Consequences of Revised Criteria for Hazardous Waste Classification in the Nordic countries – the criterion for leaching (H15)

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TemaNord 2012:547

ISBN 978-92-893-2390-1

<http://dx.doi.org/10.6027/TN2012-547>

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Cover photo: Image Select

This publication has been published with financial support by the Nordic Council of Ministers. However, the contents of this publication do not necessarily reflect the views, policies or recommendations of the Nordic Council of Ministers.

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Content

Preface.....	7
Summary, discussion and Conclusions.....	9
1. Introduction.....	13
1.1 Background.....	13
1.2 Objectives.....	15
2. Classification of Hazardous waste in the Nordic Countries.....	17
2.1 Denmark.....	17
2.2 Finland.....	18
2.3 Norway.....	19
2.4 Sweden.....	19
3. Consequences of new classification H15 criteria.....	21
3.1 New H15 classification criteria.....	21
3.2 Denmark.....	22
3.3 Finland.....	31
3.4 Sweden.....	35
4. References.....	43
5. Appendices.....	45
5.1 Leaching data for soils.....	45

Preface

This document is the status report of the project “Consequences of revised criteria for hazardous waste classification” financed by the Nordic Council of Ministers, Nordisk avfallsgruppe (NAG).

The project work has been followed by a steering group consisting of:

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Summary, discussion and Conclusions

Criterion H15 for the classification of waste as hazardous concerns “Waste capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed above” (2008/98/EC). If a waste yields a leachate with hazardous properties, the waste should be classified as hazardous. Sander et al. (2008) proposed that waste acceptance criteria (WAC) for the acceptance of waste at a non-hazardous waste landfill (2003/33/EC) should be the basis for criterion H15. In order to harmonise this criterion amongst all EU Member States, Austria has proposed that the waste acceptance leaching criteria (WAC) for the acceptance of waste at a non-hazardous waste landfill (2003/33/EC) should be the basis for criterion H15, except for some substances.

This report illustrates the consequences for hazardous waste classification by introducing the proposed H15 leachate criterion. Since the requirement for carrying out leaching tests is part of EU legislation on landfilling of waste and in some EU countries legislation on the recycling of secondary aggregates leaching data is generally limited to these waste categories. By analysing existing data on leaching from secondary aggregates and waste, that at present are landfilled, backfilled or used for construction, and comparing them to the proposed H15 criterion the amounts of waste exceeding H15 classification criteria was evaluated.

The evaluation showed that data quality on the amount of waste that is landfilled and recycled varies considerable between countries and types of waste and that leaching data is generally limited to a few waste categories. Therefore it was not always possible to include a precise estimate on how much waste would have to be classified as hazardous waste based on the proposed H15 leaching criteria.

The results for some materials of which high amounts are landfilled or backfilled today are summarised here.

Mining waste

Very large amounts of mining wastes are generated in Sweden (more than 50 million tonnes) and in Finland (more than 40 million tonnes). There are very scarce data on the proposed H15 leaching criteria but those available do not indicate that hazard classification is triggered. The leaching tests developed for the evaluation of waste acceptance at landfills are not adequate for mining wastes which undergo weathering e.g. due to oxidation of sulphides. Leaching and classification results might

have been different if the test would have been performed on weathered wastes. The effects of introducing the proposed H15 leaching criteria on mining waste are difficult to judge.

Soil, contaminated soil and virgin aggregates

Soil is one material for which large amounts are landfilled and recycled. In 2008 about 0.2 million tonnes of soil were landfilled in Denmark. Soil is an unknown proportion of the registered amount of mineral waste in Finland (47 million tonnes mineral waste) and Sweden (4.5 million tonnes mineral waste apart from mining waste). Availability of leaching data for soil was relatively good in Denmark and Sweden, more than 300 samples in total. Unpolluted soils were mostly below the proposed criteria. Some crushed natural rock (virgin aggregates) in Sweden exceeded the criterion for molybdenum. Some contaminated soils did exceed the proposed H15 leaching criteria, mostly for arsenic and antimony, but some also for other metals. The amount of soil classified as hazardous will increase as a result of the proposed H15 criteria.

Construction and demolition waste

For other mineral wastes, like construction and demolition waste, we found less leaching data available, less than 10 samples per country. None exceeded the proposed criteria. The amount of construction and demolition waste classified as hazardous will probably not increase as a result of the proposed H15 criteria.

MSWI-Bottom Ash

Bottom ash from municipal waste incineration (MSWI-BA) is also landfilled and used for construction in considerable amounts. Ca 0.4 million tonnes were produced in Sweden 2008. About 0.609 million tonnes MSWI-BA were recycled in Denmark in 2008, whilst only ca. 0.002 million tonnes were landfilled. Leaching data was available (more than 1,500 records, mainly from Denmark and some from Sweden and Finland). The majority was below the proposed criteria, but some of the MSWI-BA exceeded the proposed criteria. This was mainly due to leaching of antimony, arsenic, and chromium, but also fluoride, selenium and lead. The amount of MSWI-BA classified as hazardous will increase as a result of the proposed H15 criteria.

Fly Ash

In 2008 about 0.8 million tonnes of fly ash were recycled in Denmark and ca. 0.0023 million tonnes were landfilled. In Finland 0.3 million tonnes biomass fly ash and 0.5 million tonnes coal fly ash were produced. More than 0,2 million tons of biomass fly ash were produced in Sweden. Leaching data was scarce, less than 50 samples in total. Some of the coal fly ash exceeded the proposed criteria, with barium as the most critical element in addition to leaching of vanadium and cobalt (Finnish

data). The majority of Swedish bioashes exceeded the proposed H15 criterion for chromium, and some of the Finnish biomass ashes exceeded the proposed criteria for selenium and barium, as well as a number of other elements. The amount of fly ashes classified as hazardous will increase substantially as a result of the proposed H15 criteria.

Metallurgical slag

1.3 million tonnes of metallurgical slag are produced in Sweden (Pålsson et al., 2010). 1 million tonnes are recycled and 0.3 million tonnes are landfilled. Approximately 125 leaching tests were available, and some of these exceeded the proposed criteria. Molybdenum was the most critical element, while antimony and fluoride exceeded the criteria to a lesser extent. The amount of metallurgical slag classified as hazardous will increase substantially as a result of the proposed H15 criteria.

Other Wastes

A large remaining fraction of landfilled waste is miscellaneous (2.1 million tonnes in Finland), “not suitable for incineration” (0.5 million tonnes in Denmark), or “sorting residues and sorted landfill residues” (0.8 million tonnes in Sweden). No leaching data were readily associated with this fraction.

Conclusions

The proposed H15 criterion has been developed based on landfill conditions and for landfilling purposes. Waste material leaching properties can change due to e.g. ageing or weathering and this needs to be taken into account if leaching behaviour is included in classification. The landfill leaching test methods are also not applicable for all waste materials and require sample pre-treatment that in many cases has a significant effect on results (e.g. WEEE waste, mining waste). Evaluation of leaching properties in relation to landfilling is done differently in different member states. Some member states use one step batch tests, whereas some use percolation tests. Also L/S-ratio varies. This generates a lack of comparability that could lead to non-harmonized classification and in difficulties in waste transfer. As a consequence, introduction of specific H15 leaching criteria might lead to a practice where the leaching behaviour of wastes would have to be determined twice.

The uncertain factor of introducing the proposed H15 criteria is large both in relation to how to perform waste pre-treatment and leaching tests and in relation to the amounts of wastes that might be classified as hazardous. Further studies on these aspects are recommended before the setting of a H15 leaching criterion.

1. Introduction

1.1 Background

Under the Waste Framework Directive (2008/98/EC) waste is classified as hazardous, if it displays one or more of the properties that render it hazardous. These properties (H1-H15) are listed in Annex III to the directive:

- H 1 Explosive
- H 2 Oxidizing
- H 3-A Highly flammable
- H 3-B Flammable
- H 4 Irritant
- H 5 Harmful
- H 6 Toxic
- H 7 Carcinogenic
- H 8 Corrosive
- H 9 Infectious
- H 10 Toxic for reproduction
- H 11 Mutagenic
- H 12 Waste which releases toxic or very toxic gases in contact with water, air or an acid
- H 13 Sensitizing
- H 14 Ecotoxic
- H 15 Waste capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed above

Up till now the interpretation and application of these properties have varied between different member states. The European Commission Committee for the Adaptation to Scientific and Technical Progress of EC Legislation on waste (TAC) has created a working group to clarify and harmonize the rules for classification of waste as hazardous and non-hazardous related to the European Waste List (2000/532/EC). The main aim of the working group is to update the hazardous waste classification criteria and make those amendments that are necessary due to the recent revisions of the regulatory framework for classification, labelling and packaging of substances and mixtures (CLP Regulation (EC) No 1272/2008). This includes among others a discussion of establishment of suitable criteria for H 15 as today no common EU criteria exist for this hazardous property.

Changed classifications may have significant impact on the quantities of waste to be classified as hazardous waste and the conditions to reuse, recycle, recover, incinerate or landfill waste. Previous experience of establishing criteria for the disposal of waste has shown that unwanted environmental effects may occur as a result of criteria that are poorly adapted to northern conditions. The legislation for classification of hazardous waste can thus play an important role for ambitions to promote synergies between chemicals, product and waste policy in order to make recycling and recovery of waste materials safer and more resource efficient.

So far no criteria have established for the hazardous property H15. In order to harmonise this criterion amongst all EU Member States Sander et al (2008) proposed that waste acceptance criteria (WAC) for the acceptance of waste at a non-hazardous waste landfill (2003/33/EC) should be the basis for criterion H15. Austria has proposed that the waste acceptance criteria (WAC) for the acceptance of waste at a non-hazardous waste landfill (2003/33/EC) should be the basis for criterion H15, except for some substances.

This report illustrates the consequences for hazardous waste classification by introducing the H15 leachate criterion. Since the requirement for carrying out leaching tests is part of EU legislation on landfilling of waste and in some EU countries legislation on the recycling of secondary aggregates leaching data is generally limited to these waste categories. As a consequence, data on the amount of waste that may be affected by the introduction of leaching criteria is limited to secondary aggregates and wastes that are landfilled. By analysing existing data on leaching from secondary aggregates and waste which are currently landfilled, backfilled or used for construction, and comparing these to the proposed H15 criterion it is evaluated how much of this waste would have to be classified as hazardous.

Products registered under REACH (Regulation (EC) No 1907/2006) are not waste but the end-of-waste status is not dependent on whether waste is registered under REACH or not (i.e. waste does not cease being waste when registered under REACH). The distinction between waste and product is therefore sometimes unclear. However, the classification of hazardous waste may impact the recycling or landfilling of REACH registered products as well. Since their characteristics are of interest for comparison with leaching criteria for hazardous waste some materials undergoing REACH registration that are likely to be used in the construction sector (e.g. metallurgical slags) have been included in this study.

1.2 Objectives

The main objectives of this project are to provide environmental authorities in the Nordic countries with a status and overview of the amount of secondary aggregates or landfilled waste that might be affected by H15 leaching criteria for classification of hazardous waste in the Nordic countries.

If the data quality permits, a quantitative evaluation is given, i.e. how many tonnes secondary aggregates/waste may be affected. Where this is not possible the evaluation is done in qualitative terms.

2. Classification of Hazardous waste in the Nordic Countries

This chapter gives an overview on the current regulations and guidelines for classification of waste in the Nordic countries: Denmark, Finland, Norway and Sweden.

2.1 Denmark

In Denmark the European waste legislation is implemented by the Danish Statutory Order on waste (Danish EPA, 2010a) and a number of related statutory orders. Among other things the Statutory order on waste sets out the rules for classification of waste as hazardous or non-hazardous.

The first step of the classification process is to determine whether or not the material is a waste.

Secondly, for waste to be classified as hazardous, the waste material has to be regarded as hazardous waste according to the European Waste Catalogue (EWC, 2000/532/EC). In the Danish Statutory Order on waste the EWC is included as an appendix and the types of waste that are regarded as hazardous waste are displayed in bold writing.

In addition to that, the waste has to display one or more of the properties which render it hazardous, and the substance or sum of substances displaying those properties has (have) to be present in a concentration (%-weight) which render the waste hazardous. The concentration limits and summation rules rendering waste hazardous are given in Table 1.

Table 1 contains a reference to Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures (CLP). In case more stringent concentration limits for a substance can be found in the CLP they have to be applied instead of the generic concentration limits given in the Danish Statutory Order on waste.

Table 1. Concentration limits rendering waste hazardous (Danish Statutory order on waste) (Danish EPA, 2010a)

Property	Concentration limit (%-weight)
Very toxic (R26, R27, R28, R39) ¹⁾	0.1
Toxic (R23, R24, R25) ¹⁾	3
Toxic (R48, R39) ¹⁾	1
Harmful (R20, R21, R22) ¹⁾	25
Harmful (R48) ¹⁾	10
Corrosive (R35) ¹⁾	1
Corrosive (R34) ¹⁾	5
Irritant (R36, R37, R38) ¹⁾	20
Irritant (R41) ¹⁾	10
Sensitizing (R42, R43) ¹⁾	1 ²⁾
Carcinogenic, cat.1 or 2 (R45, R49) ¹⁾	0.1 ²⁾
Carcinogenic, cat.3 (R40) ¹⁾	1 ²⁾
Mutagenic, cat. 1 or 2 (R46) ¹⁾	0.1 ²⁾
Mutagenic, cat. 3 (R68) ¹⁾	1 ²⁾
Toxic for reproduction, cat. 1 or 2 (R60, R61) ¹⁾	0.5 ²⁾
Toxic for reproduction, cat. 3 (R62, R63) ¹⁾	5 ²⁾
Dangerous for the environment, hazardous to the aquatic environment (R50, R51, R52, R53) and other ecosystems (R54, R55, R56, R57, R58, R59) ¹⁾	Not defined
Infectious	Not defined
Other	Not defined

1) Refer to Danish Statutory order on classification, packaging, labelling, sale and storage of chemical substances and products as well as CLP Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures.

2) Concentration limit is valid for the individual substance and with the property in question.

2.2 Finland

The hazardous waste legislation has been implemented in Finland by the Finnish Waste Act 1072/1993 and several lower-level decrees. The European Waste Catalogue has been implemented by two separate acts: the applied limit values are set in the Finnish Waste Act (1390/1993, as amended by 1128/2001), and the actual list of waste entries has been set by the Ministry of the Environment Decision 1129/2001 on the List of Most Common Waste and Hazardous Wastes. The Limit values are similar to the Danish list (table 1) except for certain irritant substances (Xi, R41) for which the limit is 5%, in line with the Directive 1999/45/EC on the classification, packaging and labelling of Dangerous Preparations (DPD).

Classification of waste as hazardous or non-hazardous is primarily made based on the EWC-list. The wastes indicated with an asterisk (*) in the list are classified as hazardous wastes. A waste can in some cases be classified hazardous or non-hazardous depending on the content of hazardous substances. In case of these so called “mirror entries”, the classification is made based on an evaluation on whether the Hazardous properties (“H characteristics”) are met with or not.

The evaluation is usually done as a desk study based on the properties and the content of hazardous substances in the waste. If more than

one hazardous substance is present the summation rules of the Dangerous Preparations Directive (DPD) are to be applied. Finland does not currently have binding limit values for ecotoxicity (H14). For ecotoxicity, the general limit values of the DPD are recommended to be used in the evaluation.

In practice the classification of a waste stream is usually a demanding and complex task. The evaluation is carried out in Finland on a case-by-case basis under the supervision of local authorities.

2.3 Norway

In Norway the European Waste Catalogue with its amendments has been implemented in the Norwegian regulation on waste, chapter 11 (FOR 2004–06–01 nr 930).

The classification of hazardous waste is primarily based on the list of waste, and on the content of substances with hazardous properties in the waste above limit values from the chemical legislation.

In the case of “mirror entries” in the waste list, the content of hazardous substances in the waste must be considered. Analysis is often necessary to consider whether the content of hazardous substances is exceeding the limit values of the hazardous criteria. Summations rules of the DPD are to be applied in case of more than one hazardous substance are present. The Norwegian list of concentration limits is similar to the Danish list (table 1), except for the ecotoxicity criteria H14. For ecotoxicity general limit values of the Directive 67/548/EEC on the classification and labelling of dangerous substances are used. No summation rules are applied for ecotoxic properties. In addition to the general limit values for hazardous properties, specific lower limit values (of Directive 67/548/EEC) for a few selected substances are applied and listed in the Norwegian waste regulation.

2.4 Sweden

The hazardous waste legislation in Sweden (SFS 2001:1063) has been implemented similarly to Denmark, Finland and Norway. There are two ways for waste to be classed as hazardous:

- Waste with a * in appendix 2 to the Waste Regulation (SFS, 2001:1063)¹

¹ A revised Waste Regulation (2011:927) was issued on July 1st 2011.

- Waste with dangerous properties according to appendix 3 of the Waste Regulation

The latter (waste with dangerous properties) are applied for “mirror entries” and includes the possibility to class waste that does not have a * in the waste list to be classed as hazardous.

Appendix 3 includes definition of properties H1-H14, similar to the Danish list (table 1) but is less detailed. Classification of waste includes reference to the Directive 76/548/EEC on the classification, packaging and labelling of Dangerous Substances (DSD) and DPD.

The lack of detail in the definition of hazardous waste in Swedish regulation has triggered the publication of a large number of guidelines. Swedish EPA homepage recommends using DPD as a base for classification (Swedish EPA 2011a) even though it recommends somewhat different summation rules in relation to H14 (Swedish EPA 2011b). Swedish EPA advice against using waste acceptance leaching criteria for the acceptance of waste at a landfill (2003/33/EC) as a base for hazardous waste classification.

Several guidelines for classification of ash and contaminated soil based on total contents of contaminants and a desktop investigation relating these to reference substances and characteristics in the CLP Regulation (Adler et al., 2004; Elert et al., 2007). These guidelines apply different classification criteria related to H14 ecotoxic. Elert et al (2007) recommends using leaching methods developed under DSD (OECD 2001) to distinguish between soluble and sparingly soluble metal compounds.

Use of waste in constructions is encouraged in order to decrease the use of natural resources. Construction with waste need not be reported to the municipality if contamination risk is less than minor. Generic guidance levels of contaminants for non-sensitive areas are available and case-specific levels may be calculated. These levels comprise total content as well as leached concentrations and amounts (C_0 and L/S 10 l/kg) (Swedish EPA, 2010b).

Hazardous waste is not a priori excluded from use in constructions, since the hazardous waste classification is based on inherent characteristics and not on the risks for a specific use. However, the use of hazardous waste most likely involves a risk that is more than minor, and will require a permit review (Swedish EPA, 2010b).

3. Consequences of new classification H15 criteria

3.1 New H15 classification criteria

Criterion H15 for the classification of waste as hazardous concerns “Waste capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed above” (2008/98/EC). If a waste yields a leachate with hazardous properties, the waste should be classified as hazardous. Sander et al (2008) proposed that waste acceptance criteria (WAC) for the acceptance of waste at a non-hazardous waste landfill (2003/33/EC) should be the basis for criterion H15.

In order to harmonise this criterion amongst all EU Member States, Austria has proposed that the waste acceptance criteria (WAC) for the acceptance of waste at a non-hazardous waste landfill (2003/33/EC) should be the basis for criterion H15, except for some substances. Chloride, sulphate, dissolved organic carbon (DOC) and total dissolved solids (TDS) were introduced in the WAC because they may mobilise heavy metals, and not for their own hazardous properties, and thus the Austrian position is that these should not be criteria for the classification of waste as hazardous (The Austrian position from an excerpt by Christiansson, 2011-02-07). The waste acceptance criteria are shown in Table 2.

Introduction of additional limit values of leachate concentrations for an exhaustive list of pollutants are proposed, though no values for the limits have been given to our knowledge. The list should at least include Co, V, Sn, CN, F, hydrocarbon-index, PAH, and AOX or EOX (Christiansson, 2011-02-07).

This report concentrates on the effect of the introduction of H15 leaching criteria that correspond to Table 2. These criteria have been compared to measured values on leachates for relevant materials. We cannot include leaching data on organic contaminants in this study, since we lack relevant information on this. Neither have we included Co, V, Sn and CN, since there are no limit values suggested that we could compare existing data to. Only data from Sweden, Denmark and Finland has been available for the study.

Table 2. Criteria for acceptance of waste at a non-hazardous waste landfill (Table 2.2.2 in (2003/33/EC))

Components	L/S = 2 l/kg	L/S = 10 l/kg	Co (percolation test)
	mg/kg dry substance	mg/kg dry substance	mg/l
As	0.4	2	0.3
Ba	30	100	20
Cd	0.6	1	0.3
Cr total	4	10	2.5
Cu	25	50	30
Hg	0.05	0.2	0.03
Mo	5	10	3.5
Ni	5	10	3
Pb	5	10	3
Sb	0.2	0.7	0.15
Se	0.3	0.5	0.2
Zn	25	50	15
Fluoride	60	150	40

3.2 Denmark

3.2.1 Secondary aggregates or landfilled waste affected

Table 3 shows the amounts of secondary aggregates that were recycled in 2008 in Denmark. As can be seen concrete and soil constituted the largest fractions followed by municipal solid waste incineration bottom ash (MSWI BA).

Table 3. Amounts of secondary aggregates re-used/recycled in 2008 in Denmark (Danish EPA, 2010)

Secondary aggregates	Recycling 2008 (ktonnes)
Concrete	1,543
Tiles	240
Other types of construction and demolition waste	899
Asphalt	896
Soil	1,933
Fly ash and slag from coal fired power plants	795
MSWI BA	609

In 2008 about 1 million tonnes of waste were landfilled in Denmark. Waste classified as “not suitable for incineration” accounted for the largest amount landfilled in 2008, followed by soil and bottom ash (see Table 4).

Table 4. Waste fractions and amounts of waste landfilled in 2008 (Danish EPA, 2011)

Waste fraction	Landfilling 2008 (ktonnes)
Asbestos	32
MSWI BA	1.9
Fly ash	2.3
Not suitable for incineration	471
Other types of hazardous waste	126
Shredderwaste	7.1
Sand and screening residue (waste water treatment)	27
Sludge	20
Soil	201
Treatment residue (screening)	0.7
Waste containing inorganic compounds	1.5
Waste containing organic halogen-free compounds	0.3

In Denmark, landfills are divided into 4 landfill classes: landfill for hazardous waste, inert waste, mineral (non-hazardous) waste and mixed (non-hazardous) waste. In the Statutory order on landfills (Danish EPA, 2010b) the classes of waste to be landfilled are defined as follows:

- Hazardous waste: waste, that according to the Statutory order on waste is classified as hazardous
- Inert waste: non-hazardous waste that does not undergo any significant physical, chemical or biological transformations and that does not exceed a total organic carbon (TOC) content of max. 30 g/kg DM (dry matter)
- Mineral waste: non-hazardous waste that primarily consists of inorganic, mineral material and does not exceed a total organic carbon (TOC) content of max. 50 g/kg DM (dry matter)
- Mixed waste: non-hazardous waste that consists of organic and inorganic material with a total organic carbon content (TOC) equal to or above 50 g/kg DM (dry matter)

Hazardous waste, inert waste and mineral waste that is landfilled with hazardous waste, can only be accepted for landfilling if it fulfils the leaching criteria established for the different landfill classes. In addition to that hazardous waste, inert waste, and mineral waste that is landfilled with hazardous waste have to fulfil the total content limit value for certain organic parameters (e.g. TOC, BTEX, PCB, sum of hydrocarbons, and PAH). Testing is not required for mixed waste.

Typical examples of the different types of waste landfilled include:

- Hazardous waste: heavily polluted soil and shredder waste
- Inert waste: certain types of construction and demolition waste
- Mineral waste: soil, treatment residues, bottom ash
- Mixed waste: non-hazardous waste not suitable for incineration, sludge from waste water treatment plants

3.2.2 Sources of classification data

Three main sources of data were used to evaluate the consequences of establishing leaching based classification criteria:

- DHI's leaching database CRES
- MSWI BA leaching data base (Danish municipal waste incineration plants)
- Soil leaching data

Table 5 gives an overview over the sources of data and the type of data included (waste material, number of records, leaching test and analytical parameters). The table also shows the typical analytical parameters that are covered by the data. Since data comes from different sources and was produced during different projects, the range of analytical parameters covered varies. Whilst some materials have been analysed for additional parameters, other samples are only analysed for a limited amount of analytical parameters.

DHI owns a leaching database (CRES-database) containing around 560 records for a number of different wastes, i.e. records for 560 waste samples tested. For a number of samples several leaching tests (e.g. batch test, column test, pH-static test) were carried out. The data comes from routine testing of wastes and residual products and project work that DHI has carried out. Only data with relevance to this project was selected from the database:

- e.g. leaching tests with L/S-ratio 0.1 l/kg, 2 l/kg and 10 l/kg, respectively, were included
- pH dependent leaching tests were excluded

Since data is collected as part of project work, the amount of data is not exhaustive and therefore not necessarily representative for the waste types included.

During summer/fall 2010 DHI collected leaching data for MSWI BA from all Danish waste incineration plants as part of a research project. This leaching database covers 1,363 records (batch leaching test carried out for 1,363 samples) over the past 10 years. This set of data can be said to be representative for MSWI BA produced in Denmark.

Table 5. Overview over sources of data, waste material, no. of records, leaching tests and analytical parameters covered

Source of data	Waste material	No. of records ¹⁾	Leaching tests	Analytical parameters
CRES	C&D waste – crushed concrete	3	Column leaching test (internal DHI method),	Al, As, Ba, Ca, Cd, chloride, Co, conductivity, Cr, Cu, DOC, Fe, fluoride, Hg, K, Mg, Mn, Na, Ni, Pb, pH, Phenol-index, redoxpotential, S, Sb, Se, sulphate, Zn
	C&D waste – crushed concrete and asphalt	1		
	C&D waste – crushed concrete and tiles	2		
	C&D waste – crushed tiles	1	DS/EN 12457-1,	Fe, fluoride, Hg, K, Mg, Mn, Na, Ni, Pb, pH, Phenol-index, redoxpotential, S, Sb, Se, sulphate, Zn
	C&D waste – gypsum based	1		
	Concrete sludge	2	DS/EN 12457-3/1,	(Not all records cover all parameters.)
	Contaminated soil	12		
	Drainage sand	1	DS/EN 12457-3/2,	(Not all records cover all parameters.)
	Glass	1		
	Mixed inert container waste	3	NT ENVIR 002,	(Not all records cover all parameters.)
	MSWI APC semidry product	8		
	MSWI APC wet product sludge + FA	1	DS/CEN/TS 14405	(Not all records cover all parameters.)
	MSWI BA	65		
	MSWI FA	11		
	Road sweepings	15		
	Uncontaminated soil	37		
MSWI BA database	Municipal solid waste incineration bottom ash	1363	DS/EN 12457-3/1	Chloride, sulphate, Ca, Na, As, Cd, Cr, Cu, Ni, Pb, Zn
Soil database	unpolluted, slightly polluted and polluted soil	122 (soil pH 6 < pH < 9)		As, Ba, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Zn

1) No. of records refers to the number of samples tested:

C&D waste – construction and demolition waste

MSWI APC – municipal solid waste incineration air pollution control

MSWI BA – municipal solid waste incineration bottom ash

MSWI FA – municipal solid waste incineration fly ash

Furthermore, leaching data for different types of soil was included. This data was collected as part of three projects (Hansen et al., 2009, 2009a; Hjelmar et al., 2009), which DHI carried out for the Danish Environment Agency with the aim to set up limit values for the recycling of soil. The soil samples cover unpolluted, slightly polluted and polluted soil. Since pH is known to have large influence on the leaching of metals from soil a pH requirement was introduced for the purpose of the projects. The data for inorganic substances selected for the three projects was limited to soil samples with a soil pH 6 < pH < 9 and L/S 2 l/kg. Data was collected from different sources and therefore not all samples have been analyzed for the same analytical parameters.

In addition to that, selected data on classification of waste related to landfilling criteria and on shredder waste was included (DHI, 2005; DHI, 2011).

The proposed leaching based classification criteria (see section 3.1) have been applied to the collected leaching data. The evaluation has been carried out for:

- Criteria for metals: As, Ba, Cd, Cr_{tot}, Cu, Hg, Mo, Ni, Pb, Sb, Se, Zn
- Criteria for metals and anions: As, Ba, Cd, Cr_{tot}, Cu, Hg, Mo, Ni, Pb, Sb, Se, Zn, fluoride

Table 6 below summarizes the results of the data evaluation. The results are divided into the individual waste types and subdivided into L/S-fractions. The number of records next to the L/S refers to the records for this L/S fraction. If the leaching data exceeds the proposed classification criteria, the parameters exceeding the limit values are listed in column three called “critical elements”.

The data is then evaluated quantitatively and qualitatively. The numbers in parentheses next to the waste type show the total number of records for this waste type and how many samples out of the total would have to be classified as hazardous waste if the proposed classification criteria were applied, e.g. none of the three “C&D waste – crushed concrete” would have to be classified as hazardous waste. For a waste to be classified as hazardous it is sufficient that at least one parameter for at least one L/S ratio exceeds the relevant criterion.

The qualitative evaluation is given in column 4 and 5:

- None: all samples fulfill the criteria
- Some: at least one sample exceeds the criterion for at least one parameter and at least one L/S fraction
- All: all samples exceed the criterion for at least one parameter and at least one L/S fraction

In the last column it is indicated whether the data contains additional parameters, i.e. other than the ones covered by the evaluation.

Table 6. Results of classification of waste types based on proposed leaching criteria

L/S (l/kg)	No ¹⁾	Critical elements	Above metal criterion ²⁾	Above metal and anion criterion ³⁾	Additional parameters
C&D waste – crushed concrete (0 out of 3)					
L/S 2	3	-	None	None	Yes
C&D waste – crushed concrete and asphalt (0 out of 1)					
L/S 2	1	-	None	None	Yes
C&D waste – crushed concrete and tiles (0 out of 2)					
L/S 2	2	-	None	None	Yes
C&D waste – crushed tiles (0 out of 1)					
L/S 2	1	-	None	None	Yes
C&D waste – gypsum based (0 out of 1)					
L/S 2	1	-	None	None	Yes
L/S 10	1	-			
Concrete sludge (0 out of 2)					
L/S 2	2	-	None	None	Yes
Soil (contaminated and uncontaminated CRES) (10 out of 49)					
L/S 0.1	6	As			
L/S 2	49	As, Ni, Zn	Some	Some	Yes
L/S 10	4	As			

L/S (l/kg)	No ¹⁾	Critical elements	Above metal criterion ²⁾	Above metal and anion criterion ³⁾	Additional parameters
Soil (3 projects for Danish EPA) (122) see separate table for results					
Drainage sand (0 out of 1)					
L/S 2	1	-	None	None	Yes
Glass (0 out of 1)					
L/S 2	1	-	None	None	Yes
L/S 10	1	-			
Mixed inert container waste (2 out of 3)					
L/S 2	3	-	Some	Some	Yes
L/S 10	3	Ni			
MSWI APC semi dry product (8 out of 8)					
L/S 0.1	2	Ba, Cd, Cr, Pb, Zn			
L/S 2	2	As, Ba, Cr, Pb, Zn	All	All	Yes
L/S 10	8	Ba, Cr, Hg, Mo, Pb, Zn, fluoride			
MSWI APC wet product sludge + FA (1 out of 1)					
L/S 10	1	Pb	All	All	Yes
MSWI BA (225 out of 1428)					
L/S 0.1	9	As, Se, fluoride			
L/S 2	62	As, Cr, Hg, Pb, Sb, fluoride	Some	Some	Yes
L/S 10	50	As, Cr, Sb, Se, fluoride			
MSWI FA (10 out of 11)					
L/S 0.1	3	Ba, Cr, Mo, Pb, Se			
L/S 2	4	Cr, Mo, Se	Some	Some	Yes
L/S 10	9	Ba, Cr, Mo, Sb, Se, Pb, Zn			
Road sweepings (0 out of 15)					
L/S 2	15	-	None	None	Yes
L/S 10	5	-			

1) No. of records refers to the number of samples tested.

2) As, Ba, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Zn.

3) As, Ba, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Zn, fluoride.

Results from the evaluation of leaching data for soil collected as part of three projects, that DHI has carried out for the Danish EPA (Hansen et al., 2009, 2009a; Hjelm et al., 2009) are given in Table 7. The number of records per parameter and the number of records exceeding the proposed leaching criterion are given.

As can be seen from Table 7 arsenic is the most critical parameter for the soil samples included. Around 20% of the results exceed the classification criterion for As for L/S 2 l/kg.

Table 7. Number of leaching records for soil (L/S 2 l/kg) with 6 < pH < 9 and number of results exceeding the proposed classification criteria

Parameter	No. of records ¹⁾	No. of records exceeding criteria
As	105	21
Ba	49	-
Cd	90	-
Cr	111	-
Cu	122	-
Hg	36	1
Mo	34	2
Ni	101	-

Parameter	No. of records ¹⁾	No. of records exceeding criteria
Pb	103	1
Sb	38	7
Se	35	-
Zn	116	1

1) No. of records refers to the number of samples tested.

Figure 1 clearly shows, that in case of arsenic 20% of the soil samples would have to be classified as hazardous waste according to the proposed classification criteria, whilst none of the samples would be regarded as hazardous if the solid content based limit value for hazardous waste classification is applied. The same applies to Hg, Mo and Sb, were samples that currently – based on total content – are not classified as hazardous, receive a classification as hazardous based on the proposed criteria. Additional figures can be found in the appendix.

As can be seen for Cr, a number of MSWI BA would have to be classified as hazardous if the proposed criteria were applied. In case of Pb some of the samples would have to be classified as hazardous based on the total content, whilst another subset of samples would have to be classified as hazardous according to the proposed classification criteria.

Figure 1. Leached amount at L/S 2 vs. total content for a) As in soil, b) Cr in MSWI BA c) Pb in MSWI BA. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

a)

b)

c)

3.2.3 Evaluation of leaching data – comparison to H15 classification criteria

The leaching data collected for this project was rather limited for most of the waste fractions included. Since it might not be representative for the given waste fraction, it does not seem reasonable to use the results to evaluate how much waste might be affected by introducing H15 classification criteria. The evaluation is therefore done on a qualitative basis for those waste fractions.

For MSWI BA data covered the past 10 years and all Danish waste incineration plants and can therefore be assumed to be representative. Therefore a quantitative evaluation seems reasonable.

Data for coal bottom ash (DHI, 2005) and shredder waste (DHI, 2005; DHI, 2011) indicate that leaching results do not exceed the proposed classification criteria.

The results show that some of the soil, mixed container waste, MSWI BA and MSWI FA samples included in this evaluation would have to be classified as hazardous waste if the proposed classification criteria are applied. For soil results show that around 20% of the tested samples would have to be classified as hazardous waste whilst ca. 16% of MSWI BA samples would have to be classified as hazardous. In terms of amounts of waste this means that approx. 98,000 tonnes MSWI BA (16% of 611,000, based on 2008 statistics of MSWI BA produced) would have to be classified as hazardous waste and would consequently not be allowed to be used as secondary raw material.

In case of MSWI APC residues all samples included in the evaluation would have to be classified as hazardous waste. For coal fly ash (DHI, 2005) data shows that the proposed classification criteria are exceeded.

It should be noted that MSWI FA and shredder waste due to their content of hazardous substances typically are regarded as hazardous waste, whilst the other waste fractions and soil typically are regarded as non-hazardous.

Table 8 summarizes the results of the data evaluation and shows which types of waste might be affected by the proposed leaching based classification criteria. As can be seen the leaching data collected did not comprise all waste types. Furthermore, the table shows whether none, some or all of the samples included in the evaluation exceeded the proposed classification criteria. In case some or all samples exceeded the criteria, column 6 in the table indicates which parameters were exceeded.

Table 8. Types of waste landfilled or recovered that might be affected by the proposed leaching based classification criteria (ktonnes)

Waste type	Total in 2008	None ¹⁾	Some ²⁾	All ³⁾	Critical elements
Asbestos	32	n.a.	n.a.	n.a.	n.a.
Bottom ash ⁴⁾	611	X	X		As, Cr, Hg, Pb, Sb, Se, fluoride
C&D waste ⁵⁾	2,682	X			
Fly ash ⁶⁾	797		X	X	Ba, Cr, Mo, Pb, Sb, Se, Zn
Not suitable for incineration	471	n.a.	n.a.	n.a.	n.a.
Sand and screening residue (waste water treatment)	27	n.a.	n.a.	n.a.	n.a.
Shredder waste	7.1	X			
Sludge	20	n.a.	n.a.	n.a.	n.a.
Soil ⁷⁾	2,134		X		As, Hg, Mo, Ni, Pb, Sb, Zn

1) None: all samples fulfil the criteria.

2) Some: at least one samples exceeds the criterion for at least one parameter and at least one L/S ratio.

3) All: all exceed the criterion for at least one parameter and at least one L/S fraction.

4) In case of MSWI BA some samples exceed the criteria. In case of coal BA none exceed the criteria. Total in 2008 is sum of MSWI BA landfilled and recycled.

5) Sum of concrete, tiles and other types of C&D waste recycled.

6) In case of MSWI FA some samples exceed the criteria. In case of coal FA all exceed the criteria. Total in 2008 is the sum of fly ash landfilled and recycled.

7) Sum of recycling and landfilling of soil.

n.a – no information available.

3.3 Finland

3.3.1 Secondary aggregates or landfilled waste affected

In 2007 about 65 million tonnes of waste were generated in Finland. The main part of this waste is so called mineral waste from extractive industries (excess soil, rock). This waste is also mainly landfilled at non-hazardous waste landfills and in some cases at landfills for inert waste. For this study, especially the waste from chemical industry, ashes from energy production, sludges from metal finishing, rejects from waste treatment processes and slags from thermal treatment and metallurgical industry are of highest interest. However, the current statistical records do not provide information on the produced amounts. The amounts of waste streams identified as critical are evaluated in section 3.3.3.

Table 9. Waste generated in year 2005 Finland (ktonnes)

	Total treatment	Recovery	Energy use	Incineration	Disposal
Chemical waste	990	110	40	70	780
* of this haz. waste	170	60	30	70	20
Metal	1,400	1,400	0	0	10
Glass	170	170	0	0	10
Paper and cartoon	700	600	30	1	30
Plastics and rubber	30	10	10	1	5
Wood waste	12,000	3,300	8,600	4	30
* of this haz. waste	70	0	70	1	0.2
ELV	25	20	0	0	1
* of this haz. waste	15	10	0	0	0.7
WEE	35	20	0	0.3	10
* of this haz. waste	15	15	0	0.1	0.1
Animal and plant	600	400	0	0.1	100
Household and misc	2,100	200	150	60	1,700
* of this haz. waste	30	0	0	10	20
Sludges	600	100	300	10	200
* of this haz. waste	80	0.2	0	10	70
Mineral waste	46,900	11,800	0	0	35,000
* of this haz. waste	1,900	150	0	20	1,700
Other waste	10	0	0	1	10
* of this haz. waste	3	0	0	1	2
Total	65,400	18,200	9,100	140	37,900
* of this haz. waste	2,300	220	90	110	1,800

In Finland, landfills are divided into 3 landfill classes – landfill for hazardous waste, inert waste and non-hazardous waste. Table 10 shows the number of landfills in operation in 2009. There are no statistics available of the waste amounts disposed at different landfill types.

Table 10. Number of landfills in Finland divided in to different landfill classes.

	Landfill for hazardous waste	Landfill for non-hazardous waste	Landfill for inert waste
Total number of existing landfills	21	83	6
Number of these landfills complying with the directive	20	79	5
Number of landfills closed (no more depositing) since 16 July 2001	2	61	2
Number of landfills re-equipped		16	
Rest capacity (ktonnes)	19,205	39,780	705

In principal, all wastes to be landfilled (with exception for municipal wastes, asbestos, wastes on inert list and a few specified wastes) require testing. Finland has implemented in the waste legislation EU waste acceptance criteria for waste to be disposed at landfills for hazardous waste and inert waste. The waste acceptance criteria are evaluated at L/S 10 and recommendations for leaching test methods are given (percolation test for significant waste streams and inert wastes, and for others primarily two-stage batch test). Furthermore, guidelines are given for interpretation of test data for waste to be disposed at landfills for non-hazardous waste.

In future, due to the planned ban on landfilling of most biodegradable wastes, the characteristics of waste to be landfilled will change. According to the tentative timetable, mainly inorganic waste will be landfilled from 2016 onwards.

3.3.2 Sources of classification data

The main sources of data used for the evaluation of the consequences of establishing leaching based classification criteria were:

- mapping and evaluation of VTT leaching data from year 2000 till today covering about 1,000 test samples. For this study only the results from batch leaching test and percolation test are seen as relevant. The data record contains typically the leaching data required for evaluation of the waste acceptance at landfill
- published data on the properties of extractive wastes (mainly composition, but also some leaching results) (reports from Geological Survey of Finland)
- other published data in Finland, mainly diploma works and information from waste producers

The main types of wastes are fly ashes and slags from thermal and metallurgical processes. Also waste from different kinds of waste treatment processes are of high importance for this study. Examples of other waste streams are various process wastes, e.g. foundry wastes, spent catalysts, sorbents used in flue gas or waste water purification, discarded products, packages and paint wastes. The latter group of waste is typically produced in small amounts and the characteristics are highly process dependent and not of general concern in this context. Moreover, waste already classified as hazardous (typically based on total content of hazardous compounds, e.g. organic substances) falls out of the scope of this report and is therefore not mapped here.

VTT has a large test sample record concerning leaching results of C & D concrete wastes (all results from selective demolition). No results were near the B1b² criteria. This waste stream is typically used in earth construction and not disposed of.

² Landfill for inorganic non-hazardous waste with a low content of organic/biodegradable matter (Council Directive 2003/33/EC).

3.3.3 Amounts of waste exceeding H15 classification criteria

Table 11 gives information on waste streams whose leaching characteristics may exceed the criteria in Table 2 and therefore could potentially be classified as hazardous based on the leaching characteristics. The waste amounts are also roughly evaluated. In energy production usually a mix of fuels is used, this means that in practice it is difficult to estimate the actual waste stream generated. Especially the amounts of shredder wastes (from vehicles and WEEE) will significantly increase in future due to EU recycling targets for these waste streams.

Table 11. Types of waste that might be affected by the proposed leaching based classification criteria

Waste type	Description	Total amount landfilled or recycled (ktonne/year)	None (all fulfill)	Some (at least one exceeding)	All (all exceed)	Remarks i.e. possible critical elements (near limit) and significance
Rejects from MSW and C&D waste treatment	Sulphate from gypsum, TOC and DOC	50 kt /year ?				As, Zn, Fluoride
Fly ash	Biomass (wood, peat, waste wood) combustion	600 kt/year		Ba, Se,		Significant effect Sb, As, Mo, Pb
Fly ash	Coal combustion	500 kt / year		Ba		Moderate effect Se, V, Co
Bottom ash	MSWI	< 50 kt / year (current)		Sb		Significant effect
Dusts and sands	Construction, construction material manufacturing			Fluoride		Significant effect As, Ni, Se, Zn,
Dusts	Foundries	< 50 kt/year		Fluoride,		Significant effect Mo
Dusts	Metallurgical industry	< 50 kt / year		Fluoride,		Significant effect Chloride
WEEE, ASR	Fluff from metal recovery	70 kt/year (current)				DOC, Sb, Zn
Metallurgical sludges	Sludges from water treatments of metal finishing processes	<200 kt/year		As		Ni
Extractive waste with high sulphidic content	Tailings, waste rock	Millions ton/year				Leaching tests not applicable for sulphidic waste which will oxidate and might generate acidic drainage
Extractive waste with low sulphidic content	Tailings, waste rock	Millions ton/year		Fluoride		Gypsum waste critical regarding sulphate leaching

Critical elements identified (listed in Table 11) are fluoride and some specific metals (As, Ba, Ni, Se, Sb, Zn). The main concern is about the following waste streams:

- ashes from wood and biomass combustion (metal leaching). The biomass ashes may also have a high organic content due to insufficient combustion conditions
- other ashes from energy production (not MSWI) (in some cases Ba)
- bottom ash (in some cases Sb)
- Waste treatment rejects

The leaching tests developed for the evaluation of the waste acceptance at landfills are not applicable for wastes which undergo weathering e.g. due to oxidation of sulphides. Current leaching tests, e.g. percolation test, are performed in water saturated conditions not taking into account influence of atmospheric oxygen on e.g. sulphide oxidation. In the batch leaching test the oxygen access is not limited, but the contact time is only one day.

Extractive wastes from metal ores typically contain sulphides. Acid drainage may occur if the acid production potential owing to sulphide oxidation in contact with air exceeds the readily available buffering potential of the minerals in the waste. The acid drainage will mobilise metal leaching.

3.4 Sweden

3.4.1 *Secondary aggregates or landfilled waste affected*

Table 12 shows the amounts of waste that go to landfills or are used for construction purposes, elsewhere or on the site where the waste was produced (Swedish EPA, 2010a). Construction purposes include use for landscaping and other construction of landfills.

The largest amount is mining waste (59 million tonne landfilled). The second largest amount is mineral waste. This includes building waste like concrete and brick, but also excavated earth and contaminated soil. A considerable amount of bottom ash from municipal solid waste incineration (MSWI-BA) goes to landfilling, and a similar amount of less specified ash, slag, dust and air pollution control (APC) residues is used for construction. And a final important non-hazardous waste is the waste used by the paper industry for construction on the industrial site.

Table 12. Non-hazardous waste in Sweden that goes to landfilling, construction or reuse on site (Swedish EPA, 2010a). Amounts in ktonne

Waste type	Total amount	Amount landfilled	Amount used for construction	Amount reused for construction on site
Mining waste	59,100	59,100		
Mineral waste, much building waste like concrete, brick, sand and rock	4,516	1,616	2,900	1)
Excavated earth				
Concrete and cement				
Brick				
Sorting residues and sorted landfill residues	776	724	52	
Sorting residues	508	508		
Mixed unspecified	222	222		
Ash, mostly MSWI-BA (not including MSWI-FA and MSWI-APC)	433	433		
Ash, slagg, dust, APC residues	522		522	
Paper industry				
Green liquor sludge	384	250	70	64
Ash	185			185
Fiber sludge	175			175
Mesa	134			134
Biochemical sludge	125			125
Bark	15			15
Sorting residue (fibre from paper industry)	81		81	
Metallurgical slag (blast furnace slag not included)	300	240		60
Municipal solid waste	120	120		
Sludge	77	77		
Municipal sludge (organic)	13	13		
Industrial waste sludge (inorganic)	11	11		
Organic waste to cover landfills	93		93	
Stabilised contaminated soil	31	31		

1) A considerable amount is reused in roads, but no numbers are available.

3.4.2 Sources and evaluation of classification data

Leaching tests on non-hazardous wastes are not compulsory in Sweden, but knowledge of waste characteristics is. Leaching data has not been collected on a national level, and no database that covers the entire country is available. Two smaller databases have been used for this report: the SGI laboratory database and the Allaska database within the programme on ashes at Värmeforsk. Some reports on classification of waste from the extractive industries (excess soil, rock) were also included.

Management of waste from extractive industries is regulated under directive 2006/21/EC. Hazardous waste classification for extractive industries is of importance since mining waste represents the major waste type in Sweden and since the classification will have impact on whether or not the facility should be classified under category A in relation to directive 2006/21/EC. Classification of extractive wastes as hazardous can be triggered either based on its acid-generating properties (EWC 01 03 04*) or if it exhibits properties H1-H15 (EWC 01 03 05). There are some Swedish reports on sulphide ore mining wastes that

include basic data and classification related to the total content of hazardous substances, acid generating properties and leaching tests developed for the evaluation of the waste acceptance at landfills. None of the test data indicates that the proposed leaching H15 criteria are exceeded even in cases when the acid-generating properties of the waste trigger hazardous classification. Test data are however few and performed on fresh unweathered wastes. Test performed on weathered waste might have given another outcome.

The Swedish Geotechnical Institute (SGI) has collected leaching data for materials analysed at the SGI laboratory since 2004. Originally the SGI laboratory was the only in Sweden that provided leaching tests, but other laboratories have since expanded their activities to include leaching tests. The SGI laboratory is less streamlined than the other laboratories, more available for discussion of problems and more expensive. This attracts customers with problematic materials, large amounts of wastes, and wish for recycling which requires characterisation combined with risk assessment. Thus the SGI database is biased in this direction. The SGI database mainly contains data from standardised leaching tests, but some custom designed leaching tests similar to the standardised tests are included.

The SGI database has classed materials in four broad groups: soil and rock, ash, slag, sludge and other. The material group “other” includes e.g. molding sand, APC control residues, brick, isolation, and crushed glass. The group “soil and rock” includes a very high percentage of contaminated soils. Soils are discussed further on based on another source of leaching data.

Data on leaching test results was extracted on 3rd February 2011. Results for the main groups of materials are presented in the table below. Table 13 presents, for each group, the number of samples in the database for a specific liquid:solid ratio, the percentage of these samples that exceeded the proposed H15 criteria, and the elements exceeding the criteria. The latter have been divided according to the frequency with which they exceeded the proposed H15 criteria.

In addition to the extraction of data for the main material groups, sample and project names were inspected for materials with high volumes for landfilling or construction use that were not identified by the material group classification. These results may be found in Table 16.

Table 13. Leaching from major classified material groups compared to proposed H15 criteria (SGI laboratory database)

	Number of samples in SGI database	Over criteria	More than half of samples that exceed the criteria exceed it for	Less than half of the samples that exceed the criteria exceed it for:
Soil and rock				
L/S 0.1	52	29%	As, Zn,	Cd, Cr, Mo, Se
L/S 2	161	16%	As, Pb, Zn	Cd, Cr, Mo, Se
L/S 10	218	19%	As, Zn, Pb, Se	Ba, Cd, Sb
Ash (fuel not specified)				
L/S 0.1	51	59%	As, Ba, Cr, Mo, Pb, Se, Zn	Cd, Zn
L/S 2	172	38%	Cr, Mo, Pb	As, Ba, Cd, Sb, Se, Zn, F
L/S 10	181	44%	Ba, Cr, Mo, Pb	Sb, Se, Zn, As

	Number of samples in SGI database	Over criteria	More than half of samples that exceed the criteria exceed it for	Less than half of the samples that exceed the criteria exceed it for:
Metallurgical slag				
L/S 0.1	21	19%	Cr, Mo	Ni, Se
L/S 2	119	13%	Mo	Sb, F
L/S 10	131	10%	Mo	Sb
Sludge				
L/S 0.1	11	64%	Cr, Mn	Ni, Pb, Zn, F
L/S 2	32	66%	Mo, Cr	Se, Sb, Ni
L/S 10	62	63%	Mo, Cr,	Ni, Sb, Se, Zn, F
Other				
L/S 0.1	47	40%	Se, Sb, Mo, Cd, Cr	Cu, Hg, Ni, Pb, Zn, F

The Allaska database {Värmeforsk, 2010 #1236} purposes to collect quantitative information on the properties of residues from combustion. The ashes were produced at Swedish combustion plants. Data originate primarily from the programme on ashes at Värmeforsk. Only standardized tests have been included in Allaska. Values below the detection limit have not been included. Data on leaching properties was extracted in February 2011 from the database updated 21st February 2010.

In Table 14 and

Table 15 results from the Allaska database are shown. Allaska aggregates the samples and returns the value of the samples with lowest and highest leaching (minimum and maximum), as well as the average leaching for each element and the leaching for the sample that is median for that element. These have been compared to the proposed H15 criterion for each element, L/S ratio and test. Table 14 shows the results for the bottom ashes from waste incineration that has been subject to Värmeforsk research.

Table 15 shows the results for ash from the combustion of wood.

Table 14. Waste incineration bottom ash, MSWI-BA (Allaska)

	Approximate number of samples	Elements that exceed the proposed H15 criteria			
		Min	Median	Average	Max
L/S 0.1 percolation	58				F ¹⁾
L/S 2 percolation	58				F, Sb ¹⁾
L/S 10 percolation	58				Cl, F, S, Sb, Se
L/S 2 batch test	16				As, Sb
L/S 10 batch test	20			Sb	As, Sb

1) Only one sample in Allaska was over the detection limit for F and Sb, and this sample also exceeded the proposed H15 criteria. The source report (Pettersson et al., 2004) showed that this was boiler sand from a fluid bed incinerator, and that F leaching was over the criterion for 3 out of 4 ashes where F-leaching was reported.

Table 15. Wood ash (Allaska)

	Approximate number of samples	Elements that exceed the proposed H15 criteria			
		Min	Median	Average	Max
L/S 0.1 percolation	4				
L/S 2 percolation	4				
L/S 10 percolation	4				
L/S 2 batch test	15				Mo, Pb, Zn
L/S 10 batch test	15		Cr	Cr	Cr, Mo, Pb, Zn

The discrepancy between the SGI and Allaska databases is occasioned by the differences in selection of samples. Unlike the Danish data, there is no general information covering ashes that are produced in Sweden. Both databases gravitate towards samples from producers with an environmental interest.

Other sources have been used in addition to the SGI laboratory database and the Allaska database. Of special interest is the thesis by Cecilia Jansson, where she collected leaching properties for excavated earth for metals (Jansson, 2008). This included both contaminated and natural soils. The elements that most exceed the proposed H15 criteria are antimony and arsenic (Figure 2 and

Figure 3). Most of the sites that exceeded the criteria were contaminated. Some uncontaminated crushed natural rock exceeded the criteria for molybdenum (Figure 4). More results are shown in the appendix.

Figure 2. Antimony total content vs leaching in excavated earth. KM and MKM are Swedish guidelines for total content related to use of the site. "Farligt avfall" denotes the total content associated with classification of contaminated soil as hazardous waste. (Jansson, 2008)

Figure 3. Arsenic total content vs leaching in excavated earth (Jansson, 2008).
Explanation see Figure 2

Figure 4. Molybdenum total content vs leaching in excavated earth (Jansson, 2008). Explanation see Figure 2

3.4.3 Amounts of waste exceeding proposed H15 criteria

The amounts of waste produced in Sweden (from Table 12) has been combined with the results of section 3.4.2 in Table 16. In section 3.4.2 we showed percentages of samples that exceeded the proposed criteria. However, the available leaching data was so non-representative of the produced amounts available, that we felt that it was not acceptable to apply those percentages to the waste amounts. Therefore Table 16 shows whether none, some or all of the samples exceeded the criteria.

Based on the available leaching test data, a large amount of the following materials was expected to exceed the proposed leaching criteria for H15, and could hence be classified as hazardous waste: contaminated soil, ashes, and inorganic industrial waste sludge. A proportion of metallurgical slag and waste incineration bottom ash also exceeded the proposed H15 leaching criteria.

The most problematic elements are arsenic, antimony, molybdenum and chromium, though lead, zinc, nickel, selenium and fluoride also exceed the proposed criteria for some materials.

Table 16. Types of waste that might be affected by the proposed leaching based classification criteria

Waste type	Total amount landfilled or used in construction (ktonne)	None exceeded criteria	Some samples over criteria	All samples over criteria	Critical elements
Mining waste	59,100				
Mineral waste	4,516				
Contaminated soil			x		As, Pb, Sb, Zn, Ni, Mo
Natural soil and rock			x		Mo
Concrete and cement		x			
Brick		x			
Sorting residues and sorted landfill residues	776				
Sorting residues	508				
Mixed unspecified	222				
Ash, mostly MSWI-BA	433		x		As, F, Sb, Se
Ash, slagg, dust, APC residues	522		x		As, Cr, Mo, Pb, Zn
Paper industry					
Green liquor sludge	384	x			
Ash	185		x		Cr, Mo, Pb, Zn
Fibersludge	175				
Mesa	134	x			
Biochemical sludge	125				
Bark	15				
Sorting residue	81				
Metallurgical slag	300		x		Mo, Sb, Cr, Ni, Se
Municipal solid waste	120				
Sludge	77				

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5. Appendices

5.1 Leaching data for soils

5.1.1 Denmark

Figure 5. Leached amount at L/S 2 vrs. total content of Ba for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 6. Leached amount at L/S 2 vs. total content of Cd for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 7. Leached amount at L/S 2 vs. total content of Cr for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 8. Leached amount at L/S 2 vrs. total content of Cu for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 9. Leached amount at L/S 2 vrs. total content of Hg for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 10. Leached amount at L/S 2 vrs. total content of Mo for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 11. Leached amount at L/S 2 vrs. total content of Ni for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 12. Leached amount at L/S 2 vrs. total content of Pb for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 13. Leached amount at L/S 2 vrs. total content of Sb for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 14. Leached amount at L/S 2 vrs. total content of Se for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

Figure 15. Leached amount at L/S 2 vrs. total content of Zn for soil samples. The horizontal red line shows the proposed leaching based classification criterion and the vertical blue line shows the solid content based limit value for hazardous waste classification

5.1.2 Sweden (in Swedish)

I det pågående arbetet med att ta fram harmoniserade regler för klassificering av farligt avfall har det föreslagits att i EU:s lakkriterier för gränsvärden för deponier skall tillämpas baserat på gränsvärden för en deponi för icke farligt avfall (tabell 2.2.2 i 2003/33/EC). I en inledande studie har vi jämfört dessa kriterier med data fram tagna för massor från rena och förorenade jordar. Baserat på examensarbetet Schaktmassor som inert avfall En vägledning för entreprenörer Cecilia Jansson Earth Sciences Centre University of Gothenburg B548 200 ISSN 1400-3821.

Några av de mest intressanta resultaten är:

Antimon

Gränsvärdet för klassificering baserat på totalhalt är ca 10 000 mg/kg TS vilket inte överskrids av något prov (värden på totalhalt underskattade för förorenad halt beroende på uppslutningsmetoden). Däremot överskrider huvuddelen av proverna från skjutvallar och en betydande andel av proverna från förorenad mark dessa riktvärden (Glasbruk?). Det föreslagna lakkriteriet kommer leda till att mängderna förorenad jord som klassificeras som farligt avfall ökar kraftigt.

Arsenik

Gränsvärdet för klassificering baserat på totalhalt är ca 1 000 mg/kg TS vilket överskrids av ett fåtal prov (2,5 %). Andelen ökar med ca en faktor 4 till 9,5 % om lakkriteriet tillämpas. Det föreslagna lakkriteriet kommer leda till att mängderna förorenad jord som klassificeras som farligt avfall ökar.

Krom

Gränsvärdet för klassificering baserat på totalhalt är ca 10 000 mg/kg TS vilket inte av något prov. Inte heller lakkriteriet överskrids i något fall. Cr tycks därför vara av mindre vikt i förhållande till As för förorenad jord från impregneringsplatser. Det föreslagna lakkriteriet kommer inte leda till att mängderna förorenad jord som klassificeras som farligt avfall ökar.

Molybden

Dataunderlaget för förorenad mark är bristfälligt. De högsta halterna uppmäts för jungfruliga bergkross eller moräner. Gränsvärdet för klassificering baserat på totalhalt underskrids av samtliga medan gränsvärdet för lakbarhet överskrids av ett fåtal "naturmaterial". Den utlakade andelen av totalhalten är relativt hög. Det föreslagna lakkriteriet kan leda till att mängderna "förorenad" jord som klassificeras som farligt avfall ökar.

Nickel

Ett fåtal prover på förorenad mark överskrider antingen kriterier för lakbarhet eller totalhalt (ca 3%). Om både lakkriterier och totalhaltskriterier är det ca 4,5 % av proverna som klassificeras som farligt avfall. Det föreslagna lakkriteriet kan leda till att mängderna "förorenad" jord som klassificeras som farligt avfall ökar.

Bly

Ett betydande antal prover från förorenad mark kriterier för totalhalt (ca 13%). Antalet prover som överskrider föreslaget lakkriterie är betydligt färre ca 5 %. Endast två prover (ca 1 %) som klarar totalhaltskriterier överskrider lakkriteriet. Det föreslagna lakkriteriet kommer inte leda till att mängderna "förorenad" jord som klassificeras som farligt avfall ökar märkbart.