Remining Bauxite Residue
Handling Practice and Valorisation research in Aluminium of Greece

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Residue Valorization
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Aluminium of Greece

- The leading industrial producer of alumina and aluminium in S.E. Europe and the only vertically integrated bauxite, alumina and aluminium production plant in Europe

- Mining 650,000 tons of Greek bauxite ore, processing each year more than 1.4 million tons of Greek bauxite ore and 0.4 million tons of tropical bauxite ore.

- Producing 820,000 tons of alumina (out of which 480,000 tons are exported)

- Producing 185,000 tons of aluminium (out of which 125,000 tons are exported)
The AoG Alumina Refinery

**Bauxite Ore**

- The ore is digested under high temperature and pressure in alkaline solution
- Alumina precipitates from the alkaline "pregnant" solution
- The undissolved portion of the ore, forms the Bauxite Residue (BR) by-product

**Alumina**

- 99% Al₂O₃
- 800,000 t/year

**Bauxite Residue (BR)**

- 45% Fe₂O₃
- 25% Al₂O₃
- 9% CaO
- 5% SiO₂
- 5% TiO₂
- 750,000 t/year

**Filtration**

- 1,800,000 t/year

- AoG processes (mainly) Greek Bauxite

**Digestion**

- 60% Al₂O₃
- 20% Fe₂O₃
- 15% H₂O
- 5% Other oxides

**Precipitation**

Alumina precipitates from the alkaline "pregnant" solution

**Activities for Residue Valorization**
Activities for Residue Valorization

Worldwide only 3% wt from the 140,000,000 t of Bauxite Residue produced annually are utilized in cement and iron production.

…and this takes place mainly in China and India.
Activities for Residue Valorization

Slurry disposal
Activities for Residue Valorization

Tailing ponds
Activities for Residue Valorization

To remove the water content from the slurry so:

- It can be **safely deposited in-land** in full accordance with EC waste directives.
- It can be **easily transported** in other industrial facilities for re-use.

Filterpress is now a BAT

**AoG Vision for Red Mud**

- 2006: Installation of 1st Filterpress.
- 2008: Installation of 2nd Filterpress, storage site.
- 2009: Installation of 3rd and 4th Filterpress - gradual increase of operations.
- 2012 - today: **100% dry disposal of all bauxite residue produced from the alumina refinery.**
Activities for Residue Valorization

The Filter-Press Process

Bauxite Residue discharged with moisture between 26-28%

Filtrate is returned to washers, and re-introduced to the Bayer cycle
Activities for Residue Valorization

The BR storage site is located just behind the plant (St. Athanasios).

Storage takes place in accordance to obtained environmental permit and geotechnical study.
Activities for Residue Valorization

Central pipeline

Peripheral draining channels

Geofabric and gravel introduced at specific height intervals to enhance stability
Activities for Residue Valorization

- Currently 7 plateau active with heights 9-15 m.
- The site contains over 4,5 million tons of BR already.
- Estimated to be in operation for another 20 years.
But our goal is not to make new mountains...
Activities for Residue Valorization

AoG BR filter cake (ferroalumina)

Utilize alumino-silicates as raw materials for building products (cement, insulation material, …)

Utilize as alternative REE resource

Minor elements utilized in steel production

However till this day no single one utilization has proven economically viable or capable of valorizing 100% of the produced BR
Since 1991, AoG BR was been tested for use in

- **Cement Industry** (iron/alumina source in clinker)
- Iron production
- Brick/Tile Industry (substitution of clay)
- Geopolymer bricks
- Soil Remediation/ Vegetation cover
- Road Base Construction
- Landfill barrier / cover
- Backfilling of closed Mines
Activities for Residue Valorization

BR Utilization In Cement Production

- BR can substitute up to 5-10% of the cement raw material feed as iron and alumina sources.
- The installed production capacity of the Greek cement industry could utilize all 750,000 t of BR produced in AoG with a 5% substitution in the raw meal.
- Up till now AoG BR has been used at rates of 1.5 - 3% substitution.
- The past 5 years, 10-30 kt of BR were used in Greek cement plants annually.

This year
- the TITAN plant in Patra,
- the AGET plant in Volos,
- the VASILIKO plant in Cyprus
will utilize in total **110,000 t of BR or 15% of the annual BR produced in AoG**

*Next year we will reach 20%*
### Why not more? – Key Barriers

<table>
<thead>
<tr>
<th><strong>Technical Barriers</strong></th>
<th>Soda content, Cr content, moisture are the most common technical barriers, <strong>yet none of them is crucial.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Legislative Barriers</strong></td>
<td>EC waste transport legislation is a complicated process requiring specific permits from all parties involved. Cross borderer transport even more complicated. <strong>There is no classification for BR only for red mud.</strong></td>
</tr>
<tr>
<td><strong>Financial Barriers</strong></td>
<td><strong>Logistics is a key issue.</strong> Cement plants are willing to utilize BR only as long at is a cheaper alternative to other iron and alumina sources.</td>
</tr>
<tr>
<td><strong>Social Barriers</strong></td>
<td>Local Societies are always eager to protest against cement plants treating wastes ‘in their backyard’. <strong>BR handling during unloading and mill feeding is the biggest issue</strong> as any potential dusting of the BR would create significant protests by local societies.</td>
</tr>
</tbody>
</table>

**EWC code 01 03 09 = waste/non-hazardous**
### Activities for Residue Valorization

#### Why not more? – Lifting Barriers

<table>
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<th>Category</th>
<th>Details</th>
</tr>
</thead>
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<tr>
<td><strong>Technical Barriers</strong></td>
<td>Air drying to further reduce moisture, De-alkalization of BR, ...</td>
</tr>
<tr>
<td><strong>Legislative Barriers</strong></td>
<td>Once there is an ‘industrial-use’ for a waste it could be classified as a by-product, simplifying the transfer process. <em>Waste Declassification is a central policy decision.</em></td>
</tr>
<tr>
<td><strong>Financial Barriers</strong></td>
<td>Incentives should be provided to the cement and other plants for utilizing BR and similar wastes. <em>Gate fees do not promote industrial symbiosis.</em></td>
</tr>
<tr>
<td><strong>Social Barriers</strong></td>
<td>More effort should be placed on increasing social awareness – reducing NIMBYISM. <em>‘Popularizing science’ through RTD projects</em> could be a key.</td>
</tr>
</tbody>
</table>
Activities for Residue Valorization

Soil  Road substrate  Mine restoration  Landfill covers

In all these cases BR:
- Are used as substitutes of cheap and available raw materials (soil, clay, iron oxide…)
- Are not the main component but rather an additive in small amounts (1-30% wt)

There is need for new BR-centered processes that can be technically and financially viable
Activities for Residue Valorization

Thank you for your attention

The AoG Plant in Ag. Nikolaos

Deep Sea Port

Combined Heat and Power Plant

Aluminium Smelter

ENEXAL Pilot Plant

Alumina Refinery
Activities for Residue Valorization