Quantitative analysis on suspended solids in the innermost area of the Ariake Sea

Saga University ○ Narumol Vongthanasunthorn
Saga University Kenichi Koga
Saga University, Institute of Lowland Technology Hiroyuki Araki
Saga University, Institute of Lowland Technology Hiroyuki Yamanishi

Introduction

Vongthanasunthorn *et al.* (2002) have developed two-dimensional water quality model based on the finite-volume model (Rich 1973) for water quality analysis in the Ariake Sea. With the application of the developed model, the water quality analysis has shown that bottom mud is one of main sources of suspended solids and nutrients in the innermost area of the Ariake Sea. The release and resuspension of bottom mud occurred under the disturbance by tidal movement. In order to determine the contribution of some natural phenomena on suspended solids in the Ariake Sea, quantitative analysis on suspended solids is conducted in its innermost area using the same developed model with some modification.

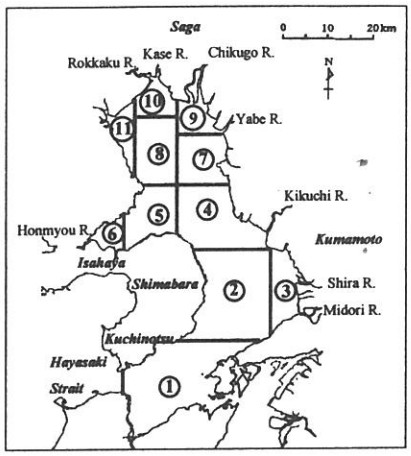

Figure 1 Water quality model in the Ariake Sea

Water quality model for suspended solids

As shown in Fig.1, water quality model is composed of 11 elements. Each element is considered in completely mixed state and no density current existing in this model. Eqs.(1) and (2) give the explanation about mass balance of suspended solids in the developed model. Inorganic and organic suspended solids are considered separately. Organic suspended solids are related to the concentration of algae (Chl-a) as shown in Eq.(2). In this study, resuspension rate is a function of maximum wind velocity and wind direction as well as the tidal movement.

$$\frac{dV_i SS_i}{dt} = \sum_j [(Advection) + (Dispersion)]_{ji} + (Discharged\ loading\ from\ land\ area)_i - (Settling)_i + (Resuspension\ due\ to\ wind\ and\ tidal\ movement)_i$$
$$TSS_i = SS_i + (SS\ in\ the\ form\ of\ algae)_i \quad (1)$$

$$\frac{dV_i SS_i}{dt} = \sum_j [Q_{ji}[\delta_{ji} SS_j + (1-\delta_{ji}) SS_i] + E'_{ji}(SS_j - SS_i)]_{ji} + (Discharged\ loading\ from\ land\ area)_i - (Ks \times Vs \times As \times SS)_i + (Kr \times Vr \times As / H)_i$$
$$TSS_i = SS_i + (YSK \times KChlA + YSR \times RChlA)_i \quad (2)$$

SS : Inorganic suspended solids (mg/l)
TSS : Total suspended solids (mg/l)
Q_{ji} : Net flow rate from element j to element i (m^3/s)
δ_{ji} : Net advection factor from element j to element i
E'_{ji} : Mixing coefficient from element j to element i (m^3/s)
Ks : Settling coefficient depending on type of suspended particles
Vs : Settling velocity (m/d)
As : Surface area of element i (m^2)
Kr : Resuspension coefficient
Vr : Resuspension rate due to wind effect and tidal movement (g/m-d)
H : water depth of element i (m)
$KChlA$: *Chl-a* (diatom) (μg/l)
$RChlA$: *Chl-a* (green algae) (μg/l)
YSK : *SS/Chl-a* (diatom) (mg-*SS*/μg-*Chl-a*)
YSR : *SS/Chl-a* (green algae) (mg-*SS*/μg-*Chl-a*)

Water quality analysis

In water quality analysis, the Ariake Sea is divided into 3 zones, innermost area, central area and gulf inlet area. The innermost zone, element 9-11, is a shallow sea area. Its total area is 155 km^2 which is about 10% of total area of the Ariake Sea. More than 50% of this zone is a tidal flat which composed of fine particles. Observed data of suspended solids are estimated from observed transparency using the relationship between suspended solids and transparency. The developed model is applied for quantitative analysis of suspended solids in the innermost area of Ariake Sea in 1991-2000.

Figs.2-4 show simulated results of suspended solids in the innermost area (element 11) comparing with those in the central area (element 7) and the gulf inlet area (element 3). At first, the simulation is carried out in order to get calibration results of present situation. Suspended solids in the Ariake Sea are high during summer to winter. The obtained results have good correlation with observed data in every zones. Organic suspended solids are shown in the same figure. High organic solids in summer are the indicator of high algal productivity in the innermost area. Influence of high organic solids in the innermost also results in high organic solids in element 3 and 7. Inorganic solids in the innermost area are high comparing with other zones. High inorganic solids have less effect on suspended solids in other elements because resuspended solids rapidly settle before being flushed out to the other zones. In the second simulation, suspended solids loading discharged through the rivers is cut off. Due to resuspension, suspended solids in the innermost area are still high in summer although the peak concentration is lower than the peak concentration of the present situation. The contribution of the discharged loading on suspended solids is also same in other zones.

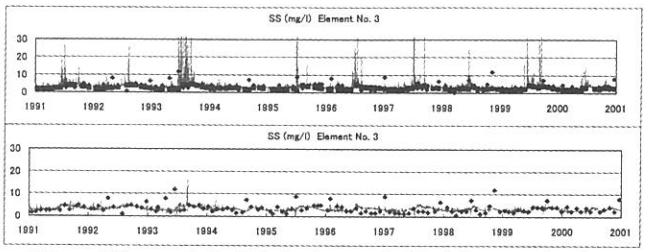

Figure 2 Suspended solids in element 3. (Top) Present situation (shown with organic SS) (Bottom) Without suspended solids loading

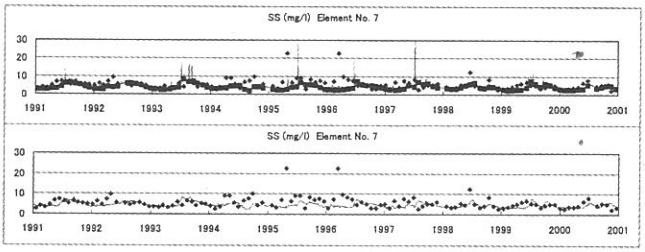

Figure 3 Suspended solids in element 7. (Top) Present situation (shown with organic SS) (Bottom) Without suspended solids loading

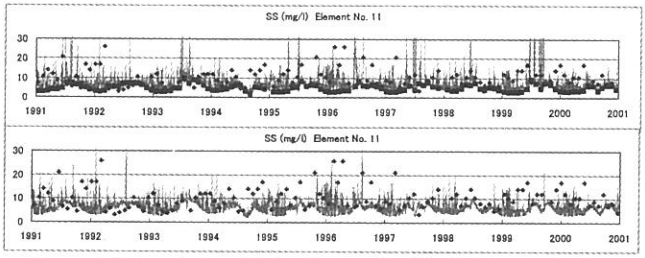

Figure 4 Suspended solids in element 11. (Top) Present situation (shown with organic SS) (Bottom) Without suspended solids loading

Conclusions

During summer to winter, suspended solids in the Ariake Sea are high especially in the innermost area. In the innermost area, high algal productivity in summer is the cause of high organic suspended solids while inorganic solids are high because of resuspended fine particles from mud bed. In other zones, percentage of organic solids is higher than inorganic solids. The contribution of discharged loading from the rivers on the suspended solids in the innermost area is insignificant and can be observed only in summer which is a period of high discharge.

Acknowledgement

The authors would like to thank Kyushu Regional Development Bureau, Ministry of Land, Infrastructure and Transportation for offering useful information of the Ariake Sea.

References

1) Rich, L.G. (1973) Environmental system engineering. McGraw-Hill. 113-114,139-141.
2) Vongthanasunthorn, N., K. Koga, H. Araki, H. Yamanishi, *et al.* (2002) Water Quality Analysis in the Ariake Sea. *Environmental systems research.* JSCE. 65-70.