Field Observation and Modeling of Combined Sewer Overflow in Upstream Region of the Horikawa River

Tominaga A[1 *], Nakanishi Y[2)] and Tsutsui K[3)]

1) Department of Civil Engineering, Nagoya Institute of Technology
Gokiso-cho, Showa-ku, Nagoya, 466-8555, Japan
e-mail: tominaga.akihiro@nitech.ac.jp
2) Civil Engineering Division, Taisei Corporation
3) Department of Civil Engineering, Nagoya Institute of Technology
* Corresponding author

1. Introduction

The Horikawa River is a contaminated urban river in Nagoya City. Its water resource is sewage processed water in most part and transmitted water from the Shonai River. This river flow is affected by tidal flow up to 13.8km from the river mouse. Since most part of the basin has combined sewerage system, a combined sewer overflow (CSO) occurs in the rain and this is thought to be a major cause of the water quality degradation. In order to take effective measure of improving water quality, it is necessary to evaluate the contribution of CSO to the total pollution in the river. In this study, field observation of the discharge and water quality was conducted in upstream region of the Horikawa River. Using this results, the model of estimating discharge and water quality of CSO was established.

2. Field observation

The field observation was conducted at the locations shown in Fig.1. The basin area is 1.86km^2. In this section, the water is only from the Shonai River on fine day but CSO flow out from the six storm outfalls in the rainfall shown in Fig.1. When it rains a lot, the water is pumped out to the Yada River. The water level was recorded at three sections with the use of pressure type water level gage. At the section A, transmitted water condition was checked. The sections of B and C have the same cross section and 80m distant from each other. Hence, the water surface gradient is obtained from the water-level difference between these sections.

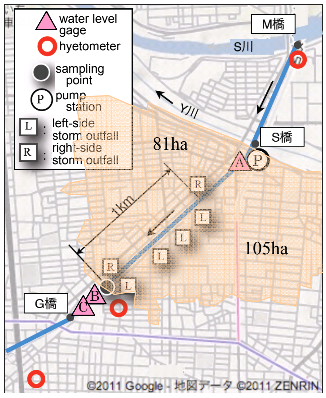

Fig.1 Observation site

At first, the discharge was measured by using an electromagnetic velocimetry in ordinary water level and the Manning's roughness coefficient was obtained ($n = 0.0325$). Assuming this roughness is constant even in high water level, the discharge was calculated from the water-level difference and mean water depth. The amount of average rainfall in the basin was obtained by the data of Nagoya City and our own hyetometer. The water was sampled into 500ml bottle at 2minute to 5minute interval during rainfall. The water samples were tested for BOD and SS promptly.

3. Results and discussion

The observation in the rain was conducted 5 times and CSO was recognized 9 times. Fig.2 shows an example of the hyetograph and hydrographs of discharge, BOD and SS at the section C. The outflow was observed 3 times in series of rain. At the first rainfall, no outflow occurred. After the second rainfall, the first CSO was recognized and BOD maximum of

48.5mg/l was observed. After the third intense rainfall, the discharge showed significant peak and SS attained the maximum value of 243mg/l. The peak of BOD became smaller than that at the first CSO. At the third CSO, BOD became small whereas SS showed rather high value. It is considered that BOD is not proportional to the outflow discharge but depends on the amount of pollutant accumulation. BOD indicates large value at the first flash event after small cumulative rainfall and deceases with an increase of cumulative rainfall even when the amount of CSO increases. The peak value of SS is almost proportional to the outflow discharge.

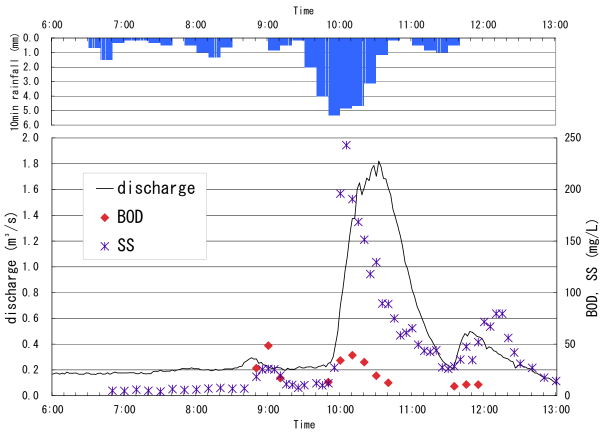

Fig.2 Hyetograph and hydrograph of CSO

4. CSO modeling

The relation between rainfall and the outflow discharge was modeled by the unit hydrograph concept. The 10 minutes outflow height *q(t)* (mm) is obtained by overlapping 10 minutes rainfall multiplied by certain coefficients during previous 60 minutes as follows:

$$q(t) = \sum_{i=1}^{6} a_i r(t - i\Delta t), \quad \sum_{i=1}^{6} a_i = 1 \qquad (1)$$

where r is 10 minutes rainfall, a_i is coefficients and Δt=10min. The coefficients a_i were determined to maximize the correlation between observed and calculated discharges. Then, 10 minutes CSO discharge Q_C (m^3) is expressed using the 10 minutes outflow height q, as follows:

$$Q_c = 1000 fA(q - 0.50) \qquad (2)$$

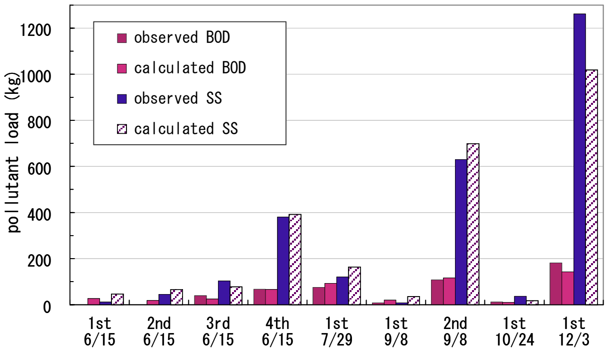

Fig.3 calculated and observed pollutant load

where f is the runoff ratio and A is the basin area (km^2). In this basin, the runoff ratio is extremely small ($f = 0.138$) because a pump station is provided. It is understood that CSO occurs when the 10 minutes outflow height q exceeds 0.5mm. BOD and SS are calculated in considering the characteristics that the pollutant load attains a peak during the rising stage and then it decreases rapidly in the falling stage.

$$B_i(t) = \int_0^t \alpha_i \left(\frac{dQ_c}{dt}\right) dt : t < t_{\max}, \quad B_i(t) = B_{i\max}, t_{\max} < t < t_p, \quad B_i(t) = B_{i\max} + \int_{t_p}^{t} \alpha_i \left(\frac{dQ_c}{dt}\right) dt : t_p < t \qquad (3)$$

where B_i is pollutant load, α_i is the coefficients, $B_{i\max}$ is the upper limit of the load, $t_{\max}$ is the time at upper limit, t_p is the peak time of CSO and i means BOD or SS. The coefficients were determined from the observed results. Fig.3 shows the comparison between calculated and observed pollutant load. The calculated loads are almost predicted well but a large discrepancy appears when the outflow discharge is small.

5. Conclusion

The characteristics of outflow discharge, BOD and SS of CSO were obtained by the field observations. These data are useful to understand the impact of CSO to the water quality management in the basin and to consider measures of reducing the CSO pollutant load.