NUTRIENTS AND CHLOROPHYLL-A DYNAMICS IN THE ARIAKE SEA

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1. Introduction

The Ariake Sea located in Kyushu Island is a typical shallow sea in Japan as shown in Fig. 1. The estuarine area and tidal flat of the Ariake Sea are habitation and spawning area for various aquatic lives[1)]. Recently, water environment in the sea has become a cause for public concern. This study aims to apply a hydrodynamic model and develop an ecological model to simulate nutrients and chlorophyll-a variations in the Ariake Sea. Computed results including algal biomass, nutrients and relevance to changing circulation show reasonable long term applicability of this model.

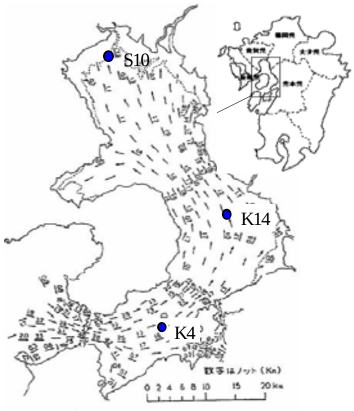

Figure 1 Map showing the Ariake Sea

2. Numerical model

The numerical model integrates a hydrodynamic model, and an ecological model that simulates the dynamic of phytoplankton, zooplankton, nutrients (ammonia, nitrate and phosphate).

2.1 Hydrodynamic model

Hydrodynamic equations consist of the continuity equation (Eq. 1) and equation of motion (Eq. 2):

$$\frac{1}{\rho c_s^2}\frac{\partial P}{\partial t}+\frac{\partial u_j}{\partial x_j}=SS \tag{1}$$

$$\frac{\partial u_i}{\partial t}+\frac{\partial\left(u_i u_j\right)}{\partial x}+2\Omega_{ij}u_j=-\frac{1}{\rho}\frac{\partial P}{\partial x_i}+g_i+\frac{\partial}{\partial x_j}\left(\nu_T\left\{\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right\}-\frac{2}{3}\delta_{ij}k\right)+u_i SS \tag{2}$$

Advection-dispersion equations, which are conservation of salinity or temperature: (Eq. 3):

$$\frac{\partial C}{\partial t}+\frac{\partial u_i C}{\partial x_i}=\frac{\partial}{\partial x_i}\left(D_i\frac{\partial C}{\partial x_i}\right)+SS \tag{3}$$

where ρ is the local density of the fluid, c_s the speed of sound in seawater, u_i the velocity in the x_i-direction, Ω_{ij} the Coriolis tensor, P the fluid pressure, g_i the gravitational vector, ν_T the turbulent eddy viscosity, δ Kronecker's delta, k the turbulent kinetic energy, C is either salinity or temperature, D_i is the associated dispersion coefficients and t denotes the time. SS refers to the respective source-sink terms and thus differs from equation to equation.

2.2 Water quality model development

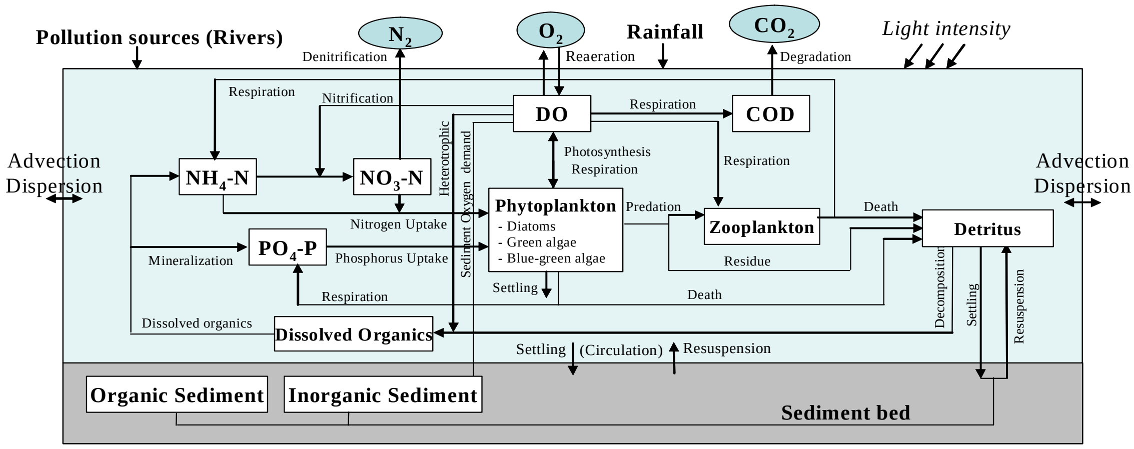

Figure 2 Main interactions among the state variables

The transport equation for a component concentration C can be computed as shown in Eq. (4), where R is the water quality process/reaction term:

$$\frac{dC}{dt} = \frac{\partial}{\partial x_i}\left(D_i \frac{\partial C}{\partial x_i} \right) + SS + R \qquad (4)$$

The biogeochemical model describes the main interactions among some compartments: water, phytoplankton, zooplankton, nutrients, detritus and superficial sediment. Figure 2 depicts the state variables in the water column, which are chlorophyll-a, zooplankton, nitrogen, phosphorus, and dissolved oxygen.

3. Model settings

The input data to the model are the basic parameter including bathymetric data, simulation period, and turbulence model. The hydrodynamic data consist of water surface elevation, resistance, salinity, water temperature, precipitation, wind condition, river flow. The model was calibrated using one year observed data from January to December, 2000.

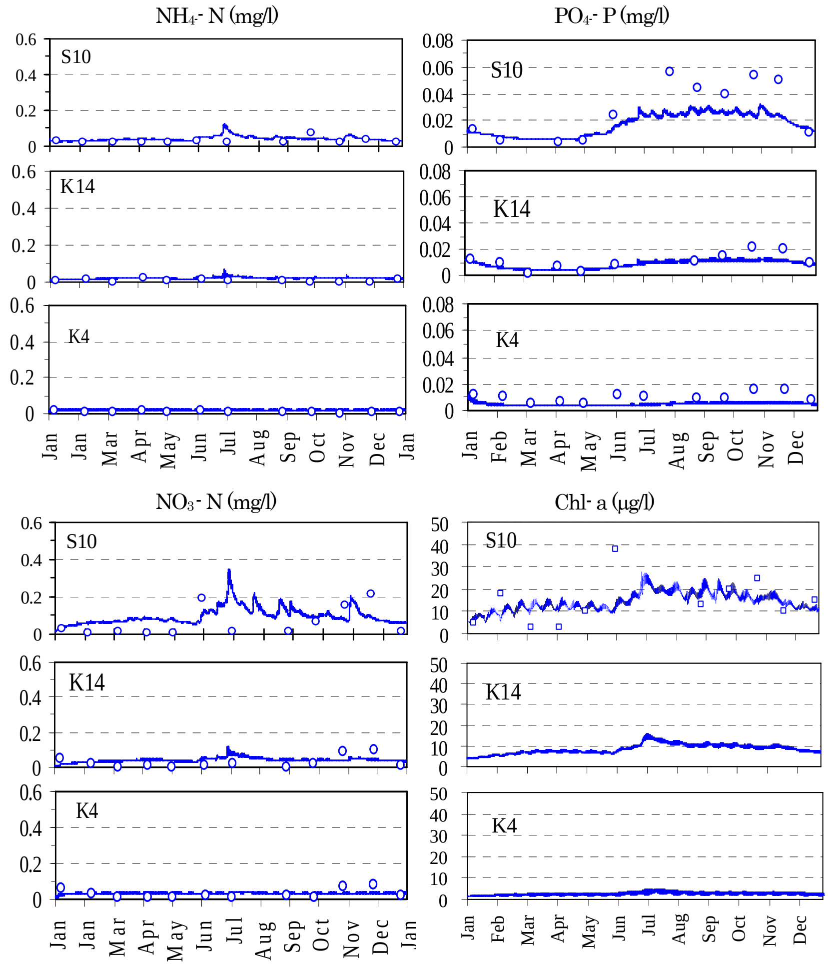

Figure 3 Simulated and observed data of NH_4-N, NO_3-N, PO_4-P and Chl-a

4. Results and discussions

After getting a good hydrodynamic model through model calibration, the water quality model is run to predict the water quality with respect to nutrients, chlorophyll-a concentrations in water column. Figure 3 shows the variation with respect to time of NH_4-N, NO_3-N, PO_4-P and Chl-a at 3 chosen observing stations shown in Fig.1. From these results, it is also clear that, in the inner part, variation of NH_4-N, NO_3-N, PO_4-P and Chl-a follows a seasonal variation, increasing during rainy seasons then decreasing during winter, as runoff from inland area contributes load and dilutes the water density in this area. As seen in this figure, nutrients concentrations are also higher in the innermost part due to loads discharged from surrounding rivers and resuspension and release from the bottom mud.

For Chl-a, the simulation model produces a very good tendency variation of Chl-a, although the surveyed Chl-a data were mainly done only in the sea inner part. Chl-a concentration was very high in the inner part, and deceased along the bay from the inner part to the inlet, due to a stronger influence of current and wave to bottom mud in the bay inner part. Highest overall Chl-a concentrations are seen in the summer months, and local maxima are observed in the innermost part during July.

5. Conclusion

In this study, a hydrodynamic model has been adapted and a water quality model has been proposed to model the hydrodynamics and the water quality in the Ariake Sea. The simulated results show a good agreement with the observed data, meaning that a good model for water quality analysis of the Ariake Sea has been obtained. The simulated results indicate the seasonal variation of NH_4-N, NO_3-N, PO_4-P and Chl-a in response to weather and boundary conditions.

References

1) Araki H., Yamanishi H., Koga K. and Sato K. (2001). Study on Environmental Change and Peculiarity of the Ariake Sea, Japan. *Water resources management* ed. Brebbia, C.A., Anagnostopoulos, P., Katisfarakis, K., et al. WIT Press: 341-350.