Advanced Analytical Approaches to Dissolved Organic Matter for a Sustainable Future: Innovations for a Net Zero Future

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ABSTRACT

Innovations and technology that improve our understanding and management of natural resources play an important role in achieving net zero emissions. This study aims to investigate the pivotal role of dissolved organic matter (DOM) characteristics in the environment, utilizing advanced analytical techniques such as Pyrolysis-Gas Chromatography-Mass Spectrometry (Py-GCMS) and Orbitrap Mass Spectrometry (Orbitrap MS). DOM is a complex mixture of organic compounds in aquatic environments that plays a significant part in carbon cycling, water quality, and ecosystem dynamics. Understanding its structure and behavior is critical for building long-term environmental management approaches. This study employs molecular composition analysis by Py-GCMS and Orbitrap MS to give a complete analysis of DOM, showing its chemical structure, characteristics, and origins within the ecosystem. Together, these techniques provide a detailed picture of the dynamics of DOM, offering valuable information to develop strategies aimed at reducing environmental impact by identifying specific harmful organic compounds in DOM, so water treatment facilities can tailor their processes to target and remove toxic substances efficiently and supporting sustainability by ensuring safer drinking water along with reducing the need for extensive chemical treatment that support the transition to a net zero world. Monitoring changes in DOM composition over time can also act as an indicator of environmental changes, such as shifts in land use or climate conditions, which helps assess the impacts of climate change on ecosystems. Py-GCMS offers insights into the thermal decomposition products of DOM they focus on breaking down large molecules into smaller fragments which can be detected in mass spectrometry, helping to identify specific organic compounds and their origins. The result divided the substances into 8 categories: Polysaccharide Aromatic, Lignin, Lipid, Tannin, and Siloxane. Among them, it was found that the main compound of every sample analyzed is lignin. Using Orbitrap MS operates at lower temperatures (around 30ºC), even though it may miss larger molecular components, with its high-resolution capabilities, allowing for precise mass measurement of DOM components, enabling the detection of even the most subtle changes in composition and reactivity molecules below 2000 Da, essential for a comprehensive understanding of NOM. The assigned MS sample peaks were described in van Krevelen diagrams employing the CHON formulas. In these regions, lignin-like and tannin-like substances are particularly abundant and were quantified to contain the largest portion of all substances (approximately 20%), indicating that all of the samples originate from a terrestrial source. This result corresponds with the Fluorescence EEM data, which have a FI value of less than 1.4 for all samples, indicating terrestrial origin. This study will enable the broader goal of conserving natural resources and enhancing human activity sustainability by expanding our understanding of DOM and its role in environmental processes.

Keyword: DOM/ Py-GCMS/ Orbitrap MS/ Sustainable development

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