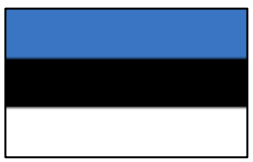
Overview on Combustion and Retorting of Estonian oil shale, environmental concerns and solutions

Uuve Kirso

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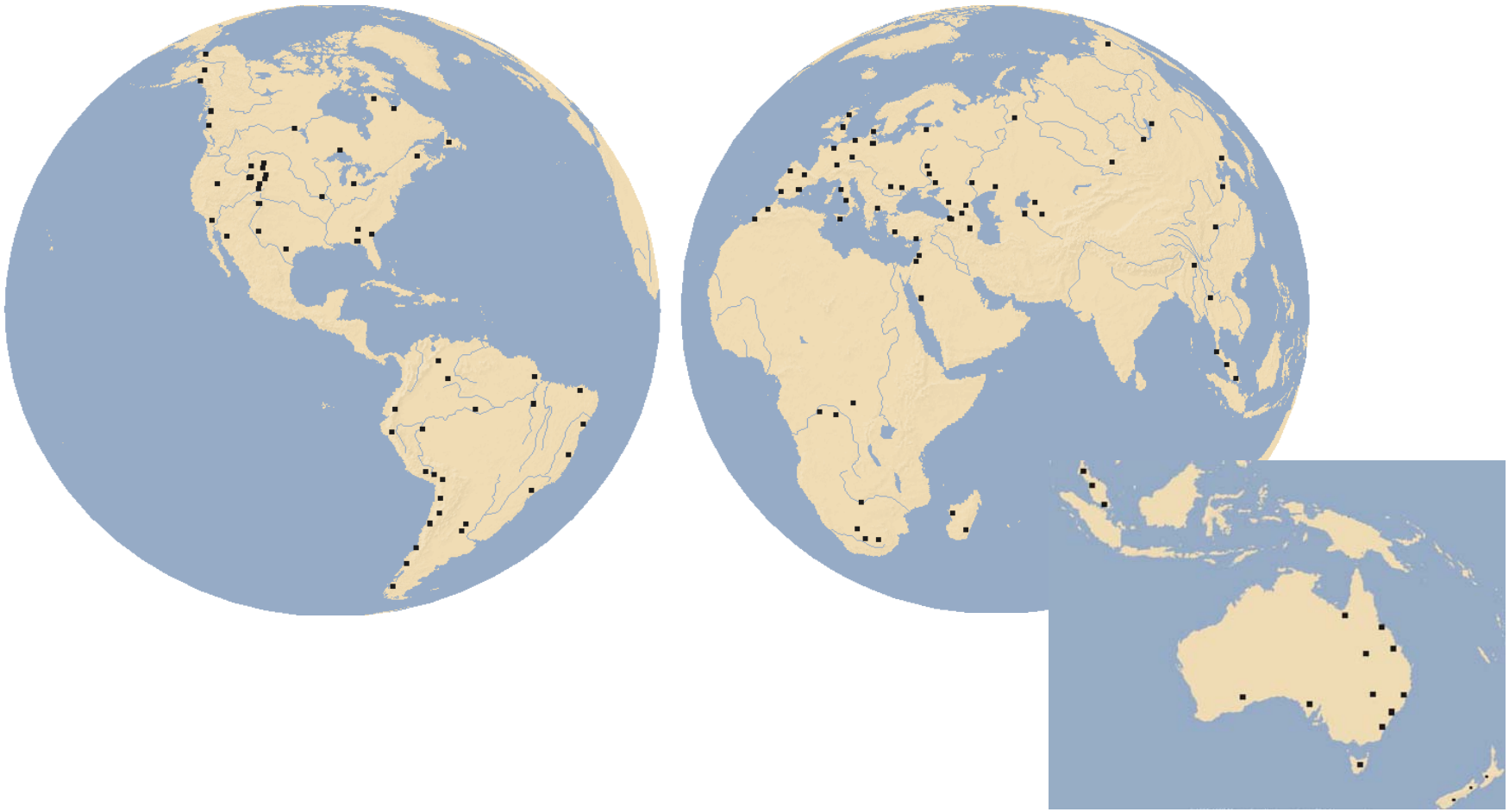
Environmental impact of energy generation
Atmospheric pollution
- chamber experiments
- health effects of fly ash
- mobility of pollutants
- significance of combustion technology

Oil production
- environmental impact
- spent shale wastes
- mobility of pollutants

Reuse of wastes
Conclusions
Co-authors
Acknowledgement

Oil shale deposits worldwide



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Oil shale reserves

411 x 10^9 t

or

2900 x 10^9 barrels of oil equivalents

A significant strategic energy source

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Exploitation and use

Brazil, Germany, China, Australia, Russia, Israel **...**

... Estonia
world's largest deposits of commercial significance (since 1916)
for producing oil (retorting 500-550 ^{o}C)

and combustion for power generation

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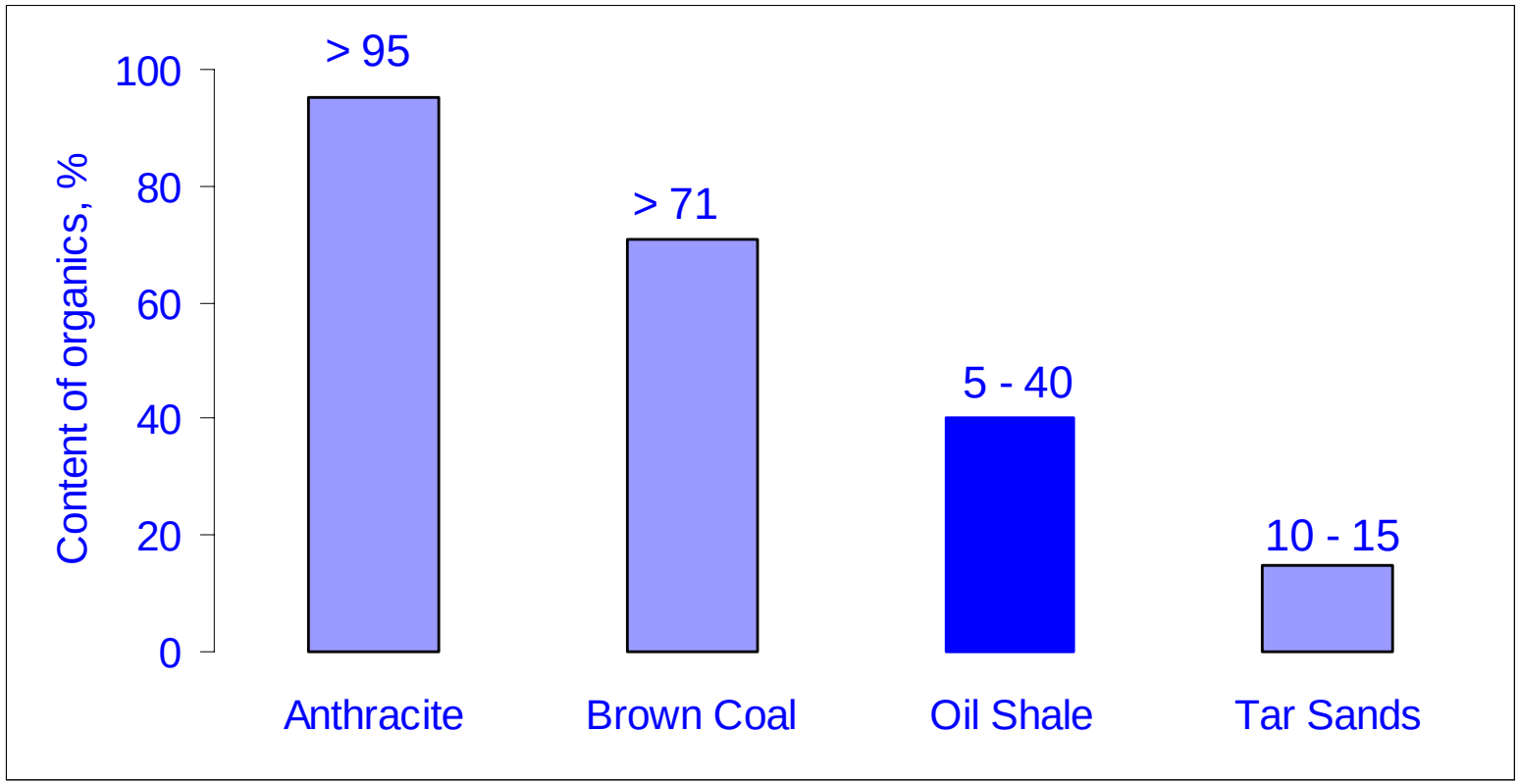
Why the oil shale is not used?

Organic content of fossil fuels, per cents



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Environmental impact

- discharge of air pollutants
- huge amount of solid wastes, e.g., ash and spent shale
- generation of hazards of deposits from past to present

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Ash dumps (Estonia)

230 Mt wastes

Alkaline water up to 5 Mm^3

Surface area > 20 km^2, height up to 30-40 m

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Spent shale deposits in Estonia

70-80 Mt of wastes

up to 120 m height and ca 200 ha of land

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Five sisters

Spent shale deposits in Scotland
(kindly provided by Dr. Kenneth G. Boyd)

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Energy generation in Estonia

by

- pulverized firing (PF) technology (from 1963)
- circulating fluidized bed (FBC) combustion (from 2004)

Total in Narva Elektrijaamad LTD (www.powerplant.ee)

2380 MWe or 484 MWth

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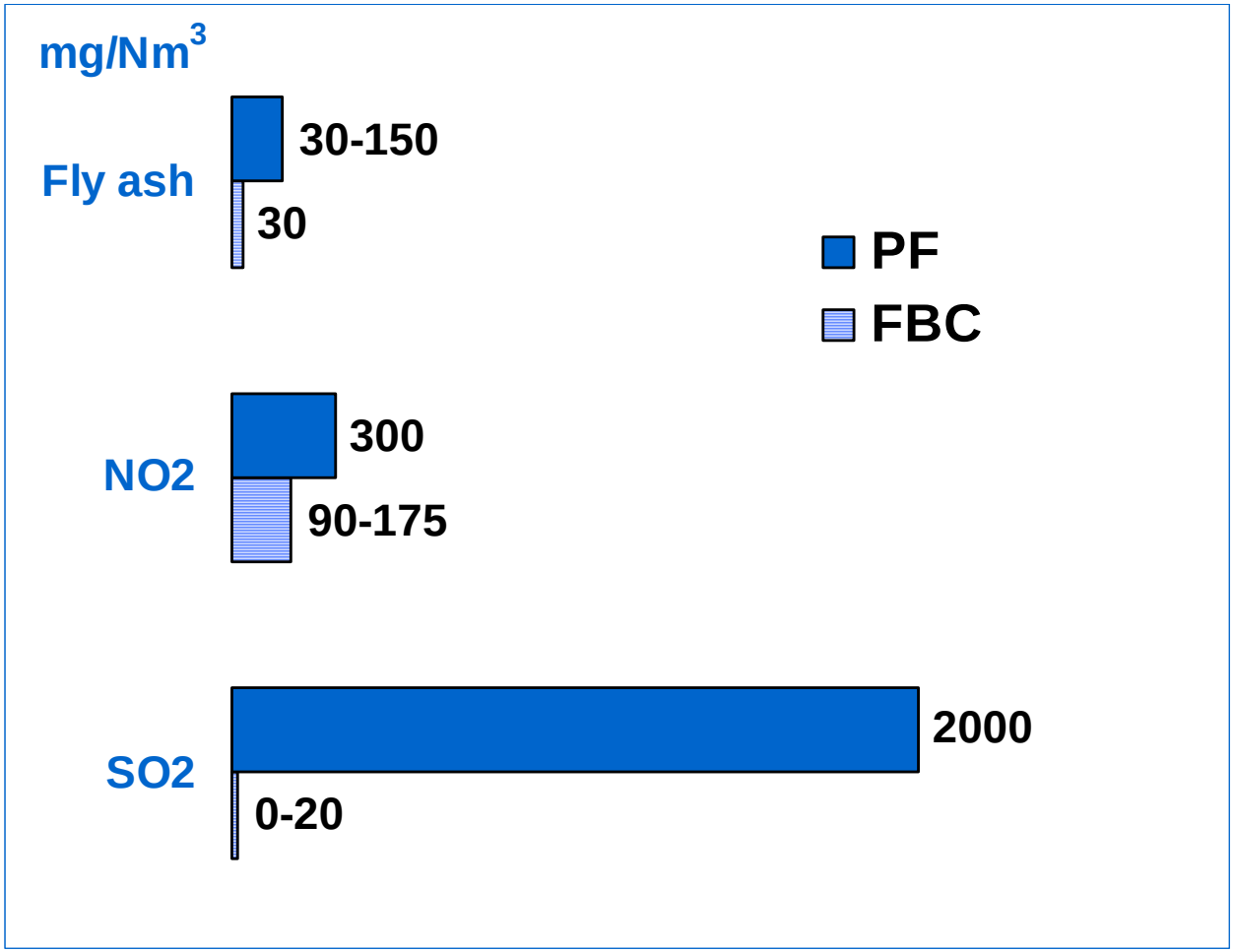
Atmospheric discharge of pollutants

FBC *vers* PF process



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Atmospheric pollution (research activity)

PF combustion

- dry deposition & wet precipitation (monitoring date)
- aging of aerosol during long range transport (modelling)
- assessment of human exposure / health effects of particles

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Chamber experiments

Fly ash (PF) was injected into the 190 m^3 outdoor chamber (UNC)

Particle size and number, humidity, temperature, light, NO, NO_x, O_3, and concentration of priority pollutants were monitored

The fly ash injected into the chamber represents the fly ash emitted into atmosphere

(Over the size distribution measurements)

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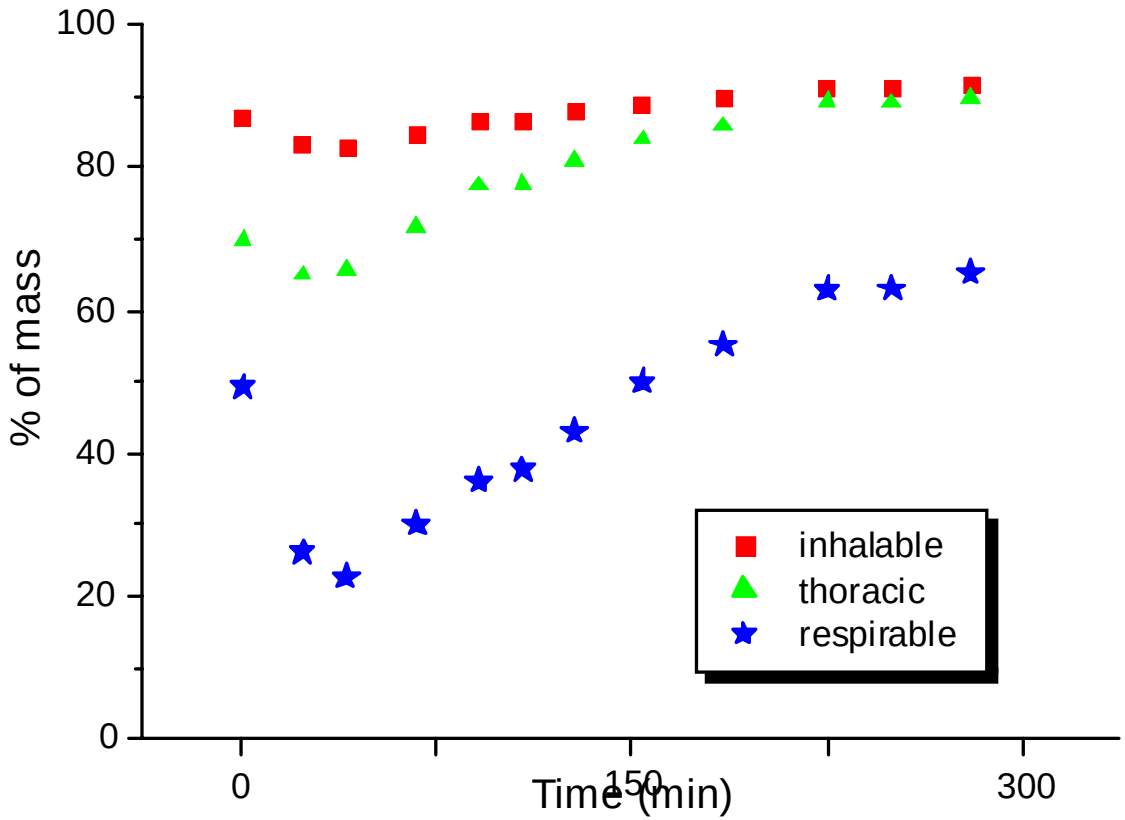
Health effects of fly ash aerosols



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Conclusions (chamber study)

During the aging/long range transport of fly ash aerosols:

- The initial aerosol mass concentration decreased quickly due to the deposition of larger particles
- The fine fraction of fly ash particles, which contributes most of the health effects, is relatively stable

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PAHs in combustion ash
(PF *vers* FBC)

The average content (µg/kg) of 16 priority PAHs (US EPA List)

PF process	FBC technology
107.8 ± 29.6	47.0 ± 11.0

What about mobility?

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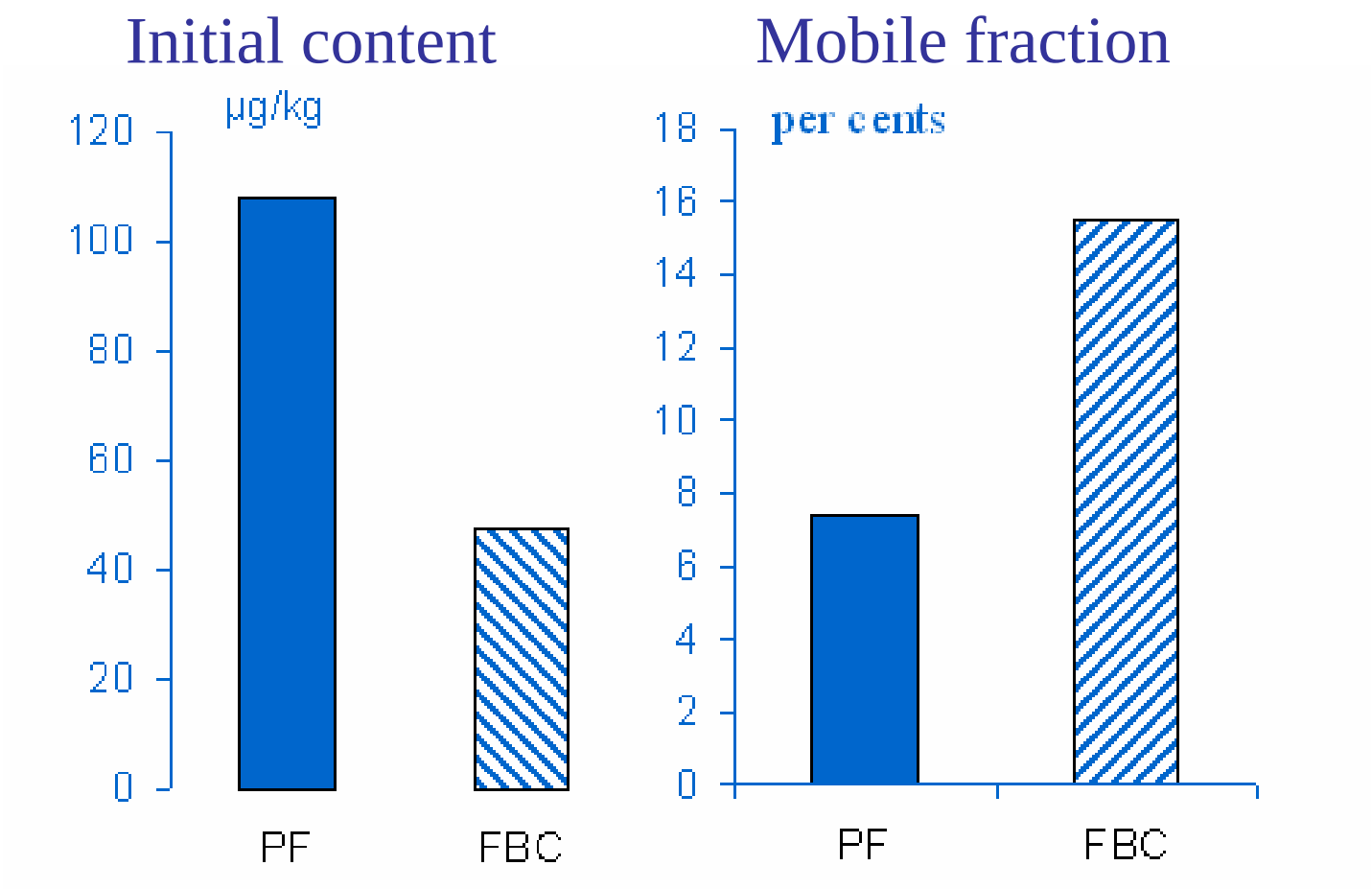
Mobility of PAHs
(PF *vers* FBC)



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Oil production

- **Retorting of oil shale** (500-550^{o}C) produced oil with discharge of gaseous products (VOC, Phenols) and toxic effluents

- The ambient air, surface and ground water could be **directly** affected

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Toxic compounds in spent shale

The content of total organic compounds:
7-24 mass percents,

including of PAHs, reaching to

13 mg/kg

(Environmental hazard assessment of spent shale. Report. Estonian Environmental Research Center, 2003)

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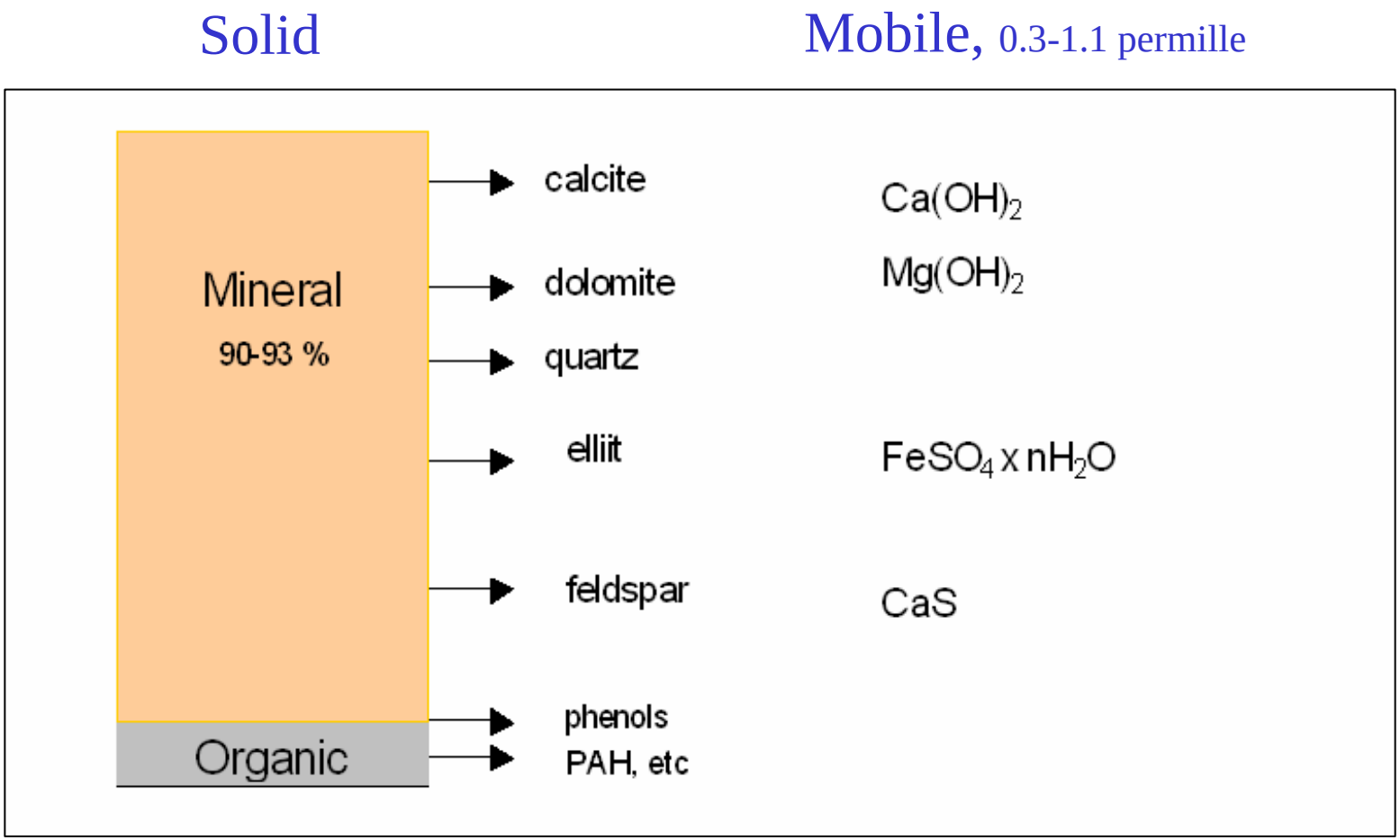
Mineral components in spent shale



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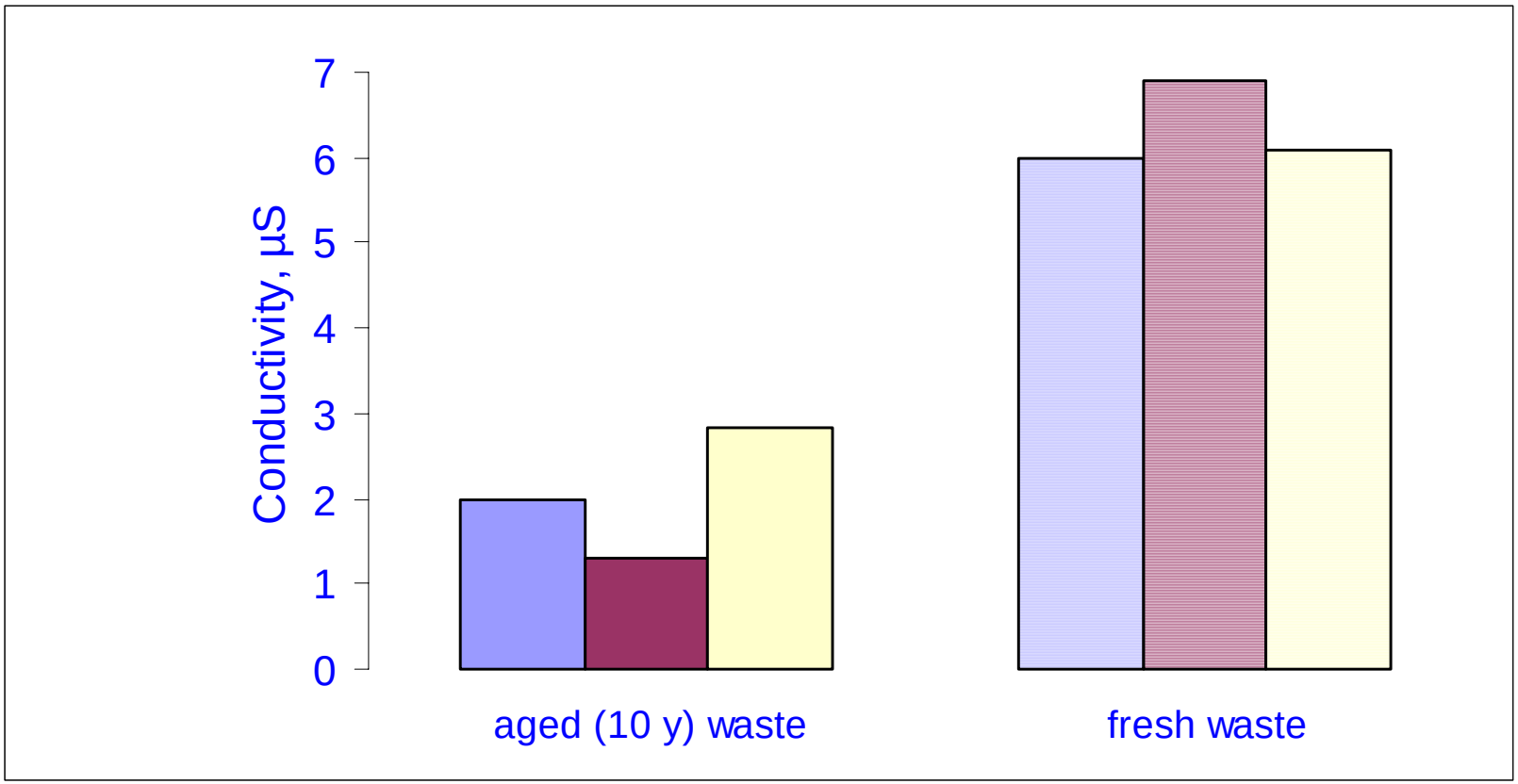
Field leachate of spent shale



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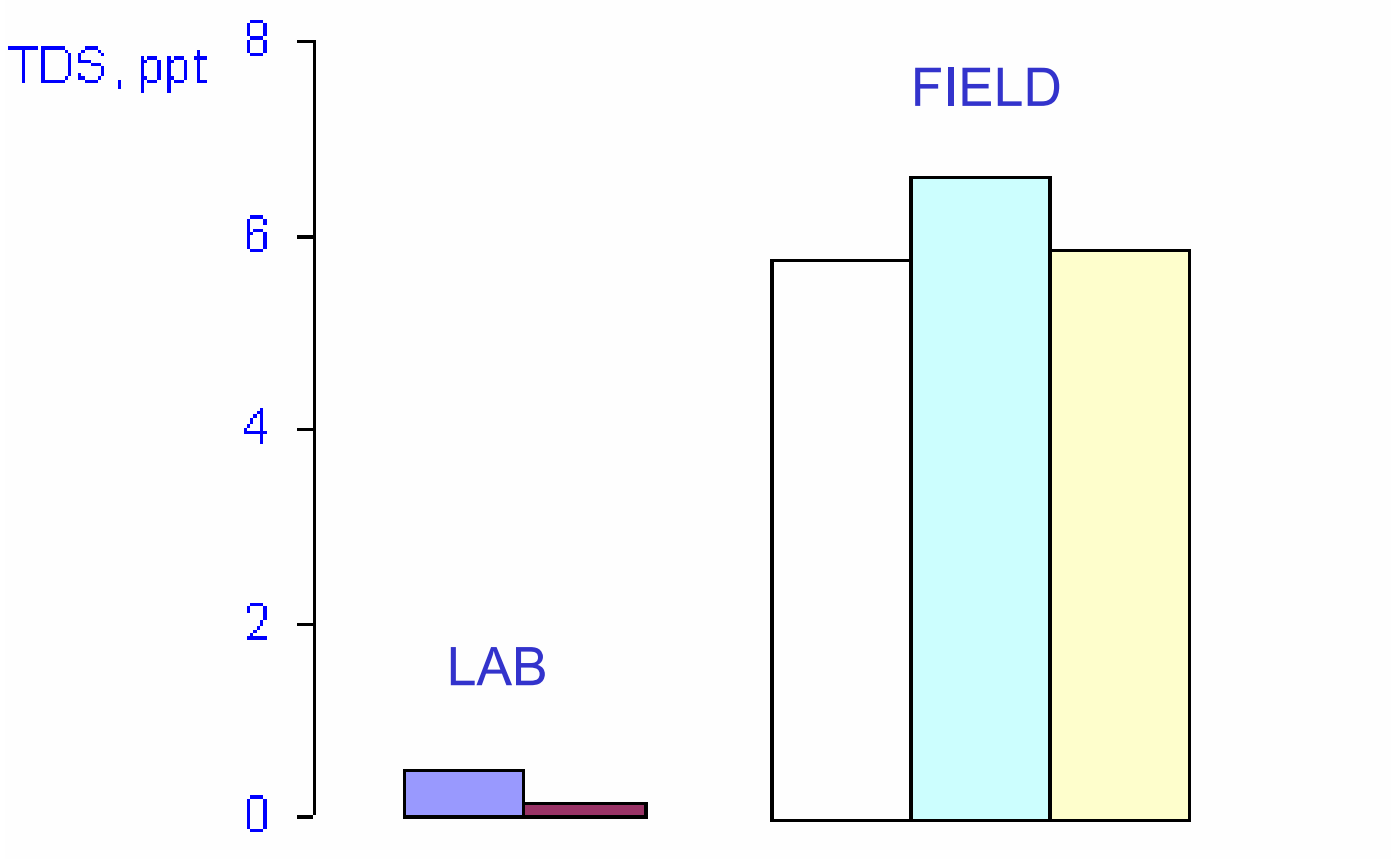
Laboratory *vers* field leaching I

Salts



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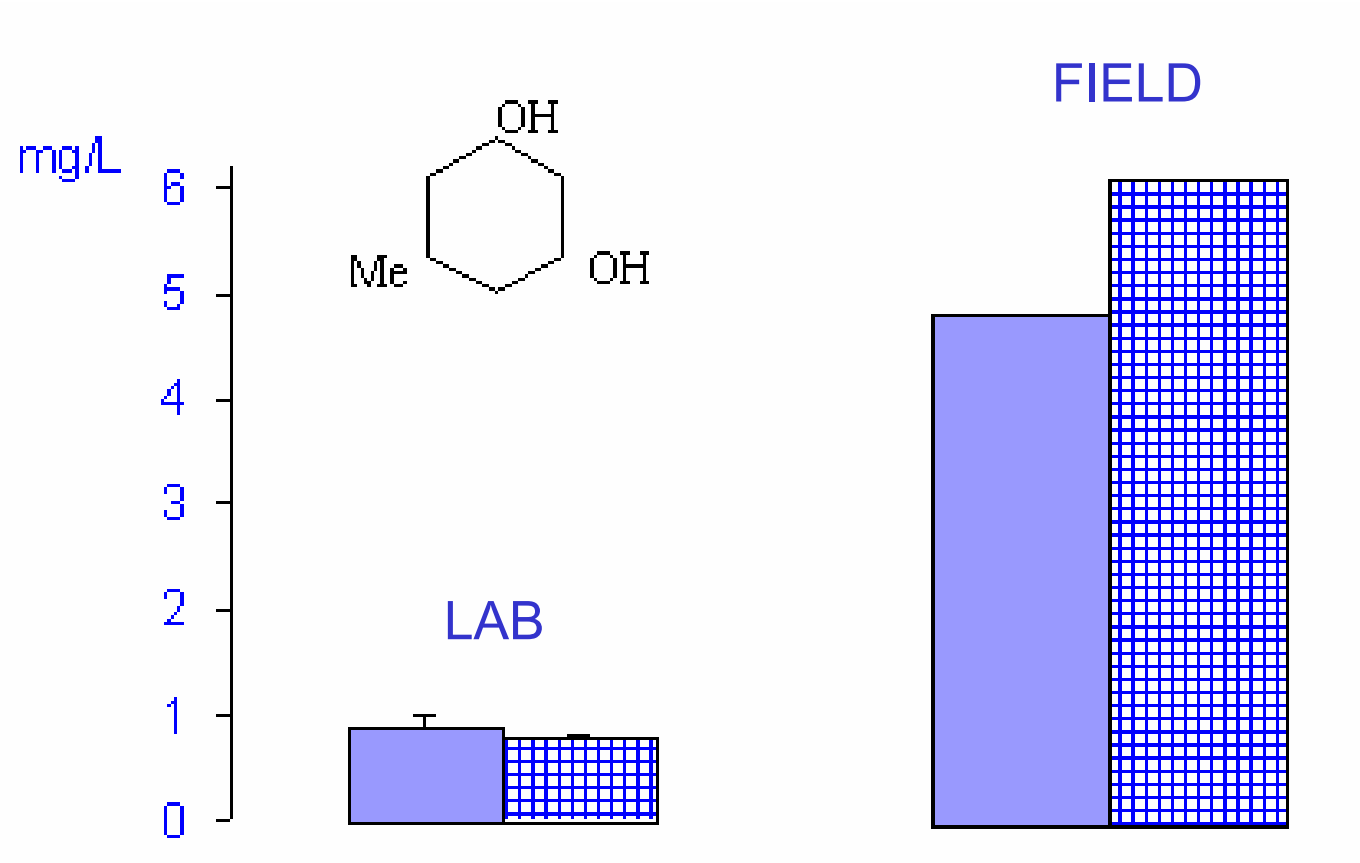
Laboratory *vers* field leaching II

Phenols

5 mR



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PAHs in field leachate of spent shale

	(range, µg/L)
Naphthalene	0.2 – 2.3
Anthracene	0.3
Pyrene	2.5 - 3.1
Acenaphthene	2.4 - 3.9
Fluorene	1.4 - 3-9
Phenanthrene	0.1 - 0.9
Fluoranthene	0.1 - 3.3

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Current activity and further perspectives I

The distribution of over 50 elements was quantified by inductively coupled plasma mass spectrometry (ICP-MS):

- Combustion ash and spent shale samples
- Laboratory and field leachates
- Post-leached solid samples
- Particulate matter of urban aerosols

The results will be published soon

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Current activity and further perspectives II

The recently introduced ultrahigh resolution FTICR (Fourier transform ion cyclotron) mass spectrometry was used for

in-depth analysis of complex anthropogenic matrices, e.g., combustion ash and spent shale samples, leachates.

The results will be published soon

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Solution is not dilution

...but reuse of solid wastes as byproducts.

An example:

Hydrothermal Alcaline Treatment of Oil Shale Ash For Synthesis of Tobermorites

by

Janek REINIK, Ivo HEINMAA, Jyri-Pekka MIKKOLA, Uuve KIRSO

Fuel, (2006), doi: 00.0016/j.fuel.2006.09.010

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Conclusions

- existing technology of oil shale combustion and retorting creates serious environmental problems

- sustainable use of oil shale implies modern technology and recycling of solid waste

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Thank you for your attention!

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