

Effect of lignite humic acid on iron bioavailability to algae in coastal waters

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Iron is one of the essential micronutrients for algal growth, and can exist in two oxidation states in seawater, Fe(II) and Fe(III). The thermodynamically stable form of iron, Fe(III), is sparingly soluble and remain at extremely low concentration in the oxygenated waters. Mobility and bioavailability of iron are mainly correlated to the solubility of Fe(III), which is controlled by complexation with natural organic chelators in seawater. The humic substances, which constitute 70 to 90% of dissolved organic carbon in wetland waters, contribute to keeping Fe(III) in the dissolved and colloidal forms in estuarine systems. In this study, we investigated the effect of lignite humic substances on Fe uptake and growth of macro-algae in a laboratory-scale experiment.

Humic substances were synthesized by acid degradation of lignite with nitric acid and produced using a modified IHSS recommended scheme. The produced humic acids were fractionated by a tangential-flow ultrafiltration system using a Vivaflow 200 system (Sartorius Stedim, UK). Algal cultures (coastal species) were grown in modified f/2 or PES media at 20°C under a 12:12 h L/D photo-period at a light intensity of 180 $\mu\text{mol photon m}^{-2} \text{s}^{-1}$ provided by cool white fluorescent lights.

In the algal growth experiments, the humic acid fractions (5–10, 10–30, 30–100 and >100 kDa) were used as an organic chelator in the medium instead of EDTA. The Fe uptake to algae in the medium with the humic acid fractions was higher than with EDTA. The lower MW fractions, particularly 10–30 kDa, assisted in achieving a better algal growth rate, although the spectroscopic characterization showed that main chemical structure of all the humic acid fractions is almost similar. The dissolution behavior of humic acid fractions in seawater indicated that the lower molecular weight fractions, such as 10–30 and 5–10 kDa, were sustained for a longer time-span compared to the higher MW fractions. The stability and solubility of dissolved and colloidal iron can be related to the corresponding bioavailability to coastal algae, which is mainly controlled by complexation with the lower MW chelators.