

Improved calibration of runoff load model using continuous monitoring data on turbidity and electrical conductivity

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Introduction

Runoff nutrient load is important to evaluate the impact to water quality deterioration in lakes (Anderson and McDonnell, 2005). In particular, the role of model simulation has been emphasized to describe spatial and temporal patterns in water quality and to identify the factors and processes that influence those conditions (Mueller et al., 1997). However, we often suffer from a lack of wet weather data for calibration in water quality modelling caused by the difficulty in taking frequent measurements of water quality parameters such as COD, total nitrogen (TN), and total phosphorus (TP). In this study, we aimed to expand data availability for model calibration by using continuously measurable data such as turbidity and electrical conductivity (EC). Then, we verified the applicability of the expanded data set for model calibration. Finally, we quantitatively estimated pollutant load in a lake basin using a distributed runoff model.

Study area and methodology

Study area is a eutrophic lake, Lake Inba, which has water surface of 11.55km² and catchment area of 541.1 km². The lake located in about 45 km east of Tokyo, Japan (35°45'13.22"N 140°11'46.04"E) has eight principal inflow rivers. A local government has carried out runoff monitoring on flow rate, turbidity, electrical conductivity (EC), COD_{Mn}, nitrogen (N) and phosphorus (P) in rivers flowing into the lake since 2002. Four sets of monitoring data in 2003 and 2007 can be used for calibration of runoff load modelling in Teguri River flowing into the lake.

The SIPHER-model (Uehara et al., 2008, Simulation of phenomena through the medium of water) was used to estimate runoff pollutant loads in this study. The GIS-based distributed model is comprised of sub-models such as evapotranspiration, ground water flow, surface flow, channel routing, point and non-point source pollutants loading models. The most critical sub-model is non-point source pollutant loading model, because its calibration is not still sufficient due to the limited runoff monitoring data. Therefore, it is prospective to estimate wet weather pollutant load using continuously measurable turbidity and EC.

3. Results and discussion

Based on the four sets of monitoring data, we investigated correlations among turbidity, EC and particulate and dissolved pollutants, respectively. Turbidity was positively correlated with particulate pollutants (COD_{Mn}, nitrogen and phosphorus) with high correlation coefficients (r), which were 0.86, 0.88 and 0.86, respectively.

Electrical conductivity showed a high correlation only with dissolved nitrogen ($r = 0.86$), while there was no clear relationship between EC and dissolved COD_{Mn} and phosphorus. From the statistical significance, we proposed the following equation to estimate TN concentration by turbidity and EC.

$$\text{TN (mg/L)} = \text{particulate nitrogen} + \text{dissolved nitrogen} = (0.0319 [T] - 0.0722) + (0.0627[\text{EC}] + 0.523),$$

where [T] is turbidity (NTU) and [EC] is electrical conductivity (mS/m).

In order to validate this equation, we compared the calculated TN with the 17 observed concentration data in Teguri River during 28th October to 1st November, 2010 with three rainfall events. **Figure 1** shows that the calculation satisfactorily reproduced the observed concentrations. On the basis of such a good accordance between calculated and observed runoff behavior, we expanded the TN concentration data using the continuous data of turbidity and EC. Although the runoff load modelling had been originally calibrated only with limited sampling data, we could elaborate the model calibration for nitrogen runoff characteristics in terms of continuous runoff trend as well as minute fluctuations. We improved the parameter adjustment in the point and non-point source pollutant load models. Simulation results describe properly the TN concentration for four days with three rainfall events as shown in **Figure 1**.

We applied the calibrated SIPHER model to estimate TN load in Teguri River basin. As an example, **Figure 2** shows the simulation results for monthly rainfall and TN load. Inflow load tends to increase with more rainfall in September and October, 2010. We were able to obtain spatial and temporal variation of TN load, which is useful information to control the eutrophication in the lake.

4. Conclusions

Turbidity and EC had a significant correlation respectively with particulate and dissolved nitrogen concentrations in an inflow river of Lake Inba under wet weather condition. We proposed a regression equation to estimate TN concentration in a inflow river with continuous data of turbidity and EC. Through the data expansion of TN concentration using the regression equation, we elaborated the model calibration for runoff variation during more than four days. The improvement in the model calibration is advantageous to estimate inflow TN load into the eutrophic lake, considering a long-term runoff variation. The better estimation of inflow load provides deeper understanding to control and manage non-point source pollutions as well as point sources in the lake watershed.

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