SOME PRELIMINARY STUDIES ON LOSS RATES OF FEW SRI LANKAN CATCHMENTS

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Introduction

In studying the hydrological behaviour of Catchments, the use of loss rates has gained prominence in recent years. The loss rate defined as the average rate of capacity loss from rainfall on a catchment during the supply period of a storm, determines the pattern of rainfall excess from the storm rainfall. In Sri Lanka, no studies have been reported on loss rates, and it was intended to carry out some preliminary investigations on few Sri Lanka Catchments.

The loss rate concept

The loss rate is usually calculated to make the volume of rainfall excess on the whole catchment, equal to the volume of "Storm runoff" from the catchment.

Generally, there are 3 ways in which runoff reaches a stream, namely the surface runoff, interflow and the ground water flow. The interflow or the sub-surface stormflow is generally considered to be the water that percolates relatively quickly through the upper layers of the soil, and seeps out into the stream without having reached the ground water table. It has an intermediate travel time between those of surface runoff and the ground water flow. Their separation often presents many difficulties and thereby introduces doubt to calculations The runoff from the major storms which are used for the calculation of loss rate value consists mainly of surface runoff, with interflow as a secondary component.

In addition to the practical problems of separating the different types of runoff, there exists a more fundamental problem of, which of these components of flow should be considered as storm runoff. This gives rise to two different types of infiltration indices.

1. Infiltration Index:
   which is the average rate of capacity infiltration on a catchment during the supply period of a storm.

   As it includes only infiltration which is the actual rate of passage of water through the surface of the soil, and excludes interception and depression storage, it is difficult to determine and is of little interest to engineers.

2. Loss Rate:
   which is the average rate of capacity loss to surface runoff during the supply period of a storm.

This would include all the losses to surface runoff such as the infiltration, interception, depression storage, and even the evapotranspiration however

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small it is during a storm period. It could also be noted that the loss rate defined under this category includes all infiltration regardless of whether it percolates deeply into the soil, or returns to the surface as interflow.

Another difficulty in the loss rate concept is that they average the losses occuring over the area of the catchment, and throughout the period of rainfall excess. The value of loss rate varies over the catchment area due to variations in the type and condition of soil and vegetal cover. It also varies with time as the losses such as infiltration, interception and depression storage decrease fairly rapidly as the catchment becomes wet.

A typical variation of infiltration capacity rate with time at a point could be illustrated by Fig. 1. This has been established by field investigations and have been confirmed by mathematical analysis in soil physics. The values of initial infiltration f_o and the final constant value f_c would depend on many factors (Ref. Wisler & Brater).

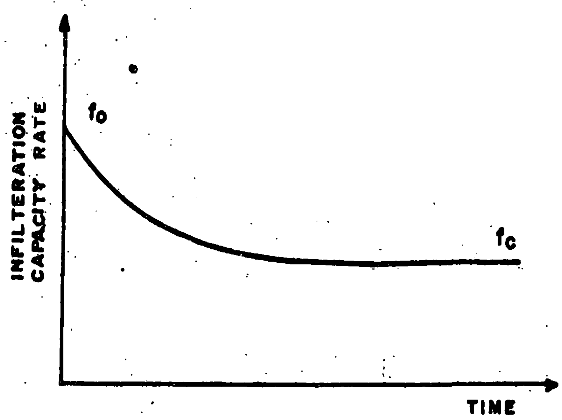


FIG. 1 TYPICAL VARIATION OF INFILTRATION CAPACITY WITH TIME

The averaging of the rate of loss throughout the period of rainfall excess is important only for relatively short storms, as interception and depression storage losses are mainly satisfied before the start of the rainfall excess and that infiltration rate reaches a constant value f_c after some time. Therefore, for long storms, the temporal averaging of the rate of loss has very little effect, as most of the capacity rate loss occurs at a reasonably constant rate.

Thus with the averaging of the losses over the catchment area, and that over the period of rainfall excess, a "loss rate" could be considered as a semi-empirical index, with some significance to the catchment behaviour.

Methodology

The general approach is to select several trial values of loss rate, subtract them in turn from the rainfall pattern and hence calculate corresponding values of rainfall excess. The actual value of loss rate can then be determined to make the volume of rainfall excess equal to the volume of storm runoff which actually occurred as determined from the hydrograph. Different procedures in carrying out this general approach give rise to the different methods, which can be grouped into three main types as follows.

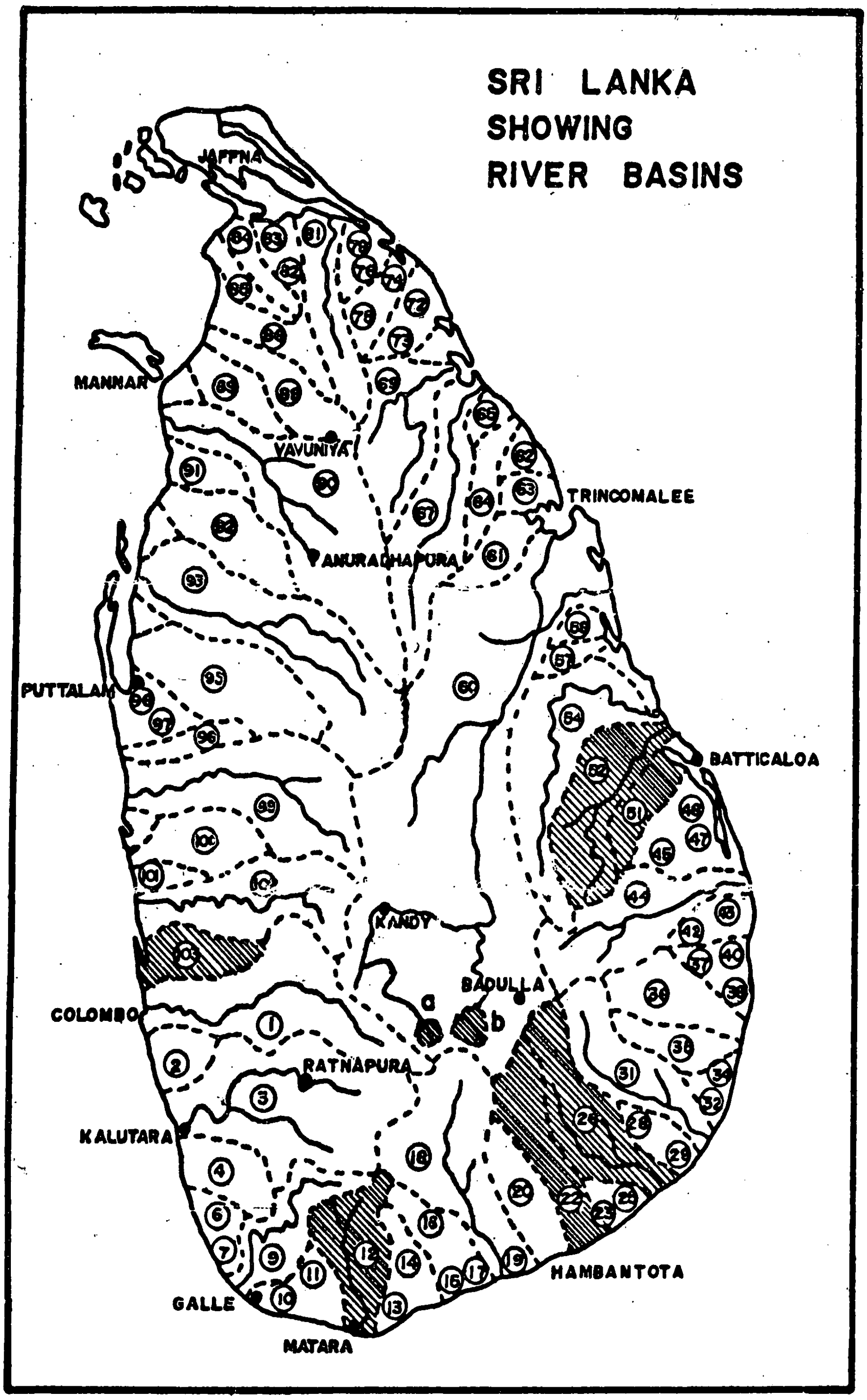
Horton Method

This procedure was described by Horton (1937) and it is probably the most widely used method. Allowance is made in this method for variation of the amount of rainfall over the catchment, by dividing the catchment into sub-areas.

Basically, the storm rainfall is assumed to be uniform over each sub-area, and the temporal pattern for each sub area is assumed to be the same as that of the nearest pluviometer. The values of rainfall excess are then calculated for several trial loss rates for each of the sub areas, and are summed up using either Thiessen polygon or Isohyetal method, to give the total rainfall excess for the catchment for each trial loss rate.

Average Storm Method

This method is described by Williams in Rouse (1950) where a simplification is made in the procedure. Using the hyetographs for the stations available



RIVER BASIN No.	CATCHMENT
12.	NILWALA GANGA AT BOPAGODA
22.	KIRINDI OYA AT LUNUGAMWEHERA
26.	MENIK GANGA AT KATARAGAMA
51.	MAGALAVATAVAN ARU AT PERIYA ARU
52a.	GALLODI ARU AT SIYAMBALANGAHAKANDIYA
52b.	RAMBUKKAN OYA AT NILOBE
60a.	MAHAWELI GANGA AT WATAWALA
60b.	UMA OYA AT WELIMADA & TALAWAKANDA
103.	ATTANAGALU OYA AT KARASNAGALA

Table 1 presents the loss rates values of some Sri Lankan Catchments calculated for few selected storm periods.

TABLE 1

River Basin No.	Catchment	Catchment Area (in Sq.km)	Storm Period	Loss Rates (mm/hr)	
				Horton method	Average Storm method
103	Attanagalu Oya at Karasnagala	114	(8-9) Nov. 1975	5.2	5.9
103	Attanagalu Oya at Karasnagala	114	(11-12) June 1979	0.6	0.2
60 a	Mahaweli Ganga at Watawala	65	(21-23) June 1973	36.3	27.0
60 a	Mahaweli Ganga at Watawala	65	(22-25) Sept. 1975	19.4	18.0
60 b	Uma Oya at Welimada	179	(11-13) Feb. 1965	9.0	6.6
60 b	Uma Oya at Talawakanda	505	8 Dec. 1971	3.9	3.3
52 b	Rambukkan Oya at Nilobe	161	(2-3) Dec. 1967	5.4	4.6
52 a	Gallodai Aru at Siyambalan-gaha Kandiya	224	(2-3) Dec. 1967	7.9	7.9*
51	Magalavatuvan Aru at Periya Aru	119	(24-25) Dec. 1969	2.0	2.0*
12	Nilwala Ganga at Bopagoda	411	(13-14) May 1977	4.8	3.8
22	Kirindi Oya at Lunugamwehera	913	(26-27) Nov. 1973	11.3	16.6
26	Menik Ganga at Kataragama	787	(26-27) Nov. 1973	57.6	59.9

* Only one gauge available for each Catchment.

an average storm hyetograph is developed for the catchment. The loss rate is then selected so that on deducting it from the average storm hyetograph, the rainfall excess is made equal to the storm runoff. In this method, no allowance is made for the aerial variation of the rainfall, in either the amount or temporal pattern.

U.S. Corps of Engineers Method

The procedure involved is described by Creager, Justin and Hinds (1945), and it could be called as a refinément to Horton's method. Here the allowance is made for several variation of rainfall by separate consideration of each rain gauge, and a different procedure is used for the temporal pattern. In Horton's method, the general assumption was to apply the nearest pluviometer pattern to the surrounding rain gauges, while in this method, a separate mass curve is synthesised for each gauge using the daily readings and all other available data. The values of rainfall excess and hence the loss rate are then calculated as in Horton's mehtod. This procedure generally entails a large amount of extra work.

Discussion and Conclusion

Theoretically, the best estimate of the loss rate would be given by the U.S. Corps of Engineers method, as it seeks to determine the rainfall pattern and the rainfall excess as it actually occurred over the catchment. But this method had to be done away with in the present study owing to the non-availability of required data.

Generally the average storm method gives appreciable differences from the Horton. The averaging of the rainfall data with regard to time or area will reduce the value of the derived loss rate, as some of the periods or areas with less than capacity rate loss will be assumed to have the capacity rate loss occuring. Another difficulty with the average storm method is that several different methods can be used for estimating the average storm hyetograph, and that subjective judgement is required in the process. Quite large differences can result in loss rate values derived from the storm patterns averaged by the different methods.

In general, for the choice of the method of derivation, two main considerations are involved. The first is the temporal and aerial distribution of rainfall. If these are uniform over the catchment, the average storm method would be quite satisfactory and it certainly involves much lesser amount of work, than the other methods. Otherwise, the Horton method should be used, if the true loss rate is required. The U.S. Corps of Engineers method appears to be very rarely justified, as it involves a very large amount of work. It would certainly be justified on large catchments where the daily rainfall totals and other observed data show a marked lack of correspondence with the patterns indicated by the nearby pluviometers. The second consideration is the magnitude of the storm to which a loss rate is to be applied relative to the magnitudes of storms from which loss rates are to be derived. If these magnitudes are similar the error in derived loss rate caused by the use of average storm method would be compensated for, in the application of the loss rate, as this process is the reverse of the average storm method of derivation. If the loss rate is being applied to a storm of greater magnitude than those used in the loss rate derivation, the error is not compensated, and to avoid that Horton method would be more suitable.

Another possibility would be the presence of "partial area storms" where during a storm, the rate of rainfall on some parts of the catchment does not exceed the rate of loss and thereby the rainfall excess and storm runoff occurring only on a portion of the catchment. In such a case, to calculate the correct value of loss rate, the computed rainfall excess values for various trial loss rates and the measured storm runoff must be expressed as the depth over the area actually contributing to runoff, rather than over the whole catchment. Care should therefore be exercised in using these values in determining a design loss rate, especially if the type and condition of soil and vegetal cover vary appreciably over the catchment.

It could be concluded that the present study is a preliminary investigation of the loss rates on few Sri Lankan Catchments, and that detailed analysis on more floods should be carried out before seeking for a basis for selection of the design loss rates for ungauged Sri Lankan Catchments.

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