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From Phosphate Rock to Fertilizer: Metal(loid) Enrichment and Isotope Tracing During the Manufacturing of Mineral Fertilizer

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Phosphate rocks are known to be enriched in certain metal(loid)s including V, Cr, As, Cd, and U. When used to manufacture phosphate-containing mineral fertilizers, these metal(loid)s can be transferred into the fertilizer product. In this study, we examine trends in the elemental concentrations and strontium isotope ratio ($^{87}Sr/^{86}Sr$) of the parent phosphate rock, produced fertilizers, and intermediate and waste products from the manufacturing process. During the manufacturing process, the phosphate rock is crushed, washed, and dried prior to leaching in sulfuric acid to producing a phosphate fertilizer additive. Up to 45% of Cr and V are removed during the washing process and nearly all of the Ra was removed during the sulfuric acid leaching. However, some Ra is retained in the phosphogypsum waste byproduct during this process. In the production of NPK mixture fertilizers, selected amounts of nitrogen (N), phosphorus (P), and potassium (K) are mixed and assigned an N-P-K value. We find a strong correlation ($R \geq 0.97$) between metal(loid) concentrations (i.e., V, Cr, As, Cd, and U) and the reported phosphorus content of fertilizers, suggesting that fertilizers with more phosphorus will also contain higher concentrations of these metal(loid)s and that phosphate rocks are the predominant source of these metal(loid)s in the NPK-fertilizers. Our data show no significant strontium isotope variation during the fertilizer manufacturing process, suggesting that phosphate fertilizers inherit their strontium isotope signature from the original phosphate rock. NPK mixture fertilizers that contain potassium in addition to phosphate have higher strontium isotope ratios due to the potassium source material having a more radiogenic strontium isotope ratio. These relationships between the metal(loid) content and strontium isotope variations in fertilizers could be used to examine potential contamination of soil and water resources associated with agricultural operations.