ASSESSMENT OF MEAN DEPTH OF PRECIPITATION FOR A CATCHMENT

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Introduction

One of the basic requirements in the hydrological study of say a catchment area or a region, is accurate estimation of the average precipitation over that area in different time periods on which depend the correct assessment of water potential. There are several methods of estimating mean rainfall over such an area. The methods commonly used are : Isohyetal method, Theissen Polygon Method and Simple arithmetic average method. The present study is to illustrate the advantage of introducing suitable stratification of the basin and obtaining weighted mean rainfall over the other methods, when the rainfall distribution over spaces follows a pattern as in the case of Bhatghar catchment.

2. Method of Estimating Mean Depth Through Stratification Technique

The description of the current methods, *viz.*, Isohyetal method, Theissen Polygon method and the Simple average method is available in standard text books on hydrology. Isohyetal method requires considerable experience and judgement as the Isohyets are likely to change from day to day. Theissen Polygon method, although superior to other methods, does not provide any measure of precision of the mean depth. The simple average method assumes uniform distribution of rainfall over the catchment.

However, when there is a trend in the rainfall from one end of the catchment to the other, the stratification technique suggested here appears to be most appropriate for arriving at an efficient estimate of the mean depth and also its precision. This method consists in dividing the catchment into different strata, each stratum consisting of homogeneous rainfall records. The stratification of the catchment should be perpendicular to the trend. The areas of strata are measured and simple arithmetic mean of rainfall values of the raingauges in each stratum is calculated and the mean for the entire catchments obtained by weighting the strata means with the respective proportions of the total area of the catchment. Means and standard errors of the mean are calculated using the standard formulae.

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3. Illustrative Example

Catchment Bhatghar is typical East-West catchment and records annual rainfall ranging from about 1016 mm to 6350 mm with the average of about 3835 mm. Rainfall in the catchment is mostly seasonal and confined to four monsoon months (June to September). Daily rainfall depths thus gauged at 8 different raingauges (arranged according to their distances from dam site) namely at (1) Bhatghar (2) Bamanghar (3) Rajgarh (4) Ranjane (5) Pangari (6) Sangwi (7) Kelad and (8) Bhordi situated in catchment area, were available successively for three years from 1965 to 1967.

Examination of daily and monthly rainfall figures of the eight raingauges of this catchment revealed that there was a gradual decreasing trend in rainfall in a West-East direction.

With the help of the rainfall data, it was decided to stratify the limited eight gauges numbered from (1) to (8) in Fig. 1 into longitudinal zones. Considering each individual station's contribution and their overall variations, gauges were stratified as shown in Fig. 1.

With this stratification the catchment average depths and their standard errors for 59 specific days on which the rainfall exceeded 50 mm of the three years were calculated by the standard formulae. Similarly simple averages and their standard errors and averages by Theissen method were also calculated for these 59 days and these statistics are presented in Table 1. Isohyetal method was, however, not found suitable for the calculation of mean rainfall in the catchment because of peculiar situation of locations of the limited number of raingauges.

It can be seen from Table 1 that means yielded by simple average method differ from the corresponding means obtained by other two methods namely Theissen and Stratification method and they are systematically of lower magnitude. The greatest difference observed was of magnitude of 23.9 mm, 19.1 mm and 30.8 mm for the years 1965, 66 and 67 respectively and on their respective dates 21st July, 28th July and 28th July. Means obtained by Theissen and stratification methods, however, did not show much differences among themselves for all the three years and the differences between them did not appear to be systematic in any way. The systematic lower means for simple average compared to those of Theissen and Stratified methods is due to equal weightage to all raingauges for calculating simple averages. The closeness between the mean values estimated by Theissen and Stratification methods amply justify that the means should be obtained after giving proper weightages to raingauges. This also demonstrates that simple average for such a catchment is likely to underestimate the mean depths. It is also worth noting the order of error one is likely to commit by using the simple average method and the extent of its reduction affected by stratification. The efficiency of stratification is seen to be quite high.

4. Conclusions

Analysis undertaken of the daily rainfall depths of some specific days having average rainfall > 50 mm in respect of the Bhatghar catchment for the period 1965 to 67 revealed that the magnitude and pattern of variation of rainfall over the catchment area requires careful study if an accurate estimation of water potential is required. Stratification technique is to be employed wherever required as in the case illustrated and would prove useful than the other two methods in providing precise estimates, particularly where the distribution of raingauges is not uniform.

5. Summary

Assessment of mean rainfall depth over a catchment when there is great deal of variation of rainfall within the catchment has been done by usual simple average and Theissen methods. Stratification technique has been suggested and its performance has been evaluated based on standard errors with special reference to the rainfall data for Bhatghar catchment which has general increasing trend in rainfall in E-W direction. The stratification technique, even with the limited data, proved to be yielding estimates of mean depths with considerable gain in efficiency in this case.

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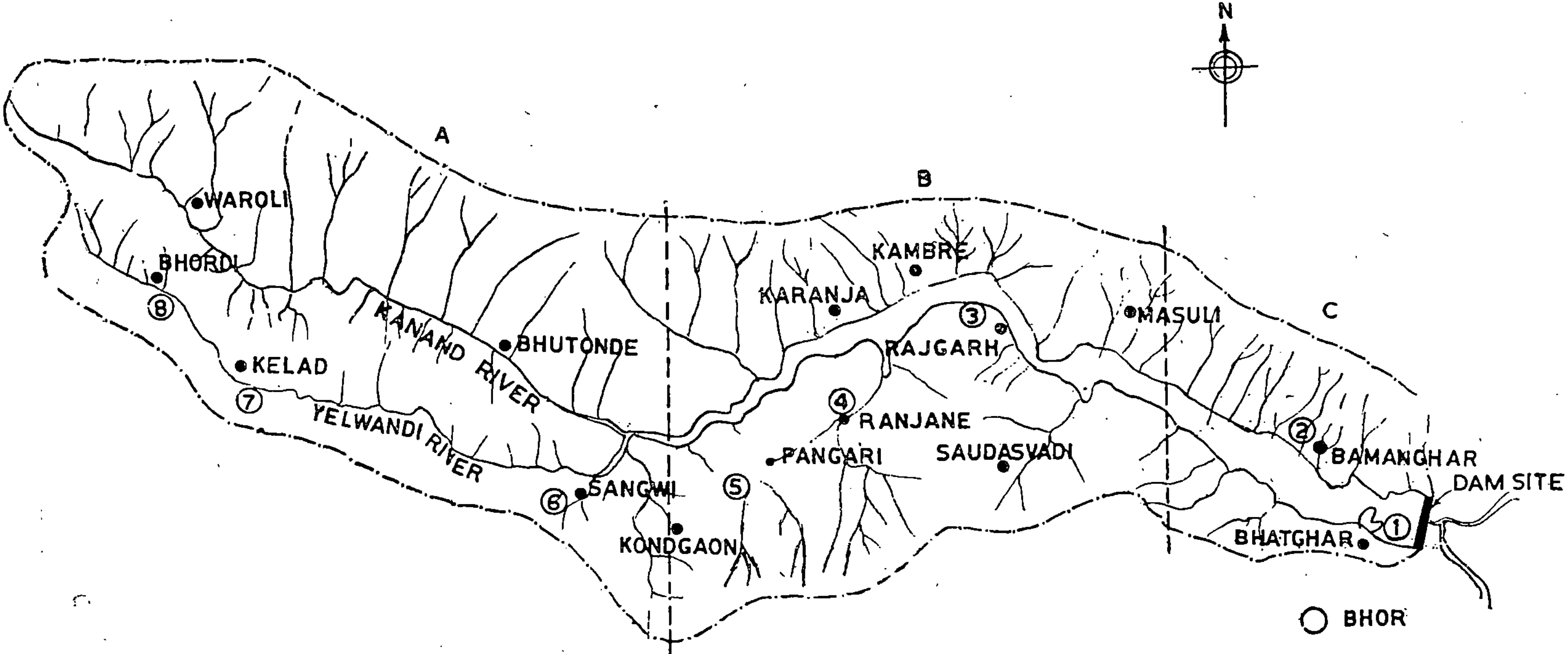
TABLE 1

Mean rainfall (mm) and standard error of the mean (m m)
Comparison of Efficiency of Methods

Period	*Mean rainfall by the methods*			*Standard error of mean (mm)*			
	Simple Average	*Stratification*	*Theissen*	*Simple Average*		*Stratification*	
				SE	*% SE*	*SE*	*% SE*
11.7.65	110 9	128.1	129 3	28.00	25.25	19.95	15.58
13	96.9	110 6	110 0	23.73	24.57	13.82	12.49
14	92.7	109.5	111.2	30.05	32 42	13.40	12.24
15	133 6	155.9	155 2	38.48	28 82	19.38	12 43
16	81.7	93.4	91.2	18.14	22.20	11 80	12.63
17	122.1	137 0	137.9	22.47	18.40	9.90	7.23
18	119.3	131.9	134.4	19.60	16.43	11.03	8.35
19	105.6	118.9	118 7	20.73	19.64	8.61	7.24
20	139.7	158.8	160.5	30.33	21.71	12.19	7.68
21	139.0	161.2	162.9	32 27	23.21	8.86	5.50
22	102.9	117.3	119.7	22.59	21.95	15.66	13.35
23	62.2	71.9	74.0	21.08	33.88	22.89	31.85
24	63.6	71.8	71.6	16.17	25.41	15.74	21.91
25	69.7	78.4	80.4	14.24	20.44	10.15	12.95
26	77.9	87.0	88.2	18.75	24.08	18.36	21.21
27	136.9	158·1	159.2	31.08	22.71	14.75	8.95
28	153.8	172.6	175.3	27.93	18.17	13.90	8.05
29	130.8	148.3	149.6	24.54	18.77	4.59	3.09
30	95.4	108.8	109.7	21.83	22.88	15.37	14.13
31.7	123.8	140.8	141.6	25.85	20.87	10.59	7.52
1.8	78.8	90.7	91.2	18.25	23.16	11.15	1.23
3	62.4	69.3	71.3	13.69	21.95	13.38	19.31
25.8	61.9	73.4	72.7	17.42	28.15	6.13	8.34
14.7.66	56.7	64.4	63.7	11.90	21.01	4.28	6.64
15	119.9	131.7	130.2	18.88	15.74	11.34	8.61
16	81.7	93.8	95.3	19.52	23.91	6 28	6.70
19	123.2	140.1	140.1	26 48	21.50	11.38	8.12
21	63.9	73.0	73.6	14.04	21.98	8.52	11 67
25	73.0	85 3	84.1	18.94	25.95	6.07	7.12
26	138.6	149.1	152.5	21.21	15 30	17.32	11.61
27	130.7	149.5	148.5	27.40	20.97	6.24	4.17
28	197.3	216 4	213.0	38.13	19.32	29.28	13.53
29	115.4	130.8	131.9	22.29	19.31	9.43	7.21
30	84.9	90.0	91.6	13.48	15.88	11 86	13.17
31.7	96.8	108.4	108 5	19.79	20 44	10.56	9.74
1.8	75 5	85.1	85 8	15.10	20 01	9.64	11.32
2	63 5	71 9	72.5	11.91	18.75	2.64	3.67
3	55 2	57.1	59.9	10.30	18.64	7.45	13.04
6.8.66	74.6	87.0	85.7	18.60	29.95	5.78	6.65
29 6.67	60.1	66 7	64.0	16.55	27.53	18.08	27.10
2 7	80.9	93.1	95.5	21.34	26.62	14.93	16.04
4	62 3	73.1	75 2	19.13	30 72	9.97	13.64
20	62.7	73.8	73.9	17 87	28 51	6 99	9.57
21	80.9	89 7	88.2	13.77	17.02	8.00	8.92
23	95 0	108 4	106 6	21 16	22.27	4 60	4.23
24	132 9	150.3	149.5	28 38	21 35	12 58	8 37
25.7	107.0	118 4	122 5	16 89	15 79	7.98	6 74
26	224 0	235.6	229.4	27.54	12.29	26 86	11.40
28	258.2	286.3	289 0	41.88	16 22	12.61	4.40
29	205.1	224 0	226 8	27.23	13.28	8.69	3 88
30	106.6	111 6	115 0	14.72	13.81	14.03	12.58
31.7	76.7	82 4	86.7	12 52	16.32	11.71	14.20
1 8	110 0	126.2	126 8	23.95	21 78	11.38	9.02
2	120.1	134·9	133.5	21.59	17.97	7.70	5.71
3	130 4	141.3	141 3	19.72	15.12	16.90	11.96
4	77.8	87.6	88.6	16 19	20.82	9.95	11·36
5.8	69.0	76.1	78.9	13.54	19.63	12.57	16.51
6	64 0	71 8	73.6	14.13	22.10	12.51	17.42
20	81.9	92.8	93.1	18.08	22 08	12.80	13.80
23 8.67	86.0	98 1	99.3	18.72	21.77	11.40	11.62



REFERENCE:—

— · — · · · CATCHMENT BOUNDARY

— — — STRATA LIMITS

• ① RAINGAUGE NOs