

# USING ASH IN A SUSTAINABLE SOCIETY, SWEDISH R&D PROGRAMME 2002-2008

Sardinia october 2009

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[www.energiaskor.se](http://www.energiaskor.se)



[www.askprogrammet.com](http://www.askprogrammet.com)

# Svenska EnergiAskor AB

is owned by 12 energy companies  
working as trade organisation  
supporting the

"Ash Research Program":

"Environmentally friendly uses  
of non coal ashes"

of Värmeforsk

( The Thermal Engineering Research Institute of Sweden)

# **The Vision of the Ash Program**

**Combustion residues  
are resources in a  
sustainable society**

# Strategy

## for the Ash Program

- **Ashes shall be useful resources**
  - That demands competition between many possible uses
- **Balance between**
  - **Non –toxic nature and waste hierarchy**
    - Swedish EPA 2003: Utility shall be given priority when the risk for health and environment is low
- **Practical research with scientific base**
  - Universities, research centers consultants
  - Technique, Environmental chemistry,
  - Good examples, Long term trials
- **A broad funding and management**
  - **Authorities:** Energy, EPA, Geo Technique, Road
  - **Producers:** Energy (District Heating), Paper industry
  - **Research funders, Boiler producer, University**

# Research program

Environmentally friendly uses of none coal ashes  
1 m€/year since 2002. 40 companies and authorities

The Thermal Engineering Research Institute of Sweden

## Forestry



- Recycling
- When outtake of energy
- Extra Growth

## Environment



- Criteria's
- Expound laws
- Test methods
- Quality control

## Geotechnique



- Roads
- Surfaces
- Concrete
- Mining

## Land filling.



- Dense layers
- Stabilization
- Covering Mine Tailings

# Results

- The results are the results from the scientists.
- The Authorities don't automatically agree
- Specially about the balance between
  - The AIM of Poisson free Nature
  - Using wastes as resources

# Information

in English

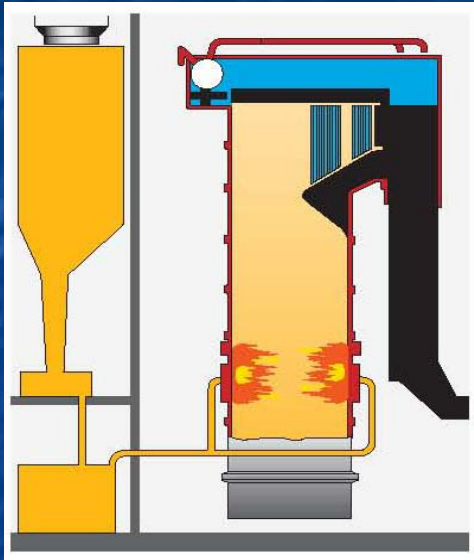
- [www.askprogrammet .com](http://www.askprogrammet.com)
- **Database Allaska**
  - Collects all results in both Swedish and English
- **Some reports in English**
  - **The major is the Synthesis of 02-08**
- **All reports have an summary in English**
- **All figures and tables have have text in English**
- **International presentations**
- **exampel: Today's speech,**
  - are found at [www.energiaskor.se](http://www.energiaskor.se)

# Ash content in different fuels

- 25% in municipal wastes
- 5% in peat (can be much more)
- 10-50% in sludge from paper industry
- 2-4% in bark, needles and branches
- 0,3-0,5% in pure wood

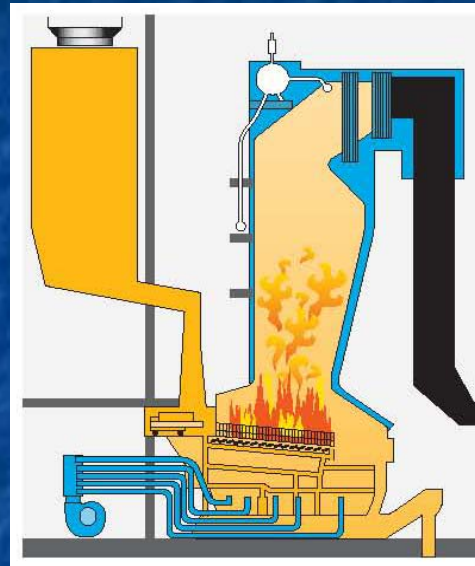
# Boilers

(the Pictures show rebuilt boilers at Söderenergi)



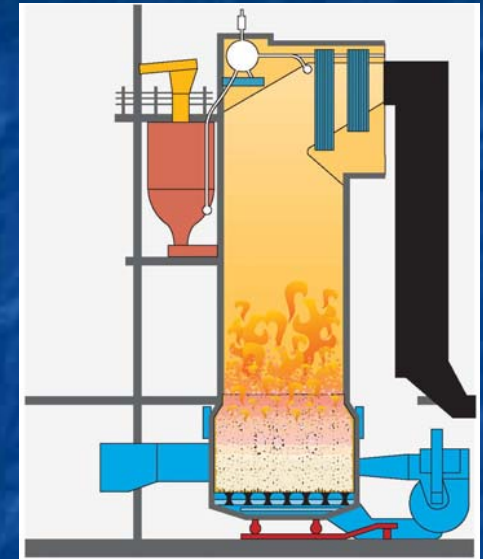
## Powder combustion

Peat, pellets  
 $\approx 1\ 200\ ^\circ\text{C}$   
Fly ashes dominate



## Grate boiler

Incinerators and  
Smaller boilers less  
than 100 MW  
All fuels as bark, wood  
chips industrial+  
household Wastes etc  
 $1\ 100\ ^\circ\text{C}$   
Bottom ashes dominate



## Fluidised bed.

All fuels as wood  
chips, peat, wastes  
 $\approx 850\ ^\circ\text{C}$   
Often equal  
amount fly/bottom  
ashes  
low NOx

# Use of ashes in Sweden 2006

Problem: Many small producers

- Roads etc 200 kton
- Forestry, Arable land 35 kton
- Backfilling to cavities 50 kton (APC)
- Construction on landfills 650 kton
- Others, unknown 175 kton
- Total 1 milj ton
- Production 1,3 milj ton T
- Construction on landfills will more or less disappear within 10-15 years

# Ashes to the forests

A Cd ion from a rotting branch is not better than the same ion from returned ash

- Ashes shall be returned to the forests
- Outtake of bio energy (branches and tops) **demands** recycling of ashes, (basic) minerals to get a sustainable forestry.
- As fertilizer of ditched forests peat land to get increased growth
- New: climate gases  $\text{CO}_2$  and  $\text{N}_2\text{O}$  will decrease!!!!  
 $\text{CH}_4 =$



# Dense layers 50/50 of ashes and digested sewage sludges (dry wt) when closure of landfills

- It is dense:  $<10^{-9}$ m/s
- It has an OK shear strength  $>30$ kPa
- It stands settlements
- It is long lasting: the biological and chemical degrading are very, very slow  
(High pH, Salts, Low percolation)

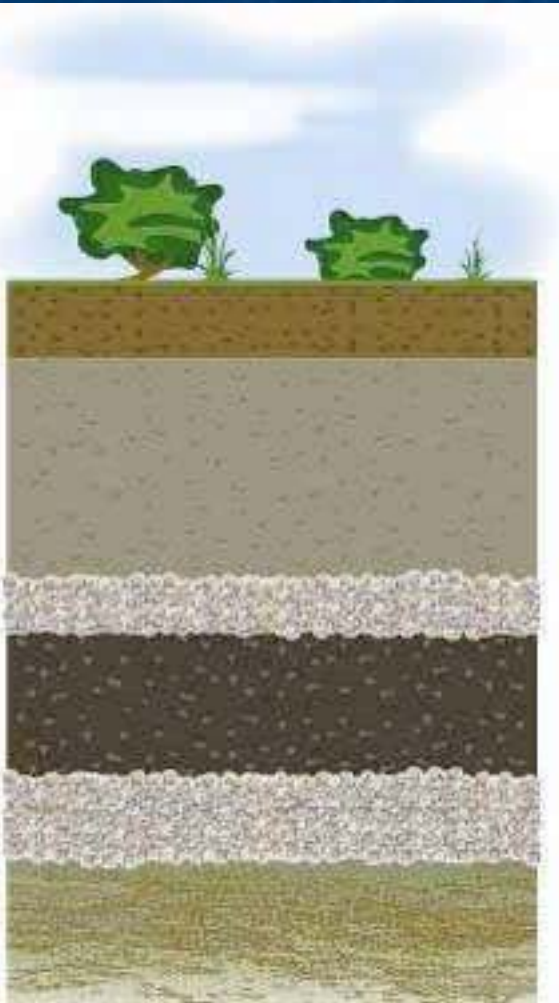


Dense layer trails at Dragmossen

# The Tveta method

see B9 Trevor et al

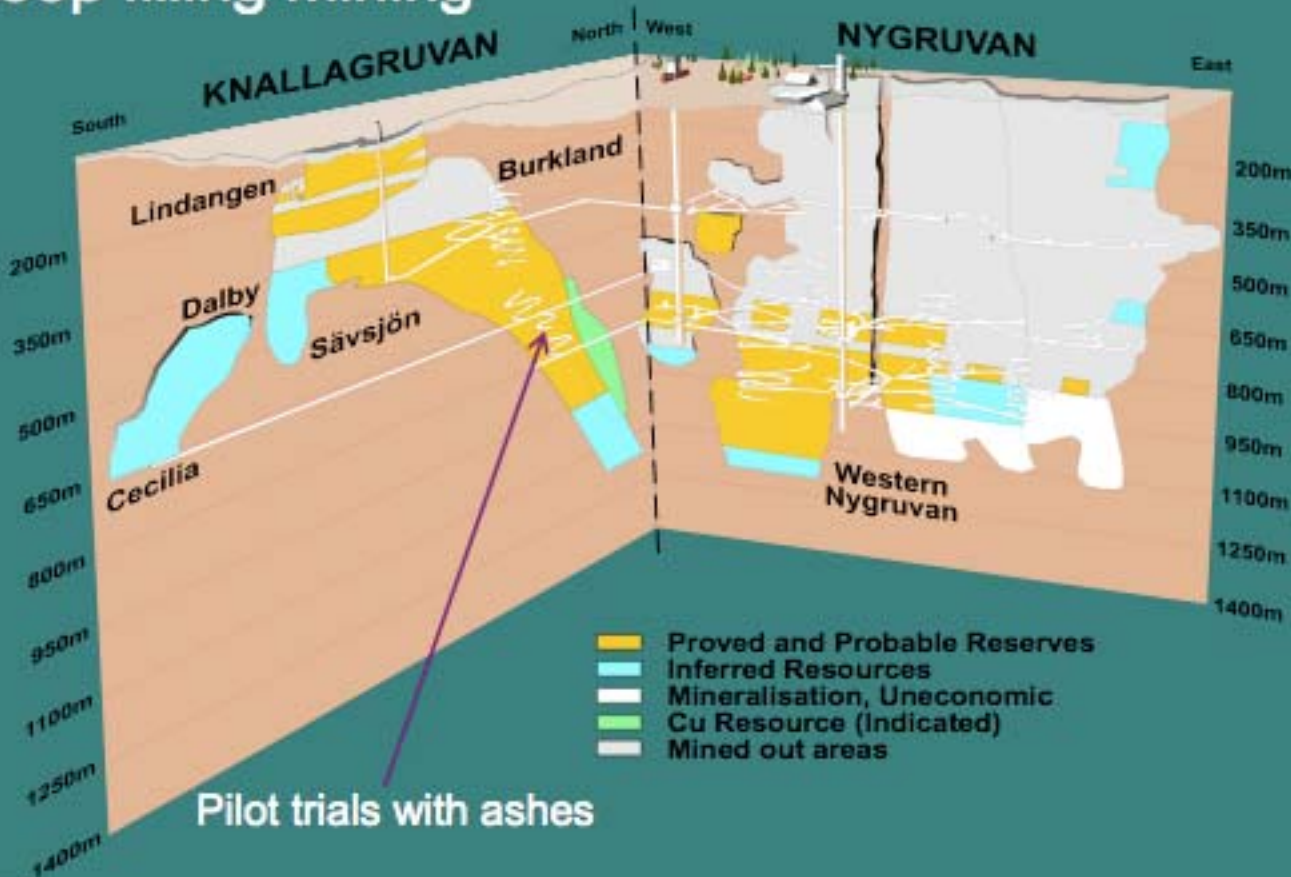
- After a lot of research work
- At the Tveta Landfill they use wastes and specially ashes in all layers
- The drainage layer with very coarse MSWI bottom ashes
- The dense layer with fly ashes and clay or only fly ashes of good quality



*Layer composition for the landfill cover system*

# Replacing Portland cement

Even non-coal ashes give similar reactions like cement.  
It can replace at least 50% of the Portland cement in  
stoop filling mining



Zink mine –  
tailings and  
cement are  
pumped into  
the cavities

# Bio/waste ashes in concrete

- Bio fly ashes cant satisfy EN 1450
  - That suits only fly ashes from SiO<sub>2</sub>-rich coals
- In concrete, bio fly ashes are good fillers and can replace some Portland cement
- Chlorides (0,1% Cl) are a problem, they corrode the armouring-iron.
- **Low quality concretes are preferred markets.**

Interesting project at Vattenfall:

- DIANAS
  - flyashes + cement as binder
  - MSWI bottom ashes as ballast

# Bio fly ashes in roads

in the sublevels



- Stiffer and stronger roads
- Stabilizes bad/old materials
- Less material! 1/4!
- Much better frost heave resistant
- Less maintenance
- No measured impact on environment
- Light weight construction

# Constructions with peat/wood fly ashes blended with 30-50% gravel



- **This plant for recycling of domestic wastes – is a light weight construction of fly ashes on clay soil**

Fly ashes have transformed this former bad farmroad to a very good road

# Constructions with bottom ashes

Very low impact of the environment



MSWI slag road is examined after 18 years of use. Very interesting scientific reports from this road



Lightweight motorway construction with roster(grate) bottom ash from coal-firing

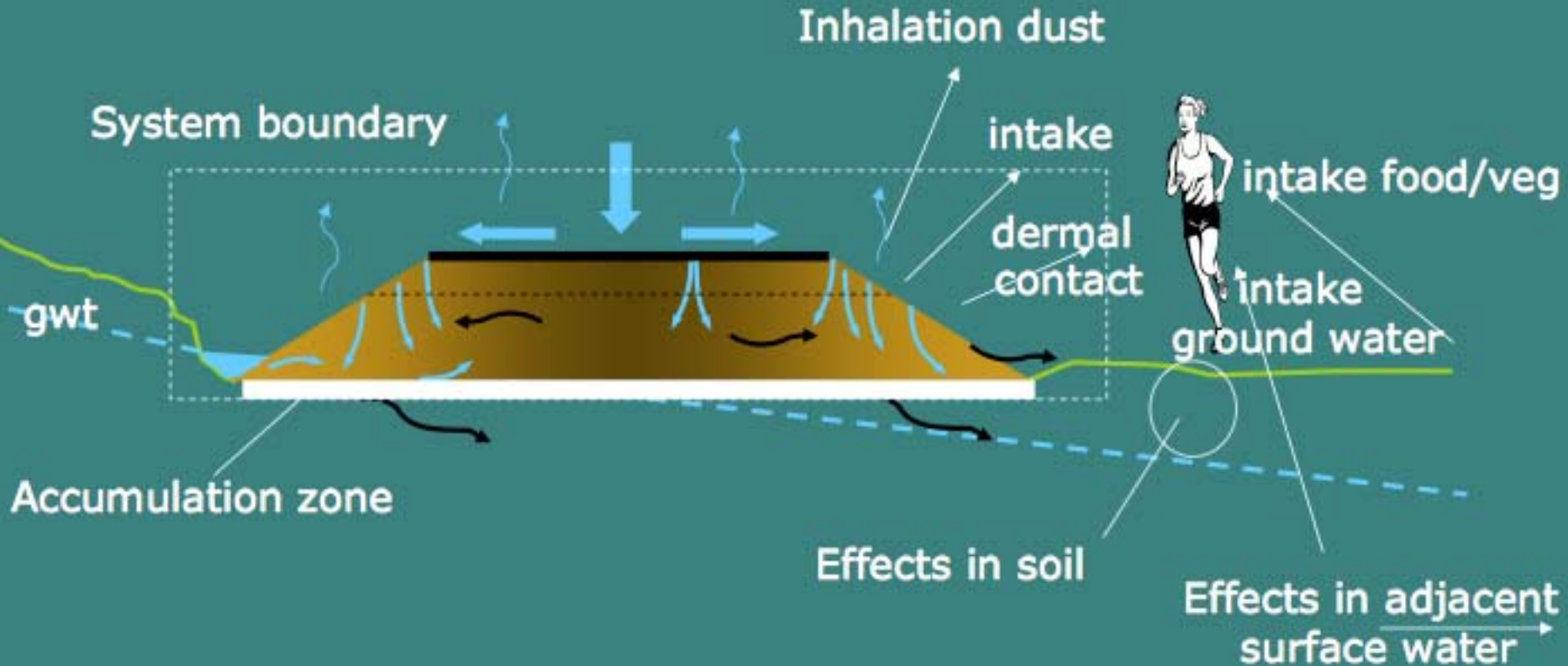


Ashes shall be tested with functional test methods as the triaxial method

# Low Risk to health and environment

- 1/100 000 to get damaged
  - To get cancer (not to die of it)
  - For one individual in the most exposed group
  - That leads to very very improbable scenarios
- Shall not increase the the amount of undesired impurities above normal variations in the recipient

# Low Risk calculation model for ashes in roads



# The critical scenario for low risk using ashes as 0,5m thick sublevel in roads without other restrictions

**Dust on vegetables are more critical than leaching!**

With one exception: Sb



Scenario:  
1/3 of his yearly intake of veg  
He hardly washes them  
Dust from  
Building the road +  
maintenance and demolition

20m



For gravel roads are calculated that ash is not used in the surface layer but some ash reaches the surface through maintenance. Moderate traffic creates dust during 64 years and 5% of the dust is ash.

Calculations are conservative as there are a lot of less known parameters,

# Low risk Leaching

- Leaching, calculated according to the TAC model for landfills, is not critical for the local risk for ashes.
- Regional risk, i.e, many roads with ashes in a watersystem leads to more stringent limits
  - – but most ashes including MSWI bottom ashes will still give low risk for health and environment when used for building roads

# Low risk leaching of antimony

- EU:s groundwater directive for Sb is based on what once was measurable. 5mg/l
- A toxical based limit should be 20 mg/l !!!!
- If the EU value is the limit than, then that must be taken in consideration for some constructions with ashes
- One CFB- plant has solved it with not burning fire protected plastics from electronics

# Low risk leaving a road

- The scenario is that the road is left in open with the ash at the surface
- and a person:
  - walks on it 40 windy days a year
  - inhales a lot of dust
  - has oral intake
  - eats 1 kg/y of plants that has taken up a lot of metals

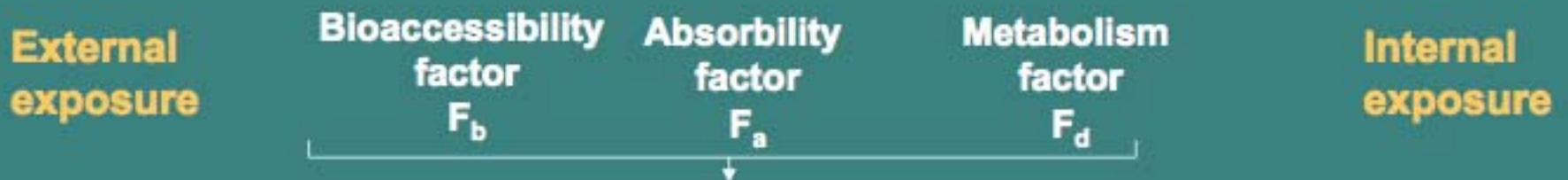
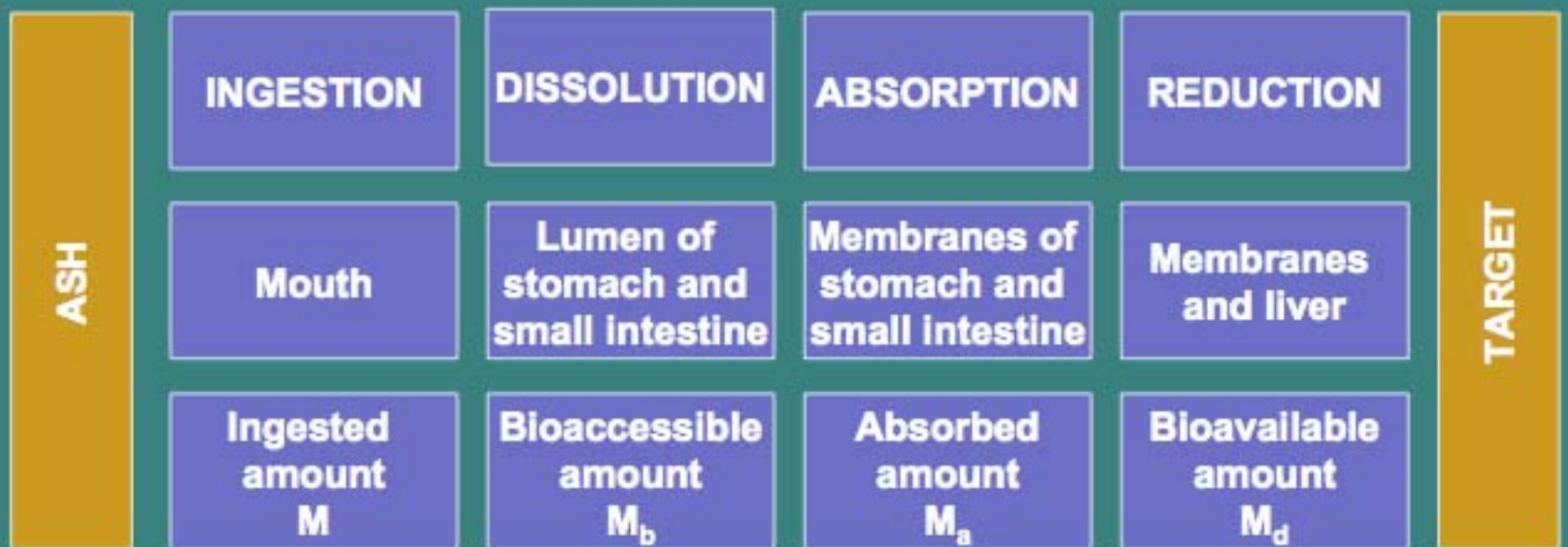
# Max contents

	Pb	Cd	Hg	Zn	As
90% of Swedish Morain Free use due to Sw EPA No risk	20	0,2	0,1	120	10
Ashes to forests due to Swedish Forests Agency	300	30	3	7 000	30
Low local risk gravel roads	1 400	330	80	>2,5 %	55
Low risk leaving ashes at the surface exposure 40 days/y	1 500	60	60	> 5%	15

# Low risk. In vitro trials

- For oral intake you normally suggest that 100% goes into the blood and pass the liver and the cell membranes into the cell etc
- SGI have made in vitro tests to look at the first step; that is what is leachable in solutions like the mouth , stomach and intestines ( $F_b$ )
- The show figures has taken in account the this first step
- and how much of the toxic limits are likely to be "occupied" by natural impurities

## Definition of Bioavailability



Oral bioavailability:  $F_{bad} = F_b \times F_a \times F_d$



# How to comply with the hazardous waste directive?

- A special methodology has been developed based on referens substances (Rolf Sjöblom who has the poster **D1** at the conference)
- The methodology has been applied to > 30 plants
- The Swedish EPA disagrees with the criteria for ecotoxicity in the methodology
- "So we must
  - Look at how zinc occurs in the ashes
  - develop a method for ecotoxic studies for ashes

# H-14 ecotox

- 3 reports strongly indicates that zinc mostly is in the form of silicates or ferrite in wetted ashes
  - (for MSWI fly ashes  $Zn(OH)_2$  might dominate)
- Tests for ecotoxicity has been done on brack water organisms: Algea Shrimp, Fish embryo and Bacteria.
- At L/S 10 all ashes **but for old MSWI-bottom ash** was at least somewhat ecotoxic.
- **But most of it was depended on  $Ca^{2+}$  and  $K^+$ !!!**  
**(New and unexpected) Not on exotoxic ions!**
- The work is continued by ITM and SGI

# Organics in ashes

## is not a big problem

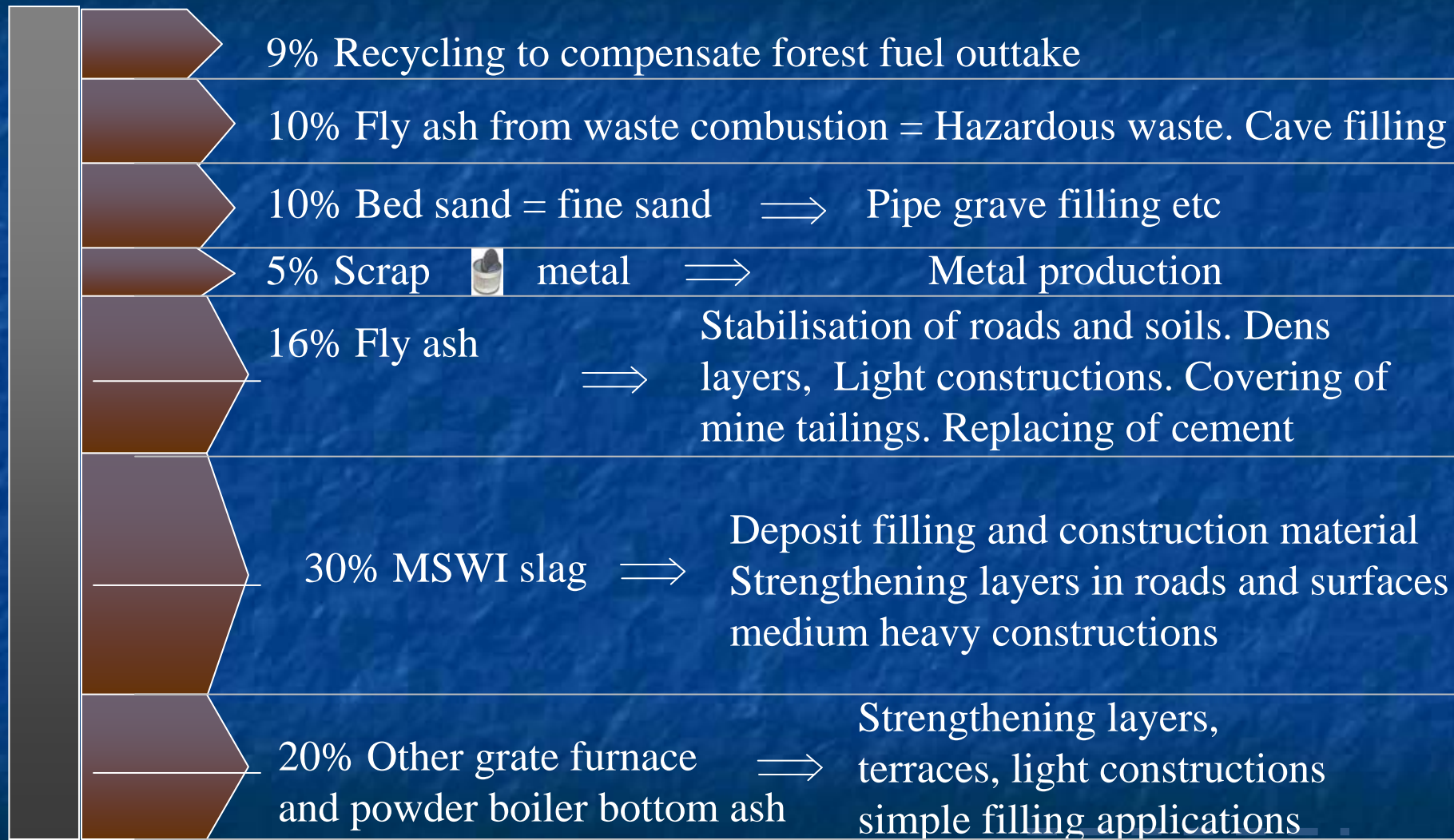
- LOI shows not only unburned but also chemical bonded water for wetted ashes.
- TOC (total organic carbon) shows total oxidize able carbon
- Most of TOC in ashes are mineralogical coal
- Very little is organic poisons
- The amount of organic poisons is not connected to TOC
- PAH's in fuels are destroyed, **PAH's in residues originate in imperfect combustion** and the concentration can be rather high when something goes wrong.
- For modern incinerators the total amount of dioxins are lower in the fly ashes than in the incoming household wastes -a Swedish Waste study in close contact with EPA

# Uses shall be given priority when the risk for health and environment is low

- As risks always are calculated in a conservative way it gives a good balance between
  - Poison free nature and
  - The waste hierarchy
- *Low risk calculations gives that most ashes can be used as resources in a sustainable society*

# What can non coal ashes be used for?

1,5 milj tons in Sweden 2008



Thanks for your attention

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you are welcomed to mail me

This presentation will be published at

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The syntheses of the ash  
programme 2002-2008 and the  
database Allaska is published in

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