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## HYDROMETEOROLOGY OF THE DAMODAR CATCHMENT

The hydrology of the Damodar Catchment has assumed great importance in view of the large multipurpose projects being undertaken in the basin. Glass[1], Central Technical Power Board[2], Satakopan[3] and Bose and Nag[4] have worked on the subject. Their main conclusions regarding rainfall are briefly given below—

(*a*) Glass[1] considered that the total mean rainfall on the whole catchment producing floods generally varies from about 3″ in 3 days to a maximum of about 12″ in 6 days.

(*b*) The Central Technical Power Board[2] assumed a maximum rainfall of 20″ in the first half of the season and 5″ in the latter half with a run-off coefficient of 90 per cent.

(*c*) Satakopan[3] studied the rainfall of the Damodar Catchment utilising the data from 1891-1943. His main conclusions regarding the maximum probable rainfall are as follows—

(*i*) A storm giving more than 13 inches of mean rainfall over the catchment may occur once in about 65 years and one giving more than 15 inches once in about 120 years.

(*ii*) The worst storm can give in the neighbourhood of the catchment 22 inches rainfall in 7 days, out of which 15 inches may fall in 3 days and 8 inches in one day, but the probability of such a storm occurring over the catchment itself is extremely small and that it may be neglected for all practical purposes. A storm giving 18 inches rainfall in 6 days of which 13 inches may fall in 3 days and 7 inches in a day may be assumed as the maximum that is likely to occur over the catchment.

(*d*) Bose and Nag[4] find that a rain-storm of magnitude equal to or greater than 12″ will occur once in 100 years and greater than 14″ in 250 years. Further a storm giving 16·2″ is likely to be equalled or exceeded only once in 1000 years.

2. The conclusions regarding maximum rainfall reached by Bose and Nag are at variance with those of Satakopan. We had also been feeling that some matters which had not been looked into required examination and some others required more detailed examination than had been done before. A detailed analysis of rainfall, utilising also the data of rainfall (1944-1950) since available, therefore appeared to be necessary.

3. The authors of this paper have recently studied in detail the hydrometeorology of the Koyna Catchment[5]. A detailed study of the Damodar Catchment on similar lines has been made. The question regarding the minimum period for which rainfall data should be available in a monsoon country like India to obtain a fair idea of the frequency distribution and probable maximum rainfall has also been considered.

4. A summary of the main results of analysis is given below—

(*i*) The main surface wind directions in the catchment during June to October are either between E to S or between SW to NW

(*ii*) The difference in the normal rainfall of the catchment of June to September, June to October and annual based on data up to 1940 and up to 1950 is negligible.

(*iii*) The mean rainfall of the catchment is 45·8″ for June to September, 45·1″ for June to October and 51·2″ for the year.

(*iv*) On an average 82 per cent of the annual rainfall occurs during June to September and 88 per cent during June to October. The percentage of annual rainfall which occurs at each of the raingauges during the monsoon period differs from the average of the catchment for this period by less than 3 per cent.

(*v*) Rainfall in July, August and September is equally variable while the fluctuations in June and October are considerably greater.

(*vi*) The distributions of seasonal rainfall and rainy days (June to September and June to October) are normal.

(*vii*) The daily, seasonal and annual rainfall of the catchment during 1891 to 1950 have not been appreciably affected by the variations in the number of raingauge stations.

(*viii*) There has been no significant change in rainfall during 1891-1950.

(*ix*) There is a five to one chance that rainfall of June to September and June to October will lie within ± 20 per cent of the normal. The corresponding limits for June to September are 33·4″ to 50·1″ and for June to October 36·3″ to 54·3″.

(*x*) Frequency distribution of daily rainfall for June to October 1891-1950 and for different sub-periods (10, 15,.....60 years) have been prepared. Similar frequency tables for rainfall of 2 to 7 consecutive days have also been prepared.

(*xi*) Semilogarithmic curves have been fitted to the frequency distributions for 1 to 7 days and probabilities of different rainfall amounts computed.

(*a*) The divergence in probabilities from month to month is very marked.

(*b*) Probabilities obtained by using data for various periods (10, 15, 20, 30, 40, 50 and 60) differ widely.

(*c*) Even in this catchment where rainfall is mainly during the monsoon months, data of at least 50 or 60 years are required for obtaining an idea of probable occurrence of rainfall of different amounts.

(*d*) The probable amounts of rainfall occurring once in about 1000 years based on data for the period 1891 to 1950 are as follows—

| Days | Inches | Days | Inches |
|---|---|---|---|
| 1 | 7·7 | 5 | 17·2 |
| 2 | 12·3 | 6 | 17·2 |
| 3 | 14·6 | 7 | 18·2 |
| 4 | 15·3 | | |

(*e*) A small difference in the rainfall amounts in higher ranges introduces big difference in probability values.

(*xii*) A study has been made of the differences in probability values by using truncated distributions. The main result is that probability values differ considerably depending upon the assumptions made in preparing the frequency tables and the method of obtaining probability. As far as possible complete distributions should be used.

(*xiii*) The highest rainfall that has occurred over the catchment in one to seven days during the years 1891 to 1950 is as follows—

| No of days | Inches | No of days | Inches |
|---|---|---|---|
| (*a*) One day | 4·91 | (*e*) Five days | 11·85 |
| (*b*) Two days | 7·40 | (*f*) Six days | 12·19 |
| (*c*) Three days | 9·21 | (*g*) Seven days | 12·32 |
| (*d*) Four days | 10·68 | | |

(*xiv*) The highest rainfall during a day at any station in the catchment during 1891 to 1950 was 12·8″ at Kodarma on 1 August 1917.

(*xv*) Estimates of probable maximum rainfall have also been obtained by (1) using Gumbell's method for rainfall data of 5, 6 and 7 days separately, (2) by using truncated distributions of the form used by Satakopan and (3) considerations of moisture content and movement of air.

(*xvi*) The distribution of daily rainfall during storm periods of five to seven days has been examined and it is found that—

(*a*) On occasions of five day rainfall exceeding 7·5″ generally more than 75 per cent of the rainfall had occurred in three consecutive days.

(*b*) On occasions of six day rainfall exceeding 9″ generally more than 75 per cent of the rainfall had occurred in three days.

(*c*) On occasions of seven day rainfall exceeding 10″, generally about 75 to 70 per cent of the rainfall had occurred in three days, and about 90 per cent of the rainfall in five days.

(*xvii*) Depth area curves have been drawn for some selected storms in the catchment.

(*xviii*) A study has been made of storms in the neighbourhood of the catchment and the question of transposition of storms has been considered. Even on occasions when the tracks of the storms were over or near the catchment, much heavier rainfall than over the catchment fell in its neighbourhood. This would suggest that while transposing storms in their neighbourhood to the catchment the magnitude of the storms is likely to be affected.

(*xix*) The maximum probable rainfall in one to seven days is as follows—

| Days | Rainfall in inches | Days | Rainfall in inches |
|---|---|---|---|
| 1 | 7·5 | 5 | 17·0 |
| 2 | 12·0 | 6 | 17·5 |
| 3 | 14·0 | 7 | 18·0 |
| 4 | 16·0 | | |

(*xx*) Frequency distribution of average daily discharges at Rhondia based on data from 1934 to 1948 has been prepared for the months June to October. The highest average daily discharge during the period was 521500 cusecs on 10 October 1941 and the peak discharge on this date was 634000 cusecs. The highest peak discharge was 640000 cusecs on 12 August 1935.

(*xxi*) A daily average discharge of 1000000 cusecs is likely to be exceeded once in about 850 years.

(*xxii*) High discharge at Rhondia (exceeding 200000 cusecs) on any date is very highly correlated with the rainfall recorded on the date and the preceding two days. This is also true of peak discharges.

(*xxiii*) The regression formula between rainfall of July to October with the corresponding seasonal flow expressed in inches is :

$$D = 0{\cdot}65\ R - 8{\cdot}68$$

Using this formula discharges have been computed from 1891 to 1950. The highest and lowest discharge during July to October according to this formula are :

Highest 1917=5621200 cusecs
or 11148800 Acre feet.

Lowest 1918=1794460 cusecs
or 3559040 Acre feet.

(*xxiv*) The influence of temperatures on monsoon seasonal run-off is not significant.

(*xxv*) The CCs of discharge on any day at Asansol with discharge of the following day (*i.e.*, with a lag of one day) at Rhondia are very highly significant.

(*xxvi*) The rainfall of the catchment on any day is highly correlated with the discharge at Asansol on the following day.

(*xxvii*) Discharge of the Damodar river at Rhondia on any day is very highly correlated with the following—

(*a*) Rainfall of preceding day (·73)

(*b*) Rainfall of preceding two days (·80)

(*c*) Rainfall of preceding day and discharge of preceding day (·82)

The regression formulae are—

(*a*) $D = 0{\cdot}3979\ D_{-1} + 5{\cdot}7958\ R_{-1} + 0{\cdot}4275$
($D$ in 10,000 cusecs)

(*b*) $D = 4{\cdot}35\ (R_{-1} + R_{-2}) + 0{\cdot}9703$
($D$ in 10,000 cusecs)

(*c*) $D = 71{\cdot}70\ R_{-1} + 14{\cdot}6757$
($D$ in 1000 cusecs)

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

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