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Test and Trend Analysis of Precipitation and Discharge in the North of Iran (Case Study: Polroud Basin)

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Abstract: Present study investigated the type and time of discharge changes in relation to precipitation in the Polroud basin. This area is located in Guilan province, north of the Iran. The purpose of this paper is to inform on the precipitation and discharge fluctuations for the period 1968 - 2005 that it has been investigated by using the Man-Kendal non parametric test. These results suggest that data series have trend and abrupt change. On the other hand there is a good fitting between discharge and precipitation trend. There is also the same trend in autumn winter and spring, especially. These parameters have ascending and descending trends in the autumn and spring, respectively. The precipitation has ascending trend, whereas descending trend of discharge is seen in summer. The discharge diagrams presents descending trend in all of the seasons. Totally, the trends of parameters were similar with regard to prepared diagram and the changes of discharge are dependent to precipitation.

Key words: Precipitation · Discharge · Man-Kendal statistic · Trend · Polroud

INTRODUCTION

Undoubtedly, the industrial ever-increasing activity can play a significant role in changing the Earth's climate. Today, its effect is specified because of the global warming phenomenon and the type of precipitation of the Earth system. On the other hand, using surface waters increased because of increasing agriculture, industrial activities and population growth. This issue led to changing of rivers discharge. For this purpose, along the years, several research have been recorded to evaluate the streamflow in relation to precipitation shortage. [1] Marengo (2005) believed, from his study of stream flows variability in the South American, which none of the significant trend is observed in the discharge average of rivers. [2] Partal and Kahya (2006) asserted that there is a significant trend in annual precipitation of January, February and September of Turkey and can be observe a considerable decrease in annual precipitation of west and south regions and especially in the Black sea coast. [3] Modarres (2007) first attempted to determination of precipitation trends in '20' stations of arid and semiarid regions in Iran and then showed that there was none of the significant trend in average mean daily of precipitation. [4] Solaimani (2009) showed that the monthly hydrometric and climatic data in ANN were ranged from 1969 to 2000. Also the results extracted from the comparative study indicated that the Artificial Neural Network method is more appropriate and efficient to predict the river runoff than classical regression model in Jarahi watershed. [5] Also Gholami *et al*. (2009) applied the HEC-HMS and Artificial Neural Network (ANN) to simulate the rainfall-runoff process over the Kasilian Watershed located in the north of Iran. They are believed the highest efficiency of this method and the desirable effect of optimized initial loss on increasing the accuracy of simulation in runoff and hydrograph. Totally the results indicated lack of climate fluctuation of arid and semiarid regions in Iran. Typically, Polroud is the largest basin on Guilan province and because of this, changes in precipitation of Polroud basin that lead to marked changes in the amount of discharge could have important human effects, especially for small farmers.

Accordingly, in this paper, a non parametric approach based on the statistical theory of extreme events was used in order to detect and analyze the extreme rainfall and discharge trends in the north of Iran.

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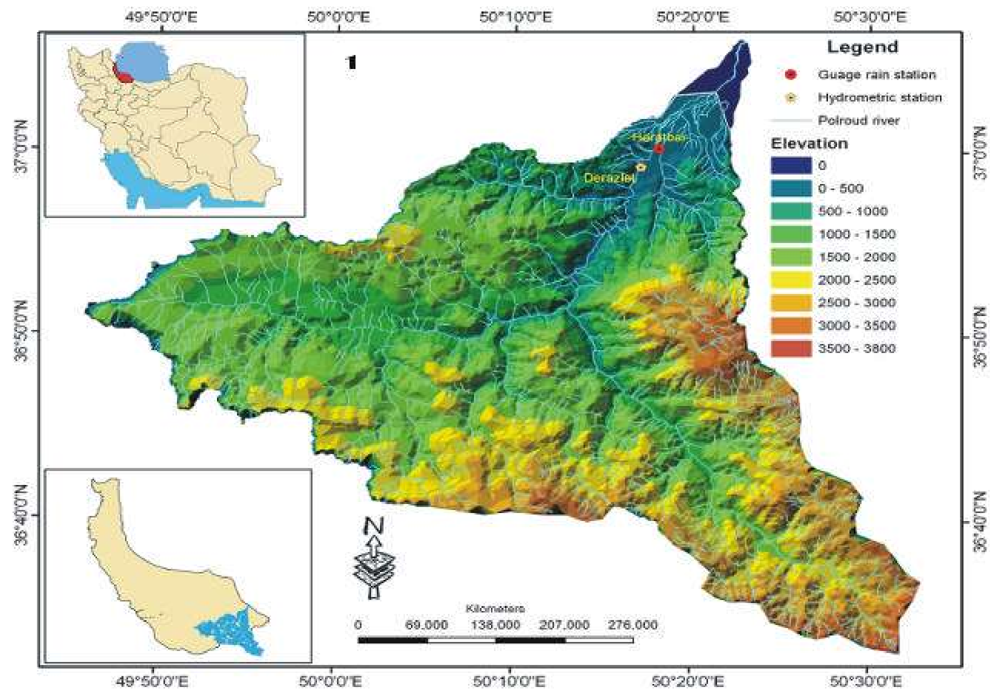

Fig. 1: Geographic location of Polroud basin

MATERIALS AND METHODS

Polroud basin is located in east of province and north of Iran and its length is '82.5' km. It is limited between the meridians 389980 E and 459858 E and parallel 4044645N and 4106092N. The area and circumference of basin are about 1773.44 km^2 and '286' km respectively and the altitude vary from '-23' m to '3756' m. The data of Haratbar gauge rain and Derazlat hydrometric stations are used which were located in the altitude of '200' m from m.s.l (Figure 1).

We have studied the discharge changes in relation to precipitation based on Man-Kendal test for the period 1968 - 2005. In this method, the test of variables is carried out in two graphic and non graphic forms. To see change of trend with time, [6] Nasri and Modarres (2009) introduced sequential values, $u(t)$ and $u'(t)$, from the progressive analysis of the Mann-Kendall test. Herein, $u(t)$ is a standardized variable that has zero mean and unit SD. Therefore, its sequential behavior fluctuates around zero level. The following steps area pplied to calculate $u(t)$ and $u'(t)$:

The values of x_j annual mean time series, (j = 1,..., n) are compared with x_i, (i = 1,..., j - 1). At each comparison, the number of cases $x_j > x_i$ is counted and denoted by n_j. The test statistic t is then calculated by equation

$$t_j = \sum\nolimits_1^j n_j \quad (1)$$

The mean and variance of the test statistic are

$$E(t) = n\,(n-1)/4 \text{ and } Var(t_j) = [j(j-1)(2j+5)]/72 \quad (2)$$

The sequential values of the statistic $u(t)$ are then calculated as

$$u(t) = t_j - E(t)/\sqrt{\text{var}(t_j)} \quad (3)$$

The values of $u'(t)$ are computed similarly backward, starting from the end of the series. It is now possible to be drawn the curve of $u(t)$ and $u'(t)$ charts, where the curve of $u(t)$ tail is standard normal curve of series and the curve of $u'(t)$ tail indicated with the inverse of series curve of $u(t)$. If + $ô_t$ > ô >- $ô_t$ then + 0.22 > ô > - 0.22, it indicates the existence of change and data is randomly, if ô < - $ô_t$ then t < -0.22, the change is negative and also ô > + $ô_t$ then t > +0.22, it indicates the existence of the positive change of time series.

Table 1: The calculation of (t) Kendal statistic, the average of monthly Polroud basin

Station	Haratbar (precipitation)	Darazlat (discharge)
October	0.05	0.12
November	0.02	0.09
December	0.00	0.08
January	-0.18	0.01
February	0.07	0.00
march	0.03	0.09
April	0.01	-0.14
may	0.04	-0.22
June	-0.01	-0.19
July	0.20	-0.08
august	-0.14	-0.18
September	0.10	-0.17

Table 2: The calculation of (t) Kendal statistic, the seasonal average of Polroud basin

Parameter	Autumn	Winter	Spring	Summer
Polroud precipitation	0.16	0.02	-0.05	0.07
Polroud discharge	0	-0.05	-0.35	-0.17

RESULT

With regard to the equation 3, the critical level of ($\hat{o}_t$) is calculated $\pm$ 0.22 for probability level of 95%. The value of more and less than $\pm$0.22 represents the existence of change. There is an increasing and decreasing change of monthly precipitation of Haratbar but there is not the heavy change of discharge of Derazlat station (Table 1). The coefficient of changes is significant in spring discharge but there were not the changes in precipitation in all seasons, but the value of '-0.35' is pointed to change in of mean discharge in spring season (Table 2). As seen in Figure 2, the discharge has had a negative trend by knowing the values of '- 2.8' in 1973 and '- 2.6' in 1982 years in autumn season and then the trend is increasing. An abrupt

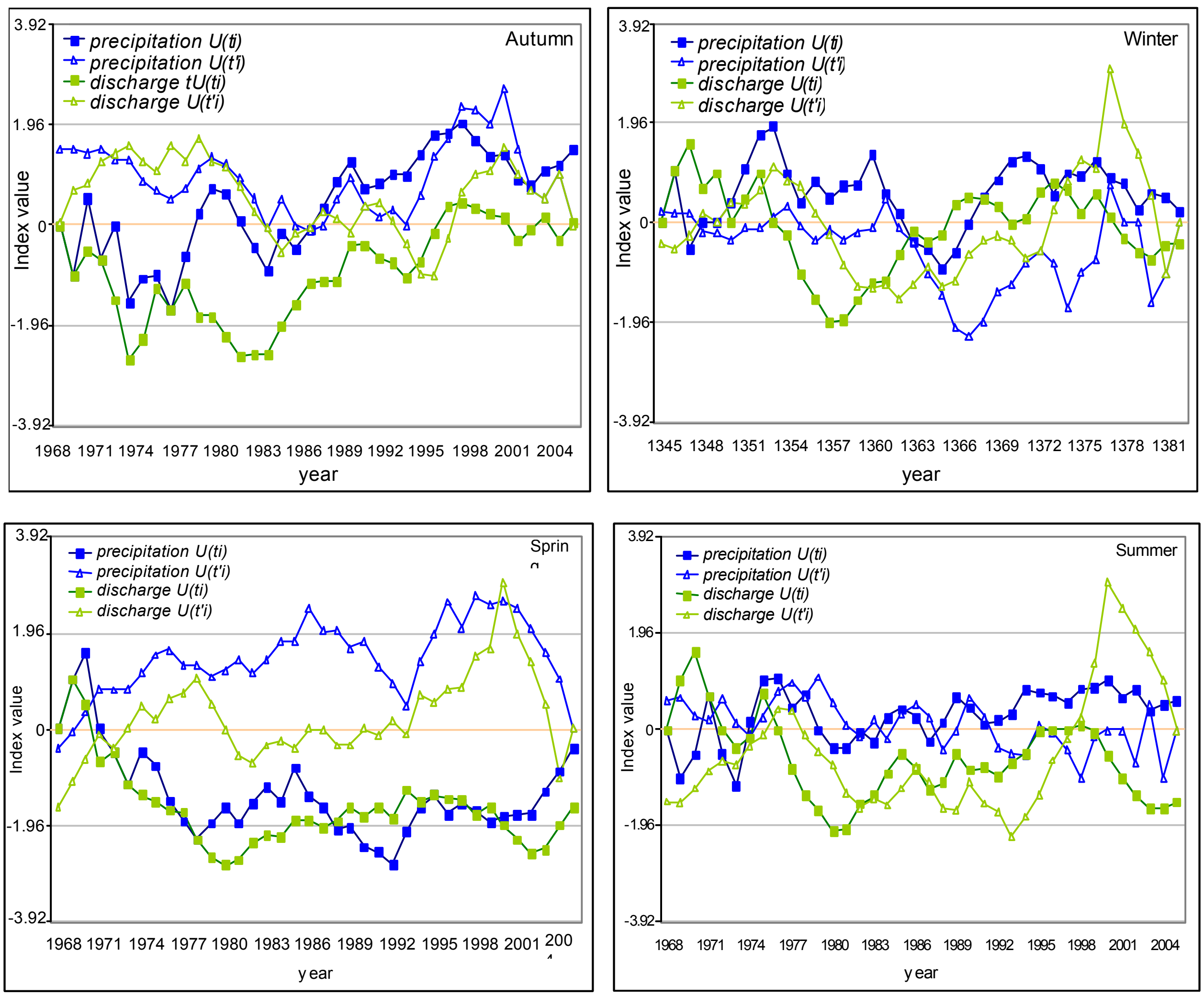

Fig. 2, 3, 4 and 5: Relationship between autumn, winter, spring and summer's precipitation and discharge in Polroud basin, respectively change is seen because of intersection of tails of $u(t)$ and $u'(t)$. There is an increasing trend by knowing the values of '2' in 1997and an abrupt change of precipitation in 1986 year. The discharge and precipitation often coincide from the first to 1997. On the other hand, both in the discharge and precipitation has an increasing trend towards ends of period. As shawn in Figure 3, in winter does not any coincide between $u(t)$ component the precipitation and discharge from early to 1996, so that precipitation has had a positive trend amount of '2' since the 1976 and discharge has had a negative trend amount of '2' since the 1981. The tails of discharge has intersected each other many times during of period which indicate eventual changes in several points of time series. By comparison, the trend of discharge is more decreased in relation to precipitation since the 1986.

As indicated in Figure 4, both the precipitation and the discharge have had two negative trends in spring. The amounts of precipitation are '-2.2' since the 1978 and '-2.9' since the 1992 and amounts of discharge are '- 2.9' since the 1980 and '- 2.5' since the 2002, then, both the parameters have had increasing trend toward the end of the period. There was an intersection between the tails of $u(t)$ and $u'(t)$ of both the parameters, totally at the beginning of period (1971) that shows a probable change in time series. Figure 5 shows the discharge has had a negative trend amount of '2' until 1981 in summer. With regard to intersection of tails of $u(t)$ and $u'(t)$ it proves two probable changes in the years of 1976 and 1998, but has not proved any importance change in precipitation.

CONCLUSION

The effect of precipitation on discharge has been proved with regard to harmonious relationship between of $u(t)$ curves of precipitation and discharge and also the existence of change and trend in both the precipitation and the discharge. Although there were intersections between the tails of $u(t)$ and $u'(t)$ of both the parameters, but there is not any synchronism between them in time series. The rhythm of the tails of $u(t)$ and $u'(t)$ of both the parameters in autumn and summer is more regular in relation to other seasons. The linear trends of both the precipitation and the discharge have mainly coincided in all seasons, except for summer, as there was the ascending liner trend in autumn and the descending liner trend in spring. Thus, the obtained results of this study were compatible with research of [7] Conway and Hulme (2005) in sub-basins of Nile and [8] Dixon *et al*. (2006) in the analysis of streamflow in west Britannia. They concluded that the changes of runoff in relation to precipitation were completely natural, but it was different with regard to conditions of basin. These results show that the discharge had more changes and fluctuations than precipitation during the time series as it is more seen in autumn. It is clear that the trend of changes is mainly increasing. But it is less seen in discharge. It is obvious that increasing of population in recent decades and increasing use of water needs for constructive, agricultural consumptions and inappropriate deforestation and other environmental changes are of important reasons in water resource reduction of rivers in relation to last decades.

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