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Evolution in the metal contaminant composition of industrial effluent from an alumina plant discharged into the Mediterranean Sea (2016-2021)

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The Marseille coastline (France), including the Calanques National Park, renowned for tourism and maritime trade, faces significant urban and industrial discharges into the Mediterranean Sea. Notably, from the 1960s, the Gardanne plant discharged metal-rich solid residues into the sea resulting from the alumina production using the Bayer process. These discharges led to significant red mud expansion on the seabed and caused local protests. As part of a long process initiated in the late 1970s, the Gardanne plant committed to cease solid residue discharge by 2015. Installation of three filter-presses between 2007 and 2015 enabled to finalize the discharge clarification. To comply with environmental regulations, the plant was permitted to discharge effluent for six more years from 2016, overseen by monitoring committees. Key compliance measures included the implementation of a CO2-treatment plant in 2019 to mitigate pH and metals concentrations.

Our study focused on metal contaminant evolution in the effluent, outfall mixing zone at sea (plume) and surrounding seawater column from 2016 to 2021. Metals quantification via SF-ICP-MS in both filtered (dissolved) and non-filtered (total) samples allowed evaluating plant-applied treatment effects on the effluent composition and metal fate in the marine environment.

Results showed a significant metal contaminant decrease in the effluent, especially for Al which decreased from 181 mg/L to 382 µg/L on 2016-2019 period. Moreover, all concentrations were below threshold limits, except for As and Cu discrete samples.

Plume analyses revealed greater variability than the effluent, with concentrations generally remaining within same ranges except for a notable drop in Al NF (from 3 581 µg/L to 280 µg/L) on 2016-2021 period. F/NF ratio increased, particularly for Al between 2016 and 2019, due to halted hydrotalcite formation resulting from effluent/ seawater mixing in 2016, which stopped following effluent neutralization in 2019.

Seawater column analyses indicated metal concentrations around background values above 300 m depth, except mainly for Al, suggesting a localized effluent effect.

These results are further discussed in a broader context exploring the circulation of scientific data among stakeholders overseeing discharge to consider a co-writing approach of result dissemination reflecting societal needs and demands regarding marine discharge environmental issues.