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Run-off Process Analyses By Water Chemistry

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Introduction

It would be 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.

Run-off Process Analysis Using Water Quality

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, 1993 for the location of the watershed). Using the model by Matsubayashi et al. (1991, 1993) four rain events were separated from the period of June 23, 1992 to October 16, 1992 with simultaneous separations for the big and small basins for the last two 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, 34.0% for October 8 to 9, 1992 and 58% for October 14 to 15, 1992. For the big basin hydrographs the old water components were 85.5% for October 8 to 9, 1992 and 81% for October 14 to 15, 1992. The rainfall event for October 8 to 9 can be seen in figure 1.

Results of the hydrograph separations shows that the big basin yields more old water contribution compared to the small basin. This means that for the small basin the old water comes more from the antecedent rainfall than from baseflow. For the big basin, a greater part of the old water comes from baseflow resulting in persistent contributions of old water. Another possible reason of these results can be traced from the geology of the two basins. Deep percolation and alternative flow routes are possible reasons for the low old water contribution for the small basin because it is situated above a highly fractured geological formation due to a nearby fault. This results in some flows coming out at a lower location than the observation weir.

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 figure1. Partial results of the observations are as follows: For the small basin, it can be seen that the ion concentrations 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 chemical condition in this basin.

To determine the actual water quality properties of each rainfall event, relationships between the discharge, rainfall and water quality quantities were 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 2.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.

To determine the relative time of contact between the water and the soil, and the possible sources of flow, basic elemental ratios were used. These are the ratios Na^+/K^+, Na^+/Cl^- and SO_4^{2-}/Cl^-. The first ratio measures the age of the water and the last two ratios measure groundwater contribution. A sample plot can be seen in figure 3. From the elemental ratios, it can be seen that more old water contributes at the start of the hydrograph for both basins. Also, the big basin shows more groundwater contribution for the start and the middle of the hydrograph. Also in figure 4, it can be seen that rainfall quality is a non-constant quantity which seems to be a function of time.

Conclusions

The result of this analysis are as follows: The big basin yields more old water percentage to the present hydrograph. For any one event, the rainwater quality is a function of the intensity of rainfall. The small basin is more sensitive to surface soil conditions than the big basin. 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. There are more old water contributing during low flows for both basins and the big basin yields more groundwater for a greater range of flows compared to the small basin. Finally, these results shows that water quality can be used as an indicator of watershed properties.

References

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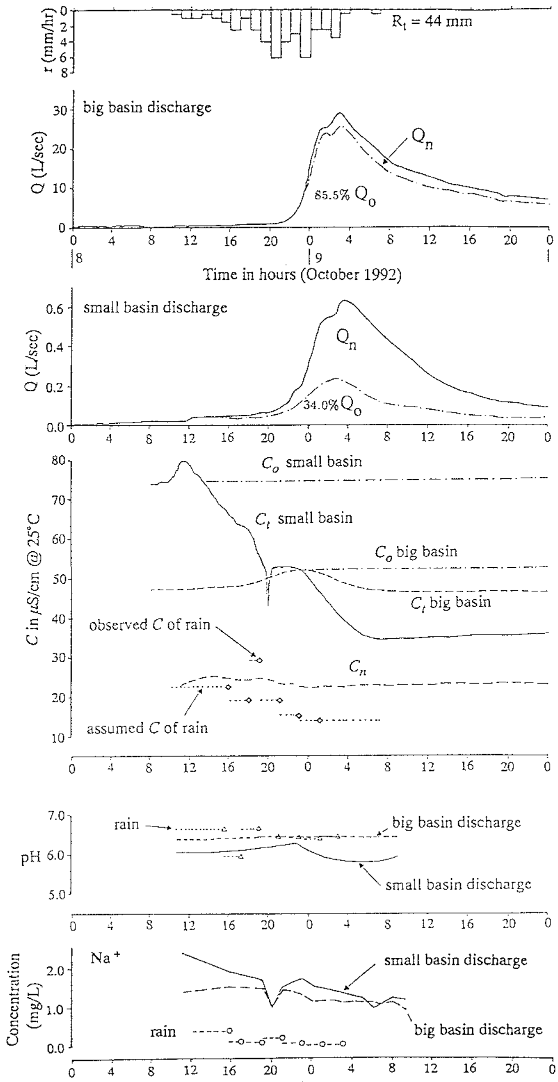

Figure 1. Hydrograph separation for the big and small basins for the rainfall event of October 8 to 9, 1992.

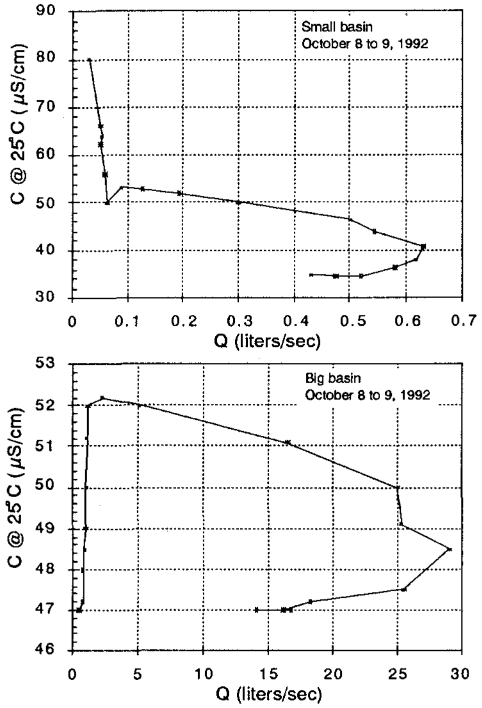

Figure 2. Discharge-Conductance function forboth basins for the rainfall event of October 8 to 9, 1992.

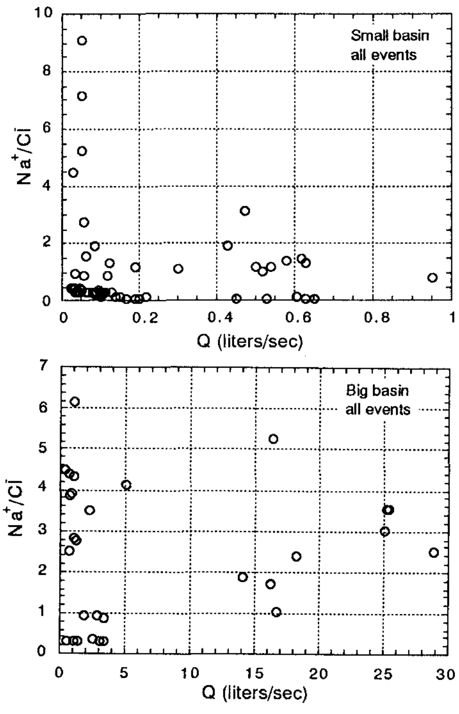

Figure 3. Elemental ratios versus discharge for both basins for all rainfall events.

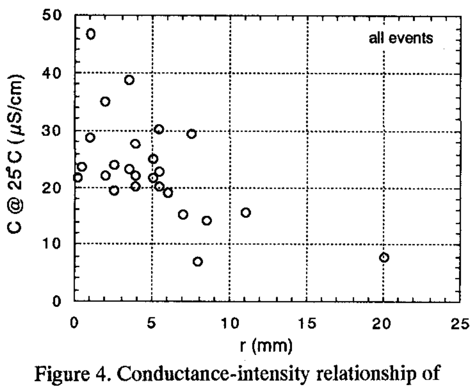

Figure 4. Conductance-intensity relationship of rainfall for all events.