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Short Term Trend of Streamflow in West Coast of India

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Abstract : In this study, the short term (25 years) streamflow data and trend recorded at 11 stations at south west coast of India, is analyzed using Mann-Kendall test and the Sen's slope method. The results were obtained on the basis of yearly, seasonal and monthly time step. The results showed significant decreasing trend in stations of Pattazhy and Thumpamon. These results were further explained on the basis of decrease in rainfall. The analysis provides valuable information for regional hydrological studies and water management.

Keywords : Mann-Kendall trend test , Precipitation-Streamflow relation, Streamflow, Sen's Slope, Trend analysis

1. Introduction

Stream flow or discharge, is the amount of water that flows through a point per unit time. It is often expressed as cubic metre per second (m^3/sec). It is one component of the runoff of water from the land to water bodies, the other component being surface runoff. The flow of a stream is depends on the amount of water moving into the stream. It is depends on weather. The discharge of water flowing in a channel is measured using stream gauges. The record of flow over time is called a hydrograph. Stream flow confers on society both benefits and hazards. Runoff downstream is a means to collect water for storage in dams for power generation .Stream flow forecasts at daily time scale are important for management of water resources systems. Its applications include flood control, water quality management, hydropower and irrigation systems.
Trend analysis is the practice of collecting information and identifying a trend, in the information. The purpose of a trend test is to determine whether the values of a series generally increase or decrease.

2. Material and Methodology

The study area selected is west coast region subzone of India between latitudes 73˚2'27.47" E. and 73˚34'9.47" E and longitudes 21˚15'19.93" N and 8˚6'59.48" N. The area is dominated by south west monsoon(June-September) and non-monsoon period(October-May).The southwest monsoon arrives as the Bay of Bengal branch and the Arabian Sea branch. The average annual rainfall is around 4200mm per year. The climate is humid and tropical. Discharge data of 11 stations from 1987-2012(25 years), was taken from WRIS site.

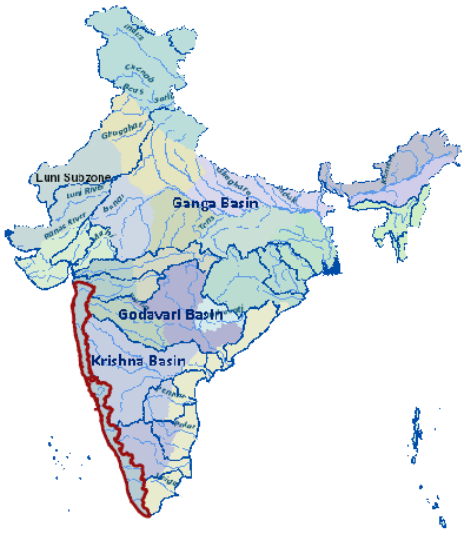

Fig 2.1 Location of study area

3. Methodology

A MATLAB program was developed for both Mann Kendall test and Sen's Slope Estimator Test. The test was done at significance level (α) 0.05, which is 95% confidence interval. For trend analysis, the MATLAB program was executed for the streamflow data series of the required time series.
When the value of Z from Mann Kendall test was positive, it showed an increasing trend and a decreasing trend of Z showed a negative pattern. The value of 'b' from Sen's Slope Estimator test gave the rate of change of the trend for the particular series.

3.1 Mann-Kendall method

The Mann-Kendall test is a nonparametric test method that can be used to verify whether trends are significant.This is done by measuring the the relationship between successive data points.
$|Z| > Z(\alpha/2)$ implies that the data shows a significant trend. A positive (negative) S value means a significant upward (downward) trend.α denotes the significance level and varying α correspond to varying $Z(\alpha/2)$.For significance level 0.05, $Z(\alpha/2) = 1.96$. Therefore, when the time series data produces $|Z| > 1.96$, there is a significant trend.

3.2 Sen's Slope method

Sen's slope method is used to calculate the trend slopes. One of the advantages of the Sen's slope method is that it is not prone to the influence of extreme values, missing data.

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4. Results and Tables

Table 4.1 : Results Of The Trend Distribution For Yearly Basis

Station	YEARLY	
	z	b
Kalampur	-0.6172	-63.8852
Kaloopara	-0.7494	-90.3128
Muthenkara	0.1322	13.9545
Pattazhy	**-2.8654**	-428.895
Ramamangalam	-0.0441	-7.4039
Perumannu	0.4849	178.575
Pudur	0.1763	5.5413
Pulamanthole	0.4849	89.5966
Malakkara	-0.8817	-299.128
Mankara	0.4408	52.4167
Thumpamon	-1.4988	-188.501

Table 4.2 : Results Of The Trend Distribution For Seasonal Basis(Winter and Pre-Monsoon)

STATION	WINTER		PRE-MONSOON	
	z	b	z	b
kalampur	**-2.3364**	-2.3018	-0.7494	-0.061
kallopaara	0.7715	1.1368	1.3666	21.6805
malakkara	-0.7274	-14.0224	-0.6833	-22.5294
mankara	1.4547	3.8564	0.2204	0.5177
muthenkara	0.7935	3.2124	1.7192	13.9706
pattazhy	1.8956	24.5959	**2.7322**	51.884
perumannu	1.3666	7.3225	0.9698	4.6088
pudur	0.529	0.9967	0.2425	0.8618
pulamanthole	-0.1763	-0.39	1.2343	10.8891
ramamangalam	1.587	36.0915	1.6311	111.391
thumpamon	-0.3086	-0.787	0.4408	2.732

Table 4.3 : Results Of The Trend Distribution For Seasonal Basis(Monsoon and Pre-Monsoon)

STATION	MONSOON		POST-MONSOON	
	z	b	z	b
kalampur	-0.7935	-48.7917	-0.9257	-25.7466
kallopaara	-1.4107	-157.672	-1.4107	-80.4478
malakkara	-1.587	-355.438	0.3527	56.115
mankara	0.0882	8.5184	0.5731	21.7553
muthenkara	0	0.6421	1.4107	49.8543
pattazhy	**-3.3944**	-361.872	**-2.4246**	-180.51
perumannu	0.0701	12.1696	0.0441	3.2273
pudur	-0.3527	-8.9973	0.2645	3.6487
pulamanthole	0.4408	62.4071	0.3086	9.938
ramamangalam	-0.6172	-101.706	-0.8817	-87.5583
thumpamon	**-2.2482**	-221.608	-0.7935	-53.579

Table 4.4: Mann Kendall And Sen's Slope Values For The Months January-March

Station	JANUARY		FEBUARY		MARCH	
	z	b	z	b	z	b
Kalampur	**-2.5568**	-2.077	-1.388	-0.034	-1.3225	0
Kallopara	0.6392	0.774	-0.3747	0	-1.4714	0
Malakara	0.022	0	-1.7413	-9.1426	**-2.667**	-19.1762
Mankara	0.7494	1.328	1.2564	2.4935	0.551	0.2351
Muthenkera	0.3527	1.1833	1.1462	1.9511	**2.3805**	4.0739
Pattazhy	1.454	12.22	**2.645**	20.3637	**3.9234**	26.195
Perumannu	1.278	4.44	1.6752	2.2252	1.41	2.4467
Pudur	0.529	0.6787	0.8376	0.7733	-0.3086	-0.1354
Pulamanthole	-1.454	-2.277	1.0139	1.002	1.7192	2.112
Ramamangalam	0.749	6.767	1.9397	29.06	**2.336**	37.719
Thumpamon	-0.705	-1.256	-1.8515	-0.8922	**-2.1601**	-1.3633

Table 4.5 : Mann Kendall And Sen's Slope Values For The Months April-June

Station	APRIL		MAY		JUNE	
	z	b	z	b	z	b
Kalampur	-1.2123	0	-0.551	-0.0029	-0.6612	-15.2413
Kallopara	**2.1954**	12.173	0.8376	6.605	-1.4988	-70.3335
Malakara	0	0	-0.2865	-4.54	-1.3666	-130.438
Mankara	-0.0441	0	0.3747	0.3686	0.2204	3.8426
Muthenkera	1.6311	5.247	-0.1783	-0.6791	-0.4408	-12.5895
Pattazhy	**3.703**	25.39	0.7053	8.1072	**-3.1299**	-78.5038
Perumannu	**2.0278**	2.07	0.7494	1.459	0.529	32.1287
Pudur	-0.3967	-0.1745	0.529	0.6787	-0.1322	-0.937
Pulamanthole	**2.733**	6.306	0.617	1.3725	0.3967	14.505
Ramamangalar	**2.292**	41.93	1.939	49.08	-0.0441	-11.5044
Thumpamon	0.7715	1.583	-1.19	-5.012	-1.8515	-59.5651

Table 4.6 : Mann Kendall And Sen's Slope Values For The Months July-September

Station	JULY		AUGUST		SEPTEMBER	
	z	b	z	b	z	b
Kalampur	-0.8376	-22.351	-0.2204	-3.9087	0.4408	12.2314
Kallopara	-0.9257	-47.3094	-1.2343	-25.4577	0.7494	44.18
Malakara	-0.8817	-99.1926	-1.3225	-43.7334	0.0441	6.4195
Mankara	-0.4849	-15.9334	0	-0.7675	1.1462	30.01
Muthenkera	-0.6172	-98.6289	-0.529	-36.8377	1.1462	52.1887
Pattazhy	**-3.0858**	-108.66	**-2.6891**	-87.8	-0.6172	-20.8388
Perumannu	-0.1763	-30.4935	0.5731	68.5922	-1.6311	75.879
Pudur	-0.8376	-9.2432	-0.3086	-2.366	0.3086	2.0817
Pulamanthole	-0.3527	-27.6875	-0.3527	-19.7668	0.9698	42.42
Ramamangalam	-0.5731	-57.241	-1.4107	-40.8032	0.3527	16.2358
Thumpamon	-1.4988	-63.369	-1.4714	-22.0639	-0.2204	-5.0856

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Table 4.7 : Mann Kendall And Sen's Slope Values For The Months October-December

Station	OCTOBER		NOVEMBER		DECEMBER	
	z	b	z	b	z	b
Kalampur	-0.5731	-12.3875	-0.8376	-6.6825	-1.3666	-4.2185
Kallopara	-0.9478	-31.8778	-1.5209	-32.2267	-0.2204	-1.9146
Malakara	-0.7053	-50.6459	-0.4849	-21.0155	0.4849	19.2425
Mankara	1.0139	13.1937	0.4408	4.9288	0	-0.0271
Muthenkera	0.9257	21.1409	0.2204	3.3329	0.3086	2.8607
Pattazhy	**-2.5568**	-80.1169	-1.6311	-47.38	0.3967	4.81
Perumannu	1.1902	31.1767	-0.3527	-7.0813	2.9557	0.4408
Pudur	0.0441	0.4155	0	-0.0378	-0.1946	-0.0882
Pulamanthole	-0.0441	-1.91	0.0882	1.99	-3.8062	-0.9257
Ramamangalam	-0.4408	-18.8553	-1.1462	-36.5327	-33.0713	-1.6311
Thumpamon	-0.7494	-24.7929	-0.7053	-22.4814	-1.3188	-0.2204

From table 4.2 and 4.3, results show that in the seasonal analysis, Pattazhy and Thumpamon showed significant trends in monsoon, with a test result of -3.3944 and -2.2482 respectively. The negative value shows decreasing trends. Also in table 7.4 and 7.5 showing the monthly analysis, Pattazhy showed significant trend in the months of June, July, August and October. Pattazhy showed significantly decreasing trend in yearly analysis as well which is shown in table 4.1.

In the monthly analysis for the months January to April Kalampur, Malakara, Thumpamon, showed negative trend and Kallopara, Muthenkara, Pattazhy ,Perumannu, Pulamanthole, Ramamngalam showed positive trend. For the months June, July ,August Ptattazhy shows a negative trend.

For further verification of results the rainfall data of Thumpamon and Pattazhy, for the year 1987-2012 ,was collected from IMD. Mann Kendall test was applied to the rainfall data and the obtained values were -2.7634 for Thumpamon and -2.6009 for Pattazhy. Fig 4.1 and 4.2 shows decreasing rainfall trend in Thumpamon and Pattazhy respectively.

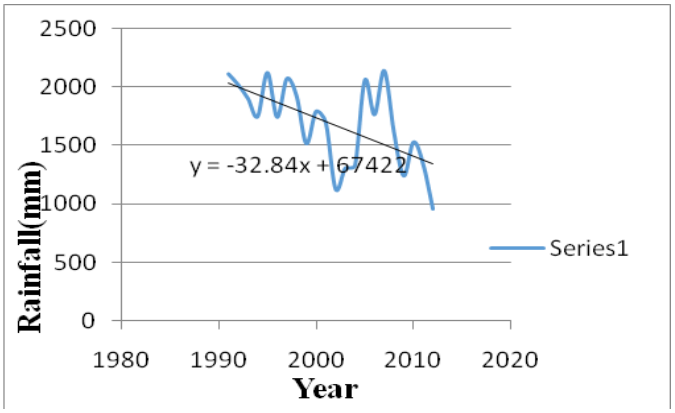

Fig 4.1 : Graph Showing Decreasing Rainfall Trend In Thumpamon

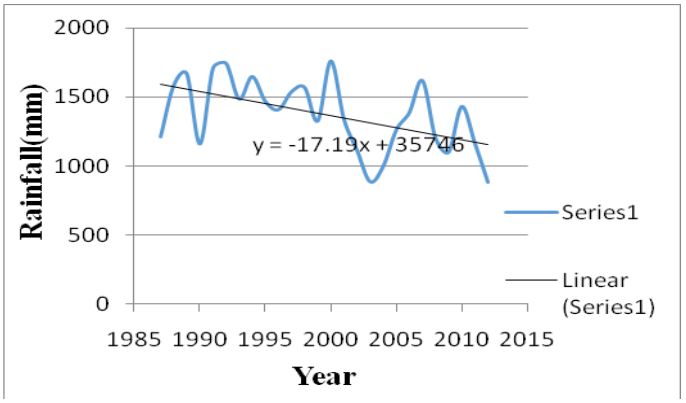

Fig 4.2 : Graph Showing Decreasing Rainfall Trend In Pattazhy

It is evident from the graph that, as rainfall decreases the streamflow values also decreases. Stream flow depends on change in precipitation which is related to water availability.

5. Conclusion

The following conclusions were made.

- In the yearly analysis Pattazhy showed a significant decreasing trend, which is greater than -1.96.
- In the seasonal analysis Kalampur (Pre-monsoon), Pattazhy(Pre-monsoon, monsoon, Post-monsoon) and Thumpamon (monsoon) showed a significant decreasing trend.
- For the months June, July ,August and October Pattazhy shows a negative trend.
- From the analysis of rainfall, a decreasing trend was observed in Pattazhy and Thumpamon, which may be the cause for the significant decrease in streamflow in these two stations.

The varying trends detected in precipitation and streamflow could be due to climate variations and human activities. Thus, the obtained results would be expected to help in water resources planning and management .

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