



Dissolved Organic Matter (Dom): Roles in Aquatic Systems and Biogeochemical Processes

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Abstract

Dissolved organic matter (DOM) is a complex mixture of organic molecules derived from biological production, decomposition, and terrestrial inputs in aquatic environments. DOM plays central roles in carbon cycling, nutrient dynamics, and water quality by influencing microbial activity, light penetration, and pollutant transport. Its composition and reactivity vary widely across ecosystems, shaped by sources, physical conditions, and biotic interactions. This article reviews the sources, composition, and ecological significance of DOM, and discusses its role in ecosystem functioning and global biogeochemical cycles. Understanding DOM dynamics is vital for predicting ecosystem responses to environmental change.

Keywords: Dissolved Organic Matter, Aquatic Ecosystems, Carbon Cycle, Microbial Degradation, Chromophoric Dissolved Organic Matter (CDOM), Biogeochemistry

Introduction

Dissolved organic matter (DOM) is an operationally defined pool of organic molecules that pass through filters (typically $<0.7 \mu\text{m}$) in aquatic systems. DOM encompasses a wide diversity of compounds, including simple sugars, amino acids, humic substances, and complex macromolecules. DOM arises from multiple sources: primary production by phytoplankton, leaching from soils and vegetation in terrestrial environments, and microbial decomposition of organic matter. Once dissolved, these organic compounds influence water chemistry, nutrient cycling, and the food web base by serving as a substrate for heterotrophic microbes.

Although DOM represents only a small proportion of total organic carbon in aquatic systems, it is one of the largest reservoirs of reactive carbon on Earth, influencing global carbon cycles. The dynamics of DOM — its production, transformation, and export — are tightly linked to ecological processes and environmental

change, including land use shifts, climate warming, and hydrological alterations. Consequently, DOM is a key indicator of ecosystem health and function, and its study integrates disciplines spanning biogeochemistry, microbial ecology, and hydrology [1].

Sources, Composition, and Ecological Role of DOM

Dissolved organic matter originates from both **autochthonous** (within-system) and **allochthonous** (external) sources:

is produced within the water body, primarily by phytoplankton and aquatic plants. It includes photosynthetic exudates, metabolic byproducts, and degradation products of algal biomass is delivered from surrounding terrestrial environments via runoff, groundwater discharge, and soil leaching. This fraction is often rich in humic and fulvic acids derived from plant and soil organic matter.

The chemical composition of DOM reflects its source and history of transformation. Laboratory and field studies using spectroscopic and chromatographic methods have identified both labile (readily degradable) compounds and more refractory fractions that persist for long periods [2]. Humic-like substances, a significant portion of terrestrial DOM, have complex aromatic structures that influence light absorption in water, while protein-like DOM often indicates fresh biological production.

Dissolved organic matter plays a critical role in the aquatic carbon cycle. DOM represents a mobile carbon pool that can be transported within and between systems via water movement. In freshwater and coastal ecosystems, DOM influences carbon dioxide production and sequestration: Heterotrophic microbes use DOM as a carbon and energy source, respiring it to CO_2 or converting it into biomass. This microbial processing regulates the turnover and fate of organic carbon in water bodies. Sunlight can alter DOM through photo-oxidation, breaking down complex molecules and making them more biologically available or promoting direct CO_2 release [3].

The balance between DOM production, transformation, and loss influences whether aquatic systems act as carbon sources or sinks. For example, waters enriched with terrestrial DOM often exhibit high microbial respiration, contributing to elevated CO_2 emissions back to the atmosphere.

Dissolved organic matter impacts ecological processes and water quality in several ways:

Chromophoric DOM (CDOM) absorbs ultraviolet and visible light, reducing light penetration and affecting primary production by phytoplankton and aquatic plants. CDOM also protects organisms from harmful UV radiation [4]. DOM acts as both a source and sink for nutrients such as nitrogen and phosphorus, affecting their availability to primary producers and microbes. Many organic pollutants bind to DOM, altering their transport, bioavailability, and degradation pathways. DOM can influence the fate of metals and hydrophobic organic compounds in water. Labile DOM fuels microbial loops, supporting bacterial growth that, in turn, transfers energy to higher trophic levels via protists and small metazoans.

Understanding DOM dynamics is therefore essential for predicting how aquatic ecosystems respond to stressors such as

nutrient enrichment, hydrological variability, and climate change [5].

Conclusion

Dissolved organic matter is a fundamental component of aquatic ecosystems, linking carbon and nutrient cycles with biological and physical processes. Its diverse sources and chemical complexity govern how DOM affects microbial metabolism, light dynamics, nutrient availability, and contaminant mobility. Anthropogenic impacts have altered the quantity and quality of DOM in many systems, with implications for water quality, carbon emissions, and ecosystem resilience. Comprehensive characterization of DOM, combined with mechanistic understanding of its sources and transformations, is critical for ecosystem monitoring and management in a changing environment.

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