Integrated water quality model in Chikugo basin and the Ariake Sea

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Introduction

Recently, many water quality analyses have been carried out in the Ariake Sea with the application of both experimental results and numerical models. Water quality simulation requires a number of observed data which makes it difficult to obtain the reliable results. In order to develop an integrated water quality model, the authors have tried substituting the observed data of Chikugo River with the result of the developed tank model in the water quality simulation in the Ariake Sea. In this study, the discharged loading from Chikugo basin is estimated by using the developed tank model and the water quality analysis is carried out in the innermost area of the Ariake Sea using the obtained result from tank model.

Water quality models in Chikugo basin and the Ariake Sea

The connection between water quality model in Chikugo basin and the Ariake Sea is shown in Fig.1. Vongthanasunthorn *et al.* (2000) and Masaki *et al.* (2001) have developed tank model for water quantity and water quality analysis in the middle reaches of Chikugo River. The developed tank model is composed of a series of three tanks. The orifice at the bottom of each tank represents the infiltration and the lateral orifice represents surface or sub-surface runoff from each tank. Sources of loading from catchment area are nature (forest and mountain), human's activities (urban and rural area) and agriculture (paddy field). Loading from each source is determined by constant unit loading rate. In Fig.1, flowrate and water quality in the middle area of Chikugo basin, between Arase and Senoshita, are simulated by using a series of three tanks. Under the assumption that loading from downstream area of Senoshita is proportional to the discharged loading at Senoshita and directly drained into the Ariake Sea, one-tank model with one lateral orifice at the bottom of the tank is installed in order to represent the direct discharge of this area.

Water quality model in the Ariake Sea is a two-dimensional finite-volume model considering that each box is in the completely mixed condition and there is no density current existing in this model. Time step of this model is one day. Model development and short-term water quality analysis in the Ariake Sea have been carried out by Vongthanasunthorn *et al.* (2002). Discharged loading of Chikugo basin obtained from tank model is applied as an input in water quality analysis in the innermost area of the Ariake Sea.

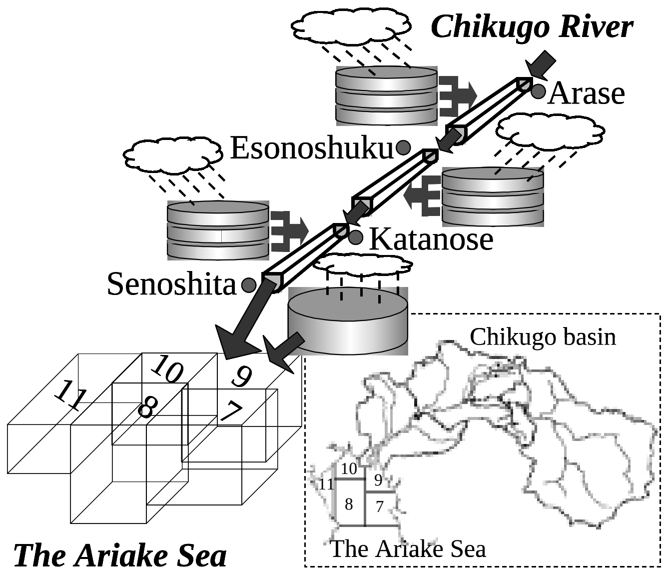

Figure 1 water quality models in Chikugo basin (tank model) and the Ariake Sea (finite-volume model)

The mass balance equation of material transported between two elements (Rich 1973) is defined in Eq.(1).

$$\frac{dV_i c_i}{dt} = \sum_j (G_{ji} + D_{ji}) \pm S_i \qquad (1)$$

where $dV_i c_i/dt$ = mass change in element i [M/T]
V_i = volume of element i [L^3]
G_{ji} = mass transport between element j and element i by advection [M/T]
D_{ji} = mass transport between element j and element i by dispersion [M/T]
S_i = reaction in element i [M/T]

Chikugo basin, the Ariake Sea, tank model, finite-volume model, unit loading rate
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Water quality loading of Chikugo River

Loading discharged from Chikugo basin can be determined by using flowrate and water quality obtained from the developed tank model. Flowrate and water quality loading discharged from Chikugo River in 1991-2000 are shown in Fig.2. Water quality loading of Chikugo River is high in summer when flowrate in the river is high and its loading is low in winter which is the low flow season.

Water quality in the innermost area of the Ariake Sea

The developed finite-volume model is applied for water quality analysis in the Ariake Sea in 1991-2000 using the calculated loading of Chikugo River and observed data in other river basins. Water quality in element 9 which locates near the mouth of Chikugo River is shown in Fig.3. It indicates that, with the application of the result obtained from tank model, the simulated water quality in element 9 has good agreement with the observed data. Water quality near the river mouth also has the seasonal pattern that is similar to the discharged loading. High concentration of water quality can be observed in the period of high discharge. However, the cause of high concentration is not only high discharged loading from Chikugo basin but there are also many factors i.e. algal production, release and resuspension from bottom mud, etc. that can affect the water quality in the Ariake Sea. In order to determine the influence of discharged loading from Chikugo basin on the water quality in the Ariake Sea, sensitivity analysis on water quality in the Ariake Sea is necessary.

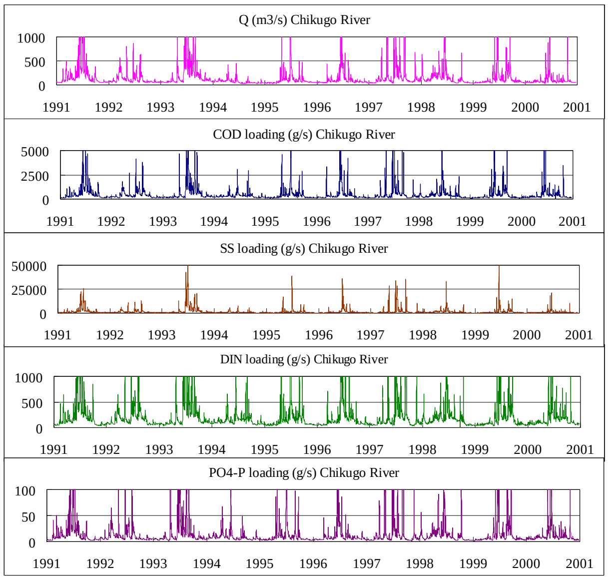

Figure 2 Flow rate and water quality loading of Chikugo River obtained from tank model

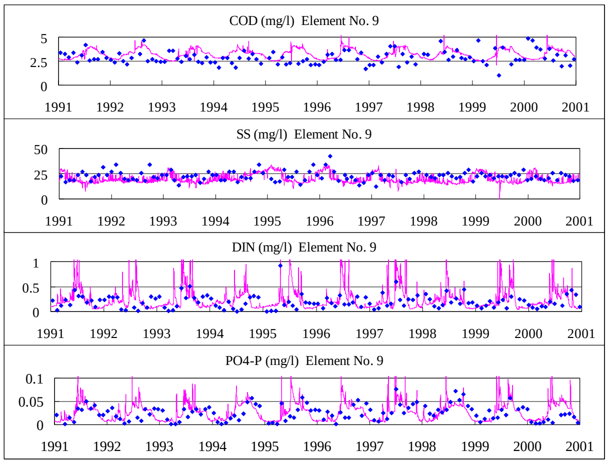

Figure 3 Simulated water quality in the innermost area of the Ariake Sea

Conclusions

1. The obtained result of finite-volume model shows that the water quality loading of Chikugo basin obtained from the developed tank model is applicable for water quality simulation in the innermost area of the Ariake Sea. It means that the developed tank model can be combined with the finite-volume model to link Chikugo basin and the Ariake Sea.

2. To determine the contribution of the discharged loading from Chikugo basin on the water quality in the Ariake Sea, sensitivity analysis on water quality will be carried out using the combined model in the future.

3. In order to develop the complete water quality model for the Ariake Sea, the development of water quality model in other river basins around the Ariake Sea is necessary.

Acknowledgement

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[Reference]

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