FLOOD HYDROGRAPH ESTIMATION IN DATA DEFICIENT SMALL RIVER BASIN

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1. INTRODUCTION

There are many river basins, particularly in developing countries where we have very less informations about the physiographical data of the basins. Over the years not much significant effort has been made to improve and modernize the data collection, primarily of the inadequate appreciation of the need for such an effort and possibly because of operational and other practical difficulties. On account of such data deficiency, it is very difficult to apply rational techniques of analysis required for formulating or evaluating any plan for water resources development and management in the basin. A kinematic wave approximation which is reported by Woolhiser(Ref.3) as an excellent repersentation for most cases of overland flow is adopted. The model equations are represented in non-dimensional form and are solved using an implicit finite difference scheme. For the verification of the solution, the characteristic scheme is also applied to the original equations. The model is applied to a river basin in Hokkaido area, Japan. The basin has an area of 69 Km^2

2. DATA DESCRIPTION

The data available are only hourly mean effective rainfall inside the basin and discharge data at the outlet of the channel. The channel is located towards west at about 60% of the total width of the basin and is throughout the basin. The basin is deficient in geometrical,physical and topographical data such as bed slop, slop length, Manning roughness, shape of the basin, land use and cover, soil type, presence of lakes and swamps.

3. THEORETICAL FORMULATION

The basic equations are:

$$\frac{\partial y}{\partial t}+\frac{\partial q}{\partial x}=r_e; \quad q=\alpha y^m \tag{1}$$

Rewriting Eq.1 in non-dimensional form as reported by Akan(Ref.1) in terms of

$$q_*=\frac{q}{rL};\, r_*=\frac{r_e}{r};\, \alpha_*=\frac{L^{1/m}}{r^{1-1/m}t_d\alpha^{1/m}};\, t_*=\frac{t}{t_d};\, x_*=\frac{x}{L} \tag{2}$$

one obtains,

$$\frac{\partial q_*}{\partial x_*}+\alpha_*\frac{\partial}{\partial t_*}(q_*^{1/m})=r_* \tag{3}$$

The initial condition : $q_*=0$ at $t_*=0$ for all x_*
Boundary condition : $q_*=0$ at $x_*=0$ for all t_*
Omitting the subscript $*$ for clarity, Eq.3 are written in implicit scheme as:

$$\frac{1}{2\Delta x}(q_i^{j+1}-q_{i-1}^{j+1}+q_i^j-q_{i-1}^j)+(\frac{2\alpha}{m\Delta t})\frac{q_i^{j+1}-q_i^j}{(q_i^{j+1})^{1-1/m}+(q_i^j)^{1-1/m}}=r^{j+1} \tag{4}$$

where Δx and Δt are the non-dimensional space and time increments.

4. APPLICATION OF MODEL AND RESULTS

The model is applied to simulate the effective rainfall shown in Fig.1 occured in the year 1975. Representing the basin as shown in Fig.2, the following relationships are defined

$$L=\varepsilon W;\, A=WL_s;\, L_s=\beta A^{\gamma} \tag{5}$$

where W is in Km, A in Km and L in Km
Hoshi(Ref.2) reported the following value for ε,β,γ
$\varepsilon = 0.6$; $\beta = 1.35$; $\gamma = 0.6$

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With the above values for $\varepsilon, \beta, \gamma$ and with area, $A=69\ Km^2$ in Eq.5, L was found to be 2417.4 m. Manning formula for roughness is assumed. Defining a parameter $\alpha_1 = 1/(\alpha)^{0.6} = (n/s_0^{1/2})^{0.6}$ for m=5/3, the various values of α_* is obtained for different values of α_1 from Eq.2. Assuming α_1 equal to 2.0 and thus $\alpha_*=0.936$, Eq.4 is solved for the peak discharge in mm/hr. The results are shown in Fig.3. Fig.3 also shows the runoff hydrograph obtained by characteristic scheme. The agreement between the two results are excellent. But Fig.3 shows that the computed peaks are consistently less than the observed one and also the time of peak is earlier than the observed peak. These discrepancies are removed by reducing the value of α_1. α_1 is assumed respectively 1.4,1.6,1.7,1.8. The results calculated with only implicit scheme for these value of α_1 are shown in Fig.4. Fig.4 shows higher peak with early time than observed one for the value of α_1 equal to 1.4,1.6 and lower peak with α_1 equal to 1.8. While the value of α_1 equal to 1.7 best fit for the calculated peak discharge to the observed peak discharge as can be seen from Fig.5. But there is still discrepancy in time of peak occurrence. It shows that the runoff does not start at the same time of rainfall start. There is about one hour time lag between them. Choosing time lag equal to one hour and value of $\alpha_1 = 1.7$, the results calculated by the model with implicit scheme only is shown in Fig.5. The results shows the good agreement.

5. CONCLUDING REMARKS

This paper reports an attempt to obtain a runoff hydrograph for an data deficient basin. The model seems acceptable in view of the solutions for a data deficient basin. However, further verification of the approach with other data deficient basins is highly desirable.

6. REFERENCES

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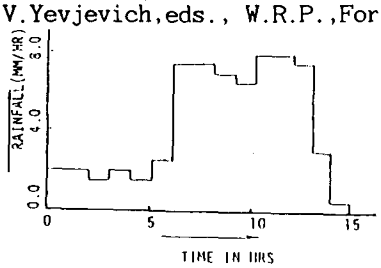

Fig.1 Effective rainfall pattern

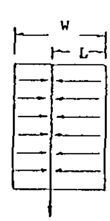

Fig.2 Basin model

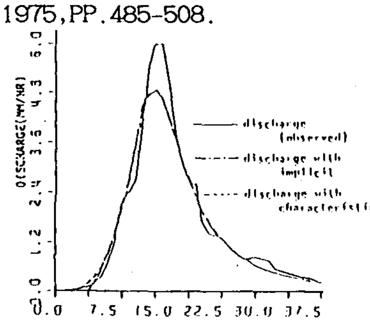

Fig.3 Discharge hydrograph by K.W.M. with implicit and characteristic scheme for $\alpha_1=2$

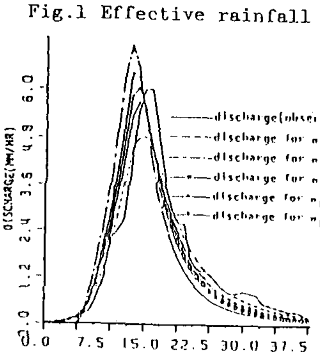

Fig.4 Discharge hydrographs by K.W.M. with implicit scheme for various values of α_1

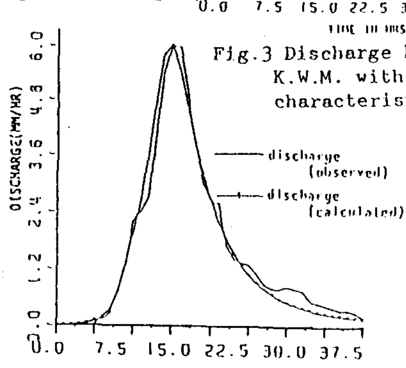

Fig.5 Discharge hydrograph for $\alpha_1=1.7$ & time lag of 1 hr.