Dissolved organic matter percolated from periphyton in the Everglades: Characterization and interaction with mercury

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Abstract

When organic matters of various kinds decompose partially, dissolved or soluble organic matters can form. The organic matters are usually produced from plants, soil, bacteria, algae, and living organisms. The Everglades wetland is rich in dissolved organic matters. The quantity and quality of these DOM have significant impact on environmental factors, specifically speciation and geochemical cycling of toxic metals such as mercury. Everglades is abundant in periphyton which can also be responsible for DOM percolation and production. The DOM from periphyton, in particular when freshly produced and released into the water, would have a profound effect on mercury species present in the water, e.g., by forming Hg-DOM complexes. This experiment is designed to perform quantitative and qualitative analysis of DOM produced by periphyton and the complexation of mercury with the produced DOM from periphyton in molecular level. In addition to organic carbon analysis, samples were analyzed for optical properties by using a spectrofluorometer for information on sources, types, and reactivity of DOM. Water samples from different types of periphyton were differentiated by measuring Chlorophyll-a and nutrients. Studies were done with addition of inorganic and methyl mercury of different concentrations in leached DOM samples from periphyton by observing fluorescence quenching for Hg-DOM complexation using 3D Excitation Emission Matrices Fluorescence Spectroscopy. Specific functional groups and fingerprints of periphyton were analyzed using Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy. The project will improve the understanding of the relation between DOM and periphyton and the environmental processes of Hg impacted by periphyton in Florida Everglades.

Research aims

- Quantitative and qualitative characterization of DOM from different types of periphyton and in Everglades surface water
- Analysis of periphyton DOM-mercury interaction through addition of different concentrations of mercury in freshly leached DOM samples from periphyton
- Characterization of specific functional groups and fingerprints of periphyton organic matter which interact with mercury

Figure 1: Periphyton dissolved organic matter impacting mercury speciation in Florida Everglades

Research Methodology

- Sample collection of surface water and different types of periphyton from Everglades
- Incubation of periphyton and organic matter leaching experiment
- Elemental analysis by measuring total and dissolved C, N, P contents
- Optical properties measurement without and with mercury of different concentrations using 3-D EEMs Fluorescence Spectroscopy
- Analysis of periphyton functional group & fingerprint regions using FTIR-ATR Spectroscopy

Figure 2: Different types of periphyton samples collected from Florida Everglades

Figure 3a: Floating mat in the beginning of incubation without and with mercury

Figure 3b: Floating mat at the end of incubation without and with mercury

Figure 3: Periphyton incubation without and with different concentrations of inorganic mercury (180 ppb; 360 ppb) and methyl mercury (180 ppb; 360 ppb)

Results

Figure 4: Periphyton DOM optical properties analysis without and with inorganic mercury (360 ppb) using 3D EEMs Fluorescence Spectroscopy

- Characterization of periphyton organic matter functional group & fingerprint regions

Figure 5: Periphyton functional group & fingerprint regions analysis using FTIR-ATR Spectroscopy

Findings and Observations

- DOM types from floating mat pore water were mostly tryptophan-like (labile), followed by tyrosine-like (refractory), then fulvic-like, and lastly humic-like (ubiquitous origin)
- Addition of inorganic mercury of 360 ppb had quenched the intensities of these DOM fluorophores the most indicating periphyton DOM-Hg complexation
- Floating mat fingerprint region exhibited the strongest absorbance intensity for CH₃, CH₂ of proteins or, C-O of COO⁻ groups and sulfate or, sulfonamide group
- C-O-C of saccharides, calcite, amide I (C=O from proteins), lipid (C=O of ester), phosphor (P=O of phosphodiester) and low absorbance of thiol (S-H) functional group were observed as well

Discussion and Conclusion

- In this project, quantitative and qualitative analysis of dissolved organic matters were performed for Everglades surface water, periphyton overlying water, and periphyton pore water from two different types of periphyton.
- The quantitative analysis yielded information on their dissolved organic carbon, total dissolved nitrogen, total dissolved phosphorus, and chlorophyll-a contents which further provided understanding of their unique environmental conditions, light, oxygen availability, nutrient uptake and photosynthetic abilities; while the qualitative analysis yielded information on their unique DOM types, sources, and reactivity.
- In order to analyze the influence of mercury in periphyton DOM, the most abundant and common floating mats were utilized by adding different concentrations of inorganic and methyl mercury in their pore water which provided information on mercury's unique ability to complex to different periphyton DOM types.
- Floating mats were also utilized to obtain information on periphyton functional group and fingerprint regions without and with incubation with mercury. Although, there were no significant differences obtained among the absorbance intensity and wavenumber regions of the groups with mercury addition, some qualitative information regarding their fingerprint regions were made.
- The influence of mercury on Chlorophyll-a concentration of periphyton was also analyzed by using floating mats by incubating them without and with different concentrations of inorganic and methyl mercury which yielded information on mercury's ability to inhibit photosynthetic ability of periphyton.

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