TUTORIAL-1

PROCESSING AND ANALYSIS OF RAINFALL DATA

Problem—1

For raingauge stations namely Jhabua, Alirajpur, Dhar and Sardarpur are located in a typical region as shown in Fig. T 1.1. The rainfall observed during a month at Jhabua, Dhar and Alirajpur are 132.1 mm, 103.3 mm and 149.8 mm respectively while the corresponding rainfall value at Sardarpur is missing.

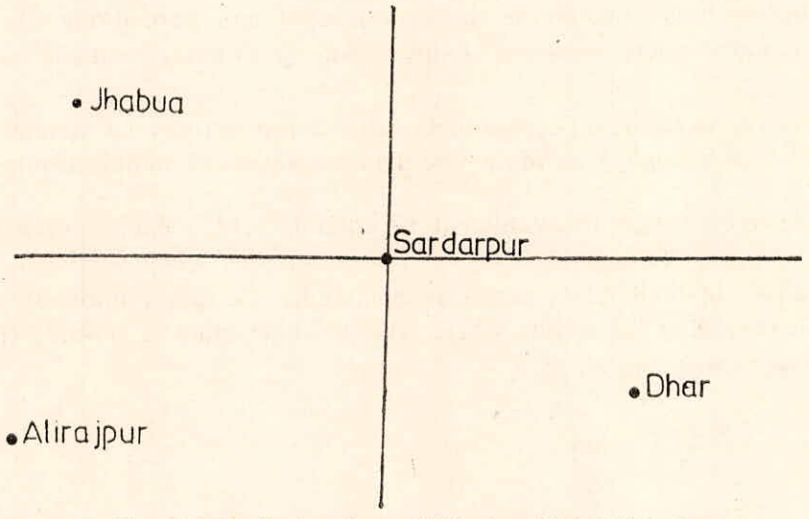

Fig. T 1.1 Estimation of Missing Rainfall Data

(i) If the normal monthly rainfall at Sardarpur, Jhabua, Dhar and Alirajpur are 236.2 mm, 202.2 mm, 232.4 mm and 220.7 mm respectively, estimate the missing rainfall at Sardarpur raingauge station using Normal ratio method.

(ii) If the distances from the Sardarpur raingauge station to Jhabua, Dhar and Alirajpur raingauge stations are 42 km, 39 km and 75 km respectively estimate the missing rainfall at Sardarpur raingauge station using Distance power method.

Solution

(i) Estimation of missing rainfall at Sardarpur Using Normal ratio method :

Missing rainfall at Sardarpur can be estimated by the following relationship :

$$P_A = \frac{\sum_{i=i}^{n} \frac{R_A}{R_i} \times P_i}{n} \qquad \ldots (T\ 1.1)$$

Where

P_A is the estimated rainfall at station A

R_A is the normal monthly or annual rainfall at station A

P_i is the observed rainfall at station i

R_i is the normal monthly or annual rainfall at station i

n is the number of rainfall observing stations excluding the station where rainfall observation is missing.

The stepwise procedure adopted for estimating the missing rainfall at Sardarpur by Normal ratio method is given below.

[Ref. Table T 1.1]

Step=1 : Enter the names of rainfall observing stations in column (1), observed rainfall in column (2) and normal monthly rainfall in column (3).

Step—2 : Calculate the ratio between the observed rainfall and normal monthly rainfall for each of the stations where the rainfall is observed. Enter these values in column (4).

Step—3 : Sum the values of the ratio obtained in step-2 and multiply by normal monthly rainfall of Sardarpur raingauge station where the observation for rainfall is missing.

For the given example this value will be equal to $1.775 \times 236.20 = 419.225$

Step—4 : The value obtained from step-3 is divided by the total number of rainfall observing stations excluding the station where rainfall observation is missing (Here equal to 3). Thus the missing rainfall at.

$$\text{Sardarpur} = \frac{419.255}{3} \text{ mm}$$

$$= 139.752$$

Table T 1.1 Estimation of Missing Rainfall at Sardarpur by Normal Ratio Method

Station	Observed rainfall [mm] [P_i]	Normal monthly rainfall [mm] [R_i]	Ratio of normal rainfall at Sardarpur to surrounding stations
(1)	(2]	(3)	(4)
Jhabua	132.1	202.2	0.653
Dhar	103 3	232 4	0.444
Alirajpur	149.8	220.7	0.678
Total			1.775

(ii) Estimation of missing rainfall at Sardarpur using Distance power method

Missing rainfall at Sardarpur can be estimated by Distance power method using the relationship.

$$P_A = \frac{\sum_{i=1}^{n} \frac{P_i}{D^x_i}}{\sum_{i=1}^{n} \frac{1}{D^x_i}} \qquad \text{(T 1.2)}$$

Where

P_A is the estimated rainfall at station A

P_i is the observed rainfall at station i

D_i is the distance of the rainfall observing station from the estimated station.

x is the power (Generally x=2 is adopted)

The stepwise procedure for estimation of missing rainfall at Sardarpur using Distance power method is given below :

(Ref. T 1.2)

Step—1 : Enter the names of the rainfall observing stations in column (1), observed rainfall in column (2) and the distances from the Sardarpur raingauge station to different rainfall observing stations in column (3).

Step—2 : Compute $\frac{1}{D_i^2}$ for each of the rainfall observing station and enter in column (4).

Step—3 : Compute $\frac{P_i}{D_i^2}$ for each of the rainfall observing stations and enter in column (5).

Step—4 : For estimating the missing rainfall at Sardarpur divide the sum of $\frac{P_i}{D_i^2}$ (obtained in column (5)) by sum of $\frac{1}{D_i^2}$ (obtained in column (4))

Hence the missing rainfall at Sardarpur

$$= \frac{0.1693}{1.4022 \times 10^{-3}}$$

$$= 120.738 \text{ mm}$$

Table T 1.2 Estimation of Missing Rainfall at Sardarpur by Distance Power Method

Station	Observed rainfall (P_i) (mm)	Distance from Sardarpur (D_i) (km)	$\frac{1}{D_i^2}$	$\frac{P_i}{D_i^2}$
(1)	(2)	(3)	(4)	(5)
Jhabua	132.1	42	5.669×10^{-4}	0.0748
Dhar	103.3	39	6.575×10^{-4}	0.0679
Alirajpur	149.8	75	1.779×10^{-1}	0.0266
Total			1.4022×10^{-3}	0.0266

Prodlem 2

The daily rainfall observed in mm at three non-recording stations on 29th and 30th August, 1978 is

Date	Makarai	Handa	Seoni
29.8.78	235.0	96.5	52.3
30.8.78	41.0	66,5	24.1

The hourly recorded rainfall at two SRRG stations on 28th, 29th and 30th August, 1978 is given in Table T 1.3. Distribute the daily rainfall at non-recording stations into hourly rainfall.

Solution

The stepwise procedure for distribution of the daily rainfall at non-recording raingauge stations into hourly rainfall is described below.

Step—1 : Cumulate daily rainfall data at each of the non-recording raingauge stations as given in Table T 1.4 and plot on graph. Join the points to form the mass curve of daily rainfall as shown in Fig. T 1.2.

Step—2 : Cumulate the hourly rainfall data at each of the two SRRG stations as given in Table T 1.5 and plot on graph. Join the points to form the mass curve of hourly rainfall as shown in Fig. T 1.2.

Step—3 : Compare the mass curves of daily rainfall with hourly rainfall to determine which of the SRRG represent which ORG Stations.

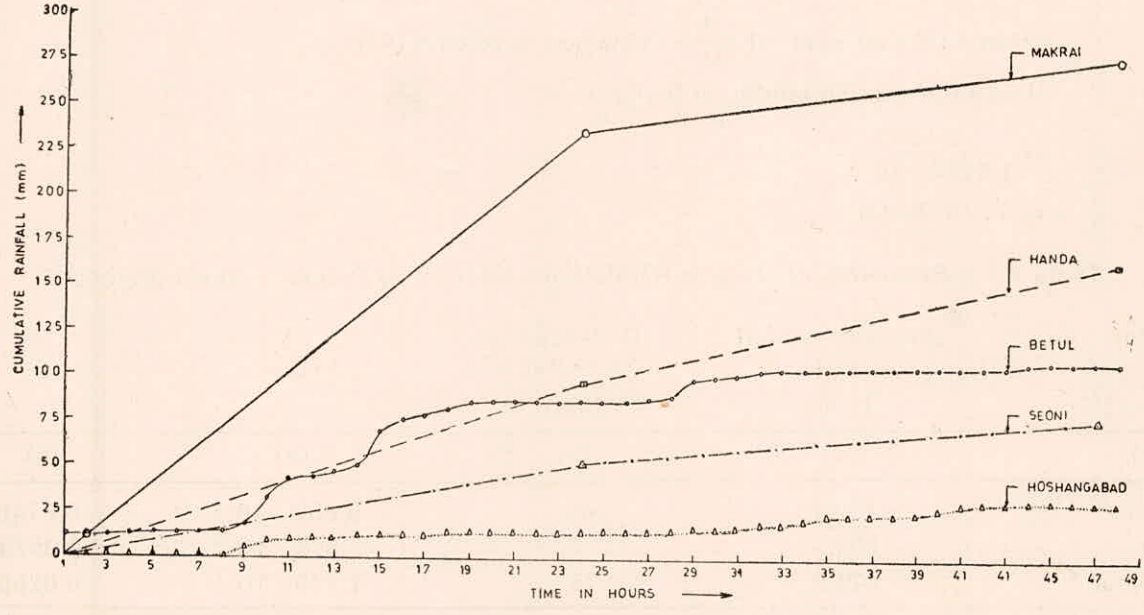

Fig. T 1.2 Mass curve for recording and non recording raingauge station

Step—4 : Compute the distribution coefficients for each recording raingauge station as the ratio of the hourly rainfall to the total rainfall in a day for the respective stations. The distribution coefficients computed for the two recording rainguage stations on 29.8.87 are given in column (2) and (3) of Table T 1.6. However, the same are computed and entered in column (2) and (3) of Table T 1.7 for 30.8.87.

Step—5 : Distribute the daily rainfall of each non-recording raingauge station into hourly rainfall values by multiplying the respective daily rainfall values with the distribution coefficient of the corresponding representative recording raingauge stations as computed in step 4. The distributed hourly values are given in column (4), (5) and (6) of Table T 1.6 and T 1.7 for the above mentioned dates.

Table T 1.3 Rainfall at SRRG Stations

Hour	Observed rainfall at Betul (mm)			Observed rainfall at Hoshangabad (mm)		
	28.8.78	29.8.78	30.8.78	28.8.78	29.8.78	30.8.78
1	0.0	2.3	0.0	0.0	0.0	2.5
2	0.0	0.9	0.0	0.0	1.6	0.5
3	0.0	6.5	0.2	0.0	1.5	0.0
4	0.3	0 5	2.0	0.0	0.0	0.2
5	5.5	0.5	0.3	0.0	0 0	0.0
6	0.6	0.0	0.3	0.5	0.0	0.0
7	0.1	0.0	0.0	0.0	0.0	0.0
8	0.8	0.0	0.0	0.0	0.0	0.0
9	12.5	0.0	0.0	0.0	0.0	0.0
10	0.0	0,0	0.4	0 0	0.0	0.0
11	0.0	0.7	0.0	0.0	0.0	0.0
12	0.0	1.3	0 0	0.0	0 0	0.0
13	0.3	9.5	0.0	0.0	1.7	0.2
14	0.0	1.4	0.0	0.0	0.0	0.6
15	0.1	1.6	0.1	0.0	0 0	0.0
16	0.8	2.1	1 6	0.0	2.6	0.0
17	4.3	0.6	0.1	5.0	0.1	0.0
18	14.0	0.1	4.5	3.5	2.8	0.0
19	12.3	0.2	0.1	2.0	1.5	0 0
20	0 5	0.3	0.1	0.0	0.3	0.0
21	1.8	0.2	12.3	0.0	0.2	0 0
22	5.0	0.6	0 0	0.7	0.2	0.1
23	18.6	0.0	0.0	0.1	0.5	0.8
24	6.3	0.0	0 0	0.0	3.0	1.4

Table T 1.4 Cumulative Daily Rainfall of Non-recording Raingauge Stations for Plotting Mass Curve

Date	Makrai		Handa		Senoi	
	Observed rainfall (mm)	Cumulative observed rainfall	Observed rainfall (mm)	Cumulative observed rainfall (mm)	Observed rainfall (mm)	Cumulative observed rainfall (mm)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
29.8.78	235.0	235.0	96.5	96.5	52.3	52.3
30.8.78	41.0	276.0	66.5	163.0	24.1	76.4

Table T 1.5

Cumulative Rainfall at SRRG Stations for Plotting Mass Curve

Hour	Betul		Hoshangabad	
	observed hourly rainfall (mm)	Cumulative observed hourly rainfall (mm)	Observed hourly rainfall (mm)	Cumulative observed hourly rainfall (mm)
(1)	(2)	(3)	(4)	(5)
9	12.5	12.5	0.0	0.0
10	0.0	12.5	0.0	0.0
11	0.0	12.5	0.0	0.0
12	0.0	12 5	0.0	0.0
13	0.3	12.8	0.0	0.0
14	0.0	12.8	0.0	0.0
15	0.1	12 9	0.0	0.0
16	0.8	13.7	0.0	0.0
17	4.3	18.0	5.0	5.0
18	14.0	32.0	3.5	8.5
19	12.3	44.3	2.0	10.5
20	0.5	44.8	0.0	10.5
21	1.8	46.6	0.0	10.5
22	5.0	51.6	0.7	11.2
23	18.6	70.2	0.1	11.3
24	6.3	76.5	0.0	11.3
1	2.3	78.8	0.0	11.3
2	0.9	79.7	1.6	12.9
3	6.5	86.2	1.5	14.4
4	0.5	86.7	0.0	14.4
5	0.5	87.2	0.0	14.4
6	0 0	87.2	0.0	14.4

[1]	[2]	[3]	[4]	[5]
7	0.0	87.2	0.0	14.4
8	0.0	87.2	0.0	14.4
9	0·0	87.2	0.0	14.4
10	0.0	87.2	0.0	14.4
11	0.7	87.9	0.0	14.4
12	1.3	89.2	0.0	14.4
13	9.5	98.7	1.7	16.1
14	1.4	100.1	0.0	16.1
15	1.6	101.7	0.9	16.1
16	2.1	103.8	2.6	18.7
17	0.6	104.4	0.1	18.8
18	0.1	104.5	2.8	21.6
19	0.2	104.7	1.5	23.1
20	0.3	105.0	0.3	23.4
21	0.2	105.2	0.2	23.6
22	0.6	105.8	0.2	23.8
23	0.0	105·8	0.5	24.3
24	0.0	105.8	3.0	27.3
1	0.0	105.8	2.5	29.8
2	0.0	105.8	0.5	30.3
3	0.2	106.0	0.0	30.3
4	2.0	108.0	0.2	30.5
5	0.3	108.3	0.0	30.5
6	0.3	108.6	0.0	30.5
7	0.0	108.6	0.0	30.5
8	0 0	108.6	0.0	30.5

Table T 1.6

Distributed Rainfall at Non-recording Stations for 29.8.87

Hours	Distribution coefficient for Betul SRRG	Distribution coefficient for Hoshangabad SRRG	Makrai* (mm)	Handa** (mm)	Seoni*** (mm)
(1)	(2)	(3)	(4)	(5)	(6)
9	0.143	0.0	33.61	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0
13	0.003	0.0	0.71	0.00	0.0
14	0.0	0 0	0.0	0.3	0.0
15	0.001	0.0	0.24	0.0	0.0

(1)	(2)	(3)	(4)	(5)	(6)
16	0.009	0.0	2.12	0.0	0.0
17	0.049	0.347	11.52	33.49	18.15
18	0.161	0.243	37.84	23.45	12.70
19	0.141	0.139	33.14	13.41	7.27
20	0 006	0.0	1.41	0.0	0 0
21	0.021	0.0	4.94	0 0	0 0
22	0.057	0.049	13 47	4.73	2 56
23	0.213	0.007	50.06	0.68	0.37
24	0.072	0.0	16.92	0.0	0.0
1	0.026	0.0	6.11	0.0	0.0
2	0.010	0.111	2.35	10.70	5.80
3	0.075	0.104	17.63	10.04	5.40
4	0.006	0.0	1.41	0.0	0.0
5	0.006	0.0	1.41	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0

Table T 1.7

Distributed Rainfall at Non-recording Stations for 30 8.87

Hours	Distribution coefficient for Betul SRRG	Distribution coefficient for Hoshangabad SRRG	Makrai* (mm)	Handa** (mm)	Seoni*** (mm)
(1)	(2)	(3)	(4)	(5)	(6)
9	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0 0	0.0
11	0.033	0.0	1.35	0.0	0 0
12	0.061	0.0	2.50	0.0	0.0
13	0.444	0.106	18.20	7.05	2.55
14	0.065	0.0	2.67	0.0	0.0
15	0.075	0.0	3.08	0 0	0.0
16	0.098	0.161	4.02	10.71	3.88
17	0.028	0.006	1.15	0.39	0.14
18	0.005	0.174	0.21	11.57	4.19
19	0.009	0.093	0.37	6.18	2.24
20	0.014	0.018	0.57	1.19	0.43
21	0.009	0.012	0.37	0.79	0.28
22	0.028	0.012	1.15	0.79	0.28
23	0.0	0.031	0.0	2.06	0.75
24	0.2	0.186	0.0	12 37	4.48
1	0.0	0.155	0.0	10.31	3.74

(1)	(2)	(3)	(4)	(5)	(6)
2	0.0	0.031	0.0	2.06	0.75
3	0.009	0.0	0.37	0.0	0.0
4	0.093	0.012	3.81	0.80	0.29
5	0.014	0.9	0.57	0.0	0.0
6	0.014	0.0	0.57	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0

* Daily rainfall at Makrai station is distributed in hourly rainfall in ratio of the rainfall at Betul SRRG station.

** Daily rainfall at Handa station is distributed in the hourly rainfall in the ratio of the rainfall at Hoshangabad station.

*** Daily rainfall at Seoni station is distributed in hourly rainfall in the ratio of the rainfall at Hoshangabad SRRG station.