

COMPARISON OF MEAN AND WEIGHTED ANNUAL RAINFALL IN ANANTAPURAM DISTRICT

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Abstract : For hydrological analysis, it is necessary to adopt a suitable method to compute the applicable rainfall by considering all the rain gauge stations of the catchment area. For computation of applicable rainfall, important methods being followed are Arithmetic mean method and Thiessen polygon method. This paper aims at comparison of applicable rainfall obtained by Arithmetic mean method and Thiessen polygon method. Anantapuram district has been selected for the present study and rainfall data for a period of 10 years has been used. It has been concluded that the values of annual rainfall obtained by Arithmetic mean method and Thiessen polygon method are not showing much variation for all the considered years.

Key words : Thiessen polygon, Annual rainfall, Rain gauge stations, Station rainfall

I. INTRODUCTION

In general, precipitation refers to all forms of water that reaches the earth from the atmosphere which are rain, snow, drizzle, hail etc. The only form of precipitation in Anantapuram district is rainfall. In order to carry out the hydrological analysis, rainfall occurred over a catchment area is necessary. But, the rain gauge stations represent only point rainfall known as station rainfall. So it is necessary to convert the values of station rainfall at various stations into a single applicable value for a catchment area. In the present study, Arithmetic mean method and Thiessen polygon method as suggested by Linsely.et.al., are considered to compute the annual rainfall. These two methods are discussed in 'A' and 'B'.

A. Arithmetic Mean Method

In this method the rainfall values at different rain gauge stations are added and divided by the total number of rain gauge stations to get the mean value of rainfall.

Mean rainfall can be obtained using equation (Eq. 1).

$$p_m = \{(p_1 + p_2 + p_3 + \dots + p_n)/n\} \dots \text{(Eq. 1)}$$

Where

p_m is the value of mean rainfall over the catchment area.

$p_1, p_2, p_3, \dots, p_n$ are the rainfall values at respective stations in a given period at 'n' number of stations within a catchment area.

This method gives good results only when rain gauges in the catchment area are uniformly distributed and the individual station rainfall values do not vary widely. However, this method does not take into account the stations outside but near the boundaries of catchment area.

B. Thiessen Poygon Method

Thiessen polygon method is one of the interpolation methods with which an accurate estimation of applicable rainfall is possible. This method assigns weight to each gauge station in proportion to the catchment area and the area surrounding the gauge station. The weighted rainfall can be obtained using equation (Eq. 2).

$$P_w = \{(p_1 \times a_1) + (p_2 \times a_2) + (p_3 \times a_3) + \dots + (p_n \times a_n)\} \text{ - (Eq. 2)}$$

Where

P_w is weighted rainfall

a_1, a_2, \dots, a_n are the percentage areas influenced by rain gauge stations in the total catchment obtained from Thiessen polygons.

p_1, p_2, \dots, p_n are the rainfall values of respective rain gauge stations.

Since this method provides a weighting factor for each gauge, gives good results even for nonuniform distribution of rain gauges and also when there is a variation in individual station rainfall values. The results obtained by the Thiessen polygon method are usually more accurate than those obtained by other methods.

According to Diskin the Thiessen method is less dependent upon the skill of the analyst and can be easily performed. Fritz R. Fiedler derived weights using Thiessen Polygons and available isohyetal information.

II. STUDY AREA

Anantapuram district is lying between $76^{\circ}45'$ East longitude and $78^{\circ}30'$ East longitude, between $13^{\circ}40'$ North latitude and $15^{\circ}15'$ North latitude. The geographical area of the district is 19134.772 sq. km. The total number of rain gauge stations existing in the district, are 63. The rainfall data for a period of 10 years from 2003-04 to 2012-13 for all the raingauge stations within the district is collected from the Chief Planning Office, Anantapuram. The rainfall data for the year, X-(X+1) refers to June of 'X' year to May of '(X+1)' year.

III. ANALYSIS

The annual rainfall for all the 63 raingauge stations has been computed using Arithmetic mean method and Thiessen polygon method. To apply the Thiessen polygon method, necessary percentage areas influenced by raingauge stations are as given by Bhavani. R. The details are given in Table I and Table II.

In tables I and II, following notations are used.

P – Percentage Influencing Area

RF – Rainfall in mm

WRF – Weighted Rainfall in mm

Table I. Details of Annual Rainfall in Anantapuram District from 2003-04 to 2007-08

S. No.	Name of Rain gauge station	P	Year, 2003-04		Year, 2004-05		Year, 2005-06		Year, 2006-07		Year, 2007-08	
			RF	WRF	RF	WRF	RF	WRF	RF	WRF	RF	WRF
1	Anantapur	0.657	455.8	3.0	454.8	3.0	698.6	4.6	342.6	2.3	960.2	6.3
2	Raptadu	1.306	562.6	8.5	425.2	6.4	755.6	11.4	315.2	4.7	1161.0	17.5
3	Garladinne	1.410	479.8	6.8	398.4	5.6	694.8	9.8	421.0	5.9	799.6	11.3
4	Atmakur	2.841	472.0	13.4	441.0	12.5	730.2	20.7	316.2	9.0	713.4	20.3
5	Kudair	2.279	291.2	6.6	471.2	10.7	599.6	13.7	384.2	8.8	750.0	17.1
6	Singanamala	1.360	362.2	4.9	351.0	4.8	475.4	6.5	413.8	5.6	924.0	12.6
7	B.K.Samudram	0.793	498.2	4.0	409.0	3.2	742.6	5.9	328.4	2.6	831.8	6.6
8	Narpala	1.709	610.0	10.4	505.4	8.6	642.0	11.0	490.6	8.4	1125.8	19.2
9	Tadipatri	1.671	759.0	12.7	371.8	6.2	591.6	9.9	415.4	6.9	971.0	16.2
10	Yadiki	2.007	666.6	13.4	488.2	9.8	631.8	12.7	496.2	10.0	975.8	19.6
11	Peddapappur	1.557	534.0	8.3	337.4	5.3	390.6	6.1	249.6	3.9	601.2	9.4
12	Puttur	1.511	621.8	9.4	432.6	6.5	711.8	10.8	470.0	7.1	982.0	14.8
13	Yellanur	1.535	492.4	7.6	395.8	6.1	605.4	9.3	430.2	6.6	961.8	14.8
14	Guntakal	1.381	674.8	9.3	502.6	6.9	1055.8	14.6	459.2	6.3	827.2	11.4
15	Gooty	2.015	469.0	9.5	499.6	10.1	918.3	18.5	416.2	8.4	1140.4	23.0
16	Pamidi	1.652	319.6	5.3	420.6	6.9	764.8	12.6	308.4	5.1	876.2	14.5
17	Peddavadugur	1.343	503.4	6.8	557.2	7.5	660.2	8.9	380.4	5.1	849.6	11.4
18	Uravakonda	2.299	509.5	11.7	351.6	8.1	960.6	22.1	529.4	12.2	935.8	21.5
19	Vajrakarur	2.178	362.5	7.9	234.6	5.1	921.2	20.1	337.8	7.4	723.4	15.8
20	Vidapanakal	1.624	475.8	7.7	335.8	5.5	845.8	13.7	424.0	6.9	725.0	11.8
21	Dharmavaram	1.961	746.4	14.6	443.8	8.7	764.8	15.0	565.6	11.1	787.2	15.4
22	Tadimari	2.062	413.2	8.5	334.4	6.9	579.8	12.0	355.4	7.3	746.0	15.4
23	Bathalapalli	1.404	308.6	4.3	281.4	4.0	696.4	9.8	449.4	6.3	634.0	8.9
24	C.K. Palli	1.650	241.6	4.0	225.6	3.7	424.0	7.0	189.1	3.1	430.6	7.1
25	Kanaganipalli	2.477	366.0	9.1	381.6	9.5	639.6	15.8	276.0	6.8	673.8	16.7
26	Ramagiri	1.547	506.2	7.8	512.0	7.9	625.6	9.7	463.0	7.2	937.0	14.5
27	Kalyandurg	2.346	514.8	12.1	494.8	11.6	980.4	23.0	671.0	15.7	955.8	22.4
28	Behuguppa	2.197	353.0	7.8	267.4	5.9	702.3	15.4	281.5	6.2	715.2	15.7
29	Kambadur	2.387	285.8	6.8	204.0	4.9	493.2	11.8	383.2	9.1	427.6	10.2
30	Kundurpi	1.597	404.5	6.5	267.4	4.3	564.2	9.0	405.8	6.5	717.0	11.5
31	Brahmasamudram	1.257	359.8	4.5	422.4	5.3	751.6	9.4	218.8	2.8	725.0	9.1
32	Settur	1.385	347.0	4.8	540.3	7.5	773.4	10.7	372.8	5.2	725.6	10.0
33	Rayadurg	1.951	370.7	7.2	450.0	8.8	973.2	19.0	403.6	7.9	903.2	17.6
34	D.Hirehal	0.994	276.0	2.7	429.2	4.3	560.0	5.6	360.8	3.6	715.2	7.1
35	Gummaghatta	0.892	504.8	4.5	357.8	3.2	638.0	5.7	286.6	2.6	577.6	5.2

(Table I continued)

S. No.	Name of Rain gauge station	P	Year, 2003-04		Year, 2004-05		Year, 2005-06		Year, 2006-07		Year, 2007-08	
			RF	WRF	RF	WRF	RF	WRF	RF	WRF	RF	WRF
36	Kanekal	2.365	419.4	9.9	443.1	10.5	909.3	21.5	519.3	12.3	730.2	17.3
37	Bommanahal	1.593	244.8	3.9	466.6	7.4	720.2	11.5	457.0	7.3	769.6	12.3
38	Penukonda	1.500	686.2	10.3	447.2	6.7	873.6	13.1	592.8	8.9	1210.4	18.2
39	Somandepalli	1.379	650.4	9.0	374.8	5.2	867.6	12.0	543.6	7.5	977.4	13.5
40	Roddam	1.573	555.6	8.7	325.0	5.1	613.2	9.6	346.6	5.5	722.8	11.4
41	Puttaparthi	0.908	656.2	6.0	475.2	4.3	881.0	8.0	347.6	3.2	733.6	6.7
42	Kothacheruvu	1.004	673.2	6.8	478.8	4.8	938.6	9.4	427.0	4.3	826.0	8.3
43	Bukkapatnam	1.148	548.0	6.3	446.0	5.1	867.0	10.0	510.4	5.9	1001.4	11.5
44	Madakasira	1.614	399.8	6.5	412.0	6.6	657.6	10.6	507.8	8.2	702.4	11.3
45	Amarapuram	0.901	495.4	4.5	401.4	3.6	849.0	7.6	293.6	2.6	662.0	6.0
46	Gudibanda	1.404	423.6	5.9	319.4	4.5	753.4	10.6	343.6	4.8	612.4	8.6
47	Rolla	0.955	579.4	5.5	491.0	4.7	873.8	8.3	361.4	3.5	626.8	6.0
48	Agali	0.580	406.6	2.4	502.8	2.9	929.8	5.4	242.0	1.4	737.0	4.3
49	Hindupur	1.037	616.0	6.4	690.8	7.2	956.0	9.9	450.4	4.7	807.0	8.4
50	Pangi	1.169	531.8	6.2	573.4	6.7	804.6	9.4	345.4	4.0	885.6	10.4
51	Lepakshi	0.981	649.8	6.4	605.2	5.9	971.2	9.5	357.4	3.5	899.2	8.8
52	Chilamathur	1.196	670.0	8.0	513.8	6.1	964.2	11.5	455.2	5.4	829.0	9.9
53	Gorantla	1.844	631.0	11.6	513.0	9.5	943.6	17.4	557.4	10.3	911.0	16.8
54	Kadiri	1.564	751.6	11.8	585.6	9.2	997.4	15.6	573.0	9.0	1333.4	20.9
55	Mudigubba	3.278	662.2	21.7	576.0	18.9	1113.8	36.5	449.6	14.7	959.2	31.4
56	Nallamada	1.847	629.8	11.6	477.8	8.8	944.4	17.4	450.4	8.3	1076.2	19.9
57	N.P. Kunta	1.587	677.2	10.7	315.4	5.0	982.2	15.6	397.6	6.3	729.0	11.6
58	Talupula	2.286	648.8	14.8	600.6	13.7	834.2	19.1	456.0	10.4	755.4	17.3
59	Nallacheruvu	1.056	798.8	8.4	527.4	5.6	997.0	10.5	360.0	3.8	951.4	10.0
60	O.D.Chervu	1.664	599.0	10.0	385.2	6.4	844.8	14.1	384.2	6.4	751.8	12.5
61	Tanaka	1.857	805.0	14.9	468.6	8.7	845.2	15.7	437.4	8.1	920.2	17.1
62	Amadagur	0.938	665.0	6.2	422.6	4.0	1133.6	10.6	362.2	3.4	740.6	6.9
63	Gandlapenta	1.337	779.0	10.4	479.6	6.4	1212.2	16.2	555.4	7.4	846.0	11.3
Weighted rainfall :				517.2		428.8		788.4		415.7		830.5
Mean rainfall :			523.4		433.6		791.1		407.9		828.8	

Table II. Details of Annual Rainfall in Anantapuram District from 2008-09 to 2012-13

S. No.	Name of Rain gauge station	P	Year, 2008-09		Year, 2009-10		Year, 2010-11		Year, 2011-12		Year, 2012-13	
			RF	WRF	RF	WRF	RF	WRF	RF	WRF	RF	WRF
1	Anantapur	0.657	674.6	4.4	618.2	4.1	747.2	4.9	520.4	3.4	578.6	3.8
2	Raptadu	1.506	708.8	10.7	511.4	7.7	818.6	12.3	558.4	8.4	351.4	5.3
3	Garladinne	1.410	676.0	9.5	579.4	8.2	595.4	8.4	479.4	6.8	376.8	5.3
4	Atmakur	2.841	605.8	17.2	560.4	15.9	575.6	16.4	344.6	9.8	347.8	9.9
5	Kudair	2.279	676.4	15.4	436.8	10.0	588.0	13.4	399.0	9.1	361.8	8.2
6	Singanamala	1.360	404.4	5.5	372.6	5.1	663.0	9.0	283.6	3.9	359.6	4.9
7	B.K.Samudram	0.793	655.8	5.2	517.2	4.1	730.6	5.8	446.4	3.5	434.4	3.4
8	Narpala	1.709	443.6	7.6	436.2	7.5	725.4	12.4	505.8	8.6	483.8	8.3
9	Tadipatri	1.671	373.6	6.2	481.4	8.0	730.2	12.2	385.4	6.4	664.6	11.1
10	Yadiki	2.007	435.8	8.7	509.0	10.2	823.2	16.5	449.6	9.0	423.4	8.5
11	Peddapappur	1.557	474.6	7.4	384.0	6.0	691.6	10.8	414.2	6.4	315.2	4.9
12	Putlur	1.511	394.8	6.0	471.4	7.1	712.2	10.8	576.8	8.7	555.4	8.4
13	Yellanur	1.535	325.8	5.0	369.4	5.7	494.0	7.6	724.8	11.1	402.4	6.2
14	Guntakal	1.381	777.2	10.7	762.0	10.5	725.8	10.0	555.6	7.7	799.8	11.0
15	Gooty	2.015	731.0	14.7	501.2	10.1	741.6	14.9	407.4	8.2	551.8	11.1
16	Pamidi	1.652	686.4	11.3	533.6	8.8	515.2	8.5	438.0	7.2	437.8	7.2
17	Peddavayadugur	1.343	534.2	7.2	443.8	6.0	500.2	6.7	390.2	5.2	398.4	5.4
18	Uravakonda	2.299	860.4	19.8	956.0	22.0	473.6	10.9	424.0	9.7	433.2	10.0
19	Vajrakarur	2.178	717.6	15.6	704.0	15.3	556.8	12.1	368.0	8.0	485.4	10.6
20	Vidapanakal	1.624	891.8	14.5	899.0	14.6	747.6	12.1	679.4	11.0	327.0	5.3

(Table II continued)

S. No.	Name of Rain gauge station	P	Year, 2008-09		Year, 2009-10		Year, 2010-11		Year, 2011-12		Year, 2012-13	
			RF	WRF	RF	WRF	RF	WRF	RF	WRF	RF	WRF
26	Ramagiri	1.547	864.0	13.4	561.2	8.7	522.0	8.1	462.0	7.1	543.8	8.4
27	Kalyandurg	2.346	696.4	16.3	885.4	20.8	928.8	21.8	450.4	10.6	347.4	8.2
28	Beluguppa	2.197	647.0	14.2	1044.2	22.9	724.8	15.9	353.4	7.8	488.0	10.7
29	Kambadur	2.387	684.8	16.3	422.8	10.1	589.6	14.1	327.8	7.8	329.2	7.9
30	Kundurpi	1.597	675.8	10.8	476.8	7.6	674.0	10.8	360.6	5.8	455.6	7.3
31	Brahmasamudra	1.257	610.4	7.7	627.4	7.9	520.8	6.5	257.6	3.2	254.0	3.2
32	Settur	1.385	839.6	11.6	655.3	9.1	853.2	11.8	400.4	5.5	373.0	5.2
33	Rayadurg	1.951	740.4	14.4	925.0	18.0	683.6	13.3	520.2	10.1	341.8	6.7
34	D.Hirehal	0.994	717.0	7.1	1042.6	10.4	612.0	6.1	603.4	6.0	472.4	4.7
35	Gummaghatta	0.892	685.2	6.1	595.6	5.3	640.0	5.7	384.2	3.4	210.2	1.9
36	Kanekal	2.365	966.4	22.9	841.0	19.9	687.8	16.3	446.8	10.6	409.6	9.7
37	Bommanahal	1.593	737.4	11.7	1052.2	16.8	551.8	8.8	326.4	5.2	341.8	5.4
38	Penukonda	1.500	1053.8	15.8	978.0	14.7	951.0	14.3	678.6	10.2	567.2	8.5
39	Somandepalli	1.379	1004.6	13.9	647.2	8.9	923.4	12.7	565.4	7.8	490.6	6.8
40	Roddam	1.573	814.4	12.8	663.8	10.4	616.8	9.7	420.2	6.6	450.2	7.1
41	Puttaparthi	0.908	518.6	4.7	601.2	5.5	986.4	9.0	629.8	5.7	533.4	4.8
42	Kothacheruvu	1.004	774.4	7.8	708.8	7.1	875.6	8.8	555.4	5.6	529.8	5.3
43	Bukkapatnam	1.148	801.8	9.2	591.6	6.8	824.8	9.5	535.0	6.1	544.8	6.3
44	Madakasira	1.614	933.0	15.1	498.6	8.0	780.2	12.6	414.8	6.7	472.8	7.6
45	Amarapuram	0.901	859.6	7.7	634.0	5.7	685.0	6.2	354.8	3.2	372.0	3.4
46	Gudibanda	1.404	701.8	9.9	728.4	10.2	791.6	11.1	447.6	6.3	525.6	7.4
47	Rolla	0.955	824.4	7.9	364.2	3.5	727.6	6.9	524.0	5.0	398.0	3.8
48	Agali	0.580	1003.2	5.8	674.6	3.9	971.8	5.6	595.0	3.5	462.2	2.7
49	Hindupur	1.037	896.8	9.3	554.2	5.7	884.0	9.2	546.4	5.7	240.6	2.5
50	Parigi	1.169	874.8	10.2	563.2	6.6	786.2	9.2	448.8	5.2	217.0	2.5
51	Lepakshi	0.981	948.6	9.3	775.8	7.6	813.6	8.0	642.2	6.3	430.2	4.2
52	Chilamathur	1.196	860.0	10.3	683.2	8.2	940.4	11.2	681.0	8.1	375.4	4.5
53	Gorantla	1.844	681.4	12.6	756.4	13.9	1025.8	18.9	596.0	11.0	371.6	6.9
54	Kadiri	1.564	971.0	15.2	696.2	10.9	892.8	14.0	737.0	11.5	705.4	11.0
55	Mudigubba	3.278	841.6	27.6	623.8	20.4	782.6	25.7	427.2	14.0	538.0	17.6
56	Nallamada	1.847	880.4	16.3	722.2	13.3	683.8	12.6	611.4	11.3	473.8	8.8
57	N.P. Kunta	1.587	536.2	8.5	510.0	8.1	726.4	11.5	711.2	11.3	288.4	4.6
58	Talupula	2.286	684.8	15.7	512.8	11.7	783.8	17.9	558.6	12.8	434.2	9.9
59	Nallacheruvu	1.056	648.6	6.8	467.4	4.9	931.8	9.8	775.4	8.2	419.8	4.4
60	O.D.Chervu	1.664	705.6	11.7	498.4	8.3	719.2	12.0	576.8	9.6	334.8	5.6
61	Tanakal	1.857	596.4	11.1	623.0	11.6	682.8	12.7	653.0	12.1	425.0	7.9
62	Amadagur	0.938	779.6	7.3	600.6	5.6	790.8	7.4	506.0	4.7	379.6	3.6
63	Gandlapenta	1.337	716.4	9.6	482.4	6.4	786.6	10.5	601.2	8.0	484.2	6.5
Weighted rainfall :				709.4		619.5		709.0		483.5		428.7
Mean rainfall :			713.9		615.3		722.3		495.7		429.8	

IV. RESULTS AND DISCUSSIONS

The calculated values of annual rainfall by Arithmetic mean method and Thiessen polygon method are shown in table III. Also the values are graphically represented in figure I.

Table III. Comparison of Mean and Weighted Annual Rainfalls of Anantapuram district

S. No.	Year	Mean ainfall in mm	Weighted rainfall in mm	Variation (Mean rainfall - Weighted rainfall) in mm
1	2003-04	523.4	517.2	6.2
2	2004-05	433.6	428.8	4.8
3	2005-06	791.1	788.4	2.7
4	2006-07	407.9	415.7	-7.8
5	2007-08	828.8	830.5	-1.7
6	2008-09	713.9	709.4	4.5
7	2009-10	615.3	619.5	-4.2
8	2010-11	722.3	709.0	13.3
9	2011-12	495.7	483.5	12.2
10	2012-13	429.8	428.7	1.1

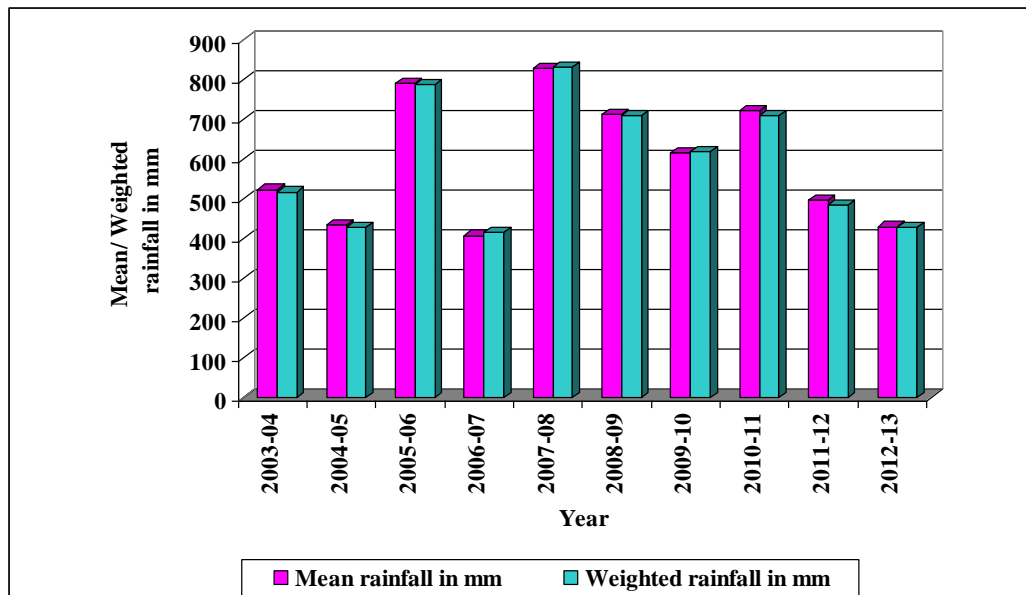


Fig. 1. Comparison of Mean and Weighted Annual Rainfalls of Anantapuram District

As per the results in table III and figure I, the values of annual rainfall obtained by Arithmetic mean method and Thiessen polygon method are not showing much variation for all the considered years. This may be mainly because of the uniform distribution of raingauge locations. The variation is ranging from a minimum of -7.8 mm to a maximum of 13.3 mm which can be considered as insignificant with respect to normal annual rainfall in the district which is about 552 mm. So, it can be concluded that for computation of annual rainfall in Anantapuram district either Arithmetic mean method or Thiessen polygon method can be used.

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