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Rainfall Intensity Variations at Different Metrological Stations of Kashmir Valley

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Abstract: ***Rainfall being an important source of water and natural source of recharge for ground water, lakes and rivers etc., its variation forms an important subject of Study. The variation of rainfall has a direct influence on the output of agriculture, occurrence of floods and design of hydraulic structures. Earlier the variation of rainfall could not be studied with precision but the developments in the metrology science have, however, rendered the study possible and precise.***

The present work study involves study of temporal and spatial variation of monthly seasonal and annual rainfall data of six stations of Kashmir valley for the period 1991 to 2020, which has been used for the determination of various rainfall-time graphs. The rainfall time curves been further used to determine the trend of pattern in temporal and spatial variation and precipitation forecasting and to determine the periods of maximum and minimum rainfall and also stations of maximum and minimum rainfall. The study also involves frequency analysis of rainfall data which forms the basis for flood forecasting and design of hydraulic structures.

The monthly variation curves show a peak in March and July and two values on June and October. March is the month of peak rainfall and average value of 181.70 mm, while October is the month of lowest with an average of 38.74 mm. Spring season contributes major portion to the total annual rainfall while autumn contributes the least. The frequency distribution chart of mean annual rainfall of Kashmir valley shows the maximum value in the rainfall intensity range 1000-1250 mm, which means that probability of annual rainfall in Kashmir valley is maximum in the range 1000-1250mm. The annual rainfall in Kashmir valley has an average value of 1140mm. The observes and forecasted values of annual rainfall show a very little percentage of error.

Keywords: Rainfall, annual, peak, frequency, temporal, spatial, forecasting

I. INTRODUCTION

With the rapid growth of human population and strained resource particularly as regards to food production and water supply for people and for agriculture and industry, the study of variations in the rainfall over a region is of utmost importance. Agriculture is one of the most important activity engaging more than 70% of the population in Kashmir. The success or failure of crops in any year is closely linked with the behaviour of the winter rainfall or snowfall. In order to increase agricultural production effective utilization of water resources is of prime importance. Rainfall is the major parameter influencing agricultural activities and its analysis is thus an important prerequisite for agricultural planning in Kashmir.

Rainfall being the predominant form of precipitation causing stream flow resulting in floods in majority of rivers. The damage caused by floods in terms of loss of life, property, and economic loss due to disruption of economic activities are all too well known. Thousands of crores of rupee are spent every year in flood control and flood forecasting. But, for flood analysis, rainfall analysis is the basic requirement, so the study of rainfall variations could help us come up with remedial measures. All the methods of flood estimation such as rational method, Unit hydrograph method and flood frequency method require analysis of rainfall data so that flood discharge can be estimated. Flood forecasting is also done on the basis of rainfall data analysis by which the damages caused by floods can be reduced.

Various hydraulic structures such as rain water harvesting systems, drainage systems, etc, are designed on the basis of rainfall and runoff which is estimated by rainfall analysis. Hydraulic structures for flood control such as dams, reservoirs, bunds, diversion canals, etc, are also designed on the basis of rainfall analysis.

The present study deals with rainfall variation on monthly, seasonal and annual basis for the six stations of Kashmir valley. The data for the study was collected from Indian Metrological Department. The data is presented with various rainfall-time curves and frequency distribution diagrams. The curves show the peak and low rainfall and frequency of particular intensity of rainfall. The average values of Kashmir valley are 1140mm.

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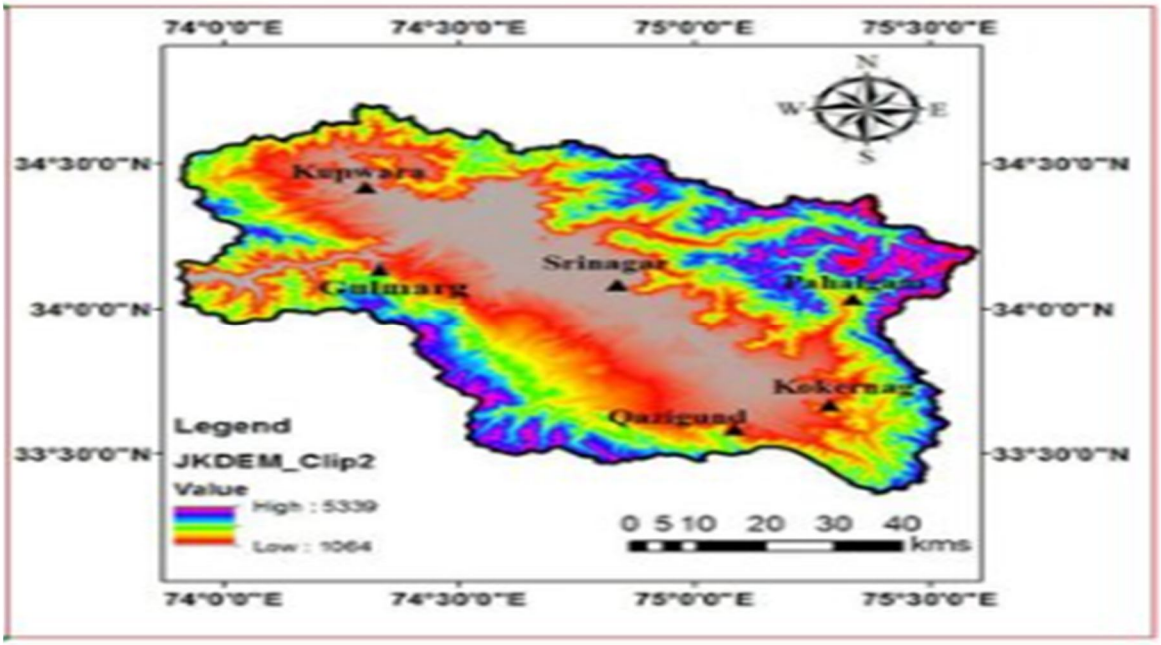
II. METHODOLOGY

A. Study Area

Coordinates Of Six Stations

S.No	Name of station	Longitude	Latitude
1.	Srinagar	34’05’	74’50’
2.	Gulmarg	34’03’	74’24’
3.	Kupwara	34’25’	74’90’
4.	Pahalgam	34’02’	75’20
5.	Kokernag	33’35’	75’30’
6.	Qazigund	33’35’	75’05’

The approximate location of the six stations of Kashmir valley is shown in the map below



The methodology has been divided into four major parts namely:

- Data collection
- Preparation of data
- Data analysis and interpretation
- Data presentation and output

1) Data Collection

The annual and monthly rainfall of six stations of the Kashmir valley is used as the data set to determine Kashmir’s rainfall temporal and spatial patterns. The data has been collected from (IMD) Srinagar.

2) Preparation of Data

Before using the rainfall records of a station, it is necessary to first check the data for continuity and consistency. The continuity of a record may be broken with missing data due to many reasons such as damage or fault in a rain gauge during a period. The missing data may be estimated by using data of the neighbouring station. In these calculations the normal data is the average of rainfall at a particular date, month of year over a specified period. Thus the normal annual precipitation at a station means the average annual precipitation based on specific time.

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a) Arithmetic Mean Method

If the normal annual precipitation is within about 10% of the normal precipitation at station X, then a simple athematic average procedure is followed to estimate P_x. Thus

$$P_x=1/M \times (P_1+P_2+P_3+P_4.....+P_m)$$

Where,

P_1= Annual rainfall at station X to be estimated

M= Number of neighbouring stations

P_1, P_2, P_3, P_m= Annual rainfall at neighbouring stations

b) Normal Ration Method

If the normal precipitation vary considerably then Px is estimated by weighing the precipitation at various stations by ratio of normal annual precipitations. This method is known as Normal Ratio Method gives px as;

$$P_x= N_1/M (P_1/N_1+P_2/N_2+P_3/N_3+..... +P_m/N_m)$$

Where,

P_x= Annual rainfall at station X to be estimated

N_x= Normal annual precipitation at station X

P_1, P_2, P_3, P_m= Annual rainfall at neighbouring stations

N_i, N_2, N_3, N_m = Normal annual precipitation at neighbouring stations

c) Data Analysis and Interpretation

Analysis of the collected data has been divide into three stage and they are:

- *Temporal Variation of Rainfall:* In this stage, The monthly, seasonal and annual variation of rainfall at each station is studied with respect to time
- *Spatial Variation of Rainfall:* In spatial variation of rainfall, the monthly, seasonal and annual variation of rainfall analysis is studied with respect to space, ie, from station to station.
- *Frequency Analysis of Rainfall:* Most of the hydrological events occur as natural phenomenon are observed only once. One of the important problems in hydrology deals with the interpreting past records of hydrological events in terms of future probabilities of occurrence of hydrological event.

III. DATA ANALYSIS

The average monthly rainfall of 30 years period calculated at the six rain gauge stations have been used for preparing variation diagrams. Monthly rainfall data of 30 years, for six stations collected from IDM Rambagh, Srinagar was used to calculate 30 years mean monthly rainfall of six stations for the 30 year period (1991-2020

MEAN MONTHLY RAINFALL IN MM OF SIX STATIONS FROM 1991-2020

Station Month	Srinagar	Gulmarg	Pahalgam	Qazigund	Kupwara	Kokernag
Jan	49.09	144.58	103.22	118.64	81.54	90.34
Feb	85.66	215.6	156.82	166.7	144.31	115.4
Mar	114.73	266.42	196.86	190.6	189.1	132.5
Apr	91.73	158.37	156.31	122.01	147.7	130.05
May	71.6	43.79	128.67	101.05	95.59	103.69
Jun	42.51	105.84	88.52	74.05	57.81	81.87
July	69.19	108.92	105.2	82.16	84.14	90.61
Aug	62.96	87.31	97.93	70.93	67.53	88.68
Sep	34.45	76.78	98.5	92.52	47.2	78.62
Oct	25.13	59.42	40.88	2.99	40.28	33.77
Nov	29.26	61.65	46.2	48.59	54.76	32.24
Dec	33.53	86.03	66.78	74.09	59.1	48.49

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A. Analysis of Seasonal Rainfall Data

Seasonal variation of rainfall over the period of 30 years has been analysed for all stations located in the study area, and the percentage contribution during each season has also been determined. The data used for analysis and preparation of variation diagrams and percentage contribution is shown below

MEAN MONTHLY RAINFALL IN MM OF SIX STATIONS FROM 1991-2020

Station Season	Srinagar	Gulmarg	Pahalgam	Qazigund	Kupwara	Kokernag
Spring	278.07	548.83	481.68	413.68	432.39	366.25
Summer	174.67	299.59	291.09	227.15	209.56	261.18
Autunm	88.86	179.91	185.62	174.11	144.13	144.64
Winter	168.3	433.47	326.84	359.44	284.98	254.25

B. Analysis of Data for Precipitation Forecasting

Two methods were used for precipitation forecasting. In the first method, simple arithmetic average of annual rainfall was used. In the second method, three year average of mean six stations is used

The graph is plotted between years from 1991-2020 and mean annual rainfall (mm) of the Kashmir valley (mean of six stations). The mean annual rainfall for the 214 and 2015 were calculated with the help of forecast curves. The calculated values are then compared with the observed values and percentage error is calculated.

C. Frequency Analysis of Monthly Rainfall Data

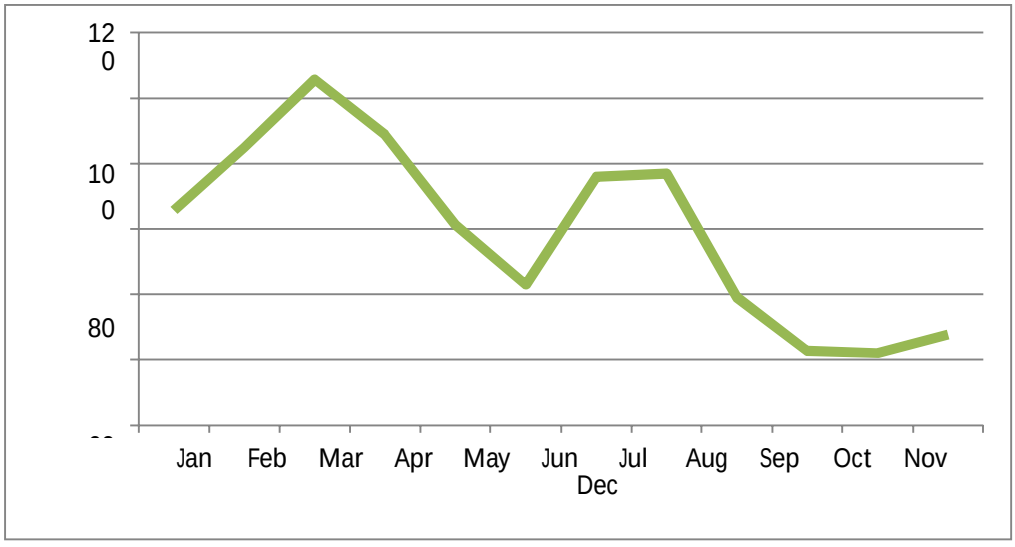
The monthly rainfall data of 30 years has been considered for preparing the monthly frequency distribution diagrams, the frequency scale ranges from 0-1. The frequency analysis of the monthly rainfall data was done by counting the occurrence of the monthly rainfall in a particular range of rainfall intensity and then dividing the counting number by the total number of months in 30 years. The monthly return period of a particular range of rainfall intensity is calculated by taking the reciprocal of frequency of that range ($t=1/F_1$) and the yearly return period is calculated by dividing the monthly return period by 12 ($t=t/12$)

IV. RESULTS AND DISCUSSION

A. Temporal Variation of Monthly Rainfall

Temporal variation of rainfall means the variation with respect to time. In this case the time variation refers to the monthly variation. The easiest way of studying the monthly temporal variation of rainfall is the graph between the rainfall in mm and time in months. These graphs were plotted for each station and also for the monthly mean of six stations

Rainfall time graph of Srinagar Station

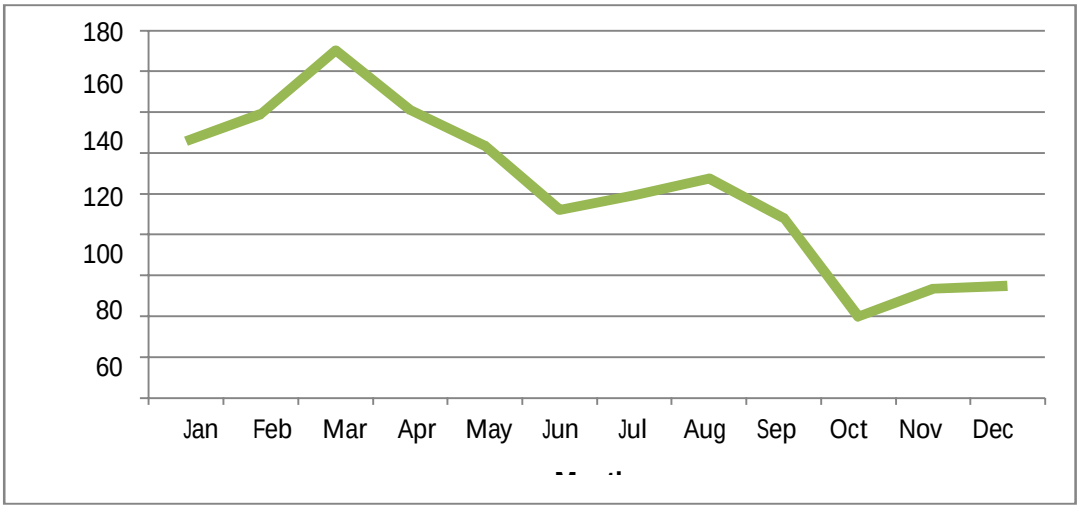


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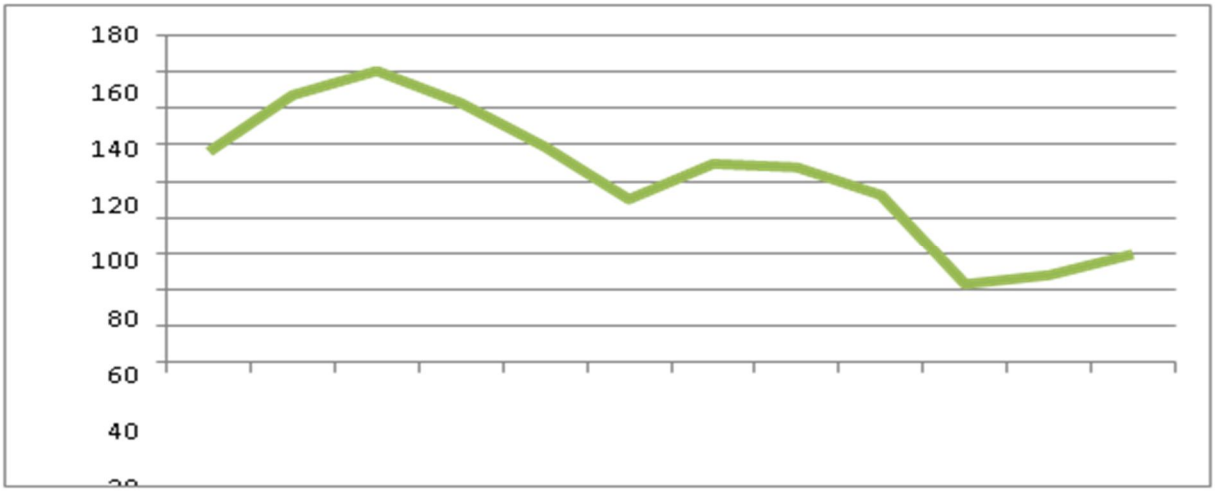
A rapidly increasing trend in rainfall intensity is noticed from January to March, with peak in March. A decrease in rainfall intensity is noticed from March to June, and then there is an increase from June to July. From July to August, rainfall intensity remains constant as shown by straight line in the graph. After Augustthere is a linear decrease in rainfall intensity till September and then a gradual decrease till October. A constant rainfall intensity can be seen in October and November with the lowest value of rainfall intensity in November. After November, there is an increase from November to December.

Rainfall-time graph of Gulmarg Station



A rapidly increasing trend in rainfall intensity is noticed from January to March, with peak in March. A wavey type of curve of precipitation with decreasing trend is observed at Gulmarg station. A decrease in rainfall intensity is noticed from March to June, and then there is an increase from June to July there is a gradual decrease in rainfall intensity till October with the lowest rainfall intensity in October. After October, there is gradual increase in rainfall intensity till December. At this station the rainfall is higher than all other stations for all months except for September where it is maximum at Pahalgam station

Rainfall -time graph of Pahalgam Station

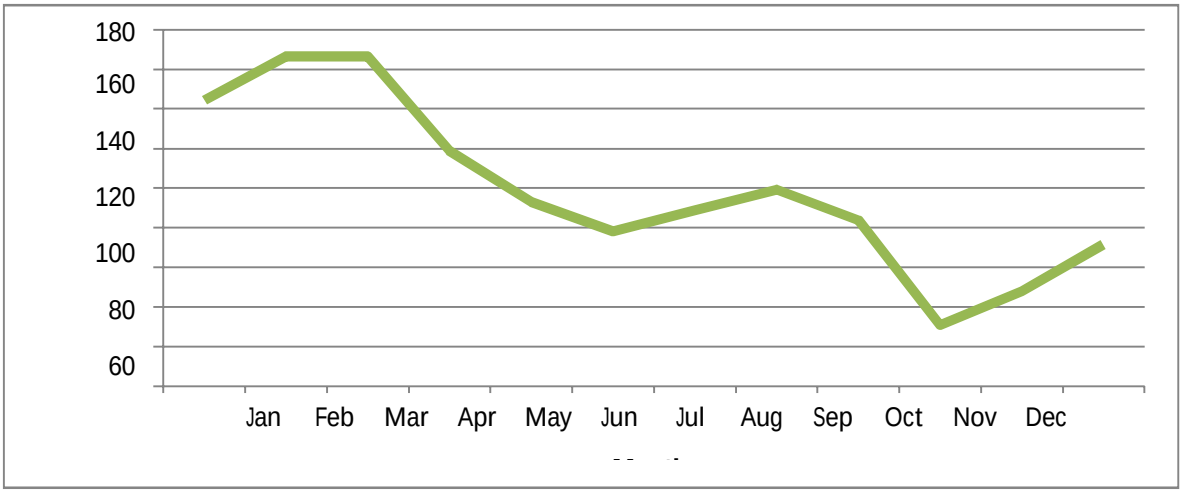


A rapidly increasing trend in rainfall intensity is noticed from January to March, with peak in March. A decrease in rainfall intensity is noticed from March to June, and then there is increase in rainfall intensity from June to July. After July there is a gradual decrease in rainfall intensity till August From August to September rainfall intensity remains constant as shown by the graph

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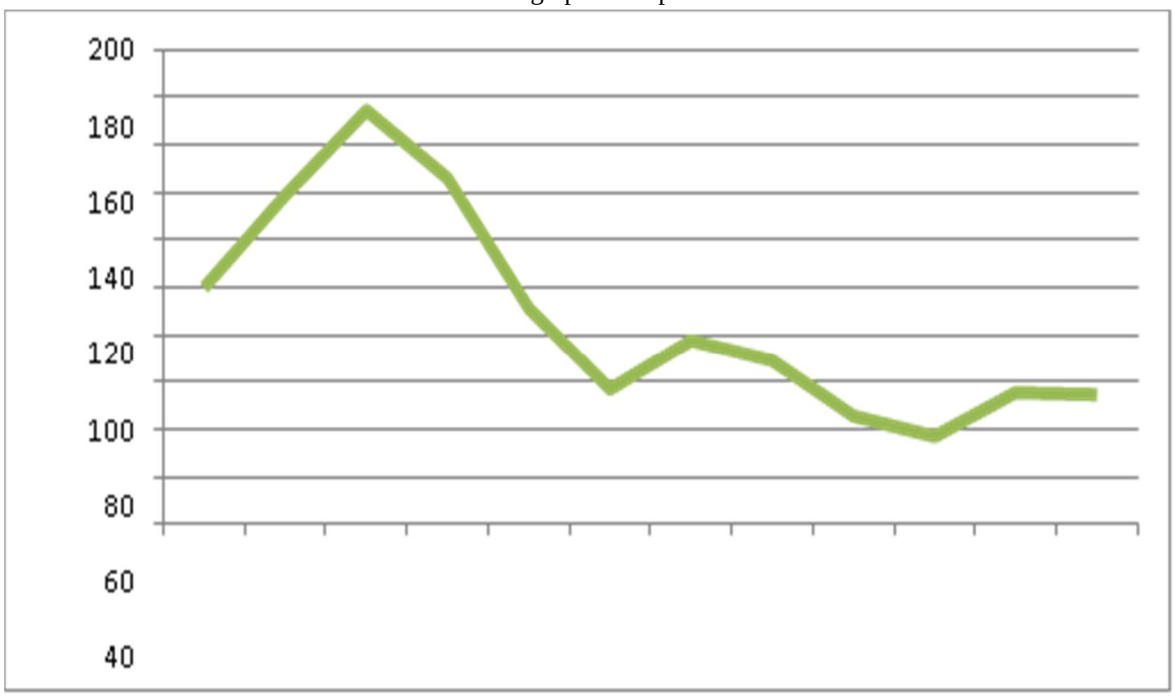
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Rainfall -time graph of Qazigund Station



A rapidly increasing trend in rainfall intensity is noticed from January to February. From February to March rainfall intensity remains constant with peak in March. A swift decrease in rainfall intensity is noticed from March to June, and then there is a linear increase from June to August. After August, there is a slight decrease in rainfall intensity till September and then a rapid decrease up to the month of October. After October, thereis a sudden increase in rainfall intensity till December.

Rainfall -time graph of Kupwara Station

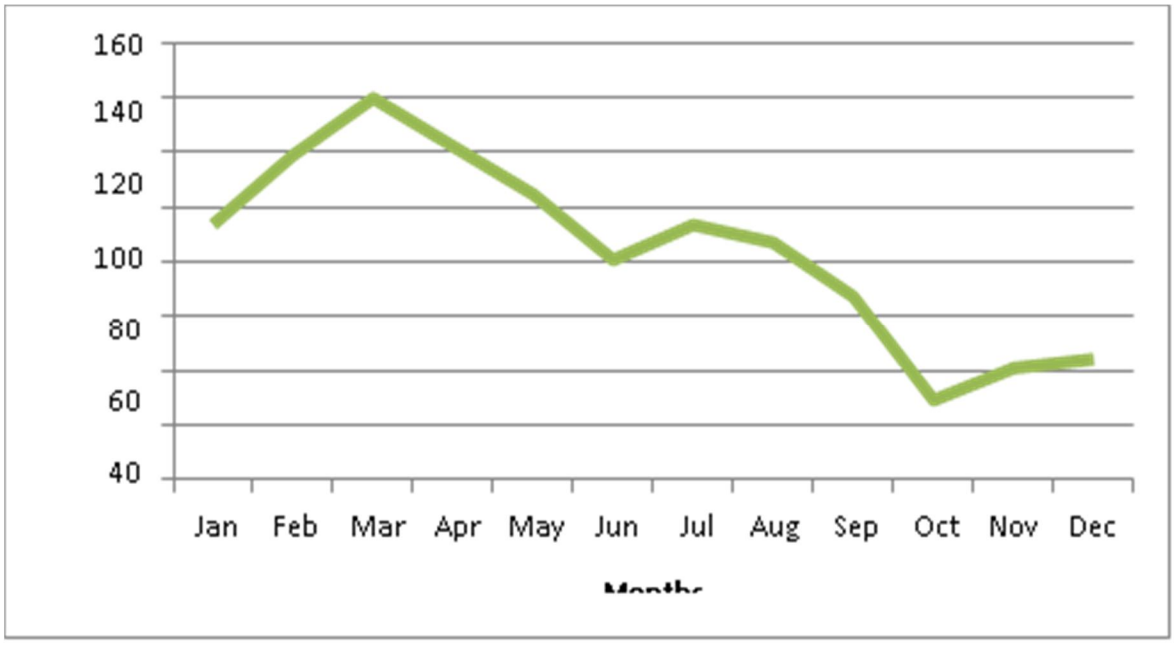


A rapidly increasing trend in rainfall intensity is noticed from January to March, with peakin March. A decrease in rainfall intensity is noticed from March to June, and then there is an increase from June to July. After July, there is a gradual decrease in rainfall intensitytill October. After October, there is an abrupt increase in rainfall intensity till November. Rainfall intensity remains constant from November to December.

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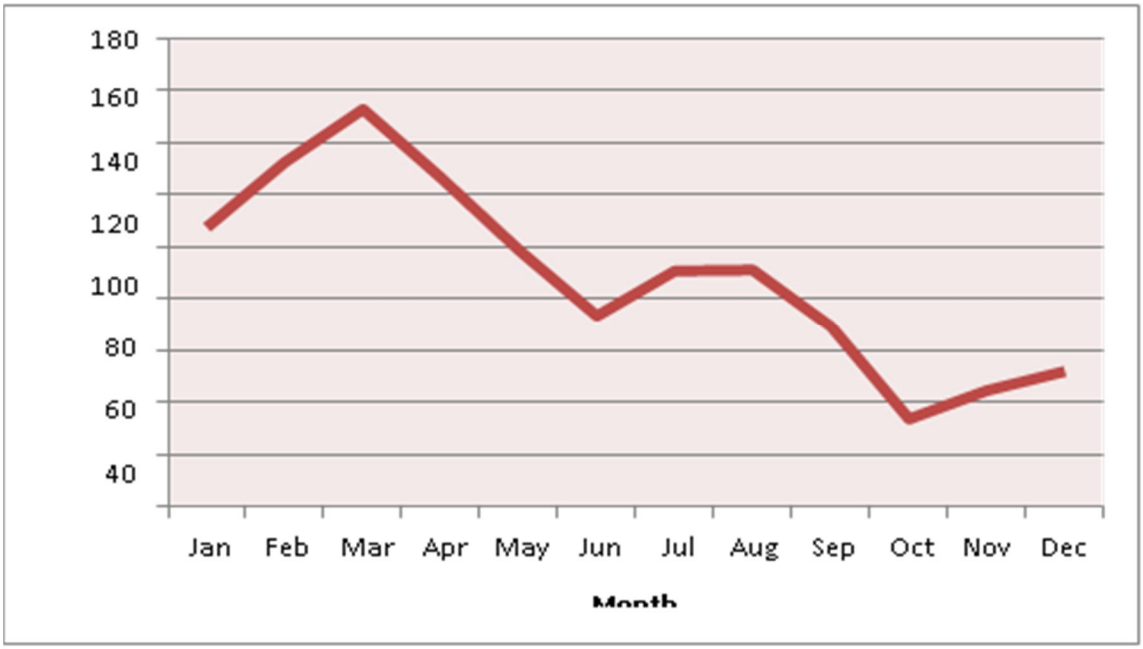
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Rainfall -time graph of Kokernag Station



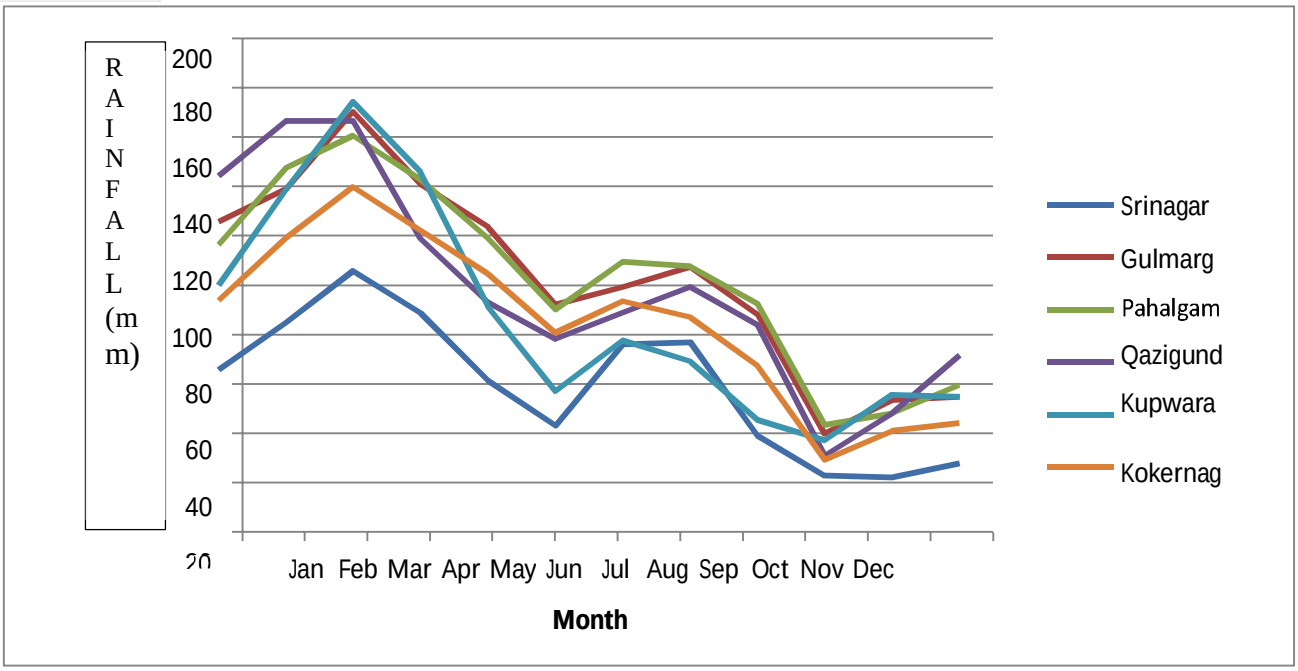
A rapidly increasing trend in rainfall intensity is noticed from January to March, with peakin March. A linear decrease in rainfall intensity is noticed from March to June, and then there is a swift increase from June to July. After July, there is a gradual decrease in rainfallintensity till October. After October, there is an abrupt increase in rainfall intensity till December.

B. Kashmir Valley (Mean of six stations)



This figure shows the variation of mean monthly rainfall of six stations, which means the monthly rainfall variation of whole Kashmir valley. The variation trend is similar to trendsshown by the six stations. The rainfall intensity first increases from January to March and then sharply decreases up to June. Then it shows a little increase in July and remains more or less constant up to August. The rainfall intensity decreases till October to reach a minimum value in that very month. From October, an increase in rainfall intensity is seen up to the month of December.

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It is clearly visible that the maximum rainfall happens to be at Kupwara station. Minimum rainfall happens to be at Srinagar station throughout the year. The decreasing order of peakmonthly rainfall, which is for the month of March, at the six stations is as:

Kupwara > Gulmarg > Qazigund > Pahalgam > Kokernag > Srinagar

The decreasing order of monthly rainfall, at the six stations, for each month can be detected from the graph. The variation with stations is maximum in first half year and thenthere is a little irregular variation in rainfall between the six stations.

V. CONCLUSIONS

The following conclusions can be drawn from the study:

1) The monthly variation of rainfall intensity is almost same at all stations i.e., all the curves shows two peaks in March and July and two valleys in June and October.

2) Monthly maximum rainfall occurs in the month of March and minimum rainfall occurs in the month of October for all stations and for mean monthly rainfall of whole Kashmir valley except Srinagar where minimum rainfall occurs in November.

3) Kupwara station has the highest average rainfall (174.40 mm) of all the stations while Srinagar station has the lowest (105.65 mm).

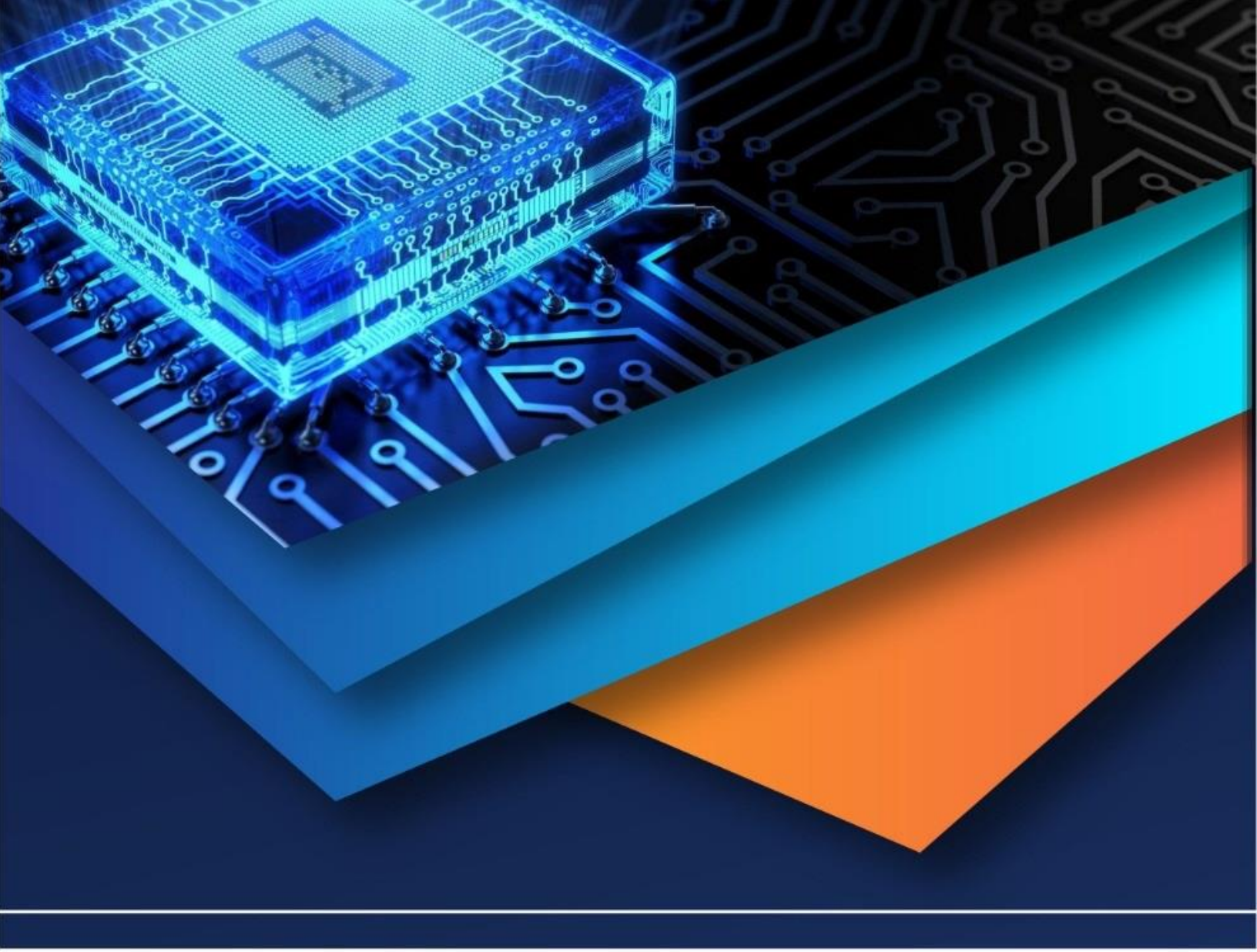
4) The correlation trends of rainfall are different for different stations.

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