Life Cycle Assessment of Alternative Road Base Materials

The case of Phosphogypsum

Myriam Saadé-Sbeih¹, Adelaïde Ferraille², Amina Alaoui Soulimani³

¹ Ecole des Ingénieurs de la Ville de Paris
² Ecole des Ponts ParisTech
³ OCP Group
Growth rates of urban agglomerations by size class

2018-2030

https://population.un.org/wup/Maps/
Material requirements of the built environment

- Estimated world consumption of sand and gravels for construction: 41 billion tons per year (UNEP 2019)

- Materials demand in built areas: buildings versus networks (Deilmann et al 2001; Schiller 2007)

- Local and global scarcity of construction primary materials, especially in the global South: sand & granulate (UNEP 2019), gypsum (Layr and Hartlieb 2019)...

- In a circular economy approach, opportunities to use secondary materials for buildings and infrastructures construction?
Phosphogypsum: waste or resource?

Disposal
- storage in open stack
- discharge into the sea

Use
- fertilizer
- cement retarder
- road base or building material

Phosphate ore extraction

Transport

Transformation PHOSPHOGYPSUM

Export

Disposal

Credits: wikimedia

CPCB (2014)

Phosphoric acid
Fertilizers: MAP; DAP; TSP

~250 Mt/yr

85%

15%
Objectives and method

• Objectives
Assess the environmental impacts of phosphogypsum (PG) valorization as road base material throughout its entire life cycle.

1) comparing environmental burdens of “conventional” versus alternative road base materials, respectively granulate and PG mixtures;

2) assessing the potential displacement of environmental impacts from a life cycle stage to another; and

3) discussing the influence of allocation approaches on the assessment.

• Method
LCA following the ISO 14044 guidelines
OpenLCA software
Ecoinvent 3.2 (cut-off version)
ReCiPe Midpoint (H)
Functional Unit and scenarios

UF: Experimental road pavement structure of 200 m length, with a width of 7 m. The project analysis period (PAP) is 25 years. The average daily traffic (AADT) is assumed to be 15 heavy duty vehicles (HDV)/day.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>PG 1</th>
<th>PG 2</th>
<th>PG 3</th>
<th>PG 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granulate</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Cement</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Phosphogypsum</td>
<td>0</td>
<td>57</td>
<td>65</td>
<td>65</td>
<td>93</td>
</tr>
<tr>
<td>Waste rock</td>
<td>0</td>
<td>36</td>
<td>28</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
LCIA scores

<table>
<thead>
<tr>
<th>Material</th>
<th>Baseline</th>
<th>PG 1</th>
<th>PG 2</th>
<th>PG 3</th>
<th>PG 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granulate</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Cement</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Phosphogypsum</td>
<td>0</td>
<td>57</td>
<td>65</td>
<td>65</td>
<td>93</td>
</tr>
<tr>
<td>Waste rock</td>
<td>0</td>
<td>36</td>
<td>28</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Scenario PG4

PG4: 0% granulate; 7% cement; 93% PG; 0% waste rock
Scenario PG3

PG3: 28% granulate; 7% cement; 65% PG; 0% waste rock
Sensitivity analysis: allocations

Scenario PG4

PG4: 0% granulate; 7% cement; 93% PG; 0% waste rock
Conclusion and perspectives

Under initial assumptions:

• Raw materials consumption ++
• Climate change - -
• Human toxicity and ecotoxicity - -

• Sensitivity analysis: inerting effect of cement (inerting, optimization of cement content)
• Temporal allocation of impacts: use versus end-of-life
• Avoided impacts related to PG disposal and granulate supply
• Comparison of other uses of phosphogypsum generated in different contexts
Thank you!
References


