MODELLING THE MERCURY CYCLE IN THE MARANO-GRADO LAGOON. MERCURY BUDGET AND EXPOSURE RISK

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Abstract
Two different models released by US-EPA, SERAFM, a steady state model, and WASP, a dynamic model, have been used to describe major dynamics in the mercury cycle in the Marano-Grado lagoon, (Northern Adriatic Sea, Italy). The lagoon shows high mercury concentration in the water column, sediments and biota due to natural and anthorpogenic sources. The model applications aim at: 1) computing mercury budgets within the lagoon and fluxes between the lagoon and the surrounding systems (watershed, Adriatic Sea, atmosphere); 2) improving the understanding of the importance of different loading sources and transformation processes on methylmercury concentration and bioavailability. Moreover, the models allow to identify major knowledge gaps and suggestions for further modeling development.

Keywords: Lagoons, Mercury, Models, North Adriatic Sea

The Marano-Grado Lagoon (Northern Adriatic Sea, Italy), covers an area of approximately 160 km2. It is one of the most important and best conserved wetland environments in the Mediterranean area, also identified as a Site of Community Importance (SCIs – IT3320037) and it provides important ecosystem services which sustain several economic activities. The lagoon is also a sink for anthropogenic contaminants, and, in particular, for mercury compounds released via natural and anthropogenic sources. Smelting activity at the Idrija mine in western Slovenia has released 39000 tons of mercury over 500 years, and a chlor-alkali plant has released around 186 tons of mercury directly into the lagoon during the 45 years of operation. Elevated Hg concentrations in sediments, ranging from 0.61 to 14.01 µg g-1, have been found related to both historical and more recent anthropogenic activities. Mercury (Hg) is a ubiquitous environmental pollutant of great concern because of the toxicity of its methylated form (MeHg) and bioaccumulative and biomagnifying properties. Mercury occurs in the marine environment in three chemical forms: elemental Hg (Hg(0)); divalent ionic Hg (Hg(II)), present in a variety of both inorganic and organic complexes; and methylated forms that include monomethylmercury (MeHg) and dimethylmercury (DMHg). All these species are linked intricately through the Hg(II) pool [1]. Within the Marano Grado Lagoon, several studies have been developed addressing the state of the mercury contamination in different media, including sediment, water column and biota, ([2, 3, 4] but the implementation of a biogeochemical model could add insight into the mercury fluxes and support the risk management [5]. Data characterising the biogeochemical cycle of mercury in the Marano-Grado Lagoon have been assembled and two models released by US EPA, publicly available, have been implemented to complement the experimental knowledge and to highlight knowledge gaps. A scenario analysis have been performed in order to highlight the relevance of different processes in the mercury fluxes in the lagoon. The two model applications enabled to focus on different aspects of the mercury biogeochemistry. Model parameters have been derived from site specific data, when available, or from parameters related to similar environments, as reported in literature. The Marano Grado lagoon have been represented as a 6 box system, interacting with the surrounding systems (Adriatic Sea, atmosphere, deepest sediments and watershed), following the classification given by [6]. The SERAFM model has been implemented describing the lagoon as indipendent six-box systems at steady state. The model calculates the concentration of the mercury species (HgII, MeHg, Hg0) in the water column, in sediment and in biota, driven by hydrological characteristics, external forcing influence, initial concentration and mercury process parameterization. The SERAFM model calculates also wildlife and human exposure risks related to methylmercury bioaccumulation. The analysis have been made under different scenarios of contamination, decontamination and exchanges with the surrounding systems. The WASP model implementation allows to reproduce the temporal evolution of the mercury in the lagoon. In this application, the Lagoon is represented as a 6 connected box system. Time variable water fluxes between the six boxes and with the Adriatic Sea have been introduced based on hydrodynamic model results. Variable river discharge, and precipitation have also been included as well as mercury and water quality concentration at the boundary systems. The WASP model allows to represent the seasonal evolution of the three from of mercury concentration in the lagoon environment, giving preliminary indications on the temporal and spatial evolution of mercury the mercury species (HgII, MeHg, Hg0) in water (total, particulate, dissolved, Fig. 1) and in sediment. The results have been compared with the available data and used to assess the relative value of different mercury sources on the availability of methylmercury to biota.

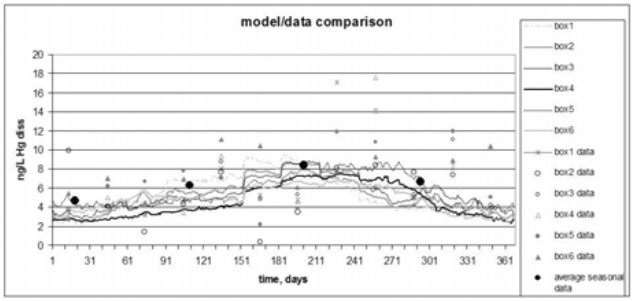

Fig. 1. WASP model predicted concentrations compared with observations and with seasonal averaged data of dissolved mercury.

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