MG3　Estimation of total nitrogen load discharged from rivers into Harima Nada

播磨灘における河川からの全窒素流入負荷量の推定

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Abstract: Harima-Nada region is one of the numerous sea basins of the Seto Inland Sea, located between the Bisan Strait and Osaka Bay. The area has been suffering a sustained oligotrophication process during the past few decades, which has affected biodiversity and seafood productivity. Since Harima Nada is a sea watershed strongly affected by riverine discharge, a coupled hydrological-chemical model (CHCM) was used to address the river's streamflow, and total nitrogen (TN) load discharged into the sea. The model was validated for the main rivers from the Hyogo Prefecture and the Shikoku Island, showing a good performance reproducing streamflow and TN load during the validation period. It was found that the Hyogo Prefecture's rivers are the main contributors of freshwater and TN load. The land-use distribution on each river's watershed showed to be the most important variable accounting for the TN load discharged. For the years considered in this study (2009-2016), the annual average of TN discharged into Harima-Nada was found almost invariant.

Keywords: Water pollution, Nitrogen nutrients, Sea watershed assessment, River's basin model

1. Background

Eutrophication and oligotrophication of water bodies are some of the most common environmental problems that need to be addressed for all countries worldwide. Coastal areas can be severely affected by the rivers that discharge into them, the reason why a good understanding of land-derived pollutants is a useful tool on the environmental assessment of marine pollution. As a sea basin of the Seto Inland Sea of Japan, Harima Nada is a good example of this problem (Figure 1). From severe eutrophication problems in the decade of 1970 to a sustained decrement in the concentration of nitrogen nutrients on the region's waters during the past decades that has caused oligotrophic conditions, the marine ecosystem and seafood production in its waters have been severely affected [1]. Much research has been conducted on the rivers and the sea for this area to elucidate the possible causes of this low nitrogen species concentration. Still, the application of a numerical model that can reproduce land-derived nutrients loads, considering the variations that rain events can cause on the nutrients load, was a gap this research aims to fill.

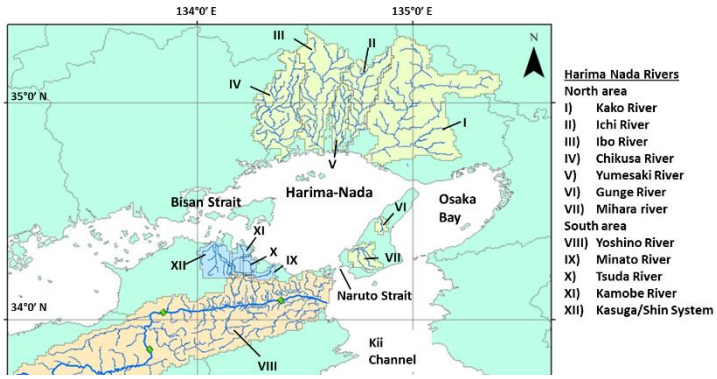

Figure 1 Harima Nada location and river's basins studied

2. Methodology

A hydrological model was coupled with a water-chemical model to simulate the hydrodynamics and

hydrochemistry of the 11 rivers that directly discharge into the studied area and the Yoshino River. Each river's watershed was represented as a model domain by a mesh of cells with a horizontal resolution of 1x1 km. GIS datasets for elevation, river channel, land usage, and forestation were combined with meteorological datasets to estimate the river's discharged freshwater and TN load. Additionally, the model was used to evaluate the importance of TN source contributors (land-use derived load and point source load from sewage and factories/business discharges) in the northern region of Harima Nada (Hyogo Prefecture). Model validation was conducted in the most significant rivers of the northern and south regions (the Kako River and the Yoshino River, respectively) to check the model's performance on streamflow and TN load.

Table 1 – Performance indices for monthly evaluation on streamflow and TN load obtained in the validation

Kako River (Hyogo Prefecture)	R^2	Nash-Sutcliffe Efficency (NSE)	RSR	pBIAS(%)
Streamflow Validation	0.93	0.81	0.37	-24.3
TN load Validation	0.97	0.89	0.33	+14.3

3. Results and discussion

The performed model validation for the discharged freshwater on the Kako and Yoshino Rivers and the TN load discharged in the Kako River (TN load validation was conducted only in the Kako River) showed that observed and calculated values have a high correlation (Table 1). The evaluation of the performance indices used to check the model was also found satisfactory. The Hyogo Prefecture's rivers showed to have an average discharge of freshwater around ten times bigger than the southern rivers (Kagawa Prefecture). Yearly variations on discharged freshwater can be observed from year to year (see Figure 2). For the TN load discharged, the observed trend was similar between both regions, being norther rivers discharge in the order of ten times bigger too. Annual variations are less significant from year to year for TN load than for discharged water due to model configuration. The Yoshino River has a bigger freshwater discharge than all the rivers that discharge in Harima Nada together, and its yearly variations are more pronounced. Additionally, the Yoshino River's discharged TN load is comparatively smaller (around 80%) than Harima Nada's northern rivers, as shown in Figure 2.

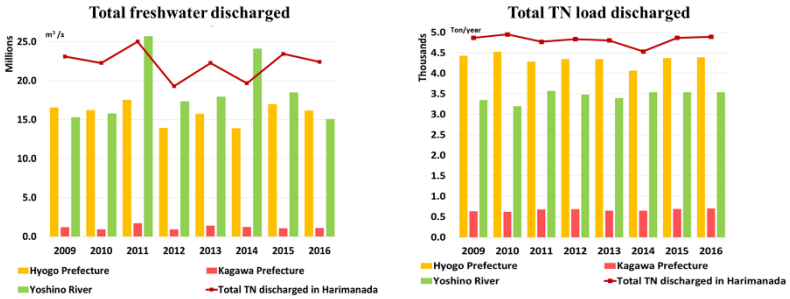

Figure 2 – Total yearly freshwater and TN load discharged from Harima Nada Rivers and the Yoshino River b

4. Conclusions

The model showed a very good performance on reproducing stream flow and TN load in the Kako and the Yoshino Rivers. The most significant contributors to freshwater and TN load into Harima Nada are the rivers from the northern region, which account for almost 90% of both studied variables. Variations in yearly freshwater are more significant than in TN load. The Yoshino River does not discharge directly into Harima Nada, but its size and its proximity could be relevant for the area, the reason why more research on its importance needs to be conducted.

References

[1]Yanagi Tetsuo, Eutrophication and Oligotrophication in Japanese Estuaries? The present status and future tasks, Springer Netherlands, pp. 39-67, 2015.