WATER QUALITY MODELING FOR THE ENVIRONMENTAL MANAGEMENT IN CHINHAE-MASAN BAY

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Introduction

Chinhae-Masan Bay is a representative semi-enclosed coastal sea of 502 km^2 in South Korea. This Bay has been reserved for its beauty and mariculture, but the water and sediment qualities are heavily deteriorated due to rapid industrialization, urban development, and also overintensive mariculture. The eutrophication, anoxic watermass formation due to thermal and salinity stratification in summer, heavy metals and toxic algal blooms seriously affect the bay ecosystem and further quality of human life in this catchment area.

In 1982, the Ministry of Environment designated the Bay as a 'Special Management Seas'. Pollution control programs were established to clean the water and restore the coastal ecosystem through the construction of a wastewater treatment plant (hereinafter WTP) and dredging of contaminated sediments in the Masan Inner Bay, which is a drainage basin of major streams running from urban and Masan/Changwon industrial complexes. The WTP has been operated since Nov. 1993, and primarily treats daily average of 200,000 ton of sewage and industrial wastewater. About 1,850 thousand tons of contaminated bottom sediments were also dredged during the period of 1990-1994. After those measures the heavy metal contents were successfully removed but nutrients were not.

Extensive/Integrated Field Measurement for Water Quality Modeling

Scientific surveys for the Bay started in 1976 and so far a great number of field measurements and analyses have been carried out, which were mostly focused on the analysis of the special scientific issues and mechanisms of the phenomena related with the water pollution. But, the cooperative research and information exchange between the related fields participated in those study were not actively made. Recently, a joint-research program, 'Study on Coastal Zone Utilization and Integrated Management,' has been launched by Korea Ocean Research and Development Institute. It has been conducted through integration of related studies such as oceanographic sciences, coastal engineering, and socio-economics.

Numerical Modeling and Calibration

First of all, the complex pollutant's interaction system is to be fully understood and modeled by the scientific review, monitoring, and the multi-disciplinary study. The main item of the environmental modeling is the seasonal and yearly water quality (hereinafter WQ) variation, i.e. long-term prediction of WQ changes. All the major factors affecting the simulated constituents are COD, DO, nutrients, phytoplankton, zooplankton, and other arbitrary first-order decaying constituents.

With the use of the joint-studies' results an efficient numerical water quality model has been set up as a tool for the environmental management in the Bay. That is horizontal 2-D WQ model which is based on the WASP-5 and modified as grid-type to improve the accuracy with respect to site-specific model structures and model parameters.

Flow, salinity, and temperature fields computed by the separate numerical models, which were extensively calibrated with those field data, were used as the hydraulic input data for the WQ model through the averaging process. The phytoplankton-zooplankton interaction studies and sediment quality analysis were made by oceanographical biology and geology divisions, respectively. About 10 WQ constituents were measured at 15 points monthly or seasonally in 1995-1996. Pollutant loads were measured at 20 major streams running into this Bay and at the outlet of the WTP. Bottom sediments were sampled at 4 sites, and SOD (sediment oxygen demand) and nutrients (ammonia, phosphate) release rates were also measured (as shown in Fig. 1).

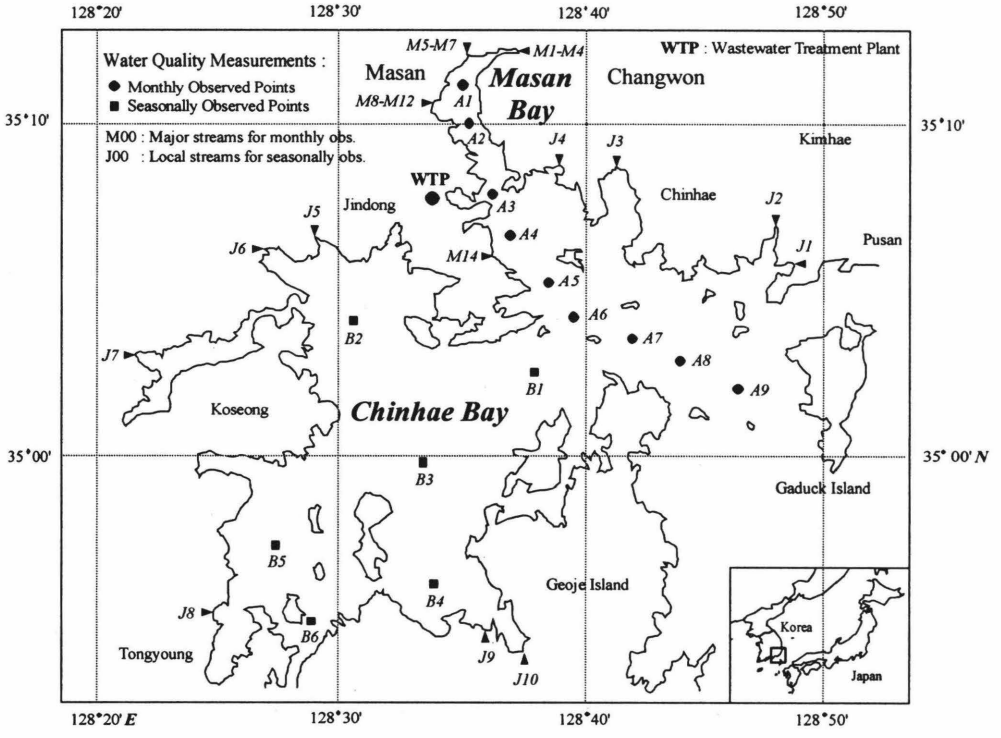

Fig. 1 Monitoring Stations in Chinhae-Masan Bay

With the data obtained through interactive studies was the model calibrated, and verified by the measured WQ data in 1995-96 (as shown in Fig. 2). This model predicts relatively well the distribution pattern of the WQ concentration in almost area even though the complex phenomena in this Bay are simplified. However, there is some limitation of model, e.g. uncompatible DO simulation because of 2-D model structure, and overestimation of WQ concentration in Masan Bay.

Model Application Results

From the model application results, it is shown that the WQ concentrations in most of the regions adjacent to land and river inflow are considerably high, but rapidly decrease along the seaward direction except Masan Bay. Because the particulate inflow-pollutants were deposited and gradually contaminated the bottom sediment on account of the regional stagnancy. Deposition rates of those particulates were assumed high in the model application. Eutrophication in the effluent discharge region was also being slowly progressed by the unefficiently treated wastewater containing amount of N and P constituents.

Seasonal concentrations of DO, COD, SS, nutrients, and phytoplankton as carbon units were simulated and compared with field measured data. From the distribution of COD concentration which is the main WQ parameter for coastal zone management in KOREA, the stagnant regions in far inside of small bays (shown in Fig. 2) appear to be seriously polluted by the pollutant releases of the sediment, low seawater-exchange rate and excessive pollutants loads beyond environmental capacity.

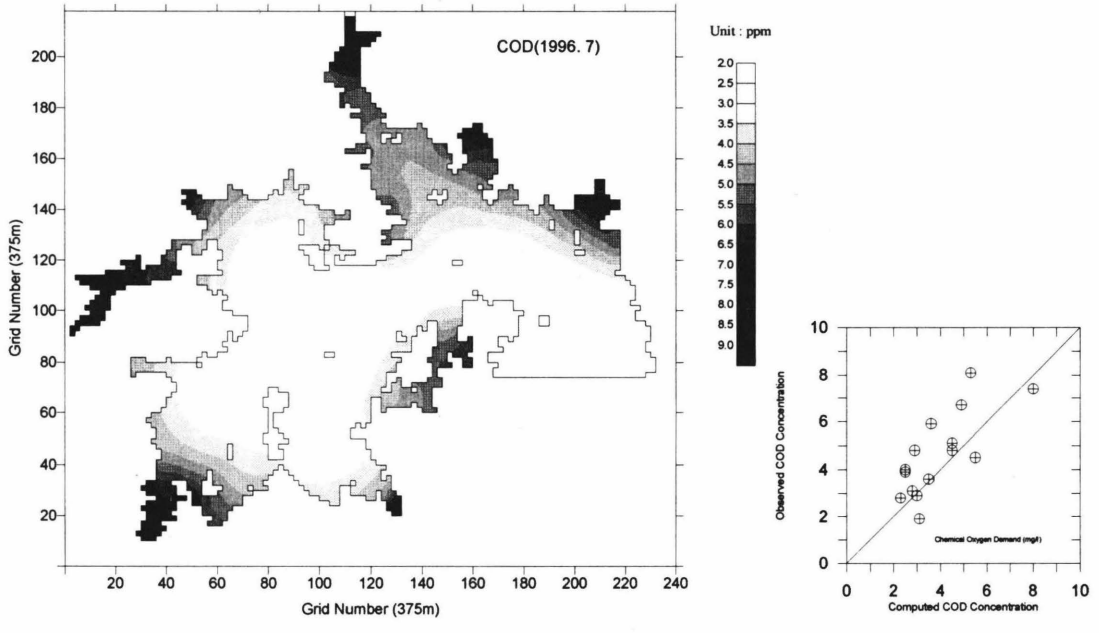

Fig. 2 COD Contour Plot and Model Calibration Results

Now, the model has gained considerable precision and confidency for the potential user of WQ management for this Bay. This model will be combined with GIS and related submodels, i.e. models of non-point source, vertical diffusion, ecosystem, water-sediment interaction and economy and be used for the simulation of various scenarios of the regional development plans.