U.S. Department of the Interior
U.S. Geological Survey

INTERACTIONS OF MERCURY WITH DISSOLVED ORGANIC CARBON IN THE FLORIDA EVERGLADES

There has been increased awareness by both public and scientific communities of mercury contamination of game fish in South Florida. Effective management strategies for dealing with this problem will require a more thorough understanding of the processes that result in the generation and transport of mercury, and control its reactivity in the Everglades. The interaction of mercury with dissolved organic carbon (DOC) has been proposed as a primary mechanism for the transport of mercury in aquatic systems because of a strong correlation between dissolved mercury and DOC concentrations in ground, lake, and stream waters. However, little is known about how mercury interacts with DOC or how strong these interactions are. The reactivity of DOC is especially important in South Florida because of the high natural production of organic carbon in the peat soils and wetlands, the relatively high carbon content of shallow ground water systems in the region, the interactions of organic matter with mercury, other trace metals (such as copper and lead), and anthropogenic organic compounds (such as pesticides), accumulation of organic carbon in corals and carbonate precipitates, and the potential changes in the quality and reactivity of DOC resulting from land use practices.

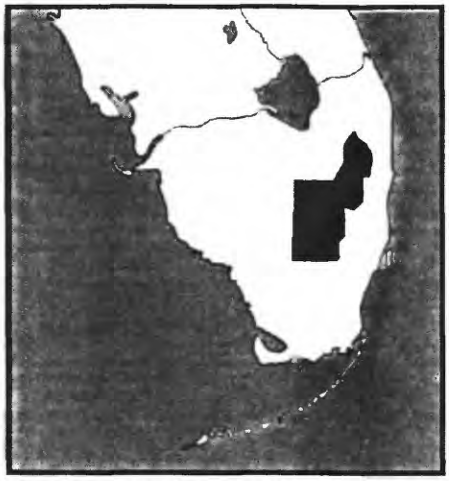
PROJECT GOAL

The chemical forms of mercury in the water column and sediments are intimately related to its overall effects on living organisms. Interactions of mercury and dissolved organic matter may play an important role in controlling both the availability of mercury for uptake by living organisms, and the types of chemical reactions that can occur with mercury. The goal of our research project is to provide information about the interactions of mercury and dissolved organic matter that will better define this important, albeit, poorly understood process. Ultimately, this research will lead to a more complete model of mercury behavior in the Everglades. Our research will focus on the effect of DOC on the transport and reactivity of mercury in the Everglades through a combined field and laboratory study. The underlying hypothesis is that the chemistry and structural characteristics of organic matter in the Everglades have a strong influence on the processes that control mercury cycling in the environment.

BACKGROUND

Organic matter in aqueous systems is important for a number of chemical and biological processes. Organic matter often controls chemical processes by acting as a pH buffer, by affecting the transport and degradation of pollutants, and by participating in reactions that result in either the dissolution or formation of minerals. Dissolved organic carbon may also play an important role in the ecology of aquatic systems by absorbing light, thereby controlling the depth at which plants can live in surface waters, by influencing the availability of nutrients, and by serving as a source of energy for microbial organisms. In an aquatic system, organic matter can be dissolved, associated with the bottom sediment, or associated with suspended particles. Each of these different forms is interrelated to other chemical components in the system, such as mercury.

The DOC story begins with microbial degradation of plant material and organic detritus by bacteria, fungi and other organisms, which results in the formation of many of the compounds that comprise the organic matter found in soils, peat, and aquatic systems. Organic matter derived from different source materials has distinctive chemical characteristics associated with those materials. These differences in chemical nature control the ecological and chemical significance of the organic matter at a given place - not all organic compounds react in the same way or to the same degree. Most of the dissolved organic matter in the Everglades originates from the degradation and leaching of organic detritus resulting from the algae, bacteria and macrophytes living within the wetland environment. In addition, organic matter is also transported to the Water Conservation Areas of the Everglades in the canals that drain the Everglades Agricultural Area.



Map of South Florida showing the study area

WHAT ARE THE KEY ISSUES FOR THE EVERGLADES?

DOC-Mercury Interactions

The role of mercury interactions with DOC is thought to be a primary mechanism for the transport of mercury in aquatic systems. However, this relationship is not clearly defined. The important questions to be addressed are: (1) By what mechanisms and how strongly does mercury interact with DOC, and (2) How do these interactions control the effects that mercury has on living organisms. The vast majority of mercury in aquatic systems resides in organic-rich soils and sediments. Interactions with DOC, however, may be important for the release of mercury into porewaters with subsequent transport into surface waters. Effective strategies for dealing with this problem will require a more thorough understanding of the processes that control the mobilization, transport, and reactivity of mercury in aquatic systems. Our studies will focus on the effect of dissolved organic carbon (DOC) on the behavior of mercury in the Everglades.

Effects of Land and Water Use Practices

Land and water use practices can result in changes in the quality, quantity, and reactivity of DOC. Modern agricultural practices, for instance, can result in the removal of native sources of DOC and the addition of anthropogenic organic compounds in the form of herbicides, insecticides, and surfactants. The DOC resulting from these practices is, therefore, different in nature from that present under more pristine conditions. In addition, the hydrologic condition of the wetlands themselves also impact the quantity and reactivity of the DOC moving through the Everglades system. For instance, water table changes can change DOC by introducing oxygen into the unsaturated zone. USGS research is attempting to determine the effect of land and water use practices on the quantity and nature of the bulk DOC in the Everglades. The first objective is to quantify the effects that these practices have on the chemical properties of the DOC. The second objective is to demonstrate that DOC interactions within a given environment determine the behavior of mercury in that system.

PLAN OF STUDY

This project will employ a combined field/laboratory approach to assess the significance and strength of DOC-mercury interactions in the Everglades. Both the inorganic composition of, and the DOC associated with, surface water, pore waters, and ground water from the Everglades will be characterized. Temporal variations in mercury and DOC concentrations will be measured at appropriate sampling locations to provide a measure of the mercury and DOC loadings in the system. These measurements will be coupled with determinations of the nature of the DOC inputs under different hydrologic conditions. Major fractions of the DOC will be isolated from the water samples for further analysis. These fractions are composed of different types of organic compounds that interact differently with mercury. The fractions will be characterized by determining chemical composition, molecular weight, and structural characteristics.

Whole water samples and the isolated fractions of the DOC will then be used to study interactions of DOC with mercury in laboratory experiments under a range of pH and concentration conditions. In addition, these measurements will also be made with previously isolated samples that vary significantly in structural composition. The goal of these measurements will be to increase our understanding of how mercury interacts with DOC. These measurements will also provide binding constants, which are a measure of the strength of the DOC-mercury interactions, that will be correlated with the structural properties of the organic matter to provide inexpensive analytical parameters to be used to estimate the strength of DOC-mercury interactions in the Everglades.

Finally, using the binding constants determined in the laboratory studies, a computer program will be used to model the geochemical behavior of mercury in the Everglades. This model will allow us to synthesize the overall effects of the DOC-mercury associations and how they change as the qualitative and quantitative character of the DOC varies.

Anticipated Schedule

March 1995: Begin seasonal sampling and sample analyses for select sites within the study area.

January 1996: Begin compiling water-quality data as a USGS Open-File Report for ongoing field work.

July 1996: Continue sampling. Begin characterizing organic matter isolates and measuring DOC-mercury binding constants.

January 1997: Continue sampling. Compile report on characteristics of DOC in the Everglades. Continue determination of mercury binding constants.

January 1998: Compile report on mercury binding constants.

Planned Products

- USGS Open-File Report of water-quality data.
- Journal articles detailing the spatial, seasonal, and hydrologic variability in DOC.
- PhD thesis and journal articles describing DOC-mercury binding constants.

COLLABORATORS

Data collection for this project requires the collaboration of scientists from the USGS (Reston, Madison and Menlo Park), from the Wisconsin Department of Natural Resources, the Benedict Estuarine Laboratory, Academy of Natural Sciences of Philadelphia, and the South Florida Water Management District. Binding constants will be determined in collaboration with scientists from the USGS (Madison) and the University of Colorado, Boulder, Colorado. Chemical modeling will be done in collaboration with the U. S. Environmental Protection Agency, Athens, Georgia.

BENEFITS

-Detailed understanding of the influence of hydrologic and seasonal factors on the variation in the nature and amount of DOC and mercury in the Florida Everglades.

-Determination of distribution coefficients for mercury with DOC and aquatic humic substances that are currently unavailable.

-Identification of easily determined analytical parameters that can be used to predict potential DOC-mercury interactions.

-Incorporation of DOC properties and distribution coefficient data for mercury into a speciation model to more adequately determine the speciation of mercury in the Everglades, and to provide predictive capabilities for the behavior of mercury in other aquatic systems.

FOR MORE INFORMATION:

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