Paolo Grisenti

Integrated research on eutrophication processes of small lakes

Abstract of the doctoral thesis

Supervisors: **Prof. Paolo Bertola**
Prof. Giuseppe Passoni (Politecnico di Milano)

The deterioration of lakes water quality is frequently due to excessive loading of nutrients from natural, agricultural, civil and industrial sources. Nevertheless, many studies have emphasized on the significant role played by phosphorus internal loads on eutrophication: the flux of phosphorus from sediments to the water body can keep eutrophication in despite of the control of nutrients external sources (i.a. Pettersson, 1998; Selig and Schlungbaum, 2003). The key processes for sediment-water exchange, are all dependent on the turbulence structure, the horizontal currents and the chemical conditions that occur on the deepest layers of the lake, particularly inside the well mixed zone above the sediments, called Benthic Boundary Layer (BBL).

More than one year measurements on Caldonazzo lake (Trento, Italy) has allowed to investigate the role of internal and external nutrients loads on eutrophication processes. An integrated approach was adopted, monitoring discharges and water quality of lake tributaries and the main physical-chemical parameters of lake water, together with the main meteorological variables. Avoiding to go into details, it has to be said that a great amount of data were collected using new automatic instrumentations together with field measurements and fortnightly laboratories analysis of water samples. The data analysis allowed to estimate the amount of internal and external nutrients loads and their relative importance in the eutrophication processes. The origin of the phosphorus concentrations found in the hypolimnion during the stratified period was studied, focusing the attention on the chemical and hydrodynamic conditions at the sediment water interface and on their effects on sediment oxygen demand and solutes release. Particularly the role of bottom currents, generated by internal seiches, on the development of the Benthic Boundary Layer was studied analysing the vertical profiles of the main chemical parameters and estimating numerically the horizontal velocity distribution induced by waves motion. The role of mixing at the end of the stratified period and of the consequent upwelling of deeper water rich of nutrients followed by severe algal bloom was clearly shown.

To investigate the role of turbulence on vertical exchange processes and on eutrophication kinetics a Direct Numerical Simulation model was developed. The model solves unsteady incompressible three–dimensional Navier-Stokes equations with Boussinesq approximation and the advection diffusion reaction equations for solutes of interest. An original approach in the eutrophication kinetics modelling was adopted to avoid to increase excessively the complexity and the computational costs of the model. Focusing the attention on small scale processes the model variables were suitable scaled. Tests were made to investigate the effect of cycles of surface cooling and heating on mixing of stratified water and consequently on phytoplankton and oxygen kinetics.