

# A review on the environmental impact of phosphogypsum and potential health impacts through the release of nanoparticles

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## Abstract

Many industrial by-products have been disposed along coastlines, generating profound marine changes. Phosphogypsum (PG) is a solid by-product generated in the production of phosphoric acid (PA) using conventional synthesis methods. The raw material, about 50 times more radioactive as compared to unperturbed soils, is dissolved in diluted sulfuric acid (70%) forming PG and PA. The majority of both, reactive hazardous elements and natural radionuclides, remain bound to the PG. A nonnegligible fraction of PG occurs as nanoparticles ( $<0.1 \mu\text{m}$ ). When PG are used for e.g., agriculture or construction purposes, nanoparticles (NPs) can be re-suspended by Aeolian and fluvial processes. Here we provide an overview and evaluation of the geochemical and radiological hazardous risks associated with the different uses of PG. In this review, we show that NPs are important residues in both raw and waste materials originating from the uses of phosphate rock. Different industrial processes in the phosphate fertilizer industries are discussed in the context of the chemical and mineralogical composition as well as size and reactivity of the released NP. We also review how incidental NPs of PG impact the global environment, especially with respect to the distribution of rare earth elements (REEs), toxic elements such as As, Se, and Pb, and natural radionuclides. We also propose the application of advanced techniques and methods to better understand formation and transport of NPs containing elements of high scientific, economic, and environmental importance.

## Keywords

Ultra-fine/Nano-particles, Phosphogypsum, Fertilizer industry, Agricultural and construction utilization, Global risks