

Coal Ash: The New Golden Treasure

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Coal Consumption and Ash Production in Israel – 2018

Electrical Power (~6,000Mwatts)

- 4 Power Plants
- 6 Million Tons Bituminous Coal/year
- 0.70 Million Tons of Class F Fly Ash (FA)
(1.3 Million Tons in 2015 – Natural Gas)
- Sources (South Africa, Colombia, Russia, USA and Australia)



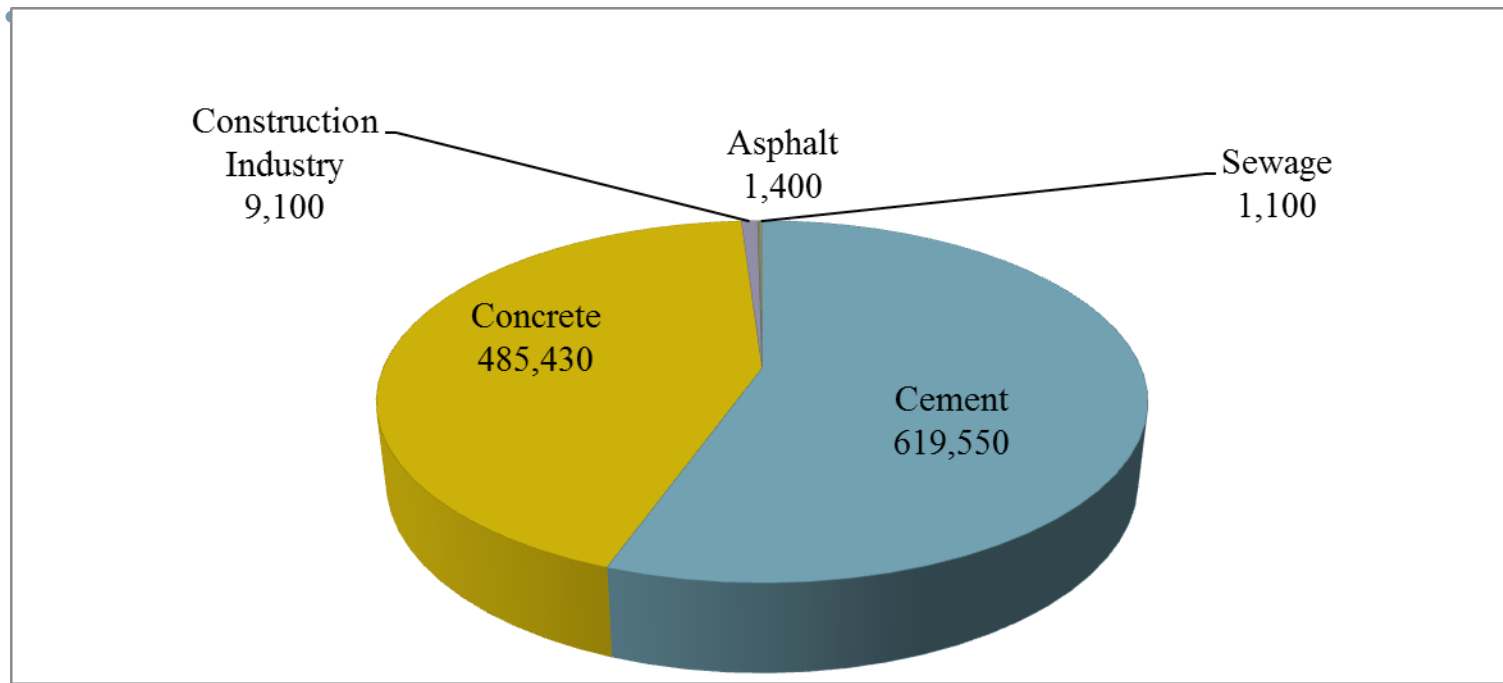
FA utilization and Disposal (worldwide)

- **Cement additive (10%w)**
- **Aggregates for roads**
- **Marine structures**
- **Bricks**
- **Basement materials**
- **Reclamation**
- **Chemicals**



FA Utilization in Israel in 2014 (100%)

- Cement Additive (10w%)
- Concrete Production
- Construction Industry (Basements, Fillers, etc.)





FA as a Chemical Reagent

- Source for chemicals (e.g. SiO_2 , Ti, Zeolites)
- Water treatment (cleaning from trace elements)
- Fixation of radionuclides?

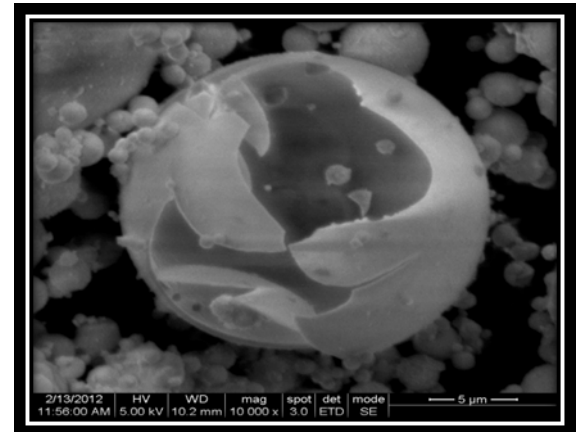
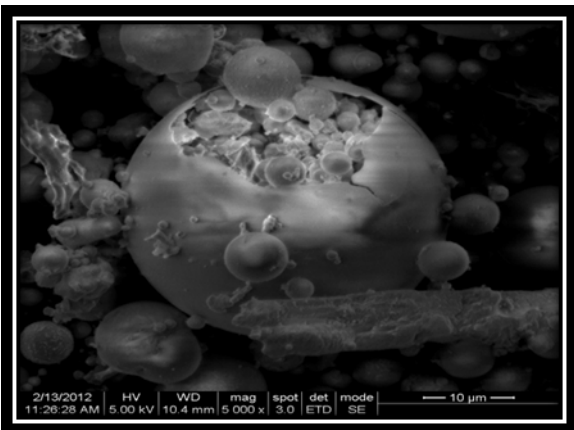
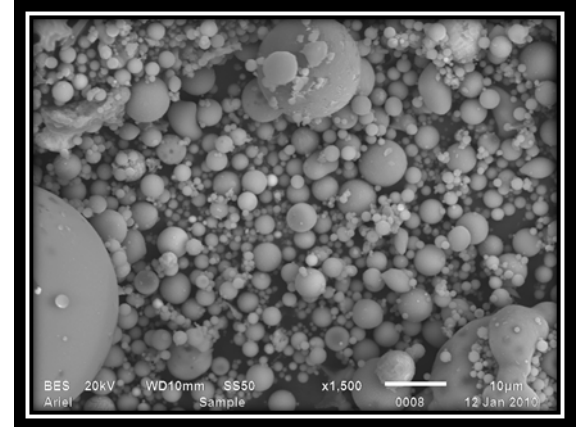
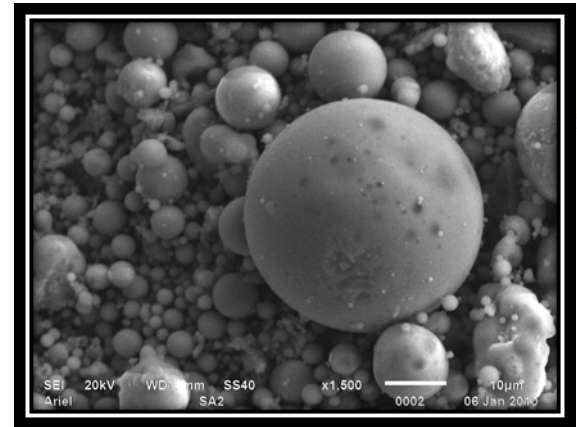
FA Properties

Small particles – 3-17 μm

Large surface area ($2-6.8 \times 10^3 \text{ cm}^2/\text{gr}$)

Strong interactions in aqueous solution:

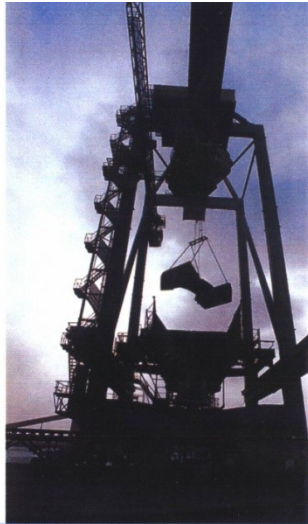
- Cations
- Coordination bonding
- Precipitates



Coal and Ash Storage

Ashklon Utility

A clamshell grab coal unloading crane — Ashdod Port



Loading coal for industry



Pier 9 — Ashdod Port



Coal stacking —





FA in Israel is Class F (highly basic)

- Produced from low S coal combustion
- High CaO content (up to 10%)
- $[Ca+K+Na+Mg] \gg [S+P]$
- Water/FA 10/1 (resulting $pH > 12.5$)

Conclusion: FA good scrubber for acidic wastes
Potential scrubber for Trace
Elements



FA Contents Major Components (w%)

| Element | SA | COL |
|-------------------------|------|------|
| SiO_2 | 42.8 | 54.4 |
| Al_2O_3 | 31.4 | 20.8 |
| TiO_2 | 1.75 | 1.05 |
| Fe_2O_3 | 3.05 | 6.18 |
| CaO | 9.91 | 4.65 |
| MgO | 2.45 | 2.05 |
| K_2O | 0.05 | 0.12 |
| Na_2O | 0.02 | 0.05 |
| P_2O_5 | 1.95 | 0.75 |
| C | 4-5 | 7-9 |
| SO ₃ | 0.25 | 0.12 |



FA Contents

Minor Components (ppm)

| Element | SA | COL |
|---------|-------|------|
| Ag | 13.6 | 42.8 |
| As | <1 | 31.4 |
| Ba | 2,350 | 1.75 |
| Be | 9.43 | 3.05 |
| Cd | <2 | 8.35 |
| Co | 40 | 2.45 |
| Cr | 150 | 0.05 |
| Cu | 77 | 0.02 |
| Mn | 360 | 1.95 |
| Ni | 68 | 4-5 |
| Pb | 73 | 0.35 |

:Major Acidic waste in Israel



Phosphate Industry

Liquid aqueous solutions (*Haifa Chemicals South-HCI/Rotem Amfert-H₂SO₄*):

pH~0-1 (0.1-1M HCl/H₂SO₄); ~0.1% Organics; 0.1-0.2%
Precipitates

Solution content:

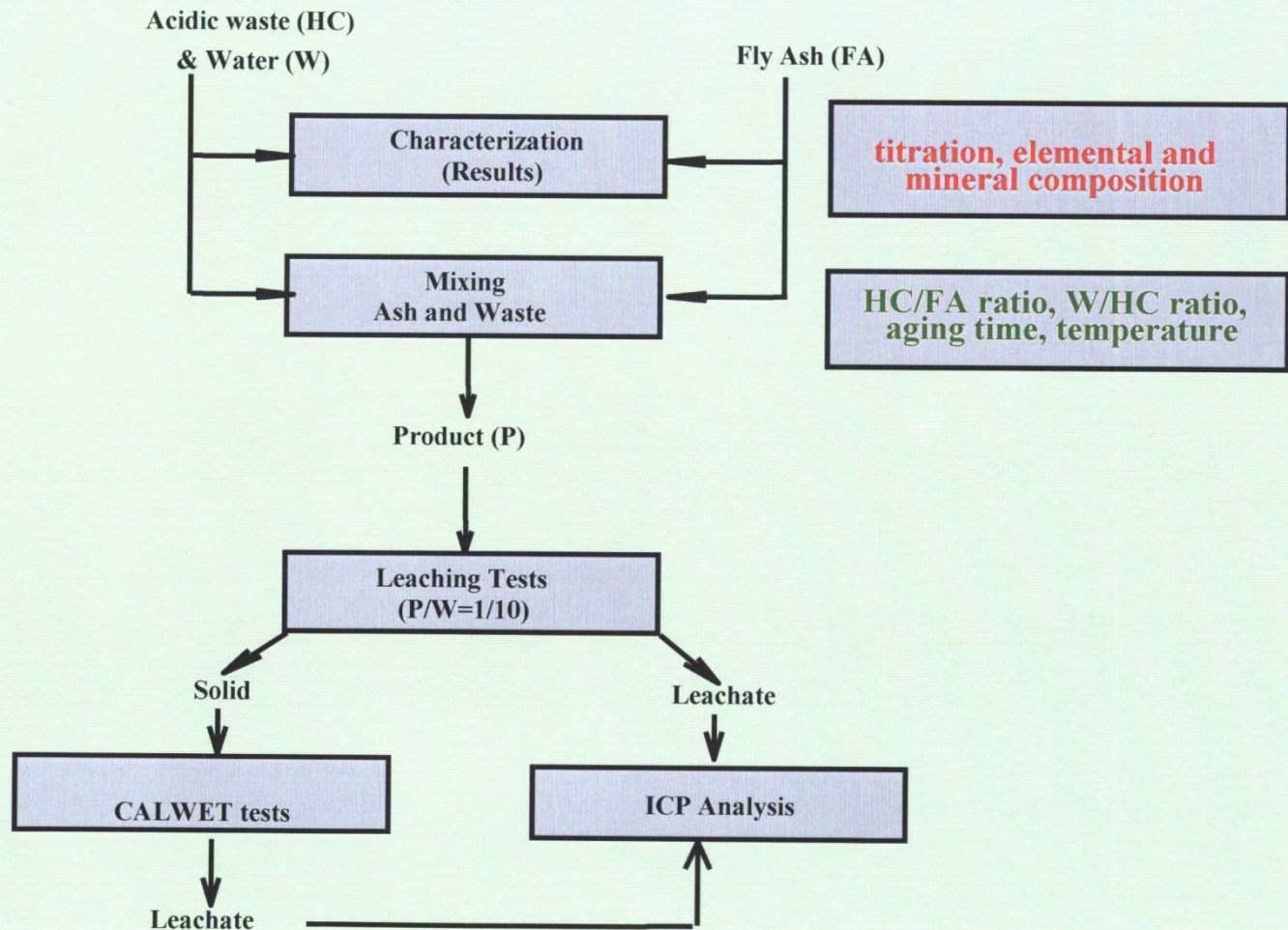
~1% PO₄³⁻ ; ~0.4% Si ; ~0.1-1M Cl

100-1,000 ppm: Fe, B, Sr, Ba, Mg, Zn, Na, K

sub-few ppm : Ag, As, Be, Cd, Co, Cr, Cu, Mn, Ni, Se,
Sn, U, Ti, Tl, V



General methodology used in the study





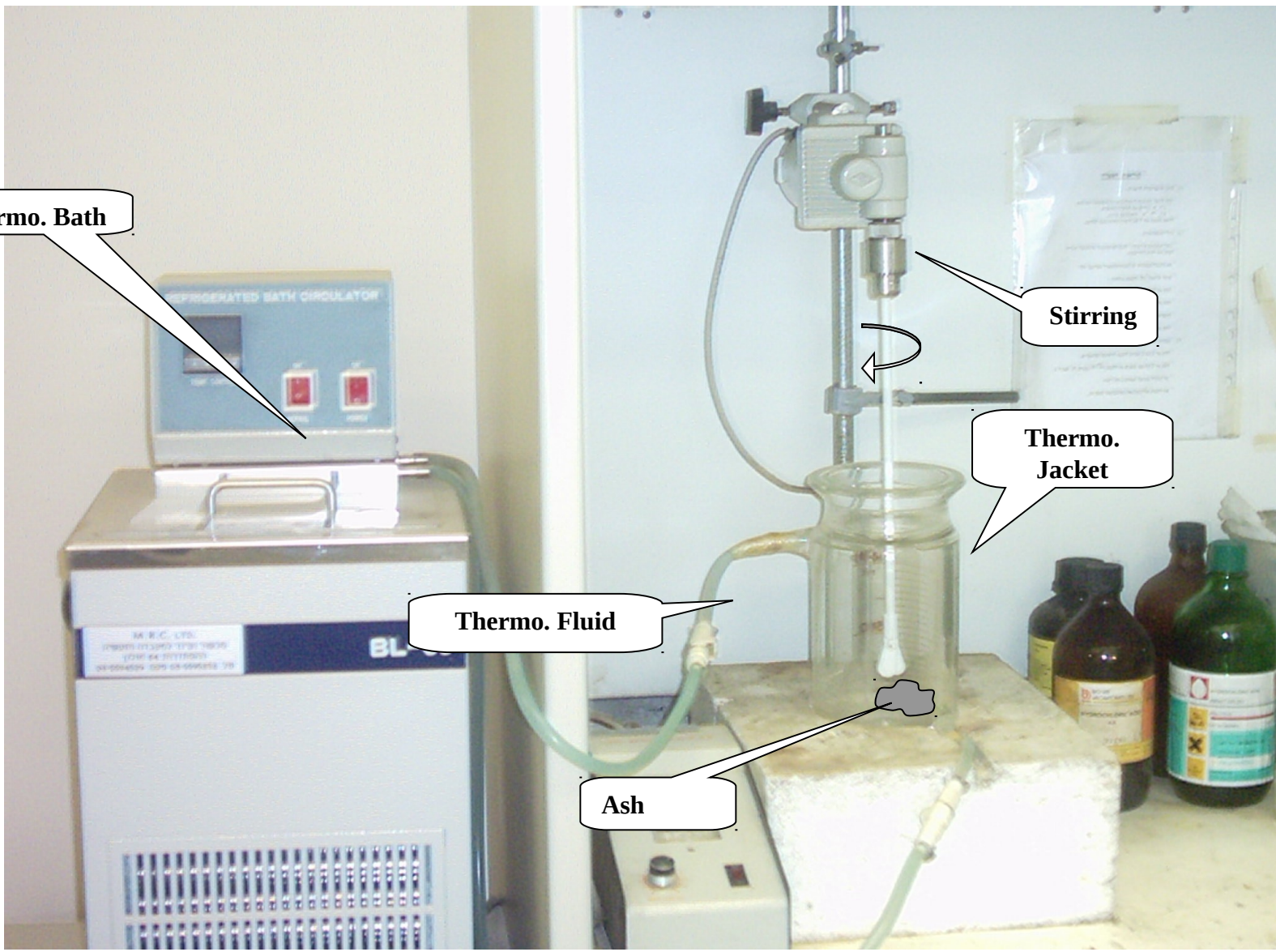
Thermo. Bath

Stirring

Thermo. Jacket

Thermo. Fluid

Ash





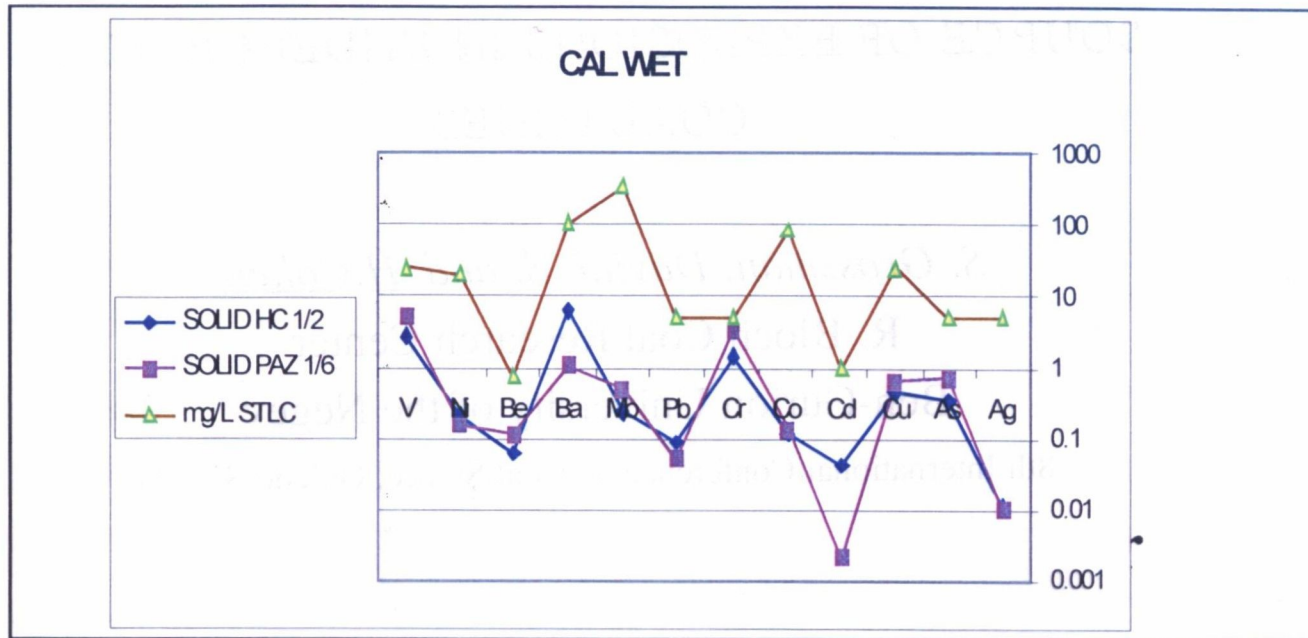
Phosphate Waste – Scrubbing Process

- Duration 20 minutes
- No Water Addition
- Solid Product

Product

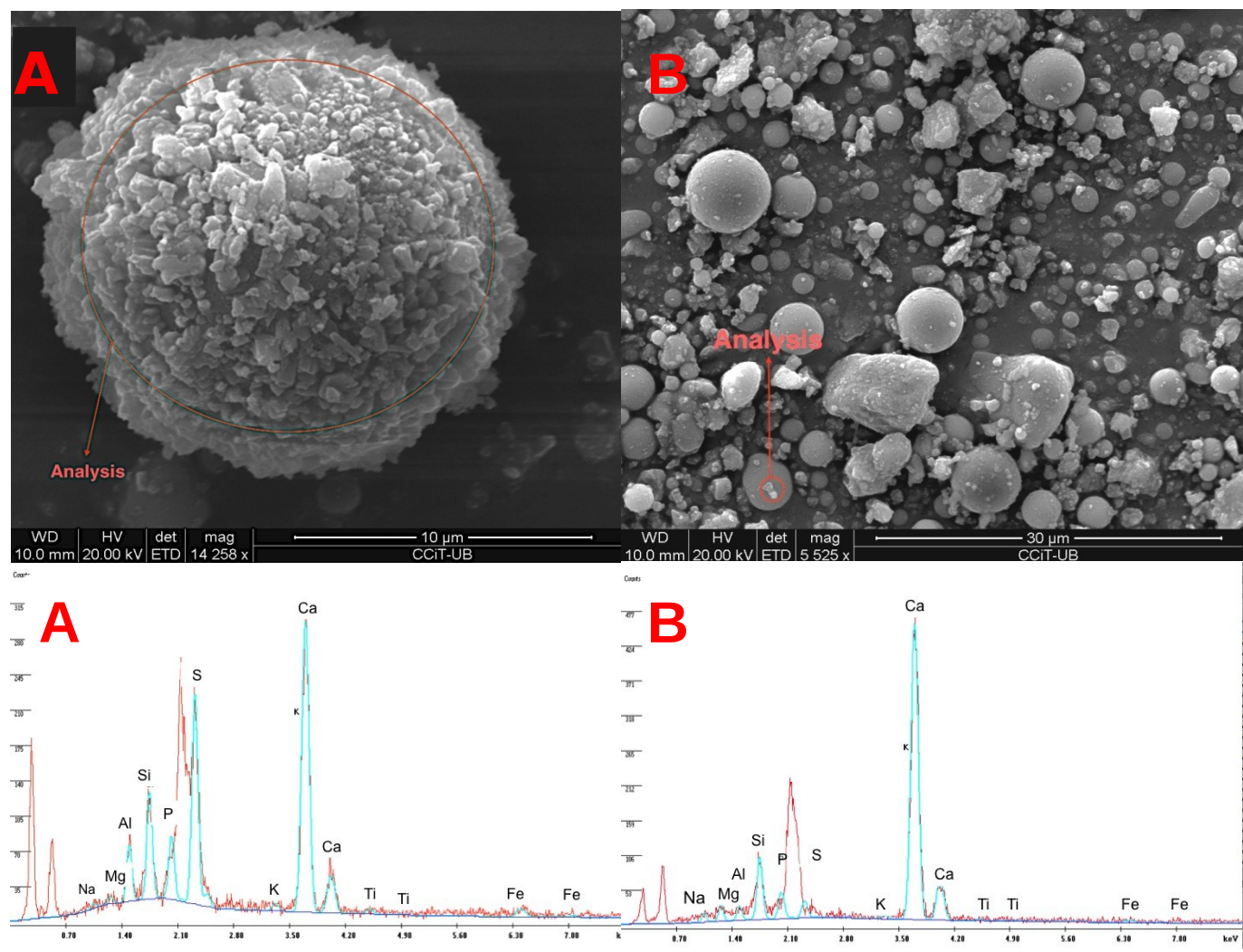
Grey aggregate (sand like)





Aggregate Products leaching with the CALWET method

SEM and EDAX of aggregate products – (A) –with SA fly ash (B) –with COM fly ash





Fixation Mechanisms

- **Ion Exchange Action**
- **Chemical Bonding**
- **Electrostatic Interaction of Solids**

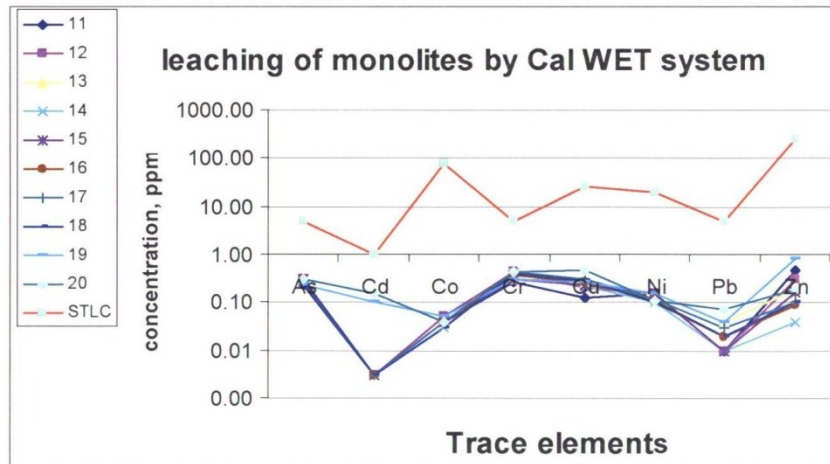
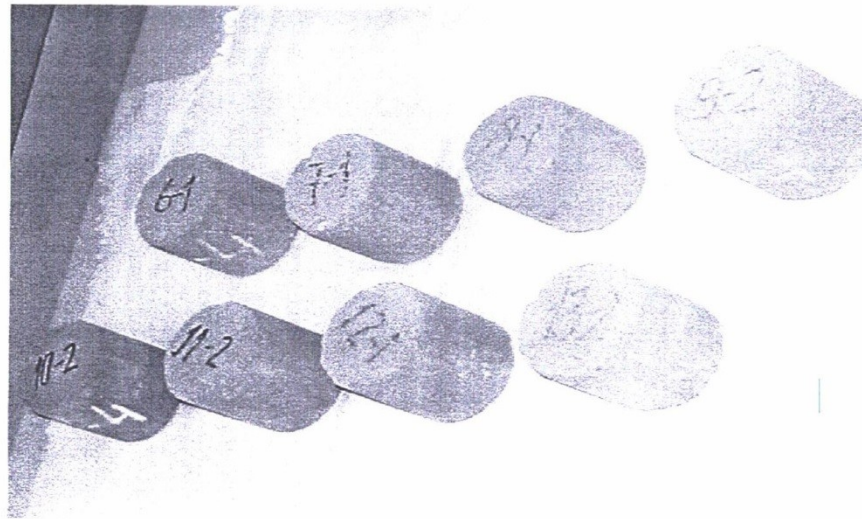
Source of fixation:

$-\text{SiO}_3^-$, $-\text{AlO}_2^-$ + large surface area



EN 12457-2 leaching method

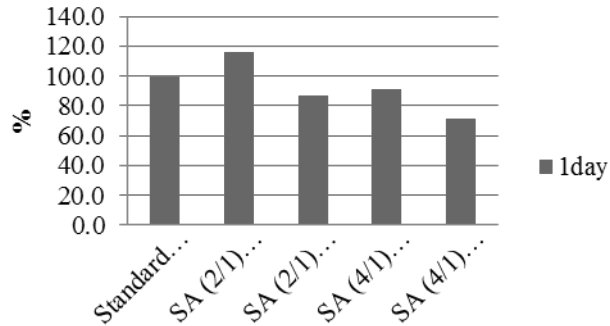
| | Decision 2003/33/EC | | |
|-----------------|---------------------|---------------|-----------|
| mg/kg | Inert | Non hazardous | Hazardous |
| SO ₄ | 1000 | 20000 | 50000 |
| Cr | 0.5 | 10 | 70 |
| Ni | 0.4 | 10 | 40 |
| Zn | 4 | 50 | 200 |
| As | 0.5 | 2 | 25 |
| Se | 0.1 | 0.5 | 7 |
| Mo | 0.3 | 10 | 30 |
| Cd | 0.04 | 1 | 5 |
| Sb | 0.02 | 0.7 | 5 |
| Ba | 20 | 100 | 300 |
| Pb | 0.5 | 10 | 50 |



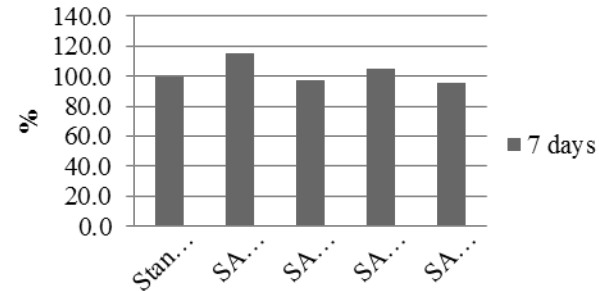


Scrubbed Waste Product - Phosphate Industry

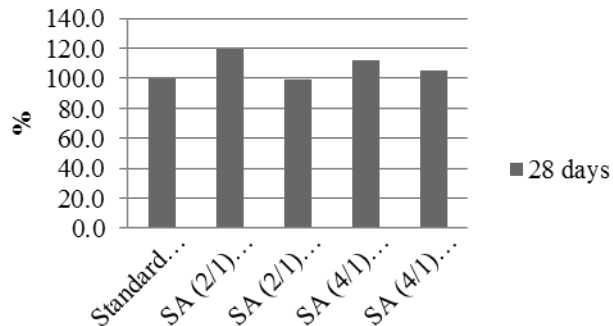
Strength test - 1 day aging



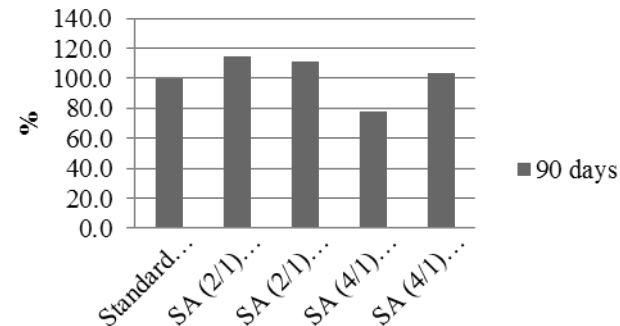
Strength test - 7 days aging



Strength test - 28 days aging



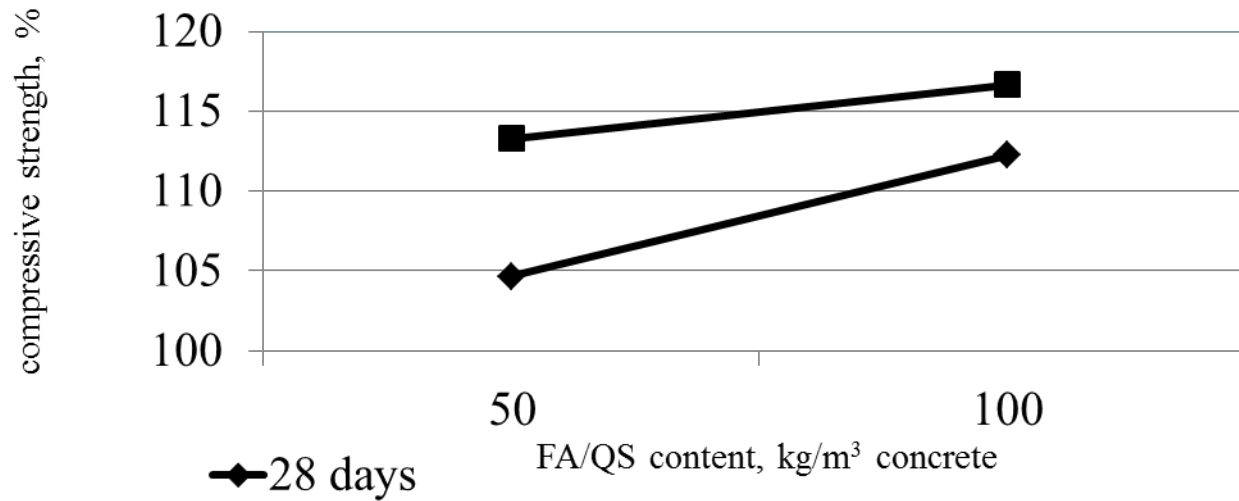
Strength test - 90 days aging



Non Hazardous Material (European Directive EN14257) •



Scrubbed Waste Product – Quarry Sludge



Non Hazardous Material (European
Directive EN14257)

\$\$\$ Economics of Ash utilization



- Price of 1ton of cement ~100 \$
- Price of treatment of 1 ton of acidic sludge ~10\$
- 100 kg of treated product substitutes cement and aggregates in 1 ton of concrete=10\$
- No storage needed

Coal Fly Ash = Golden Treasure



Conclusions

- (i) Class F coal fly ash is an excellent scrubber and fixation reagent for acidic wastes, trace elements and fine precipitates
- (ii) The fixation product is a good aggregate **(environmentally green!!! improved TCLP1311 or European 12457 directive or CALWET for concrete)** and can be used as a partial replacement in the concrete or brick industry
- (iii) It's economic value as a **chemical reagent** is much higher compared to it's value in the construction industry
- (iv) *Ashes from Oil Shales and Lignites are also potential candidates as substitutes to coal fly ash*

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Thank you for listening