Run-off Process Analyses By Water Chemistry

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1. Introduction

The quality of run-off water has been used to study the properties of the flow process through the determination of discharge components. However, it would be more beneficial to consider certain chemical properties that indicate water quality of the run-off and the rainfall not only to determine the flow components but also to get a better understanding of the flow process. This research separates the hydrograph using the specific electrical conductance of rainwater and outflow water and discusses the basin characteristics using the chemical characteristics observed. Relationships between basin properties and run-off characteristics are also studied.

2. Run-off Process Analysis Using Water Quality

2.1 Hydrograph Separation

The watersheds used in this research are relatively small basins near the Nagoya University earthquake observation station at Inuyama City in Aichi Prefecture with areas of 6,400 and 158,900 square meters respectively (please refer to Matsubayashi et al. 1991 for the location of the watershed). Using the model by Matsubayashi et al. (1991) three rain events were separated from the period of June 23, 1992 to October 10, 1992 with simultaneous separations for the big and small basins for one of the rain events. For the small basin hydrographs, the separation produced old water percentages of 44.2% for June 23 to 24, 1992, 65.9% for July 17 to 18, 1992 and 34.0% for October 8 to 9, 1992. For the big basin hydrograph the old water components was 85.5% for October 8 to 9, 1992. The rainfall event for October 8 to 9 can be seen in figure 1. Results of the hydrograph separations shows that basin size influences the old water contribution to the hydrograph where the small basin is more dependent on the antecedent rainfall event for the old water contribution to the hydrograph. The big basin is less sensitive to the antecedent event becuse of the large contribution of base flow to its hydrograph.

2.2 Analysis Using Water Quality

Aside from electrrical conductance, certain indicators of the quality of the rainwater and flow discharge were measured, namely the major ions, pH, and temperature. Some of these measurements can be seen in figure 2. Partial results of the observations are as follows: For the small basin (figure 2), it can be seen that compared to Na^+ and Cl^-, the ions K^+, NO_3^- and Ca^{++} fluctuate more in response to changes in rainfall intensity and discharge. Because of the organic and mineral backgrounds of nitrate and calcium respectively, this means that there is a considerable response to changes in the surface soil condition in this basin. Also in figure 2, it can be seen that rainfall quality is a non-constant quantity which seems to be a function of time. To determine the actual water quality properties of each rainfall event, relationships between the discharge, rainfall and water quality quantities are analyzed. This was done by plotting the discharge Q against C (conductance) , pH and ion concentrations. The Q-concentration relationships will indicate if the flow process governing each quantity is rainwater-dilutive (downward trend), soil-reactive (sharp angular downward trend) or in-soil-deposit-dilutive (upward trend). A sample Q-ion plot for the small basin can be seen in figure 3.The plot shows that the small basin is sensitive to soil and flow condition changes and the flow is partly dillutive and partly soil-reactive. The large basin is less sensitive to soil characteristics changes because of the averaging effect of the mixing of base flow, channel and slope flows.

3. Conclusions

The result of this analysis are as follows: Basin size influences the contribution of the precedent rainfall event to the present hydrograph. For one event, the rainwater quality is a function of the time of rainfall. The small basin is more sensitive to surface soil conditions than the big basin. From the Q-concentration plots, it can be deduced that the flow process in the small basin is that of a reactive-dilutive process where ionic reactions are as dominant as dilution in the flow of ions, while for the big basin , the flow process seems to be an in-soil-deposit -dilutive flow. Finally, these results shows that water quality can be used as an indicator of watershed properties.

4. Reference

Matsubayashi U., G.T. Velasquez, F. Takagi. Separations of new and old... , Proceedings of Hydraulic Engineering, JSCE, Vol.35, 99-104, 1991 (in Japanese with English abstract)

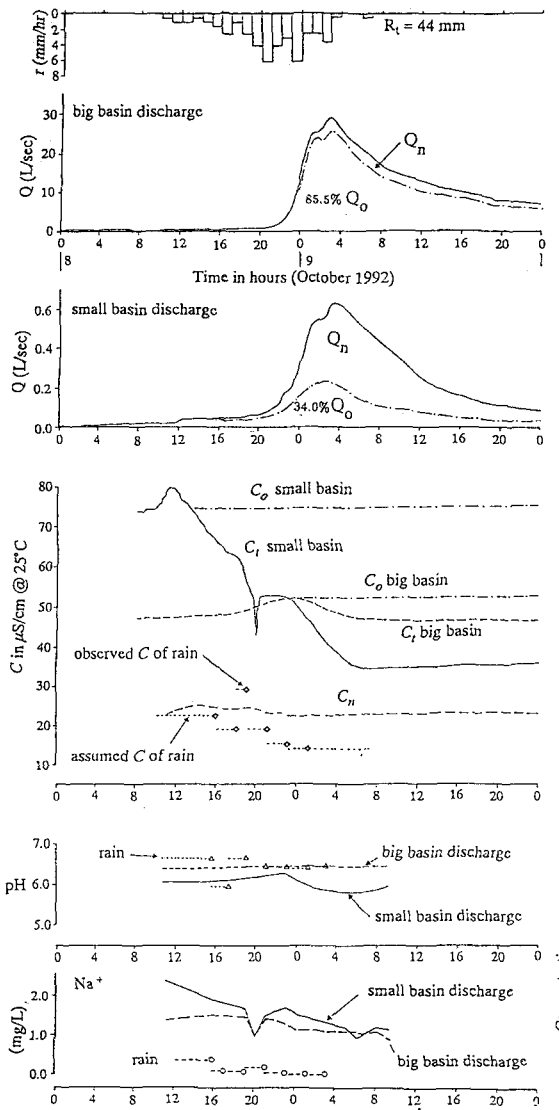

Figure 1. Hydrograph separation for the big and small basins for the rainfall event of October 8 to 9, 1992.

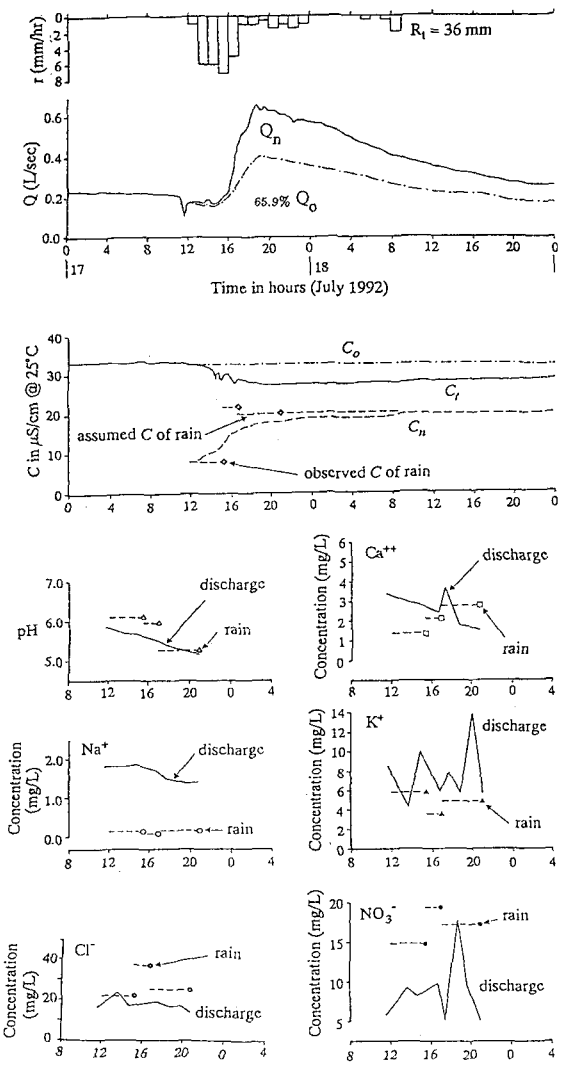

Figure 2. Water quality for run-off and rainfall for the rain event of July 17 to 18, 1992.

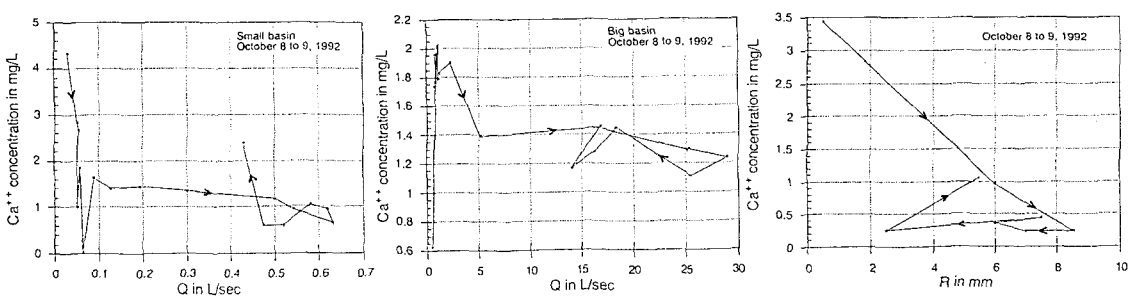

Figure 3. Discharge-concentration and intensity-concentration relationships