STUDY ON INFLUENCE OF WATER QUALITY FROM THE RESERVOIR OF ISAHAYA-BAY SEA RECLAMATION PROJECT

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1. Introduction

Isahaya bay is located in the west side of the Ariake Sea. Its total area is 2% of total area of the Ariake Sea. It is not yet clear exactly what has caused red tide and poor water qualities in the Ariake Sea. It has been suspected that the reclamation project in Isahaya bay at the inner part of the Ariake Sea might be a major contributing factor. The aim of this study is to develop a numerical model for water quality analysis in the Ariake Sea and to investigate how the discharged loading from the Isahaya reclamation project would affect water qualities of the Ariake Sea.

2. Water quality model

Two-dimensional water quality model in the Ariake Sea is developed based on the finite volume model as shown in Fig. 1. In this model, the Ariake Sea is divided into 11 elements; each divided element is considered to be in complete mixing state. This study is focused on water quality in element 6 and 5, representing the reclamation project and its adjacent area. Water quality parameters in this model are chlorophyll a (Chl-a), chemical oxygen demand (COD), suspended solids (SS), dissolved inorganic nitrogen (DIN), orthophosphate phosphorus (PO_4) and chloride ion (Cl^-).With given boundary conditions, a net flow rate between two adjacent elements can be obtained from the continuity equation in Eq.(1). (Vongthanasunthorn et al. 2004) Mass balance equation in each element of the finite volume model (Rich 1973) is described in Eq. (2).

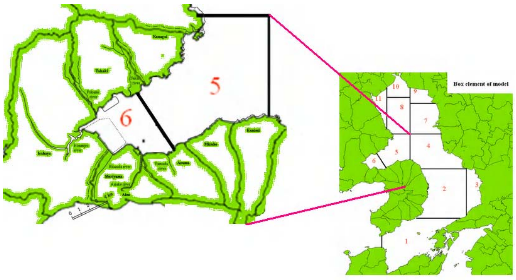

Fig. 1 The Ariake Sea and Isahaya reservoir

$$\frac{dV_n}{dt} = \sum Q_{nm} + Q_{B(n)} \quad (1)$$

$$\frac{dc_{(n)} \cdot V_{(n)}}{dt} = \sum \left\{ Q_{nm}\left[\delta_{nm} \cdot c_{(m)} + (1-\delta_{nm})c_{(n)} \right] + E'_{nm}(c_{(m)} - c_{(n)}) \right\} \quad (2)$$

V = water volume of element (m^3)
Q_{nm} = net flow rate between element n and m (m^3/s)
Q_B = boundary condition of flow rate of the element (m^3/s)
c = average concentration in the element (g/m^3)
δ_{nm} = net advection factor between element n and m (-)
E'_{nm} = mixing coefficient between element n and m (m^3/s)
S = reaction term (g/s)

Subscripts n and m denote the considered element and the adjacent element, respectively.

The reaction terms of DIN and PO_4 of element n are described as S_N and S_P in Eqs. (3) and (4). The substantial change in biomass of algae (*AG*) is shown in Eq. (5). The reaction term of suspended solids (S_S) in element *n* is expressed in Eq. (7). The reaction term of particulate COD (S_{CP}) and dissolved COD (S_{CD}) are described in Eqs. (8) and (10), respectively.

$$S_N = -\sum_{x=1}^{5} Y_{N(x)} \cdot AG_{(x)} + K_{RN} \cdot DIN_B \cdot R_M \cdot A \quad (3)$$

$$S_P = -\sum_{x=1}^{5} Y_{P(x)} \cdot AG_{(x)} + K_{RP} \cdot PO4_B \cdot R_M \cdot A \quad (4)$$

$$AG_{(x)} = \left(\mu_{(x)} - K_{D(x)} \cdot \theta_{(x)}^{(T - T_D(x))} \right) CH \cdot V \quad (5)$$

$$\mu_{(x)} = \mu_{MAX(x)} \cdot T_{G(x)} \left(\frac{DIN}{K_{N(x)} + DIN} \right) \left(\frac{PO4}{K_{P(x)} + PO4} \right) \quad (6)$$

$$S_S = SS_{RS} - K_{SS} \cdot B_S \cdot SS \cdot A \quad (7)$$

$$S_{CP} = Y_{SC} \cdot SS_{RS} - (K_{SC} \cdot PCOD + SCOD_{ALGAE})A + \sum_{x=1}^{5} Y_{C(x)} \cdot AG_{(x)} \quad (8)$$

$$SCOD_{ALGAE} = \sum_{x=1}^{5} Y_{C(x)} \cdot K_{SA(x)} \cdot CH_{(x)} \quad (9)$$

$$S_{CD} = K_{RC} \cdot DCOD_B \cdot R_M \cdot A \quad (10)$$

Y_N = DIN: Chl-a (mg DIN/μg Chl-a)
Y_P = DIP: Chl-a (mg DIP/μg Chl-a)
K_{RN} , K_{RP} = release rate of DIN and DIP (g/m^2-d)
DIN_B , $PO4_B$ = DIN and DIP in mud bed (g/m^3)
R_M = ration of mud bed area in the element (-)
A = element area (m^2)
K_D = specific decay rate (1/d)
θ = temperature coefficient for decay (-)
T_D = critical temperature for decay (℃)
T = water temperature (℃)
μ_{MAX} = maximum specific growth rate (1/d)
T_G = temperature coefficient for algae growth (-)
K_N , K_P = saturation constant of DIN and DIP (g/m^3)
CH = Chl-a (mg/m^3)
DIN = dissolved inorganic nitrogen (g/m^3)
$PO4$ = orthophosphate phosphorus (g/m^3)
SS_{RS} = resuspension suspended solids (m/d)
K_{SS} = settling velocity of SS (m/d)
B_S = settling coefficient (-)
SS = suspended solids (g/m^3)
A = element area (m^2)
Y_{SC} = PCOD content of particulate materials in mud bed (mg COD/ mg SS)
K_{SC} = settling velocity of PCOD (m/d)
$PCOD$ = particulate COD (g/m^3)
Y_C = PCOD: Chl-a (mg COD / μg Chl-a)
K_{SA} = settling velocity of algae (g/m^2-d)
K_{RC} = release rate of DCOD (g/m^2-d)
$DCOD_B$ = DCOD in mud bed (g/m^3)

In this study, the sensitivity analysis is carried out in 3 cases as shown in Table 1. Simulation period is from 1997 to 2000.

Table 1 Sensitivity analysis cases

Case	Considered condition of input loading from the Isahaya reservoir into the Ariake Sea
1	No contribution between element 5 and 6
2	Contribution of loading discharge bypass the reservoir
3	The Isahaya water quality model is integrated with the Ariake Sea model

3. Results and discussion

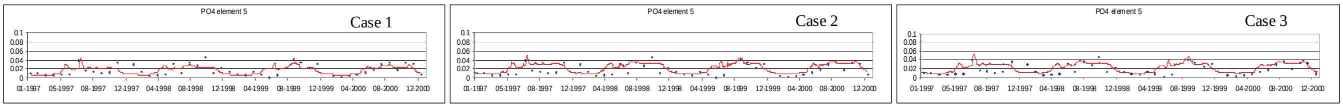

Fig. 2 PO_4 concentration (mg/l) in element 5

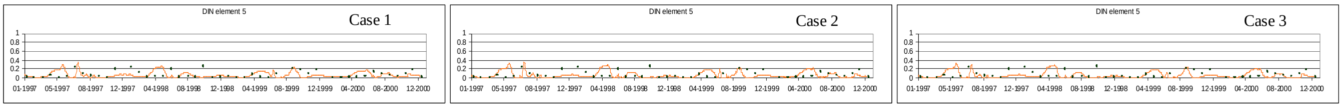

Fig. 3 DIN concentration (mg/l) in element 5

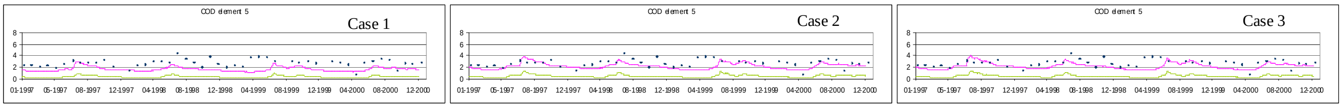

Fig. 4 COD concentration (mg/l) in element 5

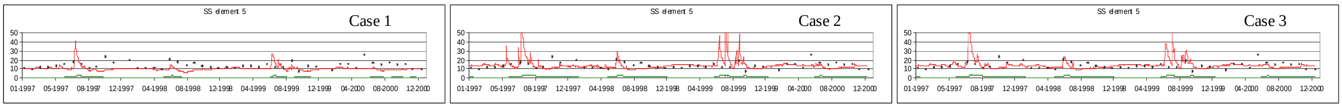

Fig. 5 SS concentration (mg/l) in element 5

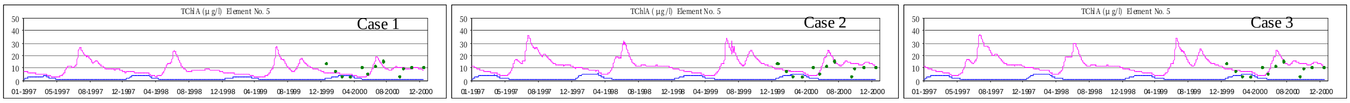

Fig. 6 Chlorophyll a concentration (μg/l) in element 5

The results of nutrient loading are shown in Fig. 2 and 3 although the results of case 2 and 3 are not too much different, both are a little higher than case 1 in which the loading from Isahaya reservoir to the Ariake Sea is neglected. It means the discharged loading from the Isahaya reservoir has just small effect to the nutrients in the Ariake Sea. The results of COD are shown in Fig. 4. In case 3 when the Isahaya model is integrated, the results are almost same with contribution of loading discharge bypass the reservoir in case 2. These results indicate that COD from Isahaya reservoir probably have small effect to the Ariake Sea. As shown in case 1,when no any contribution from the Isahaya reservoir to the Ariake Sea, COD is lower than case 2 and 3. Beside this, Chl-a concentration simulation results between contribution of loading discharge bypass the reservoir and integrated model are almost same. From the result, there is a low possibility that red tide in the Ariake Sea is transported from the Isahaya reservoir. However, there is a possibility that algae in the Isahaya reservoir will dominate the growing ability of algal production in the Ariake Sea. The results of SS are shown in Fig. 5. In some region of the simulation result in case 2 as loading discharge bypass the reservoir, SS concentration is higher than the result from the integrated model. It happens because of the settling effect in the reservoir. From these simulation results, it can be pointed out that discharge load from the Isahaya reservoir has small effect to SS concentration in the Ariake Sea.

4. Conclusions

In order to develop an analytical tool for water quality management in Isahaya reservoir and the Ariake Sea, water quality model in the Ariake Sea should be integrated with the developed model of the Isahaya reservoir. From the simulation result, it can infer that loading from Isahaya reservoir does not particularly affect the water quality in the Ariake Sea. Furthermore, a low possibility of the relationship between the red tide and the reclamation project has been revealed. Nutrients load from the Isahaya reservoir does not strongly affect the growing ability of algae in the Ariake Sea but there is a possibility that algae from the Isahaya reservoir will dominate the growing ability of algal production in the Ariake Sea.

5. Acknowledgement

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6. References

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