STUDY OF THE CIRCULATION IN THE ORBETELLO LAGOON, ITALY

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Abstract

The combination of poor hydrodynamic activity and algal blooms in the Orbetello lagoon (Italy) is causing many problems for the water quality and the conservation of fish population, the most important resource of this ecosystem. To improve the water quality of the lagoon is necessary to know the hydrodynamic behavior. This goal was achieved using both measurements and numerical simulations, carried out with a shallow water finite element model, developed at ISMAR-CNR in Venice. The study shows that numerical models could offer a very useful tool for the management and saveguarding of the water resources.

Keywords: coastal lagoons, hydrodynamic modeling, numerical simulations, Orbetello, finite element method

The Orbetello lagoon (southern coast of Tuscany, Italy) covers an area of 27 km^2 and is composed of an eastern lagoon (12 Km^2 wide) and a western lagoon (15 Km^2 wide). The two lagoons are connected by the Orbetello isthmus and separated by a dam. The average depth is about 1 meter. The lagoon exchanges water with the Thyrrenian Sea by three narrow channels: Nassa channel, Fibbia channel and Ansedonia channel. Each inlet has its own floodgate and water pumps that may pump water from the sea into the lagoon. The lagoon is a semi-enclose coastal basin characterized by shallow water, poor hydrodynamic activity, high trophic level and algal blooms, that may cause problems for the water quality and the conservation of fish population.

Numerical simulation of the lagoon hydrodynamics was performed with a shallow water finite element model, developed at ISMAR-CNR in Venice (1,2). The finite element method gives the possibility to follow carefully the topography of the system and to better represent the zones where hydrodynamic activity is more interesting. The model uses finite elements for spatial integration and a semi-implicit algorithm for integration in time. Experimental data have been used to calibrate and validate the numerical model.

A system of gauges was designed in order to collect hydrodynamic and water quality parameters at different locations. Gauges were positioned in nine points of the lagoon, as can be seen in Figure 1. Hydro-meter, Current-meter and multi-parametric gauges, collecting water temperature, salinity, oxygen and Ph, were put in front of the channel and in the middle of the lagoon. Wind-meters were put in the middle of the lagoon, too. Registration of data began in August 2001 and is ongoing. Wind data (speed and direction) and water circulation data (speed, direction and level) are collected simultaneously every ten minutes. Moreover, a detailed topographic survey was completed to precisely map the bathymetry of the lagoon, also revealing the presence or not of algae. It appeared that in the 90% of the bottom of the lagoon there was algae presence (3).

Fig. 1. Position of the gauges. 1-4-6-9 Hydro-meter, 2-3-8 Hydro-meter; current-meter; multi-parametric gauge, 5-7 Hydro-meter; current-meter; multi-parametric gauge; wind-meter.

Results of the numerical simulations show that the inner hydrodynamics circulation is mainly due to the wind action. Tidal excursion was limited to 30 cm in this area and it is not able to induce appreciable circulation. Algae presence all over the lagoon acts as a high roughness and is the main factor responsible for low water circulation in shallow water areas. During typical hydrodynamic conditions maximum speed velocity is of the order of 1 cm/s.

Some proposals were made, trying to solve the problem of the low-speed circulation inside the lagoon.

Modification of Ponte Diga: the bridge, which divides the two parts of the lagoon, has some piers positioned at distances which are not very large. The proposal was to enlarge the openings on the dam to assess if this action could improve the circulation (4).

Excavation of channels on the bottom of the lagoon: to increase the mean water velocity in some particular areas of the lagoon, it is possible to excavate some channels; these are preferential ways for the water forced by wind to pass in, and arrive to the areas in which circulation has to be increased. This proposal seemed to be efficient, with good effects on the inner circulation of the lagoon.

The next application will be the implementation of a diffusion-reaction and radiative module to investigate the distribution of salinity, temperature and oxygen, which play an important role in the trophic processes of the lagoon.

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