How can ashes be expected to perform in relation to End-of Waste criteria for waste-derived aggregates?

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Outline

- What is EoW, and what are the conditions for a waste material to qualify for EoW status?
- Some regulatory consequences of EoW
- Environmental protection (leaching) criteria for ashes used as aggregates (unrestricted or conditional use?)
- Examples of ash performance based on leaching data
- Conclusions

End-of-Waste

According to Article 6 (1) of the Waste Framework Directive (2008/98/EC), a waste material (substance or object) may cease to be waste as defined in the WFD when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions:

a) the material is commonly used for specific purposes;

b) a market or demand exists for such a material;

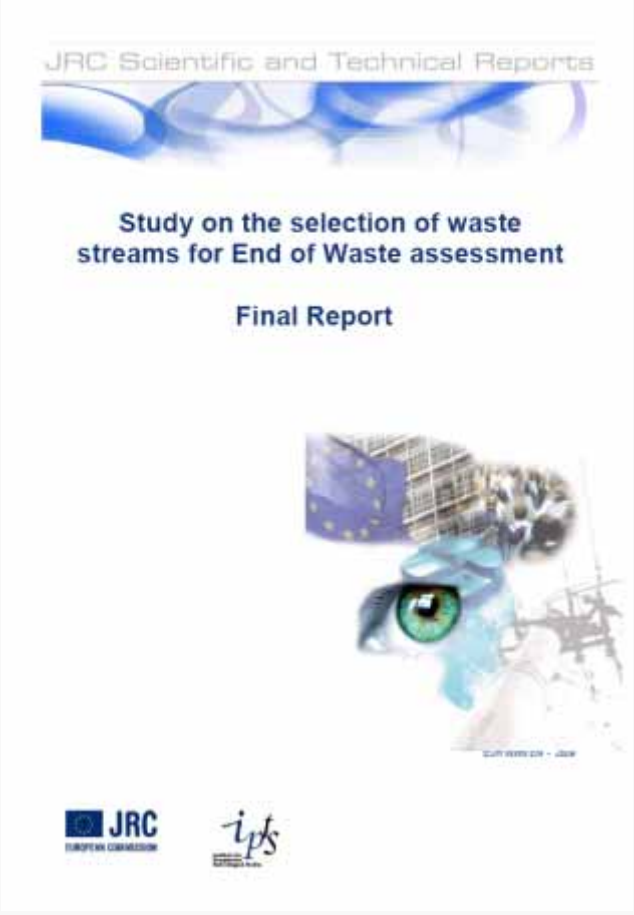
c) the material fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;

d) the use of the material will not lead to overall adverse environmental or human health impacts.

The criteria shall include limit values for pollutants where necessary and shall take into account any possible environmental effects of the material.

EoW initiatives within the EU

The EU Commission (JRC i Sevilla, Institute for Prospective Technological Studies) is responsible for the development of EoW criteria within the EU and has produced two reports on the implementation of EoW (2009)



The JRC-IPTS reports

Define the EoW concept, develop an overall methodology for classification of candidates for EoW status, and identify the most suitable candidates for non-waste classification. Three different types of waste streams are identified:

- I Streams that are in line with the basic principles of EoW and suited for further *EoW criteria assessment;*
- II Streams that may be in line with the principles;
- III Streams that are not considered appropriate for EoW classification.

EoW initiatives at EU level

The first category of waste streams has been further divided into two sub-categories, namely:

- I.1): Streams used as feedstock in industrial processes, a pathway that controls the risks of health and environmental damage. These streams include **metal scrap of iron and steel, aluminium,*** copper, plastics, paper, textiles, glass, metal scrap of zinc, lead and tin, other metals;

- I.2) Streams used in applications that imply direct exposure to the environment. In these cases, the EoW criteria to be developed in the further assessment shall include where necessary limit values for leaching pollutants, taking into account any possible adverse environmental and health effects. The streams in this subcategory include: Waste **aggregates** (e.g. C&D waste aggregates and ashes and slags (including steel slags)) and biowaste materials stabilised for recycling (compost).

*Council Regulation (EU) No 333/2011 of 31 March 2011

Some of the consequences of EoW

A waste material (such as, for example aggregates derived from MSWI bottom ash) which is declassified by achieving EoW status is no longer subject to waste legislation.

It becomes a product, and subject to product legislation, i.e. the Construction Products Directive (CPD) and its successor, the Construction Products Regulation (CPR) – and the associated harmonised European Product Standards. Existing national legislation on the use of construction products also applies.

Environmental test methods associated with CPD are currently being produced by CEN/TC 351 (implementing ER3). Whereas the test methods are/will be harmonised at EU level, the environmental criteria to be met by construction products are national (and with few exceptions non-existent).

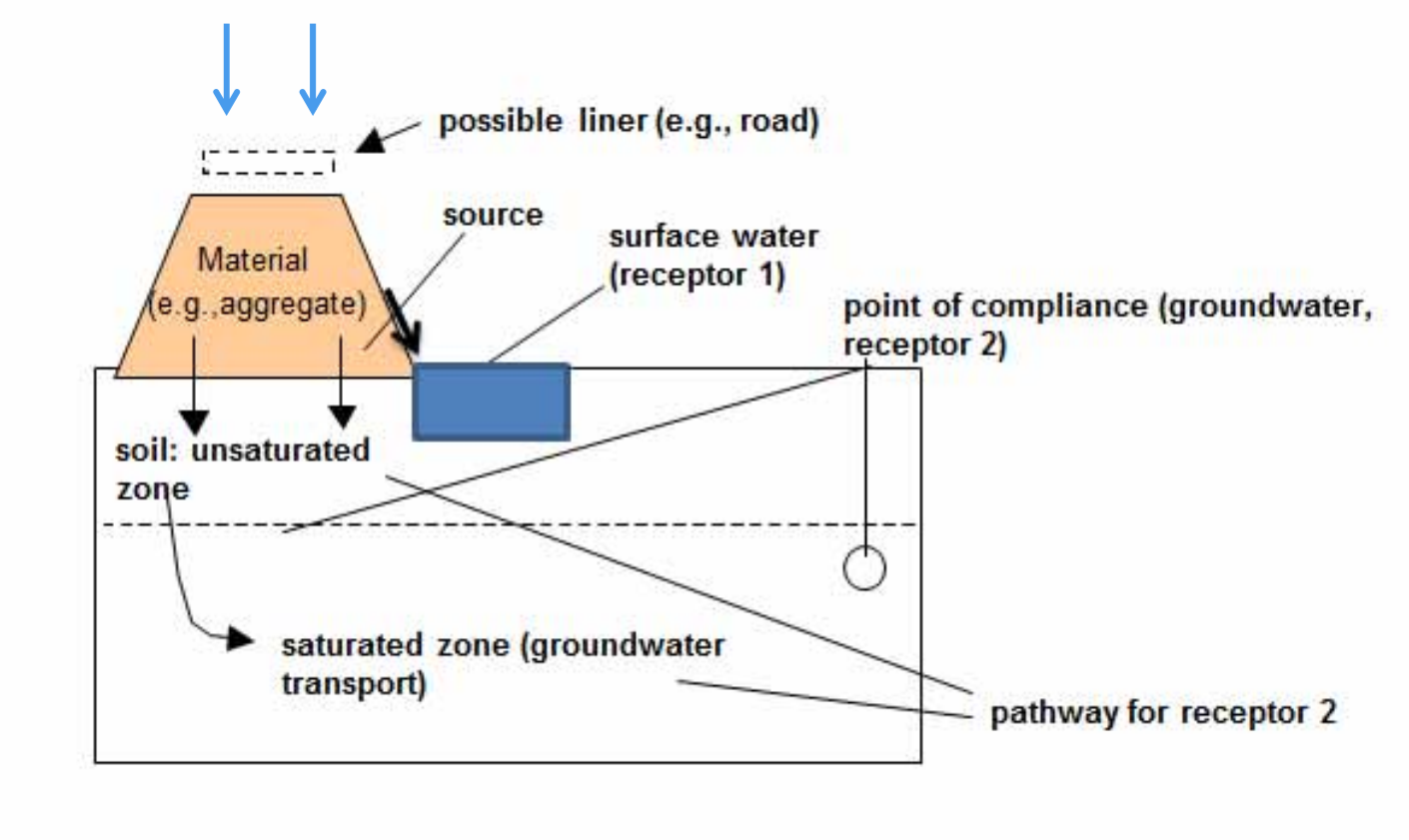
The relationship of waste-derived aggregates with EoW status with REACH is partly non-clarified (some aggregates have been registered).

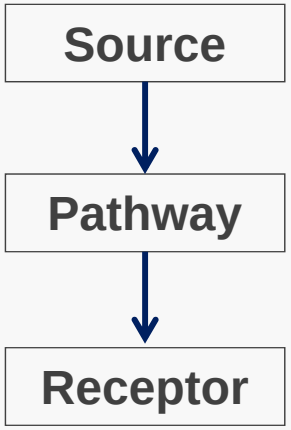
Condition d) - Protection of the environment and human health: EoW criteria for **aggregates** (limit values for leaching)

Criteria/limit values should be based on risk/impact assessment:

- Protection of the environment (groundwater, surface water, soil): **Primarily leaching**
- Protection of human health for direct exposure pathways (contact, ingestion, etc.): Primarily content

Utilisation scenarios for assessment of environmental impact (example)





Receptor 1: Reflects use without restrictions

Receptor 2: Reflects use with certain conditions (e.g. limits on height, length, width, distance to surface water or groundwater, infiltration)

Same basic principle as used in setting EU WAC for landfilling

Use without restrictions will require relatively stringent leaching criteria (example based on porewater concentrations)

Substance	WQ Criteria	Calculated limit values		LFD Inert
		L/S=2 l/kg	L/S=10 l/kg	L/S=10 l/kg
	mg/l	mg/kg	mg/kg	mg/kg
Chloride	150	189	278	800
Fluoride	1.5	2.5	6.2	10
Sulphate	250	378	754	1000
As	0.0043	0.0084	0.037	0.5
Ba	0.0093	0.016	0.049	20
Cd	0.00008	0.00011	0.00017	0.04
Cr	0.02	0.034	0.094	0.5
Cu	0.012	0.019	0.041	2
Hg	0.001	0.0019	0.0079	0.01
Mo	0.02	0.030	0.057	0.5
Ni	0.003	0.0047	0.010	0.4
Pb	0.00034	0.00054	0.0012	0.5
Sb	0.002	0.0036	0.012	0.06
Se	0.01	0.015	0.027	0.1
Zn	0.0031	0.0049	0.011	4
DOC	3	5.2	15	500

Examples of conditions that can be imposed on the use of ashes for construction purposes to reduce the impact on the environment (POC = point of compliance)

Imposed condition	Source	Pathway	Receptor
The material can only be used for specified purposes	Can be influenced	Can be influenced	May determine which receptors are relevant
Take back the material after service life	Reduction in the time span to be considered	Not affected	Not affected
Minimum distance to groundwater level	Not affected	Attenuation in the unsaturated zone may be taken into account	Depends on POC
Minimum distance to surface water	Not affected	Attenuation in the unsaturated zone and the aquifer may be taken into account	Depends on POC
Restrictions on height of application	May reduce source term	Not affected	Not affected
Restrictions on the length and width of the application	May reduce the source term	Not affected	Not affected
Restrictions on allowed rate of infiltration	Reduction of the flux (the load per time unit)	Not affected	Not affected

How will ashes perform?

If restrictions are placed on the use of ashes as aggregates in in construction works, and

If EoW leaching criteria for protection of groundwater, surface water and soil taking these restrictions into consideration are developed,

Then these leaching criteria are likely to be of the same order of magnitude as the waste acceptance criteria (WAC) - but should not be less stringent.

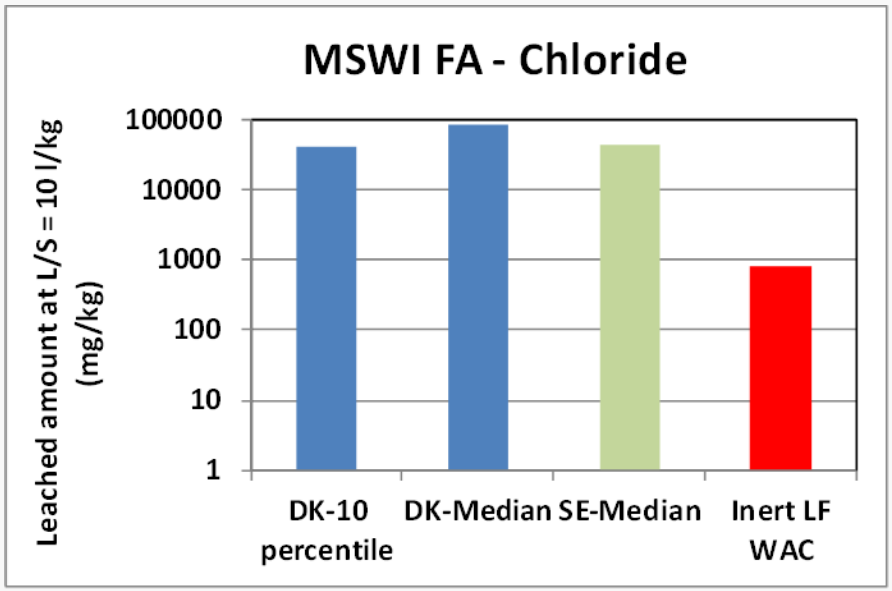
Therefore, a first rough impression of the potential compliance of a given type of ash with possible EoW leaching criteria may be obtained from a comparison of the leaching properties of the ash with the EU WAC for inert waste landfills.

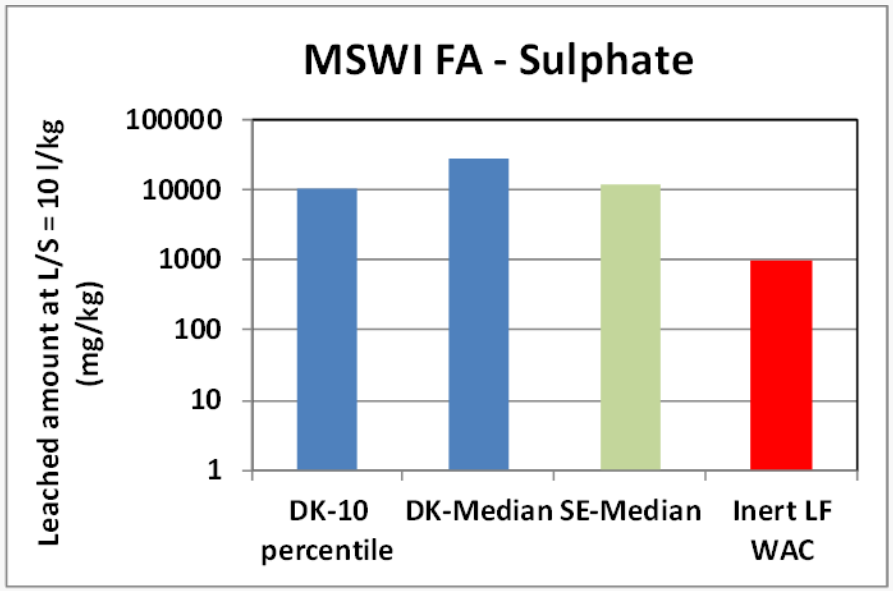
Leaching data on ashes: No of samples

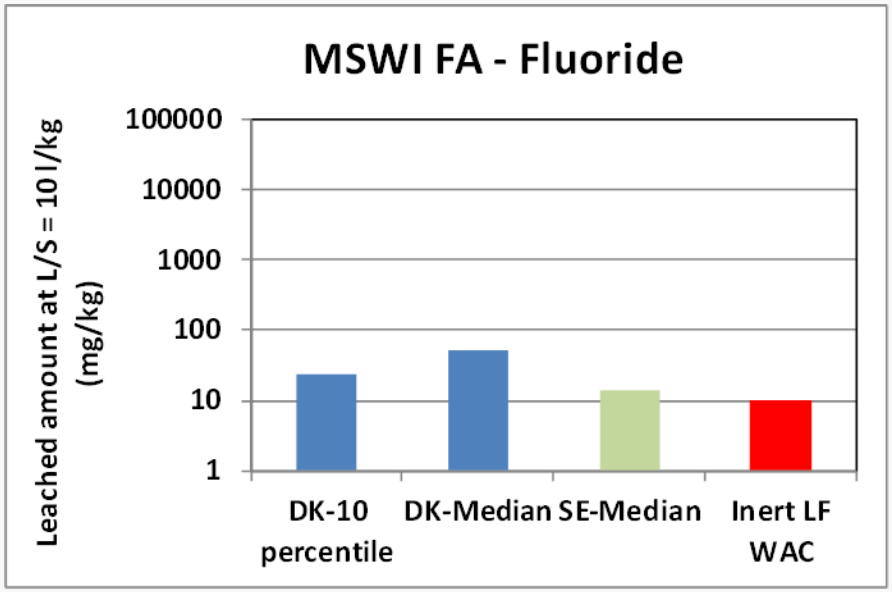
Substance	MSWI FA		MSWI BA		CBA	CFA	Wood FA
	DK	SE	DK	SE*	Internat.	Internat.	DK
Chloride	8	18	1223	21	92	35	1
Sulphate	8	7	1223	21	168	38	1
Fluoride	5	3					
As	8	7	1163	16	91	37	1
Ba	5	7	254	24	100	21	1
Cd	8	7	1253	24	88	37	1
Cr	8	7	1287	24	106	102	1
Cu	8	7	1316	24	81	32	1
Hg	8	3	247	24			
Mo	8	7	196	20	155	8	
Ni	8	7	1251	24	88	35	1
Pb	8	7	1253	24	88	37	1
Sb	5	18	174	15	154	22	
Se	5	7	178	15	154	23	
Zn	8	7	1252	24	91	97	1
DOC	6	14	478	12			1
Source:	DHI	Allaska	DHI	Allaska	LeachXS	LeachXS	DHI

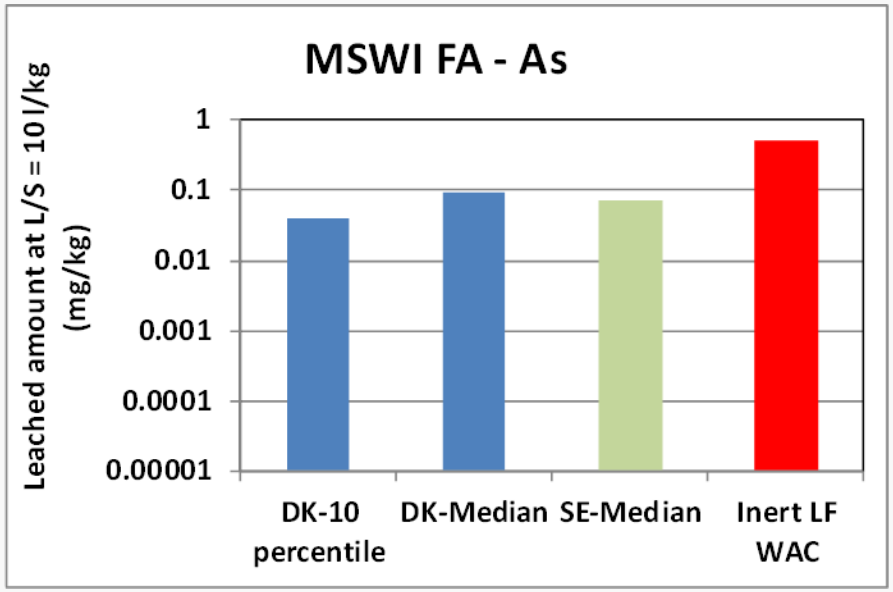
*: Only matured MSWI bottom ash

MSWI fly ash

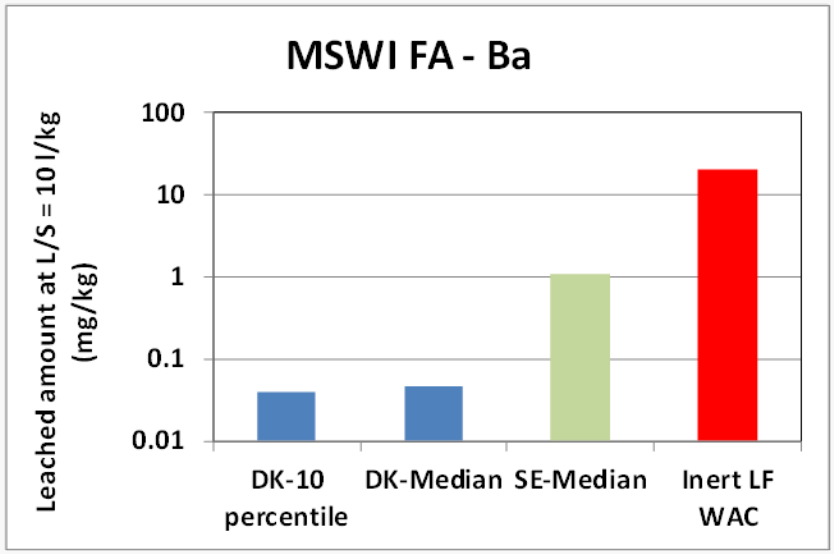

MSWI FA - Chloride
Leached amount at L/S = 10 l/kg (mg/kg)
100000
10000
1000
100
10
1
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

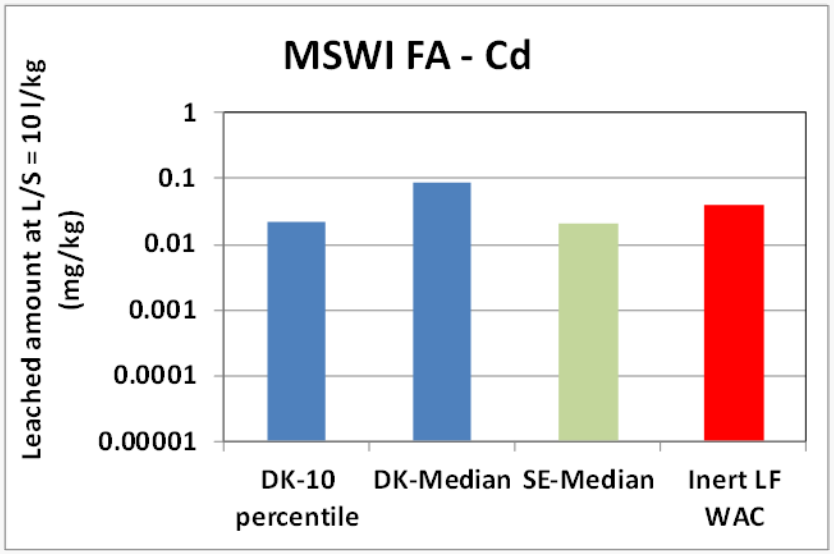

MSWI FA - Sulphate
Leached amount at L/S = 10 l/kg (mg/kg)
100000
10000
1000
100
10
1
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

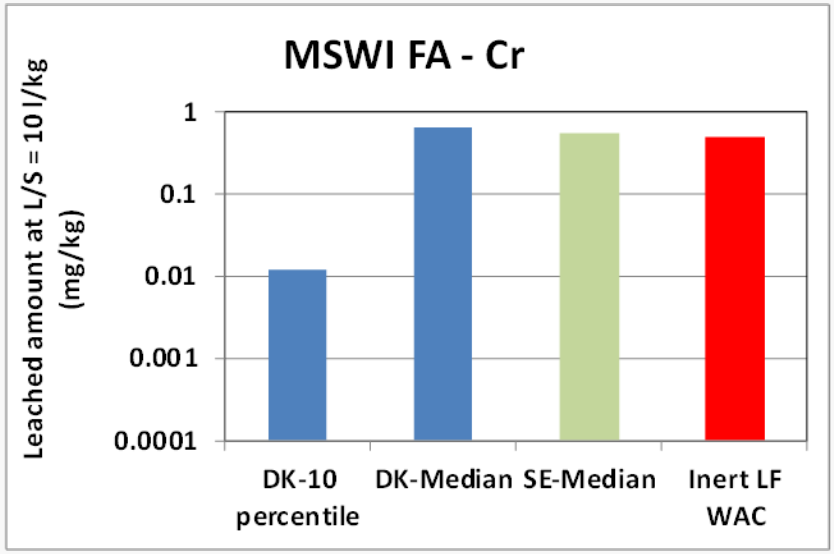

MSWI FA - Fluoride
Leached amount at L/S = 10 l/kg (mg/kg)
100000
10000
1000
100
10
1
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

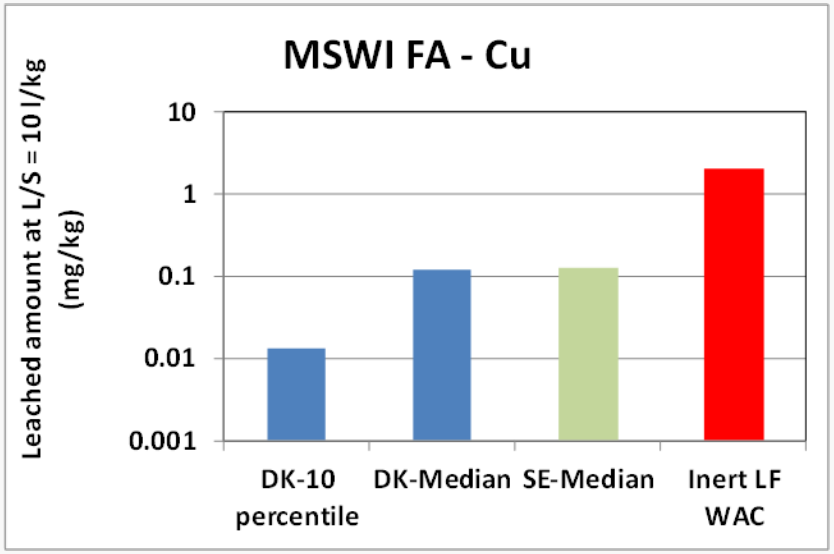

MSWI FA - As
Leached amount at L/S = 10 l/kg (mg/kg)
1
0.1
0.01
0.001
0.0001
0.00001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

MSWI fly ash

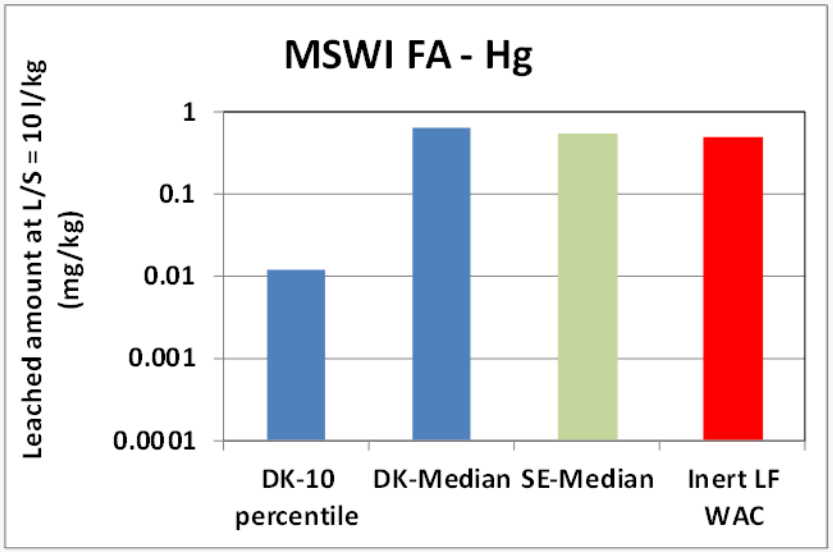

MSWI FA - Ba
Leached amount at L/S = 10 l/kg (mg/kg)
100
10
1
0.1
0.01
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

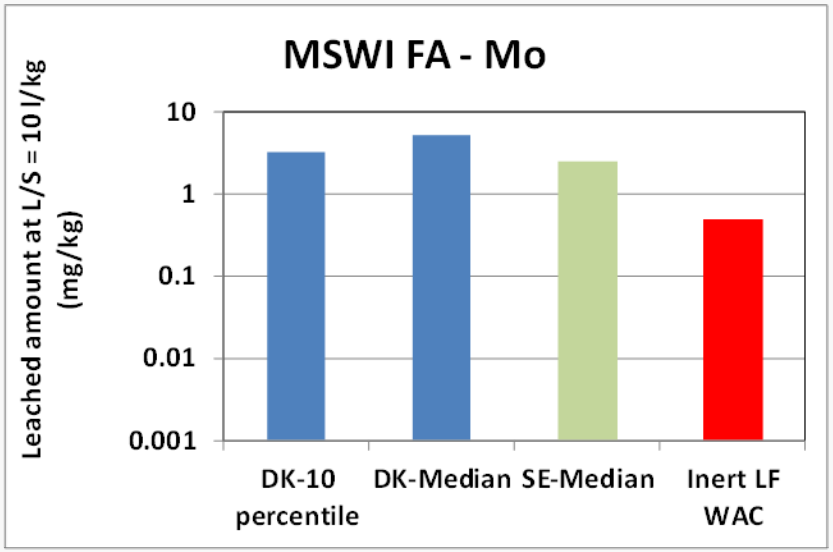

MSWI FA - Cd
Leached amount at L/S = 10 l/kg (mg/kg)
1
0.1
0.01
0.001
0.0001
0.00001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

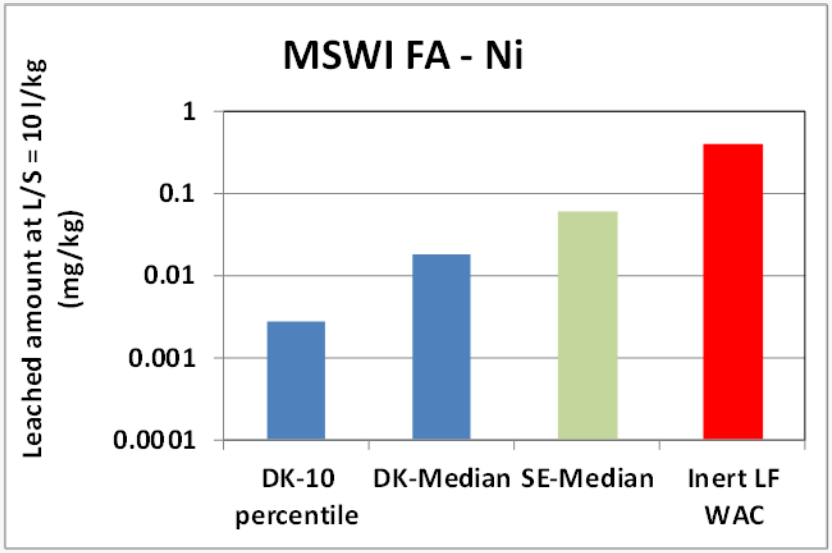

MSWI FA - Cr
Leached amount at L/S = 10 l/kg (mg/kg)
1
0.1
0.01
0.001
0.0001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

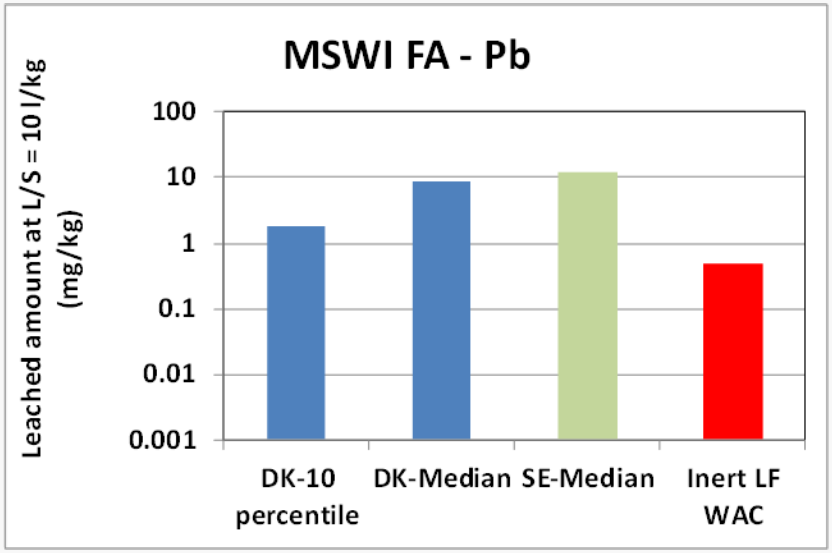

MSWI FA - Cu
Leached amount at L/S = 10 l/kg (mg/kg)
10
1
0.1
0.01
0.001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

MSWI fly ash

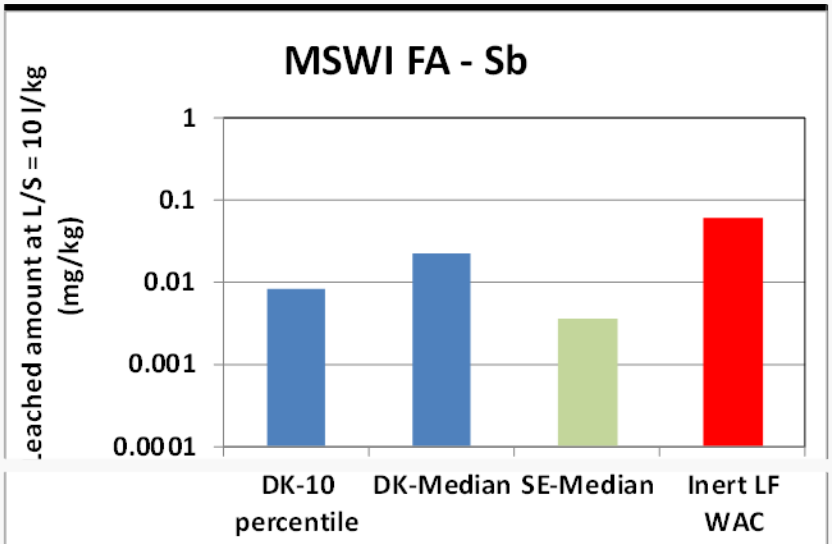

MSWI FA - Hg
Leached amount at L/S = 10 l/kg (mg/kg)
1
0.1
0.01
0.001
0.0001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

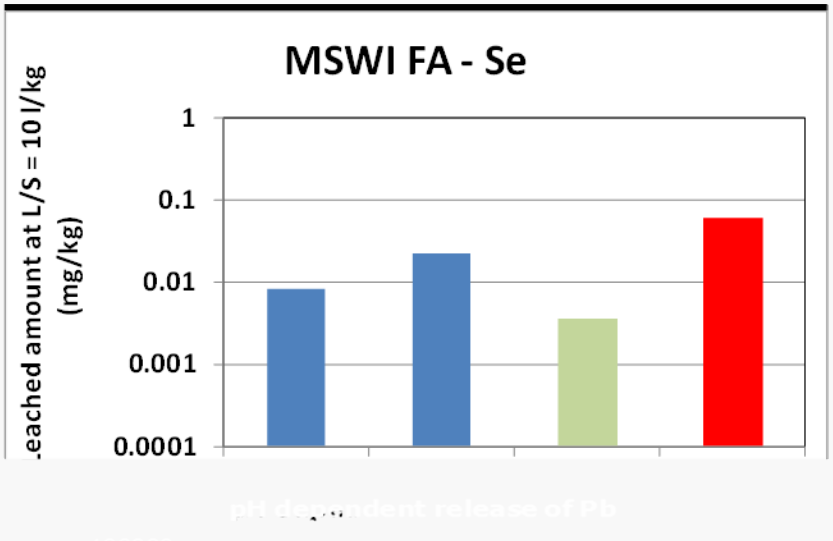

MSWI FA - Mo
Leached amount at L/S = 10 l/kg (mg/kg)
10
1
0.1
0.01
0.001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

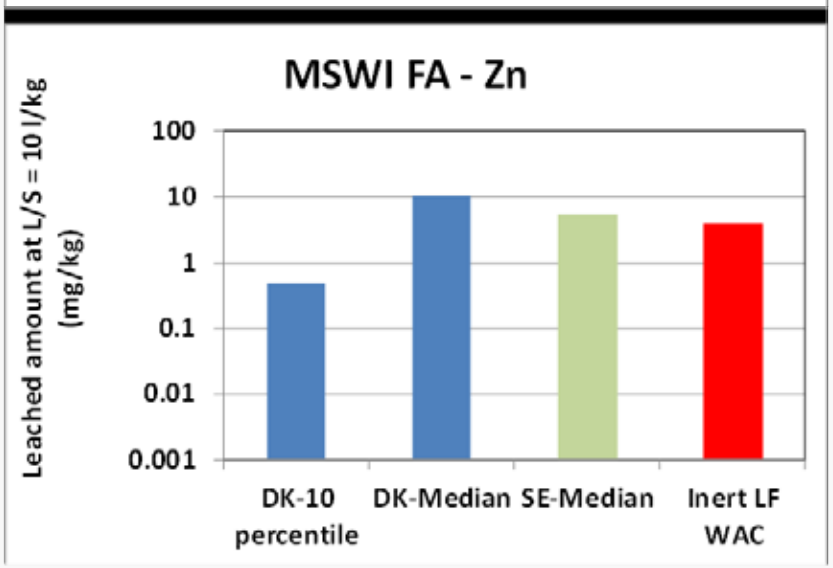

MSWI FA - Ni
Leached amount at L/S = 10 l/kg (mg/kg)
1
0.1
0.01
0.001
0.0001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

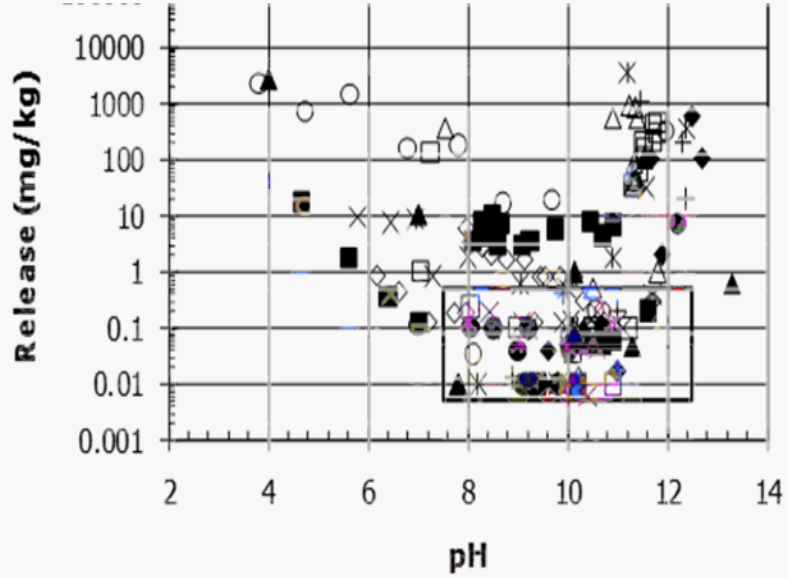

MSWI FA - Pb
Leached amount at L/S = 10 l/kg (mg/kg)
100
10
1
0.1
0.01
0.001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

MSWI fly ash

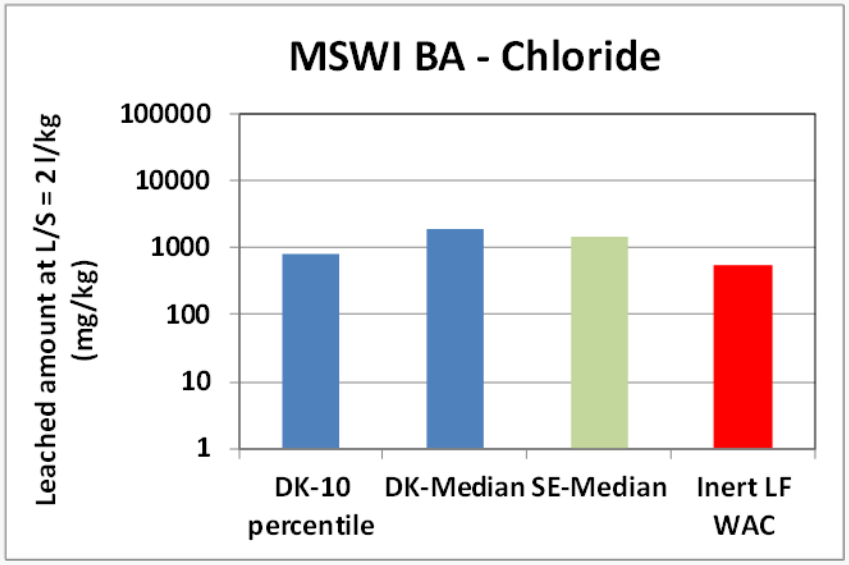

MSWI FA - Sb
Leached amount at L/S = 10 l/kg (mg/kg)
1
0.1
0.01
0.001
0.0001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

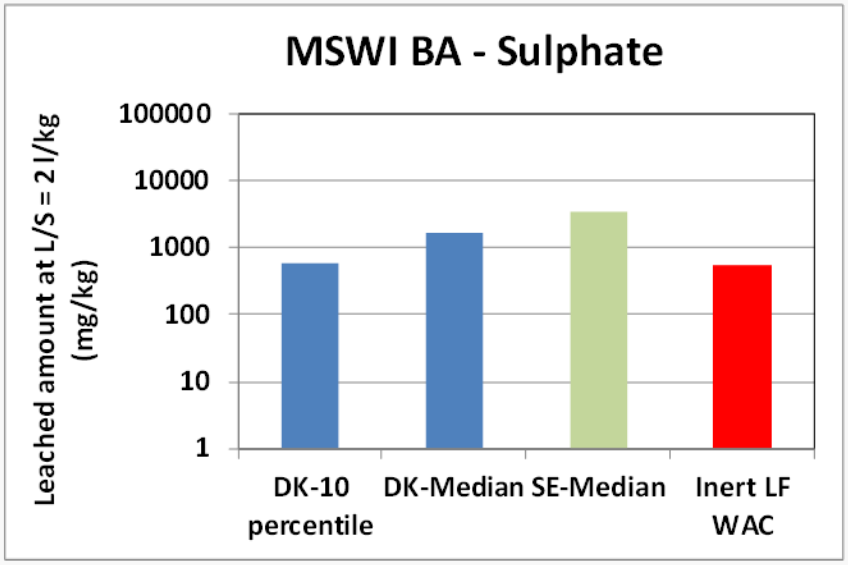

MSWI FA - Se
Leached amount at L/S = 10 l/kg (mg/kg)
1
0.1
0.01
0.001
0.0001

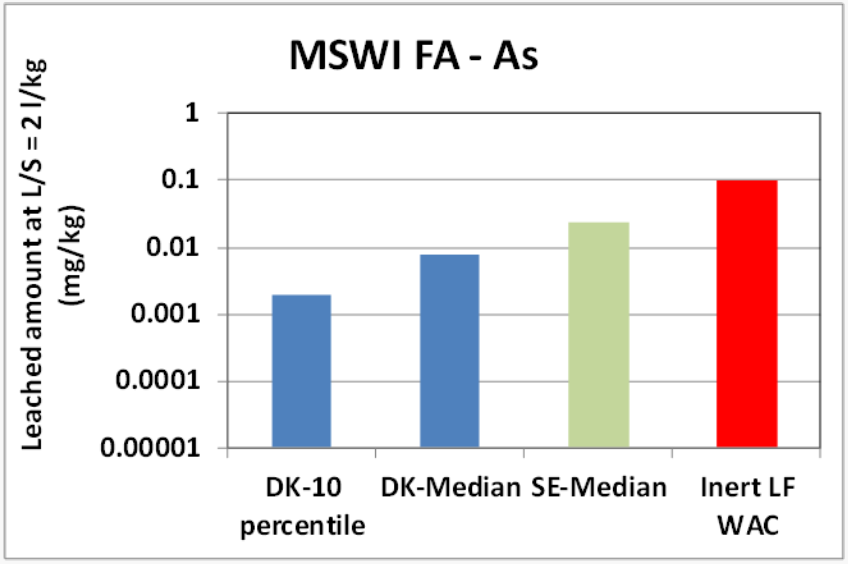

MSWI FA - Zn
Leached amount at L/S = 10 l/kg (mg/kg)
100
10
1
0.1
0.01
0.001
DK-10 percentile
DK-Median
SE-Median
Inert LF WAC

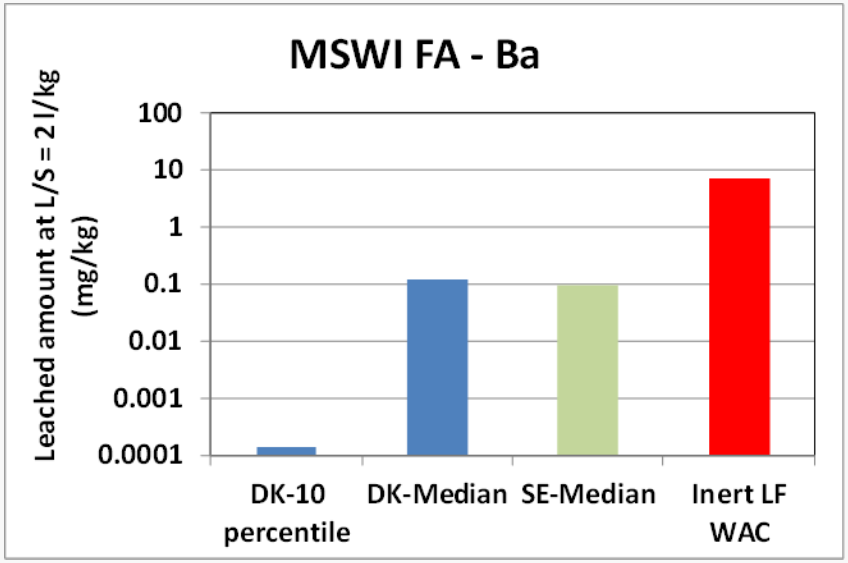

Release (mg/kg)
10000
1000
100
10
1
0.1
0.01
0.001
2
4
6
8
10
12
14
pH

MSWI bottom ash

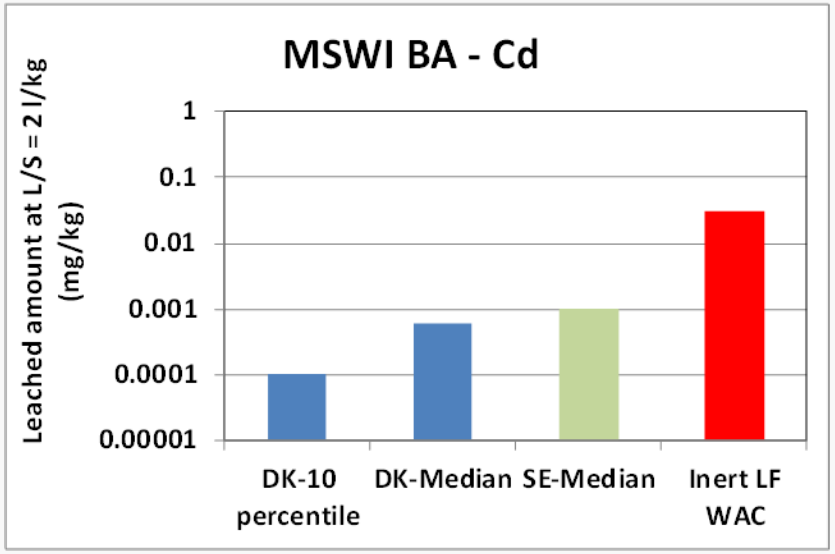


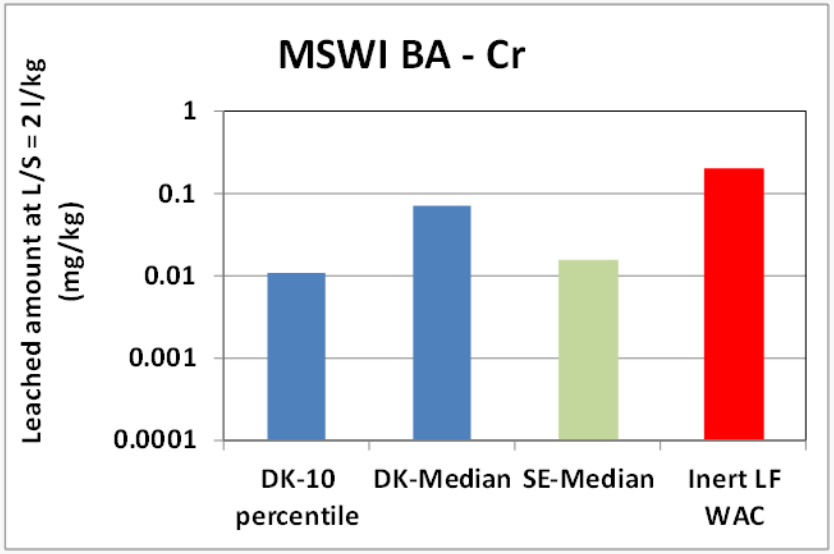


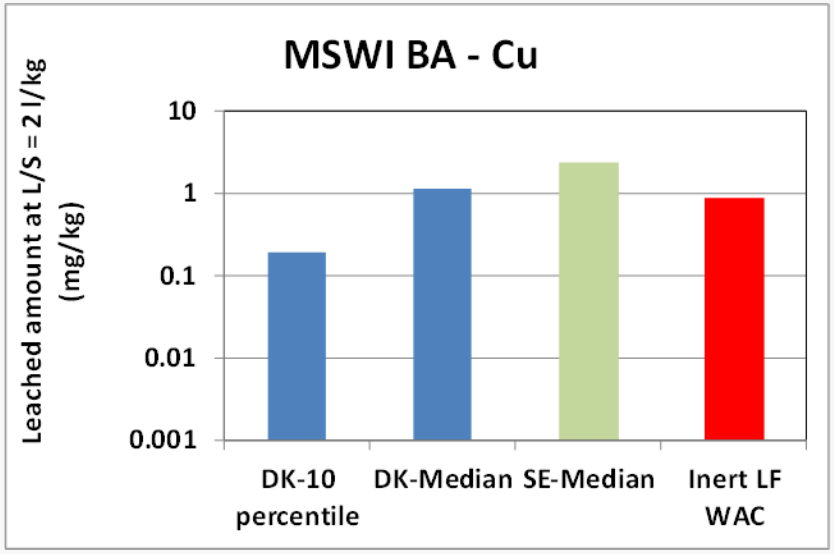


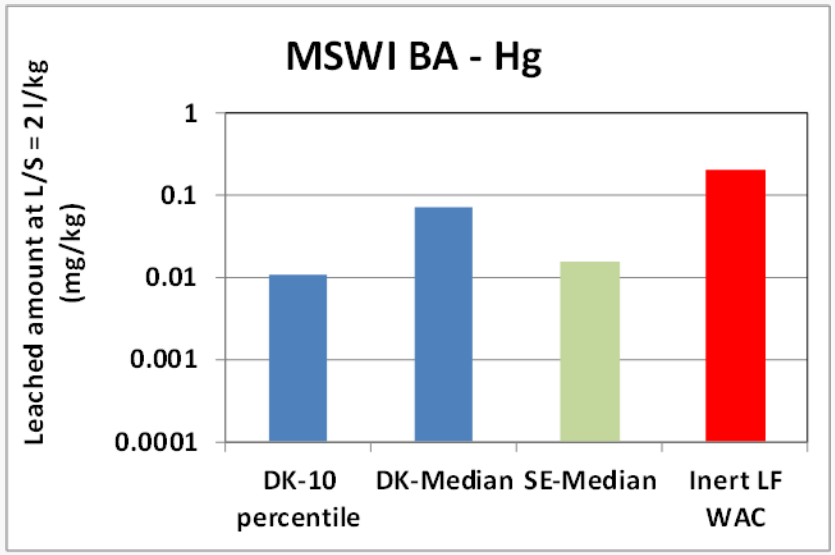


MSWI bottom ash

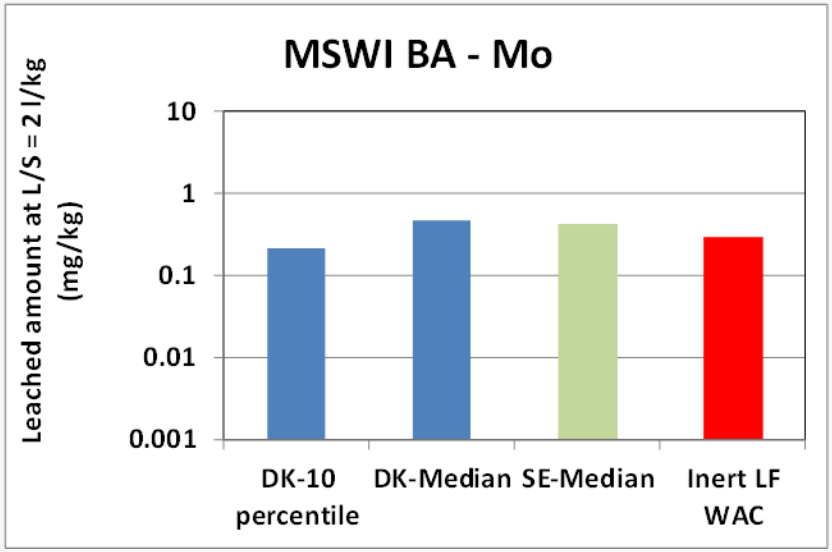


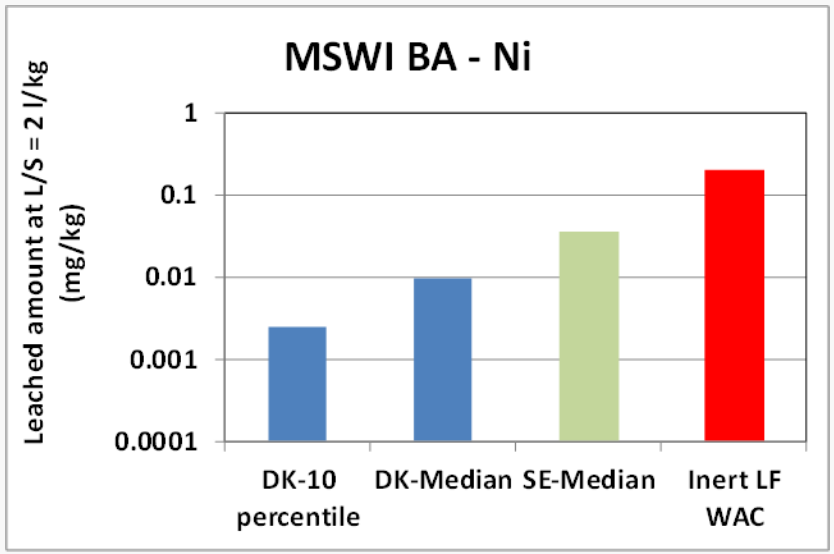


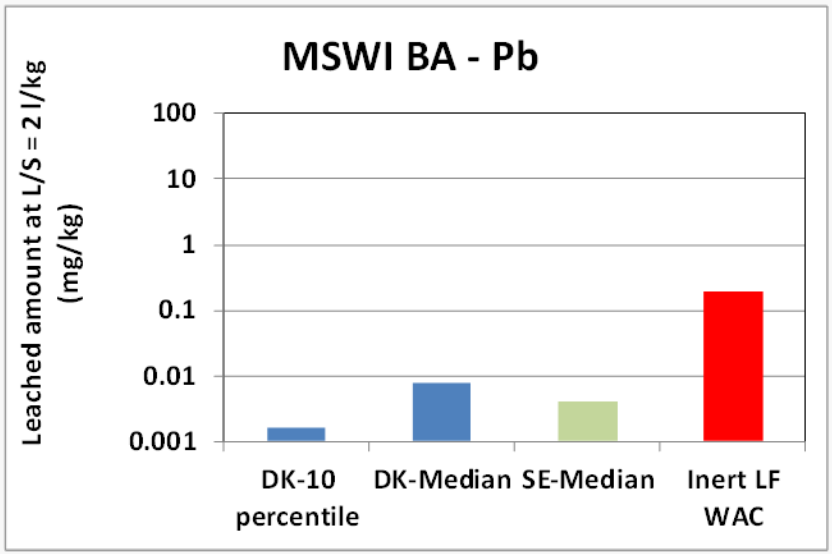


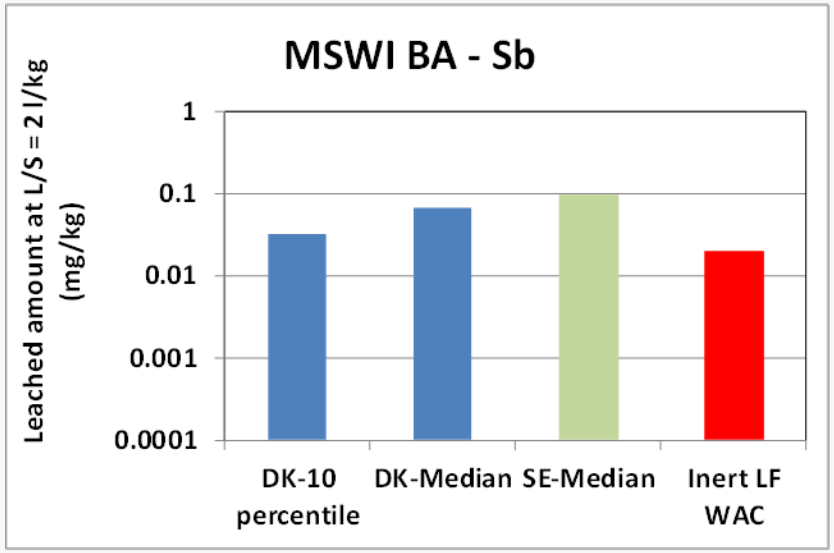


MSWI bottom ash

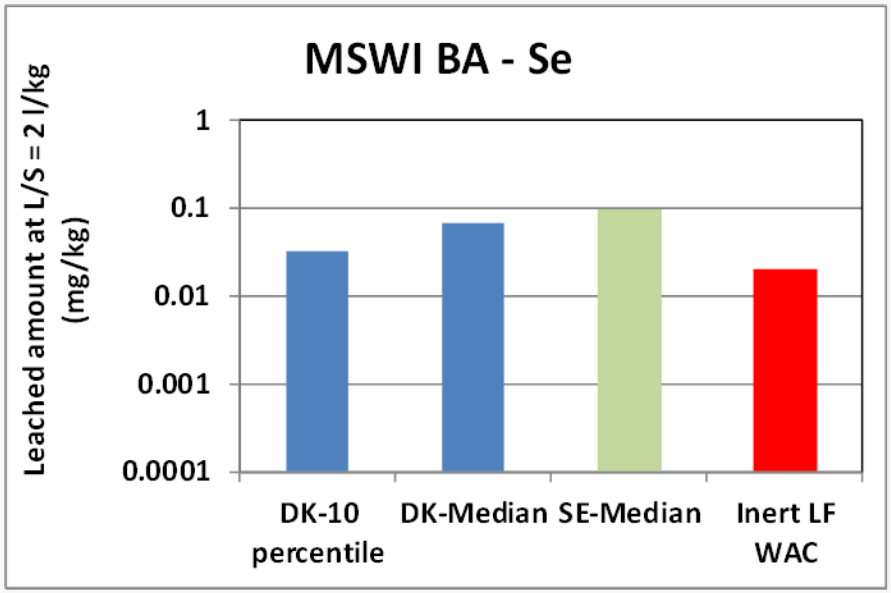


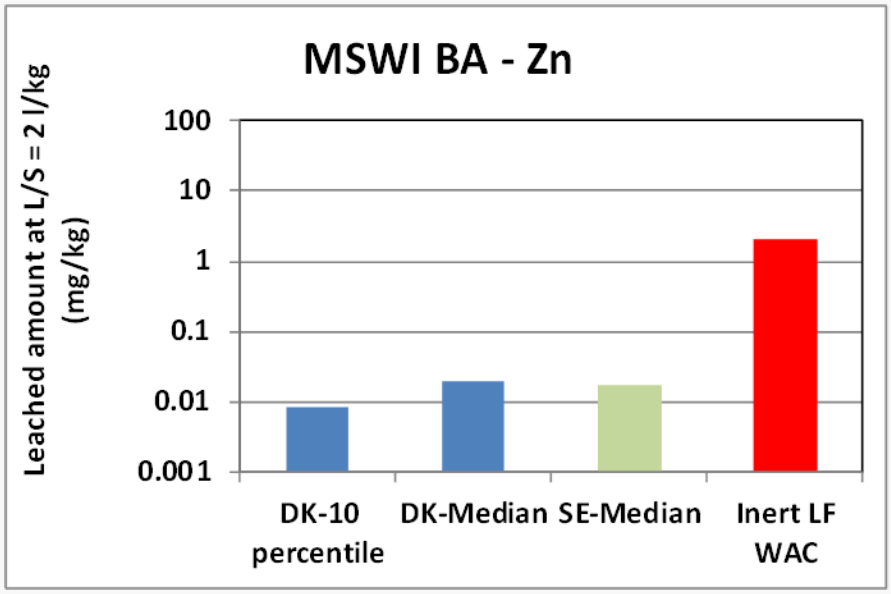


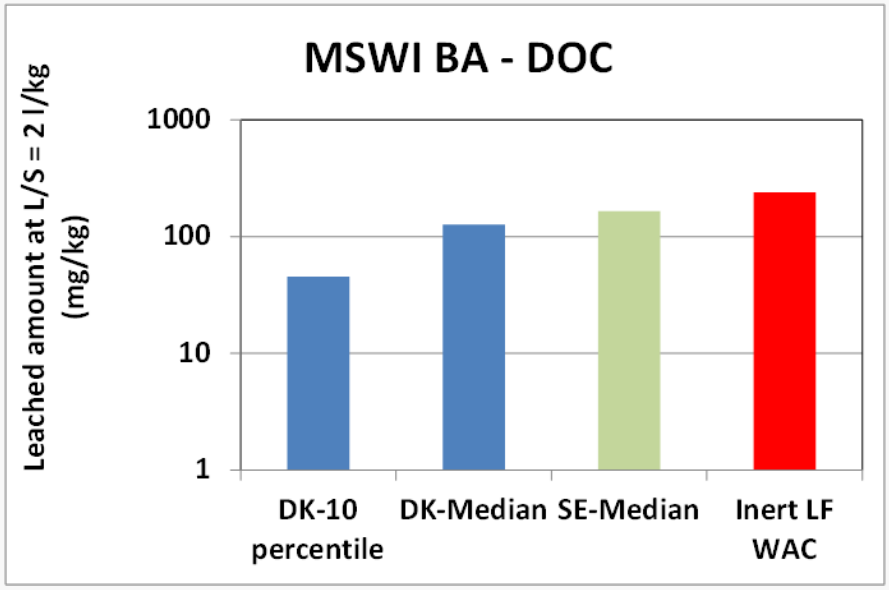




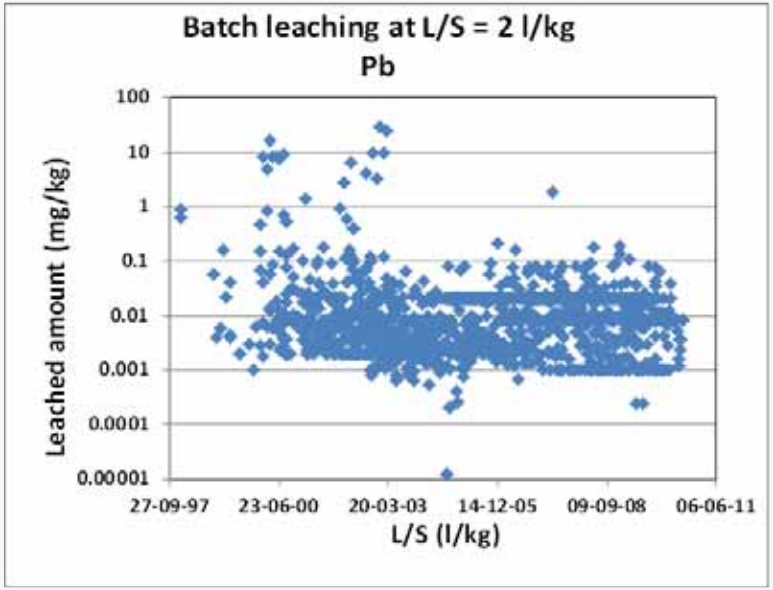
MSWI bottom ash

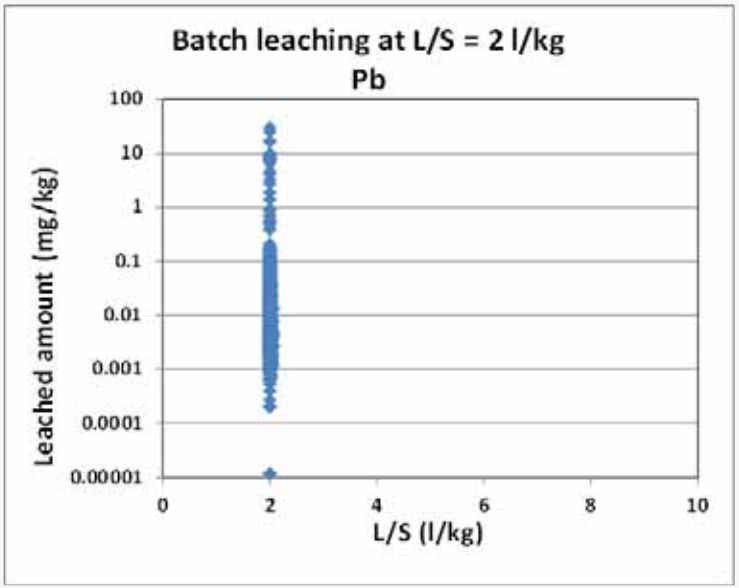


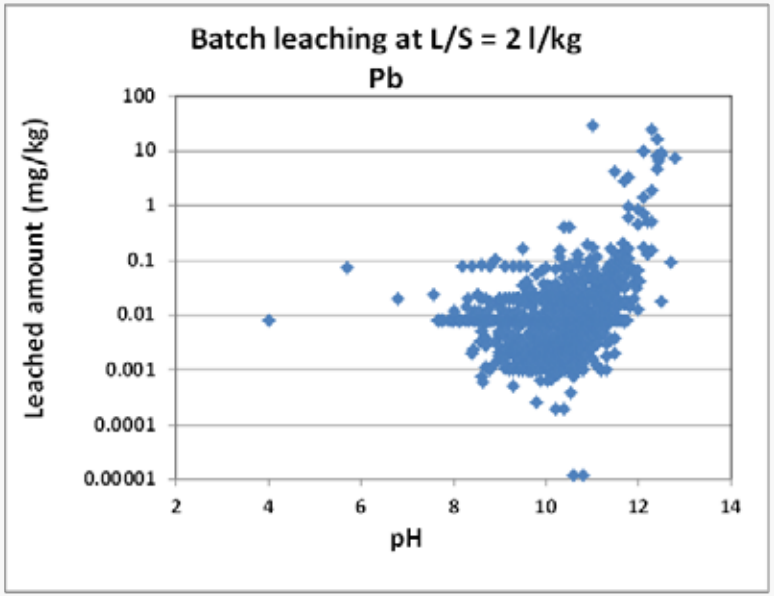




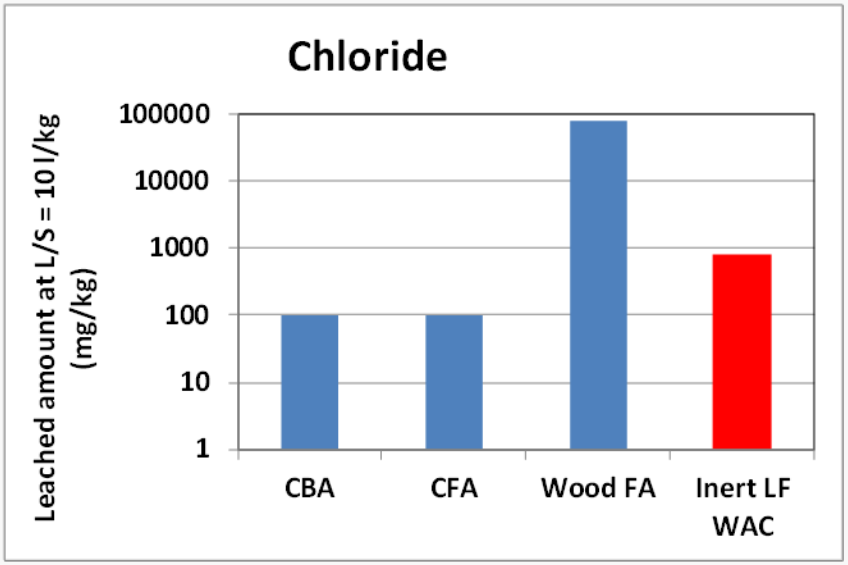
MSWI bottom ash – 1185 DK datasets

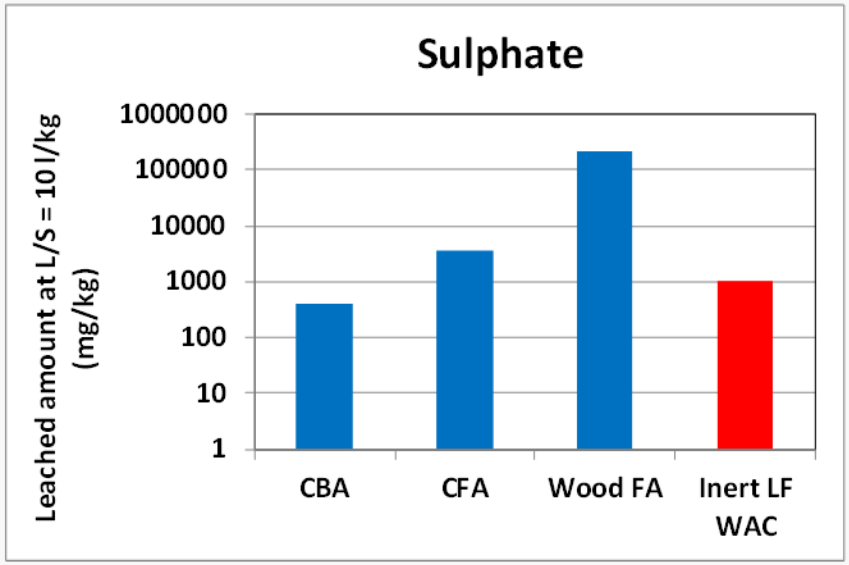


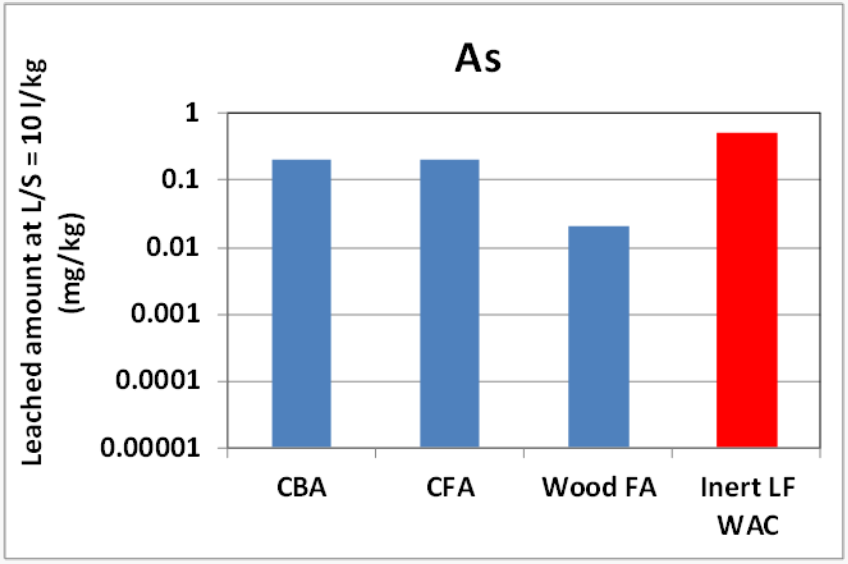


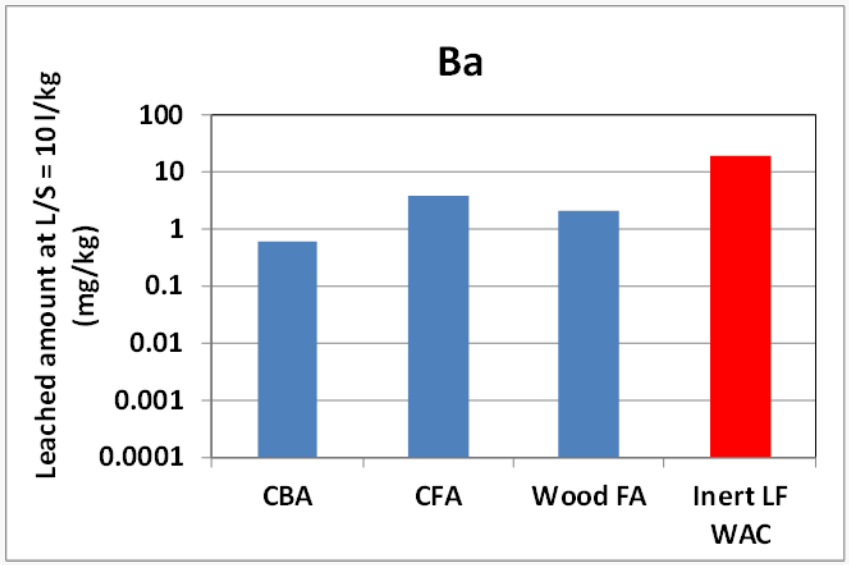


Coal FA and BA – Wood FA
Leaching data, median values

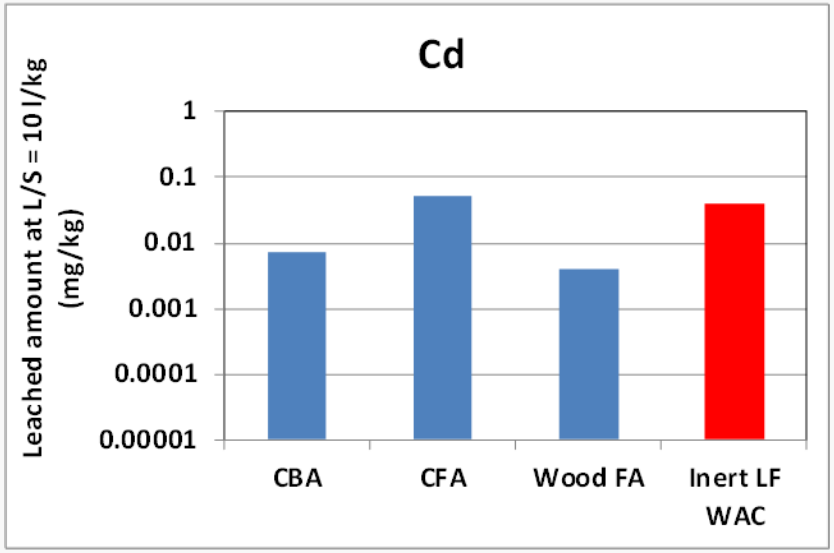


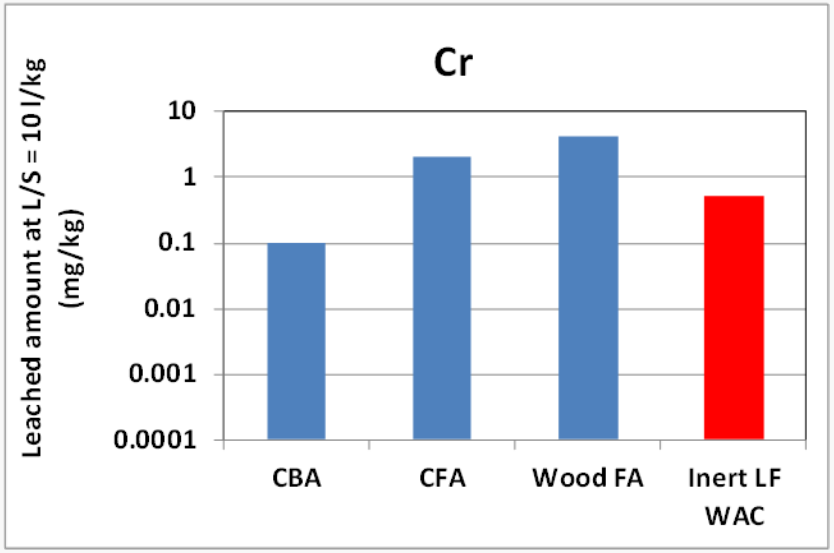


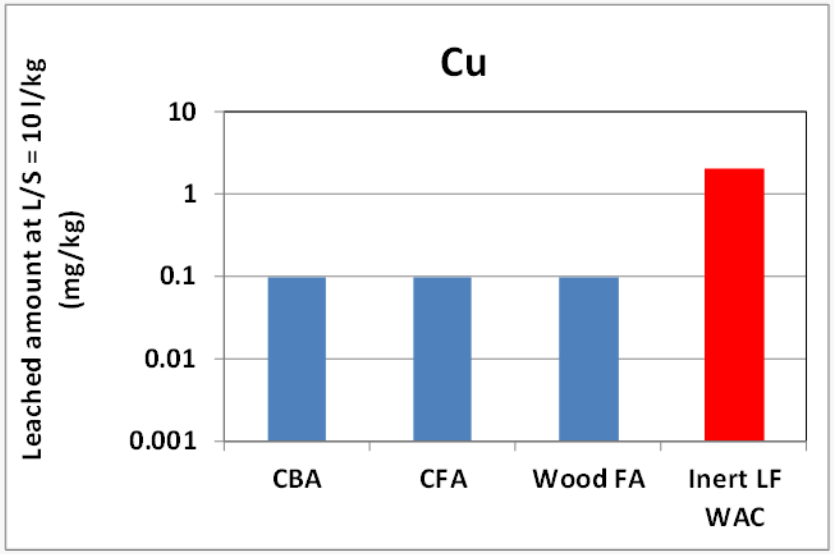


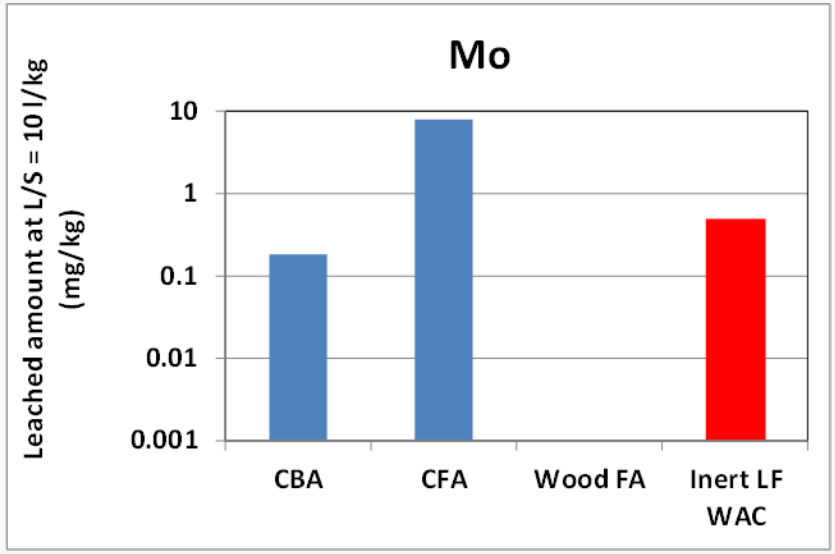


Coal FA and BA – Wood FA
Leaching data, median values

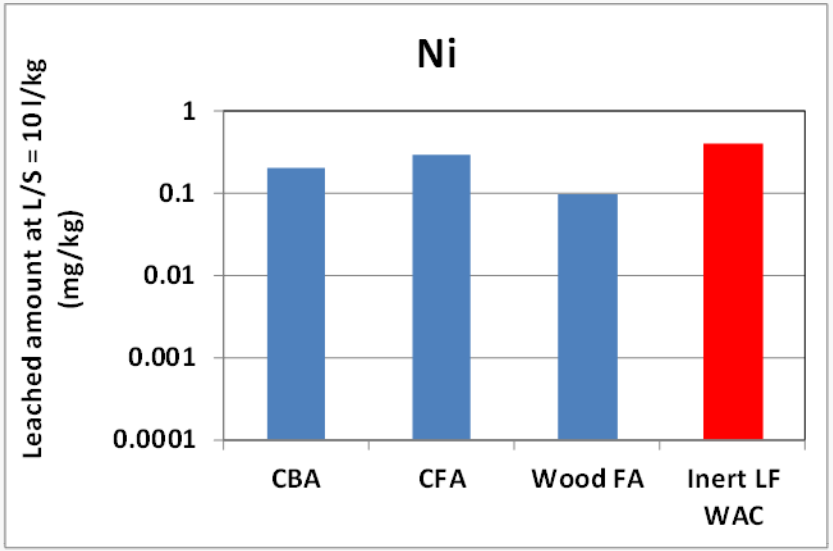


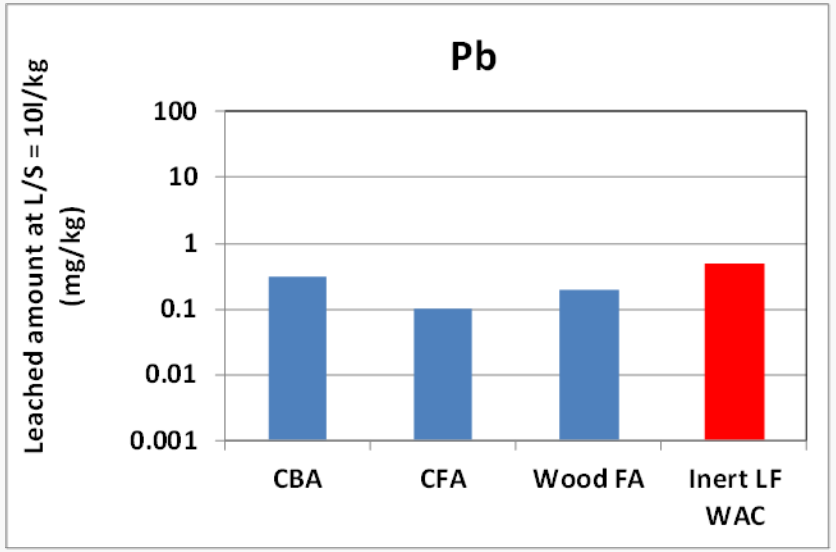


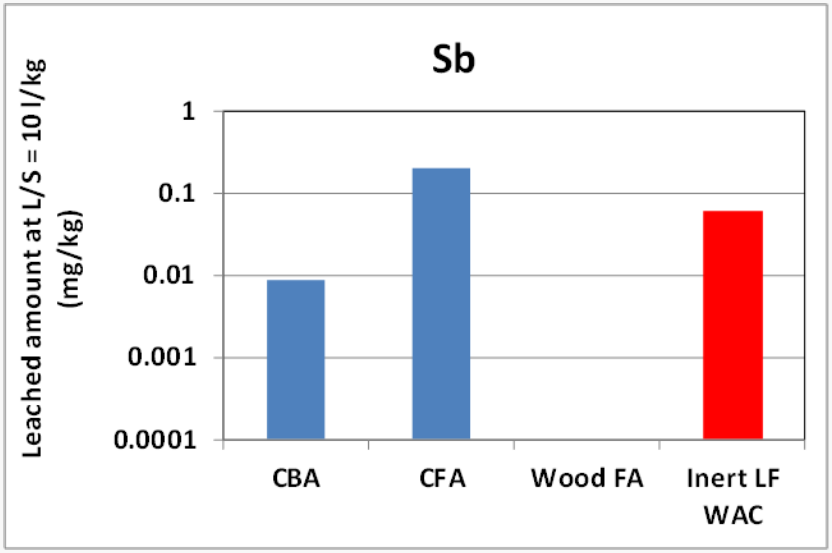


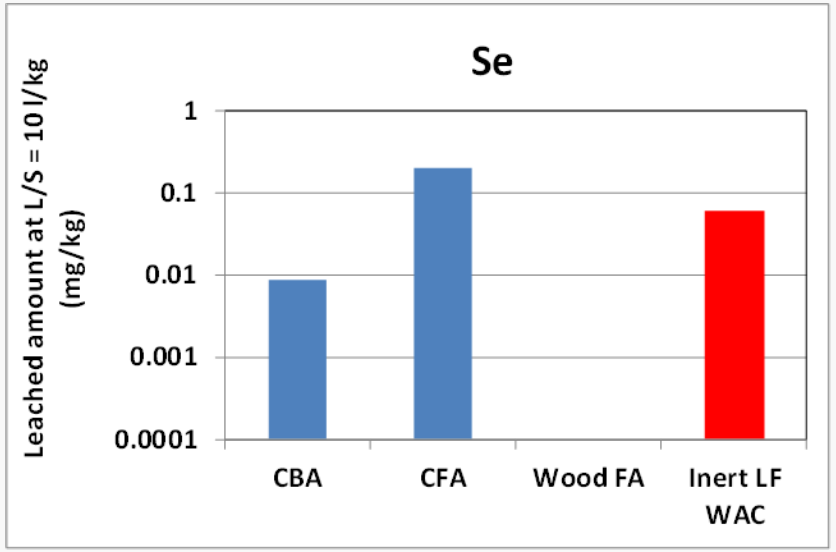


Coal FA and BA – Wood FA
Leaching data, median values

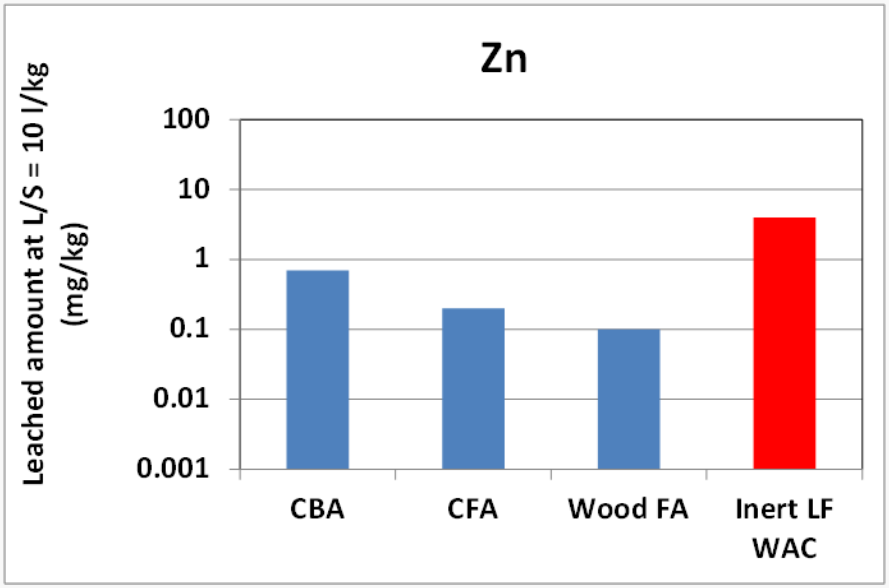








Coal FA and BA – Wood FA
Leaching data, median values



If the unstricted use leaching limit values had been applied, even CBA would not comply for As, Ba, Cd, Cr, Cu, Hg, Mo, Ni, Pb and Se.

Compliance/non-compliance of ash leaching properties with the Inert LF WAC

Substance	MSWI FA		MSWI BA		CBA	CFA	Wood FA
	DK	SE	DK	SE*	Internat.	Internat.	DK
Chloride	8	18	1223	21	92	35	1
Sulphate	8	7	1223	21	168	38	1
Fluoride	5	3					
As	8	7	1163	16	91	37	1
Ba	5	7	254	24	100	21	1
Cd	8	7	1253	24	88	37	1
Cr	8	7	1287	24	106	102	1
Cu	8	7	1316	24	81	32	1
Hg	8	3	247	24			
Mo	8	7	196	20	155	8	
Ni	8	7	1251	24	88	35	1
Pb	8	7	1253	24	88	37	1
Sb	5	18	174	15	154	22	
Se	5	7	178	15	154	23	
Zn	8	7	1252	24	91	97	1
DOC	6	14	478	12			1
Source:	DHI	Allaska	DHI	Allaska	LeachXS	LeachXS	DHI

: Compliance with Inert LF WAC

: Non-compliance with Inert LF WAC

*: Matured MSWI bottom ash

Summary and Conclusions (1/3)

- The WFD (2008/98/EC) provides an opportunity to declassify waste to become products (End-of-Waste), subject to certain conditions.

- One of the conditions is that the use of the resulting product must not lead to overall adverse environmental or human health impacts, and appropriate limit values shall be developed to ensure this.

- Waste materials obtaining EoW status are no longer subject to waste legislation, as products their use is regulated by the CPD/CPR. Test methods are European but limit values are national. Very few member states have environmental limit values pertaining to construction products.

- Waste aggregates, including ashes, are under consideration for possible development of EoW criteria.

Summary and Conclusions (2/3)

- Protection against environmental impacts should be based on leaching properties, i.e. limit values set by scenario-based impact modelling using the source-pathway-receptor chain principle. Protection against human health effects should be based on limit values on the content of potentially harmful substances.

- Two situations may be relevant for EoW assessment of aggregates:
  - Free use without restrictions or conditions (stringent limit values)
  - Use with restrictions/conditions imposed (less stringent limit values)

- Few (if any) ashes are likely to comply with the stringent leaching limit values associated with free use.

- Comparison of the leaching properties of some ashes with the EU leaching WAC for inert waste landfills may provide an indication of their performance in relation to possible future EoW criteria:

Summary and Conclusions (3/3)

- MSWI FA is likely to exceed the leaching limit values for Cl, SO4, F, Cd, Cr, Hg, Mo, Pb and Zn
- MSWI BA is likely to exceed the leaching limit values for Cl, SO4, Cu, Mo, Sb and Se
- CBA is likely to comply with the EU Inert LF WAC
- CFA is likely to exceed the leaching limit values for SO4, Cd, Cr, Mo, Sb, Se
- Wood FA (one sample, not all substances analysed) exceeded the leaching limit values for Cl, SO4 and Cr

Thank you for your attention!