APC-Residues

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Content

- Harm Potential of APC Residues (example: Pb)
- Availability Means Leachability
- Mass Balance Energy-from-Waste Plant, Quantity of APC Residues
- Options for APCr Treatment
- Driving Factors
- Considerations for Upcoming Projects
Harm Potential of APC Residues

Availability of lead

- Crystalline glass
  - 30% PbO
  - No water solubility

- Lead(II)acetate «lead sugar»
  - Pb(CH_3COO)_2
  - easily soluble in water
Harm Potential of APC-Residues

- Availability of pollutants (mainly: lead, easy soluble salts) high

Availability

<table>
<thead>
<tr>
<th>Concentration</th>
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<tbody>
<tr>
<td>Limit leachate test</td>
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<tr>
<td>Bottom ash</td>
</tr>
<tr>
<td>Earth’s Crust</td>
</tr>
<tr>
<td>Untreated APCR</td>
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</table>

"marketable product"
Example: Solubility of Pb in function of pH

Range of minimal solubility

Source: Dissertation J. Ritz

Rainwater: pH ~ 5.5

Ca(OH)$_2$: pH 12.3

Source: Dissertation J. Ritz
Availability Means Leachability

Lesson learned in hazardous waste landfill (SMDK) Kölliken (CH):

- What is soluble will be sooner or later in the groundwater
- Example: Bromine before and after clean up
Residues in Energy-from-Waste Plant

- Incineration
- Boiler
- FGT (APC)
- Stack
- Optional WWT
- Optional effluent

**Pollutants**
- HCl \(\approx 5 \text{ kg}\)
- SO\(_2\) \(\approx 2 \text{ kg}\)
- Others < 1 kg

**Bottom ash**
- Dry \(\sim 200 \text{ kg}\)

**Boiler ash**
- \(\sim 5 \text{ kg}\)

**Fly ash**
- 12 kg

**APC-Residues**

**Additives**
- HCl \(\approx 5 \text{ kg}\)
- SO\(_2\) \(\approx 2 \text{ kg}\)
- Others < 1 kg

APC = Air Pollution Control = Flue Gas Treatment (FGT)

WWT = Waste water treatment
Mass Balance Energy-from-Waste Plant

- **Semi-dry FGT lime based**
- **Dry FGT sodium bicar.**
- **wet FGT (with effluent)**

<table>
<thead>
<tr>
<th>kg per 1 t waste treated</th>
<th>SD APCr</th>
<th>Bic APCr</th>
<th>Wet APCr</th>
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<tbody>
<tr>
<td>Humidity</td>
<td></td>
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<tr>
<td>salts (halogenids)</td>
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<tr>
<td>salts (gypsum)</td>
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<tr>
<td>CaCO3</td>
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<tr>
<td>Ca(OH)2</td>
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<tr>
<td>heavy metals</td>
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<tr>
<td>Matrix</td>
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</tbody>
</table>
Salts ?
Situation Switzerland: Emission of Salt (as Chloride)

Switzerland: 300,000 t NaCl per year (avg)
Spread on roads

23 kg per head and year as Cl

Switzerland: 3.8 Mio t waste per year treated in waste-to-energy plants
Average content: 5 kg Cl / t waste

2.4 kg per head and year (as Cl)
Objective of APCr - Treatment

- Reducing availability of pollutants

Availability

Limit leachate test

Treatment

Earth’s Crust

Before

After

Concentration

"marketable product"

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Options

A. Underground backfilling (salt mine)

B. Solidification (with Cement)

C. Stabilisation (with bottom ash)

D. Extraction (pH ~ 9)

E. Extraction (pH ~ 3.5) with Zinc recovery

F. Carbonatisation

G. Thermal treatment
A) Backfilling Underground Salt Mines

**Pro and contra**
- Safely eliminated from biosphere
- Well established in Germany
- Inexpensive
- Not all sites on the same level

**Preconditions or preferences**
- Mix with different ashes and residues (incl. bottom ash)

**Availability**

**Concentration**

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B) Solidification (hydraulic binders)

**Pro and contra**

+ Model applicable in many countries
+ Established in France, UK
- Logistic laborious
- No long term stability
- Costly, “waste” of resources

**Preconditions or preferences**

- Mix with cement and/or similar hydraulic binders
- With or without previous salt extraction

**Availability**

APCr

**Concentration**

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C) Stabilization with bottom ash

**Pro and contra**
- Simple, cost effective, physically stable
- Established in USA
- Non-established elsewhere
- Salty percolate water

**Preconditions or preferences**
- Mix with bottom ash, ev. additives
- Stabilisation thanks to puzzolanic effect
D) Extraction (pH 9)

Preconditions or preferences
- Use of salt brine for bicarbonate production
- Residues to landfill

Pro and contra
+ “Re-use” of sodium
+ Established in France
- «deception»: new bicar does not contain chlorine or sulphur
- No possibilities outside France (and Italy)

Availability

Concentration
D) Extraction (pH 3.5)

**Preconditions or preferences**
- Use of acidic scrubber blow down to extract heavy metals from fly ash
- Cleaned residual ash mixed with bottom ash to landfill

**Pro and contra**
- Recycling of Zinc
- "purification" of remaining ash
- Well established in CH
- Preconditions wet FGT and effluent discharge

**Availability**

**Concentration**

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E) Carbonatisation

Pro and contra
+ Physical-chemically good stabilization
+ Carbon capture of flue gas CO₂
- No industrial plant in operation
- Applicable mainly for lime-base residues from dry or semi-dry FGT

Preconditions or preferences
- Use of CO₂ from flue gas to neutralise excess lime in residues
- Neutrals salts extracted and discharged
F) Thermal Treatment

Pro and contra

+ Very nice glassy residue
- Expensive, energy consuming
- Heavy metals and salt in a new, even more nasty residue
- No industrial plant in Europe

Preconditions or preferences

- Melting to a glass (ash matrix elements)
- Heavy metals and salts to be captured from exhaust gases
Applied Technics in Europe

Western Europe (UK, …):
B) Solidification (hydraulic binders)

France / Italy:
D) Extraction (neutral)

Scandinavia (Norway):
xy) Backfilling Langøya island

Central Europe (Germany):
A) Backfilling underground salt mines

Switzerland:
E) Extraction (acidic)
Crucial question: where shall Cl remain?

- The easily soluble salts (Halogenides) cannot be fixed – sooner or later (depending on water influx), they are washed out.

- Salt leach out mobilizes undesirably other pollutants and leaves a unstable body behind.

- Only two “safe places” for Halogenids: Sea or old salt stocks.
## Driving Factors and Crucial Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Preferred technics if “yes”</th>
<th>reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge of (salty, but otherwise clean) effluent possible ?</td>
<td>Extraction of halogenids</td>
<td>Better long term stability without salts; Economics</td>
</tr>
<tr>
<td>Backfilling underground salt mines established ?</td>
<td>Use as backfilling material</td>
<td>Economics; safe disposal</td>
</tr>
<tr>
<td>W-t-E plants also seen as material recycling ?</td>
<td>Extraction of heavy metals</td>
<td>Corresponds best to recycling philosophy</td>
</tr>
<tr>
<td>No specific regulation, no established solutions known ?</td>
<td>Stabilisation with bottom ash</td>
<td>Simple</td>
</tr>
</tbody>
</table>

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2016: APC-Residues
Thank you for your attention