EUTROPHICATION OF SEA WATER OF OSAKA BAY

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1. Introduction

Osaka Bay is located at the eastside in the Seto Inland Sea. The area is $1500km^2$ and average depth 27m, shallower at the eastside than the others. The bay con--tacts with Kitan- and Akashi Straits, and is one of the most enclosed areas in the Seto Inland Sea.

The river basins, flowing into the bay, involve big urban cities such as Osaka, Kobe, Kyoto where more than 13million people are living and producing 1% of the Gross Domestic Product in the world.

On the base of the law (Law Concerning Special Measures for Conservation of the Environment of the Seto Inland Sea), the local governments relating to the inland sea have formulated and implemented programs to meet the water quality standards for COD, nitrogen and phosphorus, derived from industrial and domestic effluents.

The water quality has still being worse in the northeast area of the bay where a number of emission sources are concentrated. The concentrations of thes epollutants have been at same levels for recent several years. The number of red tide found is ca. 20 every year.

This report describes a simulation system to evaluate effects of the programs on reduction of eutrophication in the sea water.

2. Simulation of Eutrophication

The bay is divided into 1X1km cells and each cell into 4 layers by depth in the numerical models of the simulation system, considering the difference of water density and photosynthesis levels. The system includes two categories, simulation of tidal current and that of eutrophication.

2-1. Simulation of Tidal Current

The Navier-Stokes' equation and equation of density diffusion are applied to perform tidal current simulations so that the results could be used later for simulation of eutrophication. The current involves tidal and residual currents. Tide has various kinds and cycles. This report deals with lunar-semi-diurnal tide and residual current. The residual current, caused by fresh water flowing into the bay and the topography of the bay, plays an important role in diffusion of sea pollutants. Lunar-semi-diurnal tide is the largest with the level of ca. 80cm high at Kitan Strait.

2-2. Simulation of Eutrophication

The models so far used are for diffusion of COD only. In this report, eutrophi--cation effects have been taken account into the models because COD is consider--ably influenced by activities of phytoplanktons. The simulation, as follows, consists of transformation term(related to tidal and residual current),diffusion term and biochemical term.

$$\frac{\partial S\cdot D}{\partial t} = \underbrace{-\frac{\partial}{\partial x}(S\cdot u\cdot D) - \frac{\partial}{\partial y}(S\cdot v\cdot D) - \frac{\partial}{\partial z}(S\cdot w\cdot D)}_{\text{Transportation term}}$$

$$\underbrace{+\frac{\partial}{\partial x}\left(K_x\cdot D\cdot\frac{\partial S}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_y\cdot D\cdot\frac{\partial S}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_z\cdot D\cdot\frac{\partial S}{\partial z}\right)}_{\text{Diffusion term}}$$

$$\underbrace{+\frac{dS\cdot D}{dt}}_{\text{Biochemical term}}$$

S : Concentration of matters
D : Thickness of the layer
u, v, w : x, y, z component of current velocity vector
K_x, K_y, K_z : x, y, z component of difussion coefficient

The five items,COD,nitrogen,phosphorus,DO and chlorophyll-a, are used for the simulation under biotic-organic,non-biotic-organic(detritus) and diffused nutrient salt conditions. COD,nitrogen and phosphorus,chlorophyll-a and DO are indicators of organic pollution, eutrophication-related productivity, photosyn--thesis ability, and pollution mechanism, respectively. The related biochemical process include production, respiration, excretion and death of planktons, de--composition of detritus, sedimentation, dissolution of nutrient salt from and oxygen consumption by sediment(Figure-1).

The inflow loads used here are average values in 1988~90 provided by Osaka Prefectural Government.

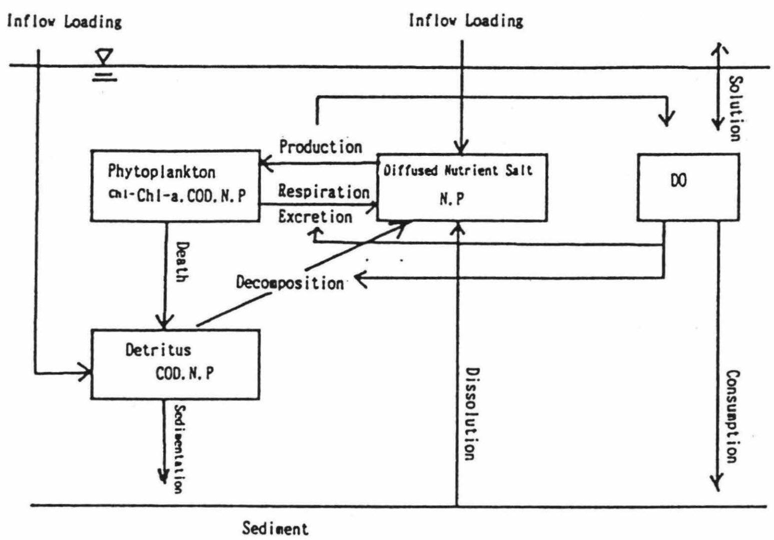

Figure-1. Eutrophication phenomena

3. Results and Discussion

The accuracy of simulated results is evaluated by comparing calculated ones with average data observed in 1988~90. The correlation coefficients are ca. 0.9 in the data of COD,nitrogen and phophorus(Figure-2). Figure-3 shows the calculated ΔCODs(produced by eutrophication) in the surface layer, indicating higher COD concentrations in the eastside of the bay.

The system can be also applied to estimate effects of the conservation pro--grams of the Seto Inland Sea on nitrogen and phosphorus reductions. Figure-4 shows the decrease of COD concentrations in the surface layer in the case of 20% reduction of nitrogen and phosphorus flowing into the bay. The effects of pro-

-grams could be evaluated by investigating reduction ratio.

Several landfill projects are currently formulated and implemented in Osaka Bay. Thereafter, accuracy of the simulation model should be further improved to support the programs for protecting the water quality in the bay from industrial and domestic effluents in the basins.

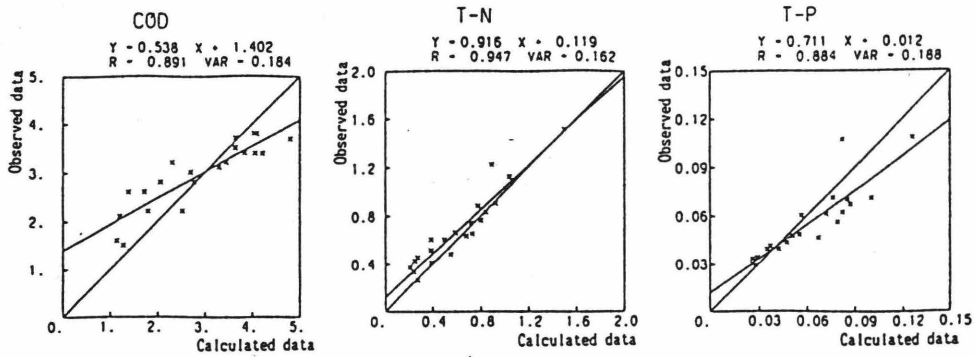

Figure-2. Correlation between calculated and observed data

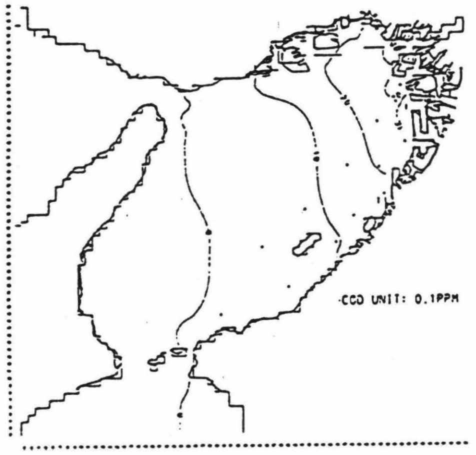

Figure-3. ΔCOD in the surface layer

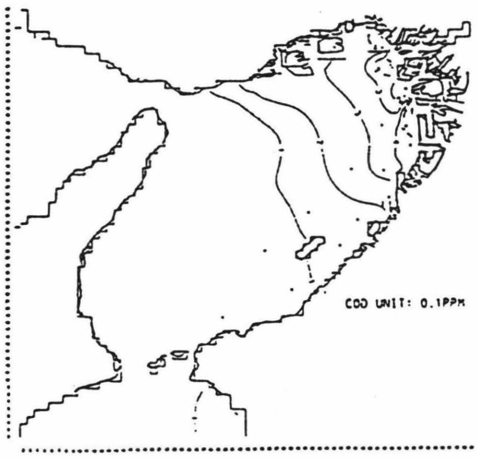

Figure-4. Decrease of COD in case of 20% reduction of N and P