

Phosphogypsum purification: Implications for use in cement production

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Abstract

Managing the large quantities of phosphogypsum (PG) generated during the wet-process phosphoric acid production (WPPA) is currently the biggest challenge facing the global phosphate fertilizer industry. Over 300 million tons of PG are generated annually, with about 47% of this production originating from China and Morocco. PG recycling rates in these countries are low, approximately 36% and 0%, respectively, with a global average estimated at only 15% (Fig. 1). The reutilization of PG is further complicated by the presence of impurities including phosphorus, fluorine, major oxides, trace elements, with radioactive elements (RAEs) (i.e. ²²⁶Ra), stand out as the most hazardous ones. Globally, the average activity concentration of ²²⁶Ra in PG is 645 Bq/kg which is 1.8-fold higher than the permissible value of 370 Bq/kg for agricultural and construction applications, as per U.S. EPA guidelines. This underscores the necessity of removing this element from PG to avoid significant market barriers for this material and to make achieving total reuse of PG an attainable objective. In the present study, the different processes for PG purification such as washing, leaching, and flotation were explored and their feasibility for industrial-scale applications was assessed. Additionally, the potential of purified PG to substitute natural gypsum within the cement industry was also evaluated.

Keywords : Phosphogypsum; purification; cement production; Morocco

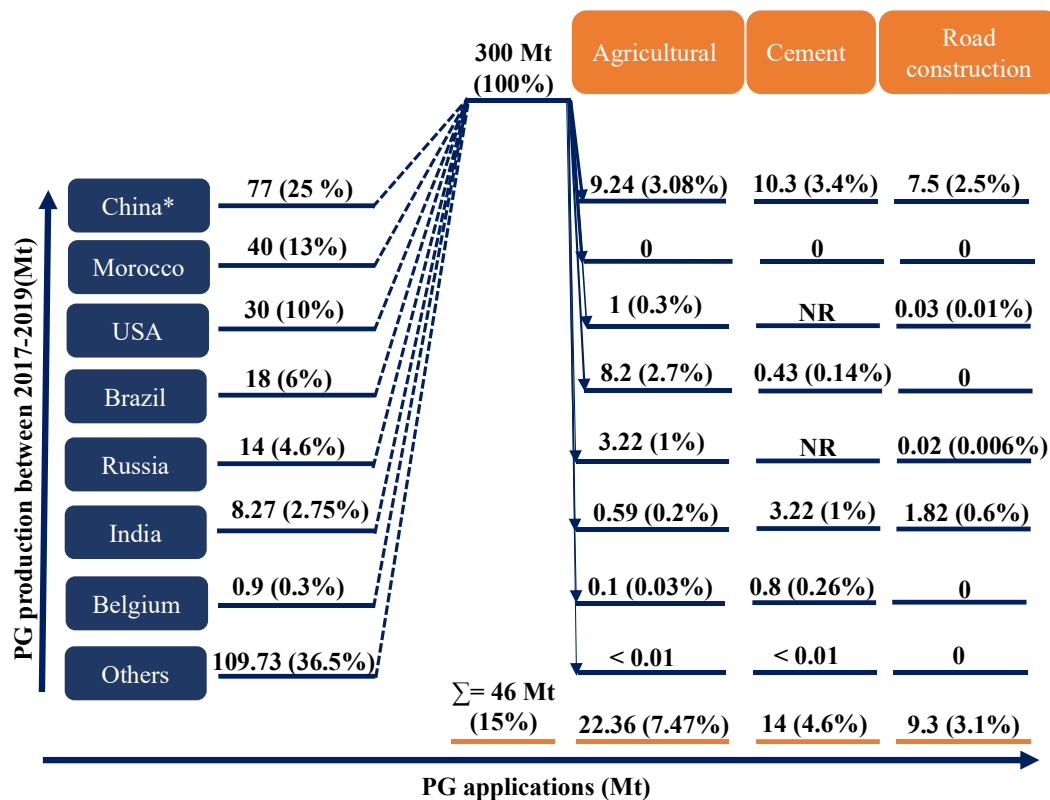


Fig. 1. PG production and recycling in different countries according to [1–7]. NR : Not reported.

* The PG application rate in China was determined using reported data from the Chinese producer Kailin Group [8].

References

- [1] IAEA, Radiation Protection and Management of NORM Residues in the Phosphate Industry, Safety Reports Series No. 78, (2013) 288.
- [2] M. Singh, M. Garg, S.S. Rehsi, Purifying phosphogypsum for cement manufacture, Constr Build Mater 7 (1993) 3–7. [https://doi.org/10.1016/0950-0618\(93\)90018-8](https://doi.org/10.1016/0950-0618(93)90018-8).
- [3] N.C. Paulo Pavinato, PRODUCTION AND USE OF PHOSPHOGYPSUM IN EQUILIBRIUM: BRAZIL, in: PHOSPHOGYPSUM LEADERSHIP INNOVATION PARTNERSHIP, n.d.
- [4] J. Hilton, Phosphogypsum Leadership Innovation Partnership, 2020.
- [5] E. Bilal, H. Bellefqih, V. Bourgier, H. Mazouz, D.G. Dumitraş, F. Bard, M. Laborde, J.P. Caspar, B. Guilhot, E.L. Iatan, M. Bounakhla, M.A. Iancu, Ş. Marincea, M. Essakhraoui, B. Li, R.R. Diwa, J.D. Ramirez, Y. Chernysh, V. Chubur, H. Roubík, H.

Schmidt, R. Beniazza, C.R. Cánovas, J.M. Nieto, N. Haneklaus, Phosphogypsum circular economy considerations: A critical review from more than 65 storage sites worldwide, *J Clean Prod* 414 (2023) 137561.
<https://doi.org/10.1016/j.jclepro.2023.137561>.

- [6] J. Qi, H. Zhu, P. Zhou, X. Wang, Z. Wang, S. Yang, D. Yang, B. Li, Application of phosphogypsum in soilization: a review, *International Journal of Environmental Science and Technology* 20 (2023) 10449–10464. <https://doi.org/10.1007/s13762-023-04783-2>.
- [7] C.Q. Wang, Z.Y. Wang, D.M. Huang, Q.C. Huang, Y. Chen, H. Zhang, Z.H. Shui, Recovery and recycling core of phosphogypsum: Characteristic hazardous elements risk assessment and analysis, *Process Safety and Environmental Protection* 170 (2023) 738–756. <https://doi.org/10.1016/j.psep.2022.12.062>.
- [8] A.J. Birky, B., Hilton, J., Johnston, PHOSPHOGYPSUM : Sustainable Management and Use, in: IFA, 1st edition, Paris, France, January 2016, 2016: pp. 23–31.