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Toxic elements in older Floridian phosphogypsum waste products of the phosphate industry

JANE WADHAMS

Florida State University

Presenting Author: jwadhams@fsu.edu

Demand for phosphate fertilizer over time has led to massive waste byproduct accumulation. The wet process treatment of phosphate for the manufacture of phosphoric acid produces industrial waste phosphogypsum (PG) at a rate of five tons of PG per ton fertilizer yielded. Florida produces approximately 90% of the phosphate for the United States and 20% for the world and has accumulated more than one billion tons of phosphogypsum. This waste PG concentrates toxic substances such as heavy metals, metalloids, and naturally occurring radionuclides that prevent its reutilization and require the waste PG to be piled into mounds several hectares wide and tens of meters tall known as gypstacks. In early 2021, hundreds of millions of gallons of process water from the Piney Point, Florida, gypstack were released into a neighboring estuary causing cyanobacteria blooms and fish kills. The amounts of toxic contaminants released and their consequences are unknown, but have contributed to growing concern over the potential leaching of toxic elements from gypstacks. This study analyzed a depth transect of phosphogypsum samples and edge outflows from Piney Point, Florida, for concentrations of toxic impurities (e.g., V, Cr, Cu, Zn, As, Cd, and Pb) by high resolution ICP-MS. The majority of V and Cr were found in silicates. Leaching experiments explored the potential mobility of contaminants through the stack and found extractable As and Cd less than 1 ppb. Concentrations of the analyzed contaminants were not found to exceed EPA regulatory limits. Compared with available data on gypstacks around the world, As and Cd in the Piney Point phosphogypsum are on the low end of the spectrum. Arsenic and Cd are below levels that limit the valorization of the phosphogypsum. It is possible that such lower values observed for the inactive Piney Point gypstack reflect extended leaching that gradually removed arsenic and cadmium. Central Florida has gypstacks ranging from decades old to active and thus affords a unique opportunity to test this finding by analyzing toxic elements as a function of gypstack age.