PROBABILITY ANALYSIS OF SHORT-TIME RAINFALLS

by

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1. Fitting tests

The empirical distribution functions of our data series have been approximated by various theoretical probability distribution functions. From fitting aspects, distribution functions *Gamma 3* (82.5%) and *Lognormal* (77.1%) were found to best represent short-time rainfall.

2. Parameters of distribution functions

Parameters of distribution functions were assessed from central moments.

Variation of mean value $\bar{x}$ and deviation σ vs. rain duration is closely approximated by a straight line on semi-logarithmic scale. Variation and asymmetry coefficients C_v and C_s vary irregularly.

Parameters of the Gamma 3 function (x_0, λ, K) vary rather irregularly over a wide range.

Among the parameters of the Lognormal distribution function, the *mean* value exhibits a regularly ascending tendency, it is fairly approximated by a *straight line* expressed by $\overline{\ln x} = A + b \lg T$. The *deviation* [$\sigma(\ln x)$] varies in a narrow range rather irregularly, it is practically independent of the rainfall duration (Fig. 1).

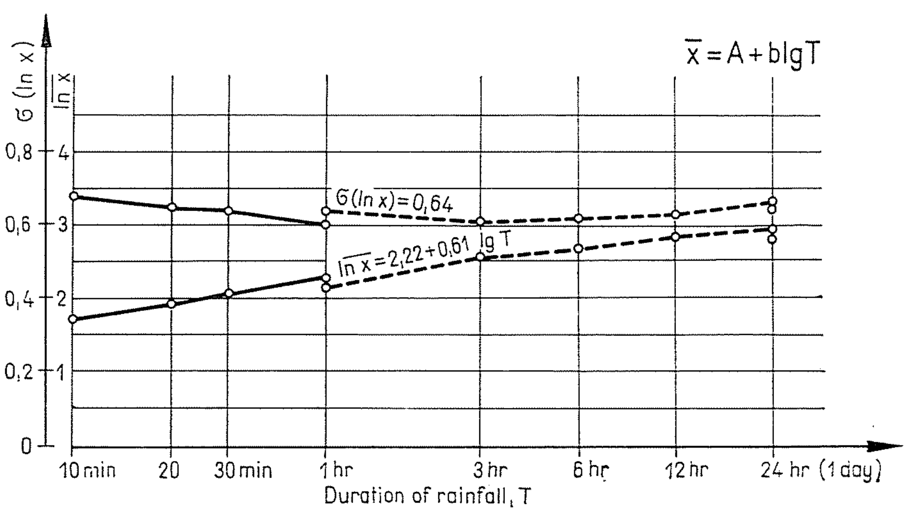

Fig. 1

Parameters of the Lognormal function are about equal in the summer months and are but slightly different from station to station. Accordingly, short-time rainfalls can be described by the same probability law in the summer months throughout the country.

3. Combined (fictitious) month

Short-time rainfalls in the four summer months (May to August) are of the same character (approximated by the same distribution function) and of a similar magnitude. Rainfalls in April and September differ in character from the former and from each other, and are much less than those in the May to August period (Fig. 2).

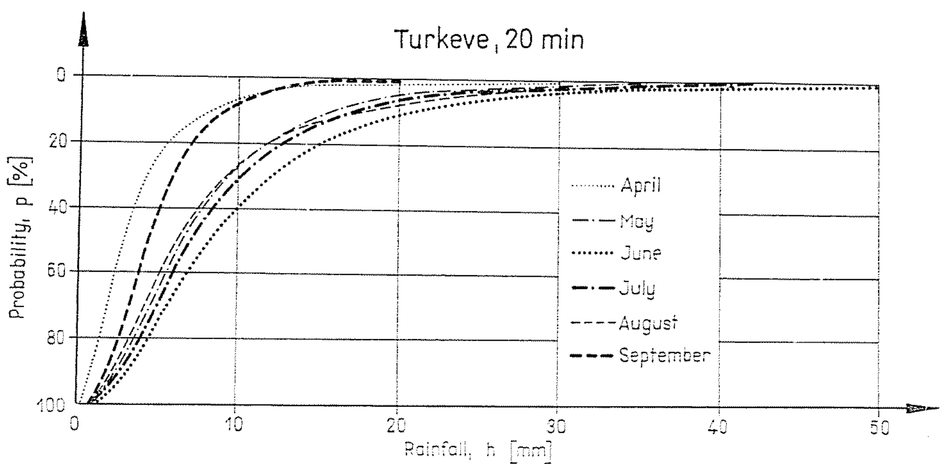

Fig. 2

It has been verified by variance analysis (and pertaining other tests) that lognormal parameters of rainfall of the same duration of the four summer months may be considered as different estimations of the same parameters. Hence, rainfall data of these four months can be contracted to one row of data (their independence being confirmed). Thereby the initial length of the data rows of 20 to 40 years is quadrupled, much contributing to the accuracy of the probability analyses. Our subsequent examinations are primarily related to this "combined month".

4. Points of view of the selection of distribution functions

Our examinations have shown that a good fitting in itself is not sufficient to evaluate a distribution function but the following aspects have to be taken into consideration:

4.1. In the range of *low probabilities* ($p < 5\%$) the various kinds of distribution functions may give rather different values for identically good fittings. Among them that one giving a physically realistic value has to be adopted.

4.2. In the range of *high probabilities* ($p > 90\%$) distribution functions of normal and gamma type may assume negative values even if escaping interpretation. The Lognormal distribution function has the natural lower limit of zero, physically correct in e.g. rainfall examination.

4.3. *Third-order central moment* (M_3) is needed for the estimation of Gamma or Pearson type function parameters. This being a low number of data ($n < 50$), it is not reliable enough. One or two outstanding values may have greater impact on M_3 than have all others, thus, parameters determined from M_3 may be distorted. Conclusion: in case of a low number of data, possibly a distribution function should be selected so that no M_3 is needed to determine its parameters.

4.4. Followability of the variation of parameters with space, time and basic period is of great importance for the selection of the distribution function type. Practical use of distribution functions is only possible (e.g. for design aids) if regularities of parameter variations are simple and easy to determine.

4.5. As criterion of the fitting examination, the 5% significance level is accepted as a rule. All of the distribution functions examined by us more than satisfied this condition, therefore it is considered necessary to restrict this criterion.

5. Rainfall functions

Plotting rainfall quantities for identical probabilities in a log-log coordinate system according to a Lognormal distribution function approximating rainfall rows of different durations of some month at a station, a *straight line* is obtained that can be verified mathematically, with a range of validity of 20 min. to 12 hours. This law is expressed by $h_p = aT^n$. With varying p, the exponent n varies but slightly and at random, i.e. the straight lines of different probabilities are parallel (Fig. 3).

Parameter n of the contracted month varies but slightly nation-wide, averaging at 0.24. Thus, n is a constant depending on geographical and climatical conditions.

The presented regularities are encountered, though, less definitely, in the examination of particular months.

Rainfall and intensity functions $h_p = aT^n$ and $i_p = aT^{n-1}$, resp. are convenient to determine the standard water discharge of any hydraulic object where the catchment time T is less than 1 day, or better, 20 min $< T <$ 12 hrs.

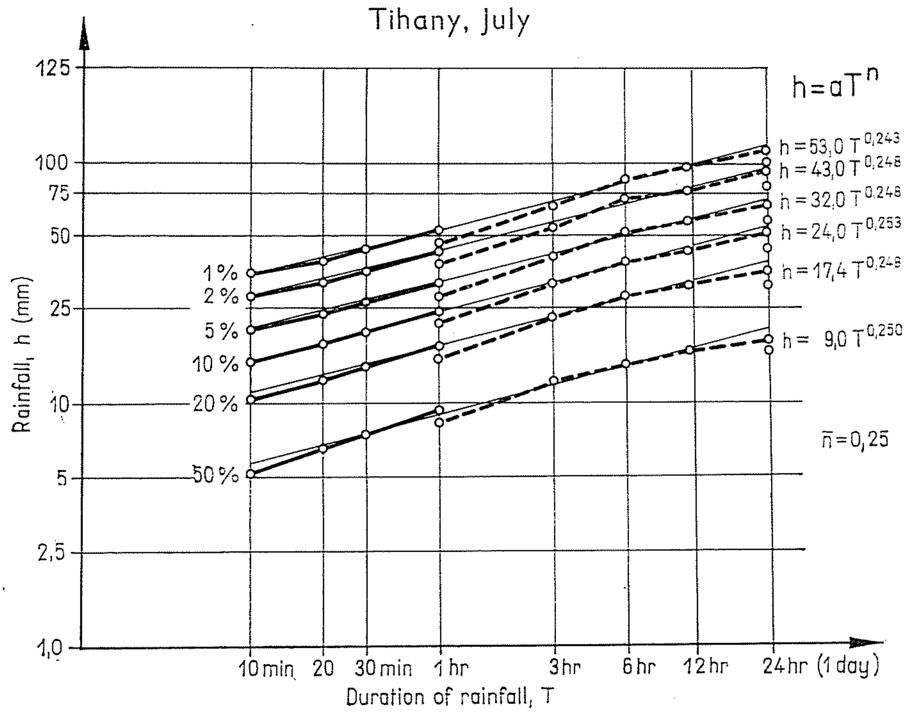

Fig. 3

Summary

Ombrograms from 15 rainfall testing stations in Hungary have been used to determine maximum monthly rainfalls shorter than one day, uniformity and independence of the 600 data rows have been verified by statistical tests (Wald—Wolfowitz, Kolmogorov—Smirnov), using a digital computer.

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