

Environmentally friendly use of non-coal ashes

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www.energiaskor.se

www.askprogrammet.com



Research program

Environmentally friendly use of non-coal ashes

Duration 2002 – 2008, 40 companies and authorities

The Swedish Thermal Engineering Research Institute
(Värmeforsk)

Forestry



- Recycling
- Growth

Environment



- Criterias
- Law
- Test methods
- Quality control

Geotechnics



- Roads
- Surfaces
- Concrete
- Mining

Landfilling



- Dense layers
- Stabilization
- Covering Mine Tailings

Information

- This speech and Allaska will be found at www.energiaskor.se
- Allaska (All ashes)
 - Database
 - All results from the Ash Programme and some more
 - Environmental and technical results
 - Will get an English manual not later than October 06
 - Are free to all

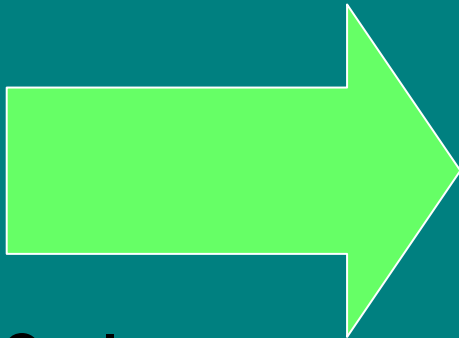
The research program has a width

- Broad Research
 - Environmental technology
 - Environmental law
 - Chemistry
 - Combustion
 - Forestry
 - Biology
 - Pelletizing
 - Mineral technology
 - Land filling
 - Geotechnology
 - Road building
 - Hydrology
 - Cement & concrete
 - Mining
- Participants
 - Authorities
 - Ash producers
 - Boiler producers
 - Consultants
 - End users
 - Scientific researchers

= A very good network
- Applied but also scientific
- Information

Solid Fuels in Sweden

Biofuel



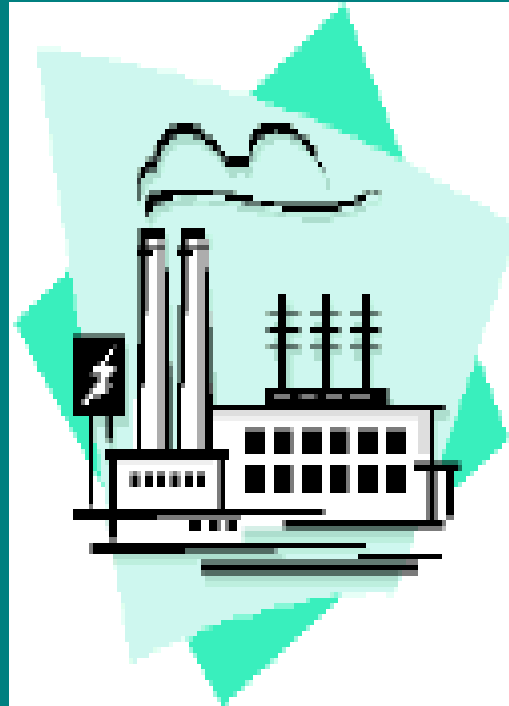
Coal



Waste



Peat



Electricity



Steam for industry



District Heating

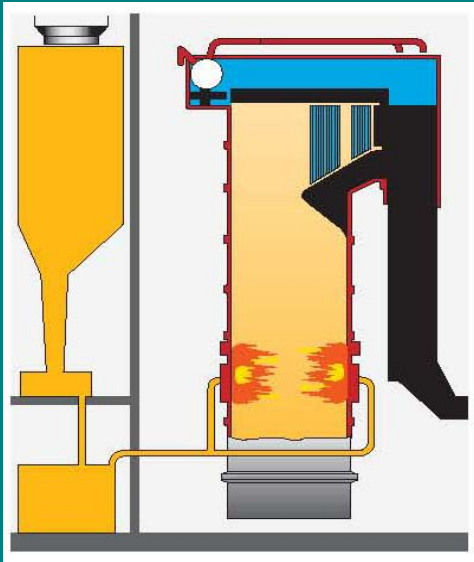


Ashes from different fuels

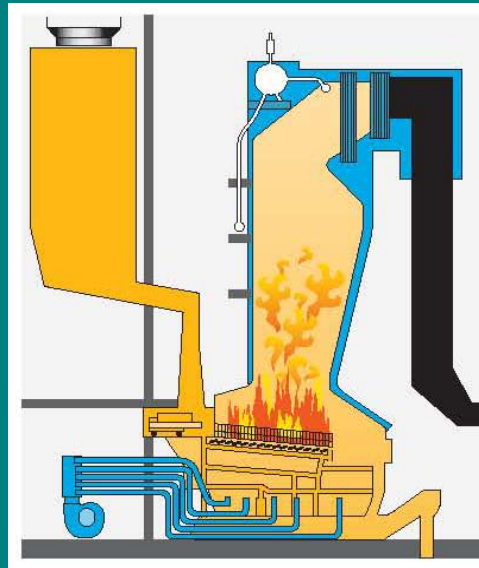
- 25% in municipal wastes
- 5% in peat (can be much more)
- 10-50% in sludge from the paper industry
- 2-4% in bark
- 0,3-0,5% in pure wood
- 8% in coal (Russian steam coal)
- 0,005-0,03% in oil

Boilers

(the pictures show rebuilt coal boilers at Söderenergi)

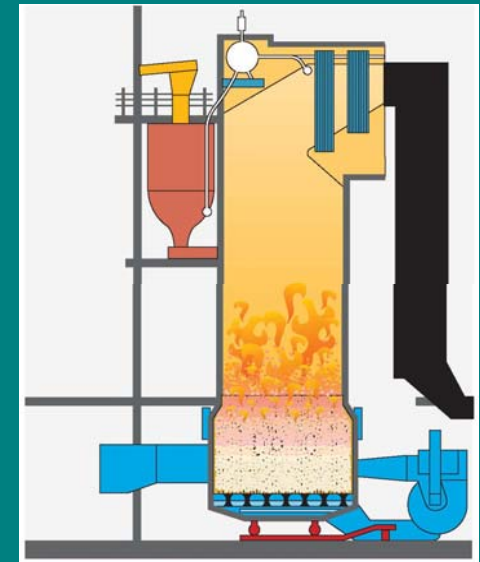


Powder boiler for
peat and pellets
(= coal boiler)
 $\approx 1\ 200\ ^\circ\text{C}$



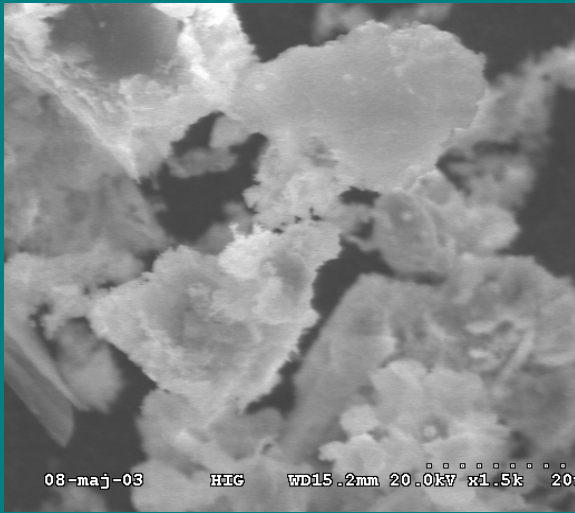
Grate boiler for
industrial wastes
 $\approx 1\ 100\ ^\circ\text{C}$

(It's not an incinerator
as the main purpose
is to produce heat even
if the fuels are wastes)



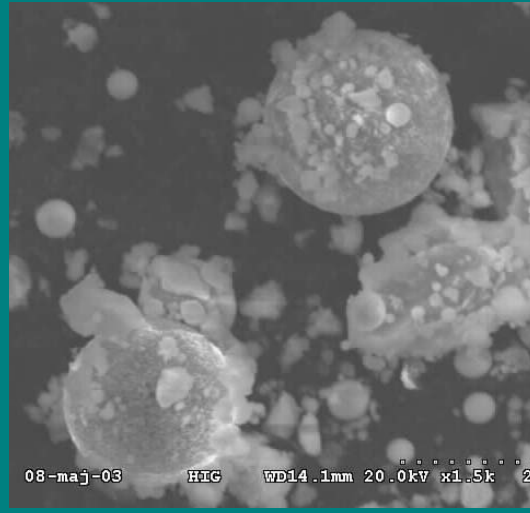
Bubbling fluid bed
for cut logging
and peat
 $\approx 850\ ^\circ\text{C}$

Particle shape of fly ashes



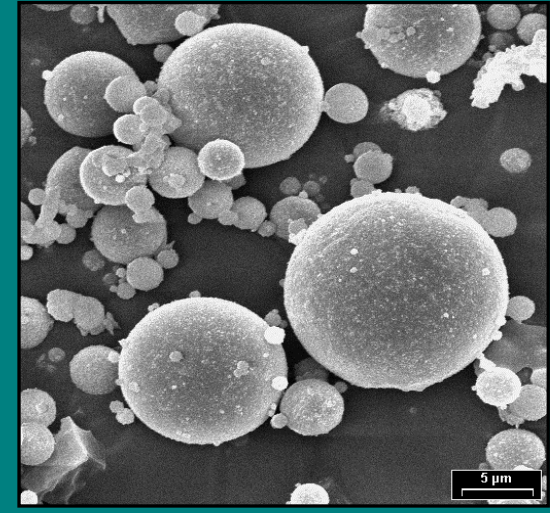
Fluid Bed - Biofuel

850 °C



Powder Boiler – Peat

1 150 °C



Powder Boiler – Coal

1 200 °C

Ash production in Sweden 2003

Grate Combustion	<u>Bottom ash</u>	<u>Fly ash</u>
Wastes household + ind.	400 000	70 000
Coal + rubber	15 000	10 000
Paper ind. bark sludge	100 000	60 000
Waste from buildings	15 000	5 000
Woodchips/peat	20 000	5 000
Sawmill industry	20 000	10 000
Powder Combustion		
Coal	10 000	30 000
Peat/woodchips etc	25 000	60 000
Fluid Bed Combustion CFBC, BFBC		
Woodchips/peat	25 000	25 000
Paper industry	30 000	70 000
Wastes household + ind.	20 000	30 000
Waste from buildings	15 000	15 000
Coal (PCFBC)	<u>20 000</u>	<u>20 000</u>
Total:	715 000	410 000 (about 20% moisture)

Uses of ashes in Sweden 2005

Forestry	15 000 t FBC wood fly ashes + grate bottom
Road building	20 000 t FBC peat/wood fly ashes
Parking places + other surfaces	40 000 t MSWI bottom ashes
Parking places + other surfaces	90 000 t powder peat/coal + other fly ashes
Surfaces for drying slimes	40 000 t bio fly ashes, some bottom ashes
Filling of former oil storage-cavern	20 000 t CFBC waste + other fly ashes
Covering of mine tailings	14 000 t CFBC fly ashes
Stabilization of MSWI fly ashes	30 000 t PCFBC coal ashes
Construction material at landfilling	300 000 t MSWI bottom ashes + other ashes
Other	31 000 t
<hr/>	
Total	600 000 t

MSWI = Municipal Solid Waste Incineration

PCFBC = Pressurized Circulation Fluid Bed Combustion



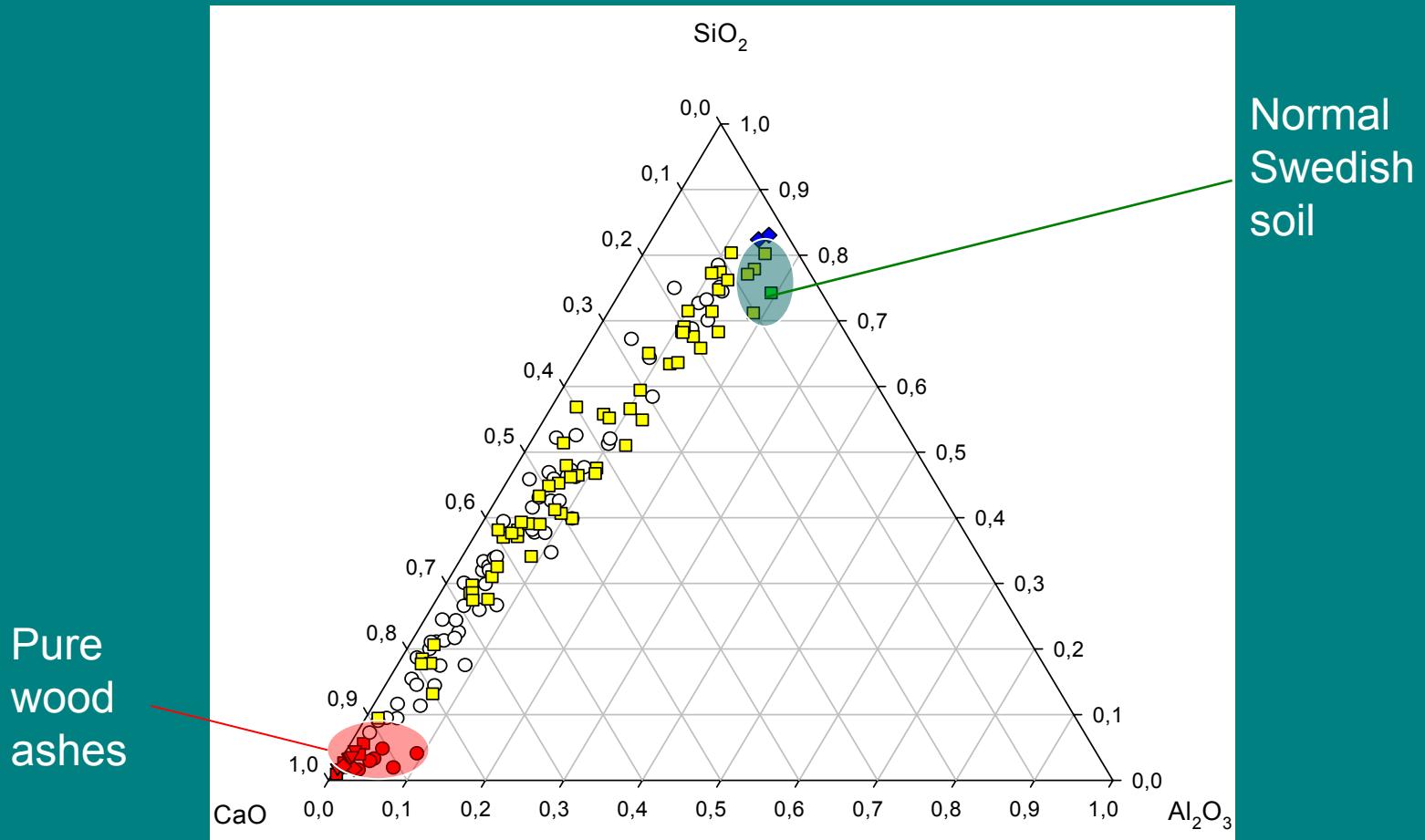
Our aim with ashes

- Ashes shall be used as resources
- Ashes shall be used where the benefits are as great as possible
 - This demands competition between many uses
 - Benefits imply both environmental benefits as well as economical benefits

Bioashes

- Ashes from trees hold a lot of CaO and less of SiO_2 and Al_2O_3
- Ordinary mineral soils in Sweden hold a lot of SiO_2 , somewhat of Al_2O_3 and very little of CaO
- Most bioashes reside between soil and pure woodashes

Bioashes from grate boilers



Recycling of ashes

Tops and branches will more and more be used for production of energy

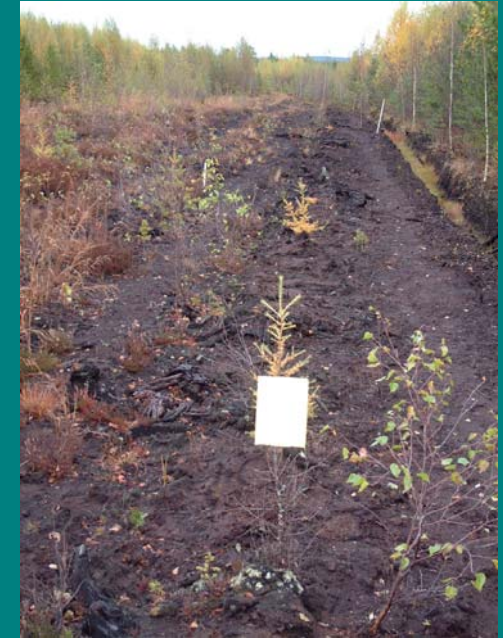
The outtake of both timber and energy will increase the outtake of nutrients more than the soil can compensate for in the long run.

Especially a problem in SW of Sweden where acid rains and low buffering capacity are common.



Recycling of/fertilizing with ashes to forests

- Returns P, K, Ca, Mg to the forests
- Lowers the acidification of the soils and waterstreams
- Increases the growth rate on organic and some minerogenic soils
- The high pH effects the nitrogen balance in the soils



Test surfaces
with without
ash fertilizing on peat soil

Ashes to the forests



The ashes must be treated before recycling: Matured, self hardened, crushed and sieved (as in the picture) or pelletized ashes so that the pH and/or the osmotic pressure will not be too high. So it is as expensive as landfilling (including taxes for landfilling of 40€/tonne).

The Ash programme tries to find benefits so that landowners will pay some of the costs.

Ashes to forests in the Ash programme

- 200 000 ha ditched forest peat soils (=organic soils) are suitable for profitable fertilizing with ashes in Sweden. The extra growth pays the costs. The effects on the climate gases are under investigation.
- Better health and higher growth rate for spruce on minerogenic soils in SW of Sweden

RecAsh

Regular recycling of wood ash to prevent waste production

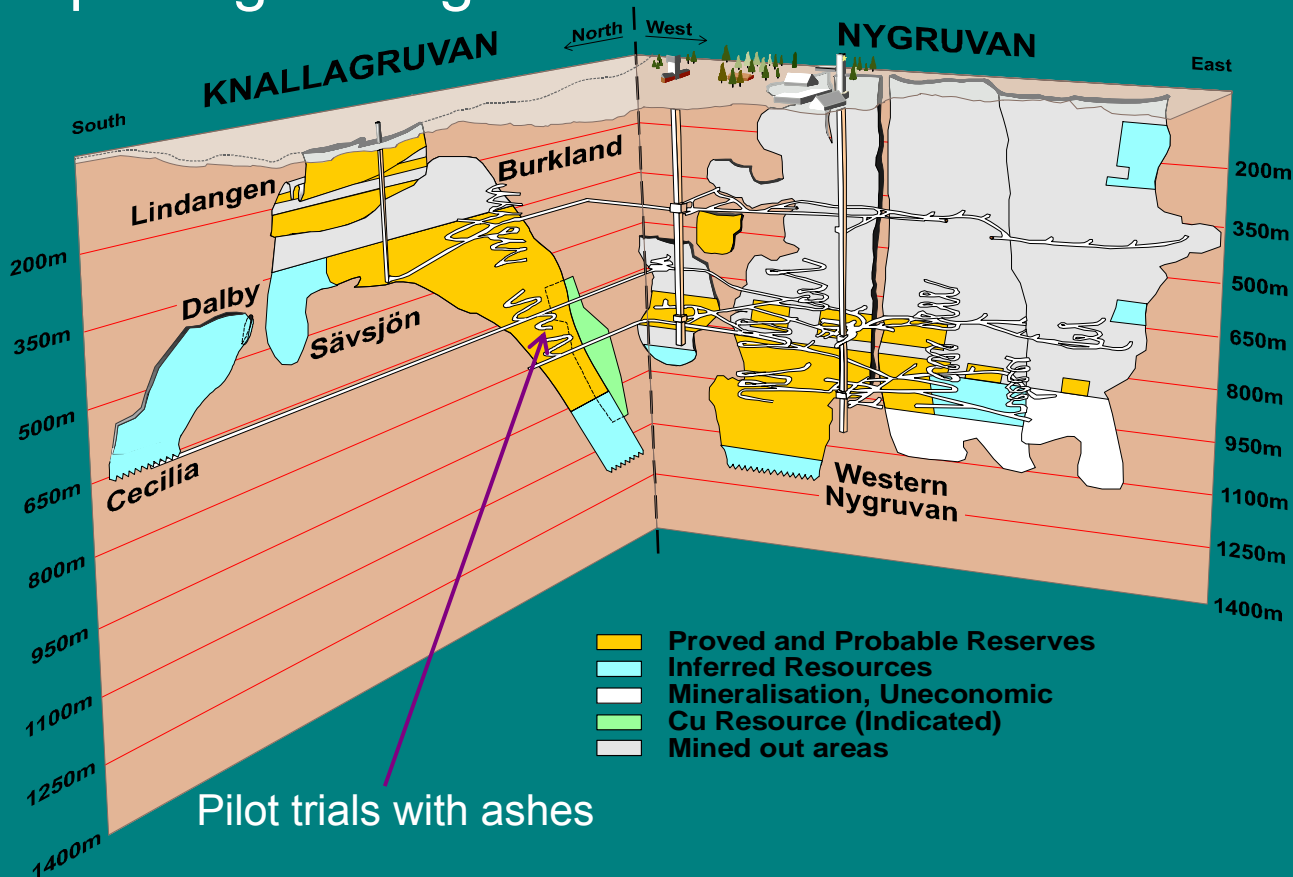
- An EU Life-Environment project
- Is a good description for recycling of ashes to forests

Read more in english :

www.recash.info

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

Pilot trials with ashes

Concrete

- Bio fly ashes can't meet EN 450
(that suits only SiO_2 -rich coal powder fly ashes)
- In concrete, bio fly ashes are good fillers. Chlorides (Cl^-) are a problem, they corrode the reinforcement iron.
- Low quality concretes are recommended markets for bioashes. There bio fly ashes can replace part of the Portland cement.

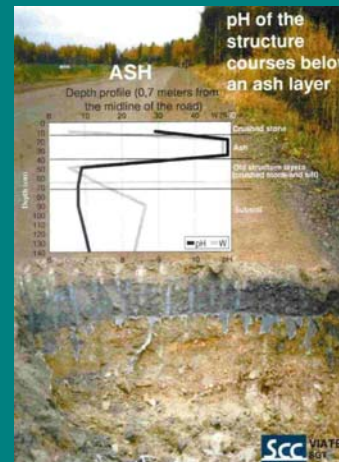
Constructions with bio fly ashes



This plant for recycling of household wastes is built on a light weight construction made of fly ashes on clay soil



Fly ashes have transformed this to a very good road



Lahtinen has shown that fly ashes in the reinforcing layer give frost resistant roads

Main road 90

Bilder från Rv 90 och Ålandtippen (blandning)



- Fly ashes in the terrace of the road
- The road became stiffer with 9,5% bio fly ashes
- 0,5% binder (Portland cement or Portland cement + lime or blast furnace slag)
- The maintenance will be lower
- Analyses can't discover any hazardous impact on the environment

Leach tests fly ashes

- Leach tests shall be done on hardened/matured fly ashes
- While waiting for methods for monolites, we suggest tests after 28 days of hardening
- In all databases, the duration of hardening should be declared

Constructions with grate bottom ashes

Very low impact on the environment



MSWI slag road is examined after 18 years of use.



Lightweight motorway construction with grate bottom ash from coal-firing



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

Grate bottom ashes are mostly OK as lightweight road building material

Handbooks

An ambitious handbook for alternative constructive materials in roads and railroads is made 2005-06 by 20 authorities and companies.

There will be special handbooks for:

- Bio fly ashes
- MSWI bottom ashes and other bottom ashes
- Cut rubber
- Foamed waste glass
- Crushed concrete
- Metallurgical slags

Dense layers of ashes and municipal sludges

when finalizing landfills

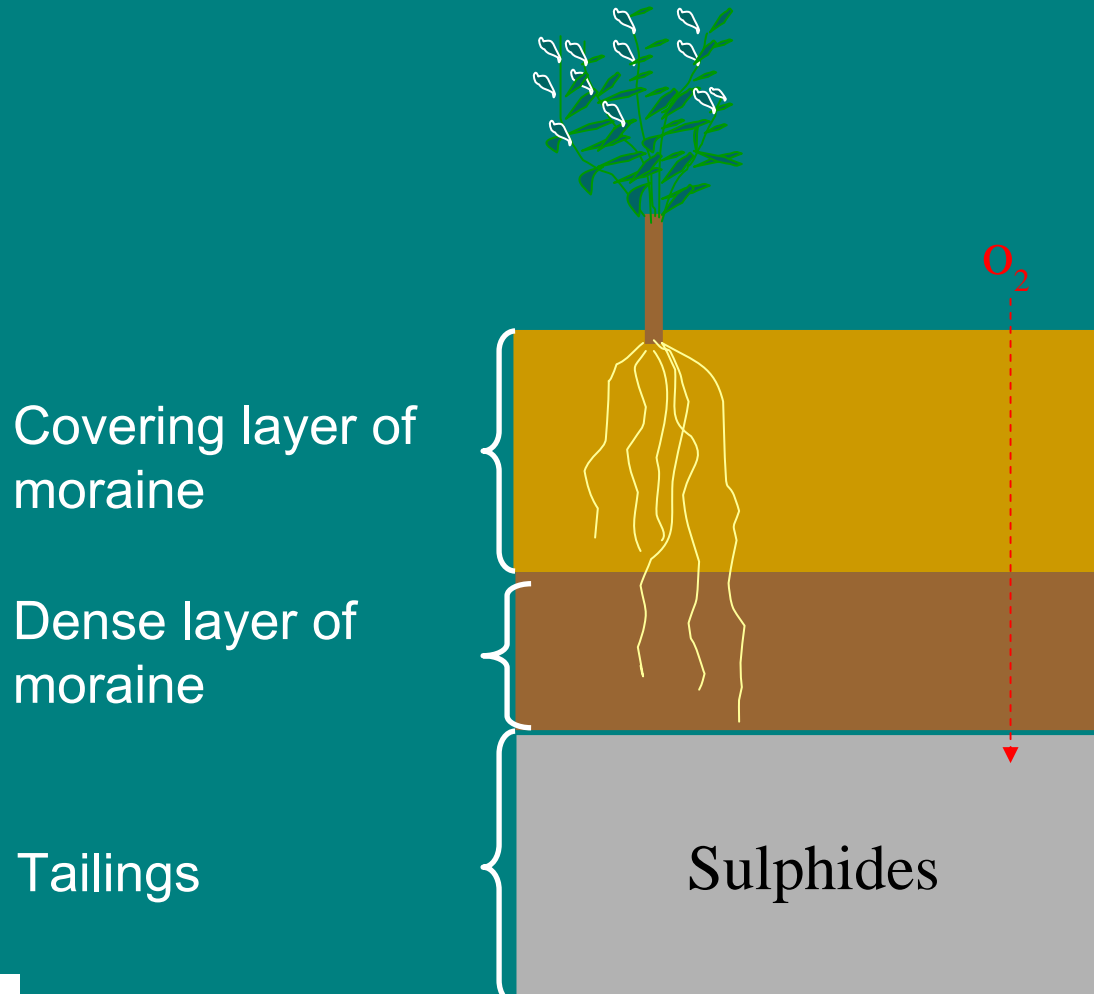
- FSA = 50/50 dry wt fly ashes/sludge
- It is dense 10^{-9} m/s
- It has an OK shear strength of 30 kPa
- It is longlasting: the biological and chemical degradation is very very slow due to:

High pH, salts, low percolation



Dense layer trails at Dragmossen

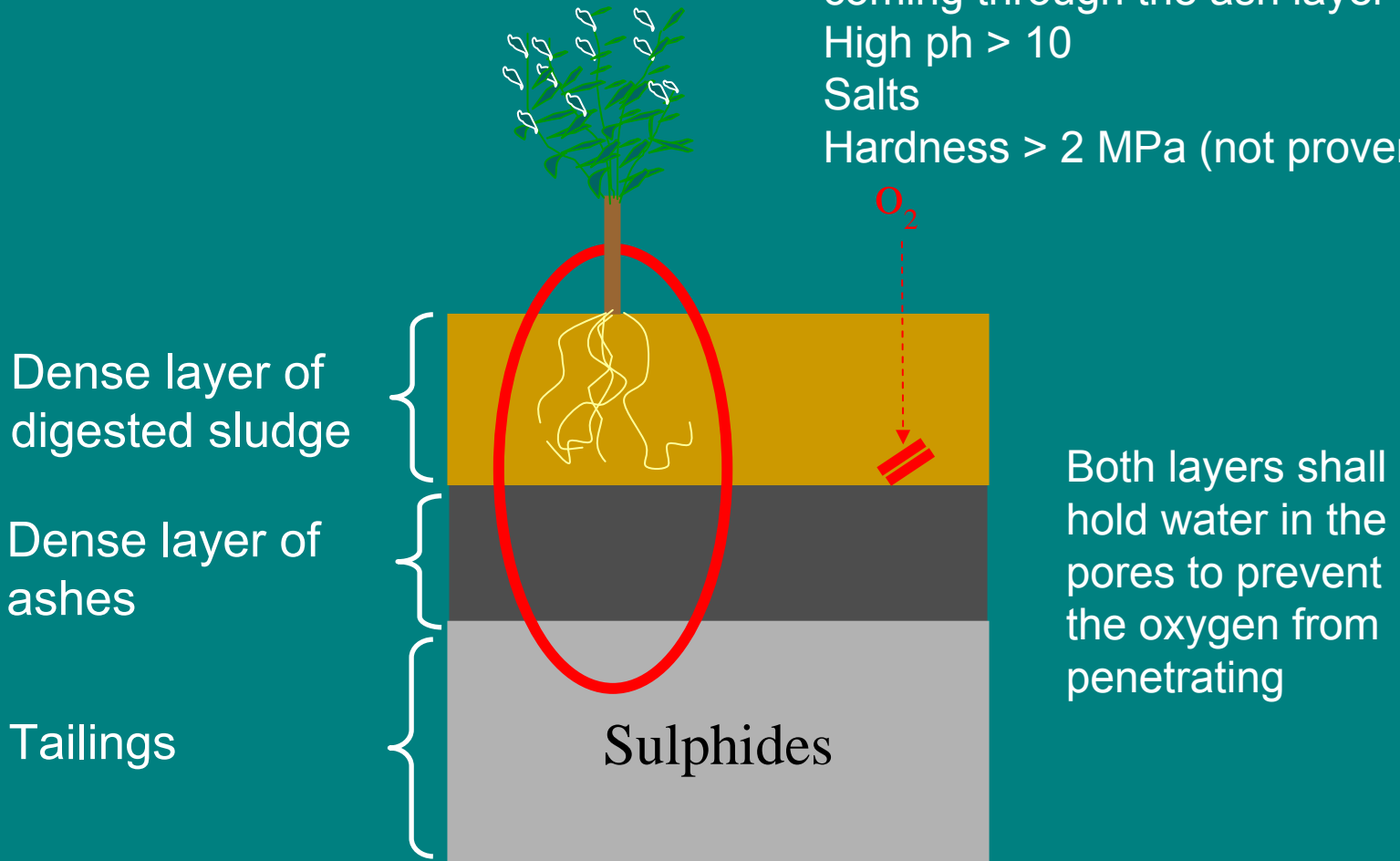
Covering Mine Tailings



Claes Ribbing, Svenska
EnergiAskor AB

Covering Mine Tailings

Fly ashes prevent the roots from coming through the ash layer
High pH > 10
Salts
Hardness > 2 MPa (not proven)



Covering Mine Tailings



Gillervattnet tailing pond at Boliden

A layer of fly ash between layers of municipal sludge prevents oxygen from reaching the sulphuric tailings. We are looking for plants that will give an “eternal” protecting top layer.



Covering Mine Tailings



Different projects

- MSWI
 - Hydrogen gas develops in water mostly from FBC fly ashes and grate bottom ashes due to Al^0
 - It is difficult with selective mobilization to alter the classification of MSWI ashes for landfilling
- MSWI-slag in roads
 - Low significance between pH and L/S 10
 - Low impact on the environment
 - LCA method for a county is developed
 - Falling weight deflector meter tests are OK after some years
- FBC bottom ashes (=boilersand)
 - Are good as sand for pipe trenches
 - Leaching of Sb is a problem when the fuel contains plastics

“Unburnt” in ashes

EN 13137

TOC = Total organic carbon

(More correct: TOC = Total oxidizable carbon)

Measures total organic and mineralogical carbon

TOC is normally the best method for measuring unburnt in ashes

LOI is OK for dry fresh ashes from powder combustion

“Unburnt” in ashes

- Loss on ignition LOI measures unburnt
 - and chemically bound water in $\text{Ca}(\text{OH})_2$
 - and in gypsum dihydrate and ettringit
- LOI 1000°C also measures
 - CO_2 from (CaCO_3)
 - SO_2 and some chlorides - oxidation

Environmental guidelines

Bendz et al has developed a method for calculating risks when using ashes. They have calculated that:

- MSWI slags below asphalt present a low risk
- Bioashes below some gravel present a low risk in gravel roads
 - Leaching is not so critical
 - Dusts on vegetables 20 m from the road during a lifetime are most critical
 - Lifetime means that the same person is affected during construction, reparation and demolition
 - For gravel roads, dusting from part of the ashes during 64 years are included
 - As and Pb are the most critical elements

The report will be published during the summer 06, so far only in Swedish with a summary in English

How to comply with the hazardous waste directive?

- Necessary to identify reference substances as follows
 - Known properties with regard to health and environment
 - Should represent relatively realistic forms for the element in question
 - Should represent actual substances in a conservative manner

How to comply with the hazardous waste directive? Continued.

- A special methodology has been developed on commission by
 - Branch organisations for heat generation and waste management (Swedish Thermal Engineering Research Institute, Ash Programme and Swedish Association of Waste Management – RVF)
 - The Swedish Environmental Protection Agency (EPA) (with support from the Swedish Chemicals Inspectorate)
- The methodology has been applied to > 20 plants
- The Swedish EPA disagrees on the ecotoxic recommendations

Ecotox H14 continued

- The Swedish and other EPAs wish to classify the waste as hazardous if it exceeds a sum of 0,25% ecotoxic substances
- Then they must look at less conservatively chosen substances
 - That is difficult but can be done
- A limit of 0,25% ecotoxics is a threat to all uses of ashes
 - That is not environmentally friendly as many are good resources with low environmental impact

Ecotox H14

Reference substances in ashes as to			Theoretical content	Measured contents in	Measured contents	Allowed contents for
Värmeforsk report 866		ekotox	in ashes	bioashes	in MSWI slags	recycling ashes
Metal	substance	factor	from spruce pine	from woodchips		to forests
			Backlund	Median Values	Mean Values	in Sweden
				Steenari et al	RVF 02:10	SKS
Sb	Sb2O3	0				
Ba	BaO	0				
As	As2O3	1	0,004	0,001	0,005	0,004
Pb	PbO	1	0,072	0,019	0,138	0,032
Cd	CdO	0				
Cu	CuO	1	0,084	0,115	0,531	0,050
Cr 50%	CrO3	1	0,032	0,001	0,048	0,010
Cr 50%	Cr2O3	0				
Hg	HgCl2	1	0,001	0,000	0,000	0,000
La	La2O3	0				
Mo	MoO3	0				
Ni	NiO	0				
V	V2O10	1	0,012		0,006	0,013
W	W03	0				
Zn	ZnO	1	0,415	0,249	0,433	0,872
Sum of ecotoxic			0,620	0,385	1,161	0,980

Ecotox H14 continued

- The Ash programme and RVF recommend since May 2004 2,5% as limit for hazardous waste while waiting for relevant methods
- That is the limit for a product to be marked as hazardous
- That is also based on conservatively chosen substances
- The leaching is lower for metals in ashes than for metals in the substances

Ecotox H14 Continued

- “The Environmental history of the Falun Mine” shows (based on scientific results):
 - A terrible outlet of metals during 600 years
 - A moderate longterm impact on nature
- Other results point in the same direction
- It is a low risk to wait for more adequate methods to accept that it is not until over a sum of 2,5% ecotoxical substances that wastes are recommended to be regarded as hazardous

Environmentally friendly uses of ashes 2006-2008

The programme will continue for another 3 years:

”At the end of 2008 it shall be possible to find environmentally friendly applications for 90% of the ashes produced in Sweden”

There are a lot of uses of non-coal ashes that are more environmentally friendly than pure landfilling.

How can we convince the authorities of that?

How can we cooperate internationally?

www.energiaskor.se

