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Interaction of the Gardanne Bayer effluent with seawater (Mediterranean Sea): influence on the trace metals behaviour

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At the end of 2015, the Gardanne alumina plant ceased discharging bauxite residues into the Mediterranean Sea, replacing them with a high-pH, high-metals-content effluent. Regulatory authorities expressed particular concerns about the fate of the effluent at sea, particularly the formation of 3 to 4-meter-high chimneys structure, accompanied by a plume of white particles, when it mixes with seawater. As part of the global effort to evaluating the environmental consequences of deep-sea tailing placement from the Gardanne plant, our study focused on understanding the formation of concretions at the outfall. Today, we can define these processes as a form of industrial (or artificial) hyperalkaline hydrothermalism. Chemical and mineral analyses showed theses concretions were primarily made of hydrotalcite, a Mg-Al double layered hydroxide. The necessary Al and hydroxide for hydrotalcite formation were supplied by the Na-Al-OH Bayer effluent, while Mg came from seawater. Through a combination of *in situ* sampling and laboratory experiments, we explored the metal and metalloids dynamics during the interaction between the Bayer effluent and seawater. The key objective was to determine whether hydrotalcite can act as a long-term sink for effluent contaminants or, conversely, facilitate their release and dispersion into the marine environment. Our results revealed that, when mixed with seawater, 1 L of effluent can form 20 to 25 g of (wet) particles. Hydrotalcite formation proved effective in removing metals and metalloids such as Al, Co, Pb, As, Ni, Cu and Ti from the effluent. In contrast, Cr and V were either partially removed or remained in the dissolved phase. Anomalies in Al and As concentrations within the plume at sea further supported their active removal. While hydrotalcite's capacity for contaminant removal is significant, its non-stability in seawater suggested that these particles will dissolve or evolve in the water column beyond the plume, raising concerns about their long-term environmental impact. The fate of the columns of concretion formed at the outfall remains also a central concern, especially given that since 2019, the plant has reduced both the alkalinity and Al concentrations in its discharges to ensure compliance with environmental regulation.

Impact of deep-sea tailing placement: case study of the Gardanne Bayer effluent discharge at sea