Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

MIS023-P11 Room:Convention Hall Time:May 22 16:15-18:45

Characterizing the dynamics of dissolved organic matter by fluorescence spectroscopy

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Dissolved organic matter (DOM) comprises the largest pool of organic matter in a wide range of aquatic environments. DOM in the ocean is one of the largest bioactive carbon reservoirs with a stock of 680 PgC in the global basis. In terrestrial aquatic environments, even though stocks of DOM are small compared to the ocean, it has been recognized that a large amount of organic matter is processed in inland waters and must be considered in the global carbon cycle. In addition, DOM plays a key role in biogeochemical cycles affecting processes such as metal complexation, light attenuation, nutrient availability, and microbial and phytoplankton activity. Recent studies clearly show that dissolved organic carbon (DOC) concentrations in terrestrial aquatic environments change with environmental disturbances such as land management. However, fluxes and mechanisms controlling the DOM dynamics in aquatic environments, e.g., transport of organic matter from land to rivers, have not been well documented and we need to improve our knowledge of this subject. The role of DOM in biogeochemical cycles, e.g., as a driver for microbial loop, is strongly related to DOM chemical characteristics or quality. Thus, we need a better understanding of DOM dynamics in aquatic environments in terms of quantity and quality.

Fluorescence spectroscopy has been widely used for characterizing DOM dynamics in aquatic environments. This technique features high sample throughput and can evaluate the dynamics of at least two very different groups of DOM, namely humic-like and protein-like fluorophores. The protein-like fluorophores have been considered to be representative of fluorescent aromatic amino acids and consequently the biologically reactive components. On the other hand, humic-like fluorophores can be used to evaluate mainly soil-derived organic matter in aquatic environments. Thus, characterization of DOM using fluorescence techniques will provide a better understanding of DOM dynamics in aquatic environments. More recently, the combined techniques of excitation-emission matrix (EEM) fluorescence with parallel factor analysis (PARAFAC) have successfully evaluated the environmental dynamics of fluorescent DOM (FDOM) components in diverse aquatic ecosystems. This technique provides higher resolution on fluorescence components in DOM, and thus, may be ideally suited to detect small, but potentially significant variations in DOM composition in apparently similar aquatic environments.

In this presentation, we will introduce fluorescence techniques, especially EEM-PARAFAC, as a tool for characterizing the DOM dynamics in aquatic environments. As an example, we will present optical properties of DOM that dissolved from flocculent particulate organic matter (floc). This study shows that light exposure of floc from the Florida Coastal Everglades results in significant DOM generation through photo-dissolution processes. DOC concentration for samples incubated under dark conditions displayed a relatively small increase, suggesting that microbial processes and/or leaching might be minor but important processes for the generation of DOM from floc. On the other hand, DOC concentration increased substantially for samples exposed to artificial sunlight, indicating the release of DOM through photo-induced alterations of floc. The fluorescence intensity of both humic-like and protein-like components also increased with light exposure. Terrestrial humic-like components were found to be the main contributors (up to 70 %) to the FDOM pool, while protein-like components comprised a relatively small percentage (up to 16 %) of the total FDOM. While the photo-dissolution of suspended sediment organic matter in coastal regions has also been reported, the photo-dissolution of floc in wetlands can be an important source of DOM to these shallow aquatic environments, particularly after storm events, with the potential to influence nutrient dynamics in such system.

Keywords: Dissolved organic matter, Fluorescence characteristics