

LAB SCALE SIMULATION OF A LEAK IN A LANDFILL COVER

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ABSTRACT

Many Swedish landfills are currently applied with a final cover. To minimise costs and the use of natural resources, waste materials can be a suitable substitute in landfill covers. Depending on the wastes' contents, their mobility and in which layer of the final cover they are used, they could potentially contribute to the emission potential of the landfill. In this study the impact on landfill leachate quality from the drainage water of a final cover is investigated.

Part of a landfill and its cover, below the upper drainage layer, was simulated in lab scale: The simulated liner was constructed from a mixture of fibre and ash residues from paper pulp production and the foundation and gas drainage layer was simulated by bottom ash from a municipal solid waste incinerator. The waste below the liner was simulated by residues from sorting of construction and demolition waste.

The leachate from the simulated damaged landfill cover had elevated concentrations of many substances including metals, ions and organic matter. However, the simulated landfilled waste could sorb several of these. Ag, Cd, Cu, Hg, N, P, Pb and Sb were sorbed to such an extent that the effect from the cover leachate was unnoticeable. The only pollutants that passed through the waste unattenuated were As, K, Na, TOC, V and Zn. In a real landfill the sorption would be even better since the waste mass will be much larger compared to the cover. Despite elevated concentrations of potentially complex forming substances there was no evidence that the cover leachate enhanced the leaching of any contaminants from the waste. Altogether the results show that the use of the studied waste materials in landfill covers can only be expected to have a small effect on the concentration of contaminants in the leachate from the landfill.

KEYWORDS

Landfill cover; Landfill liner; Leachate; Sorption; Metals; Organic matter.

1 INTRODUCTION

Many landfills (waste deposits) are being closed as a consequence of stricter European regulations [1]. According to the Swedish ordinance on the landfilling of waste (SFS 2001:512) landfills for non-hazardous and hazardous waste must be supplied with a cover upon closure. The construction of covers consumes large amounts of material. To save money and natural resources there is an interest in using alternative materials, such as suitable wastes or by-products, in the covers [2-5].

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The main goals of a landfill cover are to prevent water from reaching the waste and forming leachate, and to prevent landfill gas from escaping. The cover should typically also enable plants to establish on the landfill. To fulfil these goals landfill caps consists of several layers with different purposes. There are many ways of constructing the cover but a generalisation could consist of the following layers from bottom to top: Foundation layer, gas drainage layer, sealing layer/liner, water drainage layer, protection layer and soil/vegetation layer. [6, 7]

Fibre sludge from pulp production mixed with biomass ash, (fibre and ash residues, FAR) is one alternative material that has shown potential as a liner. This material is available in relatively large quantities in Sweden [8] and the mixture has been used in several Swedish landfills and is considered for additional ones [9].

Bottom ash from municipal solid waste incinerators (BA) is relatively often used below the sealing layer as foundation and/or gas drainage layer [9]. There are also examples of BA being proposed in or above the sealing layer [2, 9]. BA is produced whenever waste is incinerated and is available in large amounts [10].

Berger et al [11] found that there is a risk of crack formation in compacted soil liners, due to desiccation and root penetration. Although not soil, the sealing principle of FAR is also compaction [12], and therefore these problems might occur also in FAR liners.

If water was to leak through a cover made of waste materials, and further into the landfill, there is a risk that contaminants being leached from the cover could contribute to the pollutant load from the landfill as a whole. Since complexation with organic matter and ions such as Cl⁻ are suspected to enhance leaching of contaminants [13] there is even a risk that the leachate from the cover enhances the leaching from the waste. However, it is also possible that the waste has the ability to sorb pollutants from the cover. These uncertainties motivate the study of how water leaking through a landfill cover will affect the leachate from the landfill.

A scenario with crack formation is interesting to study since that gives the highest risk of significant volumes of water passing through the liner and into the waste. Travar et al [2] studied the use of BA in landfill caps and found that the amount of water passing through the liner was insignificant compared to the water already present in the waste. In the long run, when the amounts of leachate from the cap becomes more significant, the easily leachable species are expected to be depleted, and secondary minerals formed after weathering of the ash will cause retention of pollutants inside the liner. However, if cracks were to form in the liner, the seepage through the liner could be considerably larger than expected, and this could happen well before the depletion of leachable substances.

The purpose of this study was to investigate what happens when water leaking through a damaged cover percolates through the waste. This was investigated by simulating part of a landfill cover (liner and below) in lab scale. Water was passed through the simulated cover with a relatively high flow rate to simulate a leak. The thus created leachate from the cover was passed through waste to simulate landfill leachate formation under influence of the cover leachate.

2 MATERIALS AND METHODS

In this study part of a landfill cap (liner and below) was simulated to investigate how the leachate from a landfill can be affected by water leaking through a crack in the liner. The damaged cover was simulated in columns in lab scale; one column containing the cover

materials, and one containing waste that received the water from the cover. For comparison, two columns with waste were leached with deionised water. A summary of all columns used is presented in Figure 1.

2.1 Materials

The material in the simulated liner was FAR, fibre and ash residues. This material consists to 2/3 of fibre sludge, a residue from the pulp and paper industry, and 1/3 of biomass ash. This mixture, sometimes also called fibre ash, has been used in several Swedish landfills and is considered for others [9].

To simulate the layers below the liner (gas drainage and foundation layers), bottom ash from a municipal solid waste incinerator (BA) was used. BA Samples were taken from a well mixed pile where the ash had been left to weather outdoors for more than three months.

To simulate the waste below the liner, samples were taken from within a landfill. The waste had been landfilled a few years prior to the sampling and consisted of non-combustible residues from sorting of construction and demolition waste. This type of waste is expected to be common in Swedish landfills in the future [14]. It has a low pollutant load, so the risk of a noticeable contribution from the cover is relatively high. Therefore this waste was considered relevant for the current study.

2.2 Column setup

The study was mainly performed according to the standard CEN/TS 14405 for continuous leaching tests for compliance control of waste to landfills. Deviations from the standard are presented were applicable.

Acid washed PVC columns with a height of approximately 50 cm and an inner diameter of 10.5 cm were used. The size of the columns deviate from that prescribed in the standard. 90 µm HDPE filters were installed at the bottom and top of the columns, which were sealed with silicone. PVC tubing and HDPE connections were employed.

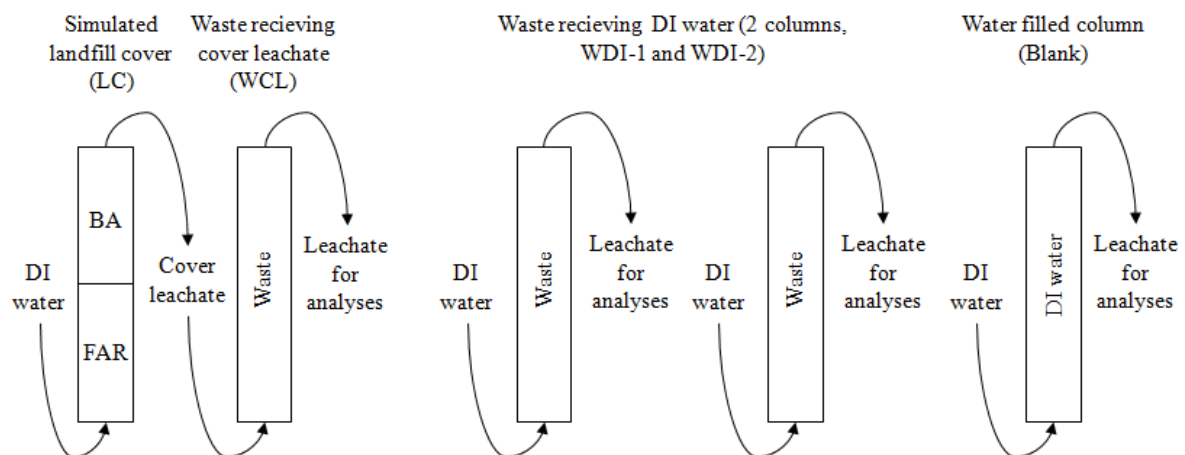


Figure 1. Column leaching setup.

The materials were packed in the columns in layers using a 500 g weight in accordance with the standard. After filling, the columns were flushed with nitrogen gas in order to create an anaerobic environment. The container with leaching fluid was regularly flushed with nitrogen to avoid introducing oxygen into the columns. The leaching fluid was pumped in an up-flow mode through the columns to comply with the standard and to avoid channelling. This flow regime gives a better and more even contact between water and solid material than in a real landfill. Thus, it can be used to simulate a worst case leaching scenario.

2.3 Simulation of leaking landfill cover

Since the water was introduced at the bottom of the column, the FAR, simulating the liner, was placed in the lower part of the column and the BA, simulating the foundation and gas drainage layer, was placed above (see Figure 1). Equal volumes of the materials were used. The standard prescribes a flow rate of approximately 1 ml/min for this setup. In this part of the study a flow rate of 3 ml/min was used. This corresponds to approximately 20 mm/h. The Swedish ordinance of the landfilling of waste (SFS 2001:512) prescribes a maximum flow of 50 mm/year through the liner. However, after a rain event the infiltration through a crack will be considerably higher than this limit although the drainage layer above the liner will be able to prevent some of it. This motivated the high flow rate applied in this part of the study. However, due to practical problems the flow rate was initially often lower than the target and the pump occasionally had to be stopped. Samples at liquid to solid ratio (L/S) 0.1, 0.2, 0.5, 1, 2, 5 and 10 were taken for future studies. The remaining eluate (none at L/S 0.1 and 0.2) was collected and mixed for further use in this study and analysed for metals, ions and total organic content (TOC).

2.4 Simulation of waste receiving cover leachate

Three columns filled with waste simulated the landfill body (Figure 1). One (WCL) received the cover leachate (mixture of all L/S from 0.5 to 10) and two (WDI-1 and WDI-2) received deionised water as a reference. There was also an empty column (Blank, filled with only deionised water). A flow rate of approximately 1 ml/min, as prescribed in the standard, was used. Samples from L/S 0.1, 2 and 10 were analysed for metals, ions and TOC.

2.5 Analyses

The samples were stored at <8 °C and analysed by the Section of Plant Ecology and Systematics, Department of Ecology, Lund University. Ag, Al, As, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Si, V and Zn were analysed using ICP MS (Elan 6000, PerkinElmer) or ICP AES (OPTIMA 3000 DV, PerkinElmer) depending on concentration. F, Cl and SO₄-S were analysed using ion chromatography (861 Advanced Compact IC, column Metrosep A Supp 5, Metrohm, Herisau Switzerland). TOC and N were analysed using TOC-VCPH with N-module TNM-1 (Shimadzu, Tokyo Japan).

2.6 Comparisons and statistics

To study the effects from the cover leachate several different steps were undertaken. Several aspects were studied and compared in order to get around the difficulties caused by large variations and a small number of samples (see section 3.2).

First, the leachate from the simulated damaged landfill cap (mixture of all L/S from 0.5 to 10) was compared to the leachate from the waste leached with DI water. The purpose was to study if the pollutant contribution from the cap would be important compared to that from the landfill. Since there was only one column with cover material, statistical comparisons could

not be made. Instead, a concentration in the cover leachate was considered elevated if it was more than double that in the leachate from the waste. Comparisons were made to a weighted average of all L/S from WDI-1 and WDI-2. Concentrations were studied rather than release in mg/kg dry matter as this is more relevant when studying sorption in the waste (see below).

The second step was to study the effects from the cover leachate on the leachate from the waste. For each substance the three waste columns were compared using a two-way ANOVA with the factors column and L/S ratio. Since the main interest was to show which substances were *not* affected by the cover leachate (meaning that the waste has the ability to sorb this substance) a relatively narrow confidence interval (80 %) was applied. This will also give a worst case approach when investigating if the cover leachate is enhancing the leaching of any substances in the waste.

Another way to elucidate the mechanisms behind the leaching and thus identify potential sorption is to look at the evolution of the concentrations. This was done by studying the trend for each substance in each column. However the limited number of samples analysed from each column (L/S 0.1, 2 and 10) did not allow statistical tests with significant results and therefore this part of the study was purely qualitative.

3 RESULTS AND DISCUSSION

3.1 Cover leachate composition

The concentrations in the cover leachate (Table 1) were compared to those found in bottom ash leachate in other studies [2, 6, 15]. It was clear that the leachate from the cover in this study had relatively high concentrations of Hg, Mg, N, TOC and Zn. It had low concentrations of Cl, Cr and Pb. For SO₄-S, Al, As, Ca, Cd, Cu, K, Mo, Na, Ni and Sb the concentrations were in the same order of magnitude in all studies or variations were too big to draw conclusions. Ag, Br, Co, F, Fe, Mn, P, Si, Ti and V were not reported in any of the other studies. This study used a column setup while the other studies used batch leaching. The L/S ratio was the same (10) in all the compared studies but the mixture used in this study did not include L/S 0.1 and 0.2, fractions expected to have high concentrations.

Regardless of the differences between the studies we can see that the leachate from the simulated landfill cover is similar to that from BA. The higher TOC and N concentrations are likely due to the FAR. Travar et al [2] studied BA mixed with digested sewage sludge and found even higher N and DOC concentrations. The differences in metal content can be due to differences in input to the incinerator, but contribution from the FAR cannot be ruled out. Organic matter is feared to enhance leaching of metals from BA, but van Praagh and Persson [16] mixed municipal solid waste incineration fly ash with compost and found no apparent short term effect on metal leaching. The low Cl concentrations cannot only be accounted for by “dilution” of BA with FAR. Possibly they are due to variations in incinerator input.

In order to assess its potential impact on a landfill, the leachate from the simulated landfill cover (LC) was compared to the leachate from the waste (average of columns WDI-1 and WDI-2), see Table 1. Concentrations rather than release in mg/kg dry matter are presented as that is more relevant to the discussion on sorption given in section 3.3. The cover leachate had high concentrations (more than double) of Ag, Al, As, Br, Cd, Cl, Cu, Hg, K, Mo, N, Na, P, Pb, Sb, TOC, V and Zn. Therefore, if there would be a crack in the cover, there could be a significant contribution of pollutants from the cover material to the landfilled waste. Complexing agents such as TOC, Cl and nitrogen (as NH₄) might further enhance the

leaching of certain pollutants from the waste. Therefore there is a need to study the effects from the cover leachate on the quality of the leachate from the waste.

Table 1. Concentrations (mg/l) in leachate from a lab scale simulation of a landfill cover and from waste. The leaching fluid was deionised water. (No. of samples from waste was two)

Material	Cover (L/S 0.5-10)	Waste (average of L/S 0.1, 2, 10)	
Type	One sample	Average	Standard dev.
Ag	$4.2 \cdot 10^{-5}$	$9.1 \cdot 10^{-7}$	$7.2 \cdot 10^{-7}$
Al	0.39	$6.9 \cdot 10^{-4}$	$2.5 \cdot 10^{-4}$
As	$5.7 \cdot 10^{-3}$	$9.9 \cdot 10^{-4}$	$1.3 \cdot 10^{-4}$
Br	1.2	0	0
Ca	170	617	5.62
Cd	$1.7 \cdot 10^{-4}$	$2.8 \cdot 10^{-5}$	$1.2 \cdot 10^{-5}$
Cl	69	2.4	0.20
Co	$1.4 \cdot 10^{-4}$	$3.7 \cdot 10^{-3}$	$3.9 \cdot 10^{-3}$
Cr	$4.0 \cdot 10^{-3}$	$2.6 \cdot 10^{-3}$	$1.9 \cdot 10^{-4}$
Cu	0.13	$1.2 \cdot 10^{-4}$	$4.0 \cdot 10^{-4}$
F	0.11	3.7	0.26
Fe	$1.3 \cdot 10^{-3}$	1.4	0.75
Hg	$3.6 \cdot 10^{-4}$	$1.8 \cdot 10^{-5}$	$1.7 \cdot 10^{-6}$
K	48	16	0.18
Mg	2.6	9.2	0.31
Mn	0.035	1.7	0.24
Mo	0.053	0.012	$5.7 \cdot 10^{-3}$
N	4.7	1.6	0.53
Na	0.013	14	0.52
Ni	$4.3 \cdot 10^{-3}$	0.019	0.013
P	0.013	$6.6 \cdot 10^{-3}$	$1.9 \cdot 10^{-3}$
Pb	$2.2 \cdot 10^{-4}$	$2.3 \cdot 10^{-5}$	$2.2 \cdot 10^{-5}$
Sb	0.032	$3.8 \cdot 10^{-4}$	$1.0 \cdot 10^{-4}$
Si	0.59	7.1	0.12
SO ₄ -S	141	517	6.6
Ti	$4.6 \cdot 10^{-4}$	$1.7 \cdot 10^{-3}$	$2.8 \cdot 10^{-5}$
TOC	85	12	0.92
V	$5.5 \cdot 10^{-3}$	$3.9 \cdot 10^{-4}$	$5.1 \cdot 10^{-5}$
Zn	0.25	0.035	0.023

3.2 Waste leachate composition

The concentrations in the leachate from the waste columns are presented in Table 2. There is substantial variation between the two waste columns leached with DI water (WDI-1 and WDI-2). This might be due to the heterogeneity of the waste material and uncertainties in the analyses, but there is also a risk that samples were contaminated. Although all columns had been rinsed with acid, there seems to have been some cases of contamination. In the empty column (data not shown) most substances had concentrations above zero but lower than the waste columns. Some of them had, however, very high concentrations, most notably Pb (2600 % of waste columns), P (120 % of waste columns) and TOC (76 % of waste columns). The most probable cause was insufficient cleaning of the columns, but contamination during sample handling might also have occurred. However, not all columns seemed to be contaminated with these substances so it was not motivated to exclude any of the waste column data on the basis of these results. However, caution has to be taken when interpreting the results, e.g. by being conservative when defining when two results are really different.

3.3 Effects from cover leachate on leachate from the waste

In order to find differences between the waste column that received cover leachate (WCL) and those that received deionised water (WDI-1 and WDI-2), the concentration of each substance in their effluents were compared using ANOVA. In order to deal with the problems of large variations and the risk of contamination, WCL was required to be significantly different (at the 80 % level) from both the other columns.

If, for a certain substance, there was no difference between the three waste columns, this means that the cover leachate did not impact the leachate from the simulated landfill with regard to that substance. If, in addition, the concentration of that substance was elevated in the cover leachate going into the waste, there was an uptake of this substance in the waste. This was true for Ag, Cd, Cu, Hg, N, P, Pb and Sb. However, some of the concentrations being elevated in the cover leachate were still elevated after the passage through the waste, namely Al, As, Br, Cl, K, Mo, Na, V, TOC, and Zn. However it was obvious that Al had still been sorbed quite efficiently since only 1 % of the ingoing concentrations remained.

Ca and Cr were elevated in the WCL leachate even though their influent concentrations were not deemed high. This could indicate that the cover leachate increased the leaching of these substances from the waste. For Ca the difference between the WCL and the WDI leachates was very small, but detectable thanks to very little variation with regard to this element. Even though the concentration in the cover leachate was only 30 % of that in the average of WDI-1 and WDI-2 it is much elevated compared to DI water (not shown). Therefore the elevated concentration in the WCL leachate is assumed to be caused by the small addition from the cover leachate. For Cr where the concentration in the cover leachate was 150 % of that in the waste leachate (and much elevated compared to DI water), the same explanation is adopted. Hence no enhanced leaching from the waste due to the cover leachate could be seen.

The trends in concentrations were studied as an additional way of identifying sorption in the waste. The assumption was that if the major mechanism behind the concentrations is leaching, then the concentrations should decrease with increasing L/S ratio as is seen for most of the substances in the effluent from columns WDI-1 and WDI-2 (Table 2). If the concentrations were, instead, increasing, that would suggest that another mechanism was playing a major role. This could be saturation of the waste with regard to that contaminant, i.e. some sorption was taking place, but the sorption sites were being depleted. The trends were studied visually since the small number of samples from each column (three) did not permit statistically significant

trend analyses. The concentrations of Cl, Br, Ca, Cd and Mo increased in the WCL column (Table 2). There was no concentration that had increasing trends in both WDI-1 and WDI-2. This suggests that Cl, Ba, Ca, Cd and Mo were sorbed to some extent in the waste.

Table 2. Concentration (mg/l) in leachate from columns filled with waste. The columns were: waste leached with cover leachate (WCL) and two columns with waste leached with DI water (WDI-1 and WDI-2)

Fluid	WCL			WDI-1			WDI-2		
	0.1	2	10	0.1	2	10	0.1	2	10
Ag	$7 \cdot 10^{-6}$	$4 \cdot 10^{-6}$	$2 \cdot 10^{-6}$	$5 \cdot 10^{-6}$	$3 \cdot 10^{-6}$	$1 \cdot 10^{-6}$	$2 \cdot 10^{-6}$	$2 \cdot 10^{-6}$	0
Al	$2.9 \cdot 10^{-3}$	$3.1 \cdot 10^{-3}$	$3.1 \cdot 10^{-3}$	$2.9 \cdot 10^{-3}$	$1.2 \cdot 10^{-3}$	$7.7 \cdot 10^{-4}$	$1.2 \cdot 10^{-3}$	$8.6 \cdot 10^{-4}$	$4.2 \cdot 10^{-4}$
As	0.01	$4.0 \cdot 10^{-3}$	$3.5 \cdot 10^{-3}$	$3.5 \cdot 10^{-3}$	$2.3 \cdot 10^{-3}$	$7.8 \cdot 10^{-4}$	$3.2 \cdot 10^{-3}$	$1.9 \cdot 10^{-3}$	$6.3 \cdot 10^{-4}$
Br	0.10	0.19	0.47	0	0	0	0	0	0
Ca	670	680	690	650	640	620	660	640	630
Cd	$6.3 \cdot 10^{-5}$	$7.2 \cdot 10^{-5}$	$9.5 \cdot 10^{-5}$	$6.8 \cdot 10^{-5}$	$5.7 \cdot 10^{-5}$	$3.1 \cdot 10^{-5}$	$3.8 \cdot 10^{-5}$	$3.1 \cdot 10^{-5}$	$1.6 \cdot 10^{-5}$
Cl	42	60	64	14	8.7	0.58	17	8.9	0.86
Co	0.03	0.02	$2.0 \cdot 10^{-3}$	0.03	0.02	$3.0 \cdot 10^{-3}$	$2.0 \cdot 10^{-3}$	$2.5 \cdot 10^{-3}$	$5 \cdot 10^{-4}$
Cr	0.0081	0.0076	0.0070	0.0066	0.0049	0.0023	0.0063	0.0047	0.0020
Cu	$4.7 \cdot 10^{-3}$	$1.7 \cdot 10^{-3}$	$8.7 \cdot 10^{-4}$	$7.3 \cdot 10^{-3}$	$1.3 \cdot 10^{-3}$	$1.0 \cdot 10^{-3}$	$8.2 \cdot 10^{-3}$	0	0
F	2.4	3.1	2.1	2.8	4.4	3.8	4.4	3.6	3.5
Fe	0.32	0.45	0.15	0.39	0.20	1.07	0.11	0.43	2.4
Hg	$5.4 \cdot 10^{-5}$	$2.4 \cdot 10^{-5}$	$3.6 \cdot 10^{-5}$	$5.5 \cdot 10^{-5}$	$2.1 \cdot 10^{-5}$	$1.5 \cdot 10^{-5}$	$3.8 \cdot 10^{-5}$	$1.8 \cdot 10^{-5}$	$1.9 \cdot 10^{-5}$
K	73	63	52	48	39	11	46	34	12
Mg	66	36	4.4	42	32	3.1	43	29	4.4
Mn	4.1	3.6	1.0	3.8	3.7	1.4	2.4	2.5	1.2
Mo	0.034	0.040	0.042	0.024	0.026	0.013	0.016	0.014	0.0061
N	8.3	6.6	3.7	7.0	5.3	1.1	4.3	3.4	0.64
Na	140	140	140	63	46	4.8	70	43	6.3
Ni	0.15	0.084	0.011	0.14	0.084	0.014	0.031	0.023	0.0060
P	0.057	0.028	0.011	0.045	0.022	0.0041	0.030	0.016	0.0024
Pb	$4.7 \cdot 10^{-4}$	$1.7 \cdot 10^{-4}$	$1.8 \cdot 10^{-5}$	$9.4 \cdot 10^{-4}$	$1.5 \cdot 10^{-4}$	0	$5.3 \cdot 10^{-5}$	$2.1 \cdot 10^{-5}$	$3.0 \cdot 10^{-6}$
Sb	$1.9 \cdot 10^{-3}$	$8.6 \cdot 10^{-4}$	$6.5 \cdot 10^{-4}$	$2.1 \cdot 10^{-3}$	$8.9 \cdot 10^{-4}$	$3.3 \cdot 10^{-4}$	$8.6 \cdot 10^{-4}$	$6.1 \cdot 10^{-4}$	$2.3 \cdot 10^{-4}$
Si	22	10	7.4	20	10	6.4	13	9.6	6.4
SO ₄ -S	540	490	500	550	510	520	480	540	530
Ti	0.0064	0.0034	0.0023	0.0060	0.0028	0.0014	0.0040	0.0026	0.0014
TOC	160	83	60	73	32	7.0	55	28	6.3
V	$1.2 \cdot 10^{-3}$	$1.1 \cdot 10^{-3}$	$1.1 \cdot 10^{-3}$	$8.2 \cdot 10^{-4}$	$6.1 \cdot 10^{-4}$	$3.9 \cdot 10^{-4}$	$7.5 \cdot 10^{-4}$	$5.6 \cdot 10^{-4}$	$3.1 \cdot 10^{-4}$
Zn	0.093	0.052	0.010	0.57	0.19	0.013	0.024	0.059	0.0089

To summarise, out of the 18 concentrations that were elevated in the cover leachate, only six (As, K, Na, TOC, V and Zn) passed through the waste without attenuation. Ag, Cd, Cu, Hg, Sb, N, P and Pb were sorbed to such an extent that there was no detectable increase in concentration. These results show that even though the cover leachate will contribute to the pollutant load of the landfill, the studied waste is capable of attenuating most of the contaminants to some extent. In this study the volume of cover and the volume of waste was the same. In a real landfill the waste mass would be much greater and the sorption in the waste would be even more important.

4 CONCLUSIONS

Compared to leachate from waste leached with deionised water the leachate from a simulated damaged landfill cover had elevated concentrations of Ag, Al, As, Br, Cd, Cl, Cu, Hg, K, Mo, N, Na, P, Pb, Sb, TOC, V and Zn. Therefore there is a risk that this leachate contributes to the pollutant load from the landfill.

A simulated landfilled waste appeared to sorb several substances from the infiltrating cover leachate. Ag, Cd, Cu, Hg, N, P, Pb and Sb were sorbed to such an extent that their concentrations were no longer elevated. In addition Al, Br, Ca and Cl seemed to be sorbed to some extent. The only pollutants from the cover that passed through the waste unattenuated were As, K, Na, TOC, V and Zn. In a real landfill the sorption will be even bigger than showed here since the waste mass will be much larger compared to the cover.

Despite elevated concentrations of potential complex forming substances such as Cl, N and TOC there was no evidence that the cover leachate enhanced the leaching of any contaminants from the waste.

The results presented here are based on a limited number of samples and therefore not all of them could be statistically proven. There might also have been some contamination affecting the samples. Although those limitations make a single result less reliable the general trends in the study are still convincing; that the waste has the ability to sorb contaminants and thus limit the potentially polluting effect from a damaged landfill cover.

Altogether the results show that in spite of the possible risk of crack formation in liners based on the principle of compaction, the use of the studied waste materials in landfill covers does not lead to large additional emission potential from the landfill as a whole. The benefits of not having to use virgin material for landfill closure must also be taken into account. Further on, also virgin materials are likely to contribute with leachable species.

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