Water Quantity Analysis in Chikugo River

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1. Introduction

Due to increasing number of water users in Chikugo River, water balance and characteristics of its discharge need to be analyzed for integrated water resources management. The objectives of this study are to analyze water balance, which will be useful for pollutant loading analysis in the future. The study area is a part of this river. It is divided into 3 sub-basins as shown in figure.1. Around 43% of total agricultural area in Chikugo River basin is located in this area. In pollutant loading analysis, separating irrigation period and non-irrigation period is a useful approach in according to define pollutant sources. Pollutants generated in Chikugo River basin are from forest, urban area and paddy fields[1]. It is found that about 30-40% of total NO_3 loading in Chikugo River comes from forest area. NO_3 loading from urban area and paddy field in irrigation period is higher than those in non-irrigation period[2]. In this study, tank model is used for calculating flow rate of Chikugo River in both irrigation period and non-irrigation period.

2. Tank model

Tank model is a simple mathematical model for discharge calculation based on water cycle. Some phenomena such as precipitation, evapotranspiration and infiltration are major factors that affect inflow and water loss in each tank. The results from runoff calculation determine water balance of each tank. The tank model used in daily discharge calculation of Chikugo River is composed of 3 series of tanks. Discharges from hydraulic structures, such as dams and water gates, in each sub-basin are also included as inputs of the other tanks.

From the mass balance principle, water balance in each tank can be calculated from eq.1.

$$\frac{dV}{dt} = Qin - Qout \qquad (1)$$

V = water volume

Qin = inflow = upstream discharge + precipitation + discharge from dams and gates

Qout = outflow = evapotranspiration + infiltration + runoff

3. Water quantity analysis

The problem encountered in water balance analysis in Chikugo River is the difficulty in measuring amount of irrigation water intake and return to Chikugo. Daily discharge of Chikugo River at Senoshita, Katanose and Esonoshuku during 1994-1996 are calculated under 3 conditions below.

- No hydraulic structure
- With dams
- With dams and water gates

After adjusting tank parameters and percentage of water intake by trial and errors method, the discharge from dams

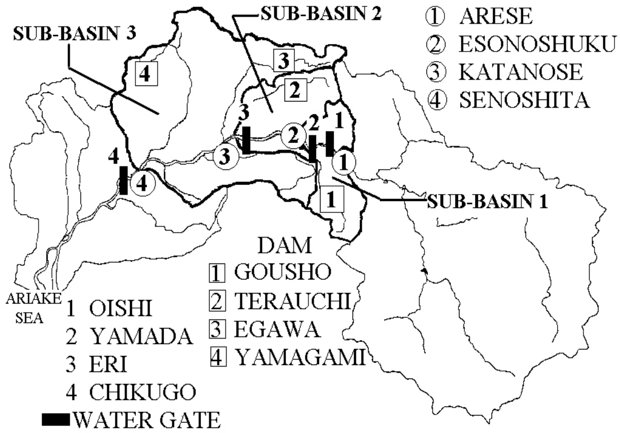

Figure .1 Chikugo River Basin.

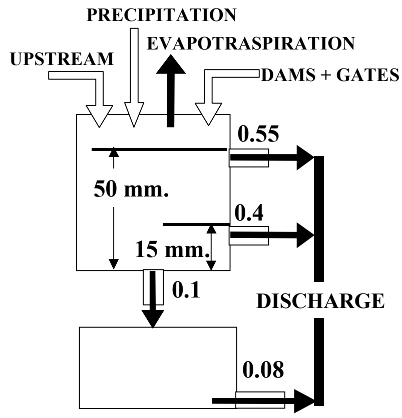

Figure. 2 One series of tanks in tank model.

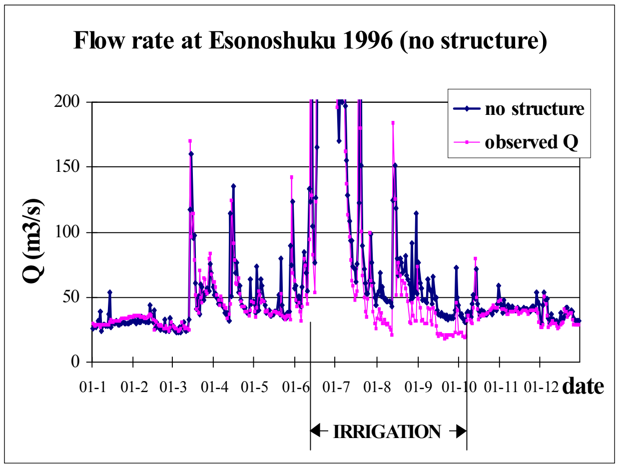

Figure.3 Calculated flow rate at Esonoshuku by tank model (without structure).

Chikugo River, tank model, water quantity analysis, water balance, irrigation period, non-irrigation period
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and water gates are calculated. The obtained results are close to the observed data as shown in figures 3, 4 and 5.
In non-irrigation period, the flow rates are not much different for each condition. On the other hand, it is found that in irrigation period, computed flow rate of Chikugo River at Esonoshuku in case of no structure and in case of having dams only are much higher than in case of having dams and water gates.
In water balance analysis, it shows that water intake to each sub-basin is changed every year. In irrigation period, total intake for sub-basin no.1 and no.3 is about 40% of total discharge from Oishi gate and more than 50% of discharge from Yamada gate is transferred to sub-basin no.3. This is because agricultural area in sub-basin no.3 is very large, about 70% of total agricultural area of this study area. In non-irrigation period, most of the water from each gate is distributed to sub-basin in which it is located. Figure.6 shows that the calculated flow rate at Senoshita in case of no structure is very close to the observed flow rate. It is found that water withdrawn at upstream portion returns back to the main river at Senoshita.

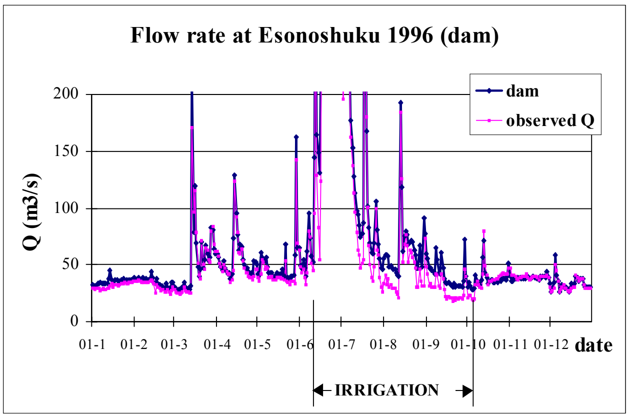

Figure.4 Calculated flow rate at Esonoshuku (with dam).

4. Summary

Because of its simplicity and being based on hydrologic cycle, it is easy to understand and manipulate tank model. Besides simulating flow rate of Chikugo River, its water balance can also be determined by using tank model. The results obtained in this study show that the existing of water gates greatly affect flow rate of Chikugo River. Dividing the period of water use is good approach in analyzing water balance and pollutant loading from paddy field, forest area and urban area. In addition to water quantity analysis, pollutant loading can be calculate by using tank model with some modification.

[**Reference**]
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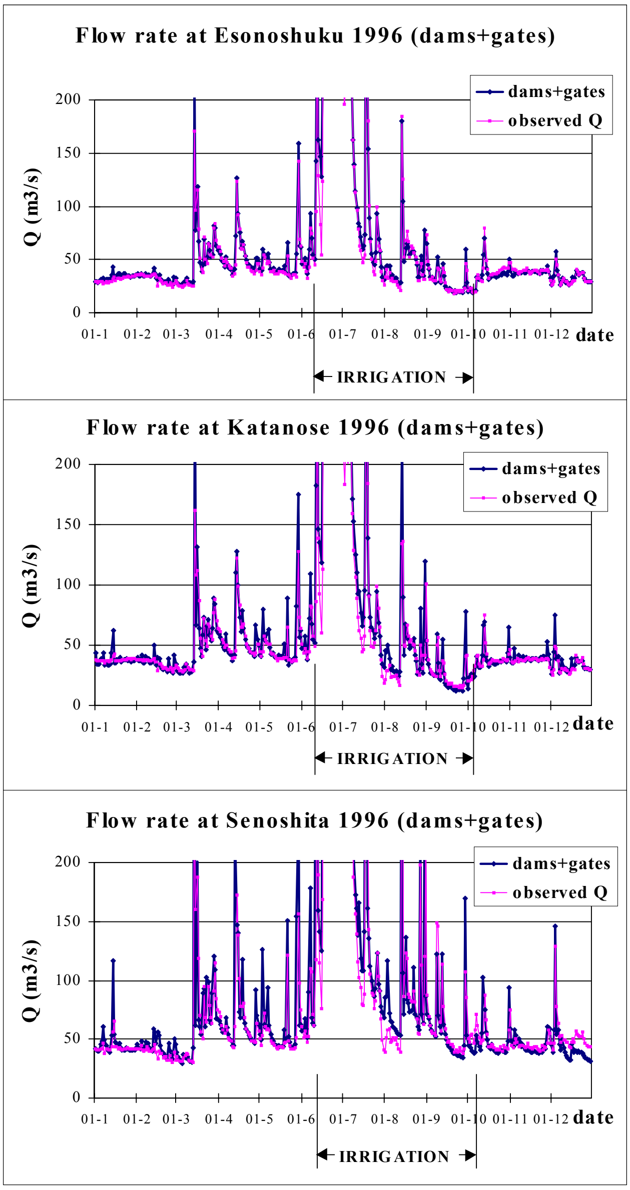

Figure.5 Calculated Flow rate by tank model (with existing of dams and water gates).

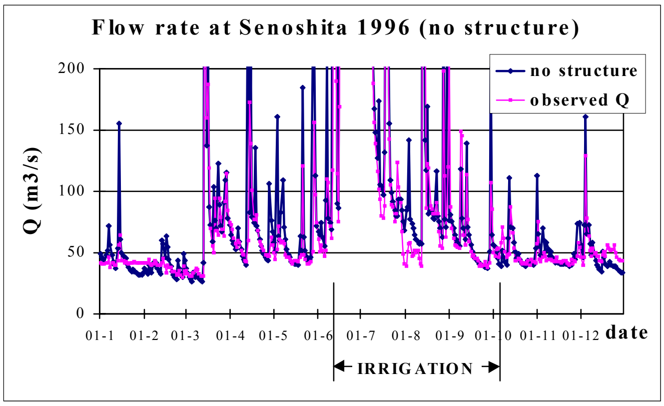

Figure.6 Calculated flow rate at Senoshita (without structure).