II-574 Using Specific Electrical Conductance of Flow Water to Separate Event and Pre-event Waters

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1. Introduction

Using an unstable tracer such as the specific electrical conductance of water C for hydrograph separation has been used to determine solute dilution in flow (*Pilgrim et al., 1979; Nakamura, 1971*) and in flow phenomenon studies (*Matsubayashi et al., 1991*). However, due to the differences in modeling approaches of previous researches, variations in results have been reported. This paper intends to investigate the functionality of the C-contact time model by Matsubayashi *et al.* (1991) in hydrograph separation, and also the limitations of certain assumptions taken in modeling. The results shows that hydrograph separation results using C is in logical agreement with general beliefs of flow separation. Also, for the basin studied, the presence of base flow has been detected.

2. Model Concept

The model is generally of Matsubayashi *et al.* (1991) where in the general separation equations,

$$Q_n + Q_o = Q_t \quad , \quad C_n Q_n + C_o Q_o = C_t Q_t, \tag{1}$$

C_n is a time variant quantity derived experimentally, and C_o is assumed to take the constant value of C_t immediately before the effect of the rain is felt in the total flow. Here C and Q stands for conductance and flow respectively, and the subscripts n, o and t stands for new (event), old (pre-event), and total flow in that order. The effect of long and C varying rain is considered through equation (2).

$$C_n^c(t) = \frac{\int_0^t C_n(t-\tau)r(\tau)\mathrm{d}\tau}{\int_0^t r(\tau)\mathrm{d}\tau} \quad (2) \quad ; \quad C_{25} = \frac{C_T - 0.114(T-25)}{1+\frac{T-25}{41.8}} \quad (3)$$

In equation (2), $r(\tau)$ is the rainfall intensity, and $C_n^c(t)$ is the total C_n function up to the time t. Here, the experimental curve 1 (figure 1, see Matsubayashi *et al.* 1991 for details on the experimental procedure for deriving these curves) was used for the initial burst of rain and curve 2 being used for further bursts thereafter. Curve 3 is used for rainfall bursts assumed to have produced surface flow. For the sake of reporting uniformity, all C values were converted to those at $25°C$ using equation (3) (Velasquez *et al.*, 1992), where C_T is the C at T temperature.

3. Application

Five rainfall events were separated from the period of September 15, 1990 to November 11, 1990 from the experimental basin at Inuyama in Aichi Prefecture (three hydrographs are shown in figure 2). The basin, 6400 m^2 in area and thickly forested, is mainly of paleozoic shale and sandstone whose soil thickness varies from 0.3 meter at the ridge to about 1 to 1.5 meters at the channel (see Matsubayashi *et al.* 1991 for map of basin).

Using the model described above, the hydrographs were separated as in figure 2. Figure (2-a) shows two separations, one with a dotted line and one with a dash-dot line. The dotted line represents a separation assuming that surface flow occurred during the period 23:00 to 24:00 hrs. The other separation assumes no surface flow. Both separations have the *old* water below the line and the *new* water above. Figures (2-b) and (2-c) shows one separation each, both assuming no surface flows. For figures (2-a) and (2-b), the pre-event (*old*) water dominates the flow with 69% to 73% of the total flow while for figure (2-c) this contribution was only 40%. Because (2-c) event was preceded by six days of no rain, it can be taken that the low yield of pre-event water for (2-c) was due to a low contribution of base flow. Consequently, (2-a) and (2-b) were preceded only by rain just two days before; and because of the similarity between (2-b) and (2-c), the contribution of the base flow can be estimated by the difference of the two separations.

4. Conclusions

From observations of the data, it can be stated that for this experimental basin; (a) the equilibrium C value lie between 30 to 35 $\mu S/cm$ irrespective of the season, the rain intensity, the rate of flow, the C of the rain and the C of the flow before the rain; (b) the troughs in the values of C_t corresponds to intense rain inputs and not to the hydrograph peak.

From the analysis of the results of the model for this basin; (a) pre-event (*old*) waters dominate the flow if base flow is present; (b) if there is no base flow, the mobilized soil water contributes less to the total flow; (c) application of the surface curve (curve 3, figure 1) produces more *new* water contribution.

5. References

[1] Matsubayashi *et al.*, Separation of..., *Proceedings of Hydraulic Engineering, JSCE*, Vol.35, 99–104, 1991.
[2] Nakamura, R., Run-off analysis by electrical conductance of water, *Journal of Hydrology*, 14, 197–212, 1971.
[3] Pilgrim *et al.*, Use of specific conductance..., *Water Resources Research*, 15, 329–339, 1979.
[4] Velasquez *et al.*, An experimental..., *Proceedings of Hydraulic Engineering, JSCE*, Vol.36, 587–592,1992.

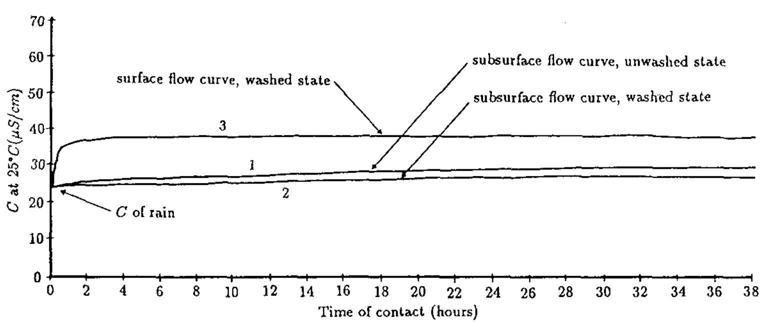
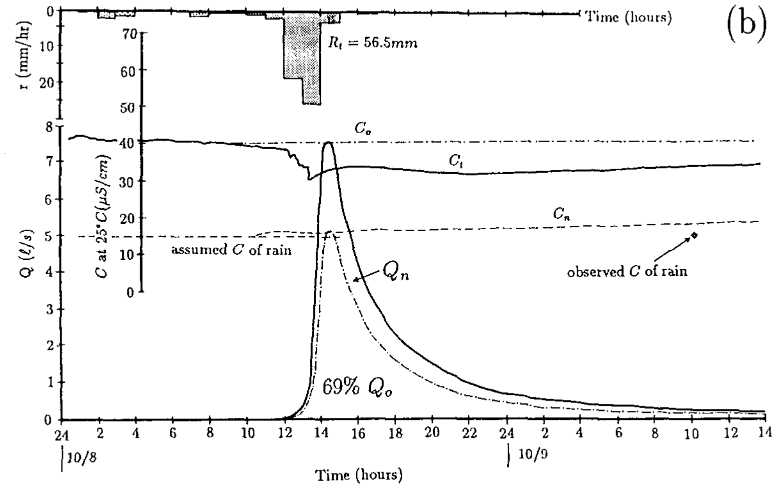
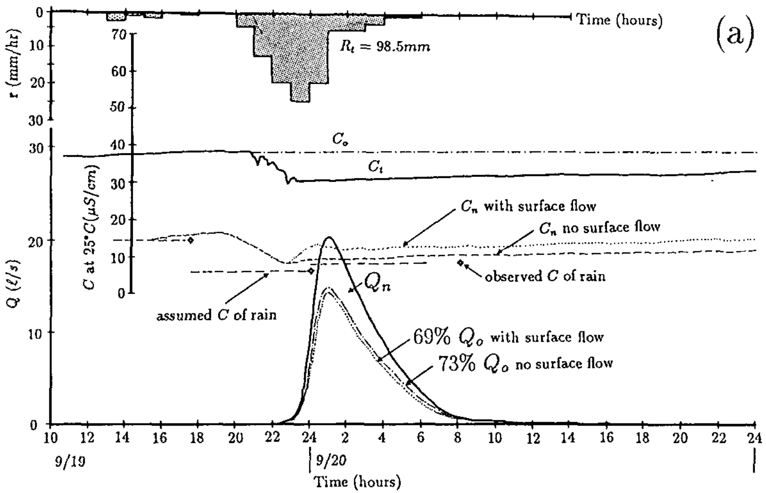


Figure 1. Experimental functions of C and time of contact between water and soil for surface and subsurface flows (*from Matsubayashi et al. 1991*).





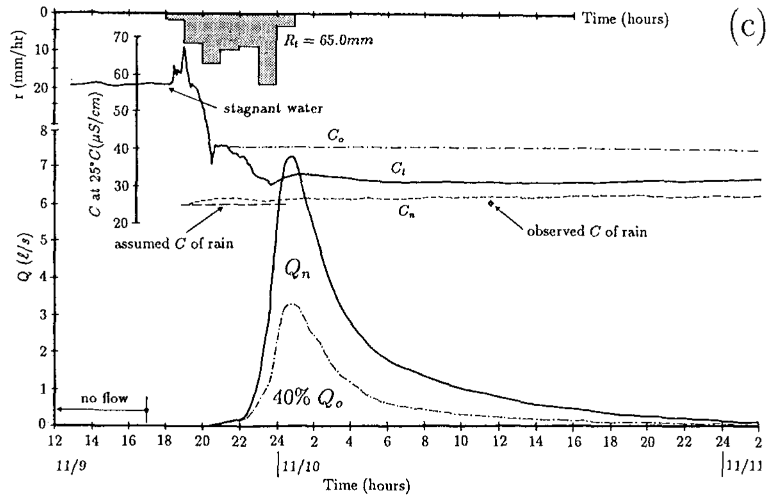


Figure 2. Separated hydrographs for the periods; (a) September 19 to 20, 1990, (b) October 8 to 9, 1990, (c) November 9 to 11, 1990.