models have been developed to describe the processes in landfilled municipal solid waste (MSW), where the main issue is biodegradation. In the case of mixed waste and shredder waste such processes are of less importance (although smaller parts of the wastes will be biodegradable and will influence the conditions in the landfill). Instead, the leaching of substances from the waste and the chemical processes occurring in the inorganic parts of the waste, changes in pH and redox potential due to these processes and exposure to the environment, and in turn the influence of these changes on the chemical processes. The release of substances from the waste by leaching is to a large extent controlled by the presence (and formation) of minerals and the presence of various salt.

A model which can describe the source term, i.e. the release of substances with the leachate, as a function of time based on input data derived from the physical scenario and environmental/chemical characterisation of the waste in a landfill, would be ideal. Some models focus only on the source term and processes in the landfill, while others integrate both source term and subsequent transport through the unsaturated and/or saturated zone (the pathway) to a point of compliance (the receptor).

The main criteria for a source term model suitable for this project would therefore be that it should focus on leaching processes and source strength, not on biodegradation and gas production.

An overview of the literature studied and the main models considered is shown in table 6.1. The result of the literature study is presented by dividing the results into four groups:

1. Simple models with simple equations for e.g. concentration in leachate
2. Computer models for landfill, including leaching, biodegradation and gas production
3. Geochemical models, e.g. specialised for landfills
4. Other computer models, e.g. mathematical or hydrodynamic
5. Models/methods with focus on MSW

The survey was by no means meant to be exhaustive or all-encompassing and the choice of model was of course somewhat biased by the fact that jointly with ECN in the Netherlands and Vanderbilt University in the USA, DHI owns the database/expert system LeachXS which has extensive speciation modelling capabilities. DHI therefore has easy access to this modelling tool.



Table 6.1 Overview of literature studied. References marked with > are background documents for selected models.

No.	Group	Studied references	Models considered
1	Simple models	> (Doka 2004) > (Miljøstyrelsen and DHI 2006) (Sanchez and Kosson 2005)	Ecoinvent 2000 (partly) CSTR-model
2	Computer models for landfills	(Slack, et al. 2007) (Golder 2008) (Schroeder, et al. 1994) (Bou-Zeid and El-Fadel 2004) > (de Cortazar and Monzon 2007) > (de Cortazar and Monzon 2007)	LandSim MODUELO2
3	Geochemical models	> (Halim, et al. 2005) > (van Zomeren, et al. 2006) (Mathlener, et al. 2006) (De Windt, Badreddine and Legneau 2007)	Leach XS
4	Other computer models	(Yildiz, Ünlü and Rowe 2004) (GroundwaterSoftware.com 2008) (Ozkaya, Demir and Bilgil 2006)	
5	Models/methods with focus on MSW	(Gisbert, et al. 2003) (Kindlein, Dinkler and Ahrens 2003) (Zacharof and Butler 2001) (White, Robison and Ren 2004) (Ustohalova, Ricken and Widmann 2006) (Kouzeli-Katsiri, Bosdogianni and Christoulas 1998)	

It was concluded that the main part of existing models focus on municipal solid waste (MSW), which contains too much biologically degradable material to be comparable to shredder waste and mixed waste. It was therefore decided only to attempt to perform modelling with the LeachXS computer model. Leach XS has been applied extensively speciation of a wide range of wastes and materials, including soil and mixtures of wastes resembling mixed waste. For speciation purposes LeachXS applies the same basic thermodynamic database as for example PHREEQC and other models but it also has a powerful ability to take into account the influence of dissolved organic matter (DOC) on the leachability of inorganic substances. It was decided to attempt to investigate if LeachXS can be used to describe the speciation and release of substances by leaching from shredder waste.

6.3 Modelling with LeachXS

The LeachXS tool using the ORCHESTRA modelling environment was used for geochemical modelling of both pH dependence leaching behaviour and percolation data from AV Miljø. The ORCHESTRA embedded MINTEQA2 thermodynamic database was used for all calculations.

In general, modelling of pH dependence leaching behaviour consists of several consecutive steps including:



- 1) speciation calculation using solution concentrations determined in the pH dependence leaching test
- 2) identification of potential solubility controlling minerals based on their saturation index ($-1 \leq SI \leq 1$), literature study, and probability of occurrence under experimental conditions
- 3) recalculation of the solution speciation using those minerals as the controlling ones (at this step, the other potential controlling processes e.g. complexation with dissolved organic carbon and/or surface sorption on hydrous ferric oxides may be included in the calculation)
- 4) comparison with the original experimental data
- 5) changes in the mineral input list (and/or in complexation/sorption parameters) in order to improve the fit with experimental data (if needed)
- 6) repeating step 3

LeachXS is structured in such a way that modelling of pH dependence leaching behaviour must precede percolation modelling since the information on mineral solubility as a function of pH is crucial for the latter. In the percolation modelling exercise, the information on total contents of elements in solid phase is coupled with the pH dependence leaching data while various physical parameters (e.g. active/inactive porosity, flow velocity, diffusion, etc.) are considered in an effort to mimic the results of percolation experiments. Below a detailed description of the pH dependence modelling exercise on shredder waste is given.

6.4 Modelling, the pH dependence case

As mentioned in section 6.3, during the pH dependence modelling the influence of additional parameters such as concentration of dissolved organic carbon (DOC) and hydrous ferric oxide (HFO) may be taken into account. It is also possible to specify the fractionation of the DOC consisting of dissolved humic acid (DHA). Note that DHA is the truly reactive fraction of the total DOC contents which is determined analytically. The model performance is then optimised by adjusting these parameters as well as testing the model with different minerals (mentioned in the previous section).

6.4.1 Mineral set

As a result of the iteration procedure described in section 6.3, the resulting final list of the solubility controlling minerals for shredder waste appeared to consist of the following 20 minerals:

- | | |
|---|--|
| • Barite | BaSO_4 |
| • Brochantite | $\text{Cu}_4(\text{SO}_4)(\text{OH})_6$ |
| • Calcite | CaCO_3 |
| • CaZincate | $\text{CaZn}_2(\text{OH})_6 \cdot 2\text{H}_2\text{O}$ |
| • $\text{Cd}(\text{OH})_2[\text{C}]$ | |
| • $\text{Cd}_4(\text{OH})_6\text{SO}_4$ | |
| • Clinoenstatite | $\text{Mg}_2\text{Si}_2\text{O}_6$ |



- Cr₂O₃
 - Fluorite
 - Gibbsite[C]
 - Hausmannite
 - Na-Jarosite
 - Laumontite
 - Ni₂SiO₄
 - Pb(OH)₂[C]
 - Zincite
 - AA_2CaO_Fe₂O₃_8H₂O[s]
 - AA_3CaO_Al₂O₃_6H₂O[s]
 - AA_3CaO_Al₂O₃_6H₂O[s]
 - AA_CaO_Al₂O₃_10H₂O[s]
 - AA_Fe(OH)₃[am]
- | |
|--|
| CaF ₂ |
| Al(OH) ₃ |
| Mn ₃ O ₄ |
| NaFe ₃ (SO ₄) ₂ (OH) ₆ |
| CaAl ₂ Si ₄ O ₁₂ :4H ₂ O |
| ZnO |
| solid solution |
| solid solution |
| solid solution |
| solid solution |

Note that some of the names used above refer to mineral names used in the LeachXS database; they do not necessarily reflect proper nomenclature.

In addition, the following parameters were selected/used:

- The amounts of solid humic acid (HSA) was set to 0.0005 kg/kg
- The sum of pH and pE was set to 13. This represents mildly reduced conditions
- The DHA/DOC ratio was kept at the LeachXS default value of 0.2 (20% of DOC is present as DHA)
- The amounts of HFO were set to 0 kg/kg. This effectively eliminates surface sorption/complexation
- Carbonate was not been measured in the test sample. A concentration of 7.7 mg HCO₃⁻/kg was included.

The results in terms of predicted and measured concentrations and the partitioning between the liquid and solid phases of a number of elements are shown in Appendix G. As it can be seen, the prediction of the leachability of some elements fit nicely with the results of the pH dependence test, but for several elements the prediction was not really successful, and it was concluded that further progress could not be achieved without a major effort that would exceed the framework of the study. It was therefore decided not to apply the modelling to the percolation case.

6.4.2 Sensitivity analyses

The sensitivity of the model was tested by changing the values of HSA, the sum pH + pE, and DHA respectively. An overview of the impacts from these changes on results of the modelling is given in table 6.2.



Table 6.2 Sensitivity testing of the pH dependence modelling results to changes in HSA; pH+ pE and DHA.

Parameter	Original value	Variation	Effect	Conclusion
HSA	0.0005 kg/kg	0.0001 kg/kg	None	<p>Extreme content of HSA is needed to have effect on modelling result.</p> <p>An estimate of HSA is 2*TOC concentration. For the shredder it is 0.00036 kg/kg.</p>
		0.001 kg/kg	None	
		0.01 kg/kg	<p>Very small change for Cd²⁺.</p> <p>Minor change for CrO₄²⁻</p>	
pH + pE	13 (10-15 mildly reduced conditions)	9 (< 10 reducing conditions)	<p>The curve for pH- pE is off track of the measurements. Ba²⁺, Fe³⁺, SO₄²⁻ and Mn²⁺ less correlation between model and measured values.</p>	Mildly reduced conditions seems appropriate for the shredder waste modelling
		17 (>15 oxidized conditions)	SO ₄ ²⁻ and CrO ₄ ²⁻ less correlation between model and measured values.	
DHA	20 % of DOC	Used a set of measured DHA data for another waste type.	None	
		5 % of DOC	Insignificant effects on several metal ions. Positive effect on CrO ₄ ²⁻ and Cu ²⁺	Cu ²⁺ mobility decreases as complexation decreases
		80 % of DOC	For Fe ³⁺ , Mn ²⁺ and Cu ²⁺ less correlation between model and measured values.	

6.5 A simplified assessment of the aftercare period

Under certain conditions, and when the physical layout and hydraulic/water balance situation for a landfill or a cell is known the L/S scale may be converted to a time scale for that particular utilisation scenario. This can be done by means of the following equation (Hjelmar, 1990):

$$T = (L/S) \times d \times H/I \quad (6.1)$$

where

T is the time since the production leachate from the application started (years)

L is the total volume of leachate produced at time T (m³)

S is the total mass of aggregate used in the application (tonnes, dry mass)

d is the average dry bulk density of the aggregate in the application (tonnes/m³)



H is the average height of the application (m)

I is the annual net rate of infiltration of precipitation (m^3/m^2)

It is assumed that percolation of the infiltrated precipitation is the sole source of leachate in the application. The application of the equation is also based on an overall, average consideration of the landfill or cell in question, i.e. on the assumption that the flow of infiltrating precipitation is fairly uniform. The lysimeter tests reported in chapter 2 and the recent experiences from Reno Djurs have clearly shown that this condition is not fulfilled for landfilled shredder waste. This must be taken into account and should perhaps lead to measures that can improve this situation.

Despite of this, equation (6.1) and the data collected from the laboratory and lysimeter characterisation are used below to provide a first, crude estimation of the duration of the aftercare period for the shredder waste landfilled at AV Miljø.

The quality criteria to be fulfilled by the leachate at the end of the aftercare period (or when active environmental protection systems are no longer required) are given in Appendix 16 of AV Miljø's environmental permit from 2006. These criteria are shown in table 6.3, and using the data shown in figure 18a to 18d and Appendix A, an estimate is made of the L/S value at which the concentrations of the regulated substances (As, Cd, Cr, Cu, Hg, Ni, Pb and Zn) will have decreased to a value at or below the criteria.

Assuming a bulk density of $0.6 \text{ tonnes}/\text{m}^3$ for the landfilled shredder waste an average height of 5.5 m and a rate of infiltration of precipitation of 330 mm/year, equation (6.1) is then used to estimate the length of time it will take to reach the estimated L/S values. The substance which needs to reach the highest L/S value in order for the concentration to decrease to or below the criterion will then determine the duration of the aftercare period.

The results are presented in table 6.3 which shows the leachate quality criteria for end of active environmental protection systems from the permit, the L/S value where this would occur according to the laboratory and lysimeter leaching tests, and the corresponding period of time (from the appearance of the first leachate or the finalisation of the filling of the cell, whichever comes last), i.e. approximately the duration of the aftercare period. The table also shows the concentrations of the regulated substances measured in the leachate from two of the cells with shredder waste.

Table 6.3 Simplified estimation of the aftercare period and measured leachate concentrations of the substances for which the environmental permit has set limit values in relation the end of the aftercare period.

Substance	Criteria	L/S for concentration < criteria	Time to reach L/S	Measured conc. in leachate	
				Cell 2.2.1 (2009)	Cell 1.5.1 (2008)
	mg/l	l/kg	years	mg/l	mg/l
As	0.0122	0.2	2	0.018	0.005
Cd	0.025	0.1	1	0.000075	< 0.0001
Cr	0.010	1	10	0.002	< 0.01
Cu	0.028	10	100	0.0061	< 0.01
Hg	0.003	0.5	5	< 0.0002	< 0.0002
Ni	0.082	0.15	1.5	0.052	0.04
Pb	0.014	0.2	2	0.00078	< 0.1
Zn	0.859	1	10	0.004	0.03



The results in table 6.3 show that for most substances, the concentrations in the leachate are fairly low, and the time needed to reach the concentration level required to allow the operator to stop using active environmental protection measures is very short for most substances except for Cu, when the results of column and lysimeter leaching tests are used to assess the L/S value where the concentration criteria are fulfilled. Based on Cu the duration of the aftercare period should be approximately 100 years. The short period required to get below the criteria values for most of the substances is consistent with the fact that all of the measured leachate concentrations of these substances from 2008 and 2009 except for As are below the criteria values. This is also true for Cu, which could have been expected to be substantially higher, since the estimated time for Cu to reach the criteria value is 100 years.

These discrepancies clearly illustrate the uncertainty of the applied method and the need for better understanding of the chemical (and biological) processes occurring in the landfilled waste, in particular the possible reduction of sulphate and the potential formation of sulphide which may have formed precipitates with many of the trace elements. When the landfill eventually becomes oxidised, the sulphides may also be oxidised and start releasing the formerly immobilised heavy metals and trace elements. It will also be necessary to obtain a better understanding of the distribution of the flow of water through the waste and in particular of how the flow pattern can be improved and become more uniform.



7 SUMMARY AND CONCLUSIONS

The overall aim of this project was to develop a reliable tool for prediction and reduction of the duration of the aftercare period for landfills, in particular landfills for shredder waste and mixed waste.

The approach has been to collect data on the quantity and quality of leachate from landfilled shredder waste and mixed waste as a function of time and L/S from old and existing landfills, including AV Miljø, on the one hand and produce such data from laboratory and large scale lysimeter leaching test on the other hand.

Based on speciation, source and transport modelling, and using the insight gained from the studies of the full scale landfills and the laboratory and lysimeter leaching tests, and using primarily laboratory characterisation leaching data as input to the source model, it was the intention to develop a reliable tool for prediction of the quantity and quality of leachate from shredder and mixed waste landfills and apply the model to scenarios relevant to AV Miljø in order to predict the duration of the aftercare period and, if possible, to assess various possibilities for reducing this period.

The final step should be to validate the model by applying it to some of the existing landfills for which information and data have been collected and compare the results to the observed leachate behaviour at the landfill.

Samples were collected of recently landfilled shredder waste and mixed waste from AV Miljø and subjected to basic characterisation in the laboratory (chemical analysis, column and batch leaching tests, pH-dependence leaching tests, and equilibrium column leaching tests for non-volatile organic substances) and large scale lysimeter leaching studies where the wastes have been exposed to ambient conditions.

After approximately 1½ years of the lysimeter tests (corresponding to L/S = 0.8 to 1.0 l/kg), comparison of the laboratory and lysimeter leaching tests on the shredder waste has shown that – with a few exemptions including Co, Cu, Ni and Zn – there was in general a good agreement between the results from the two lysimeters with shredder waste. There is, however, less agreement between the results from the lysimeters and the results of the column leaching tests carried out on the same material. From field experiments it is known that the flow pattern of the percolating rainwater through the very heterogeneous shredder waste can be very unevenly distributed. This is also seen to be the case here, the flow distribution between the middle and wall sections differ substantially between the two lysimeters, and this may contribute to the observed differences from the column tests where the flow is assumed to be more even due to the application of up-flow. In an assessment of the results of the first year of operation of the lysimeters it was shown that a better agreement between lysimeter and column test results (particularly for the salts) could be obtained if the L/S in the lysimeter tests was calculated on the basis of the assumption that only 40% of the waste in the lysimeters actually is in contact with the percolating water. However, later results seem to indicate that this situation has changed somewhat and a larger fraction of the waste actually participates in the leaching process. In general, higher amounts of leached substances are observed from the column leaching test than from the lysimeters. It may possibly be explained by the heterogeneity of the shredder waste, occurrence of biological processes in the waste in the lysimeters, small differences in pH. A difference in redox potential could also be



expected, but has not been observed (e.g. by release of ferrous iron). Only small amounts of PAH, BTEX, hydrocarbons and PCB were leached from the shredder waste.

For the mixed waste L/S had reached $L/S = 1.7$ l/kg after 1½ years. There was good agreement between the results from the two lysimeters with mixed waste. For the salts and some of the trace elements that are not overly sensitive to changes in pH or redox potential there was a very good agreement between the results of the lysimeter tests and the column leaching results. A horizontal concentration curve for Ca is a clear indication of solubility control, probably due to the presence of calcium sulphate (gypsum). For some of the trace elements that are sensitive to changes in pH and redox potential the agreement is not so good. As for the shredder waste, the leaching of specific organic substances from the mixed waste was negligible.

Information on landfilled waste, landfill design, leachate quality and quantity were collected from 9 different landfills, including AV Miljø. The data has been used in this study and stored in a database for future use. The original quality criteria for the landfills and data to be included in the study could not be fulfilled, so a number of uncertainties about the actual types of waste and the water balances as well as a certain degree of in-mixing of other types of waste than shredder waste and mixed waste had to be accepted. It is a general problem that monitoring samples of leachates from several cells with different types of waste have often been collected at a point where they have been combined prior to treatment. For this study leachate samples from single cells were pursued. More detailed studies of the landfilled waste and the composition of the leachate were carried out at AV Miljø. This included sampling and chemical analysis of filtered and unfiltered leachate from shredder waste and mixed waste to assess the consequences of the fact that practically all leachate analyses carried out as part of the required monitoring programmes are performed on unfiltered samples, while filtered samples would provide better information in this project. The substances for which the filtration caused the largest reduction in the analytical result were P, Fe, Pb, Cd, Cu, Zn and Al. This must be taken into account when leachate monitoring data are used for comparison with results from laboratory and lysimeter leaching data where the leachate normally has been filtered prior to analysis. Three substances (calcium, chloride and copper) and dissolved organic carbon (DOC) was selected as “model” substances and used in comparisons of the generation of leachates from seven different landfills. The comparison showed both some similarities and some distinct differences between the individual landfills or landfill cells.

Following a brief survey of different leachate models, the database/expert system LeachXS which has extensive speciation modelling capabilities was selected and tried out on the leaching data for shredder waste. The model predictions of the leachability of some elements fit very well with the results of the pH dependence test, but for several elements the prediction was not really successful, and it was concluded that further progress could not be achieved without a major effort that would exceed the framework of the study. It was therefore decided not to apply the model any further in this study.

Instead a simple model calculation using a conversion of the L/S scale for the column and lysimeter leaching tests was performed on a scenario describing the conditions at a cell with shredder waste at AV Miljø to estimate the time required for the leaching of selected substances to decrease below the limit values at which the active environmental protection systems are no longer required. For most of the regulated substances (As, Cd, Cr, Hg, Ni, Pb and Zn) the duration was very short, 10 years or less. However, for Cu a



duration of 100 years was found based on the leaching test results. But the analyses of leachate from a shredder waste cell at AV Miljø showed concentration levels of Cu that was already below the limit value. The same was true for all the other substances except As, which was higher than the limit value (contradictory to the model prediction based on laboratory and lysimeter leaching data). These discrepancies clearly illustrate the uncertainty of the applied method and the need for better understanding of the chemical (and biological) processes occurring in the landfilled waste, in particular the possible reduction of sulphate and the potential formation of sulphide which may have formed precipitates with many of the trace elements. When the landfill eventually becomes oxidised, the sulphides may also be oxidised and start releasing the formerly immobilised heavy metals and trace elements. It will also be necessary to obtain a better understanding of the distribution of the flow of water through the waste

Although this project did not secure the expected landfill and leachate data of the desired quality (they were simply not available) and failed to provide a reliable model for calculation of the duration of the aftercare period, it has increased the knowledge of the behaviour of landfills for shredder waste and mixed waste and the properties of leachate from these landfills, it has provided a large number of datasets that can be used in the continued efforts to improve the understanding of landfills and reduce the duration of the aftercare period. The project has contributed substantially in demonstrating the extremely uneven distribution of the flow of infiltrating waste through landfilled shredder waste. The lysimeter tests will be continued and are likely to add further to the understanding of the behaviour of the two types of waste. The information and data from this study will be used in combination with the other on-going efforts and R&D projects within the Danish landfill network DepoNet aiming at better understanding and improvement of landfills and moving towards more sustainable landfilling strategies and techniques.



8 REFERENCES

AV Miljø. *Årsrapport 2007*. Yearly status report, Copenhagen: AV Miljø, 2008.

Bou-Zeid, E., and M. El-Fadel. "Parametric sensitivity analysis of leachate transport simulation at landfills." *Waste Management* 24 (2004): 681-689.

Christensen, T. *Affaldsteknologi*. Copenhagen: Teknisk Forlag, 1998.

Copenhagen County. "Miljøgodkendelse, AV Miljø, Avedøreholmen 97, 2650 Hvidovre." *Copenhagen County case No. 9845104-100*. Copenhagen, 14 June 2006.

Danish Environmental Protection Authority. "Bekendtgørelse om deponingsanlæg." *Bekendtgørelse nr. 252*. Copenhagen, 30 Marts 2009.

de Cortazar, A., L. G., and I. T. Monzon. "Application of simulation models to the diagnosis of MSW landfills: An example." *Waste Management* 27 (2007): 691-703.

de Cortazar, A., L., G., and I. T. Monzon. "MODUELO 2: A new version of an integrated simulation model for municipal solid waste landfills." *Environmental Modelling & Software* 22 (2007): 59-72.

De Windt, L., R. Badreddine, and V. Legneau. "Long-term reactive transport modelling of stabilized/solidified waste: from dynamic leaching tests to disposal scenarios." *Journal of Hazardous Materials B* 139 (2007): 529-536.

DHI. *Testning af danske affaldstyper*. Technical note, Miljøstyrelsen, 2006.

Doka, G. *Excerpt "landfill models" from the ecoinvent 200 report on landfills*. Doka Life Cycle Assessments, 2004.

Enviroplan. *Forureningsundersøgelser for lossepladserne matr nr 7f og 7 g af Uggeløse. Fase II*. Lyngbe: I/S Amagerforbrænding, 1985.

Gisbert, T., C. Bloquet, G. Barina, and C. Petitpas. "Assessing the quantity of leachate: A simple tool for short and long term prediction and its evaluation on real size landfill sites." *Ninth International Waste Management Symposium*. Sardinia, 2003. 13-14.

Golder. "Chapter 1: Introduction to LandSim." In *LandSim Manual*, by Golder. 2008.

Grontmij I Carl Bro. *Sengeløse Losseplads, Matr.nr.3n, Vasby, Sengeløse, Hedehusene. Årsrapport 2007*, Copenhagen: Sengeløse Losseplads I/S, 2008.

GroundwaterSoftware.com. <http://www.groundwatersoftware.com/hydrus.htm>. 10 10 2008.

Halim, C. E., S. A. Short, J. A. Scott, R. Amal, and G. Law. "Modelling the leaching of Pb, Cd, As and Cr from cementitious waste using PHREEQC." *Journal of Hazardous Materials A* 125 (2005): 45-61.

Hansen, J.B., Hjelmar, O., Asmussen, O.W., Klem, S., Gamst, J., Wahlström, M., Larsson, L., Breedveld, G.D. Leaching of non-volatile organic compounds from soil and



waste: Evaluation of two leaching tests. In Proceedings of 10th International Waste Management and Landfill Symposium, October 3-7, Cagliari, Sardinia, 2005.

Helsinki University of Technology. "Automotive shredder residue (ASR) and compact disc (CD) waste: options for recovery of materials and energy." TKK-ENY-14, Energy Engineering and Environmental Protection, Espoo, 2003.

Hjellnes Consult (2008a). Analyser av lettfraksjon fra fragmenteringsverk. Prøvetaking Høsten 2007. 2359, Statens forurensningstilsyn, sft, Oslo (in Norwegian).

Hjellnes Consult (2008b). Undersøkelser av lettfraksjon fra fragmenteringsverk. Utlekningstester 2008. 2447, Statens forurensningstilsyn, sft, Oslo (in Norwegian).

Hjelmar, O., Leachate from land disposal of coal fly ash. *Waste Management & Research*, 8, pp 429-449, 1990.

Kindlein, J., D. Dinkler, and H. Ahrens. "Verification and application of coupled models for transport and reaction processes in sanitary landfills." *Ninth International Waste Management Symposium*. Sardinia, 2003. 17-18.

Kouzeli-Katsiri, A., A. Bosdogianni, and D. Christoulas. "Prediction of leachate quality from sanitary landfills." *Journal of Environmental Engineering* 125, no. 10 (1998): 950-.

LeachXS database. "Shredder waste 1." Energy research Centre of the Netherlands, Unknown.

Mathlener, R. A., T. Heimovaara, H. Oonk, H. A. van der Sloot, and A. van Zomeren. *Opening the black box. Process-based design criteria to eliminate aftercare of landfills*. The Netherlands: Dutch Sustainable Landfill Foundation, 2006.

Miljøstyrelsen, and DHI. *Notat vedrørende akseptkriterier for deponering. Metoder og forudsætninger*. Memo, Copenhagen: Miljøstyrelsen, 2006.

Nourreddine, M. "Recycling of auto shredder residue." *Journal of Hazardous Materials*, 2007: 481-490.

Ozkaya, B., A. Demir, and M. S. Bilgil. "Mathematical simulation of long-term monitoring of leachate components from two different landfill cells." *Journal of Hazardous Materials A* 135 (2006): 32-39.

Sanchez, F., and D. S. Kosson. "Probabilistic approach for estimating the release of contaminants under field management scenarios." *Waste Management* 25 (2005): 463-472.

Schroeder, P. R., T. S. Dozier, P. A. Zappi, B. M. McEnroe, J. W. Sjostrom, and R. L. Peyton. *The hydrologic evaluation of landfill performance (HELP) model*. Cincinnati, Ohio: Risk Reduction Engineering Laboratory, Office of Research and development, U.S. Environmental Protection Agency, 1994.



Slack, R. J., J. R. Gronow, D. H. Hall, and N. Voulvoulis. "Household hazardous waste disposal to landfill: Using LandSim to model leachate migration." *Environmental Pollution* 146 (2007): 501-509.

SYSAV. "Vatten från Spillepens avfallsanläggning en beskrivning av systemens uppbyggnad och lakvattnets sammensättning." INTERREG IIIA - Källsamarbetet. Sysav delprojekt: Lakvattenkaraktärisering, 2007.

Ustohalova, V., T. Ricken, and R. Widmann. "Estimation of landfill emission lifespan using process oriented modeling." *Waste Management* 26 (2006): 442-450.

van Zomeren, A., J., C. L. Meeussen, H. Oonk, L. Luning, and H. A. van der Sloot. *Database. Evaluation of geochemical and biochemical processes and release from landfills*. The Netherlands: Dutch Sustainable Landfill Foundation, 2006.

Vandkvalitetsinstituttet ATV. *Forureningsforhold i forbindelse med lossepladserne i Uggeløse*. Hørsholm: Allerød Kommune, 1986.

White, J., J. Robison, and Q. Ren. "Modelling the biochemical degradation of solid waste in landfills." *Waste Management* 24 (2004): 227-240.

Yildiz, E. D., K. Ünlü, and R. K. Rowe. "Modelling leachate quality and quantity in municipal solid waste landfills." *Waste Management & Research* 22/2 (2004): 78-92.

Zacharof, A. I., and A. P. Butler. "Application of a stochastic flow and transport model for landfill leachate production to tracer test data." *Eighth International Waste Management and Landfill Symposium*. Sardinia, 2001. 119-128.



A P P E N D I C E S



A P P E N D I X A

Characterisation of AV Miljø shredder waste from cell 2.2.1





Grundlæggende karakterisering af prøve af shredderaffald i forbindelse med lysimeterforsøg ved KMC og Aftercare-projektet ved AV Miljø	
Materiale/DHI-ID:	Indbygget shredderaffald fra AV Miljø, R-094-06
Lysimetre:	Nr. 1 og 2
Dato for prøve-tagning:	7. juni 2006
Dato for denne version:	Januar 2009/OH

1. Prøvetagning og forbehandling

Den 7. juni 2006 blev der fra 11 forskellige steder i celle 2.2.1 udtaget i alt 11.480 kg shredderaffald, som blev placeret i en tildækket container og senere anvendt til opfyldning af KMC-lysimetrene 1 og 2. I hvert af de 11 prøvetagningspunkter blev der foretaget tre nedstik med gravemaskine. Fra hver grabfuld blev der, inden shredderaffaldet blev overført til containeren, med en skovl udtaget en delprøve, som blev placeret i to plasttromler. På denne måde blev der udtaget sammenlagt 226 kg shredderaffald i plasttromlerne, som efterfølgende blev lukket og bragt til DHI. På DHI blev shredderaffaldet fra de to tønder sigtet, blandet og neddelt. Materiale større end 10 mm blev nedknust, og materiale, som ikke kunne nedknuses (metal og sten), blev frasorteret. Efter yderligere forbehandling blev prøven underkastet analysering samt en række karakteriseringstests. Prøven af shredderaffald er på DHI registreret som R-094-06.

Prøvetagning og forbehandling er beskrevet mere detaljeret i bilag 1.

2. Karakteriseringens omfang

2.1 Oversigt

I tabel 1 ses en oversigt over omfanget af den grundlæggende karakterisering.

Tabel 1

Oversigt over den grundlæggende karakteriseringstestning

Test/analyse	Bemærkninger
Totalindhold af uorganiske komponenter	
Indhold af TOC	
Indhold af kulbrinter, PAH, BTEX og PCB	
Kolonnevaskningstest CEN/TS 14405	Uorganiske komponenter og DOC
Batchudvaskningstest EN 12457-1	Uorganiske komponenter og DOC
pH-statisk udvaskningstest CEN/TS 14997	Uorganiske komponenter og DOC
Ligevægtskolonnetest	Ikke-flygtige organiske komponenter



2.2 Analysering for indhold af uorganiske og organiske komponenter

En repræsentativ delprøve er blevet sendt til ECN i Holland til totaloplukning og efterfølgende bestemmelse af totalindhold af Si, Al, Ca, Mg, Ti, Na, K, Fe, S, P, As, B, Ba, Br, Cd, Cl, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, S, Sb, Se, Sr, V, W, Zn.

En anden repræsentativ delprøve blev sendt til Pirkanmaa Regional Environment Centre Laboratory i Finland til analysering for indhold af TOC.

En tredje repræsentativ delprøve blev sendt til Eurofins til analysering for indhold af kulbrinter, PAH, BTEX og PCB.

Resultaterne af faststofanalyserne er vist i bilag 2 og bilag 3.

2.3 Udførelse af kolonneudvaskningstest for uorganiske komponenter og DOC

På en repræsentativ delprøve nedknuet til < 4 mm er der udført en kolonneudvaskningstest (udvaskning med en demineraliseret vand i en kolonne med diameter = 10 cm) i henhold til CEN/TS 14405. Der er opsamlet 7 eluatfraktioner i intervallet L/S = 0 – 10 l/kg. Eluaterne, der opsamlet under nitrogen, er efterfølgende blevet filtreret gennem et 0,45 µm filter og sendt til Analytica til analysering for klorid, fluorid, sulfat, HCO₃, Si, Ca, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se og Zn. Andre prøver er sendt til ECN til analysering for opløst organisk stof, DOC.

Resultaterne er vist i bilag 4, både som koncentrationer i eluaterne (mg/l) og som akkumulerede udvaskede mængder som funktion af L/S (mg/kg). De akkumulerede udvaskede mængder er endvidere afbildet som funktion af L/S. Signaturene for de enkelte målepunkter er fyldte ruder – de punkter, hvor der er anvendt åbne ruder, repræsenterer resultater, som er lavere end detektionsgrænsen for den pågældende analyse (detektionsgrænsen er anvendt som måleværdi).

2.4 Udførelse af batchudvaskningstest for uorganiske komponenter og DOC

På en repræsentativ delprøve af shredderaffaldet nedknuet til < 4 mm er der gennemført en batchudvaskningstest ved L/S = 2 l/kg i henhold til EN 12457-1 med demineraliseret vand. Eluatet er efter filtrering sendt til Analytica til analysering for klorid, fluorid, sulfat, TDS (total opløst tørstof), HCO₃, Si, Ca, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se og Zn. Andre prøver er sendt til ECN til analysering for opløst organisk stof, DOC.

Resultaterne er vist i bilag 4. De udvaskede stofmængder er afbildet sammen med resultaterne af kolonneudvaskningstesten. Resultaterne af batchtesten er angivet med åbne cirkler ved L/S = 2 l/kg.

2.5 Udførelse af pH-statisk udvaskningstest for uorganiske komponenter og DOC

På repræsentative delprøver af shredderaffaldet, nedknuet til < 2 mm, er der gennemført pH-statisk udvaskningstest med demineraliseret vand ved L/S = 10 l/kg med fastholdt pH i 48 timer i henhold til CEN/TS 14997. I testen fastholdes pH ved hjælp af computerkontrolleret feedback-styring og tilsætning af HNO₃ eller NaOH. Der er udvasket ved 8 forskellige pH-værdier, pH = 2, 4, 6, 7, 8,1 (shredderaffaldets egen-pH, ingen tilsætning af syre eller base), 9,1, 10,1 og 12,1. Eluaterne er efter filtrering gennem et 0,45 µm filter sendt til Analytica til analysering for klorid, fluorid, sulfat, Si, Ca, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, Sn og Zn. Andre prøver er sendt til ECN til analysering for opløst organisk stof, DOC. Resultaterne er vist i bilag 5, både som koncentrationer (mg/l) og som udvaskede stofmængder (mg/kg). Resultaterne er endvidere afbildet som koncentrationer som funktion af pH. Resultaterne af udvaskningerne uden syre-/basetilsætning er afbildet i bilag 4 sammen med resultaterne af kolonneudvaskningstesten (angivet som en åben trekant ved L/S = 10 l/kg).



Baseret på tilsætningerne af syre og base og de målte pH-værdier er shredderaffaldets syre-/baseneutraliseringskapacitet angivet på en figur i bilag 5.

2.6 Udførelse af ligevægtskolonnetest for ikke-flygtige organiske komponenter

På en repræsentativ delprøve af shredderaffaldet (nedknust til < 4 mm) er der gennemført en ligevægtskolonnetest ved L/S = 1,87 l/kg og en kontakttid på 7 dage. Testen er udviklet af DHI og DTU for Miljøstyrelsen til brug for undersøgelse af udvaskningen af ikke-flygtige organiske komponenter. Eluatet er blevet sendt til Eurofins til analysering for kulbrinter og PAH. Resultaterne er vist i bilag 6.

3. Vurdering af resultaterne i forhold til klassificering og lovgivning

Shredderaffald er automatisk klassificeret som farligt affald i henhold til den gældende version af det europæiske affaldskatalog EAK. En nøjere vurdering af, om shredderaffaldet rent faktisk har de egenskaber, som berettiger til klassificeringen som farligt affald, kræver et nøjere kendskab til de såkaldt H-egenskaber (kombineret med R-sætninger) i bekendtgørelsen om farligt affald. En af disse egenskaber kan være indholdet af farlige stoffer. Selv om faststofanalyserne i bilag 2 kan give en indikation, så vil en egentlig klassificering forudsætte et nøjere kendskab til de forbindelser, som de forskellige grundstoffer indgår i. For visse stoffer, der regnes for meget giftige, som f.eks. Cd og Hg, kan vurderingen dog baseres på totalindholdet baseret på grundstoffet. Den laveste grænseværdi for totalindholdet for klassificering som farligt affald er 0,1 % eller 1000 mg/kg. Da indholdet af Cd og Hg er henholdsvis 33 mg/kg og 1,8 mg/kg, giver dette ikke umiddelbart grundlag for karakterisering af shredderaffaldet som farligt affald. En nøjere gennemgang vil være nødvendig. En egenskab ved nogle typer shredderaffald, som måske kunne spille en rolle i denne sammenhæng, er risikoen for selvantændelse (H3-A i EU-direktivet om farligt affald).

Vurderet i forhold til det af Miljøstyrelsen udsendte Høringsudkast til Bekendtgørelse om deponeringsanlæg af 4. juni 2008 overholder den undersøgte prøve af shredderaffald ikke udvaskningskravene til modtagelse på en ikke-kystnært placeret deponeringsenhed for farligt affald (FA0). Af faststofanalyserne i bilag 2 ses det, at TOC-indholdet med 18 % overstiger kravværdien på 6 % for modtagelse af farligt affald til deponering. Rådsbeslutningens faktor 3-regel, som i øvrigt ikke helt ville løse problemet i dette tilfælde, kan ikke anvendes for TOC i farligt affald. Dog kan en høj værdi af TOC accepteres, hvis DOC i kolonne- og batchudvaskningstesten over holder kravværdierne (hvilket de, som fremgår nedenfor, ikke gør).

Baseret på kolonneudvaskningstesten CEN/TS 14405 overskrides udvaskningskravene for deponering på et FA0-anlæg for Mo, Ni, Sb og DOC, mens det for Zn er meget tæt på grænseværdien. Baseret på batchudvaskningstesten EN 12457-1 overskrides udvaskningskravene for deponering på et FA0-anlæg for Mo og Sb, mens de faktisk overholdes for DOC. Det skal dog nævnes, at DOC både for en kolonnetest og en batchtest udført på shredderaffald fra H.J. Hansen overskred både denne grænseværdi (FA0) og grænseværdien for kystnære deponeringsanlæg for farligt affald (FA1-FA3) betydeligt. I henhold til høringsudkastet vil det i sådanne tilfælde være resultatet af kolonneudvaskningstesten, der er afgørende. For den undersøgte prøve overholder resultatet af batchudvaskningstesten udvaskningskravet for kystnære deponier for farligt affald (FA1, FA2 og FA3), mens resultatet af kolonneudvaskningstesten (der som nævnt ovenfor er afgørende) overholder alle udvaskningskrav undtagen kravet til DOC for deponering på FA1-, FA2- og FA3-anlæg.

Bilag 1 Prøvetagning

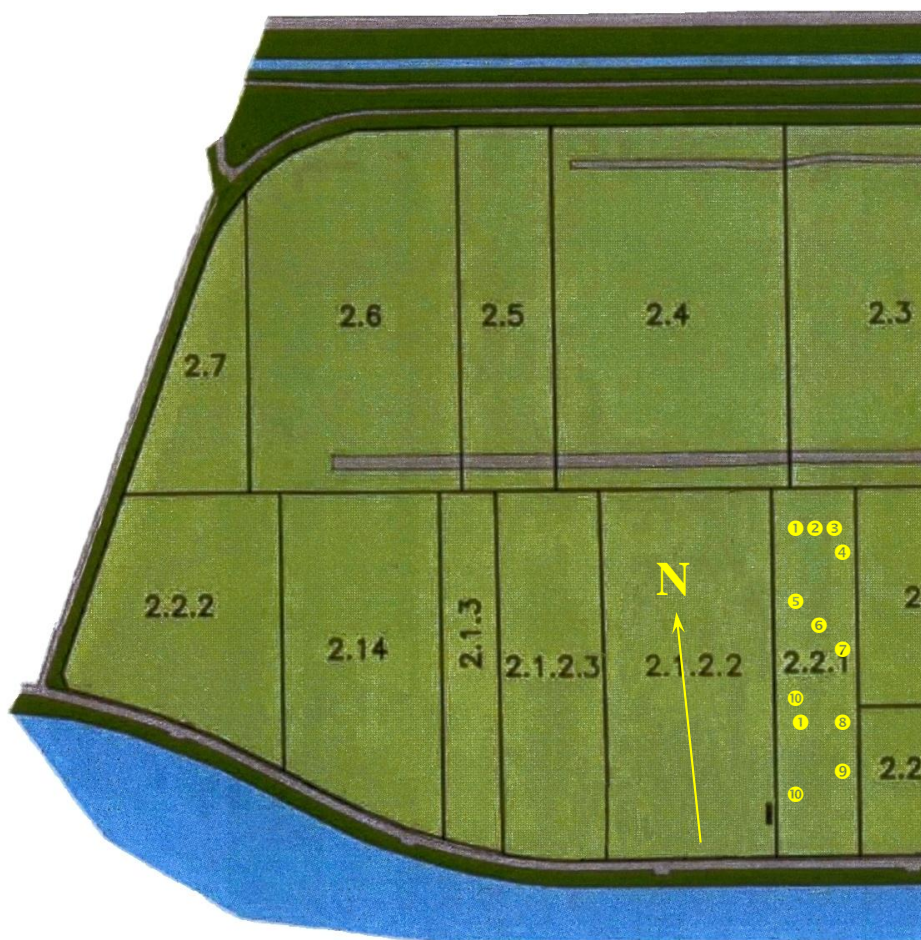
Beskrivelse af prøvetagning og forbehandling

Prøverne af shredderaffald blev udtaget fra celle 2.2.1 (se figur 1) den 7. juni mellem klokken 9:00 og 10:00 af AV Miljø og DHI. Med gravemaskine blev der udtaget tre stik på 11 forskellige steder på cellen (markeret med gult på figur 1). Af hvert stik blev der med håndskovl udtaget en delmængde til karakterisering. Prøverne til karakterisering, i alt 226 kg, blev samlet i to plasttønder. Gravemaskinen læssede affaldet op på skovlen af en gummiged. Når gummigedens skovl var fuld, blev affaldet vejret og læsset i en container. Følgende mængder shredderaffald blev indsamlet til containeren:

Prøvetagningssted 1 – 3:	3.080 kg
Prøvetagningssted 4 – 6:	3.020 kg
Prøvetagningssted 7 – 9:	2.630 kg
Prøvetagningssted 10 – 11:	2.760 kg

I alt: 11.480 kg

Containeren blev tildækket og henstillet, indtil en del af shredderaffaldet den 7. juni 2007 blev anbragt i lysimetrene 15 og 16 hos KMC. De to tønder med shredderaffald til karakterisering blev bragt til DHI.



Figur 1

Oversigt over cellerne på AV Miljø og prøvetagningsstederne i celle 2.2.1.

Bilag 1 Prøvetagning

Figur 2 viser nogle billeder fra prøvetagningen på AV Miljø den 7. juni 2006.



Figur 2
Udtagning af prøver af shredderaffald fra celle 2.2.1 på AV Miljø den 7. juni 2006.

Bilag 1

Prøvetagning

På DHI blev shredderaffaldet fra de to tønder sigtet gennem et 10 mm sold. Herved blev affaldet fra de to tønder sammenblandet og opdelt i to fraktioner: 163 kg < 10 mm og 63 kg > 10 mm. Fraktionen > 10 mm blev derefter yderligere homogeniseret og neddelt ved "coning and quartering" til en prøve på 12,25 kg, som derefter i en Retch SM2000 snitemølle blev knust eller flået til en partikelstørrelse < 10 mm. Fraktionen < 10 mm blev ligeledes yderligere homogeniseret og ved "coning and quartering" neddelt til en prøvemængde på 32,77 kg. De to fraktioner blev derefter omhyggeligt blandet og neddelt til en samlet mængde på 11,66 kg, som efter frasortering af 1,09 kg jern og sten blev anvendt til udvaskningstest (efter yderligere nedknusning til < 4 mm) og faststofanalyser (efter yderligere nedknusning til < 2 mm).

Bilag 2

Resultater af analyser af faststofindhold af uorganiske stoffer og TOC

Faststofindhold							
DHI-sag:	Aftercare	Godk. af:	OH				
Sagsnr.:	53451	Dato:	30/04/2008				
Prøve modtaget:	07/06/2006						
Materiale:	Shredderaffald						
Prøve-ID:	Shredder waste from landfill (cell 2.2.1) at AV Miljø						
LRJ-nr.:	R-094-06						
Oplukningsmetode B1:	50% HF (1:1-fortyndet koncentreret flussyre)						
Oplukningsmetode B8:	50% HNO3 + 45% HF + 5% HClO4						
Oplukningsmetode C:	Alkalismeltning						
Oplukningsmetode D:	Fosforsyre i overensstemmelse med EN 13137						
Parameter	Enhed	Analyse- resultat	Analysemetode	Opluk- ning	Type	Analyselab	Akk.
Si	mg/kg TS	93000		B1	Total	ECN	
Fe	mg/kg TS	14000		B8	Total	ECN	
Ti	mg/kg TS	3900		B1	Total	ECN	
Ca	mg/kg TS	37000		B8	Total	ECN	
Mg	mg/kg TS	6700		B8	Total	ECN	
Na	mg/kg TS	8700		B8	Total	ECN	
K	mg/kg TS	4100		B8	Total	ECN	
Al	mg/kg TS	30000		B8	Total	ECN	
As	mg/kg TS	29		B8	Total	ECN	
B	mg/kg TS	560		B8	Total	ECN	
Ba	mg/kg TS	2100		B8	Total	ECN	
Br	mg/kg TS	230		C	Total	ECN	
Cd	mg/kg TS	33		B8	Total	ECN	
Cl	mg/kg TS	4300		C	Total	ECN	
Co	mg/kg TS	520		B8	Total	ECN	
Cr	mg/kg TS	770		B8	Total	ECN	
Cu	mg/kg TS	46000		B1	Total	ECN	
Hg	mg/kg TS	1.8		B8	Total	ECN	
Mn	mg/kg TS	1900		B8	Total	ECN	
Mo	mg/kg TS	51		B8	Total	ECN	
Ni	mg/kg TS	1800		B8	Total	ECN	
P	mg/kg TS	1200		B8	Total	ECN	
Pb	mg/kg TS	3000		B8	Total	ECN	
S	mg/kg TS	2600		B8	Total	ECN	
Sb	mg/kg TS	130		B8	Total	ECN	
Se	mg/kg TS	< 3		B8	Total	ECN	
Sn	mg/kg TS	380		B8	Total	ECN	
Sr	mg/kg TS	240		B8	Total	ECN	
V	mg/kg TS	39		B8	Total	ECN	
W	mg/kg TS	2400		B8	Total	ECN	
Zn	mg/kg TS	14000		B8	Total	ECN	
TOC	g/kg TS	180	EN 13237-B	D	Total	PREC	X

Bilag 3
Analysér af faststofindhold af organiske stoffer

Faststofindhold af organiske stoffer						
DHI-sag:	Aftercare	Godk. af:	OH			
Sagsnr.:	53451	Dato:	17/05/2007			
Prøve modtaget:	07/06/2006					
Materiale:	Shredder waste					
Prøve-ID:	Shredder waste from landfill (cell 2.2.1) at AV Miljø					
LRJ-nr.:	R-094-06					
Kulbrinter og BTEX'er bestemt efter ekstraktion r Sum PAH-forbindelser = 16 EPA-forbindelser Akk. = Akkrediteret bestemmelse						
Parameter	Analyse-resultat (mg/kg TS)	RSD (%)	DL (mg/kg)	Analysemetode	Analyselab	Akk.
Kulbrinter:						
Benzen - C10	16	25	2.5	GC/FID	Eurofins	X
C10- C25	1700	10	10	GC/FID	Eurofins	X
C25 - C35	6800	31	25	GC/FID	Eurofins	X
Sum Benzen - C35	8600				Eurofins	X
BTEX-forbindelser:						
Benzen	< 0.1	11	0.1	GC/FID	Eurofins	X
Toluen	0.64	15	0.1	GC/FID	Eurofins	X
Ethylbenzen	0.93	10	0.1	GC/FID	Eurofins	X
O-Xylen	7.4	14	0.1	GC/FID	Eurofins	X
MP-Xylen	0.44	11	0.1	GC/FID	Eurofins	X
PAH-forbindelser:						
Naphthalen	0.21	12	0.005	MK2004-GC/MS	Eurofins	X
Acenaphthylen	0.099	12	0.005	MK2004-GC/MS	Eurofins	X
Acenaphten	0.042	12	0.005	MK2004-GC/MS	Eurofins	X
Fluoren	0.11	12	0.005	MK2004-GC/MS	Eurofins	X
Phenanthren	0.57	12	0.005	MK2004-GC/MS	Eurofins	X
Anthracen	0.021	12	0.005	MK2004-GC/MS	Eurofins	X
Fluoranthen	1.4	12	0.005	MK2004-GC/MS	Eurofins	X
Pyren	1.5	12	0.005	MK2004-GC/MS	Eurofins	X
Benz(a)anthracen	0.57	12	0.005	MK2004-GC/MS	Eurofins	X
Chrysen/Triphenylen	0.66	12	0.005	MK2004-GC/MS	Eurofins	X
Benz(b+j+k)fluoranthen	1.1	12	0.005	MK2004-GC/MS	Eurofins	X
Benzo(a)pyren	0.52	12	0.005	MK2004-GC/MS	Eurofins	X
Indeno(1,2,3-cd)pyren	0.21	12	0.005	MK2004-GC/MS	Eurofins	X
Dibenz(a, h)anthracen	0.056	12	0.005	MK2004-GC/MS	Eurofins	X
Benzo(g, h, i)perylen	0.28	12	0.005	MK2004-GC/MS	Eurofins	X
Sum PAH-forbindelser	7.4				Eurofins	X
Polyklorerede biphenyler:			0			
PCB nr. 28	1.5	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 52	0.95	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 101	1	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 118	0.74	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 138	0.78	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 153	0.45	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 180	0.13	15	0.005	MK2004-GC/MS	Eurofins	X
TOC	180000	20		EN 13137, Method B	Pirkanmaa	X

Bilag 4
Resultater af kolonneudvaskningstest og batchtest

Kolonneudvaskningstest		CENTS 14405				Side 1 of 2			
DHI-sag:	Aftercare					Kolonnediameter:	10 cm		
Sagsnummer:	53451					Fyldhøjde:	36 cm		
Prøve udtaget:	07/06/2006					Tørvægt af testport.:	2330 g		
Materiale:	Shredderaffald					Materialet knust før test?	Ja		
Prøve-ID:	Shredder waste from landfill (cell 2.2.1) at AV Miljø					Til hvilken kornstørrelse (mm)?	< 4		
LRJ nr.:	R-094-06								
Udv.medie:	Demineraliseret vand	Eluatfraktioner opsamlet:				Fraktion	Akkum.	Flow	
Lineær flowhast.:	14.2 cm/dag					L/S (l/kg)	L/S (l/kg)	ml/time	
Temperatur:	ca. 20 grader C	Fraktion 1:	0.264 liter	0.11	0.11	52.7			
		Fraktion 2:	0.206 liter	0.09	0.20	35.1			
Test startet:	07/12/2006	Fraktion 3:	0.719 liter	0.31	0.51	39.4			
Udført af:	SEK/OWA	Fraktion 4:	1.217 liter	0.52	1.03	49.6			
QA/QC:	OH	Fraktion 5:	2.259 liter	0.97	2.00	49.7			
Godkendt dato:	07/05/2007	Fraktion 6:	6.956 liter	2.99	4.99	48			
		Fraktion 7:	11.714 liter	5.03	10.01	44.8			
Sammensætning af eluater:									
Parameter	Unit	L/S (l/kg)		L/S (l/kg)		L/S (l/kg)		L/S (l/kg)	
		From:	0.00	0.11	0.20	0.51	1.03	2.00	4.99
		To:	0.11	0.20	0.51	1.03	2.00	4.99	10.01
pH	-		7.7	7.9	7.8	8.0	7.7	8.0	7.6
Ledningsevne	mS/m		2200	1500	700	260	140	82	56
Klorid	mg/l		6500	3200	880	110	13	5.8	2.9
Fluorid	mg/l	<	1	<	1	<	0.75	0.31	0.29
Sulfat	mg/l		3100	2500	1500	470	220	93	31
HCO3	mg/l		250	370	1800	2400	320	460	320
Si	mg/l		11	9.4	6.7	4.5	3.4	2.4	2.2
Ca	mg/l		510	390	210	150	130	110	110
Mg	mg/l		880	580	290	180	94	38	17
Na	mg/l		3700	2500	1100	150	33	9.2	4.6
K	mg/l		480	350	220	110	46	15	6.3
Al	mg/l		0.13	0.1	0.054	0.029	0.029	0.056	0.09
As	mg/l		0.079	0.052	0.023	0.0062	0.0031	0.0015	< 0.001
Ba	mg/l		0.099	0.072	0.059	0.051	0.066	0.092	0.12
Cd	mg/l		0.025	0.016	0.0037	0.00013	< 0.00005	< 0.00005	< 0.00005
Co	mg/l		0.51	0.56	0.33	0.2	0.13	0.051	0.031
Cr	mg/l		0.01	0.0021	0.00064	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Cu	mg/l		2.1	3.8	1.5	0.19	0.091	0.033	0.03
Fe	mg/l		3.1	8	7.4	5.3	2.7	1.2	3
Hg	mg/l		0.0081	0.02	0.0063	0.00064	0.0003	9.7E-05	3.3E-05
Mn	mg/l		5.8	6.1	3.3	2.2	1.6	1.1	0.99
Mo	mg/l		0.15	0.16	0.13	0.079	0.059	0.045	0.038
Ni	mg/l		0.35	0.4	0.28	0.19	0.11	0.052	0.033
Pb	mg/l		0.014	0.016	0.0056	0.0025	0.00088	0.00099	0.00031
Sb	mg/l		0.042	0.043	0.031	0.012	0.0057	0.0019	0.00062
Se	mg/l		0.0044	0.0034	0.0015	0.0005	0.00024	0.00016	9.2E-05
Zn	mg/l		3.4	4	2.3	1.2	0.53	0.051	0.011
DOC	mg/l		570	70	1300	890	350	61	12

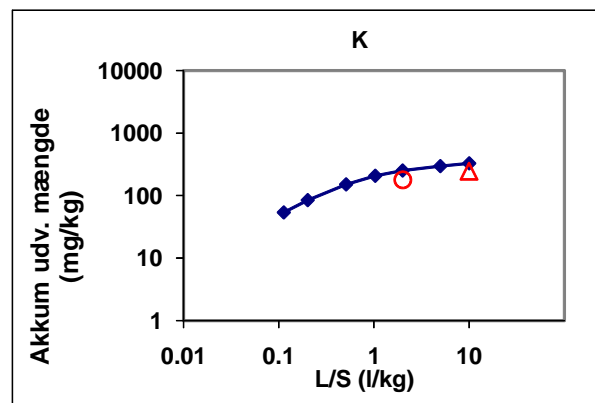
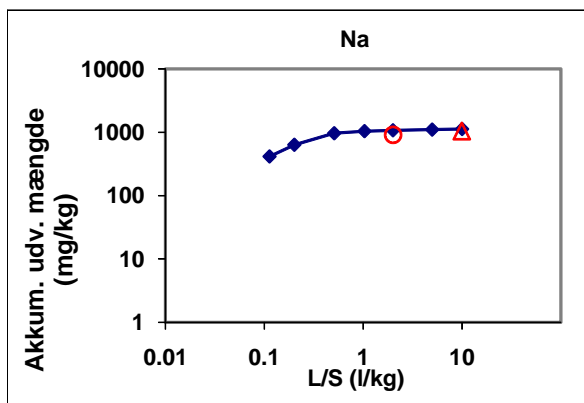
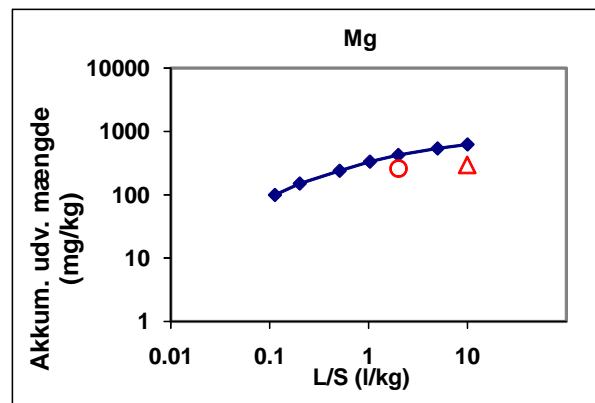
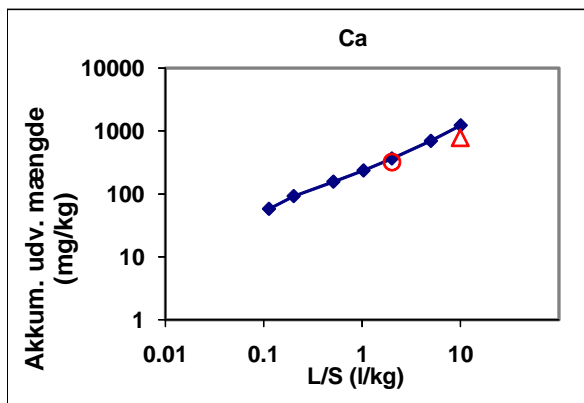
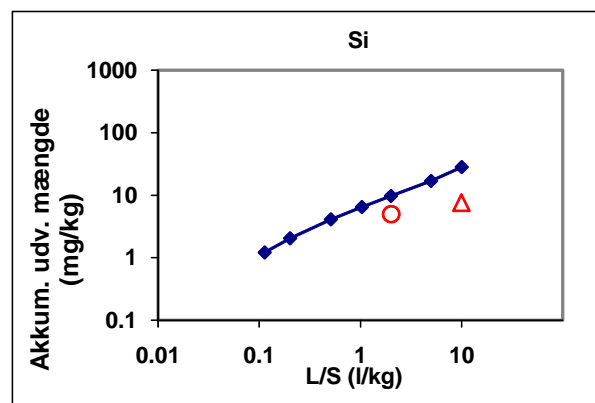
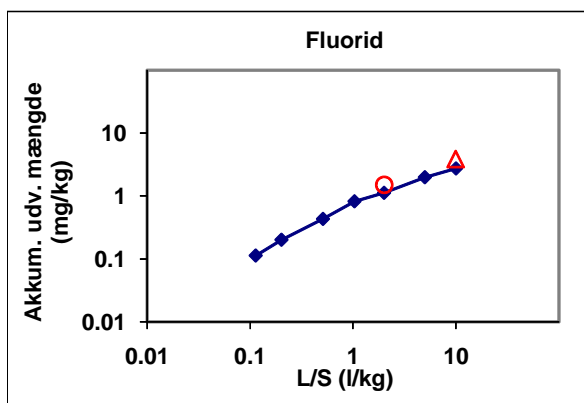
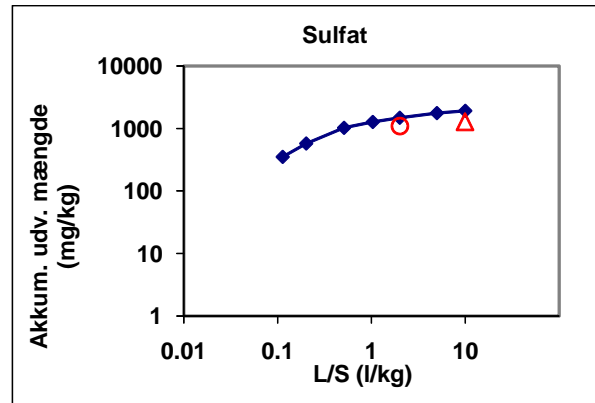
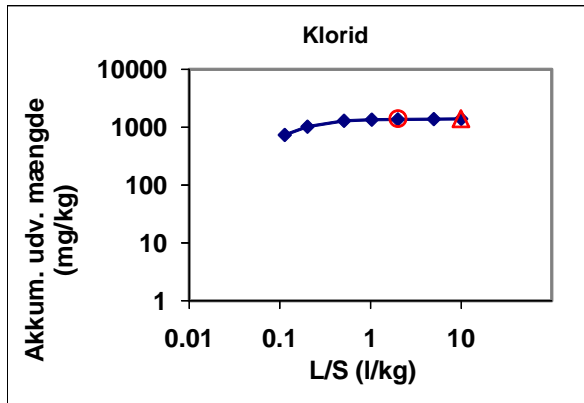
Bilag 4
Resultater af kolonneudvaskningstest og batchtest

Kolonueudvaskningstest		CENTS 14405				Page 2 of 2			
DHI-sag:	Aftercare					Kolonnediameter:	10 cm		
Sagsnummer:	53451					Fyldehøjde:	36 cm		
Prøve udtaget:	07/06/2006					Tørvægt af testport.:	2330 g		
Materiale:	Shredderaffald					Materialet knust før test?	Ja		
Prøve-ID:	Shredder waste from landfill (cell 2.2.1) at AV Miljø					Til hvilken kornstørrelse (mm)?	< 4		
LRJ nr.:	R-094-06								
Udv.medie:	Demineraliseret vand	Eluatfraktioner opsamlet:				Fraktion	Akkum.	Flow	
Lineær flowhast.:	14.2 cm/dag					L/S (l/kg)	L/S (l/kg)	ml/time	
Temperatur:	ca. 20 grader C	Fraktion 1:	0.264 liter	0.11	0.11	52.7			
		Fraktion 2:	0.206 liter	0.09	0.20	35.1			
Test startet:	07/12/2006	Fraktion 3:	0.719 liter	0.31	0.51	39.4			
Udført af:	SEK/OWA	Fraktion 4:	1.217 liter	0.52	1.03	49.6			
QA/QC:	OH	Fraktion 5:	2.259 liter	0.97	2.00	49.7			
Godkendt dato:	07/05/2007	Fraktion 6:	6.956 liter	2.99	4.99	48			
		Fraktion 7:	11.714 liter	5.03	10.01	44.8			
Akkumulerede udvaskede stofmængder:									
Parameter	Unit	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)
		Fract.:	0.11	0.09	0.31	0.52	0.97	2.99	5.03
Klorid	mg/kg	740	1000	1300	1300	1400	1400	1400	1400
Fluorid	mg/kg	< 0	< 0	< 0	< 1	1	2	< 3	
Sulfat	mg/kg	350	580	1000	1300	1500	1800	1900	
HCO3	mg/kg	29	61	600	1900	2200	3600	5200	
Si	mg/kg	1.2	2.0	4.1	6.5	10	17	28	
Ca	mg/kg	58	92	160	240	370	700	1200	
Mg	mg/kg	100	150	240	330	430	540	620	
Na	mg/kg	420	640	960	1000	1100	1100	1100	
K	mg/kg	54	85	150	210	250	300	330	
Al	mg/kg	0.015	0.024	0.040	0.055	0.083	0.25	0.70	
As	mg/kg	0.009	0.014	0.021	0.024	0.027	0.031	< 0.036	
Ba	mg/kg	0.011	0.018	0.036	0.062	0.13	0.40	1.0	
Cd	mg/kg	0.003	0.004	0.005	0.005	< 0.01	< 0.01	< 0.01	
Co	mg/kg	0.058	0.11	0.21	0.31	0.44	0.59	0.75	
Cr	mg/kg	0.0012	0.001	0.002	< 0.002	< 0.002	< 0.004	< 0.006	
Cu	mg/kg	0.24	0.57	1.0	1.1	1.2	1.3	1.5	
Fe	mg/kg	0.35	1.1	3.3	6.1	8.7	12	27	
Hg	mg/kg	0.00091	0.0027	0.0047	0.0050	0.0053	0.0056	0.0057	
Mn	mg/kg	0.65	1.2	2.2	3.4	4.9	8.1	13	
Mo	mg/kg	0.017	0.031	0.072	0.110	0.17	0.30	0.49	
Ni	mg/kg	0.040	0.075	0.160	0.260	0.37	0.52	0.69	
Pb	mg/kg	0.0016	0.0031	0.0048	0.0061	0.0070	0.010	0.011	
Sb	mg/kg	0.0047	0.0085	0.018	0.024	0.030	0.035	0.039	
Se	mg/kg	0.00049	0.00079	0.0013	0.0015	0.0017	0.0022	0.0027	
Zn	mg/kg	0.39	0.74	1.5	2.1	2.6	2.8	2.8	
DOC	mg/kg	64	71	470	940	1300	1500	1500	

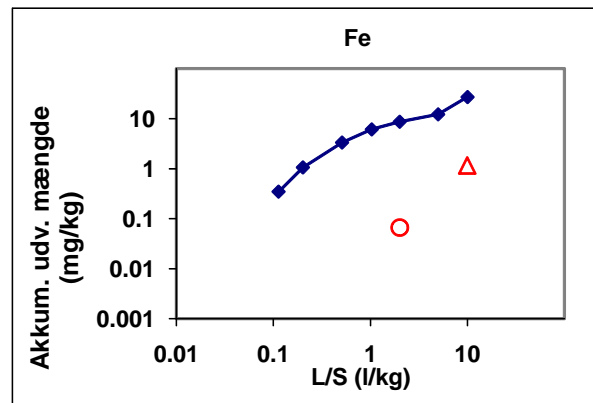
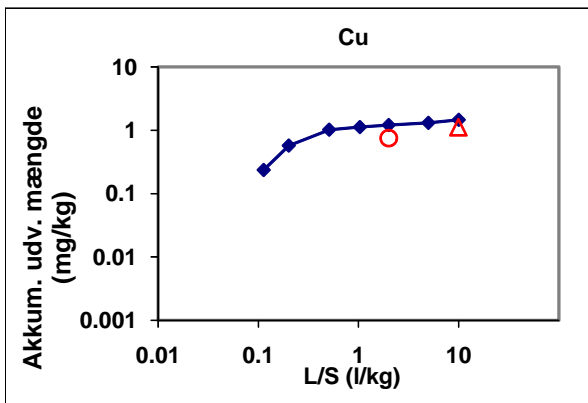
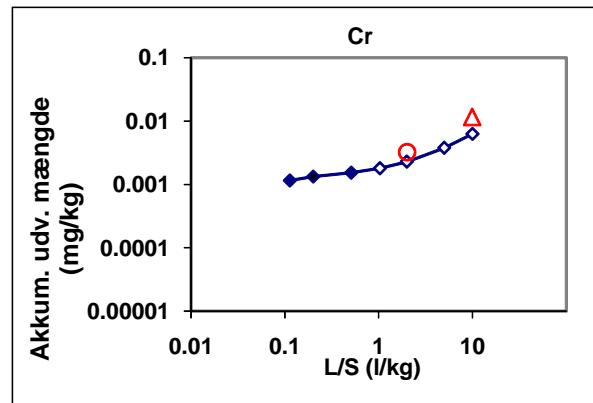
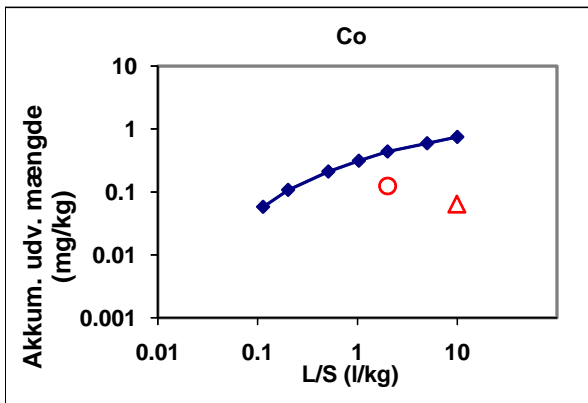
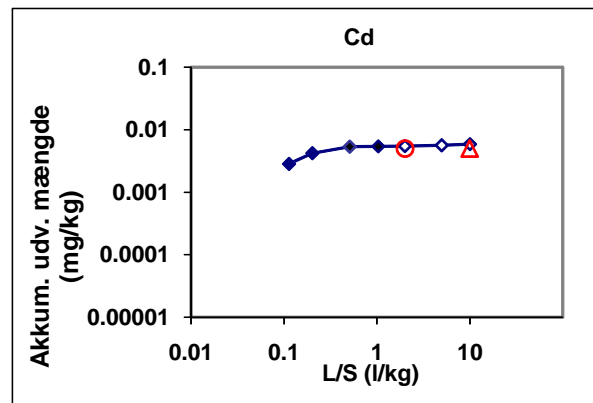
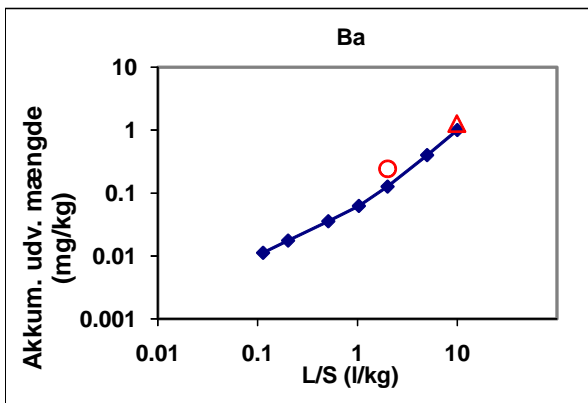
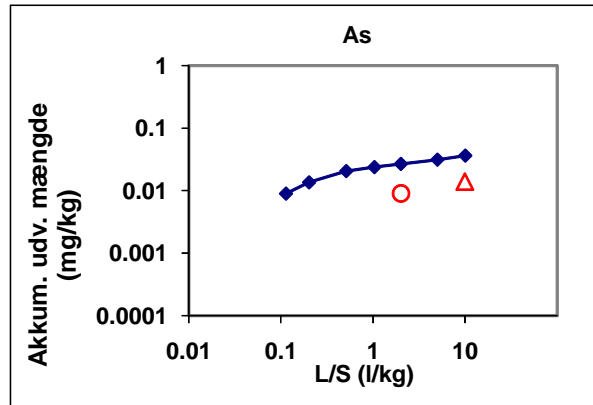
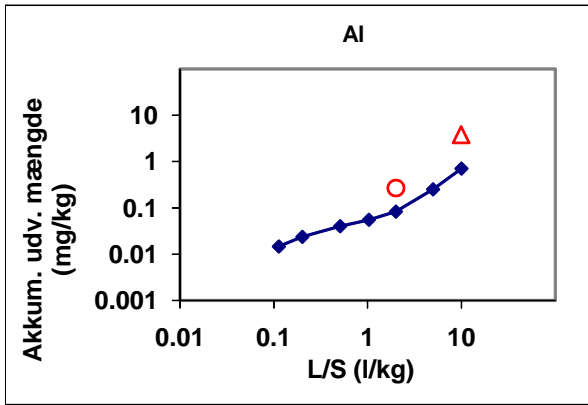
Bilag 4
Resultater af kolonneudvaskningstest og batchtest

Compliance batch leaching test EN 12457-1		Batchtest v. L/S = 2 l/kg, mat. < 4 mm, t = 24 timer			
DHI-sag:	Aftercare	Test udført af:	SEK		
Sagsnr.:	53451	Udført dato:	2/11-3/11 2006		
Prøve modtaget:	07/06/2006	Godkendt af:	OH		
		Godk.-dato:	14/05 2007		
Materiale:	Shredderaffald				
Prøve-ID:	Shredder waste from landfill (cell 2.2.1) at AV Miljø				
LRJ-nr.:	R-094-06				
Tørstofindhold i testportion:	824.17	gTS/kg	Eluent:	Demineraliseret vand	
Vådvægt af testportion:	424	g	Temperatur:	Ca. 20 grader C	
Vandindhold i testportion:	74.6	ml	Kontaktid:	24:20 timer:min	
Vol. af udv.-medium tilsat:	626.88	ml			
Faktisk L/S:	2.0	l/kg			
Er prøven nedknust?	Ja				
Er prøven tørret?	Nej				
Mængde > 4 mm (% w/w):					
Parameter	Koncentration i eluatet mg/l	Udvaskede stofmængder mg/kg	Analysemetode	Analyselab	Akk. (X)
Klorid	700	1400	EN ISO 10304	Analytica	X
Fluorid	<	< 1.5	EN ISO 10304	Analytica	X
Sulfat	550	1100	EN ISO 10304	Analytica	X
Si	2.5	5	ICP-AES	Analytica	X
Ca	160	320	ICP-AES	Analytica	X
Mg	130	260	ICP-AES	Analytica	X
Na	450	910	ICP-AES	Analytica	X
K	89	180	ICP-AES	Analytica	X
Al	0.13	0.27	ICP-SFMS	Analytica	X
As	0.0045	0.009	EN ISO 10304-1	Analytica	X
Ba	0.12	0.24	ICP-SFMS	Analytica	X
Cd	0.0025	0.005	ICP-SFMS	Analytica	X
Co	0.062	0.12	ICP-SFMS	Analytica	X
Cr	0.0016	0.0032	ICP-SFMS	Analytica	X
Cu	0.38	0.75	ICP-SFMS	Analytica	X
Fe	0.033	0.066	ICP-SFMS	Analytica	X
Hg	0.00037	0.00075	AFS	Analytica	X
Mn	1.2	2.3	ICP-AES	Analytica	X
Mo	0.098	0.2	ICP-SFMS	Analytica	X
Ni	0.056	0.11	ICP-SFMS	Analytica	X
Pb	0.0064	0.013	ICP-SFMS	Analytica	X
Sb	0.015	0.029	ICP-SFMS	Analytica	X
Se	0.00079	0.0016	AFS	Analytica	0
Zn	0.68	1.4	ICP-AES	Analytica	X
DOC	100	210			
pH	8.2		DS287	DHI	
Ledningsevne (mS/m)	381		DS/EN 27888	DHI	
Redoxpotentiale (mV)	354			DHI	
TDS	2700	5400	DIN 38409-H1	Analytica	X

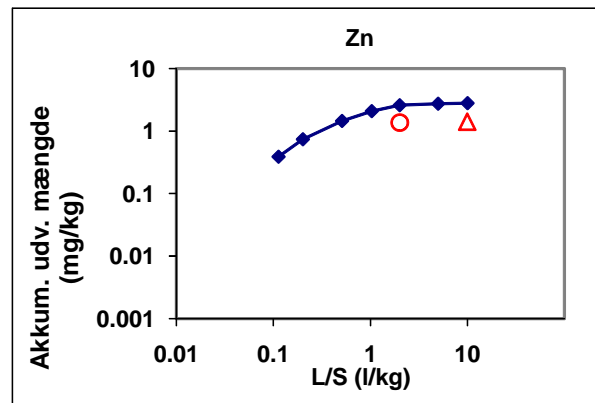
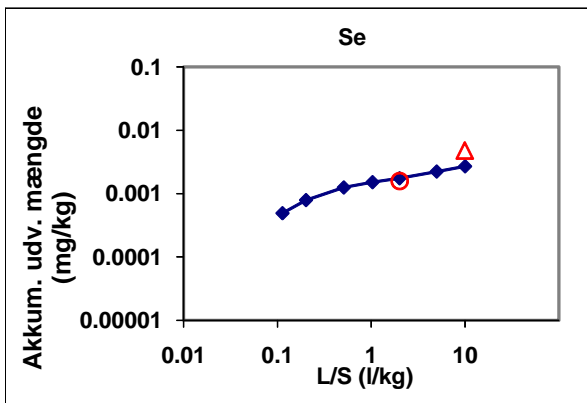
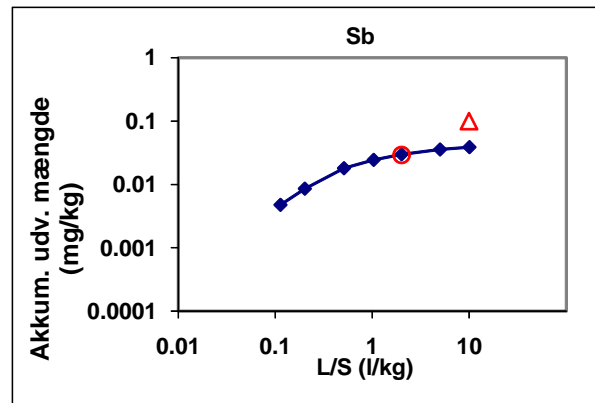
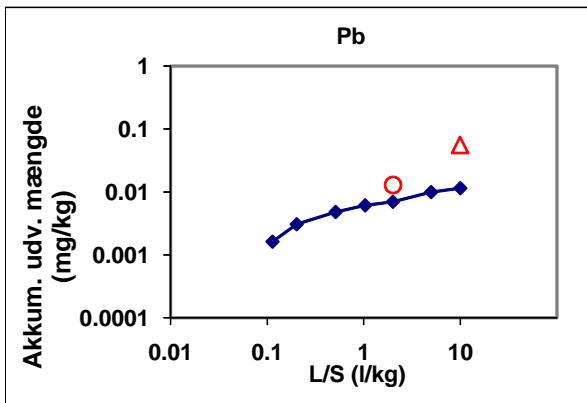
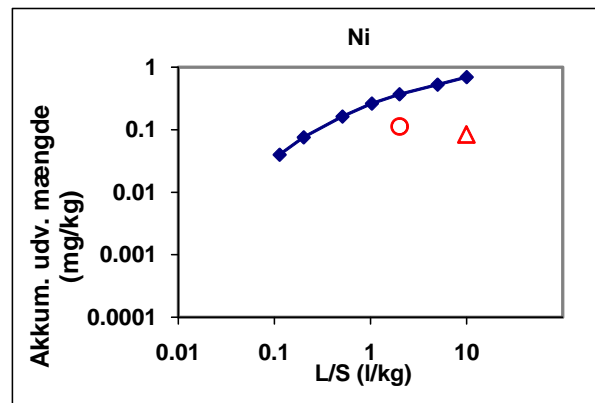
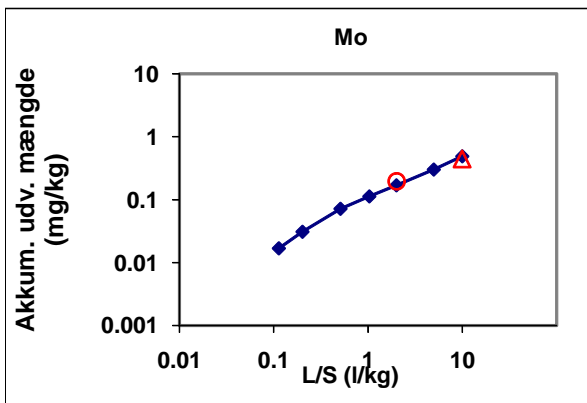
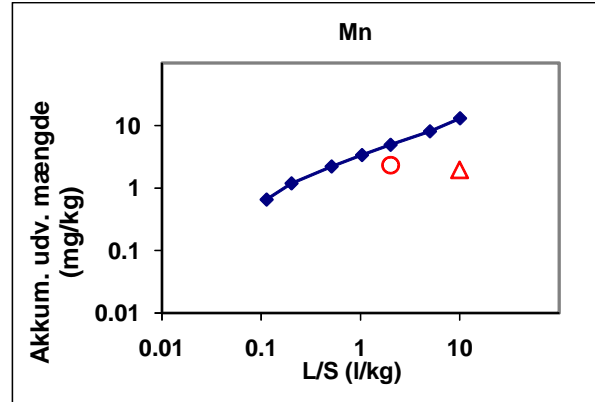
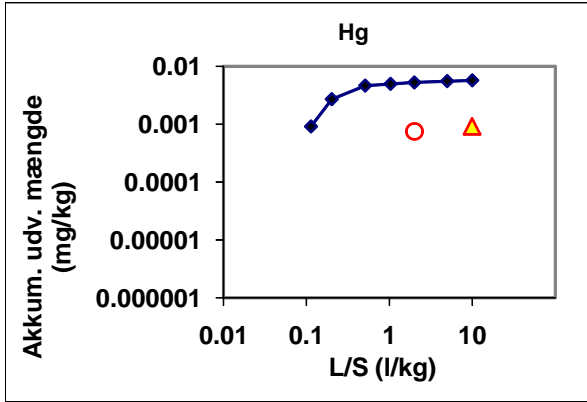
Bilag 4
Resultater af kolonneudvaskningstest og batchtest



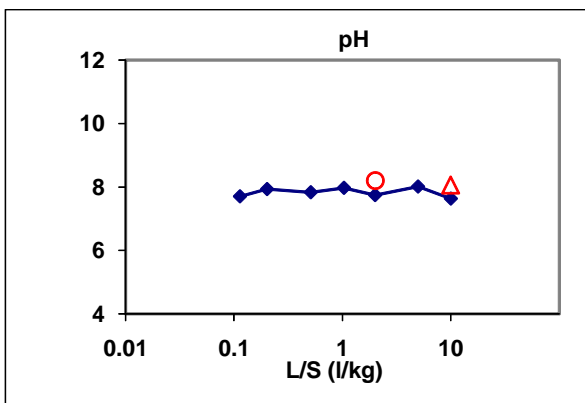
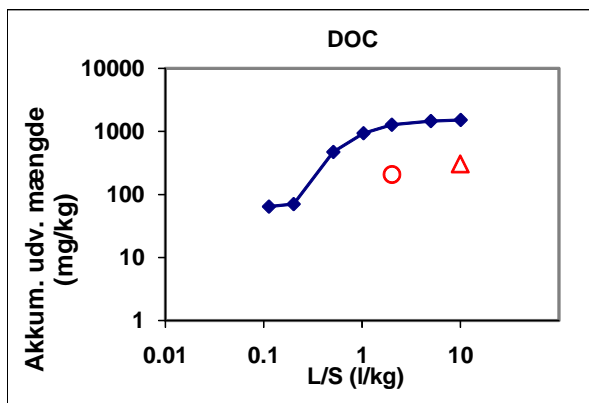
Bilag 4
Resultater af kolonneudvaskningstest og batchtest



Bilag 4
 Resultater af kolonneudvaskningstest og batchtest



Bilag 4
Resultater af kolonneudvaskningstest og batchtest



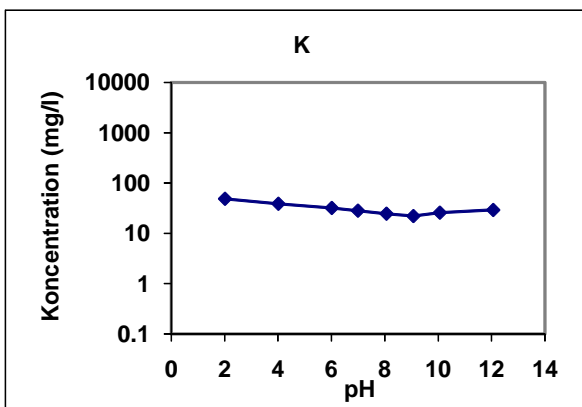
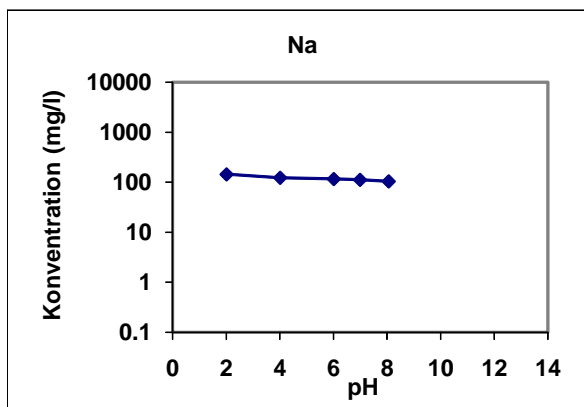
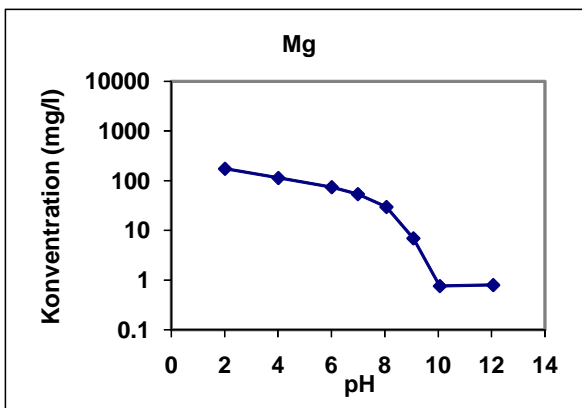
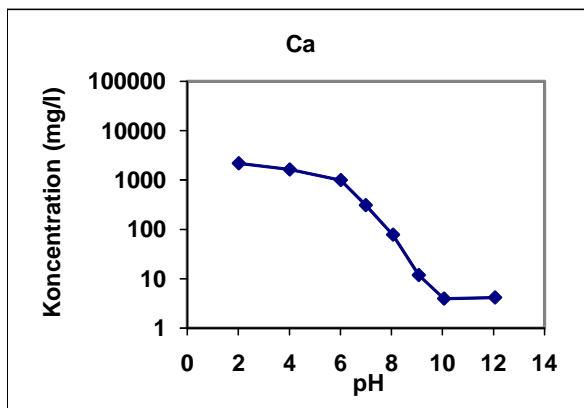
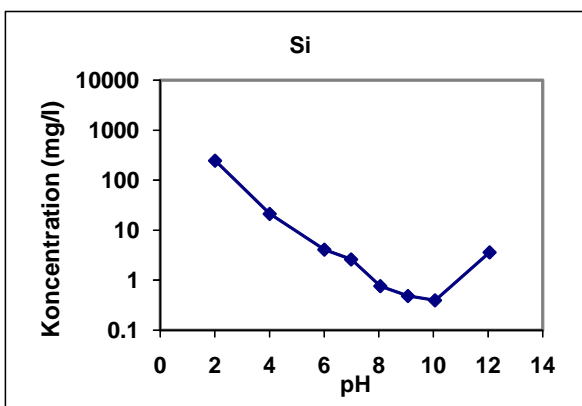
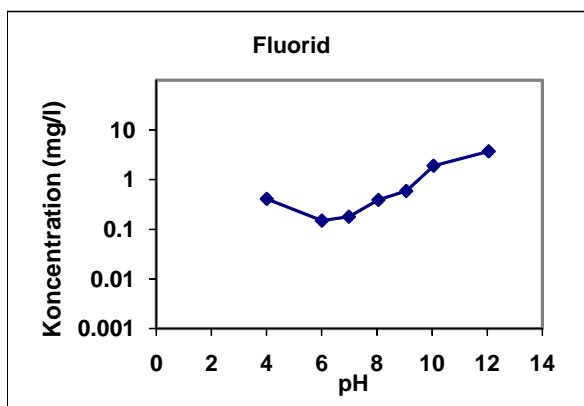
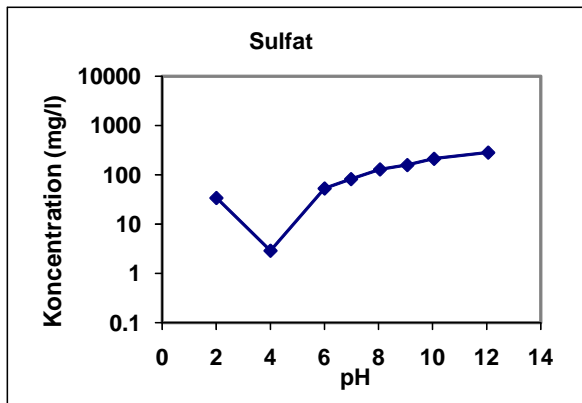
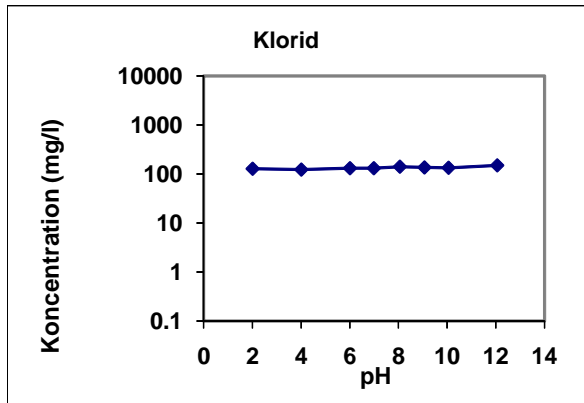
Bilag 5
Resultater af pH-statisk udvaskningstest

pH-statisk udvaskningstest			CEN/TS 14997			Page 1 of 2			
DHI-sag:	Aftercare					Temperatur Ca. 20 d grader C			
Sagsnr.:	53451					Forbehandl l Formalet til < 0.125 mm			
Prøve udt.:	07/06/2006					Test udført af: SEK			
Materiale:	Shredderaffald					Godkendt af: OH			
Prøve-ID:	Shredder waste from landfill (cell 2.2.1) at AV Miljø					Godk.-dato: 30/04/2007			
LRJ-nr.:	R-094-06								
Batch nr	Slut-pH	Start-pH	Tørvægt af testportion (g)	Volumen af vand (ml)	Volumen syre/base (ml)	Normalitet af syre (M)	Normalitet af base (M)	Kon-takttid (timer)	Faktisk L/S (l/kg)
1	2.01	8.7	59.9	547.6	135.7	1.0		48	11.4
2	4.01	8.5	60.3	548.0	59.5	1.0		48	10.1
3	6.01	8.3	60.2	577.2	30.2	1.0		48	10.1
4	6.99	8.3	60.6	603.1	4.9	1.0		48	10.0
5	8.06	8.3	60.7	603.5	0.0			48	9.9
6	9.07	8.4	60.6	584.2	23.1		0.5	48	10.0
7	10.06	8.5	60.8	553.8	54.8		0.5	48	10.0
8	12.06	8.5	60.4	542.5	64.0		1.0	48	10.0
Eluate composition:									
Parameter	Enhed	pH 2.0	pH 4.0	pH 6.0	pH 7.0	pH 8.1	pH 9.1	pH 10.1	pH 12.1
Klorid	mg/l	130	120	130	130	140	140	130	150
Fluorid	mg/l	1.1	0.41	0.15	0.18	0.39	0.59	1.9	3.7
Sulfat	mg/l	34	2.9	53	82	130	160	210	280
Si	mg/l	250	21	4.1	2.6	0.76	0.48	0.4	3.6
Ca	mg/l	2200	1600	1000	310	78	12	3.9	4.2
Mg	mg/l	180	110	74	54	30	6.9	0.76	0.79
Na	mg/l	150	120	120	110	110	250	1000	2000
K	mg/l	49	39	32	28	25	22	26	29
Al	mg/l	690	110	0.033	0.06	0.38	3.9	40	350
As	mg/l	0.012	< 0.01	0.0022	< 0.002	0.0014	0.0022	0.0033	0.011
Ba	mg/l	7.1	5.3	0.95	0.34	0.13	0.18	0.053	0.13
Cd	mg/l	1.7	1.3	0.2	0.0098	0.0005	0.00033	< 0.00005	0.0046
Co	mg/l	10	3.5	0.85	0.16	0.0064	0.0027	0.00088	0.021
Cr	mg/l	1.7	0.047	0.00067	< 0.0005	0.0012	0.0039	0.0035	0.051
Cu	mg/l	190	51	0.93	0.15	0.11	0.18	0.23	5.7
Fe	mg/l	1100	61	0.026	0.029	0.12	0.69	0.031	2.3
Hg	mg/l	0.00018	0.00022	0.000059	2.9E-05	9.3E-05	0.00018	0.00013	0.0021
Mn	mg/l	48	29	14	3.2	0.2	0.026	0.0046	0.09
Mo	mg/l	< 0.005	< 0.005	0.00098	0.0089	0.045	0.075	0.13	0.12
Ni	mg/l	24	6.6	0.83	0.11	0.0084	0.011	0.0022	0.049
Pb	mg/l	52	8.4	0.011	0.0027	0.0056	0.026	0.0029	0.2
S	mg/l	12	4.1	20	32	47	60	80	67
Sb	mg/l	0.033	0.002	0.0032	0.0049	0.01	0.015	0.033	0.17
Se	mg/l	0.00033	0.00016	0.00029	0.00035	0.00048	0.00058	0.0012	0.005
Sn	mg/l	0.23	< 0.005	0.00056	0.00082	0.0017	0.0037	0.0023	0.047
Zn	mg/l	1100	680	97	3.7	0.14	0.34	0.036	2.9
DOC	mg/l	47	19	19	22	31	38	51	220
Redox pot.	mV	432	337	301	300	274	283	311	180

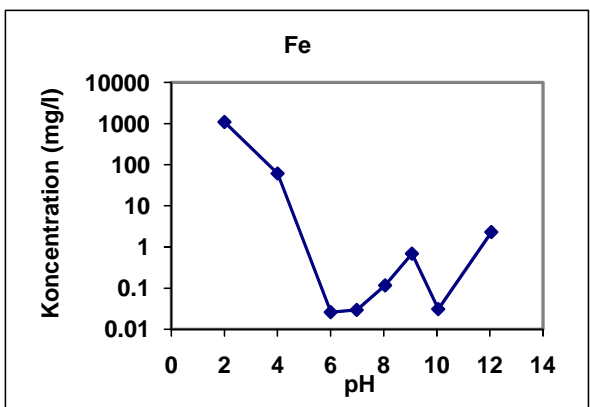
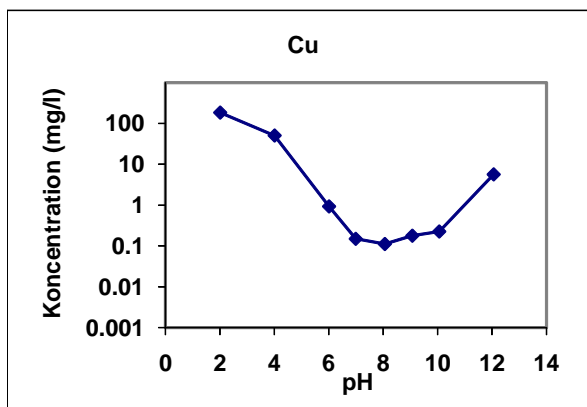
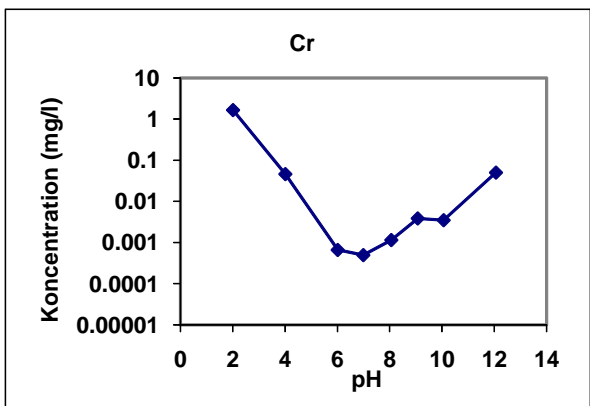
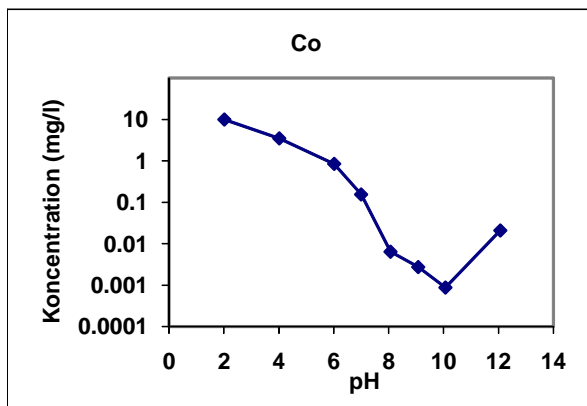
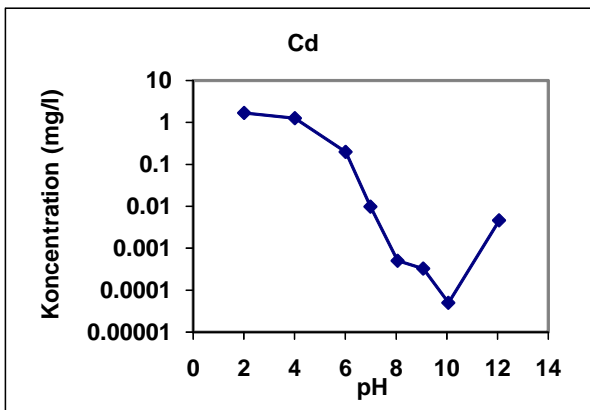
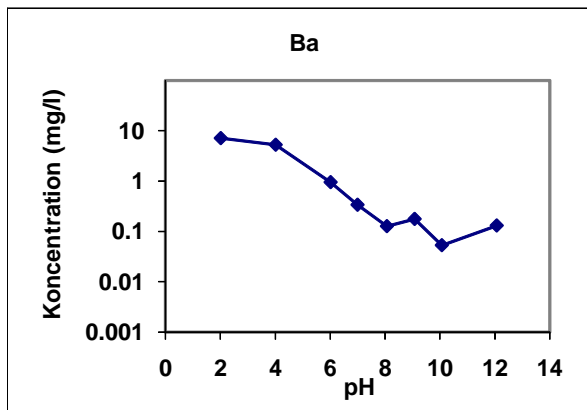
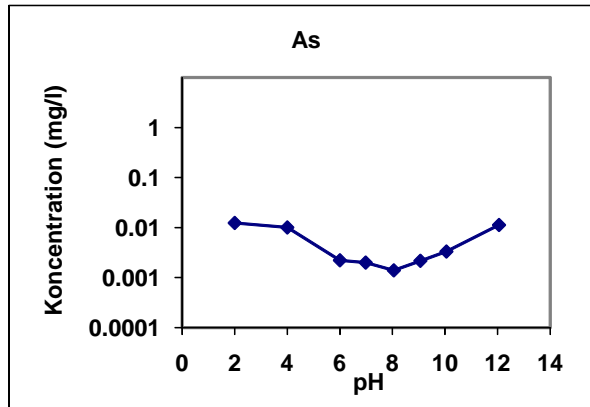
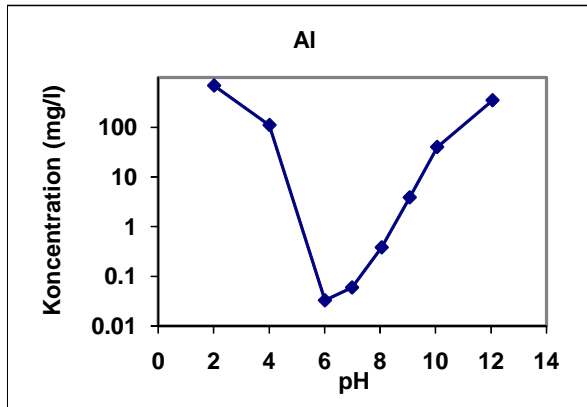
Bilag 5
Resultater af pH-statisk udvaskningstest

pH-statisk udvaskningstest		CEN/TS 14997		Page 2 of 2					
DHI-sag:	Aftercare			Temperatur Ca. 20 d/ grader C					
Sagsnr.:	53451			Forbeha Formalet til < 0.125 mm					
Prøve udt.:	07/06/2006			Test udført af: SEK					
Materiale:	Shredderaffald			Godkendt af: OH					
Prøve-ID:	Shredder waste from landfill (cell 2.2.1) at AV Miljø			Godk.-dato: 30/04/2007					
LRJ-nr.:	R-094-06								
Batch nr	Slut-pH	Start-pH	Tørvægt af testportion (g)	Volumen af vand (ml)	Volumen syre/base (ml)	Normalitet af syre (M)	Normalitet af base (M)	Kon-taktid (timer)	Faktisk L/S (l/kg)
1	2.0	8.7	59.9	547.6	135.7	1.0		48	11.4
2	4.0	8.5	60.3	548.0	59.5	1.0		48	10.1
3	6.0	8.3	60.2	577.2	30.2	1.0		48	10.1
4	7.0	8.3	60.6	603.1	4.9	1.0		48	10.0
5	8.1	8.3	60.7	603.5	0.0			48	9.9
6	9.1	8.4	60.6	584.2	23.1			48.0	10.0
7	10.1	8.5	60.8	553.8	54.8			48.0	10.0
8	12.1	8.5	60.4	542.5	64.0			48.0	10.0
Udvaskede stofmængder									
Parameter	Enhed	pH 2.0	pH 4.01	pH 6.0	pH 7.0	pH 8.06	pH 9.07	pH 10.06	pH 12.06
Klorid	mg/kg	1500	1200	1300	1300	1400	1400	1300	1500
Fluorid	mg/kg	13	4.1	1.5	1.8	3.9	5.9	19	37
Sulfat	mg/kg	390	29	530	820	1300	1600	2100	2800
Si	mg/kg	2800	210	41	26	7.6	4.8	4	36
Ca	mg/kg	25000	17000	10000	3100	780	120	39	42
Mg	mg/kg	2000	1100	750	540	300	69	7.6	7.9
Na	mg/kg	1700	1200	1200	1100	1000	2500	10000	20000
K	mg/kg	560	390	320	280	250	220	260	290
Al	mg/kg	7900	1100	0.33	0.6	3.8	39	400	3500
As	mg/kg	0.14	< 0.1	0.022	< 0.02	0.014	0.022	0.033	0.11
Ba	mg/kg	81	53	9.6	3.4	1.3	1.8	0.53	1.3
Cd	mg/kg	19	13	2	0.098	0.005	0.0033	0.0005	0.046
Co	mg/kg	110	35	8.6	1.6	0.064	0.027	0.0088	0.21
Cr	mg/kg	19	0.47	0.0067	< 0.005	0.012	0.039	0.035	0.51
Cu	mg/kg	2100	510	9.4	1.5	1.1	1.8	2.3	57
Fe	mg/kg	13000	620	0.26	0.3	1.2	6.9	0.31	23
Hg	mg/kg	0.002	0.0022	0.00059	0.00029	0.00092	0.0018	0.0013	0.021
Mn	mg/kg	< 550	290	140	32	2	0.26	0.046	0.91
Mo	mg/kg	0.057	< 0.05	0.0099	0.089	0.44	0.75	1.3	1.2
Ni	mg/kg	270	67	8.4	1.1	0.084	0.11	0.022	0.49
Pb	mg/kg	600	84	0.11	0.027	0.056	0.26	0.029	2
S	mg/kg	140	41	200	320	470	600	800	670
Sb	mg/kg	0.38	0.02	0.032	0.049	0.099	0.15	0.33	1.7
Se	mg/kg	0.0037	0.0016	0.0029	0.0035	0.0048	0.0058	0.012	0.05
Sn	mg/kg	2.6	< 0.05	0.0057	0.0082	0.017	0.037	0.023	0.47
Zn	mg/kg	13000	6900	980	37	1.4	0 3.4	0.36	29
DOC	mg/kg	530	190	190	220	300	0 380	510	2300

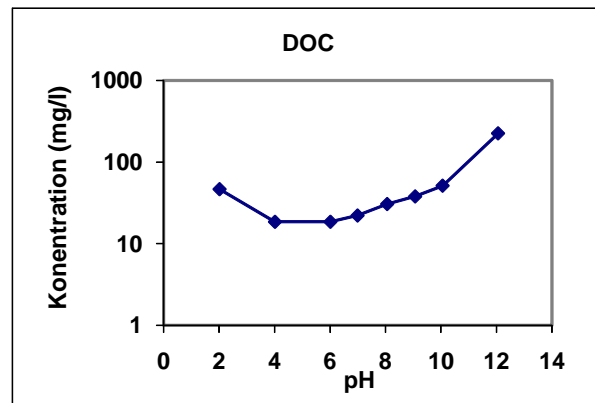
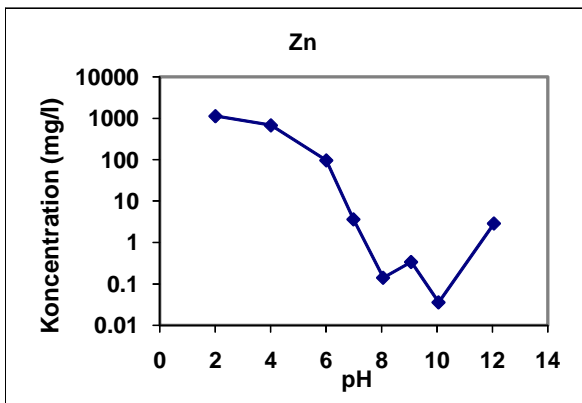
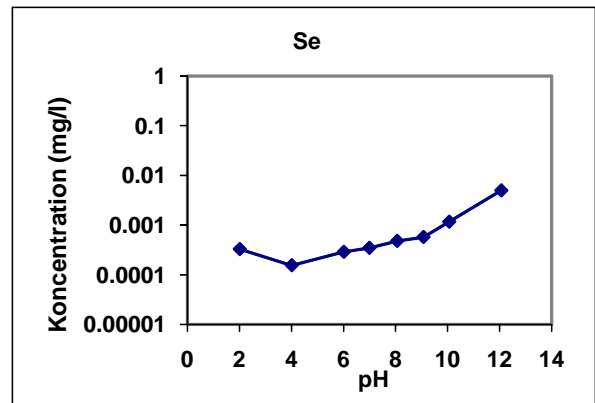
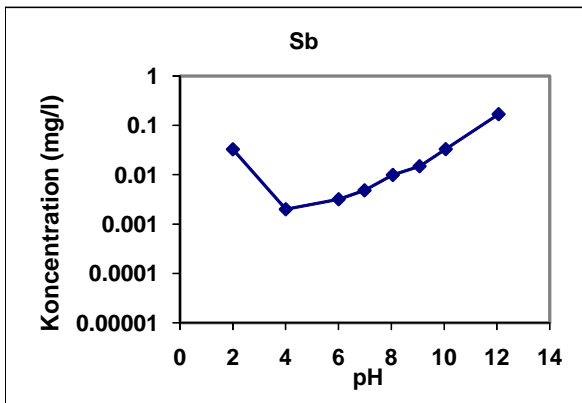
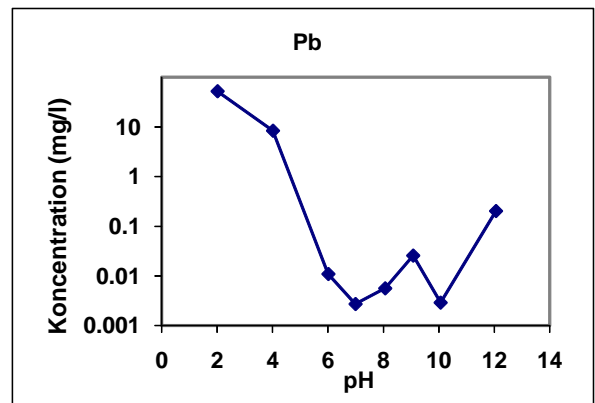
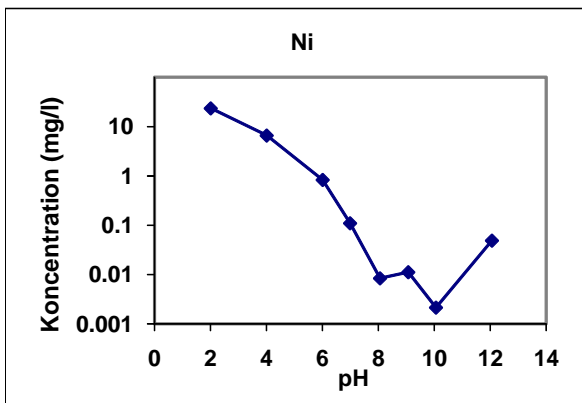
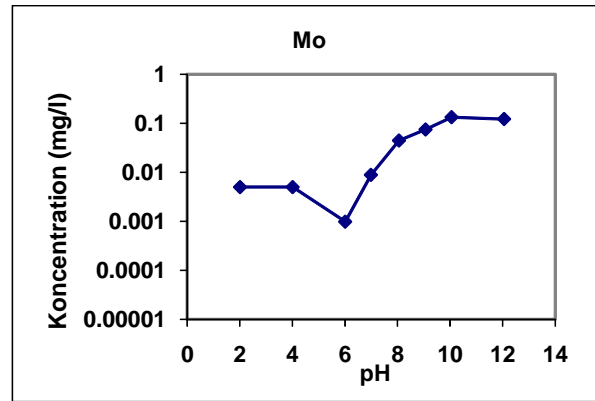
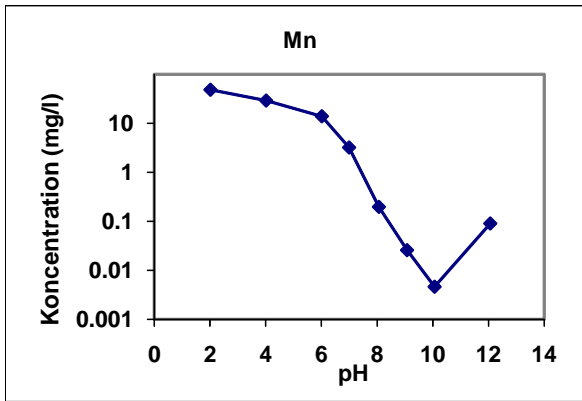
Bilag 5
Resultater af pH-statisk udvaskningstest



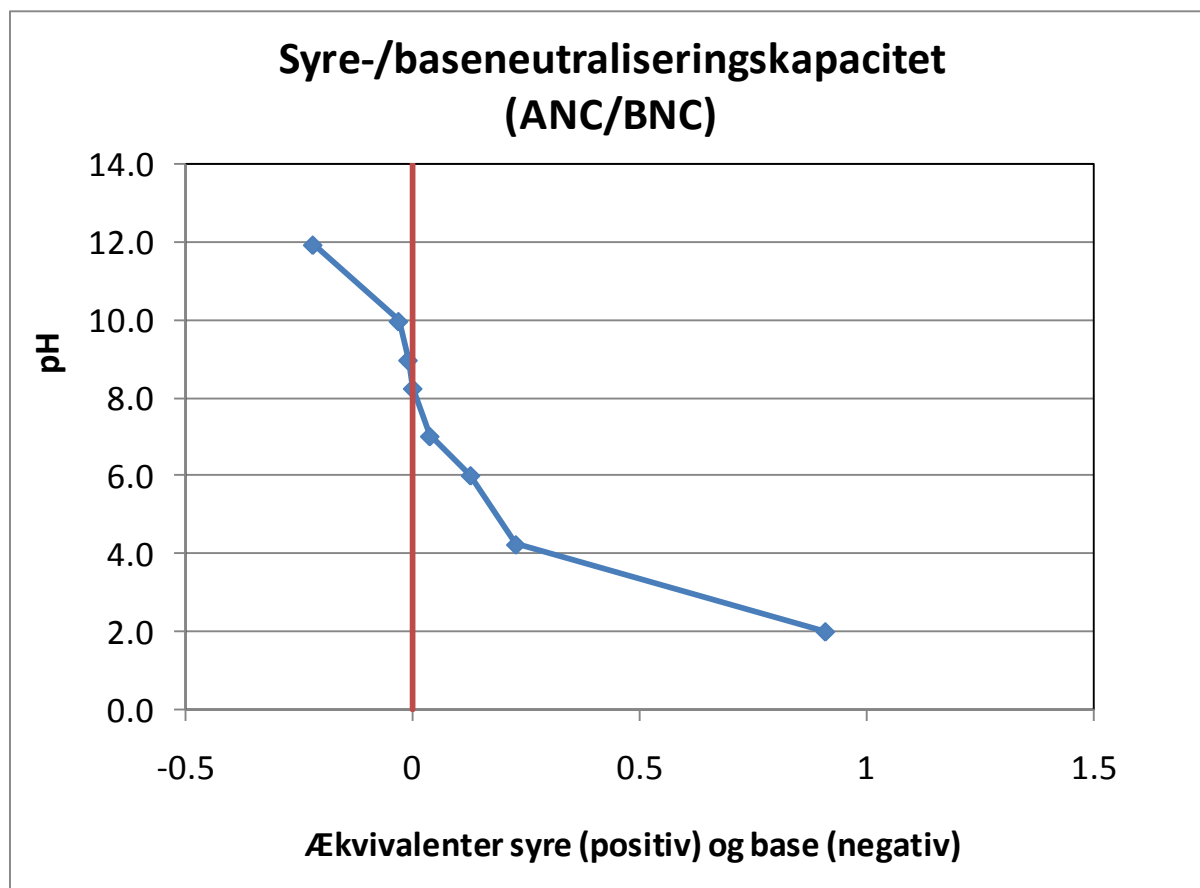
Bilag 5
Resultater af pH-statisk udvaskningstest



Bilag 5
Resultater af pH-statisk udvaskningstest



Bilag 5
Resultater af pH-statisk udvaskningstest



Bilag 6
Resultater af ligevægtskolonnetest

Ligevægtskolonnetest: DHI-metode M22-1						
DHI-sag:	Aftercare	Test udført af:	SEK			
Sagsnr.:	53451	Udført dato:	13/12-21/12 2006			
Prøve modtaget:	07/06/2006	Godkendt af:	OH			
		Godk.-dato:	14/01 2009			
Materiale:	Shredderafald					
Prøve-ID:	Shredder waste from landfill (cell 2.2.1) at AV Miljø					
LRJ-nr.:	R-094-06					
Tørstofindhold i testportion:	824 gTS/kg	Eluent:	Demineraliseret vand			
Vådvægt af testportion:	1336 g	Temperatur:	ca. 20 grader C			
Vandindhold i testportion:	235 ml	Kontaktid:	07:00 dage:timer			
Vol. af udv.-medium tilsat:	1821 ml					
Faktisk L/S:	1.87 l/kg					
Er prøven nedknust?	Ja					
Er prøven tørret?	Lufttørret					
Mængde > 4 mm (% w/w):						
Parameter	Koncentration i eluatet		Udvaskede stofmængder	Analysemetode	Analyselab	Akk. (X)
	µg/l	µg/kg				
Kulbrintefraktioner:						
Benzen - C10	22	41	GC/FID (pentan-ekstr.)	Eurofins	X	
C10 - C25	220	410	GC/FID (pentan-ekstr.)	Eurofins	X	
C25 - C35	32	60	GC/FID (pentan-ekstr.)	Eurofins	X	
Sum Benzen - C35	270	510	GC/FID (pentan-ekstr.)	Eurofins	X	
PAH-forbindelser:						
Naphthalen	< 0.01	< 0.19	MK2260-GC/MS	Eurofins	X	
Acenaphthylen	< 0.01	< 0.19	MK2260-GC/MS	Eurofins	X	
Acenaphthen	< 0.01	< 0.93	MK2260-GC/MS	Eurofins	X	
Fluoren	< 0.01	< 0.19	MK2260-GC/MS	Eurofins	X	
Phenanthren	< 0.01	< 0.19	MK2260-GC/MS	Eurofins	X	
Anthracen	< 0.01	< 0.19	MK2260-GC/MS	Eurofins	X	
Fluoranthren	< 0.01	< 0.37	MK2260-GC/MS	Eurofins	X	
Pyren	< 0.01	< 0.37	MK2260-GC/MS	Eurofins	X	
Benz(a)anthracen	< 0.01	< 0.037	MK2260-GC/MS	Eurofins	X	
Chrysen/Triphenylen	< 0.01	< 0.037	MK2260-GC/MS	Eurofins	X	
Benz(b+j+k)fluoranthren	< 0.01	< 0.093	MK2260-GC/MS	Eurofins	X	
Pyren	< 0.01	< 0.037	MK2260-GC/MS	Eurofins	X	
Indeno(1,2,3-cd)pyren	< 0.01	< 0.019	MK2260-GC/MS	Eurofins	X	
Dibenz(a, h)anthracen	< 0.01	< 0.019	MK2260-GC/MS	Eurofins	X	
Benzo(g, h, i)perylene	< 0.01	< 0.037	MK2260-GC/MS	Eurofins	X	
Sum PAH-forbindelser	< -	-	-	-		
pH	7.7		DS287	DHI		
Ledningsevne (mS/m)	520		DS/EN 27888	DHI		
Turbiditet (NTU)	4.3			DHI		

A P P E N D I X B

Characterisation of AV Miljø mixed waste from cell 2.4

Grundlæggende karakterisering af prøve af blandet affald i forbindelse med lysimeterforsøg ved KMC og Aftercare-projektet ved AV Miljø	
Materiale/DHI-ID:	Indbygget blandet affald fra AV Miljø, R-096-06
Lysimetre:	Nr. 3 og 4
Dato for prøve-tagning:	9. juni 2006
Dato for denne version:	Maj 2009/OH

4. Prøvetagning og forbehandling

Den 9. juni 2006 blev der fra hvert af 9 forskellige steder på den aktive tipfront i celle 2.4 på AV Miljø med gravemaskine udtaget 3 stik. Alle 27 stik blev lagt i én bunke og nedkust med en kompaktor. Den 12. juni 2006 kl. 9:00 – 12:00 blev affaldet med en gravemaskine med grab læsset på skovlen af en gummiged, og i alt 6 skovlfulde (totalt 17,54 tons) blev overført til en tildækket container og senere anvendt til opfyldning af KMC-lysimetrene 13 og 14. I forbindelse med overførslen fra gravemaskine til gummiged blev der fra hver grabfuld med en skovl udtaget to parallelle prøver, som blev placeret i to plasttromler, som efterfølgende blev bragt til DHI.

På DHI blev affaldet fra de to tromler (med henholdsvis 78,6 kg (prøve A) og 70,1 kg (prøve B) blandet affald) sigtet og neddelt hver for sig. Materiale større end 10 mm blev nedkust/-klippet/-hakket, og materiale, som ikke kunne nedknuses (metal og sten), blev frasorteret. Efter yderligere forbehandling blev prøven fra den ene tromle (prøve B (R-094-06)) underkastet kemisk analysering samt en række karakteriseringstests. Fra den anden tromle, A, blev der udtaget tre delprøver svarende til prøven fra tromle B. Disse tre prøver blev sammen med en delprøve fra tromle B underkastet en batchudvaskningstest til belysning af prøvetagningens og forbehandlingens betydning for udvaskningsresultatet.

Prøvetagning og forbehandling er sammen med resultaterne af batchudvaskningstestene beskrevet mere detaljeret i bilag 1.

5. Karakteriseringens omfang

5.1 Oversigt

I tabel 1 ses en oversigt over omfanget af den grundlæggende karakterisering.

Tabel 1
Oversigt over den grundlæggende karakteriseringstestning

Test/analyse	Bemærkninger
Totalindhold af uorganiske komponenter	
Indhold af TOC	
Indhold af kulbrinter, PAH, BTEX og PCB	
Kolonueudvaskningstest CEN/TS 14405	Uorganiske komponenter og DOC
Batchudvaskningstest EN 12457-1	Uorganiske komponenter og DOC
pH-statisk udvaskningstest CEN/TS 14997	Uorganiske komponenter og DOC
Ligevægtskolonnetest	Ikke-flygtige organiske komponenter

5.2 Analysering for indhold af uorganiske og organiske komponenter

En repræsentativ delprøve er blevet sendt til ECN i Holland til totaloplukning og efterfølgende bestemmelse af totalindhold af Si, Al, Ca, Mg, Ti, Na, K, Fe, S, P, As, B, Ba, Br, Cd, Cl, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, S, Sb, Se, Sr, V, W, Zn.

En anden repræsentativ delprøve blev sendt til Pirkanmaa Regional Environment Centre Laboratory i Finland til analysering for indhold af TOC.

En tredje repræsentativ delprøve blev sendt til Eurofins til analysering for indhold af kulbrinter, PAH, BTEX og PCB.

Resultaterne af faststofanalyserne er vist i bilag 2 og bilag 3.

5.3 Udførelse af kolonneudvaskningstest for uorganiske komponenter og DOC

På en repræsentativ delprøve nedknust til ca. < 4 mm er der udført en kolonneudvaskningstest (udvaskning med en demineraliseret vand i en kolonne med diameter = 10 cm) i henhold til CEN/TS 14405. Der er opsamlet 7 eluatfraktioner i intervallet L/S = 0 – 10 l/kg. Eluaterne, der opsamlet under nitrogen, er efterfølgende blevet filtreret gennem et 0,45 µm filter og sendt til Analytica til analysering for klorid, fluorid, sulfat, HCO₃, Si, Ca, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se og Zn. Andre prøver er sendt til ECN til analysering for opløst organisk stof, DOC.

Resultaterne er vist i bilag 4, både som koncentrationer i eluaterne (mg/l) og som akkumulerede udvaskede mængder som funktion af L/S (mg/kg). De akkumulerede udvaskede mængder er endvidere afbildet som funktion af L/S.

5.4 Udførelse af batchudvaskningstest for uorganiske komponenter og DOC

På tre delprøver af prøve A og én delprøve af prøve B af det blandede affald nedknust til ca. < 4 mm er der gennemført batchudvaskningstests ved L/S = 2 l/kg i henhold til EN 12457-1 med demineraliseret vand. Eluaterne er efter filtrering sendt til Analytica til analysering for klorid, fluorid, sulfat, TDS (total opløst tørstof), HCO₃, Si, Ca, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se og Zn. Andre prøver er sendt til ECN til analysering for opløst organisk stof, DOC.

Resultaterne er vist i bilag 4. De udvaskede stofmængder er afbildet sammen med resultaterne af kolonneudvaskningstesten.

5.5 Udførelse af pH-statisk udvaskningstest for uorganiske komponenter og DOC

På repræsentative delprøver af prøve B af det blandede affald, nedknust til ca. < 2 mm, er der gennemført pH-statisk udvaskningstests med demineraliseret vand ved L/S = 10 l/kg med fastholdt pH i 48 timer i henhold til CEN/TS 14997. I testen fastholdes pH ved hjælp af computerkontrolleret feedback-styring og tilsætning af HNO₃ eller NaOH. Der er udvasket ved 8 forskellige pH-værdier, pH = 2,0, 3,8, 6,1, 7,4 (det blandede affalds egen-pH, ingen tilsætning af syre eller base), 8,2, 8,9, 9,8 og 11,8. Eluaterne er efter filtrering gennem et 0,45 µm filter sendt til Analytica til analysering for klorid, fluorid, sulfat, Si, Ca, Mg, Na, K, Al, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, Sn og Zn. Andre prøver er sendt til ECN til analysering for opløst organisk stof, DOC. Resultaterne er vist i bilag 5, både som koncentrationer (mg/l) og som udvaskede stofmængder (mg/kg). Resultaterne er endvidere afbildet som koncentrationer som funktion af pH. Resultaterne af udvaskningerne uden syre-/basetilsætning er afbildet i bilag 4 sammen med resultaterne af kolonneudvaskningstesten.

Baseret på tilsætningerne af syre og base og de målte pH-værdier er det blandede affalds syre-/baseneutraliseringskapacitet angivet på en figur i bilag 5.

5.6 Udførelse af ligevægtskolonnetest for ikke-flygtige organiske komponenter

På en repræsentativ delprøve af prøve B af det blandede affald (nedknust til ca. < 4 mm) er der gennemført en ligevægtskolonnetest ved L/S = 1,87 l/kg og en kontakttid på 7 dage. Testen er udviklet af DHI og DTU for Miljøstyrelsen til brug for undersøgelse af udvaskningen af ikke-flygtige organiske komponenter. Eluatet er blevet sendt til Eurofins til analysering for kulbrinter og PAH. Resultaterne er vist i bilag 6.

6. Vurdering af resultaterne i forhold til klassificering og lovgivning mv.

Det blandede affald fra AV Miljø synes at svare til den definition af blandet affald, som er givet i Bekendtgørelse nr. 252 af 31. marts 2009 om deponeringsanlæg: "En delmængde af ikke-farligt affald, som består af en blanding af organisk og uorganisk materiale med et indhold af total organisk kulstof (TOC) på 50 g eller mere per kg tør prøve". Der er ikke fundet stofindhold i eller egenskaber af det undersøgte affald, som giver anledning til at klassificere dette som farligt affald, og det målte indhold af TOC på 230 g/kg overstiger jo klart de 50 g/kg.

Både visuelt og under forbehandlingen fremgik det, at det blandede affald havde et meget stort indhold af plast (der blev ikke skelnet mellem PVC og andre plasttyper), træ, tagpap og lignende, som for en stor dels vedkommende formentlig ville være forbrændingseget, hvis det blev/kunne frasorteres.

På grund af det store indhold af langsomt nedbrydeligt organisk materiale kan det forventes, at de fundne udvaskningsforhold på længere sigt vil ændre sig noget som følge af biologisk aktivitet.

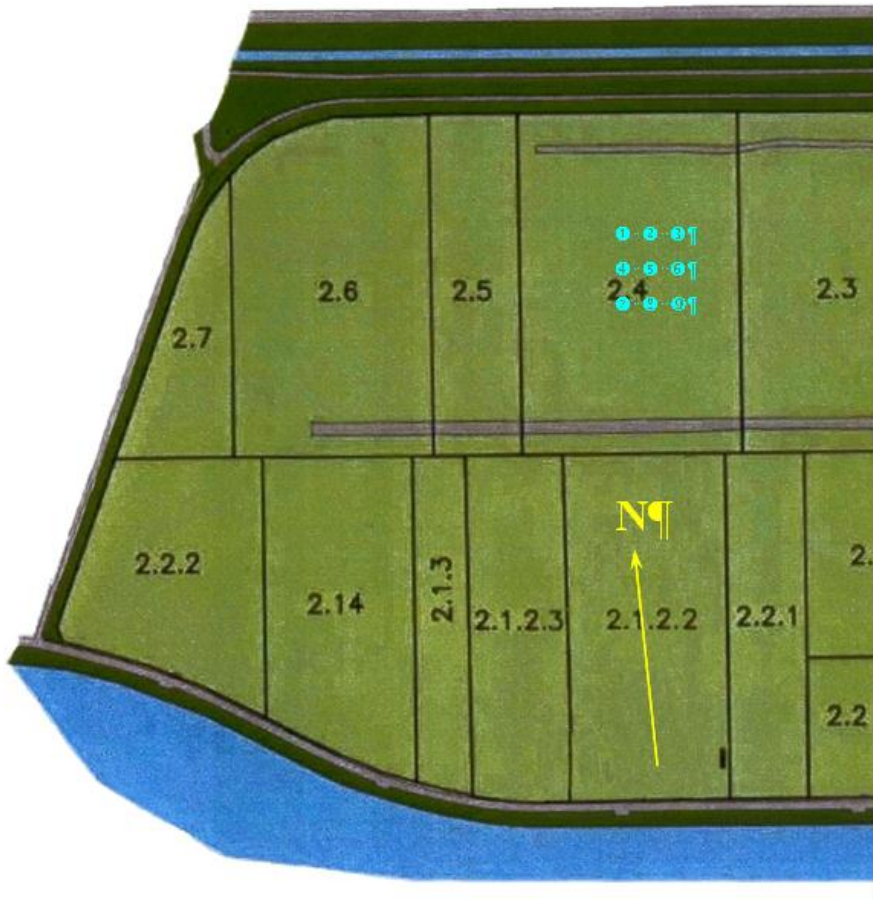
Bilag 1 Prøvetagning

Beskrivelse af prøvetagning og forbehandling

Udtagning af prøver

Den 9. juni 2006 blev der fra hvert af 9 forskellige steder på den aktive tipfront i celle 2.4 (se figur 1) på AV Miljø med gravemaskine af AV Miljø udtaget 3 stik. Alle 27 stik blev lagt i én bunke og nedknust med en kompaktor. Den 12. juni 2006 kl. 9:00 – 12:00 blev affaldet af AV Miljø og DHI med en gravemaskine med grab læsset på skovlen af en gummiged, og i alt 6 skovlfulde (på henholdsvis 2680 kg, 2880 kg, 2900 kg, 3080 kg, 2880 kg og 3120 kg, svarende til ialt 17,54 tons) blev overført til en tildækket container og senere anvendt til opfyldning af KMC-lysimitrene 13 og 14. I forbindelse med overførslen fra gravemaskine til gummiged blev der fra hver grabfuld med en skovl udtaget to parallelle prøver, som blev placeret i to plastromler. De to plastromler med blandet affald til karakterisering blev efterfølgende bragt til DHI.

Containeren blev tildækket og henstillet, indtil en del af det blandede affald den 7. juni 2007 blev bragt i lysimetrene 3 og 4 hos KMC.



Figur 1

Oversigt over cellerne på AV Miljø og prøvetagningsstederne i celle 2.4.

Figur 2 viser nogle billeder fra prøvetagningen på AV Miljø den 12. juni 2006.

Bilag 1 Prøvetagning



Figur 2
Udtagning af prøver af blandet affald fra celle 2.4 på AV Miljø den 12. juni 2006.

Forbehandling af prøver

De to plastromler med blandet affald (prøve A og prøve B), som i princippet var ens, blev efter modtagelsen på DHI vejret og underkastet en forbehandling. Prøve A (R-095-06) vejede 78,58 kg og prøve B (R-096-06) vejede 70,14 kg.

På DHI blev prøve B (R-096-06) sigtet gennem et 10 mm sold. Fraktionen > 10 mm, som bl.a. bestod af træ, hård plast, plastposer, tagpap og jern (sidstnævnte blev frasorteret) blev kørt gennem en flis-

Bilag 1 Prøvetagning

maskine efter at træ, hård plast, plastposer og tagpap var blevet hugget og klippet til mindre stykker. Materialet blev derefter yderligere sønderdelt i en Retch SM2000 snitemølle efter at den hårde plast, plastposer og tagpap var blevet overhældt med flydende nitrogen. Efter yderligere neddeling ved coning and quartering og riffelneddeler blev fraktionen < 10 mm sammenblandet med den behandlede fraktion, som oprindeligt var > 10 mm, men som nu også var < 10 mm. Den kombinerede fraktion blev efter neddeling til 7,75 kg sønderdelt til < ca. 4 mm til anvendelse i udvaskningstests. En mindre mængde sønderdeltes til < 2 mm til analyse for indhold af uorganiske og organiske komponenter samt til den pH-statistiske udvaskningstest. Der blev frasorteret 2,226 kg jern og sten.

Prøve A (R-095-06) blev underkastet en tilsvarende behandling. Efter nedknusning og neddeling til en samlet mængde på 40,41 kg < 10 mm, blev prøven A ved hjælp af en riffelneddeler opdelt i to prøver, A1 og A2 (R-169-06). Prøve A1 blev på samme måde yderligere neddelt til prøverne A1.1 (R-167-06) og A1.2 (R-168-06). Der blev i alt frasorteret 1,147 kg jern og sten fra prøve A. Prøverne A.1.1, A1.2 og A2 blev sammen med prøve B underkastet en batchudvaskningstest, EN 12457-1, ved L/S = 2 l/kg.

Figur 3 viser nogle billeder af det blandede affald under forbehandlingen.



Figur 3
Billeder af det blandede affald under forbehandlingen, hvor det er splittet op i forskellige fraktioner, som bliver sammenblandet igen efter nedknusning til < 10 mm.

Resultater af batchudvaskningstests

De tre delprøver af A-prøven (A1.1, A1.2 og A2), som i princippet er ens, og den parallelt udtagne prøve B, som i princippet svarer til prøve B, er blevet underkastet en batchudvaskningstest EN 12457-1 (L/S = 2 l/kg og 24 timers kontakttid). Resultaterne er vist i Bilag 4 og resumeret i tabel 1, som også viser beregninger af middelværdier og standardafvigelser (absolut og relativ) for henholdsvis prøverne

Bilag 1 Prøvetagning

A1.1, A1.2 og A2 (N = 3) og A1.1, A1.2, A2 og B (N = 4). Resultaterne af de enkelte udvaskningstests er også vist på figurerne 4a og 4b med angivelse af standardafvigelser.

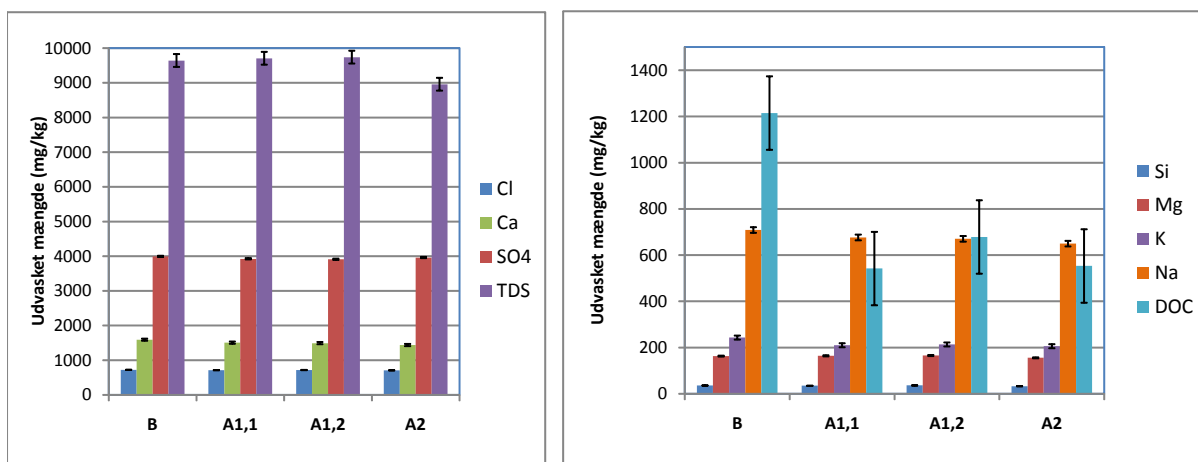
Af tabel 1 fremgår det, at den relative standardafvigelse på målingerne med enkelte undtagelser (herunder Ba, Co og Cu) viser, at repetérbarheden af testen er forbavsende god, ikke mindst når affaldets karakter (og det begrænsede antal tests) tages i betragtning. For parametrene K, As, Ba, Cu, Mo og DOC ses der en relativ standardafvigelse når prøve B medtages, som er mere end dobbelt så stor som standardafvigelsen for prøve A alene. Det viser, at prøvetagningen synes at have større indflydelse på resultatet end forbehandlingen.

Tabel 1

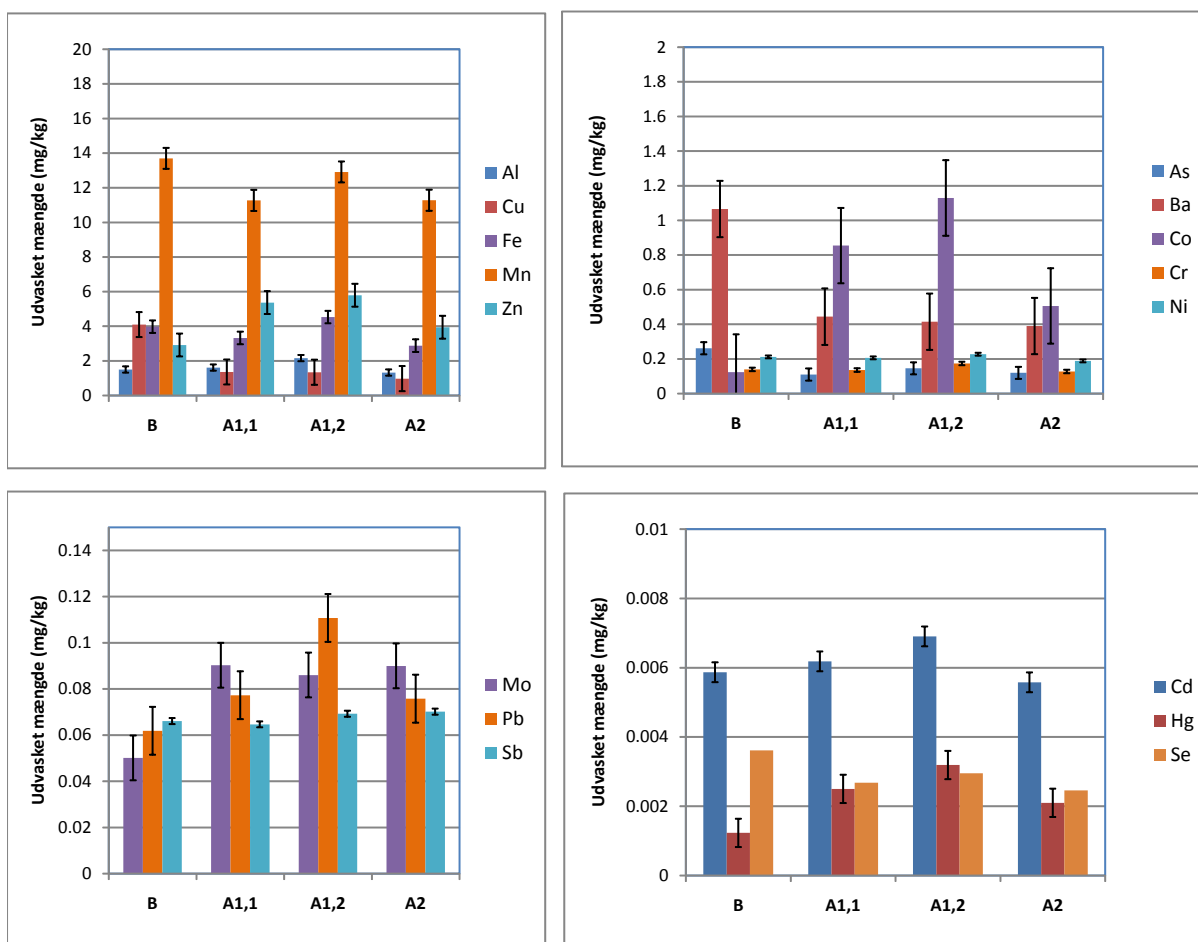
Resultater af batchudvaskningstests på prøver af blandet affald. Middelværdier og standardafvigelser er beregnet for de tre A-prøver alene (N = 3) og for de tre A-prøver + prøve B (N = 4). Alle (del)prøver er her tillagt lige stor vægt.

Parameter	B	A1,1	A1,2	A2	Middel A	Std.	Rel. Std.	Middel A+B	Std.	Rel. Std.
	R-096-06 mg/kg	R-167-06 mg/kg	R-168-06 mg/kg	R-169-06 mg/kg	N = 3 mg/kg	N = 3 mg/kg	N = 3 %	N = 4 mg/kg	N = 4 mg/kg	N = 4 %
Cl	723	710	714	706	710	4.33	0.61	713	7.14	1.0
F	< 5	2.20	< 1.5	< 1.5						
SO4	3992	3922	3911	3959	3931	24.8	0.63	3946	36.8	0.93
Si	36	35	37	33	34.8	1.88	5.4	35	1.64	4.7
Ca	1591	1505	1491	1438	1478	35.5	2.4	1506	63.6	4.2
Mg	163	165	166	156	162	5.48	3.4	162	4.52	2.8
Na	709	676	671	650	666	14.0	2.1	676	24.4	3.6
K	244	210	214	206	210	3.81	1.8	218	17.1	7.8
Al	1.5	1.6	2.2	1.3	1.697	0.422	25	1.65	0.358	22
As	0.26	0.11	0.15	0.12	0.125	0.0184	15	0.159	0.0698	44
Ba	1.07	0.44	0.42	0.39	0.416	0.0272	6.5	0.579	0.326	56
Cd	0.0059	0.0062	0.0069	0.0056	0.00622	0.000664	11	0.00613	0.00057	9.3
Co	0.12	0.85	1.13	0.51	0.830	0.313	38	0.653	0.436	67
Cr	0.14	0.14	0.17	0.13	0.146	0.0245	17	0.144	0.0203	14
Cu	4.1	1.4	1.3	0.97	1.23	0.218	18	1.94	1.44	74
Fe	4.0	3.3	4.5	2.9	3.58	0.855	24	3.68	0.725	20
Hg	0.0012	0.0025	0.0032	0.0021	0.00260	0.000553	21	0.00226	0.000818	36
Mn	14	11	13	11	11.8	0.947	8.0	12.3	1.22	9.9
Mo	0.050	0.090	0.086	0.090	0.0887	0.00237	2.7	0.0791	0.0194	25
Ni	0.21	0.21	0.23	0.19	0.207	0.0195	9.4	0.208	0.0161	7.7
Pb	0.062	0.077	0.11	0.076	0.0879	0.0198	23	0.0814	0.0208	25
Sb	0.066	0.065	0.069	0.070	0.0680	0.00297	4.4	0.0675	0.00261	3.9
Se	0.0036	0.0027	0.0030	0.0025	0.00270	0.000248	9.2	0.00293	0.000500	17
Zn	2.9	5.4	5.8	3.9	5.03	0.968	19	4.50	1.32	29
DOC	1214	542	679	553	591	75.7	13	747	318	43
TDS	9642	9706	9739	8957	9467	442	4.7	9511	371	3.9

Bilag 1 Prøvetagning



Figur 4a
Resultater af batchudvaskningstests på prøver af blandet affald.



Figur 4b
Resultater af batchudvaskningstests på prøver af blandet affald.

Bilag 2

Resultater af analyser af faststofindhold af uorganiske stoffer og TOC

Faststofindhold							
DHI-sag:		Aftercare		Godk. af:		OH	
Sagsnr.:		11700096 (53451)		Dato:		30/04/2008	
Prøve modtaget:		12/06/2006					
Materiale:		Blandet affald fra AV Miljø					
Prøve-ID:		Blandet affald B Nord					
LRJ-nr.:		R-096-06					
Oplukningsmetode B1:		50% HF (1:1-fortyndet koncentreret flussyre)					
Oplukningsmetode B8:		50% HNO3 + 45% HF + 5% HClO4					
Oplukningsmetode C:		Alkalismeltning					
Oplukningsmetode D:		Fosforsyre i overensstemmelse med EN 13137					
Parameter	Enhed	Analyse- resultat	Analysemetode	Opluk- ning	Type	Analyselab	Akk.
Si	mg/kg TS	180000		B1	Total	ECN	
Fe	mg/kg TS	14000		B8	Total	ECN	
Ti	mg/kg TS	2600		B1	Total	ECN	
Ca	mg/kg TS	51000		B8	Total	ECN	
Mg	mg/kg TS	9700		B8	Total	ECN	
Na	mg/kg TS	12000		B8	Total	ECN	
K	mg/kg TS	8600		B8	Total	ECN	
Al	mg/kg TS	26000		B8	Total	ECN	
As	mg/kg TS	180		B8	Total	ECN	
B	mg/kg TS	380		B8	Total	ECN	
Ba	mg/kg TS	650		B8	Total	ECN	
Br	mg/kg TS	13		C	Total	ECN	
Cd	mg/kg TS	2.0		B8	Total	ECN	
Cl	mg/kg TS	2400		C	Total	ECN	
Co	mg/kg TS	26		B8	Total	ECN	
Cr	mg/kg TS	340		B8	Total	ECN	
Cu	mg/kg TS	430		B1	Total	ECN	
Hg	mg/kg TS	0.49		B8	Total	ECN	
Mn	mg/kg TS	830		B8	Total	ECN	
Mo	mg/kg TS	3.8		B8	Total	ECN	
Ni	mg/kg TS	59		B8	Total	ECN	
P	mg/kg TS	760		B8	Total	ECN	
Pb	mg/kg TS	250		B8	Total	ECN	
S	mg/kg TS	3300		B8	Total	ECN	
Sb	mg/kg TS	6.8		B8	Total	ECN	
Se	mg/kg TS	2.9		B8	Total	ECN	
Sn	mg/kg TS	32		B8	Total	ECN	
Sr	mg/kg TS	220		B8	Total	ECN	
V	mg/kg TS	82		B8	Total	ECN	
W	mg/kg TS	210		B8	Total	ECN	
Zn	mg/kg TS	590		B8	Total	ECN	
TOC	g/kg TS	230	EN 13237-B	D	Total	PREC	X

Bilag 3
Analyser af faststofindhold af organiske stoffer

Faststofindhold af organiske stoffer						
DHI-sag:	Aftercare		Godk. af:	OH		
Sagsnr.:	11700096 (53451)		Dato:	17/05/2007		
Prøve modtaget:	12/06/2006					
Materiale:	Blandet affald fra AV Miljø					
Prøve-ID:	Blandet affald B Nord					
LRJ-nr.:	R-096-06					
Kulbrinter og BTEX'er bestemt efter ekstraktion r Sum PAH-forbindelser = 16 EPA-forbindelser Akk. = Akkrediteret bestemmelse						
Parameter	Analyse-resultat (mg/kg TS)	RSD (%)	DL (mg/kg)	Analysemetode	Analyselab	Akk.
Kulbrinter:						
Benzen - C10	3.0	25	2.5	GC/FID	Eurofins	X
C10- C25	1100	10	10	GC/FID	Eurofins	X
C25 - C35	4700	31	25	GC/FID	Eurofins	X
Sum Benzen - C35	5900				Eurofins	X
BTEX-forbindelser:						
Benzen	< 0.10	11	0.1	GC/FID	Eurofins	X
Toluen	< 0.10	15	0.1	GC/FID	Eurofins	X
Ethylbenzen	< 0.10	10	0.1	GC/FID	Eurofins	X
O-Xylen	0.59	14	0.1	GC/FID	Eurofins	X
MP-Xylen	< 0.10	11	0.1	GC/FID	Eurofins	X
PAH-forbindelser:						
Naphthalen	0.60	12	0.005	MK2004-GC/MS	Eurofins	X
Acenaphthylen	2.9	12	0.005	MK2004-GC/MS	Eurofins	X
Acenaphten	1.5	12	0.005	MK2004-GC/MS	Eurofins	X
Fluoren	1.6	12	0.005	MK2004-GC/MS	Eurofins	X
Phenanthren	15	12	0.005	MK2004-GC/MS	Eurofins	X
Anthracen	5.0	12	0.005	MK2004-GC/MS	Eurofins	X
Fluoranthen	31	12	0.005	MK2004-GC/MS	Eurofins	X
Pyren	25	12	0.005	MK2004-GC/MS	Eurofins	X
Benz(a)anthracen	16	12	0.005	MK2004-GC/MS	Eurofins	X
Chrysen/Triphenylen	14	12	0.005	MK2004-GC/MS	Eurofins	X
Benz(b+j+k)fluoranthen	28	12	0.005	MK2004-GC/MS	Eurofins	X
Benzo(a)pyren	13	12	0.005	MK2004-GC/MS	Eurofins	X
Indeno(1,2,3-cd)pyren	5.2	12	0.005	MK2004-GC/MS	Eurofins	X
Dibenz(a, h)anthracen	1.6	12	0.005	MK2004-GC/MS	Eurofins	X
Benzo(g, h, i)perylen	3.9	12	0.005	MK2004-GC/MS	Eurofins	X
Sum PAH-forbindelser	160				Eurofins	X
Polyklorerede biphenyler:						
PCB nr. 28	< 0.005	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 52	0.011	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 101	0.013	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 118	< 0.005	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 138	0.011	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 153	0.014	15	0.005	MK2004-GC/MS	Eurofins	X
PCB nr. 180	0.011	15	0.005	MK2004-GC/MS	Eurofins	X
TOC	230000			EN 13137, Method B	Pirkanmaa	X

Bilag 4
Resultater af kolonneudvaskningstest og batchtest

Kolonueudvaskningstest		CEN/TS 14405				Side 1 of 2			
DHI-sag:	Aftercare					Kolonnediameter:	10	cm	
Sagsnummer:	11700096 (53451)					Fyldehøjde:	34.4	cm	
Prøve udtaget:	12/06/2006					Tørvægt af testport.:	1496	g	
Materiale:	Blandet affald fra AV Miljø					Materialet knust før test?	Ja		
Prøve-ID:	Blandet affald B Nord					Til hvilken kornstørrelse (mm)?	< 4		
LRJ nr.:	R-096-06								
Udv.medie:	Demineraliseret vand	Eluatfraktioner opsamlet:				Fraktion	Akkum.	Flow	
Lineær flowhast.:	14.2 cm/dag					L/S (l/kg)	L/S (l/kg)	ml/time	
Temperatur:	ca. 20 grader C	Fraktion 1:	0.157	liter	0.11	0.11	26.2		
		Fraktion 2:	0.199	liter	0.13	0.24	40.9		
Test startet:	07/12/2006	Fraktion 3:	0.466	liter	0.31	0.55	37.7		
Udført af:	SEK/OWA	Fraktion 4:	0.715	liter	0.48	1.03	43.3		
QA/QC:	OH	Fraktion 5:	1.578	liter	1.05	2.08	50.8		
Godkendt dato:	07/05/2007	Fraktion 6:	4.193	liter	2.80	4.88	49.7		
		Fraktion 7:	7.394	liter	4.94	9.83	45.3		
Sammensætning af eluater:									
Parameter	Unit	L/S (l/kg)							
		Fra:	0.00	0.11	0.24	0.55	1.03	2.08	4.88
		Til:	0.11	0.24	0.55	1.03	2.08	4.88	9.83
pH	-		7.3	7.5	7.4	7.3	7.3	7.4	7.4
Ledningsevne	mS/m		860	860	73	49	32	25	18
Klorid	mg/l		1100	210	760	260	36	1.5	1.0
Fluorid	mg/l		1.9	< 0.75	2.2	1.8	1.1	6.3	2.6
Sulfat	mg/l		2700	510	2300	1900	1700	1500	960
HCO3	mg/l		300	360	1500	1100	480	230	170
Si	mg/l		22	25	24	24	22	19	16
Ca	mg/l		810	890	860	810	660	640	510
Mg	mg/l		220	220	190	120	55	2.9	0.47
Na	mg/l		1000	980	710	340	88	5.7	3.7
K	mg/l		310	310	260	160	69	15	4.0
Al	mg/l		0.40	0.48	0.41	0.31	0.22	0.099	0.10
As	mg/l		0.66	1.0	0.93	0.87	0.49	0.24	0.12
Ba	mg/l		0.22	0.23	0.17	0.13	0.078	0.059	0.052
Cd	mg/l		0.0032	0.0028	0.0032	0.0017	0.00041	0.000064	< 0.000050
Co	mg/l		0.15	0.17	0.16	0.12	0.068	0.023	0.019
Cr	mg/l		0.34	0.42	0.37	0.30	0.16	0.059	0.037
Cu	mg/l		1.4	1.7	1.9	1.1	0.26	0.061	0.030
Fe	mg/l		71	120	120	100	69	44	17
Hg	mg/l		0.0010	0.0011	0.00092	0.00045	0.00013	0.000040	< 0.000020
Mn	mg/l		15	18	17	15	11	7.7	2.3
Mo	mg/l		0.038	0.038	0.034	0.033	0.029	0.022	0.019
Ni	mg/l		0.25	0.26	0.24	0.15	0.074	0.018	0.0051
Pb	mg/l		0.030	0.046	0.11	0.16	0.047	0.0082	0.0052
Sb	mg/l		0.043	0.037	0.025	0.019	0.0091	0.0027	0.0018
Se	mg/l		0.0036	0.0038	0.0032	0.0024	0.0012	0.00049	0.00038
Zn	mg/l		1.5	1.6	1.3	0.42	0.14	0.054	0.025
DOC	mg/l		780	370	410	100	43	25	57

Bilag 4
Resultater af kolonneudvaskningstest og batchtest

Kolonueudvaskningstest		CEN/TS 14405			Page 2 of 2				
DHI-sag:	Aftercare				Kolonnediameter:	10	cm		
Sagsnummer:	11700096 (53451)				Fyldehøjde:	34.4	cm		
Prøve udtaget:	12/06/2006				Tørvægt af testport.:	1496	g		
Materiale:	Blandet affald fra AV Miljø				Materialet knust før test?	Ja			
Prøve-ID:	Blandet affald B Nord				Til hvilken kornstørrelse (mm)?	< 4			
LRJ nr.:	R-096-06								
Udv.medie:	Demineraliseret vand	Eluatfraktioner opsamlet:			Fraktion	Akkum.	Flow		
Lineær flowhast.:	14.2 cm/dag				L/S (l/kg)	L/S (l/kg)	ml/time		
Temperatur:	ca. 20 grader C	Fraktion 1:	0.157 liter	0.11	0.11	26.2			
		Fraktion 2:	0.199 liter	0.13	0.24	40.9			
Test startet:	07/12/2006	Fraktion 3:	0.466 liter	0.31	0.55	37.7			
Udført af:	SEK/OWA	Fraktion 4:	0.715 liter	0.48	1.03	43.3			
QA/QC:	OH	Fraktion 5:	1.578 liter	1.05	2.08	50.8			
Godkendt dato:	07/05/2007	Fraktion 6:	4.193 liter	2.80	4.88	49.7			
		Fraktion 7:	7.394 liter	4.94	9.83	45.3			
Akkumulerede udvaskede stofmængder:									
Parameter	Unit	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	L/S (l/kg)	
		Frakt:	0.11	0.13	0.31	0.48	1.05	2.80	4.94
Klorid	mg/kg	110	140	380	500	540	540	550	
Fluorid	mg/kg	0.20	< 0.30	0.99	1.8	3.0	21	34	
Sulfat	mg/kg	280	350	1100	2000	3800	8000	13000	
HCO3	mg/kg	32	79	560	1100	1600	2200	3100	
Si	mg/kg	2.3	5.6	13	25	47	99	180	
Ca	mg/kg	85	200	470	860	1600	3400	5900	
Mg	mg/kg	23	53	110	170	230	240	240	
Na	mg/kg	110	240	460	620	710	730	750	
K	mg/kg	33	74	150	230	300	350	370	
Al	mg/kg	0.042	0.11	0.23	0.38	0.61	0.89	1.4	
As	mg/kg	0.069	0.20	0.49	0.91	1.4	2.1	2.7	
Ba	mg/kg	0.023	0.053	0.11	0.17	0.25	0.41	0.67	
Cd	mg/kg	0.00033	0.00071	0.0017	0.0025	0.0029	0.0031	< 0.0034	
Co	mg/kg	0.016	0.038	0.087	0.14	0.21	0.28	0.29	
Cr	mg/kg	0.036	0.092	0.21	0.35	0.51	0.68	0.86	
Cu	mg/kg	0.14	0.37	0.96	1.5	1.7	1.9	2.1	
Fe	mg/kg	7.4	23	59	110	180	300	390	
Hg	mg/kg	0.00011	0.00026	0.00054	0.00076	0.00090	0.0010	< 0.0011	
Mn	mg/kg	1.6	4.0	9.4	16	28	49	60	
Mo	mg/kg	0.0040	0.0091	0.020	0.035	0.065	0.13	0.22	
Ni	mg/kg	0.026	0.060	0.14	0.21	0.28	0.34	0.36	
Pb	mg/kg	0.0031	0.0092	0.044	0.12	0.17	0.19	0.22	
Sb	mg/kg	0.0045	0.0094	0.017	0.026	0.036	0.044	0.052	
Se	mg/kg	0.00038	0.00088	0.0019	0.0030	0.0043	0.0057	0.0076	
Zn	mg/kg	0.15	0.37	0.79	0.99	1.1	1.3	1.4	
DOC	mg/kg	82	130	260	310	350	420	710	

Bilag 4
Resultater af kolonneudvaskningstest og batchtest

Parameter	Koncentration i eluatet mg/l	Udvaskede stofmængder mg/kg	Analysemetode	Analyselab	Akk. (X)
Compliance batch leaching test EN 12457-1 Batchtest v. L/S = 2 l/kg, mat. < 4 mm, t = 24 timer					
DHI-sag:	Aftercare		Test udført af:	SEK	
Sagsnr.:	11700096 (53451)		Udført dato:	2/11-3/11 2006	
Prøve modtaget:	12/06/2006		Godkendt af:	OH	
			Godk.-dato:	14/05 2007	
Materiale:	Blandet affald fra AV Miljø				
Prøve-ID:	Blandet affald B Nord				
LRJ-nr.:	R-096-06				
Tørstofindhold i testportion:	869.00	gTS/kg	Eluent:	Demineraliseret vand	
Vådvægt af testportion:	404.29	g	Temperatur:	21.1 grader C	
Vandindhold i testportion:	53.0	ml	Kontaktid:	24:00 timer:min	
Vol. af udv.-medium tilsat:	648.36	ml			
Faktisk L/S:	2.0	l/kg			
Er prøven nedknust?	Ja				
Er prøven tørret?	Nej				
Mængde > 4 mm (% w/w):					
Klorid	360	720	EN ISO 10304	Analytica	X
Fluorid	< 2.5	< 5.0	EN ISO 10304	Analytica	X
Sulfat	2000	4000	EN ISO 10304	Analytica	X
Si	18	36	ICP-AES	Analytica	X
Ca	800	1600	ICP-AES	Analytica	X
Mg	82	160	ICP-AES	Analytica	X
Na	360	710	ICP-AES	Analytica	X
K	120	240	ICP-AES	Analytica	X
Al	0.75	1.5	ICP-SFMS	Analytica	X
As	0.13	0.26	EN ISO 10304-1	Analytica	X
Ba	0.53	1.1	ICP-SFMS	Analytica	X
Cd	0.0029	0.0059	ICP-SFMS	Analytica	X
Co	0.062	0.12	ICP-SFMS	Analytica	X
Cr	0.070	0.14	ICP-SFMS	Analytica	X
Cu	2.1	4.1	ICP-SFMS	Analytica	X
Fe	2.0	4.0	ICP-SFMS	Analytica	X
Hg	0.00062	0.0012	AFS	Analytica	X
Mn	6.9	14	ICP-AES	Analytica	X
Mo	0.025	0.050	ICP-SFMS	Analytica	X
Ni	0.11	0.21	ICP-SFMS	Analytica	X
Pb	0.031	0.062	ICP-SFMS	Analytica	X
Sb	0.033	0.066	ICP-SFMS	Analytica	X
Se	0.0018	0.0036	AFS	Analytica	0
Zn	1.5	2.9	ICP-AES	Analytica	X
DOC	610	1200			
pH	8.09		DS287	DHI	
Ledningsevne (mS/m)	452		DS/EN 27888	DHI	
Redoxpotentiale (mV)	359			DHI	
TDS	4800	9600	DIN 38409-H1	Analytica	X

Bilag 5
Resultater af pH-statisk udvaskningstest

Compliance batch leaching test EN 12457-1		Batchtest v. L/S = 2 l/kg, mat. < 4 mm, t = 24 timer			
DHI-sag:	Aftercare	Test udført af:	SEK		
Sagsnr.:	11700096 (53451)	Udført dato:	2/11-3/11 2006		
Prøve modtaget:	12/06/2006	Godkendt af:	OH		
		Godk.-dato:	14/05 2007		
Materiale:	Blandet affald fra AV Miljø				
Prøve-ID:	Blandet affald 1 Syd, Prøve A1, 1				
LRJ-nr.:	R-167-06				
Tørstofindhold i testportion:	863 gTS/kg	Eluent:	Demineraliseret vand		
Vådvægt af testportion:	406.3 g	Temperatur:	21.1 grader C		
Vandindhold i testportion:	55.7 ml	Kontaktid:	24:15 timer:min		
Vol. af udv.-medium tilsat:	646.1 ml				
Faktisk L/S:	2.00 l/kg				
Er prøven nedknust?	Ja				
Er prøven tørret?	Nej				
Mængde > 4 mm (% w/w):					
Parameter	Koncentration i eluatet mg/l	Udvaskede stofmængder mg/kg	Analysemetode	Analyselab	Akk. (X)
Klorid	360	710	EN ISO 10304	Analytica	X
Fluorid	1.1	2.2	EN ISO 10304	Analytica	X
Sulfat	2000	3900	EN ISO 10304	Analytica	X
Si	18	35	ICP-AES	Analytica	X
Ca	750	1500	ICP-AES	Analytica	X
Mg	82	160	ICP-AES	Analytica	X
Na	340	680	ICP-AES	Analytica	X
K	110	210	ICP-AES	Analytica	X
Al	0.80	1.6	ICP-SFMS	Analytica	X
As	0.055	0.11	EN ISO 10304-1	Analytica	X
Ba	0.22	0.44	ICP-SFMS	Analytica	X
Cd	0.0031	0.0062	ICP-SFMS	Analytica	X
Co	0.43	0.85	ICP-SFMS	Analytica	X
Cr	0.068	0.14	ICP-SFMS	Analytica	X
Cu	0.68	1.4	ICP-SFMS	Analytica	X
Fe	1.7	3.3	ICP-SFMS	Analytica	X
Hg	0.0013	0.0025	AFS	Analytica	X
Mn	5.6	11	ICP-AES	Analytica	X
Mo	0.045	0.090	ICP-SFMS	Analytica	X
Ni	0.10	0.21	ICP-SFMS	Analytica	X
Pb	0.039	0.077	ICP-SFMS	Analytica	X
Sb	0.032	0.065	ICP-SFMS	Analytica	X
Se	0.0013	0.0027	AFS	Analytica	0
Zn	2.7	5.4	ICP-AES	Analytica	X
DOC	270	540	EN 1484	ECN	
pH	8.0		DS287	DHI	
Ledningsevne (mS/m)	440		DS/EN 27888	DHI	
Redoxpotentiale (mV)	360			DHI	
TDS	4900	9700	DIN 38409-H1	Analytica	X

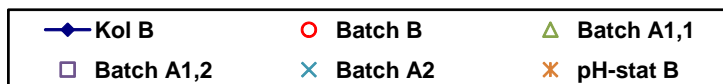
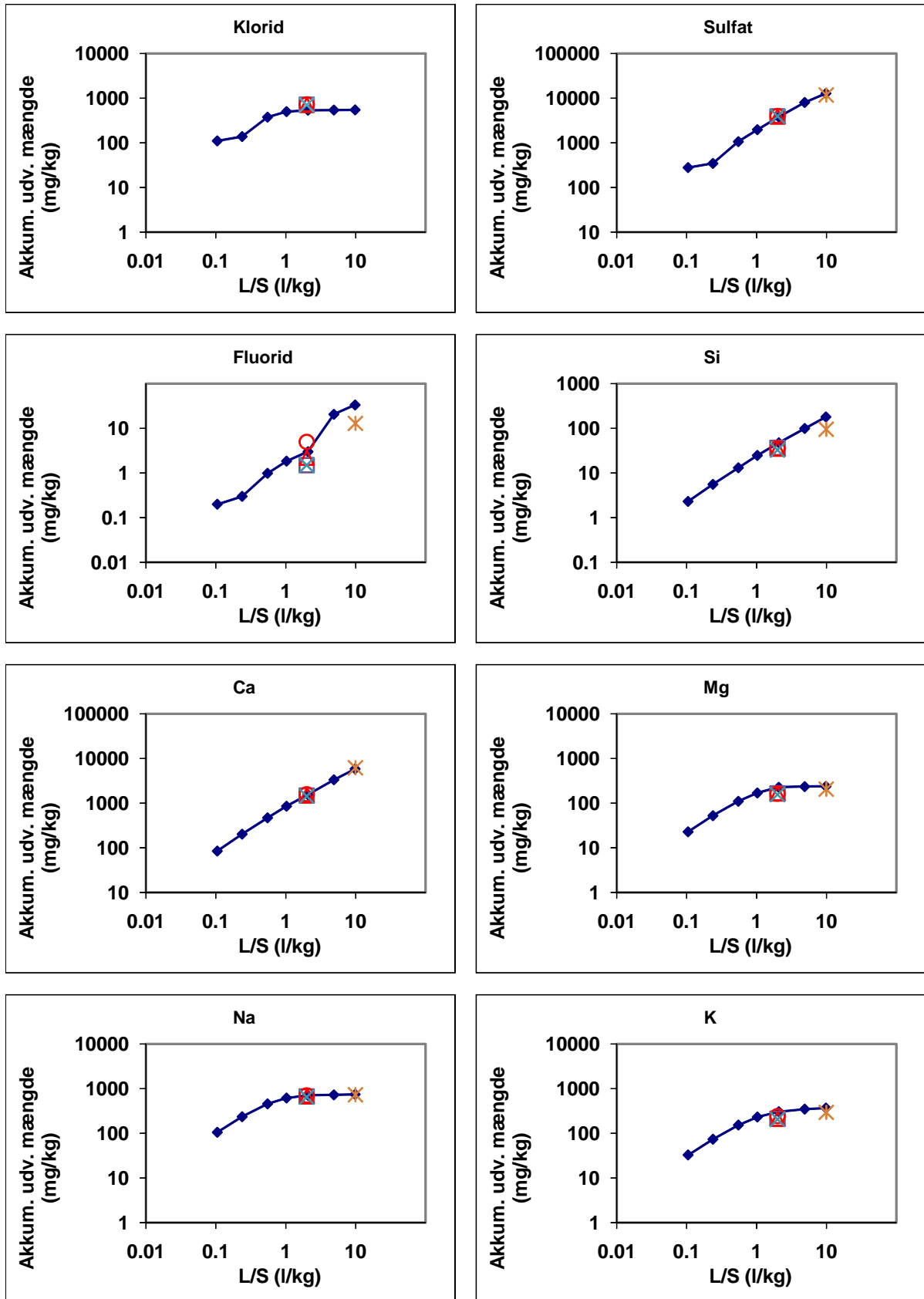
Bilag 5
Resultater af pH-statisk udvaskningstest

Compliance batch leaching test EN 12457-1		Batchtest v. L/S = 2 l/kg, mat. < 4 mm, t = 24 timer			
DHI-sag:	Aftercare	Test udført af:	SEK		
Sagsnr.:	11700096 (53451)	Udført dato:	2/11-3/11 2006		
Prøve modtaget:	12/06/2006	Godkendt af:	OH		
		Godk.-dato:	14/05 2007		
Materiale:	Blandet affald fra AV Miljø				
Prøve-ID:	Blandet affald 1 Syd, Prøve A1, 2				
LRJ-nr.:	R-168-06				
Tørstofindhold i testportion:	863	gTS/kg	Eluent:	Demineraliseret vand	
Vådvægt af testportion:	406.02	g	Temperatur:	21.1 grader C	
Vandindhold i testportion:	55.62	ml	Kontaktid:	24:10 timer:min	
Vol. af udv.-medium tilsat:	643.64	ml			
Faktisk L/S:	2.00	l/kg			
Er prøven nedknust?	Ja				
Er prøven tørret?	Nej				
Mængde > 4 mm (% w/w):					
Parameter	Koncentration i eluatet mg/l	Udvaskede stofmængder mg/kg	Analysemetode	Analyselab	Akk. (X)
Klorid	360	710	EN ISO 10304	Analytica	X
Fluorid	< 0.75	< 1.5	EN ISO 10304	Analytica	X
Sulfat	2000	3900	EN ISO 10304	Analytica	X
Si	18	37	ICP-AES	Analytica	X
Ca	750	1500	ICP-AES	Analytica	X
Mg	83	170	ICP-AES	Analytica	X
Na	340	670	ICP-AES	Analytica	X
K	110	210	ICP-AES	Analytica	X
Al	1.1	2.2	ICP-SFMS	Analytica	X
As	0.073	0.15	EN ISO 10304-1	Analytica	X
Ba	0.21	0.42	ICP-SFMS	Analytica	X
Cd	0.0035	0.0069	ICP-SFMS	Analytica	X
Co	0.57	1.1	ICP-SFMS	Analytica	X
Cr	0.087	0.17	ICP-SFMS	Analytica	X
Cu	0.67	1.3	ICP-SFMS	Analytica	X
Fe	2.3	4.5	ICP-SFMS	Analytica	X
Hg	0.0016	0.0032	AFS	Analytica	X
Mn	6.5	13	ICP-AES	Analytica	X
Mo	0.043	0.086	ICP-SFMS	Analytica	X
Ni	0.11	0.23	ICP-SFMS	Analytica	X
Pb	0.056	0.11	ICP-SFMS	Analytica	X
Sb	0.035	0.069	ICP-SFMS	Analytica	X
Se	0.0015	0.0030	AFS	Analytica	0
Zn	2.9	5.8	ICP-AES	Analytica	X
DOC	340	680	EN 1484	ECN	
pH	7.9		DS287	DHI	
Ledningsevne (mS/m)	440		DS/EN 27888	DHI	
Redoxpotentiale (mV)	360			DHI	
TDS	4900	9700	DIN 38409-H1	Analytica	X

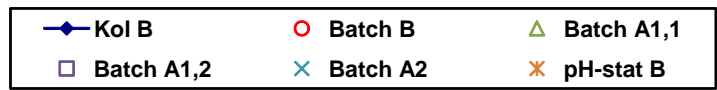
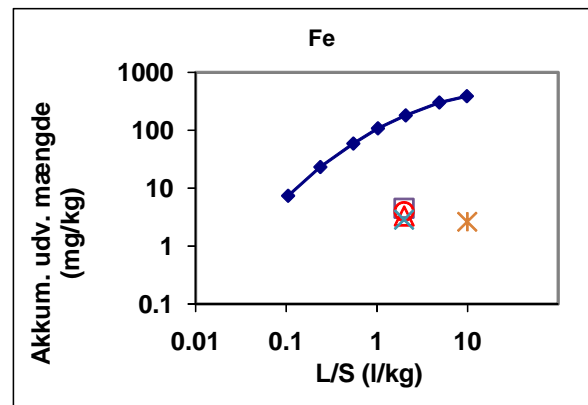
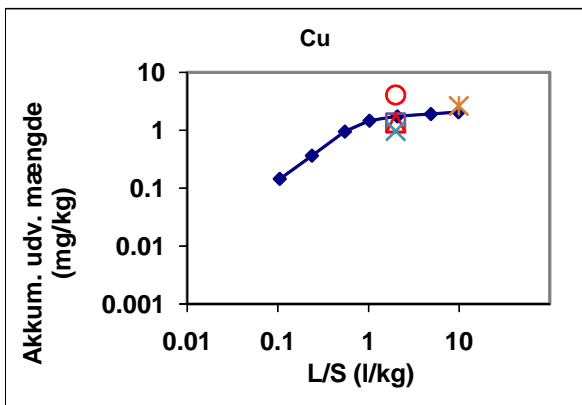
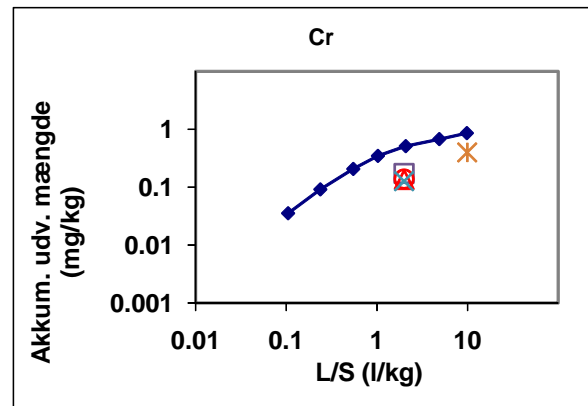
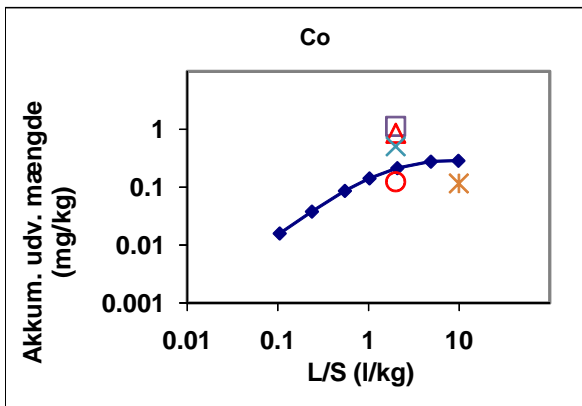
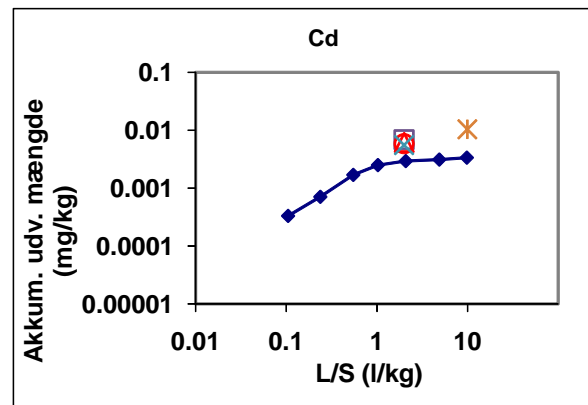
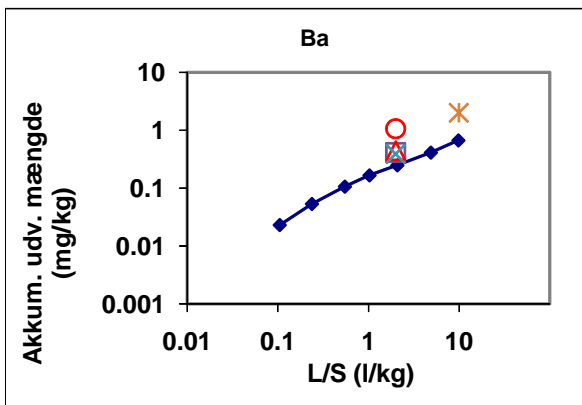
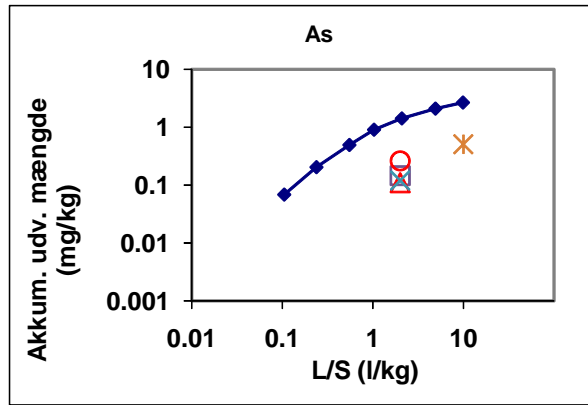
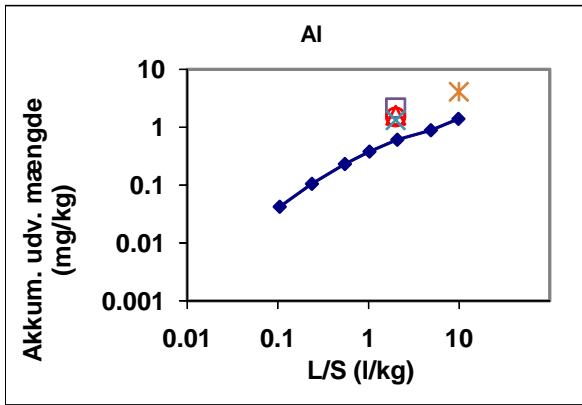
Bilag 5
Resultater af pH-statisk udvaskningstest

Compliance batch leaching test EN 12457-1		Batchtest v. L/S = 2 l/kg, mat. < 4 mm, t = 24 timer			
DHI-sag:	Aftercare	Test udført af:	SEK		
Sagsnr.:	11700096 (53451)	Udført dato:	2/11-3/11 2006		
Prøve modtaget:	12/06/2006	Godkendt af:	OH		
		Godk.-dato:	14/05 2007		
Materiale:	Blandet affald fra AV Miljø				
Prøve-ID:	Blandet affald 1 Syd, Prøve A2				
LRJ-nr.:	R-169-06				
Tørstofindhold i testportion:	863 gTS/kg	Eluent:	Demineraliseret vand		
Vådvægt af testportion:	406.15 g	Temperatur:	21.1 grader C		
Vandindhold i testportion:	55.64 ml	Kontaktid:	24:05 timer:min		
Vol. af udv.-medium tilsat:	645.16 ml				
Faktisk L/S:	2.00 l/kg				
Er prøven nedknust?	Ja				
Er prøven tørret?	Nej				
Mængde > 4 mm (% w/w):					
Parameter	Koncentration i eluatet mg/l	Udvaskede stofmængder mg/kg	Analysemetode	Analyselab	Akk. (X)
Klorid	350	710	EN ISO 10304	Analytica	X
Fluorid	< 0.75	< 1.5	EN ISO 10304	Analytica	X
Sulfat	2000	4000	EN ISO 10304	Analytica	X
Si	16	33	ICP-AES	Analytica	X
Ca	720	1400	ICP-AES	Analytica	X
Mg	78	160	ICP-AES	Analytica	X
Na	330	650	ICP-AES	Analytica	X
K	100	210	ICP-AES	Analytica	X
Al	0.66	1.3	ICP-SFMS	Analytica	X
As	0.060	0.12	EN ISO 10304-1	Analytica	X
Ba	0.20	0.39	ICP-SFMS	Analytica	X
Cd	0.0028	0.0056	ICP-SFMS	Analytica	X
Co	0.25	0.51	ICP-SFMS	Analytica	X
Cr	0.064	0.13	ICP-SFMS	Analytica	X
Cu	0.49	0.97	ICP-SFMS	Analytica	X
Fe	1.4	2.9	ICP-SFMS	Analytica	X
Hg	0.0011	0.0021	AFS	Analytica	X
Mn	5.6	11	ICP-AES	Analytica	X
Mo	0.045	0.090	ICP-SFMS	Analytica	X
Ni	0.094	0.19	ICP-SFMS	Analytica	X
Pb	0.038	0.076	ICP-SFMS	Analytica	X
Sb	0.035	0.070	ICP-SFMS	Analytica	X
Se	0.0012	0.0025	AFS	Analytica	0
Zn	2.0	3.9	ICP-AES	Analytica	X
DOC	280	550	EN 1484	ECN	
pH	8.0		DS287	DHI	
Ledningsevne (mS/m)	440		DS/EN 27888	DHI	
Redoxpotentiale (mV)	360			DHI	
TDS	4500	9000	DIN 38409-H1	Analytica	X

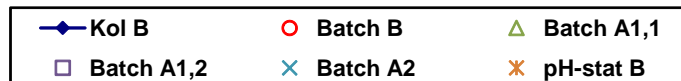
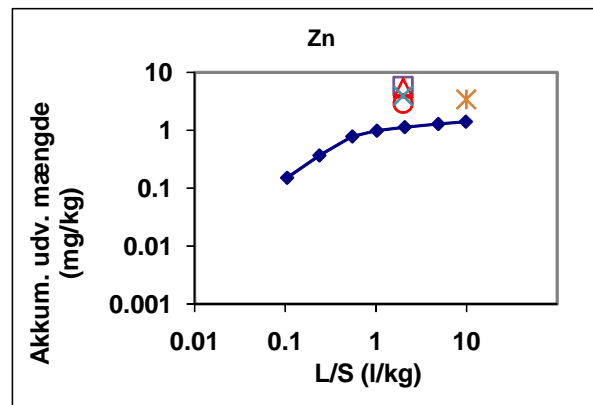
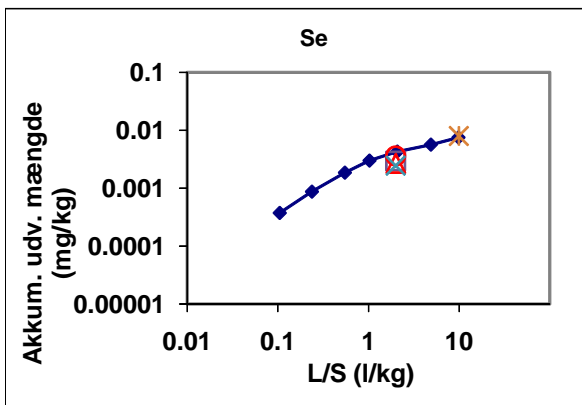
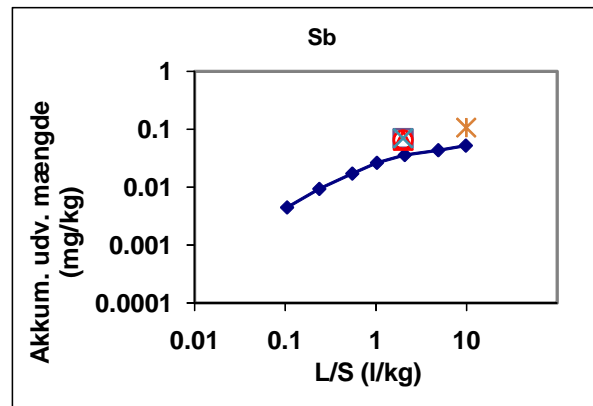
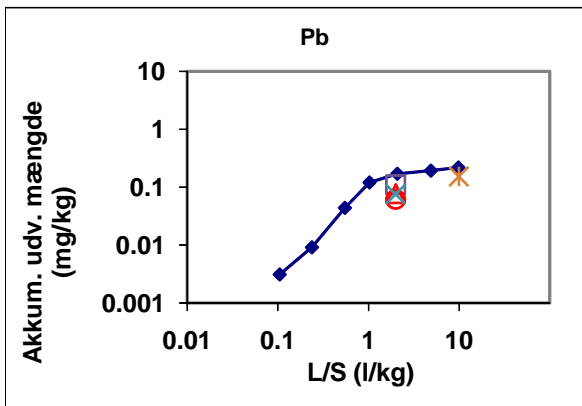
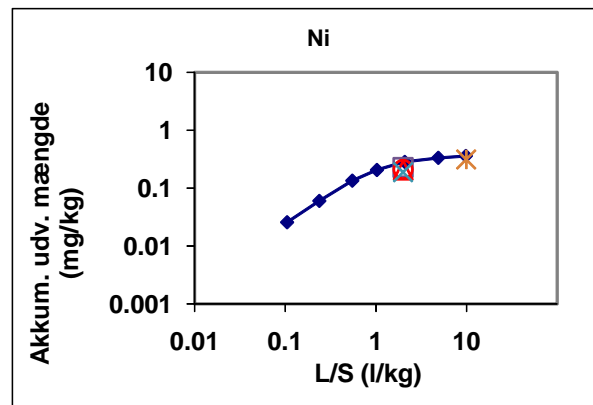
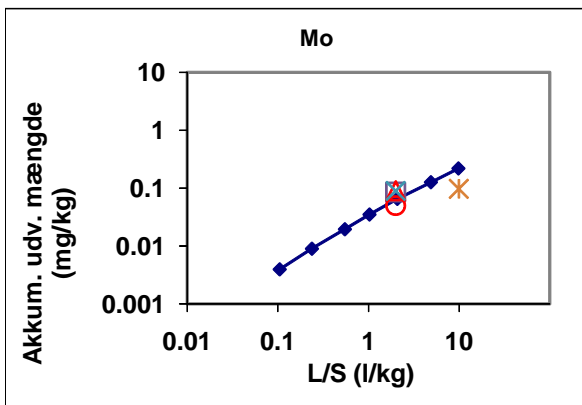
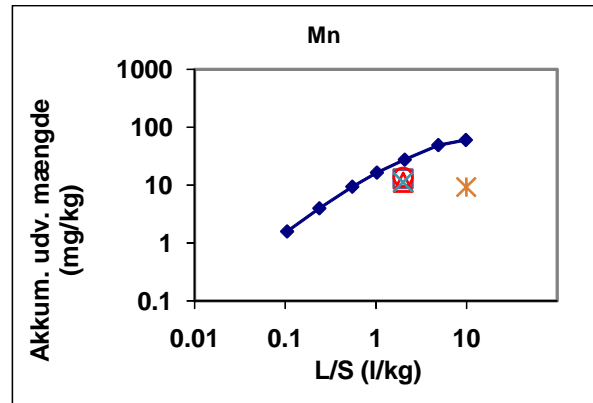
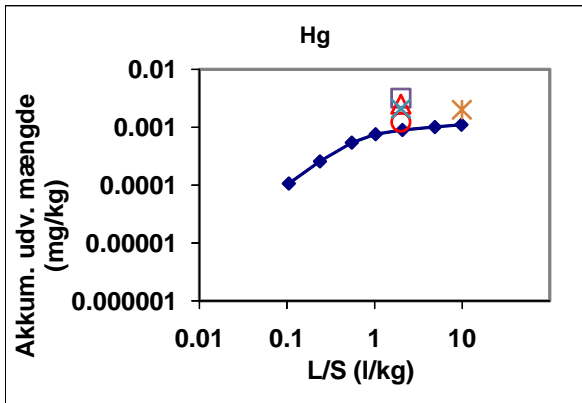
Bilag 4
 Resultater af kolonneudvaskningstest og batchtest



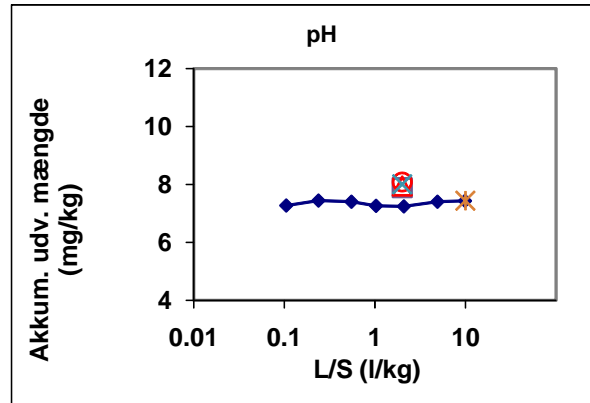
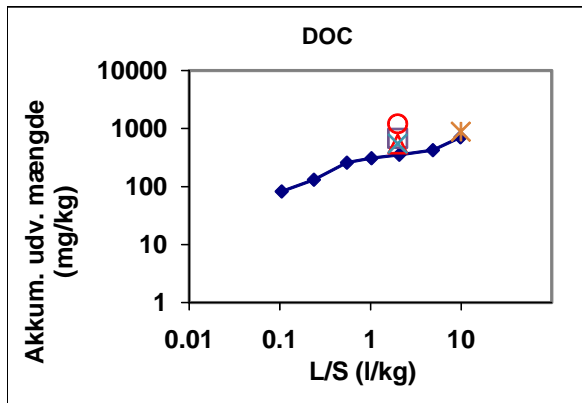
Bilag 4
 Resultater af kolonneudvaskningstest og batchtest



Bilag 4
 Resultater af kolonneudvaskningstest og batchtest



Bilag 4
Resultater af kolonneudvaskningstest og batchtest



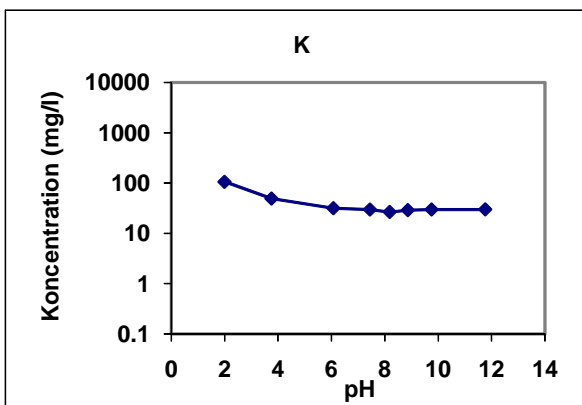
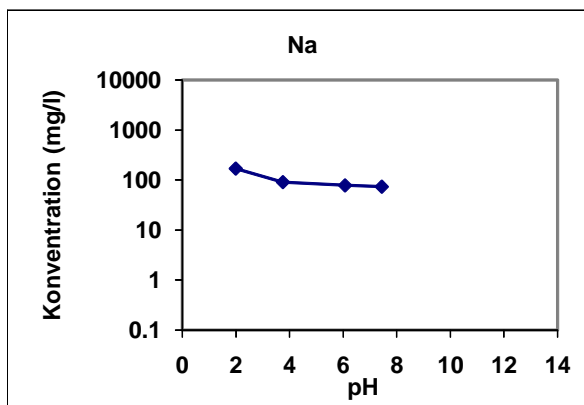
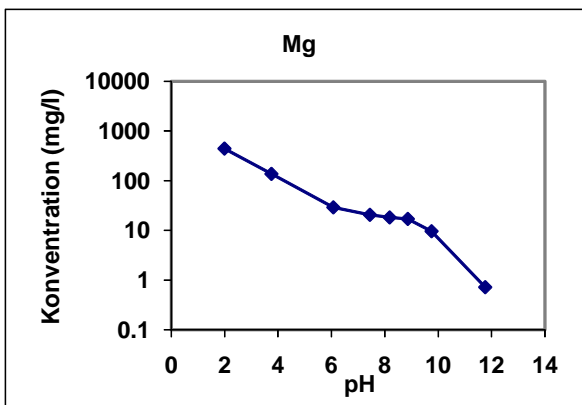
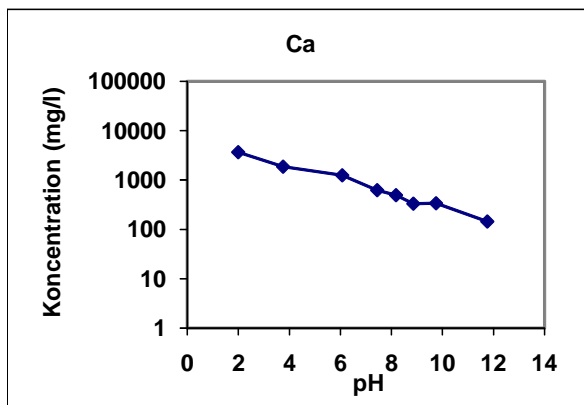
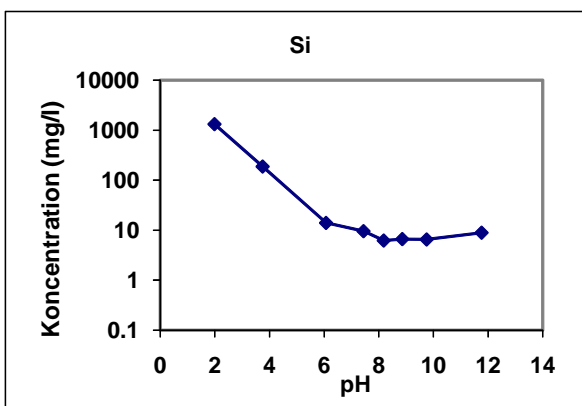
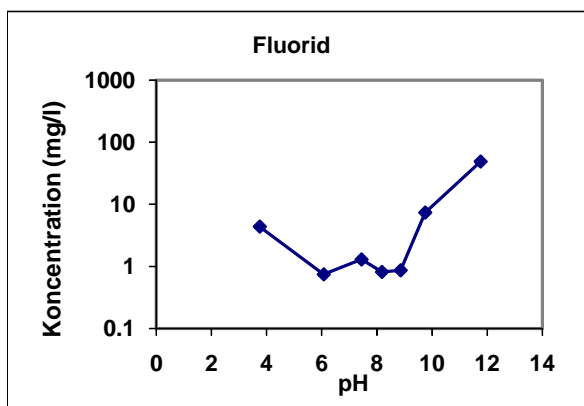
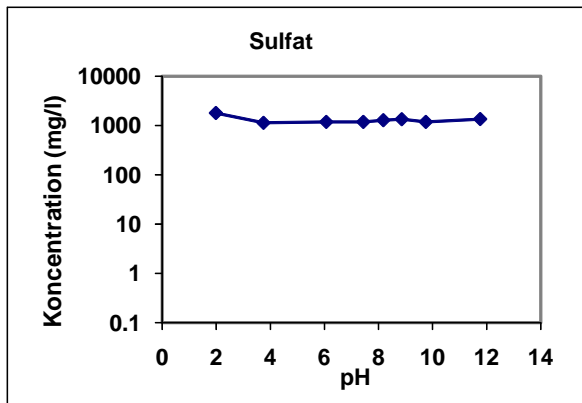
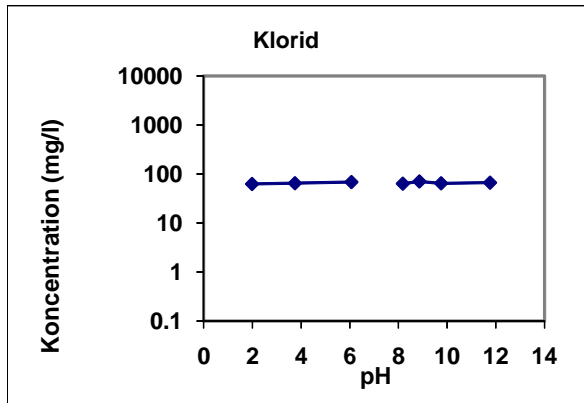
Bilag 5
Resultater af pH-statisk udvaskningstest

pH-statisk udvaskningstest			CEN/TS 14997			Page 1 of 2			
DHI-sag: Aftercare						Temperatur Ca. 20 d grader C			
Sagsnr.: 11700096 (53451)						Forbehandl l Formalet til < 2 mm			
Prøve udt.: 12/06/2006						Test udført af: SEK			
Materiale: Blandet affald fra AV Miljø						Godkendt af: OH			
Prøve-ID: Blandet affald B Nord						Godk.-dato: 28/04/2009			
LRJ-nr.: R-096-06									
Batch nr	Slut-pH	Start-pH	Tørvægt af testportion (g)	Volumen af vand (ml)	Volumen syre/base (ml)	Normalitet af syre (M)	Normalitet af base (M)	Kon-takttid (timer)	Faktisk L/S (l/kg)
1	1.99	7.7	60.3	502.0	134.9	1.0		48	10.6
2	3.75	7.8	60.0	551.0	50.8	1.0		48	10.0
3	6.07	7.7	60.4	584.4	17.0	1.0		48	10.0
4	7.44	7.4	60.7	603.1	0.0			48	9.9
5	8.18	7.9	60.2	599.1	2.3		1.0	48	10.0
6	8.86	8.0	60.3	593.8	7.9		1.0	48	10.0
7	9.75	7.9	60.6	589.3	11.7		1.0	48	9.9
8	11.76	7.8	60.2	571.1	29.8		1.0	48	10.0
Eluate composition:									
Parameter	Enhed	pH	pH	pH	pH	pH	pH	pH	pH
		2.0	3.8	6.1	7.4	8.2	8.9	9.8	11.8
Klorid	mg/l	63	65	69		64	71	65	67
Fluorid	mg/l	1.7	4.4	0.75	1.3	0.82	0.87	7.4	49
Sulfat	mg/l	1800	1100	1200	1200	1300	1300	1200	1400
Si	mg/l	1300	190	14	9.6	6.3	6.7	6.6	9.0
Ca	mg/l	3700	1900	1300	630	500	330	340	150
Mg	mg/l	450	140	29	21	18	17	9.7	0.72
Na	mg/l	170	91	78	74	150	350	450	1000
K	mg/l	110	49	32	30	27	29	30	30
Al	mg/l	560	68	0.21	0.41	0.22	0.86	0.24	6.6
As	mg/l	0.61	0.089	0.035	0.051	0.068	0.12	0.13	0.26
Ba	mg/l	0.83	0.34	0.42	0.20	0.31	0.30	0.53	0.064
Cd	mg/l	0.079	0.047	0.011	0.0011	0.00026	0.00041	0.00038	0.0011
Co	mg/l	0.45	0.21	0.054	0.012	0.0041	0.0040	0.0044	0.0067
Cr	mg/l	4.6	0.31	0.068	0.040	0.030	0.054	0.041	0.16
Cu	mg/l	21	5.8	0.43	0.27	0.25	0.40	0.83	2.5
Fe	mg/l	420	67	0.24	0.94	0.47	1.7	0.34	1.5
Hg	mg/l	< 0.000020	0.00010	0.000041	0.00020	0.00017	0.00038	0.00021	0.00096
Mn	mg/l	51	19	4.8	1.1	0.22	0.075	0.027	0.070
Mo	mg/l	< 0.0050	0.00079	0.0058	0.0098	0.011	0.015	0.016	0.010
Ni	mg/l	1.4	0.47	0.095	0.032	0.017	0.020	0.023	0.037
Pb	mg/l	3.0	0.25	0.0055	0.015	0.0072	0.024	0.0053	0.019
S	mg/l	480	360	430	540	490	510	460	490
Sb	mg/l	0.058	0.0084	0.014	0.011	0.0090	0.010	0.011	0.021
Se	mg/l	0.00095	0.00072	0.00073	0.00080	0.00080	0.0012	0.0013	0.0031
Sn	mg/l	0.047	0.0016	0.00087	0.0019	0.0013	0.0035	0.0016	0.0011
Zn	mg/l	37	19	5.1	0.34	0.11	0.13	0.11	0.34
DOC	mg/l	120	62	78	89	92	120	180	440
Redox pot.	mV	390	284	295	286	296	278	232	103

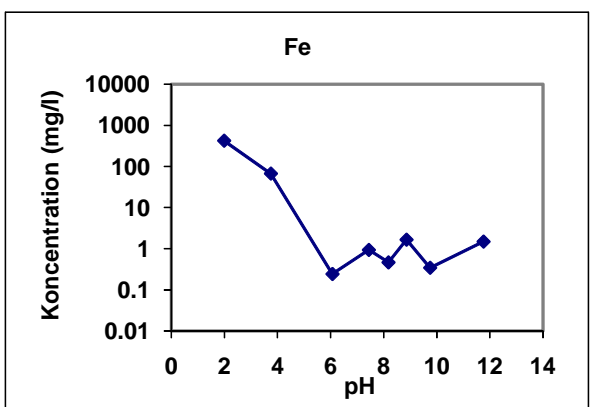
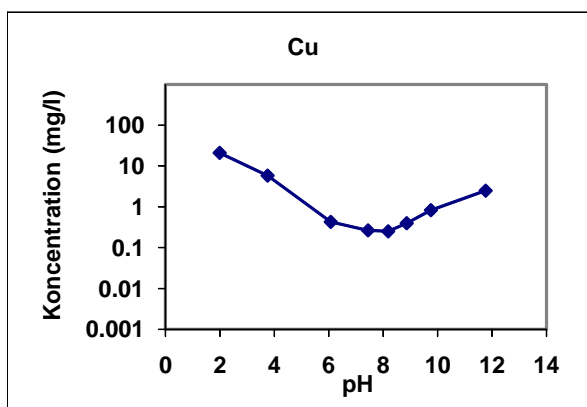
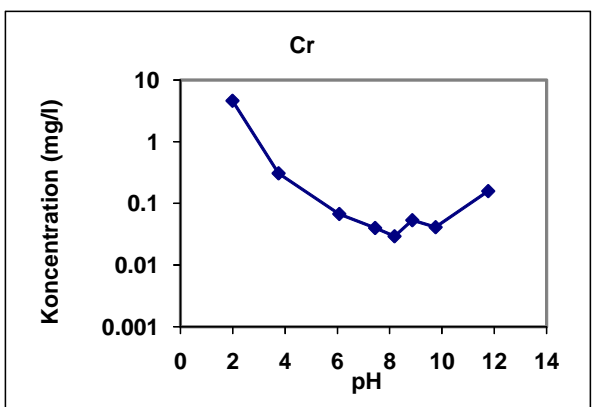
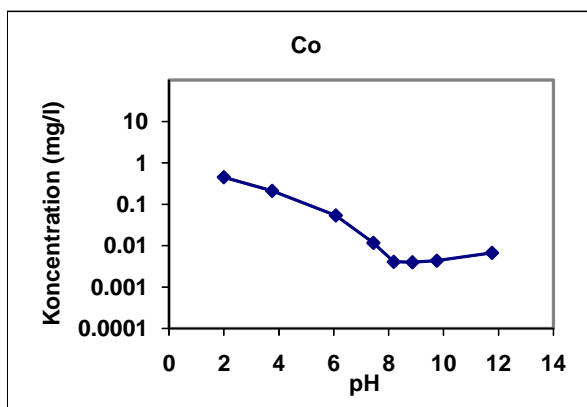
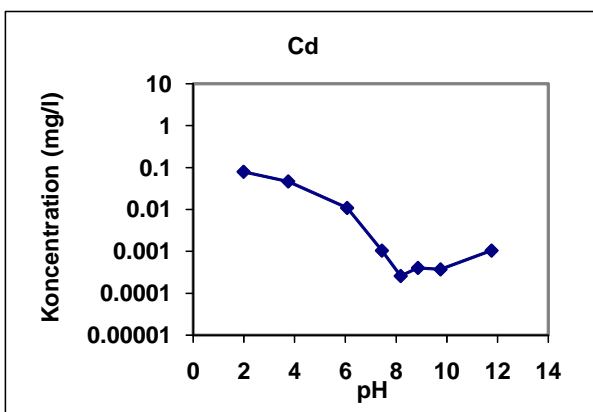
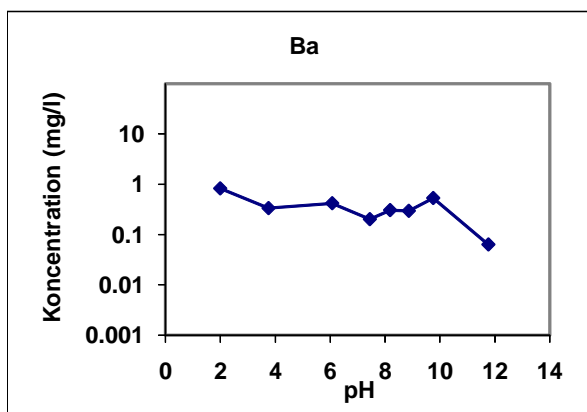
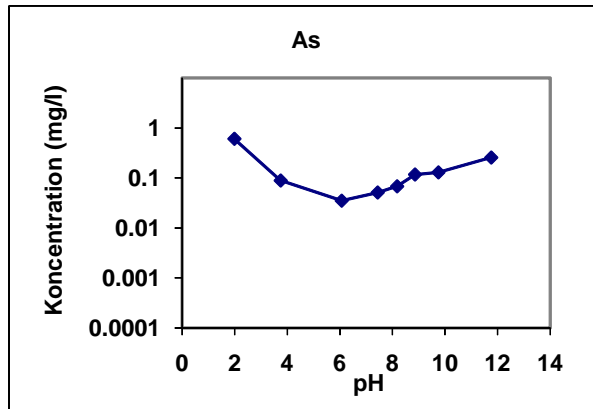
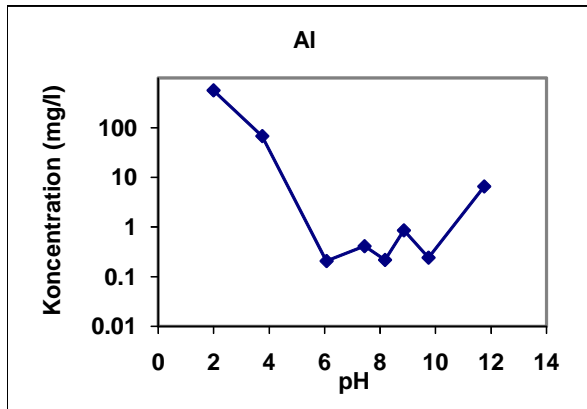
Bilag 5
Resultater af pH-statisk udvaskningstest

pH-statisk udvaskningstest		CENTS 14997		Page 2 of 2					
DHI-sag:	Aftercare			Temperatur	Ca. 20 d. grader C				
Sagsnr.:	11700096 (53451)			Forbeha	Formalet til < 2 mm				
Prøve udt.:	12/06/2006			Test udført af:	SEK				
Materiale:	Blandet affald fra AV Miljø			Godkendt af:	OH				
Prøve-ID:	Blandet affald B Nord			Godk.-dato:	28/04/2009				
LRJ-nr.:	R-096-06								
Batch nr	Slut-pH	Start-pH	Tørvægt af testportion (g)	Volumen af vand (ml)	Volumen syre/base (ml)	Normalitet af syre (M)	Normalitet af base (M)	Kon-taktid (timer)	Faktisk L/S (l/kg)
1	2.0	7.7	60.3	502.0	134.9	1.0		48	10.6
2	3.8	7.8	60.0	551.0	50.8	1.0		48	10.0
3	6.1	7.7	60.4	584.4	17.0	1.0		48	10.0
4	7.4	7.4	60.7	603.1	0.0			48	9.9
5	8.2	7.9	60.2	599.1	2.3		1.0	48	10.0
6	8.9	8.0	60.3	593.8	7.9		1.0	48.0	10.0
7	9.8	7.9	60.6	589.3	11.7		1.0	48.0	9.9
8	11.8	7.8	60.2	571.1	29.8		1.0	48.0	10.0
Udvaskede stofmængder									
Parameter	Enhed	pH	pH	pH	pH	pH	pH	pH	pH
		2.0	3.75	6.1	7.4	8.18	8.86	9.75	11.76
Klorid	mg/kg	670	650	690		640	710	640	670
Fluorid	mg/kg	18	44	7.5	13	8.2	8.7	73	490
Sulfat	mg/kg	19000	11000	12000	12000	13000	13000	12000	13000
Si	mg/kg	14000	1900	140	96	63	67	65	90
Ca	mg/kg	39000	19000	12000	6200	4900	3300	3400	1400
Mg	mg/kg	4700	1400	290	210	180	170	96	7.2
Na	mg/kg	1800	910	780	730	1500	3500	4500	10000
K	mg/kg	1100	490	310	300	270	290	300	300
Al	mg/kg	6000	680	2.1	4.1	2.2	8.6	2.4	65
As	mg/kg	6.4	0.89	0.35	0.51	0.68	1.2	1.3	2.6
Ba	mg/kg	8.7	3.4	4.2	2.0	3.1	3.0	5.3	0.63
Cd	mg/kg	0.84	0.47	0.11	0.010	0.0026	0.0041	0.0037	0.010
Co	mg/kg	4.8	2.1	0.54	0.12	0.041	0.040	0.043	0.067
Cr	mg/kg	49	3.1	0.68	0.40	0.29	0.54	0.41	1.6
Cu	mg/kg	220	59	4.3	2.6	2.5	4.0	8.2	25
Fe	mg/kg	< 4500	680	2.4	9.3	4.6	17	3.4	15
Hg	mg/kg	0.00021	0.0010	0.00041	0.0020	0.0017	0.0038	0.0021	0.0096
Mn	mg/kg	< 540	190	48	11	2.2	0.75	0.27	0.70
Mo	mg/kg	0.053	0.0079	0.058	0.097	0.11	0.14	0.15	0.10
Ni	mg/kg	15	4.8	0.95	0.31	0.16	0.20	0.23	0.37
Pb	mg/kg	31	2.5	0.054	0.15	0.072	0.24	0.052	0.19
S	mg/kg	5000	3600	4300	5300	4900	5100	4600	4900
Sb	mg/kg	0.61	0.084	0.14	0.11	0.090	0.10	0.11	0.20
Se	mg/kg	0.010	0.0072	0.0073	0.0080	0.0080	0.012	0.012	0.030
Sn	mg/kg	0.49	0.016	0.0086	0.018	0.013	0.035	0.016	0.011
Zn	mg/kg	400	190	50	3.4	1.0	1.3	1.1	3.4
DOC	mg/kg	1200	620	780	890	920	1200	1800	4400

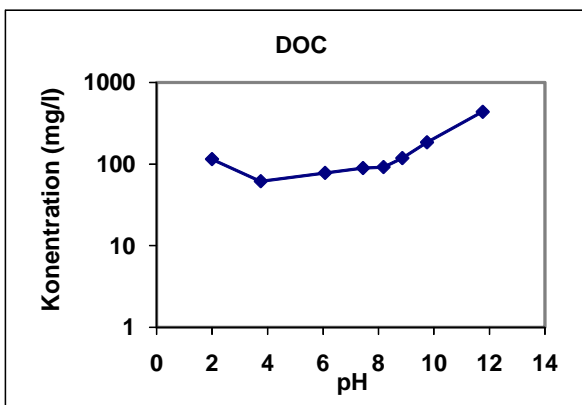
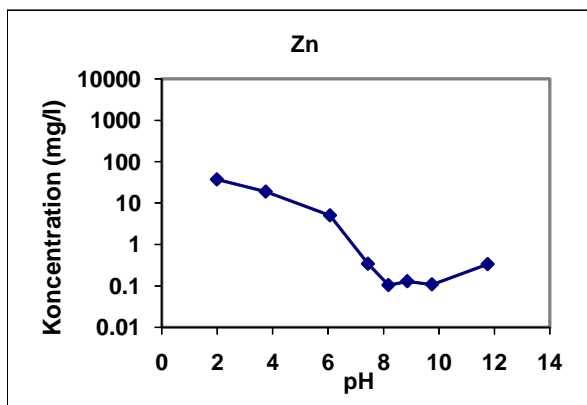
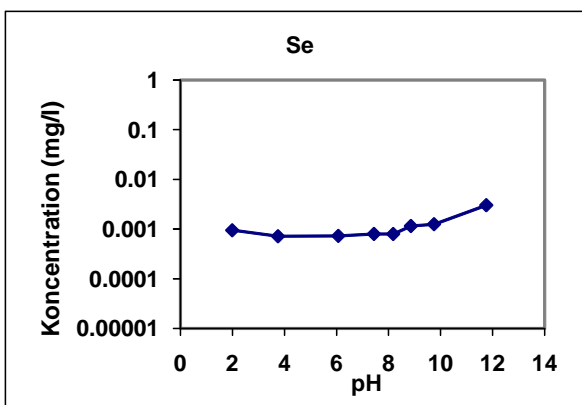
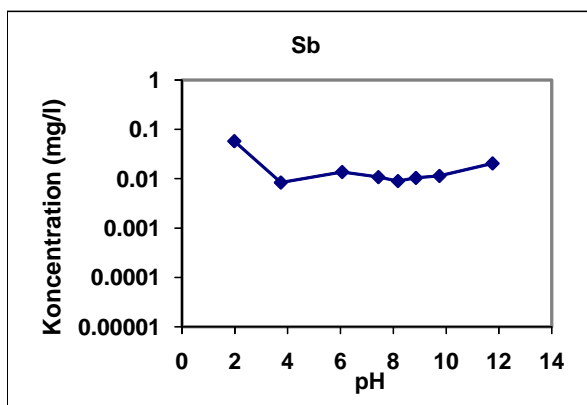
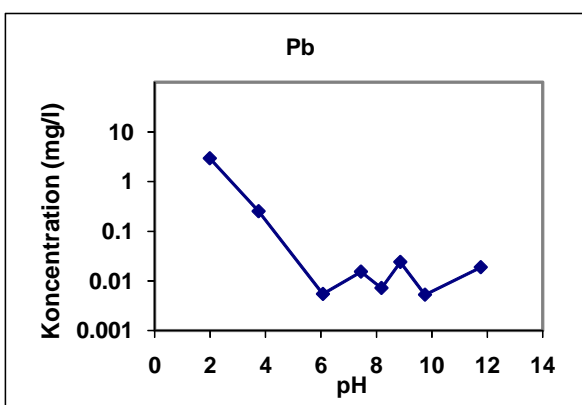
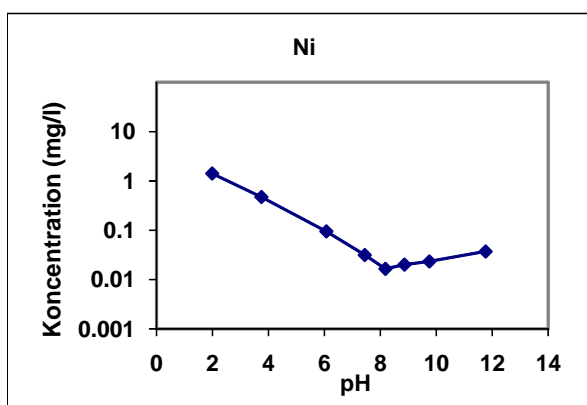
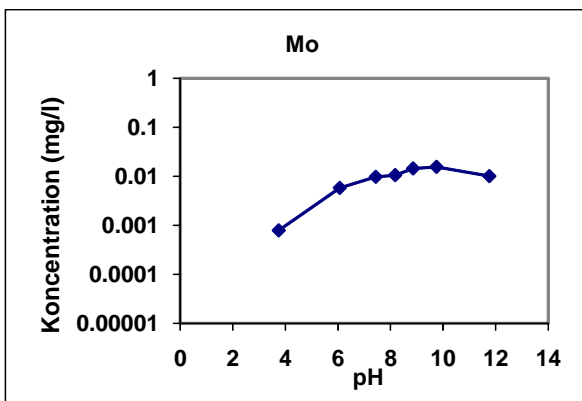
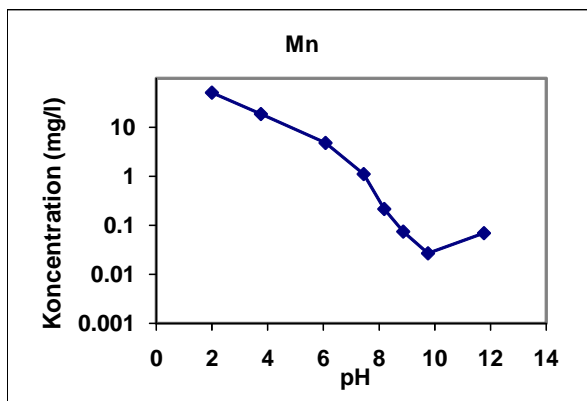
Bilag 5
Resultater af pH-statisk udvaskningstest



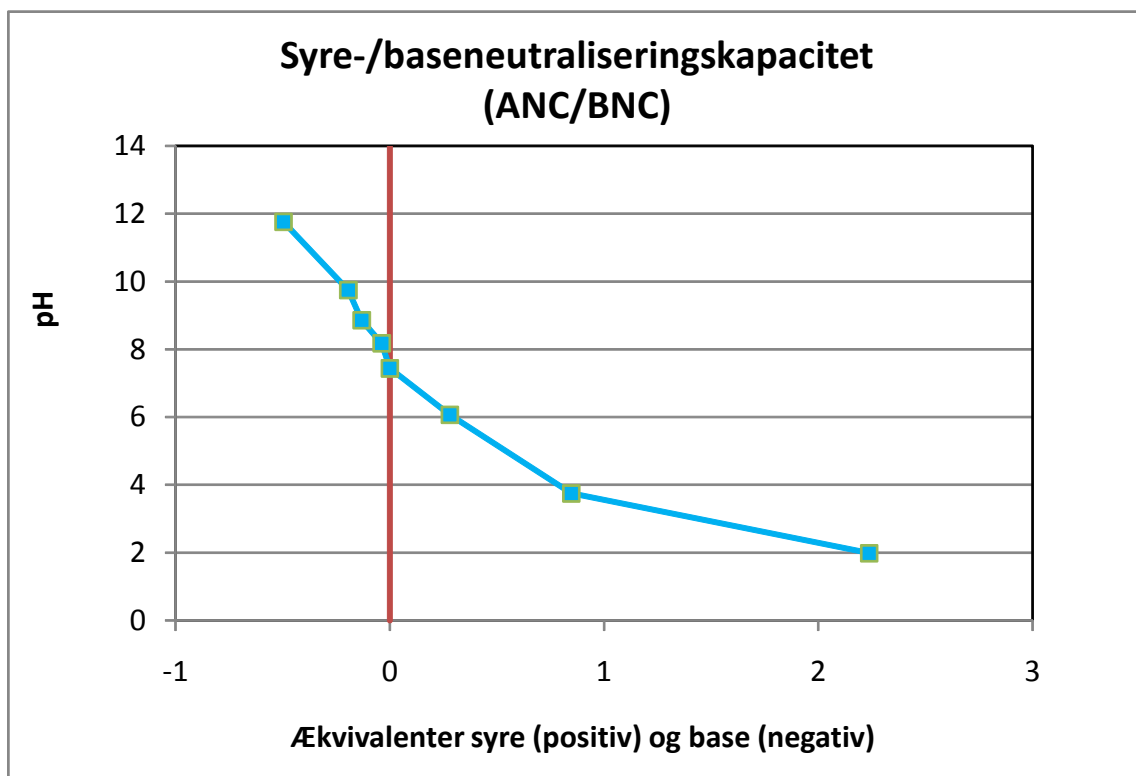
Bilag 5
Resultater af pH-statisk udvaskningstest



Bilag 5
 Resultater af pH-statisk udvaskningstest



Bilag 5
Resultater af pH-statisk udvaskningstest



Bilag 6
Resultat af ligevægtskolonnetest

Ligevægtskolonnetest: DHI-metode M22-1					
DHI-sag:	Aftercare	Test udført af:	SEK		
Sagsnr.:	11700096 (53451)	Udført dato:	13/12-21/12 2006		
Prøve modtaget:	12/06/2006	Godkendt af:	OH		
		Godk.-dato:	14/04 2009		
Materiale:	Blandet affald fra AV Miljø				
Prøve-ID:	Blandet affald B Nord				
LRJ-nr.:	R-096-06				
Tørstofindhold i testportion:	869 gTS/kg	Eluent:	Demineraliseret vand		
Vådvægt af testportion:	1403 g	Temperatur:	20.1 grader C		
Vandindhold i testportion:	184 ml	Kontaktid:	07:00 dage:timer		
Vol. af udv.-medium tilsat:	1529 ml				
Faktisk L/S:	1.40 l/kg				
Er prøven nedknust?	Ja				
Er prøven tørret?	Lufttørret				
Mængde > 4 mm (% w/w):					
Parameter	Koncentration i eluatet µg/l	Udvaskede stofmængder µg/kg	Analyselab	Analyselab	Akk. (X)
Kulbrintefraktioner:					
Benzen - C10	6.2	8.7	GC/FID (pentan-ekstr.)	Eurofins	X
C10 - C25	410	580	GC/FID (pentan-ekstr.)	Eurofins	X
C25 - C35	71	100	GC/FID (pentan-ekstr.)	Eurofins	X
Sum Benzen - C35	490	680	GC/FID (pentan-ekstr.)	Eurofins	X
PAH-forbindelser:					
Naphthalen	0.12	0.17	MK2260-GC/MS	Eurofins	X
Acenaphthylen	< 0.10	< 0.14	MK2260-GC/MS	Eurofins	X
Acenaphthen	0.43	0.60	MK2260-GC/MS	Eurofins	X
Fluoren	0.18	0.25	MK2260-GC/MS	Eurofins	X
Phenanthren	0.76	1.1	MK2260-GC/MS	Eurofins	X
Anthracen	0.73	1.0	MK2260-GC/MS	Eurofins	X
Fluoranthren	2.5	3.5	MK2260-GC/MS	Eurofins	X
Pyren	1.9	2.7	MK2260-GC/MS	Eurofins	X
Benz(a)anthracen	0.51	0.72	MK2260-GC/MS	Eurofins	X
Chrysen/Triphenylen	0.59	0.83	MK2260-GC/MS	Eurofins	X
Benz(b+j+k)fluoranthren	1.1	1.5	MK2260-GC/MS	Eurofins	X
Pyren	0.61	0.86	MK2260-GC/MS	Eurofins	X
Indeno(1,2,3-cd)pyren	0.47	0.66	MK2260-GC/MS	Eurofins	X
Dibenz(a, h)anthracen	0.12	0.17	MK2260-GC/MS	Eurofins	X
Benzo(g, h, i)perylen	0.38	0.53	MK2260-GC/MS	Eurofins	X
Sum PAH-forbindelser	10	14	-	-	
pH	7.36		DS287	DHI	
Ledningsevne (mS/m)	500		DS/EN 27888	DHI	
Turbiditet (NTU)	53			DHI	

A P P E N D I X C

Volumes of leachate produced by the lysimeters

Lys	Dato	Prøve	Fil	M/K	Frakt.	Midt	Kant	Total
1					liter	liter	liter	liter
	2008.05.08		839;1;08-05-2008 11:59:22;0;167,800	M	167.8	167.8	0.0	167.8
	2008.08.01		843;1;01-08-2008 15:08:37;0;32,200	M	32.2	200	0.0	200.0
	2008.08.06		849;1;06-08-2008 11:28:10;0;164,700	M	164.7	364.7	0.0	364.7
	2009.05.14		878;1;14-05-2009 15:10:00;0;48,200	M	48.2	412.9	0.0	412.9
1.1	2009.06.23	E-055-09	897;1;23-06-2009 11:35:09;1;4,200	M	4.2	417.1	0.0	417.1
1.2	2009.09.15	E-092-09	909;1;15-09-2009 16:13:02;1;96,800	M	96.8	513.9	0.0	513.9
1.3	2010.03.19	E-030-10	945;1;19-03-2010 09:07:03;1;31,600	M	70	583.9	0.0	583.9
1.4	2010.05.19	E-042-10	960;1;19-05-2010 12:15:45;1;-22,200	M	190	773.9	0.0	773.9
	2010.06.15	flaske itu	964;1;15-06-2010 10:53:50;0;135,700	M	135.7	909.6	0.0	909.6
	2010.08.18		106;1;18-08-2010;100,000	K		909.6	100	1009.6
1.5	2010.08.19	E-082-10	993;1;19-08-2010 17:51:26;1;16,300	M	16.3	925.9	100.0	1025.9
1.6	2010.09.08	E-092-10	1002;1;08-09-2010 11:39:27;1;188,500	M	188.5	1114.4	100.0	1214.4
1.7	2010 10 15	E-100-10	1013;1;15-10-2010 12:22:53;1;89,900	M	89.9	1204.3	100.0	1304.3
1.8	2010 11 25	E-130-10	1032;1;25-11-2010 17:50:29;1;157,300	M	157.3	1361.6	100.0	1461.6
1.9	2010 12 08	E-139-10	1050;1;08-12-2010 11:59:34;1;66,700	M	66.7	1428.3	100.0	1528.3
1.10	2010 12 29	-	1054;1;29-12-2010 12:27:16;1;110,100	M	110.1	1538.4	100.0	1638.4
1.11A	2011 01 26	E-035-11	1092;1;26-01-2011 17:32:51;1;113,800	M	113.8	1652.2	100.0	1752.2
	2011 02 24		154;1;24-02-2011;20.000	K		1652.2	20	1772.2
1.12	2011 02 24	E-045-11	1104;1;24-02-2011 10:05:18;1;125.600	M	125.6	1777.8	120.0	1897.8

Lys: Lysimeter (og KMCs prøvebetegnelser)
 Prøve: DHI-ID for udtagne prøver
 Fil: Tømningsfil for midterfelt (M) eller kantfelt (K)
 M/K: Midter- eller kantfelt
 Frakt: Udtaget mængde på den angivne dato
 Akkum: Akkumuleret mængde på den angivne dato

	2009.05.14		879;2;14-05-2009 15:10:04;0;32,500	M	32.5	32.5		0.0	32.5
2.1	2009.06.22 E-056-09		896;2;22-06-2009 12:36:39;1;9,000	M	9	41.5		0.0	41.5
2.2a	2009.08.21 E-084-09		908;2;21-08-2009 11:23:02;1;87,200	M	87.2	128.7		0.0	128.7
2.2b	2009.11.03 E-101-09		918;2;03-11-2009 16:02:15;1;162,300	M	162.3	291		0.0	291.0
	2009.12.28		70;2;28-12-2009;130,000	K		291	130	130.0	421.0
2.3	2010.04.06 E-036-10		952;2;06-04-2010 12:11:47;1;110,900	M	110.9	401.9		130.0	531.9
	2010.04.29		84;2;29-04-2010;75,000	K		401.9	75	205.0	606.9
2.4	2010.06.09 E-049-10		962;2;09-06-2010 17:18:33;1;88,100	M	88.1	490		205.0	695.0
2.5	2010.06.22 E-051-10		965;2;22-06-2010 15:08:50;1;93,200	M	93.2	583.2		205.0	788.2
	2010.07.09		94;2;09-07-2010;110,000	K		583.2	110	315.0	898.2
2.6	2010.08.11 E-057-10		972;2;11-08-2010 15:56:10;1;114,100	M	114.1	697.3		315.0	1012.3
	2010.08.16		981;2;16-08-2010 14:58:19;0;193,700	M	193.7	891		315.0	1206.0
2.7	2010.08.20 E-084-10		995;2;20-08-2010 14:54:00;1;92,200	M	92.2	983.2		315.0	1298.2
2.8	2010.09.08 E-093-10		1003;2;08-09-2010 11:39:46;1;144,900	M	144.9	1128.1		315.0	1443.1
	2010 10 15		121;2;15-10-2010;90,000	K		1128.1	90	405.0	1533.1
	2010 10 15		1012;2;15-10-2010 11:30:36;0;0,000	M	0	1128.1		405.0	1533.1
2.9	2010 10 28 E-103-10		1016;2;28-10-2010 17:14:17;1;111,900	M	111.9	1240		405.0	1645.0
2.10	2010 11 09 E-129-10		1028;2;09-11-2010 15:40:14;1;100,000	M	100	1340		405.0	1745.0
	2010 11 25		1033;2;25-11-2010 17:50:40;0;148,200	M	148.2	1488.2		405.0	1893.2
2.11	2010 12 01 E-134-10		1049;2;01-12-2010 16:56:23;1;50,500	M	50.5	1538.7		405.0	1943.7
2.12	2010 12 29 E-024-11		1055;2;29-12-2010 12:27:25;1;109,200	M	109.2	1647.9		405.0	2052.9
2.13	2011 01 14		141;2;14-01-2011;50,000	K		1647.9	50	455.0	2102.9
	2011 01 14		1071;2;14-01-2011 13:33:15;1;19,500	M	19.5	1667.4		455.0	2122.4
	2011 01 21		1089;2;21-01-2011 17:34:20;0;100,600	M	100.6	1768		455.0	2223.0
	2011 01 26		1093;2;26-01-2011 17:33:04;0;28,100	M	28.1	1796.1		455.0	2251.1
	2011 02 07		1106;2;07-03-2011 08:50:04;1;87.700	M	87.7	1883.8		455.0	2338.8
2.14	2011 03 07 E-043-11		156;2;07-03-2011;20.000	K		1883.8	20	475.0	2358.8

Lys: Lysimeter (og KMCs prøvebetegnelser)
 Prøve: DHI-ID for udtagne prøver
 Fil: Tømningsfil for midterfelt (M) eller kantfelt (K)
 M/K: Midter- eller kantfelt
 Frakt: Udtaget mængde på den angivne dato
 Akkum: Akkumuleret mængde på den angivne dato

Lys	Dato	Prøve	Fil	M/K	Midt		Kant		Total
					Frakt. liter	Akkum. liter	Frakt. liter	Akkum. liter	Akkum. liter
	3								
	2008.08.01		844;3;01-08-2008 15:09:24;0;112,400	M	112.4	112.4		0.0	112.4
	2009.05.14		880;3;14-05-2009 15:10:09;0;72,000	M	72	184.4		0.0	184.4
3.1	2009.06.04	E-048-09	Ikke registeret i database	M		184.4		0.0	184.4
3.2	2009.06.23	E-058-09	898;3;23-06-2009 11:35:22;1;65,400	M	65.4	249.8		0.0	249.8
3.3	2009.09.15	E-093-09	910;3;15-09-2009 14:56:45;1;63,300	M	63.3	313.1		0.0	313.1
3.4	2009.11.03	E-102-09	919;3;03-11-2009 16:02:22;1;123,300	M	123.3	436.4		0.0	436.4
3.5	2009.11.16	E-108-09	923;3;16-11-2009 11:36:00;0;142,700	M	142.7	579.1		0.0	579.1
3.6	2009.12.11	E-111-09	931;3;11-12-2009 15:20:44;1;61,500	M	61.5	640.6		0.0	640.6
	2009.12.28		71;3;28-12-2009;130,000	K		640.6	130	130.0	770.6
	2010.02.12		937;3;12-02-2010 14:45:44;0;0,000	M	0	640.6		130.0	770.6
3.7	2010.03.09	E-026-10	942;3;09-03-2010 14:49:42;1;30,800	M	30.8	671.4		130.0	801.4
3.8	2010.03.25	E-031-10	950;3;25-03-2010 09:43:29;1;64,800	M	64.8	736.2		130.0	866.2
	2010.04.29		85;3;29-04-2010;105,000	K		736.2	105	235.0	971.2
	2010.08.10		98;3;10-08-2010;110,000	K		736.2	110	345.0	1081.2
	2010.08.13		103;3;13-08-2010;100,000	K		736.2	100	445.0	1181.2
	2010.08.19		107;3;19-08-2010;125,000	K		736.2	125	570.0	1306.2
	2010.08.27		113;3;27-08-2010;130,000	K		736.2	130	700.0	1436.2
3.9	2010.09.08	E-094-10	1005;3;08-09-2010 13:39:39;1;8,800	M	8.8	745.0		700.0	1445.0
3.10	2010 10 15	E-101-10	1014;3;15-10-2010 12:22:35;1;64,700	M	64.7	809.7		700.0	1509.7
3.11	2010 10 28	E-104-10	1017;3;28-10-2010 17:14:29;1;52,700	M	52.7	862.4		700.0	1562.4
	2010 11 09		1029;3;09-11-2010 15:40:22;0;91,900	M	91.9	954.3		700.0	1654.3
	2010 11 12		125;3;12-11-2010;100,000	K		954.3	100	800.0	1754.3
	2010 11 26		130;3;26-11-2010;135,000	K		954.3	135	935.0	1889.3
3.12	2010 12 14	E-140-10	1051;3;14-12-2010 11:20:44;1;70,400	M	70.4	1024.7		935.0	1959.7
	2010 12 29		137;3;29-12-2010;95,500	K		1024.7	95.5	1030.5	2055.2
3.13	2011 01 14	E-025-11	142;3;14-01-2011;30,000	K		1024.7	30	1060.5	2085.2
	2011 01 14		1072;3;14-01-2011 13:33:45;1;14,700	M	14.7	1039.4		1060.5	2099.9
	2011 01 17		1078;3;17-01-2011 10:49:08;0;62,200	M	62.2	1101.6		1060.5	2162.1
	2011 01 26		1094;3;26-01-2011 17:33:20;0;67,800	M	67.8	1169.4		1060.5	2229.9
	2011 03 07		157;3;07-03-2011;80,000	K		1169.4	80	1140.5	2309.9
3.14	2011 03 07	E-044-11	1107;3;07-03-2011 08:50:28;1;53,200	M	53.2	1222.6		1140.5	2363.1
3.15	2011 04 12	E-047-11	1109;3;12-04-2011 10:59:29;1;67,000	M	67	1289.6		1140.5	2430.1

Lys: Lysimeter (og KMCS prøvebetegnelser)
 Prøve: DHI-ID for udtagne prøver
 Fil: Tømningsfil for midterfelt (M) eller kantfelt (K)
 M/K: Midter- eller kantfelt
 Frakt: Udtaget mængde på den angivne dato
 Akkum: Akkumuleret mængde på den angivne dato

Lys	Dato	Prøve	Fil	M/K	Midt		Kant		Total
					Frakt. liter	Akkum. liter	Frakt. liter	Akkum. liter	Akkum. liter
	4								
	2008.05.08		840;4;08-05-2008 11:59:29;0;154,600	M	154.6	154.6		0.0	154.6
	2008.08.01		845;4;01-08-2008 15:09:29;0;70,000	M	70	224.6		0.0	224.6
	2008.09.04		855;4;04-09-2008 17:22:56;0;152,900	M	152.9	377.5		0.0	377.5
	2008.11.21		862;4;21-11-2008 10:24:06;0;162,500	M	162.5	540.0		0.0	540.0
4.1	2009.05.14	E-049-09	881;4;14-05-2009 15:10:13;0;82,700	M	82.7	622.7		0.0	622.7
	2009.06.04		Ingen fil	M		622.7		0.0	622.7
4.2	2009.06.23	E-60-09	899;4;23-06-2009 11:35:31;1;9,200	M	9.2	631.9		0.0	631.9
4.3	2010.03.29	E-037-10	951;4;29-03-2010 14:50:32;1;74,500	M	74.5	706.4		0.0	706.4
4.4	2010.04.22	E-039-10	954;4;22-04-2010 13:13:03;1;78,300	M	78.3	784.7		0.0	784.7
4.5	2010.05.19	E-043-10	955;4;19-05-2010 11:25:24;1;95,900	M	95.9	880.6		0.0	880.6
	2010.05.26		86;4;26-05-2010;30,000	K		880.6	30	30.0	910.6
	2010.06.02		87;4;02-06-2010;100,000	K		880.6	100	130.0	1010.6
	2010.06.10		89;4;10-06-2010;130,000	K		880.6	130	260.0	1140.6
4.6	2010.06.22	E-052-10	966;4;22-06-2010 15:09:20;1;70,300	M	70.3	950.9		260.0	1210.9
4.7	2010.07.16	E-056-10	970;4;16-07-2010 11:36:54;1;40,200	M	40.2	991.1		260.0	1251.1
4.8	2010.08.11	E-058-10	973;4;11-08-2010 15:56:24;1;85,600	M	85.6	1076.7		260.0	1336.7
	2010.08.16		982;4;16-08-2010 14:58:27;0;196,200	M	196.2	1272.9		260.0	1532.9
	2010.08.27		1001;4;27-08-2010 16:58:45;0;183,800	M	183.8	1456.7		260.0	1716.7
4.9	2010.09.08	E-095-10	1006;4;08-09-2010 13:40:16;0;37,400	M	37.4	1494.1		260.0	1754.1
	2010.09.22		117;4;22-09-2010;90,000	K		1494.1	90	350.0	1844.1
	2010 10 28		1018;4;28-10-2010 17:14:41;0;185,500	M	185.5	1679.6		350.0	2029.6
	2010 11 09		1030;4;09-11-2010 15:40:30;0;104,200	M	104.2	1783.8		350.0	2133.8
4.10	2010 11 25	E-131-10	1034;4;25-11-2010 17:50:48;1;171,600	M	171.6	1955.4		350.0	2305.4
4.11	2010 12 14	E-141-10	1052;4;14-12-2010 11:20:56;1;110,900	M	110.9	2066.3		350.0	2416.3
4.12	2011 01 14	E-026-11	143;4;14-01-2011;45,000	K		2066.3	45	395.0	2461.3
	2011 01 14		1073;4;14-01-2011 13:33:52;1;77,300	M	77.3	2143.6		395.0	2538.6
	2011 01 26		147;4;26-01-2011;100,000	K		2143.6	100	495.0	2638.6
	2011 01 26		1095;4;26-01-2011 17:33:29;0;17,100	M	17.1	2160.7		495.0	2655.7
4.13	2011 02 24	E-042-11	155;4;24-02-2011;15,000	K		2160.7	15	510.0	2670.7
	2011 02 24		1105;4;24-02-2011 10:06:30;1;102,400	M	102.4	2263.1		510.0	2773.1
4.14	2011 04 12	E-048-11	1110;4;12-04-2011 10:59:40;1;85,900	M	85.9	2349.0		510.0	2859.0

Lys: Lysimeter (og KMCs prøvebetegnelser)
 Prøve: DHI-ID for udtagne prøver
 Fil: Tømningsfil for midterfelt (M) eller kantfelt (K)
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 Frakt: Udtaget mængde på den angivne dato
 Akkum: Akkumuleret mængde på den angivne dato

A P P E N D I X D

Results of analysis of leachate samples from the lysimeters

Parameter	Enhed	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
		E-055-09	E-092-09	E-030-10	E-042-10	E-082-10	E-092-10	E-100-10	E-130-10
pH	-	7.48	7.48	8.10	7.81	7.44	7.49	7.54	7.7
Ledn.evne	mS/m	596	600	337	267	337	245	225	188
Redox-pot.						417	392	283.1	370.6
Klorid	mg/l	972	817	361	231	226	176	181	
Fluorid	mg/l	0.56	0.73	0.51	0.51	0.45 <	0.5	0.49	
Sulfat	mg/l	504	479	364	282	287	265	271	
HCO3	mg/l	1600	1800	1200	1100	1600	1300	1100	
Si	mg/l	10.1	11	7.44	7.73	10.4	10.2	9.25	
Ca	mg/l	44.4	49.2	41.4	37.7	56	73.3	70.4	
Mg	mg/l	157	192	148	143	198	197	195	
Na	mg/l	981	911	455	345	375	197	195	
K	mg/l	164	170	112	101	138	109	98.8	
Al	mg/l	0.0041	0.0052 <	0.002	0.0036	0.00575	0.00487	0.0205	
As	mg/l	0.0050	0.0050	0.0031	0.0023	0.0029	0.0019	0.002	
Ba	mg/l	0.043	0.048	0.028	0.026	0.034	0.0454	0.0309	
Cd	mg/l	< 0.00005	0.00022 <	0.00005 <	0.00005	0.0000947	0.000055 <	0.00005	
Co	mg/l	0.0015	0.00096	0.00048	0.00036	0.000604	0.000386	0.000487	
Cr	mg/l	0.0018	0.0008 <	0.0005	0.00079	0.000546	0.000518	0.00053	
Cu	mg/l	0.0573	0.0398	0.0247	0.0182	0.0302	0.0219	0.0216	
Fe	mg/l	< 0.004	0.006 <	0.004	0.0176	0.0043 <	0.004 <	0.004	
Hg	mg/l	0.00014	8.8E-05	0.0000539	3.2E-05	0.0000503	0.0000429	0.000022	
Mn	mg/l	< 0.0002	0.0014 <	0.0002 <	0.0002	0.00137	0.000632	0.000397	
Mo	mg/l	0.19	0.14	0.10	0.073	0.0775	0.0531	0.0674	
Ni	mg/l	0.022	0.022	0.011	0.010	0.0166	0.0153	0.0122	
Pb	mg/l	< 0.0002	0.0027	0.0006	0.0006	0.0014	0.000666	0.00213	
Sb	mg/l	0.010	0.0078	0.0079	0.0080	0.00921	0.00925	0.00803	
Se	mg/l	0.0023	0.0026	0.0014	0.0013	0.00153	0.00102	0.00104	
Zn	mg/l	0.020	0.017	0.0062	0.0082	0.0162	0.0125	0.0175	
DOC	mg/l	101	38	40	36	37	27		
Benzen	µg/l	< 0.04 <	0.2 <	0.04 <	0.04 <	0.04 <	0.04		
Toluen	µg/l	< 0.04 <	0.2 <	0.04 <	0.04 <	0.04 <	0.04		
Ethylbenzen	µg/l	< 0.02 <	0.2 <	0.02 <	0.02 <	0.02 <	0.02		
o-xylen	µg/l	< 0.02 <	0.2 <	0.02 <	0.02 <	0.02 <	0.02		
m+p-xylen	µg/l	< 0.02 <	0.2 <	0.02 <	0.02 <	0.02 <	0.02		
C6-C10	µg/l	< 2	6 <	2 <	2 <	2 <	2		
C10-C25	µg/l	< 8 <	8	55 <	8	50 <	8		
C25-C35	µg/l	< 10 <	10 <	10 <	10 <	10 <	10		
C10-C15	µg/l	< 8 <	8 <	8 <	8 <	8 <	8		
C15-C20	µg/l	< 8 <	8	19 <	8	22 <	8		
C20-C25	µg/l	< 8 <	8	36 <	8	26 <	8		
C35-C40	µg/l	< 10 <	10 <	10 <	10 <	10 <	10		
Naphtalen	µg/l	< 0.01	0.010 <	0.01 <	0.01 <	0.01 <	0.01		
Acenaphtylen	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01		
Acenaphten	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01		
Flouren	µg/l	< 0.01 <	0.01 <	0.01 <	0.01	0.041 <	0.01 <	0.01	
Phenathren	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Anthracen	µg/l	< 0.01	0.027 <	0.01	0.020 <	0.01 <	0.01		
Flouranthen	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Pyren	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Benzo (a) anthracen	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Chrysen/triphenylen	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Benz(b,j,k) flouranthen	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Benzo (a) oyren	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Ideno(j)pyren		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Dibenzo(a,h)anthracen	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Benzo(g,h,i)perylen	µg/l	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
L/S	l/kg	0.200	0.218	0.247	0.328	0.435	0.515	0.553	0.620
Udtaget (dato)		2009 06 23	2009 09 15	2010 03 19	2010 05 19	2010 08 19	2010 09 08	2010 10 15	2010 11 25

Parameter	Enhed	1.9	1.10	1.11A	1.12
		E-139-10		E-035-11	E-045-11
pH	-	7.81		7.94	
Ledn.evne	mS/m	210		176	
Redox-pot.		338.2		322.6	
Klorid	mg/l	130		100	
Fluorid	mg/l	< 1		0.31	
Sulfat	mg/l	251		236	
HCO3	mg/l	950		760	
Si	mg/l	7.01		6.26	
Ca	mg/l	65		62.4	
Mg	mg/l	160		146	
Na	mg/l	137		103	
K	mg/l	72.2		59.7	
Al	mg/l	0.00307		0.0029	
As	mg/l	0.00135		0.00134	
Ba	mg/l	0.0306		0.0249	
Cd	mg/l	< 0.00005		< 0.00005	
Co	mg/l	0.000336		0.000281	
Cr	mg/l	< 0.0005		0.000535	
Cu	mg/l	0.0206		0.0149	
Fe	mg/l	< 0.004		< 0.004	
Hg	mg/l	0.0000286		0.0000324	
Mn	mg/l	0.000607		< 0.0002	
Mo	mg/l	0.0568		0.0591	
Ni	mg/l	0.0116		0.0112	
Pb	mg/l	0.00119		0.00101	
Sb	mg/l	0.00723		0.00669	
Se	mg/l	0.00106		0.00111	
Zn	mg/l	0.007		0.00587	
DOC	mg/l				
Benzen	µg/l				
Toluen	µg/l				
Ethylbenzen	µg/l				
o-xylen	µg/l				
m+p-xylen	µg/l				
	µg/l				
C6-C10	µg/l				
C10-C25	µg/l				
C25-C35	µg/l				
C10-C15	µg/l				
C15-C20	µg/l				
C20-C25	µg/l				
C35-C40	µg/l				
Naphtalen	µg/l				
Acenaphtylen	µg/l				
Acenaphten	µg/l				
Flouren	µg/l				
Phenathren	µg/l				
Anthracen	µg/l				
Flouranthen	µg/l				
Pyren	µg/l				
Benzo (a) anthracen	µg/l				
Chrysen/triphenylen	µg/l				
Benz(b,j,k) flouranthen	µg/l				
Benzo (a) oyren	µg/l				
Ideno()pyren					
Dibenzo(a,h)anthracen	µg/l				
Benzo(g,h,i)perylen	µg/l				
L/S	l/kg	0.648	0.695	0.743	0.805
Udtaget (dato)		2020 12 08	2010 12 29	2011 01 26	2011 02 24

Parameter	Enhed	2.1	2.2	2.2b	2.3	2.4	2.5	2.6	2.7
		E-056-09	E-084-09	E-101-09	E-036-10	E-049-10	E-051-10	E-059-10	E-084-10
pH	-	7.53	7.53	7.65	8.27	7.45	7.71	6.9	7.44
Ledn.evne	mS/m	812	900	816	375	231	334	151	320
Redox-pot.			250		373	386	342	410	440
Klorid	mg/l	1700	1680	1580	397	286	276	268	219
Fluorid	mg/l	0.54 <	1.2 <	0.60	0.55	0.5 <	1	0.41	0.36
Sulfat	mg/l	581	596	639	431	342	566	314	308
HCO3	mg/l	1600	2200	1900	1300	1400	1400	1700	1600
Si	mg/l	9.74	11.6	9.94	5.99	6.34	6.39	8.24	7.68
Ca	mg/l	107	73.4	60.8	37.8	50.2	50.1	71.9	82.2
Mg	mg/l	181	250	235	151	174	177	237	236
Na	mg/l	1300	1530	1370	519	376	378	350	263
K	mg/l	186	272	237	134	132	138	154	134
Al	mg/l	0.0023 <	0.002	0.0031	0.0036 <	0.002	0.00325 <	0.002	0.00475
As	mg/l	0.0048	0.0041	0.0038	0.0021	0.0020	0.0017	0.00227	0.00112
Ba	mg/l	0.051	0.062	0.047	0.023	0.028	0.0322	0.0651	0.0504
Cd	mg/l	0.00022 <	0.00005 <	0.00005 <	0.00005	0.00011 <	0.00005 <	0.00005	0.000188
Co	mg/l	0.019	0.012	0.005	0.0012	0.002	0.00159	0.00282	0.00338
Cr	mg/l	0.0048	0.0017	0.0018	0.0013	0.0011	0.000701	0.000834 <	0.0005
Cu	mg/l	0.069	0.063	0.056	0.048	0.050	0.0535	0.0735	0.0953
Fe	mg/l	0.0204	0.013	0.0124	0.0066 <	0.004 <	0.004 <	0.004 <	0.004
Hg	mg/l	0.00011	0.00012	0.000091	0.000044	0.000043	0.0000248	3.43E-05	0.0000326
Mn	mg/l	0.25	0.13	0.040	0.0045	0.014	0.00273	0.0151	0.0104
Mo	mg/l	0.23	0.31	0.22	0.12	0.11	0.0886	0.0905	0.0646
Ni	mg/l	2.3	1.4	0.67	0.12	0.17	0.128	0.239	0.159
Pb	mg/l	< 0.002	0.00045	0.00033	0.00023	0.00031	0.000504	0.000605	0.000272
Sb	mg/l	0.0119	0.010	0.010	0.011	0.013	0.0138	0.0126	0.0141
Se	mg/l	0.00188	0.0024	0.0020	0.0010	0.0010	0.000826	0.000755	0.000727
Zn	mg/l	0.0362	0.079	0.062	0.063	0.10	0.114	0.223	0.353
DOC	mg/l	116.6	58.5	85.5	45.3	39	40	41	41
Benzen	µg/l	< 0.04 <	0.04		< 0.04 <	0.04 <	0.04 <	0.04 <	0.04
Toluen	µg/l	< 0.04 <	0.04		< 0.04 <	0.04 <	0.04 <	0.04 <	0.04
Ethylbenzen	µg/l	< 0.02 <	0.02		< 0.02 <	0.02 <	0.02 <	0.02 <	0.02
o-xylen	µg/l	< 0.02 <	0.02		< 0.02 <	0.02 <	0.02 <	0.02 <	0.02
m+p-xylen	µg/l	< 0.02 <	0.02		< 0.02 <	0.02 <	0.02 <	0.02 <	0.02
C6-C10	µg/l	< 2 <	2		< 2 <	2 <	2 <	2 <	2
C10-C25	µg/l	9	13		11	9	44	25	83
C25-C35	µg/l	< 10 <	10		< 10 <	10 <	10	31 <	10
C10-C15	µg/l	< 8 <	8		< 8 <	8 <	8 <	8 <	8
C15-C20	µg/l	< 8 <	8		< 8 <	8	23	11	41
C20-C25	µg/l	< 8 <	8		< 8 <	8	16	10	37
C35-C40	µg/l	< 10 <	10		< 10 <	10 <	10 <	10 <	10
Naphtalen	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Acenaphthylen	µg/l	< 0.01 <	0.01		0.015 <	0.01 <	0.01 <	0.01 <	0.01
Acenaphthen	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Flouren	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Phenathren	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Anthracen	µg/l	< 0.01	0.015		0.014 <	0.01 <	0.01 <	0.01	0.019
Flouranthen	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Pyren	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Benzo (a) anthracen	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Chrysen/triphenylen	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Benzo(b,j,k) flouranthen	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Benzo (a) oeyren	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ideno(l)pyren		< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Dibenzo(a,h)anthracen	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
Benzo(g,h,i)perylen	µg/l	< 0.01 <	0.01		< 0.01 <	0.01 <	0.01 <	0.01 <	0.01
L/S	l/kg	0.018	0.056	0.126	0.231	0.301	0.342	0.439	0.563
Udtaget (dato)		2009 06 22	2009 08 21	2009 11 03	2010 04 06	2010 06 09	2010 06 22	2010 08 11	2010 08 20

Parameter	Enhed	2.8	2.9	2.10	2.11	2.12	2.13	2.14
		E-093-10	E-103-10	E-129-10	E-134-10	E-024-11	-	E-043-10
pH	-	7.45	7.58	7.62	7.84	7.76		
Ledn.evne	mS/m	273	237	230	209	206		
Redox-pot.		454	283.7	422	428.9	400.3		
Klorid	mg/l	202	200	192	180	128		
Fluorid	mg/l	< 0.5	0.46	1.8	< 1	1		
Sulfat	mg/l	308	301	294	626	282		
HCO3	mg/l	1500	1100	1100	1000	910		
Si	mg/l	8.53	7.67	7.03	6.17	5.79		
Ca	mg/l	82.4	73.9	72	67.1	63.7		
Mg	mg/l	232	219	200	179	170		
Na	mg/l	231	194	167	142	117		
K	mg/l	130	107	105	86.4	78.6		
Al	mg/l	0.00311	0.00703	0.00322	0.00369	0.0032		
As	mg/l	0.00156	0.0016	0.0017	0.00142	0.00115		
Ba	mg/l	0.0462	0.0373	0.0354	0.0307	0.027		
Cd	mg/l	0.000121	0.000169	< 0.00005	9.26E-05	< 0.00005		
Co	mg/l	0.00155	0.00118	0.00169	0.00194	0.00104		
Cr	mg/l	0.000995	0.00118	0.000649	0.00088	0.00109		
Cu	mg/l	0.0755	0.0552	0.0618	0.0607	0.0425		
Fe	mg/l	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004		
Hg	mg/l	3.44E-05	0.0000221	2.31E-05	2.09E-05	< 0.00002		
Mn	mg/l	0.00412	0.00151	0.00384	0.00451	0.00128		
Mo	mg/l	0.0715	0.0996	0.0778	0.071	0.0762		
Ni	mg/l	0.176	0.15	0.124	0.118	0.0964		
Pb	mg/l	< 0.0002	0.000776	0.000917	0.000869	0.0018		
Sb	mg/l	0.0113	0.0106	0.01	0.0105	0.00824		
Se	mg/l	0.000633	0.000622	0.000592	0.000688	0.000534		
Zn	mg/l	0.246	0.167	0.168	0.175	0.136		
DOC	mg/l	35						
Benzen	µg/l	< 0.04						
Toluen	µg/l	< 0.04						
Ethylbenzen	µg/l	< 0.02						
o-xylen	µg/l	< 0.02						
m+p-xylen	µg/l	< 0.02						
C6-C10	µg/l	< 2						
C10-C25	µg/l	9.3						
C25-C35	µg/l	< 10						
C10-C15	µg/l	< 8						
C15-C20	µg/l	< 8						
C20-C25	µg/l	< 8						
C35-C40	µg/l	< 10						
Naphtalen	µg/l	< 0.01						
Acenaphylen	µg/l	< 0.01						
Acenaphten	µg/l	< 0.01						
Flouren	µg/l	< 0.01						
Phenathren	µg/l	< 0.01						
Anthracen	µg/l	0.01						
Flouranthen	µg/l	< 0.01						
Pyren	µg/l	< 0.01						
Benzo (a) anthracen	µg/l	< 0.01						
Chrysen/triphenylen	µg/l	< 0.01						
Benz(b,j,k) flouranthen	µg/l	< 0.01						
Benzo (a) oiren	µg/l	< 0.01						
Ideno()pyren	µg/l	< 0.01						
Dibenzo(a,h)anthracen	µg/l	< 0.01						
Benzo(g,h,i)perylen	µg/l	< 0.01						
L/S	l/kg	0.625	0.713	0.760	0.842	0.890	0.920	1.022
Udtaget (dato)		2010 09 08	2010 10 28	2010 11 09	2010 12 01	2010 12 29	2011 01 14	2011 03 07

Parameter	Enhed		3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8
			E-048-09	E-058-09	E-093-09	E-102-09	E-108-09	E-111-09	E-026-10	E-031-10
pH	-		7.28	7.28	7.28	7.42	7.58	7.5	7.6	7.8
Ledn.evne	mS/m		832	595	529	490	289	414	323	336
Redox-pot.	mV				239			359	512	395
Klorid	mg/l		1230	557	384	308	192	172	123	95
Fluorid	mg/l	<	1.2	1.7	1.5	1.7	1.5	1.5	1.4	1.6
Sulfat	mg/l		2810	2510	2310	2340	2130	2100	1860	1750
HCO ₃	mg/l		520	400	380	410	300	<1,0	280	230
Si	mg/l		9.96	14.5	13.5	14.3	16	15.8	15.1	14.1
Ca	mg/l		531	525	489	534	505	518	498	496
Mg	mg/l		231	148	129	128	107	109	95.8	84.5
Na	mg/l		1220	680	568	510	387	362	298	240
K	mg/l		268	218	194	176	143	135	112	96.7
Al	mg/l		0.029	0.026	0.023	0.020	0.016	0.013	0.011	0.0062
As	mg/l		0.023	0.056	0.035	0.045	0.098	0.072	0.094	0.084
Ba	mg/l		0.15	0.14	0.06	0.05	0.04	0.031	0.033	0.028
Cd	mg/l		0.0011	0.00041	0.00043	0.00019	0.00021	0.000084	0.000084	0.00014
Co	mg/l		0.0041	0.0023	0.0017	0.0013	0.0011	0.00097	0.00076	0.00070
Cr	mg/l		0.070	0.077	0.053	0.057	0.042	0.040	0.038	0.030
Cu	mg/l		0.18	0.24	0.20	0.20	0.18	0.14	0.13	0.10
Fe	mg/l		0.11	0.16	0.14	0.14	0.12	0.095	0.079	0.054
Hg	mg/l	<	0.00002	< 0.00002	3.4E-05	2.6E-05	4.3E-05	4.0E-05	2.2E-05	< 0.00002
Mn	mg/l		0.0037	0.0019	0.0018	0.0018	0.0020	0.0011	0.0014	0.00092
Mo	mg/l		0.054	0.060	0.059	0.047	0.029	0.026	0.028	0.031
Ni	mg/l		0.14	0.084	0.068	0.052	0.042	0.032	0.028	0.024
Pb	mg/l		0.0021	0.0014	0.0014	0.00088	0.00076	0.00066	0.00076	0.00048
Sb	mg/l		0.010	0.019	0.014	0.013	0.019	0.013	0.015	0.013
Se	mg/l		0.0026	0.0018	0.0027	0.0024	0.0018	0.0020	0.0014	0.0011
Zn	mg/l		0.076	0.077	0.034	0.026	0.017	0.017	0.025	0.015
DOC	mg/l		288	200	145	164	133	125	94	83
Benzen	µg/l	<	0.04	< 0.04	< 0.04	<	0.04	< 0.04	< 0.04	<
Toluen	µg/l	<	0.04	< 0.04	< 0.04	<	0.04	< 0.04	< 0.04	<
Ethylbenzen	µg/l	<	0.02	< 0.02	< 0.02	<	0.02	< 0.02	< 0.02	<
o-xylen	µg/l	<	0.02	< 0.02	< 0.02	<	0.02	< 0.02	< 0.02	<
m+p-xylen	µg/l	<	0.02	< 0.02	< 0.02	<	0.02	< 0.02	< 0.02	<
C6-C10	µg/l	<	2	< 2	2	<	2	< 2	2	< 2
C10-C25	µg/l	<	8	< 8	8	<	8	< 8	8	< 8
C25-C35	µg/l	<	10	< 10	10	<	10	< 10	10	< 10
C10-C15	µg/l	<	8	< 8	8	<	8	< 8	8	< 8
C15-C20	µg/l	<	8	< 8	8	<	8	< 8	8	< 8
C20-C25	µg/l	<	8	< 8	8	<	8	< 8	8	< 8
C35-C40	µg/l	<	10	< 10	10	<	10	< 10	10	< 10
Naphtalen	µg/l	<	0.01	< 0.01	0.015	<	0.01	< 0.01	0.01	< 0.01
Acenaphylen	µg/l	<	0.01	< 0.01	0.01	<	0.01	0.013	< 0.01	< 0.01
Acenaphten	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Flouren	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Phenathren	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Anthracen	µg/l		0.090	0.53	0.12	<	0.01	0.068	0.12	0.080
Flouranthen	µg/l	<	0.01	< 0.01	0.014	<	0.01	< 0.01	0.01	< 0.01
Pyren	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Benzo (a) anthracen	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Chrysen/triphenylen	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Benz(b,j,k) flouranthen	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Benzo (a) oyren	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Ideno()pyren	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Dibenzo(a,h)anthracen	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
Benzo(g,h,i)perylen	µg/l	<	0.01	< 0.01	0.01	<	0.01	< 0.01	0.01	< 0.01
L/S	l/kg		0.132	0.179	0.225	0.314	0.416	0.460	0.576	0.622
Udtaget (dato)			2009 06 04	2009 06 23	2009 09 15	2009 11 03	2009 11 16	2009 12 11	2010 03 09	2010 03 25

Parameter	Enhed	3.9		3.10		3.11		3.12		3.13		3.14		3.15	
		E-094-10	E-101-10	E-104-10	E-140-10	E-025-11	E-044-11	E-047-11							
pH	-	7.26	7.44	7.44	7.54	7.48									
Ledn.evne	mS/m	298	267	257	270	275									
Redox.pot.	mV	405	282.9	294.1	367.5	410.9									
Klorid	mg/l	52	31	31	23	22	17	6.6							
Fluorid	mg/l	1.5	1	1.3	1.5	1.4	1.7	0.59							
Sulfat	mg/l	1750	1660	1600	1480	1530	1460	1020							
HCO3	mg/l	370	320	260	300	300	190	190							
Si	mg/l	23.5	22.7	22	22.3	20.7	19.1	18.7							
Ca	mg/l	571	596	570	550	582	528	502							
Mg	mg/l	71.1	58	54.8	48.7	54.3	43.7	40.5							
Na	mg/l	173	138	127	101	106	76.3	68							
K	mg/l	92.3	74.4	66.9	51.5	60.5	42.7	37.1							
Al	mg/l	0.0153	0.013	0.00984	0.00771	0.00987	0.00659	< 0.002							
As	mg/l	0.11	0.092	0.109	0.158	0.123	0.133	0.134							
Ba	mg/l	0.0392	0.0387	0.0335	0.0297	0.0304	0.0226	0.0215							
Cd	mg/l	0.000175	0.000191	0.000187	0.000124	0.000127	7.79E-05	< 0.00005							
Co	mg/l	0.000798	0.000685	0.000617	0.000459	0.000478	0.000466	0.00039							
Cr	mg/l	0.0291	0.0289	0.0291	0.0256	0.0241	0.0218	0.018							
Cu	mg/l	0.144	0.128	0.13	0.109	0.0967	0.0928	0.0698							
Fe	mg/l	0.11	0.0747	0.0693	0.0725	0.0594	0.0481	0.0401							
Hg	mg/l	0.00005	< 0.00002	< 0.00002	< 0.00002	2.11E-05	< 0.00002	< 0.00002							
Mn	mg/l	0.00855	0.0014	0.00101	0.00403	0.00151	0.000958	0.00073							
Mo	mg/l	0.0201	0.0207	0.0216	0.0155	0.0173	0.0208	0.0213							
Ni	mg/l	0.028	0.0264	0.0222	0.0174	0.0193	0.0144	0.0129							
Pb	mg/l	0.000554	0.00112	0.000717	0.00122	0.000748	0.00178	0.000829							
Sb	mg/l	0.0184	0.0182	0.0168	0.0149	0.0153	0.0147	0.0145							
Se	mg/l	0.0012	0.00109	0.000995	0.00119	0.000936	0.00109	0.000999							
Zn	mg/l	0.0495	0.0534	0.0289	0.0344	0.0659	0.0294	0.0246							
DOC	mg/l	70													
Benzen	µg/l	< 0.04													
Toluen	µg/l	< 0.04													
Ethylbenzen	µg/l	< 0.02													
o-xylen	µg/l	< 0.02													
m+p-xylen	µg/l	< 0.02													
C6-C10	µg/l	< 2													
C10-C25	µg/l	< 8													
C25-C35	µg/l	< 10													
C10-C15	µg/l	< 8													
C15-C20	µg/l	< 8													
C20-C25	µg/l	< 8													
C35-C40	µg/l	< 10													
Naphtalen	µg/l	< 0.01													
Acenaphtylen	µg/l	< 0.01													
Acenaphten	µg/l	< 0.01													
Flouren	µg/l	< 0.01													
Phenathren	µg/l	< 0.01													
Anthracen	µg/l	0.086													
Flouranthen	µg/l	< 0.01													
Pyren	µg/l	< 0.01													
Benzo (a) anthracen	µg/l	< 0.01													
Chrysen/triphenylen	µg/l	< 0.01													
Benz(b,j,k) flouranthen	µg/l	< 0.01													
Benzo (a) oyren	µg/l	< 0.01													
Ideno(pyren	µg/l	< 0.01													
Dibenzo(a,h)anthracen	µg/l	< 0.01													
Benzo(g,h,i)perylen	µg/l	< 0.01													
L/S	l/kg	1.038	1.085	1.122	1.408	1.498	1.698	1.746							
Udtaget (dato)		2010 09 08	2010 10 15	2010 10 28	2010 12 14	2011 01 14	2011 03 07	2011 04 12							

Parameter	Enhed		4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8
			E-049-09	E-060-09	E-037-10	E-039-10	E-043-10	E-052-10	E-056-10	E-058-10
pH	-		7.13	7.17	7.82	7.77	7.45	7.26	7.3	7.08
Ledn.evne	mS/m		450	670	347	340	331	332	61	294
Redox-pot.					376	379	384	392	388	400
Klorid	mg/l		375	733	106	95	82	74		50
Fluorid	mg/l		0.98	1.3	1.4	1.4	1.3	1.1		1.2
Sulfat	mg/l		1750	2330	1690	1670	1620	2170		1610
HCO ₃	mg/l		480	580	320	350	380	430		530
Si	mg/l		17.5	20.6	21.6	21.8	23.5	24.6		30.6
Ca	mg/l		644	682	504	511	526	548		620
Mg	mg/l		79.7	133	77.1	71.9	69.2	63.8		63.5
Na	mg/l		381	769	262	239	216	179		161
K	mg/l		108	206	101	98.4	93.6	94.7		96.7
Al	mg/l		0.020	0.032	0.010	0.010	0.012	0.0138		0.0136
As	mg/l		0.090	0.13	0.20	0.17	0.21	0.239		0.194
Ba	mg/l		0.10	0.11	0.04	0.044	0.052	0.0532		0.0818
Cd	mg/l		0.00064	0.00068	0.00015	0.00014	0.00016	0.000227		0.000293
Co	mg/l		0.0038	0.0052	0.0010	0.00092	0.0011	0.0011		0.00113
Cr	mg/l		0.036	0.080	0.034	0.033	0.033	0.0413		0.0429
Cu	mg/l		0.19	0.49	0.20	0.18	0.21	0.216		0.259
Fe	mg/l		0.11	0.27	0.099	0.092	0.092	0.117		0.142
Hg	mg/l	<	0.00002	3.5E-05	7.8E-05	3.3E-05	3.9E-05	2.61E-05		4.27E-05
Mn	mg/l		0.0028	0.0073	0.0026	0.0023	0.0022	0.0042		0.00662
Mo	mg/l		0.057	0.057	0.030	0.026	0.028	0.0284		0.0303
Ni	mg/l		0.063	0.099	0.027	0.025	0.027	0.0321		0.0353
Pb	mg/l		0.028	0.0044	0.00079	0.00063	0.00057	0.000666		0.000792
Sb	mg/l		0.016	0.025	0.017	0.017	0.019	0.023		0.0228
Se	mg/l		0.0016	0.0021	0.0010	0.00093	0.00093	0.00105		0.000973
Zn	mg/l		0.093	0.077	0.067	0.051	0.080	0.115		0.155
DOC	mg/l		155	281	93	82	86	62	72	74
Benzen	µg/l	<	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Toluen	µg/l	<	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Ethylbenzen	µg/l	<	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
o-xylen	µg/l	<	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
m+p-xylen	µg/l	<	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
C6-C10	µg/l	<	2	2	2	2	2	2	2	2
C10-C25	µg/l	<	8	8	8	8	8	8	8	8
C25-C35	µg/l	<	10	10	10	10	10	10	10	10
C10-C15	µg/l	<	8	8	8	8	8	8	8	8
C15-C20	µg/l	<	8	8	8	8	8	8	8	8
C20-C25	µg/l	<	8	8	8	8	8	8	8	8
C35-C40	µg/l	<	10	10	10	10	10	10	10	10
Naphtalen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Acenaphthylen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Acenaphthen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Flouren	µg/l	<	0.01	0.01	0.01	0.01	0.039	0.01	0.01	0.01
Phenathren	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Anthracen	µg/l		0.15	0.16	0.081	0.074	0.18	0.01	0.077	0.110
Flouranthen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Pyren	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Benzo (a) anthracen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chrysen/triphenylen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Benz(b,j,k) flouranthen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Benzo (a) oyren	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ideno()pyren	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dibenzo(a,h)anthracen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Benzo(g,h,i)perylen	µg/l	<	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
L/S	l/kg		0.381	0.386	0.432	0.480	0.538	0.740	0.765	0.817
Udtaget (dato)			2009 05 14	2009 06 23	2010 03 29	2010 04 22	2010 05 19	2010 06 22	2010 07 16	2010 08 11

Parameter	Enhed		4.9	4.10	4.11	4.12	4.13	4.14
			E-095-10	E-131-10	E-141-10	E-026-11	E-042-11	E-048-11
pH	-		7.13	7.41	7.34	7.1		
Ledn.evne	mS/m		280	241	274	260		
Redox-pot.			413	403.1	390.1	461.3		
Klorid	mg/l		33		22	22	18	6.7
Fluorid	mg/l		1.2		1.2	1.3	2	0.52
Sulfat	mg/l		1580		1430	1420	1490	987
HCO3	mg/l		460		390	310	230	230
Si	mg/l		31.7		27.7	24.6	24.1	23.2
Ca	mg/l		619		585	560	553	525
Mg	mg/l		50.8		41.6	39.9	35.3	32.6
Na	mg/l		123		90.8	81.5	71.3	61.9
K	mg/l		79.4		51.8	50.6	43.2	36.6
Al	mg/l		0.0132		0.00804	0.00639	0.00721	0.00248
As	mg/l		0.195		0.245	0.202	0.209	0.209
Ba	mg/l		0.0578		0.0431	0.0346	0.0324	0.0302
Cd	mg/l		0.00028		0.000199	0.000161	0.000142	6.94E-05
Co	mg/l		0.00078		0.000729	0.000516	0.00063	0.000518
Cr	mg/l		0.0359		0.032	0.0253	0.0261	0.0217
Cu	mg/l		0.236		0.17	0.136	0.141	0.112
Fe	mg/l		0.109		0.0775	0.0672	0.0599	0.0503
Hg	mg/l		6.46E-05		2.71E-05	2.66E-05	2.14E-05	< 0.00002
Mn	mg/l		0.00679		0.00316	0.00196	0.00171	0.00121
Mo	mg/l		0.0239		0.0224	0.0252	0.0282	0.0313
Ni	mg/l		0.0326		0.023	0.0202	0.0186	0.0159
Pb	mg/l		0.000515		0.00112	0.000561	0.000941	0.00191
Sb	mg/l		0.0209		0.0168	0.0147	0.0155	0.0153
Se	mg/l		0.001		0.00107	0.000725	0.000909	0.000761
Zn	mg/l		0.183		0.172	0.133	0.0835	0.101
DOC	mg/l		77					
Benzen	µg/l	<	0.04					
Toluen	µg/l	<	0.04					
Ethylbenzen	µg/l	<	0.02					
o-xylen	µg/l	<	0.02					
m+p-xylen	µg/l	<	0.02					
C6-C10	µg/l	<	2					
C10-C25	µg/l	<	8					
C25-C35	µg/l	<	10					
C10-C15	µg/l	<	8					
C15-C20	µg/l	<	8					
C20-C25	µg/l	<	8					
C35-C40	µg/l	<	10					
Naphtalen	µg/l	<	0.01					
Acenaphtylen	µg/l	<	0.01					
Acenaphten	µg/l	<	0.01					
Flouren	µg/l	<	0.01					
Phenathren	µg/l	<	0.01					
Anthracen	µg/l		0.098					
Flouranthen	µg/l	<	0.01					
Pyren	µg/l	<	0.01					
Benzo (a) anthracen	µg/l	<	0.01					
Chrysen/triphenylen	µg/l	<	0.01					
Benz(b,j,k) flouranthen	µg/l	<	0.01					
Benzo (a) oyren	µg/l	<	0.01					
Ideno(pyren		<	0.01					
Dibenzo(a,h)anthracen	µg/l	<	0.01					
Benzo(g,h,i)perylen	µg/l	<	0.01					
L/S	l/kg		1.072	1.410	1.477	1.505	1.633	1.748
Udtaget (dato)			2010 09 08	2010 11 25	2010 12 14	2011 01 14	2011 02 24	2011 04 12

A P P E N D I X E

Detailed sampling at AV Miljø November 2008 and May 2009

Ekstra analyser november 2008

Enhed: mg/l hvis ikke andet er angivet	Ikke filtreret		Filtreret		Ikke filtreret		Filtreret		Ikke filtreret		Filtreret		Ikke filtreret		Filtreret	
Prøvetagningssteder	Målebygværk	Målebygværk	Målebygværk	Målebygværk	Hane 1E	Hane 1E	Samlebrønd S1.2	Samlebrønd S1.2	Hane 1D	Hane 1D	Samlebrønd S1.5.1	Samlebrønd S1.5.1				
pH (-)	7.9	7.9	7.3	7.9	7.2	7.8	7.4	7.8	8	8.1	7.5	7.9				
CN-total	<0,01	<0,01		<0,01	0.01	0.01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01				
Phenoler	Påvist															
Anioniske overfladsaktive stoffer	0.39															
Hæmning (1:1) (%)	<10															
Pb	<0,1	-		<0,1	<0,1	-	<0,1	-	<0,1	-	<0,1	-				
Cd	0.0025	0.0001		0.0002	<0,0001	-	0.0008	0.0006	0.0002	0.0001	<0,0001	-				
Cr-total	0.01	<0,01		<0,01	0.02	0.02	<0,01	-	<0,01	-	<0,01	-				
Cu	0.03	<0,01		<0,01	<0,01	-	<0,01	-	<0,01	-	0.01	<0,01				
Zn	0.04	<0,01		0.05	<0,01	-	0.02	<0,01	<0,01	-	0.09	0.03				
Ag	<0,002	<0,002		<0,002	<0,002	-	<0,002	-	<0,002	-	<0,002	-				
Hg	<0,0002	<0,0002		<0,0002	<0,0002	-	<0,0002	-	<0,0002	-	<0,0002	-				
As	0.019	0.013		0.005	0.068	0.068	0.014	0.004	24	24	5	5				
Sn	0.002	0.0011		0.0005	0.001	0.0008	<0,001	-	4	3.2	3	3.4				
Ledningsevne (mS/m)	1040	1040	580	580	1230	1220	760	760	1690	1690	530	530				
Tørstof (TDS)	6500	6400		3620	7730	7700	4680	4530	10700	10800	3180	3210				
NH4-N	103	102		41	103	108	38	37	200	195	99	99				
N-total	115	116		47.6	109	109	41.4	46.1	235	234	103	101				
P-total	2.09	0.294		1.19	3.65	2.27	2.53	1.35	1.48	0.602	3	2.71				
COD	670				560		50									
BOD5	81				23		1.7		90		17					
Fe	15	3.6		1.3	3.1	0.4	7.3	0.3	1.3	0.8	0.85	0.13				
Mn	1	1		0.93	0.88	0.88	0.27	0.24	0.13	0.13	0.24	0.24				
Klorid	2500	2500		1200	3000	2900	1600	1600	4700	4800	790	780				
Sulfat	240	240		280	430	430	500	500	54	54	120	120				
Flygtige syrer	49				33		<10		130		29					
Ni	0.03	0.03		<0,02	0.03	0.02	<0,02	-	0.06	0.06	0.04	0.04				
PAH	Påvist															
Temperatur	18.1	18.1	18.1													
Olie	0.4		0.2		<0,1		0.4		0.5		0.5					
Sulfid			0.04		0.04		0.01		0.55		0.1					
Parametre som ikke indgår i det eksisterende program																
HCO3	1760	1730		859	2180	2140	1040	1040	80	105	1960	1860				
Fluorid	1.9	1.8		1.1	1.3	1.2	9.3	9.3	4.1	4	5.1	5				
Si	15.4	15.3		9.9	16.9	16.8	9.59	9.05	16.4	16.2	10.8	11.1				
Ca	224	224		252	220	220	218	218	45	45	115	114				
Na	1700	1700		810	2020	2020	1060	1060	3300	3300	780	780				
K	300	300		160	459	459	245	245	545	545	117	117				
Al	<0,1	-		<0,1	<0,1	-	<0,1	-	<0,1	-	<0,1	-				
Ba	0.8	0.63		221	0.45	0.34	0.12	0.06	2.6	2.3	0.09	0.07				
Co	0.004	0.004		0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.002	0.002				
Mo	0.057	0.056		0.035	0.012	0.012	0.554	0.488	0.16	0.13	23	21				
Sb	<0,1	-		<0,1	<0,1	-	<0,1	-	<0,1	-	<0,1	-				
Se	0.002	0.002		<0,001	0.002	0.002	0.002	0.002	0.004	0.004	0.01	0.01				
NVOC (bliver DOC på filit. prøve)	210	200		93	190	180	18	17	420	430	220	190				
Redoxpotential (mV)	110	110	105	105	95	95	75	75	150	150	197	197				

Ionstyrke (mol/l)

Ion balance

Tydelig forskel på filtrerede og ufiltrerede prøver

Mullig forskel eller generel men mindre forskel på filtrerede og ufiltrerede prøver

Kan ikke vurderes

Svag tendens til højere værdier i filtrerede prøver end ufiltrerede

Indgår ikke i vurderingen

Tillægsanalyseprogram AV Miljø maj 2009

For Celle 2.2.1 og Celle 2.4

Bemærk: Prøverne skal i videst muligt omfang filtreres i felten

Parametre	Kommentar	Celle 2.2.1		Celle 2.4	
		Ikke filtreret	Filtreret	Ikke filtreret	Filtreret
pH (-)	Feltmåling	7.84	8.01	7.43	7.91
Temperatur	Feltmåling	22		16.5	
Phenoler			påvist		påvist
Pb	Lavere detektionsgrænse (0,002 mg/l)	0.003	0.00078	0.003	0.0002
Cd	Tidligere påvist forskel m/u filtrering	0.0001	0.000075	0.0002	0.000028
Cr-total	Lavere detektionsgrænse (0,003 mg/l)	0.003	0.002	0.074	0.045
Cu	Lavere detektionsgrænse (0,002 mg/l)	0.008	0.0061	0.007	0.001
Zn	Lavere detektionsgrænse (0,002 mg/l)	0.026	0.004	0.81	0.113
Hg	Kun på filtreret hvis noget i uden filtrering	<0,0002	<0,0002	<0,0002	<0,0002
As	Tidligere påvist forskel m/u filtrering	0.018	0.018	0.052	0.032
Sn			0.002		<0,001
Ledningsevne (mS/m)	Feltmåling	1732		1063	
Tørstof (TDS)			11400		6730
Suspenderet stof		71		190	
NH4-N			103		184
N-total			103		158
P-total	Tidligere påvist forskel m/u filtrering	1.44	1.4	4.75	3.55
COD			960		660
BOD5			33		12
Fe	Tidligere påvist forskel m/u filtrering	1.8	0.87	8.9	1.2
Mn			0.1		0.42
Klorid			5000		2400
Sulfat			160		290
Flygtige syrer (eddikesyre)			14		38
Ni			0.052		0.029
PAH			0.00073		0.00086
Olie			< 0,10		5.3
Parametre som ikke indgår i det eksisterende AV Miljø program					
HCO3			2720		2960
Fluorid			2		0.68
Si			14.4		18.1
Ca			46		234
Na			3500		1400
K			510		610
Mg	Ny parameter	72	75	159	157
Al	Lavere detektionsgrænse (0,002 mg/l)	0.34	0.01	1.7	0.02
Ba	Tidligere påvist forskel m/u filtrering	1.05	0.98	0.81	0.44
Co			0.0024		0.0028
Mo	Tidligere påvist forskel m/u filtrering	0.043	0.032	0.003	0.0014
Sb	Lavere detektionsgrænse (0,002 mg/l)	0.016	0.012	0.021	0.01
Se			0.018		0.006
NVOC	Bliver DOC på filt. prøve	160	170	140	126
Redoxpotentiale (mV)	Feltmåling	-202		-105	
Ion styrke (mol/l)			0.19		0.13
Ion balance			-5.2%		-9.5%

A P P E N D I X F

Operation and covering periods for all AV Miljø cells

Drift af celler på AV Miljø

Celle	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008		
1.1	RGA																				Shredder	Fortsætter
1.1.1		RGA																			Shredder	Fortsætter
1.2										I (Slutafdækning afsluttet!)												
1.3																						
1.4																						Fortsætter
1.5																						Fortsætter
1.5.1																						
1.6																						Fortsætter
1.6.1																						Fortsætter
2.1											RGA											Slået sammen, hedder nu 2.1
2.1.1												RGA										Shedder
2.2												RGA										
2.2.1																						
2.2.1																						
2.1.2.2																						Fortsætter
2.1.2.3																						
2.1.3																						
2.1.4																						
2.2.2																						
2.3																						Fortsætter
2.4																						
2.5																						
2.6																						
2.7																						

- I drift/etableret
- Fyldt op
- Delvis afdækket
- Slutafdækket
- Tømt for RGA
- Plastoverdækket - delvis
- Part in Unit 1E

Afdækning af celler på AV Miljø																				
Celle	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1.1							RGA													
1.1.1							RGA													
1.2																				
1.3																				
1.4										Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist		Delvist	Delvist	Delvist
1.5	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist	Delvist
1.5.1																				
1.6										Delvist	Delvist	Delvist	Delvist	Delvist	Delvist		Delvist		Delvist	Delvist
1.6.1																			Delvist	Delvist
2.1										RGA										
2.1.1										RGA										
2.2										RGA										
2.2.1										RGA										
2.1.2.2																				Har aldrig været afdækket
2.1.2.3																				Har aldrig været afdækket
2.1.3																				Har aldrig været afdækket
2.1.4																				Har aldrig været afdækket
2.2.2																				Har aldrig været afdækket
2.3																				Delvist
2.4														Delvist	Delvist					
2.5																				
2.6																				
2.7																				
	Fra excelark med grønne regnskaber 2001->. Afdækket, afvander til kanal eller (rent vand)																			
	Fra excelark med grønne regnskaber 2001->. Afdækket (perkolat) eller befæstet (perkolat)																			
	Oplyst på mail fra Finn Jensen, AV Miljø. Oktober 2008																			
	Oplysninger desuden indhentet fra Finn Jensen 2/12-08 om årene 1998-2000.																			

Afledning til perkolatsystem på AV Miljø

Celle	Areal	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008		
1.1	17100	RGA										Shred.								Fortsætter			
1.1.1	6300	RGA										Shred.								Fortsætter			
1.2	15300	I (Slutafdækning afsluttet!)																					
1.3	24300																						
1.4	23400											19500	19500	19500	19500	19500	19500	19500	10000	10000	10000	Fortsætter	
1.5	36900																					Fortsætter	
1.5.1	8100																						
1.6	27900											11000	11000	11000	11000	11000	11000	5000	18000	18000	Fortsætter		
1.6.1	17100																					Fortsætter	
2.1	3150											RGA										Slået sammen, hedder nu 2.1	
2.1.1	10350											RGA										Shedder	
2.2	2700											RGA											
2.2.1	8100											RGA											
2.1.2.2	18000																					Fortsætter	
2.1.2.3	10800																						
2.1.3	5600																						
2.1.4	11600																						
2.2.2	10450																						
2.3	22500																					15900	Fortsætter
2.4	22500																						
2.5	9000																						
2.6	19775																						
2.7	9000																						
TOTAL Areal		40500	46800	46800	81550	126550	146325	169725	198075	248925	124850	124850	130450	158475	176475	248225	294275	332925	329925	311925	296025		
		<ul style="list-style-type: none"> I drift/etableret Fyldt op Delvis afdækket Slutafdækket Plastoverdækket (evt. tal angiver afdækket areal) Part in Unit 1E 																					

A P P E N D I X G

Result for pH-case modelling of shredder waste in LeachXS

