SBE19 Graz
SUSTAINABLE BUILT ENVIRONMENT D-A-CH CONFERENCE 2019
11-14 September, 2019
-
Cities 5: Greening the Infrastructure

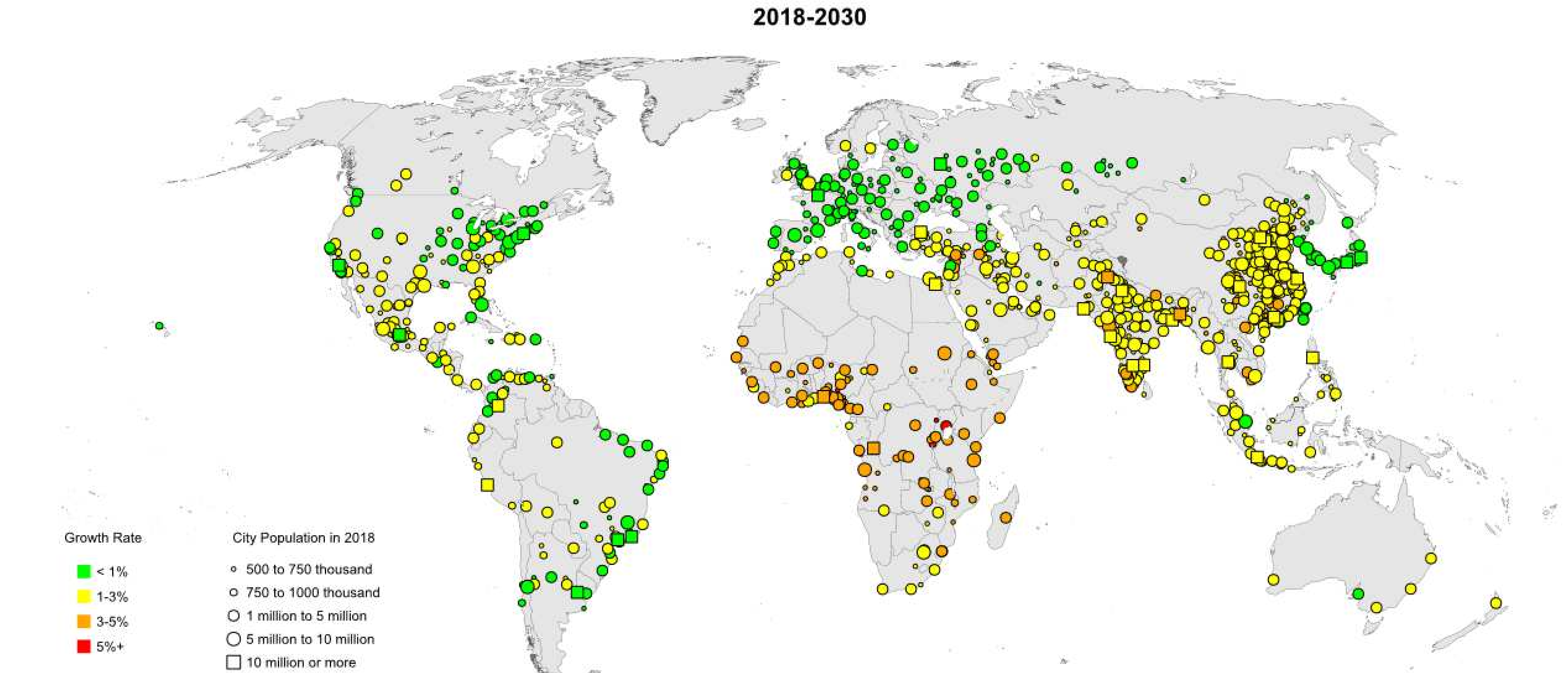
Life Cycle Assessment of Alternative Road Base Materials
-
The case of Phosphogypsum

Myriam Saadé-Sbeih[1], Adelaïde Ferraille[2], Amina Alaoui Soulimani[3]

[1] Ecole des Ingénieurs de la Ville de Paris
[2] Ecole des Ponts ParisTech
[3] OCP Group

1

Growth rates of urban agglomerations by size class

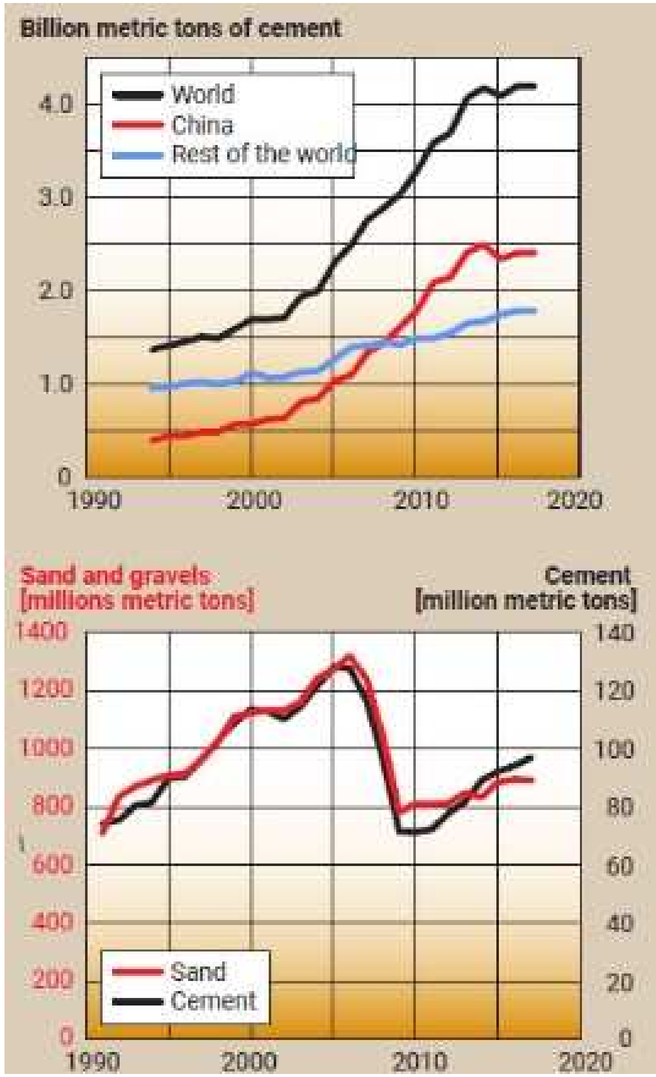


Data source: World Urbanization Prospects: The 2018 Revision
The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan the Republic of South Sudan has not yet been determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

https://population.un.org/wup/Maps/

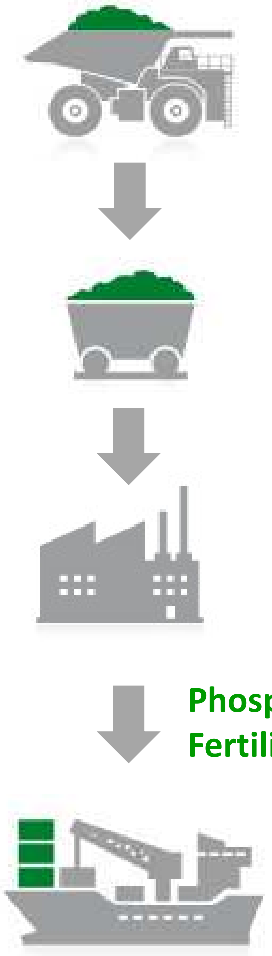
Material requirements of the built environment

- 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?



UNEP (2019)

Phosphogypsum: waste or resource?



Phosphate ore extraction

Transport

Transformation

Phosphoric acid
Fertilizers: MAP; DAP; TSP

Export

~250 Mt/yr

PHOSPHOGYPSUM

85%

Disposal

Credits: wikimedia

- storage in open stack
- discharge into the sea

15%

Use

CPCB (2014)

- fertilizer
- cement retarder
- road base or building material

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

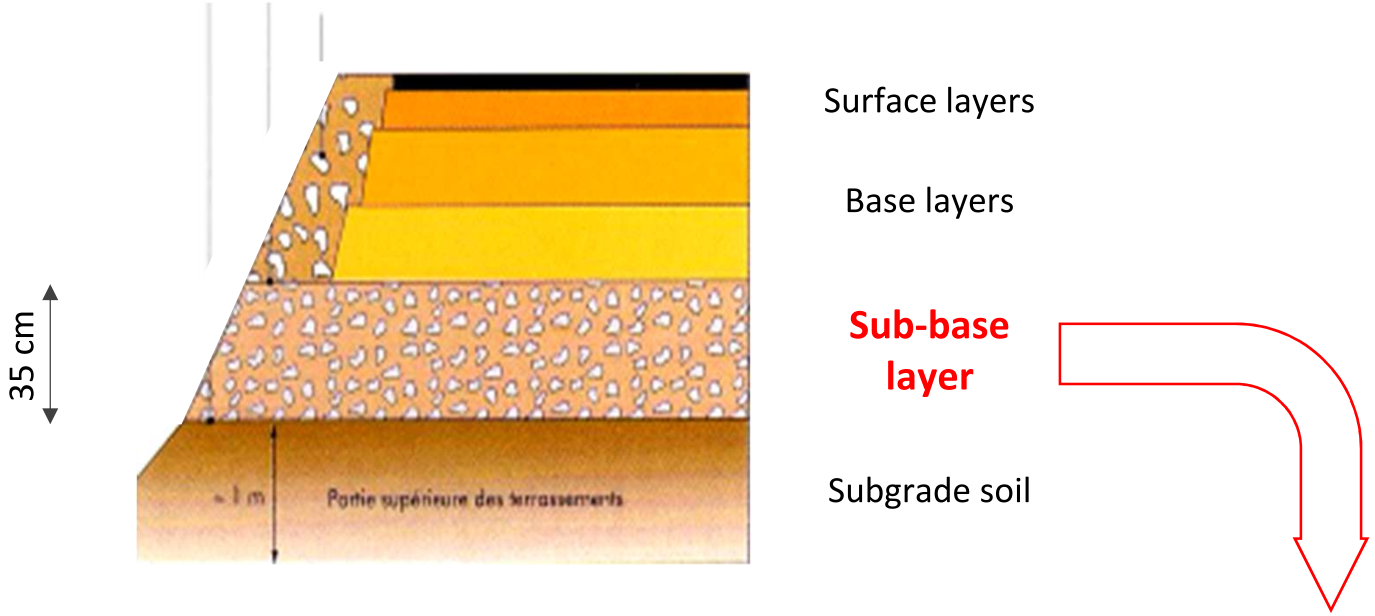
OpenLCA software

Ecoinvent 3.2 (cut-off version)

ReCiPe Midpoint (H)

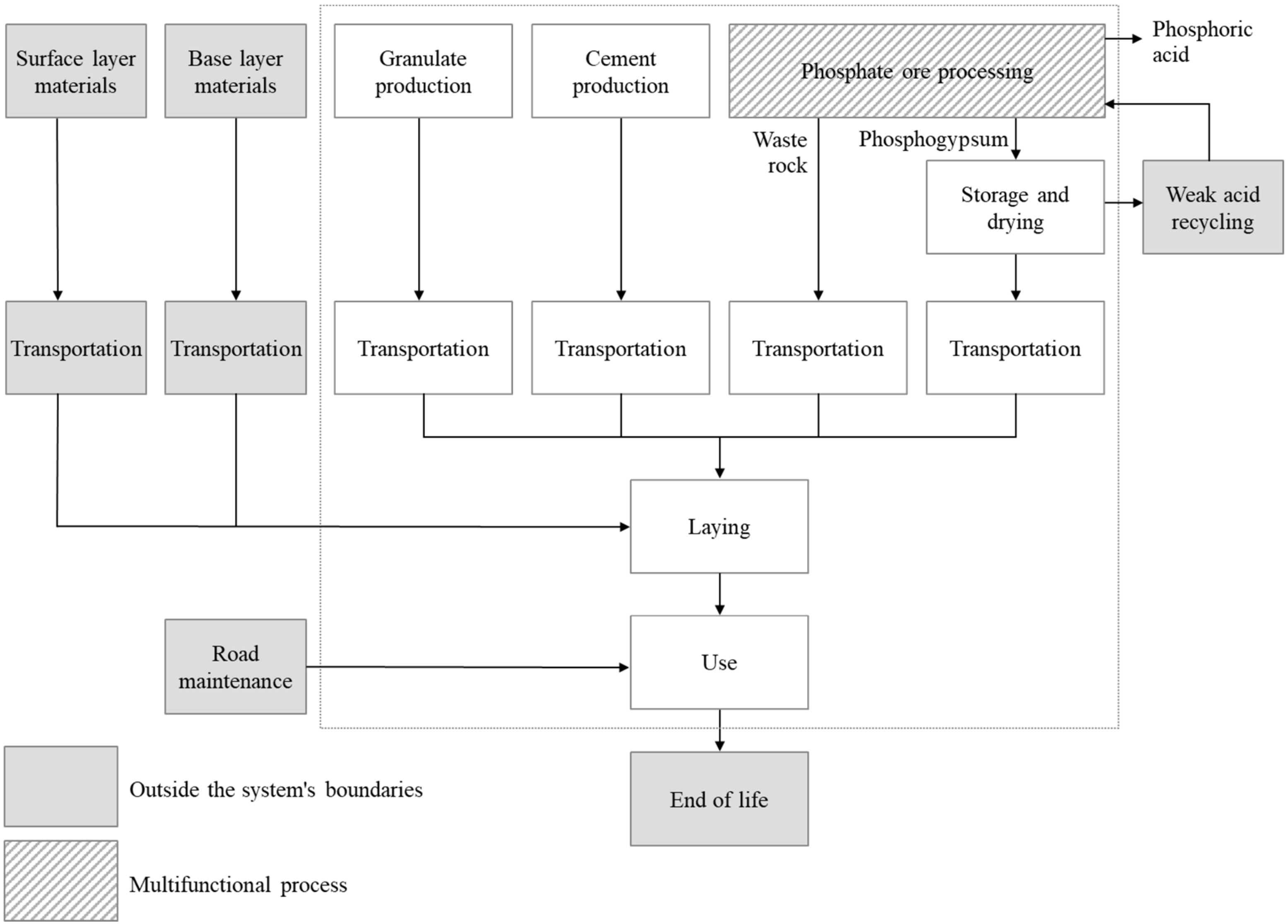
Functional Unit and scenarios

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.

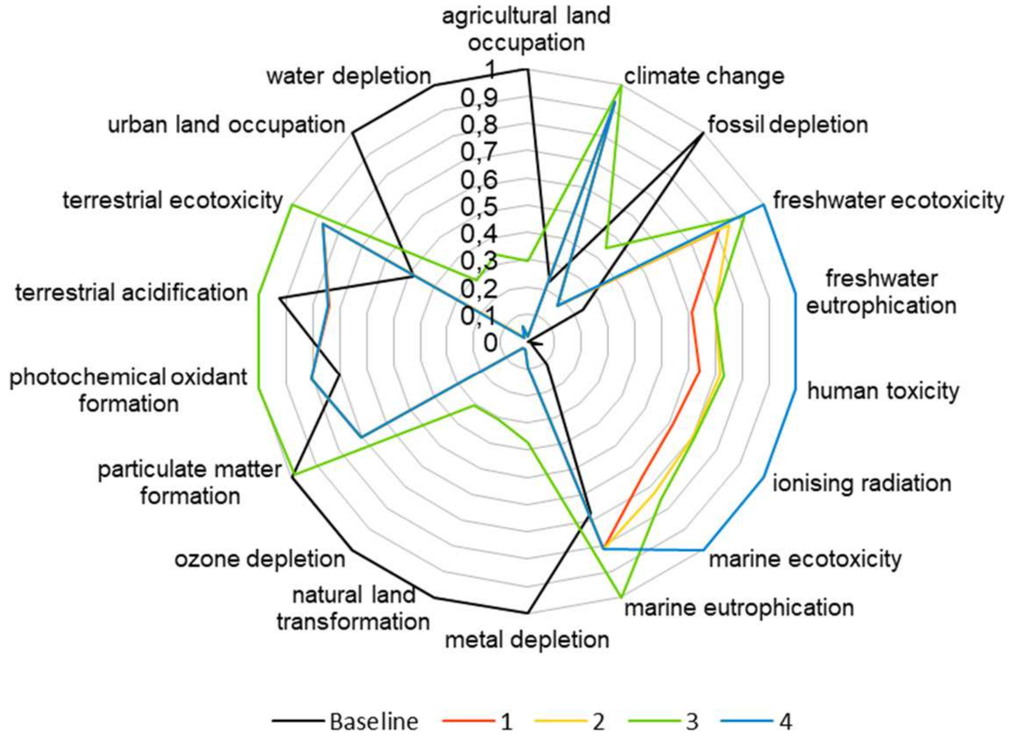


	Baseline	PG 1	PG 2	PG 3	PG 4
Granulate	100	0	0	28	0
Cement	0	7	7	7	7
Phosphogypsum	0	57	65	65	93
Waste rock	0	36	28	0	0

System boundaries

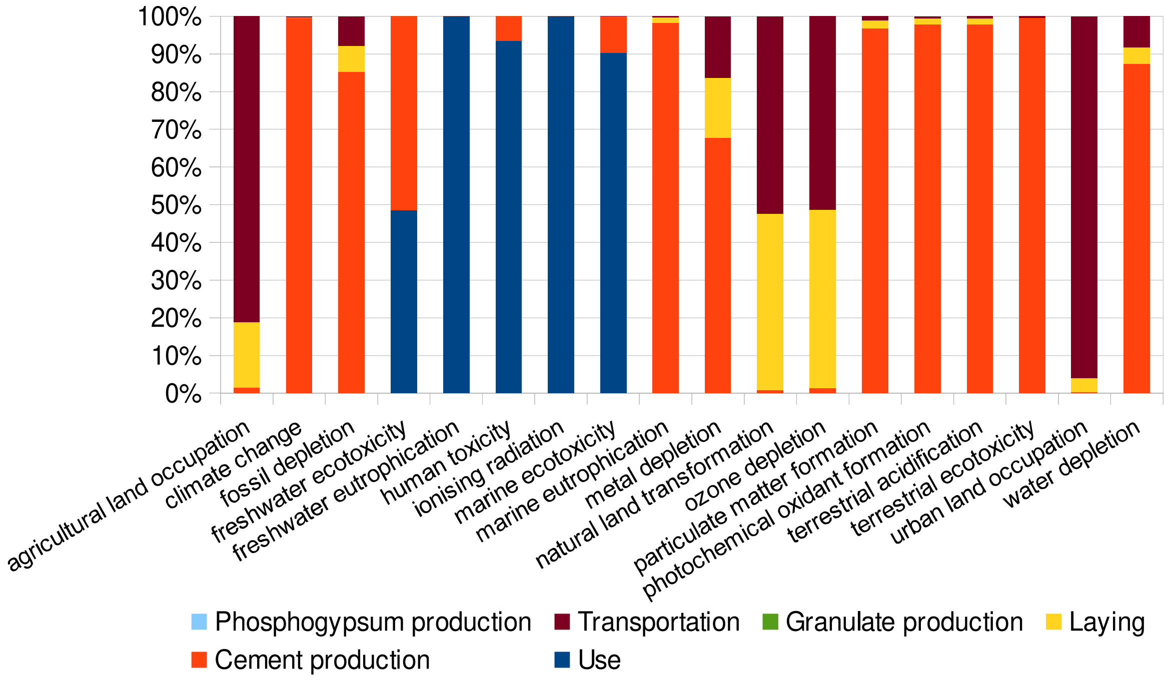


LCIA scores



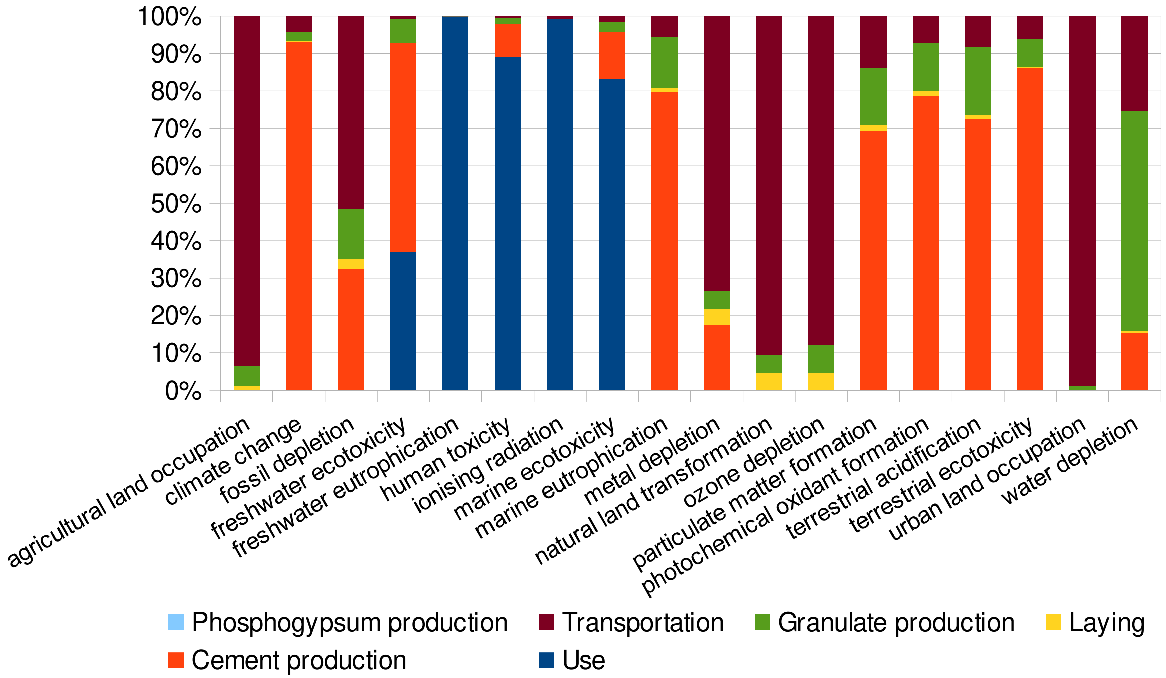
	Baseline	PG 1	PG 2	PG 3	PG 4
Granulate	100	0	0	28	0
Cement	0	7	7	7	7
Phosphogypsum	0	57	65	65	93
Waste rock	0	36	28	0	0

Scenario PG4



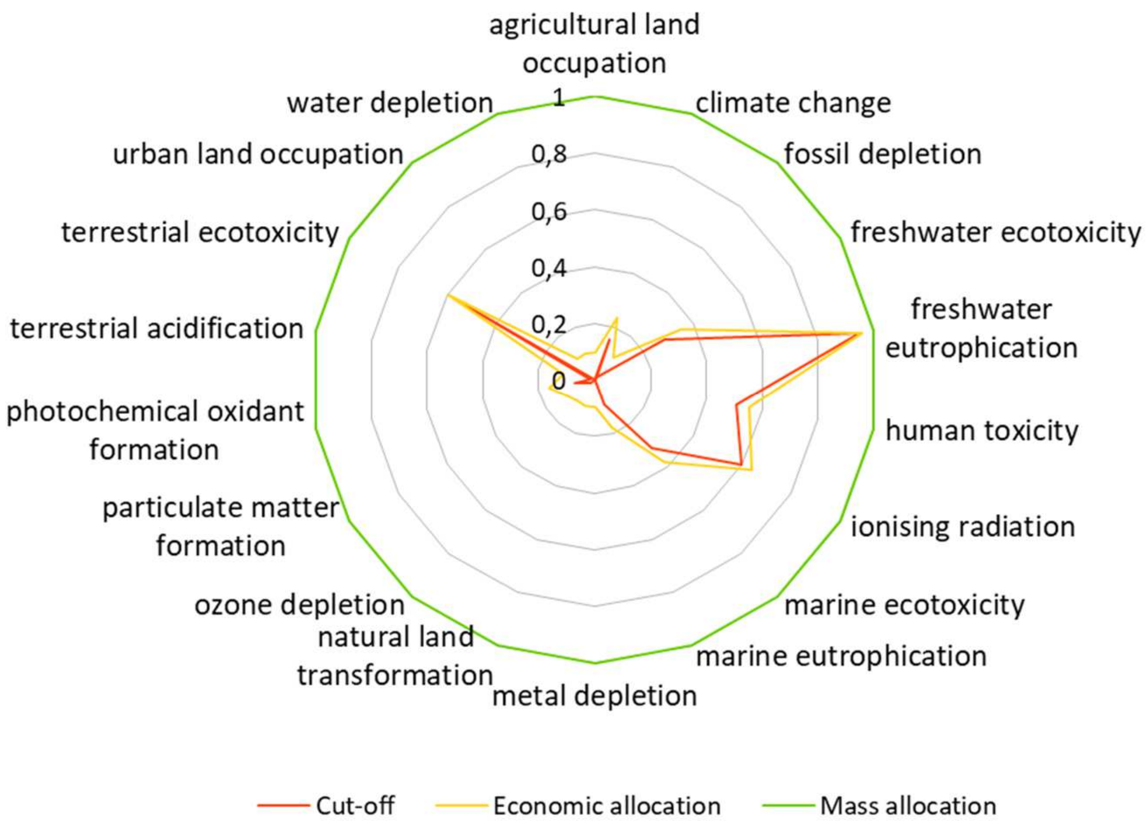
PG4: 0% granulate; 7% cement; 93% PG; 0% waste rock

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 phosphogyspum generated in different contexts

Thank you !

References

- Labrincha, J. et al (2017), From NORM by-products to building materials, Editor(s): Wouter Schroeyers, Naturally Occurring Radioactive Materials in Construction, Woodhead Publishing, 183-252, ISBN 9780081020098, https://doi.org/10.1016/B978-0-08-102009-8.00007-4.
- Layr, K. and Hartlieb, P. (2019), Market Analysis for Urban Mining of Phosphogypsum, Berg Huettenmaenn Monatsh (2019) Vol. 164 (6): 245–249, https://doi.org/10.1007/s00501-019-0855-8
- Schiller, G. (2007), Urban infrastructure: challenges for resource efficiency in the building stock, Building Research and Information, 35(4):399-411.
- UNEP (2019), Sand and Sustainability: Finding new solutions for environmental governance of global sand resources. GRID-Geneva, United Nations Environment Programme, Geneva, Switzerland.