The MIRACLE Project: an Interdisciplinary Research on Mercury in the Marano & Grado Lagoon (northern Adriatic sea)

Stefano Covelli[1], Michele Giani[2], Milena Horvat[3], Mark Hines[4], Franco Baldi[5], Sergio Predonzani[6], Daniela Berto[7], Katia Crovatto[8]

[1]Dept. of Geosciences, University of Trieste, Via Weiss 2, 34128 Trieste, Italy
[2]Nat. Inst. of Ocean. & Appl. Geophysics, Via Picard 54, 34151 S.Croce (TS), Italy
[3]Dept. of Environ. Sciences, "*Jožef Stefan*" Institut, Jamova 39, 1000 Ljubljana, Slovenia
[4]Dept. of Biological Sciences, University of Massachusetts Lowell, Lowell, MA 01854, USA
[5]Dept. of Environmental Sciences, University, Dorsoduro 2137, 30123 Venice, Italy
[6]*Osservatorio Alto Adriatico*, ARPA-FVG, Via Cairoli 14, 33057, Palmanova (UD), Italy
[7]ISPRA, Loc. Brondolo, 30015 Chioggia (VE), Italy
[8]Regional Authority of Friuli VG, Ct. Savorgnan 9, 33057 Palmanova (UD), Italy

Phone: +39-(0)-40-5582030
E-mail: covelli@units.it

Introduction: The "**MIRACLE**" (**M**ercury **I**nterdisciplinary **R**esearch for **A**ppropriate **C**lam farming in **L**agoon **E**nvironment" Project was financially supported by the *Commissario Delegato* for the Marano and Grado Lagoon in 2008-2009. It was aimed at two specific issues, understanding Hg biogeochemical cycling in the Lagoon and testing the coexistence of clam (*Tapes philippinarum*) farming with Hg contamination in the sediments. The Lagoon is one of the most Hg contaminated coastal zones in the Mediterranean, due to both industrial processes (chlor-alkali plant) and long-term mining activity. As a consequence, the presence of Hg in this Lagoon environment must be considered as a permanent issue.

Methods: Mercury contamination was measured in several matrices (water, sediment, biota) and its mobility was tested along with its speciation in relation to biogeochemical processes occurring in the coastal environment, where bacterial communities have a primary role in converting Hg to its more toxic form, methylmercury (MeHg). Hg species bioaccumulation was investigated on natural and seeded clams, which are the most important commercial bivalves in the Lagoon.

Results and Discussion: Hg speciation analyses in sediments show that Hg is more available for methylation when it is not present as a sulfide. However, even where Hg is more readily available for methylation, MeHg content in the sediment is very low according to literature values. Regarding the effects of dredging operations on the lagoon channels, Hg mobility, as a consequence of sediment resuspension, was also tested in the laboratory showing that resuspension events, limited in time, have a poor impact on the water column, due to the dilution of the Hg species available. As a consequence of high Hg contents in sediments, the microbial community is largely composed (up to 70% of the total) of Hg-resistant and Hg-tolerant bacteria. Radiotracer experiments confirmed active Hg methylation by sulfate-reducing bacteria (SRB), under anaerobic conditions. On the other hand, SRB are also active demethylators and, in the Lagoon, demethylation rates were more rapid than any ever value reported in similar determinations. Benthic chamber experiments to quantify *in situ* fluxes of Hg and MeHg production and mobilization from the sediment to the water column were higher during the summer, thus confirming the evidence obtained from studying the microbiology of the Lagoon. These findings were then compared to real bioaccumulation rates on the field, using seeded and natural populations of clams in selected areas of the Lagoon. Hg content in the seeded bivalves was always lower than the 0.5 mg/g w.w. limit for commercialization. At the same time, as clams grew bigger in size, their Hg and MeHg concentration decreased, becoming lower than in the starting seeded pool. During growth, it is possible that a dilution of Hg species occurs in clams. In addition, during experiments conducted on the bacterial population, several Hg-resistant bacterial strains were identified, which are capable of active detoxification, forming colonies on the clams soft tissues. For natural clam populations, it was noticed that Hg and MeHg concentrations tend to increase with size (depending on the location), exceeding limits only for individual clam > 35 mm in the Grado Lagoon. It clearly appears that, despite very high Hg contamination levels, seeded clams, in association with the bacterial community, are able to grow and their Hg accumulation does not exceed the concentration limits for commercialization. It can be hypothesized that other areas of the Lagoon, which are currently unused or prohibited for clam farming, could be suitable for such activities, thus representing an economic and occupational resource for the resident population.

Acknowledgements are warmly due to all the participants belonging to the Research Units involved in the Project.