HYDROMETEOROLOGY OF KOYNA CATCHMENT

The Koyna river has its source in the western slopes of the Malcompeth Plateau on the Western Ghats and flows in a southward direction for about 40 miles, turns sharply near Helwak and joins the Krishna river near Karad. The elevation of the catchment varies from about 2000 to 4600 ft above sea level. The river bed falls gradually from an elevation of about 2200 ft at the foot of the Malcompeth (Mahabaleshwar) Plateau to an elevation of about 1900 ft near Helwak. There are fairly high and steep mountains on both sides of the river bed. Beyond the mountains to the west, the country falls almost precipitously to about 500 ft above sea level. The catchment area is very rugged with steep slopes and is shown in Fig. 1. The area of the catchment up to the proposed dam site at Helwak is about 345 sq miles and up to Helwak Gauging site about 2 miles downstream, 360 sq miles.

There are only five rain-gauges in and near the catchment area with records of rainfall of 20 years or more. These are Malcompeth (Mahabaleshwar), Sonat, Bamnoli, Kas and Helwak. The rainfall in the catchment varies from about 100″ to about 260″, and the isohyets over the catchment run generally in a north to south direction. The normal date of onset of the southwest monsoon over the area is the first week of June and the date of withdrawal is first week of October. About 95% of the rainfall at all the five raingauges occurs during the monsoon months June to September when the winds are from a westerly direction.

The main cause of heavy rainfall in the catchment is found to be strong monsoon associated with or without disturbed weather over or from the North Bay of Bengal. No storms or depressions directly affect the catchment causing very heavy rain over the area.

In the monsoon months when there is a steady current of moist winds striking the

hills almost at right-angles throughout the day, rain occurs during all hours and the diurnal variation is not marked. Rainfall of 1 cent or more occurs at all the five places almost daily during July and August and on two-thirds of the days in June to September.

In order to examine how far the rainfall at one station is associated with that at the other stations in the catchment, inter-correlations were worked out for annual, monthly (July and August) and select occasions of heavy rainfall. It was found that the daily rainfall at any of these stations on days of heavy rainfall may not be associated with proportional heavy falls at the other stations, but taken over a longer period of a month or a year the rainfall at any station is, however, generally highly correlated with those at the other stations.
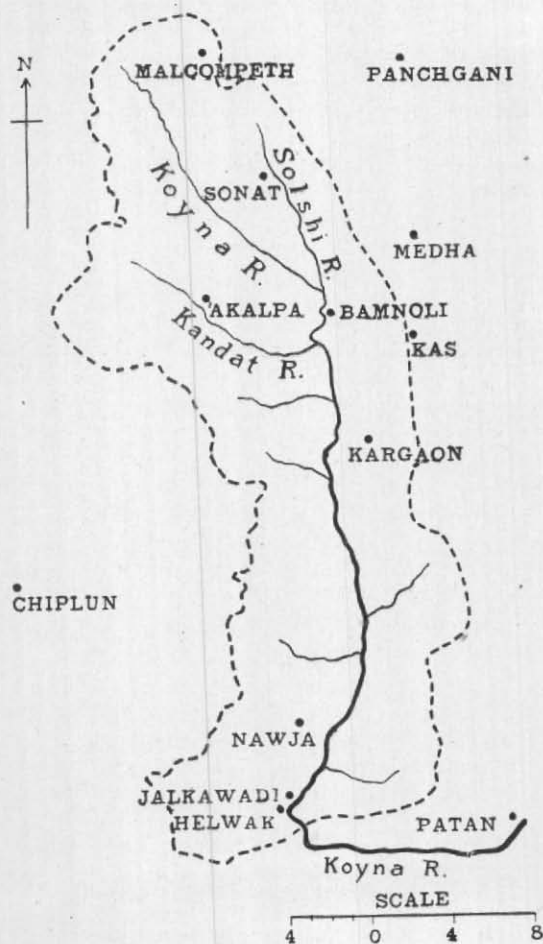

Fig. 1

One of the main problems is to find the frequencies of rainfall of different amounts. Frequency distribution of rainfall at 1″ intervals was worked out for the five rain-gauges. The probability of rainfall of different amounts was obtained by fitting the partly bounded function

$$y = a\, e^{\,-c^2\, (\,\log d\,(x+b)\,)^2}$$

to these frequency data. This analysis indicates that rainfall exceeding 20″ may occur once in about 20 to 30 years at Mahabaleshwar and Helwak, while at Bamnoli and Kas it may occur once in more than 110 years. The probabilities are different for the stations and it is necessary to obtain the mean rainfall of the catchment and work out the probabilities of different amounts.

Practically the whole of the rainfall occurs when the wind is from a westerly direction and almost at right-angles to the length of the catchment with the result that the variation of rainfall in the area follows a pattern which can be visualised and which makes the approximate drawing of isohyets possible. Isohyets for the year, the monsoon months and for nine days of heavy rainfall were drawn and the mean rainfall calculated. The arithmetic mean of the rainfall at the five stations was found generally to agree with the mean obtained from isohyets. The arithmetic average of the rainfall of the five stations may, therefore, be taken as the mean rainfall of the catchment. The average of the 5 stations for the uniform period 1907—26 gives 180·69″. The mean annual rainfall of the catchment may be taken as 181″.

The mean annual rainfall of the catchment is highly correlated (+0.97) with Mahabaleshwar annual rainfall and the linear regression equation connecting the two is

Mean Annual Rainfall of Catchment = 0·7981 (Annual Rainfall of Mahabaleshwar)—17.445.

Annual rainfall of Mahabaleshwar is available from 1861 but the mean rainfall of the catchment is available only for 20 years. Utilising the above regression equation the mean rainfall for the catchment was calculated from Mahabaleshwar data

from 1861. According to this, the highest mean rainfall of the catchment is 304″ in 1896 and the lowest rainfall in the catchment 94″ in 1899.

The mean rainfall for each day during the monsoon months was worked out for the years 1907 to 1926 and one-day, two-day, three-day, four-day and five-day rainfall frequencies prepared. The semi-logarithmic curve mentioned before was fitted to these data and the probabilities of different rainfall intensities are as follows—

(i) One-day period—The highest mean rainfall in a single day was 12.39″. The probability of rainfall exceeding 15″ is once in 23 years, 18″ once in 68 years, 20″ once in 134 years and 25″ once in about 615 years.

(ii) Two-day period—The highest rainfall in any two-day period was 24.63″. The probability of rainfall in two consecutive days exceeding 25″ is once in 12 years, 30″ once in 45 years, 35″ once in 95 years, 40″ once in 239 years and 50″ once in about 1285 years.

(iii) Three-day period—The highest rainfall in any three-day period was 34.55″. The probability of rainfall in three consecutive days exceeding 40″ is once in about 22 years, 42″ once in 30 years, 45″ once in 47 years, 50″ once in 94 years, 55″ once in 183 years, 60″ once in 342 years and 70″ once in about 1120 years.

(iv) Four-day period—The maximum rainfall in any four-day period was 41.11″. The probability of rainfall in four consecutive days exceeding 50″ is once in 19 years, 55″ once in 35 years, 60″ once in 63 years, 65″ once in 110 years, 70″ once in 187 years, 75″ once in 310 years and 80″ once in about 510 years.

(v) Five-day period—The maximum rainfall in any five-day period was 47.43″. The probability of rainfall in five consecutive days exceeding 60″ is once in 20 years, 65″ once in 34 years, 70″ once in 56 years, 75″ once in 91 years, 80″ once in 145 years, 90″ once in about 355 years and 100″ once in about 820 years.

The correlation coefficients between annual Koyna river discharges and rainfall at each of the five raingauge stations in the catchment and with the mean rainfall of the catchment are positive and highly significant.

It would appear from this analysis that the rainfall of Mahabaleshwar could be used to obtain the run-off and related quantities instead of the mean rainfall. The linear regression equations for annual discharges are as follows—

With Mahabaleshwar—

Run-off (inches)
=0.7145 (Mahabaleshwar rainfall)
                    −6.7461

With mean rainfall of catchment—

Run-off (inches)
=0.8439 (Mean rainfall) + 18.2031.

As, however, the mean annual rainfall of the catchment is available for only 20 years, the rainfall data of Mahabaleshwar have been used to obtain run-off for the years 1861 to 1906 and 1927 to 1949 from the above formula. According to this, the maximum run-off during 1861—1949 was 280″ (5.361 million Acre-feet) in 1896 and the lowest was 81″ (1.551 million Acre-feet) in 1899. The mean annual run-off is 170″ or 14280 million cu ft or 3.3 million Acre-feet. The average ratios of Mahabaleshwar rainfall (annual) and mean rainfall of the catchment to the run-off based on data for 1907 to 1926 work out to .69 and .92 respectively.

We have data of self-recording raingauge at Mahabaleshwar for about 20 years. Although we have no hourly records for other stations in the catchment, it is likely that the pattern of diurnal rainfall at other places is similar to that of Mahabaleshwar. From a consideration of the rainfall records of Mahabaleshwar, it is felt that the probable heaviest falls in 1, 3, 6, 9 and 12 hrs given below are unlikely to be exceeded in the catchment.

In	1 hr	..	4″
	3 hrs	..	8″
	6 hrs	..	11″
	9 hrs	..	13″
	12 hrs	..	15″

A fuller account of the investigations will be published separately as a Memoir of the India Meteorological Department.

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