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Sargassum leachate undergoes distinct molecular transformations in carbonate and silicate sand beaches as revealed by ultra-high resolution mass spectrometry

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Mass strandings of pelagic *Sargassum* across the tropical Atlantic are transforming shore ecosystems and their biogeochemical cycles, yet the fate of the Sargassum leachate, its initial decomposition product, in sandy beaches remains poorly understood. We investigated how sand mineralogy regulates the transformation of leachate at the molecular-level using ultra-high resolution FT-ICR mass spectrometry. In 50-70% of assigned molecular formulae, relative abundance changed more than 50%, reflecting rapid decomposition during the 28-day incubations. Leachate-only controls showed preferential loss of reduced, aliphatic compounds and an increase in more oxygenated, aromatic-like formulae. Carbonate sand incubations promoted gains in compounds characterized by intermediate O/C ratios, as well as increases in sulfur-containing formulae, implying mineral-mediated stabilization and microbial sulfur incorporation. In contrast, silicate sand incubations retained a larger fraction of aliphatic material and revealed distinct nitrogen-compound dynamics. The results emphasize that carbonate and silicate sand beaches differentially regulate the oxidation state, heteroatom content, and thermodynamic favorability of stranded macroalgal leachate, with broad implications for coastal carbon cycling under increasing *Sargassum* influx.

