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Impact of 30 Years Changing of River Flow on Urmia Lake Basin

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ABSTRACT: Changes in the amount and distribution of flow discharge are a remarkable manifestation of climate change. Reducing or increasing the amount of flow discharge affects many other climatic and environmental phenomena such as runoff, flood, humidity and also affect many human activities such as agriculture, economics ,the fight against soil erosion and so on. In this study, the trend of river flow discharge in the Urmia lake basin was investigated in two annual and monthly scales using modified non-parametric Mann-Kendall test (MMK) with complete removal of the self-correlation structure. To this end, 26 hydrometric stations were surveyed in the Urmia Lake basin during the statistical period of 1984-2013. Also, non-parametric Pettitt test was used to determine the time of change in flow trend. The results of the trend of the studied stations in the Urmia lake basin showed that the course of the changes in the flow discharge is decreasing in most months. On a yearly scale, at all stations, there was a trend of decreasing flow in the basin area. Also, the trend of flow discharge decline is more intense in both autumn and winter. The time of change in the decreasing trend of the flow discharge in the Urmia Lake basin was also taking place between 1994 and 1998. Also the results indicated that the decreasing trend of Urmia Lake water level data occurred one year after the decreasing trend in flow data.

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1- Introduction

In recent decades, human activities have led to significant changes in the world's climate and water resources. In closed basins (like Urmia Lake) rainfall and discharge can be one of the important and influential factors in river flow changes. Decrease or significant increase of rainfall and its changes, along with the increase of air temperature in the catchment area, has significant effects on the discharge rate of rivers. Many studies have been conducted to investigate the long-term trend of hydrological variables such as river flow and precipitation in different parts of the world [1-11]. Investigating the trend of river flow changes due to the influence of rainfall, temperature and natural factors of the earth.

Extensive research has been conducted on the trend of fluctuating flow in the world. According to Gan (2000), runoff variability in drought-prone areas are extremely high [12]. For example, minor changes in temperature and precipitation in arid and semi-arid areas will cause large changes in runoff. Déry et al. (2005) reported a decrease of about 13 percent of flows of 42 rivers to the Gulf of Angora for 37 years from 1964 to 2000 [13]. Stojković et al. (2014) examined the monthly, annual and seasonal changes in the flow of the SAVA River at two hydrometric stations using the Mann-Kendall test. They are concluded that the long-term periodicity of annual flows has a considerable impact on the time series trend. [14]. Abghari et al. (2013) studied the monthly and annual flows of mountainous regions in western Iran over the statistical period from 1970 to 2009. They reported a significant decline trend in October and November [15]. Abeysingha et al. (2016) studied the trend of river flow in the Gamti River basin in northern India during the statistical period of 1982-2012 and analyzed its relationship with rainfall changes and human factors. The results indicate that the decreasing trend of annual flow in the studied basin due to increased water withdrawal from the basin, increase in air temperature, population increasing and also a significant decrease in rainfall [16]. Regarding the review of the sources, a variety of parametric and nonparametric methods have been used to investigate the process of hydrological variables. Among them, the non-parametric method of Kendall has been widely used, some of which have been considered by the effect of self-correlation, and some of the correlation effects, the hydrological parameters have been studied.

Considering the presented materials and also climate change and in the regions of Urmia Lake, it seems that the study of changes in the rivers flow trend of the Urmia Lake and also the study of the time of changing its trend should be important. In fact, the objectives of this study are to study the trend of flow discharge changes in the lake basin of Urmia, taking into account the effect of internal correlation and mass

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inputs to the basin, and the time of changing the trend of these data and its effects on the Urmia Lake water surface during the statistical period 1984-2013.

2- Materials and Method

2- 1- Case Study

Urmia Lake, which is the accumulation center for the surplus water flow of all the rivers in the Urmia basin, with an area of approximately 5750 square kilometers and a mean altitude of 1276 meters above sea level, is located in the north and middle of Urmia Lake Basin. Around Urmia Lake, there are 16 wetlands with areas between 5 and 120 hectares (of which some have dried up) and are of high ecosystem values. Urmia Lake basin is situated between the eastern longitude coordinates of 44° 14′ to 47° 53′ and the northern latitudes of 35° 40′ to 38° 30′. The precipitation changes in Urmia Lake basin varies from 220 to 900 mm and the mean precipitation is 263 mm, where the amount of precipitation increases by moving from the central parts of the basin toward the surrounding highlands. The location of Urmia Lake and the studied hydrometric stations in Urmia Lake basin are shown in Fig. 1and the attributes of the employed hydrometric stations are presented as Table 1.

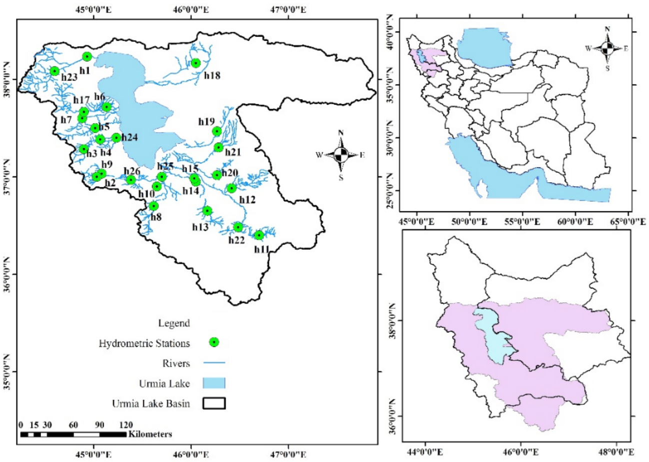

Figure 1. Location of Urmia Lake basin and selected hydrometer stations

Table 1. Basic characteristics of selected hydrometer stations in Urmia Lake basin

No	Station	Elevation (m)	Latitude (m)	Longitude (m)
h1	Yalghoz Aghaj	1300	4231337	493873
h2	Oshnaveyeh	1480	4098203	507115
h3	Hashem Abad	1570	4125939	491135
h4	Dizaj	1320	4137031	506197
h5	Band	1390	4150342	501768
h6	Abajalo Sofla	1290	4174758	512338
h7	Kalhor	1500	4161442	489407
h8	Kotar	1380	4061772	555381
h9	Pey Ghala	1500	4094873	503559
h10	Polebahramlo	1285	4083976	557910
h11	Safakhaneh	1475	4029658	652446
h12	Chobchole	1370	4082502	626548
h13	Dashband	1350	4056684	604579
h14	Simineh	1290	4089841	593487
h15	Tazekand	1290	4093149	591671
h16	Mirabad	1525	4142585	487614
h17	Tapik	1450	4169207	491181
h18	Akhola	1310	4225198	591975
h19	Sofi	1260	4147770	612303
h20	Shirinkand	1380	4097845	612973
h21	Gheshlag Amir	1450	4128921	613443
h22	Sri Ghamesh	1380	4038208	632580
h23	Chehriq	1600	4214767	464919
h24	Babarood	1285	4139274	521242
h25	Gerdeyaghob	1280	4095101	562284
h26	Naqade	1340	4091612	533824

2- 2- Trend analysis

The aim of process test is to specify whether an ascending or a descending trend exists in the data series. Since parametric tests have some assumptions, including normality, stability, and independence of variables, where most of these assumptions do not apply to hydrologic variables, the nonparametric methods are more preferred in meteorological and hydrological studies. The nonparametric methods are less sensitive to extreme values compared to parametric tests in the examination of trends. Nonparametric tests can also be utilized for data time series regardless of linearity or nonlinearity of the trend [17]. One of the most well-known nonparametric tests is the Mann-Kendall test [18, 19]. Overall, this test has four revisions described by [20]. In the present study, the third revision that completely removes the autocorrelation effect of time series is used.

2- 3- Mann-Kendall Test (MK)

The classic form of Mann-Kendall test [18, 19] has been used in many studies. If the number of data time series is n within the study period, the statistic S calculates as follows:

$$S=\sum_{k=1}^{n-1}\sum_{j=k+1}^{n} sgn(x_j - x_k) \tag{1}$$

Where x_j indicates the value of j^{th} data, n indicates the number of data, and sgn (θ) is called the sign function that is defined as:

$$sgn(x)=\begin{cases} +1 & if(x_j - x_k)>0 \\ 0 & if(x_j - x_k)=0 \\ -1 & if\ (x_j - x_k)<0 \end{cases} \tag{2}$$

When $n \geq 8$, the statistic S has a normal distribution, where it's mean and variance calculates as follows:

$$E(s) = 0 \tag{3}$$

$$Var(S) = \frac{n\text{-}(n\text{-}1)(2n+5)\text{-}C}{18} \tag{4}$$

Where C is a factor related to variance correction. If same data exist successively in a time series, C should be calculated by Equation 5 and applied in the Equation 4:

$$C = \sum_{t=1}^{m} t_i(t_i - 1)(2t_i - 5) \tag{5}$$

Where t_i is the number of tie data within the i[th] group. Finally, the MK test statistic (Z) is calculated as follows:

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var(s)}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sqrt{Var(s)}} & \text{if } S < 0 \end{cases} \tag{6}$$

The null hypothesis (no trends) is accepted when $-Z_{1-\alpha/2} \leq Z \leq Z_{1-\alpha/2}$, otherwise H_0 is rejected and its opposite hypothesis i.e. the existence of a trend is accepted [20].

2- 4- The modified Mann-Kendall test (MMK)

Before applying the Mann-Kendall test, we should be sure that the considered data series have no significant autocorrelation. However, most of the hydro-climatological time series may have a significant autocorrelation [20]. When a series has a positive autocorrelation coefficient, there is an increased chance for Mann-Kendall test to reveal the existence of a trend in this series. In this case, the null hypothesis, i.e. lack of trend is rejected, yet this hypothesis should not actually be rejected [20]. The modified Mann-Kendall test was presented by [21] and has been used by [22] for the analysis of the trend of Indian rivers. In this method, the effect of all significant autocorrelation coefficients is eliminated from the time series before applying the Mann-Kendall test. In the MMK test, the modified variance V (S)* is calculated as follows:

$$V(S)^* = V(S)\frac{n}{n^*} \tag{7}$$

$$\frac{n}{n^*} = 1 + \frac{2}{n(n-1)(n-2)} \cdot \sum_{i=1}^{n-1}(n-i)(n-i-1)(n-i-2)r_i \tag{8}$$

Where r_i is the i delayed autocorrelation coefficient and V(S) is estimated by Eq. (4). To calculate the Z statistic in the modified Mann-Kendall test in Equation 6, V(S) is substituted by V(S)*. The value of the Z statistic obtained from the above equation is compared with normal standard Z at α significant level. r_i is the lag-i significant autocorrelation coefficient of the i[th] rank of time series and defined as:

$$r_i = \frac{\frac{1}{n-i}\sum_{j=1}^{n-i}(x_j - \bar{x})(x_{j+1} - \bar{x})}{\frac{1}{n}\sum_{j=1}^{n}(x_j - \bar{x})^2} \tag{9}$$

Where n is the data set length, x_j is the value of j[th] data and x the average value of the data set. The Z statistic of MMK is computed by substituting Var(S)* in Equation 7. It is noteworthy that when $-Z_{1-a/2} < Z < Z_{1-a/2}$, the null hypothesis (no trend) is accepted at the significance level of α. Else, the null hypothesis will be unacceptable and the other possible hypothesis will be taken at the significance level of α [20].

2- 5- Change point detection

Pettitt test is a non-parametric test that was developed in 1979 by Pettitt. This method is used in order to find change points in a time series [23]. In this study, the statistic was used to find a sudden change in temperature data. This statistic is a test with the rank basis and without a distribution in order to detect significant changes in the mean of time series and it is important when there is no assumption about the change time. Pettitt test statistic is as follows [24]:
First $U_{t,n}$ time series is obtained as follows:

$$U_{t,n} = \sum_{i=1}^{t}\sum_{j=i+1}^{n} \operatorname{sgn}(x_j - x_i) \tag{10}$$

Where t is statistical period length and n is the number of data in the statistical series. Also $\operatorname{sgn}(x_j\text{-}x_i)$ is calculated as Equation 4. By calculating the value of k as Equation 11 and replacing it in Equation 12, p statistic is obtained.

$$P = 2 \times e^{\frac{6k^2}{n^3+n^2}} \tag{11}$$

$$k = \max\left[U_{t,n}\right] \tag{12}$$

In this test, H_0: indicates the homogeneous data and H_1 represents failure occurrence in the studied time series. If the calculated p value is less than α or significant level (0.05), this change point in the series can be considered statistically significant. In fact, the calculated p value is risk value or H_0 rejecting error, that if the error is less than 5%, this change can be considered significant. In this study, Pettitt test was done based on Monte Carlo 10000 simulations.

3- Results and Discussion

3- 1- Results of the trend of monthly and annual flow changes in the studied basin

In this study, the trend of flow discharge data of hydrometric stations of the Urmia Lake basin was calculated by using the modified Mann-Kendall test in two annual and monthly scales during the statistical period of 1984-2013. Figure 2 also shows the masses of inputs to Iran. According to Figure 2, the effects of the masses of the lobes entering the lake basin of Urmia were investigated.

The trend of flow data (m^3/s) of the hydrometric stations examined on a monthly and annual scale using the modified Kendall test. The results of the study of the monthly and annual trend of the studied stations were presented in Table 2. The results of the trend of monthly river flow in hydrometric stations in the Urmia lake basin indicated that in station h13 that located in the south of Urmia Lake, all months except February have a decreasing trend in the flow data in a monthly scale. The trend of flow data in the October and March was decreased at the significance level of 5%. The trend of flow data in the December, January and May are significant at the level of 10%. It also has a significant 10% in annual scale. The months November, April, June, July, August, and September provided a high decline in the monthly flow data. At station h14, like station h13, all months have a decreasing trend. Except the February, March, July, and August, there is a significant downward trend in the monthly flow data.

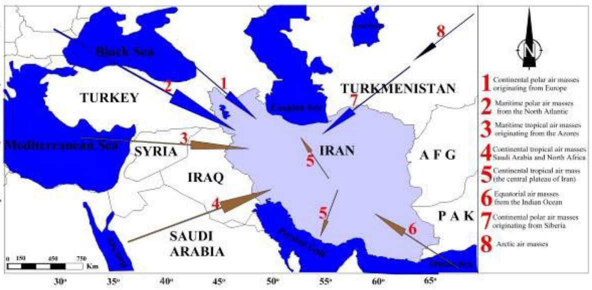

Figure 2. Effective Air Masses upon Iran in the summer and winter seasons (Atlantic Atmospheric and climatic disasters [8]

The monthly flow trend in September is significant at the level of 5%. The trend of flow data in the December, January, May and June is significant at the level of 10%. It also has a significant 10% in annual scale. The months of October, January, and April provided a steep downward trend in the monthly flow data. At the station h22 in the south-east of the studied basin, the months of October, November, March, April, June, July, August, and September have an non-significant trend during the month of July, August, and September. The trend of monthly changes in December, February and January is significant at a significant level of 5%. The trend of flow data in May is significant at the level of 10%. On an annual scale, there is also a significant trend at a level of 5%. At station h23 in the north-west of the studied basin, all months have a decreasing trend. The trend of monthly scale in January, February, April, May, June, July and September is significant at the level of 5%. The trend of flow data in October and August is significant at the level of 10%. On an annual scale, there is also a significant trend at a level of 5%. The October, January, and April months provided a dramatic drop in monthly Flow. h7 station that located in the west of Urmia Lake, have a significant downward trend in the monthly scale in all months except December, January, February, March, May and June. The monthly flow data in November, September, April, July and October are significant. On an annual scale, there is also a significant trend at a level of 5%.

At the station h11 in the southwest of the Urmia Lake basin, all months have a decreasing trend. The January and May have a significant downward trend in the monthly flow data. The monthly trend in February, March and September is significant at the level of 5%. The trend of flow data in the months of October, November, December, April, June and June is significant at the level of 10%. On an annual scale, there is also a significant trend at a level of 5%. At the station h5 in the west of Urmia Lake, next to the stations h6 and h7, there is an increasing trend in monthly flow data in August and September. The months of November, July, and August have experienced a non-significant trend. Monthly flow changes are significant in most months. On the annual scale, there is also a significant trend at the level of 5%. March showed a high decline in the monthly flow. At the southwest station of Urmia Lake (h15), all months have experienced a significant decline. On the annual scale, there is also a meaningful trend at the level of 10%. The most decreasing trend in the monthly discharge of the studied station is May to September, which includes the spring and summer seasons. At the h8 hydrometric station in the south of the lake and south of the h10, all the months have experienced a downward trend. On the annual scale, there is also a significant trend at a level of 10%. The month of June shows a high decline in the monthly Flow. The most decreasing trend in the monthly discharge of the station is May to September, which includes spring and summer seasons.

At hydrometric station h25 that located in south of Urmia Lake and north of the h10, all months have experienced a downward trend. On the annual scale, there is also a significant trend at a level of 10%. The most decreasing trend is happened in the monthly scale in January-September, which is part of the winter, spring and summer season. At the station h17 in the west of Urmia Lake, all of months have experienced a downward trend. On an annual scale, there is also a significant trend at the level of 5%. There was no severe decline at this station (h25). At the station h6 in the west of Urmia Lake, all months have decreasing trend. On an annual scale, there is also a significant trend at a level of 5%. June shows a steep decline in the monthly flow. The most slowdown in the monthly flow of the station is from April to August, which includes the spring and summer seasons. At the station h9 that located in the southwest of Urmia Lake, all months except February and March have experienced a downward trend. The two months of February and March have an increasing trend in monthly flow data.

On an annual scale, there is also a significant trend at a level of 5%. The most decreasing trend is happened in the monthly flow of this station in June to November, which includes autumn and summer seasons. The station h26 is located like as the station h9 in the south-west of Urmia Lake. At this station (h26), in most of the studied stations, all months experienced a downward trend. The months of March, April, and May have a decreasing and unnecessary trend, and monthly flow data in February are significant at a significant level of 5%. The trend of flow data in the months of December, January and June is significant at a level of 10%. The most decreasing trend in the monthly flow in this station occurred in July to November, which includes the autumn and summer seasons. The southern Urmia Lake station (h10) has experienced a decreasing trend for all months. It also has a significant 10% annual rate. The months of November, April, June and July show a high decline in the monthly flow. In the south-west of Urmia Lake at the station h2, all months have experienced a downward trend. On an annual scale, there is also a significant trend at a level of 5%. The most decreasing trend in the monthly discharge of this station is occurred in the summer months. At the station h24 that located in the western part of the studied basin, all the months experienced a decreasing trend. On an annual scale, there is also a significant trend at a level of 10%. August is the worst downturn. The most decreasing trend in the monthly flow occurred in the summer and autumn months. The hydrometric station h4 that located in the west of the Urmia Lake Basin, has experienced a steady decline in all months. It also has a significant trend in level of 10% in annual scale.

Like the Babaroud station, this station also has the significant downtrend in August. The most decreasing trend in the monthly flow occurred in the summer months. At station h12, most months, except March have experienced a downward trend. On an annual scale, there is also a significant trend at a level of 5%. The months of December, July, August and September include the most severe declining trend. At this station, the monthly flow of changes in March is incremental and non-significant. At station h3 that located in the west of the Urmia Lake Basin, all the months except February and March experienced a downward trend. Meanwhile, the months of February and March is increasing and the other are decreasing. August is the worst downturn. At the h1 station that located in the north-west of Urmia Lake, all months experienced a downward trend except the September. On an annual scale, there is also a downward trend at a significant level of 5%. The most decreasing trend in the monthly discharge of this station is occurred in the summer and spring months. At this station, the trend of monthly flow in September is incremental and non-significant. At the last hydrometric station in the north-east of this basin (h18), all of the months except August and September is experiencing a downward trend. On an annual scale, there is also a significant trend at a level of 10%. At this station, the trend of monthly changes in August and September is incremental and non-significant. At the h20 station in the south-east of Urmia Lake, as the Akhola station, all months except the August and September months experienced a downward trend. An unnatural downward trend was also observed on an annual scale. At this station, the trend of monthly changes in August and September is incremental and non-significant. In the northern part of the station (h20) there is an h21 hydrometric station. At this station (h21), all months have experienced a downturn. The high decline was observed in November and February. The most decreasing trend in the monthly discharge of this station is the autumn and winter months. The h19 station is located in the south-east of Urmia Lake. At this station (h19), all months, except March, have experienced a downturn. On an annual scale, a decreasing trend was observed at a level of 10%. The highest decline was seen in January.

Table 2. Z-statistic values of monthly and annual river flow trend of studied hydrometric stations in Urmia Lake basin

Station name	Station No	October	November	December	January	February	March	April	May	June	July	August	September	Annual
Babarood	h24	-2.40	-2.28	-1.71	-1.75	-1.38	-0.76	-2.20	-1.15	-1.55	-2.04	-3.51	-1.80	-2.09
Dizaj	h4	-1.82	-2.03	-1.65	-1.94	-1.18	-0.69	-1.32	-1.14	-1.51	-2.35	-4.60	-2.25	-1.83
Chobchole	h12	-2.41	-2.53	-2.89	-2.00	-0.86	0.12	-1.07	-1.53	-2.25	-2.83	-3.53	-2.72	-1.50
Hashem Abad	h3	-1.27	-1.25	-0.57	-0.77	0.27	1.20	-0.40	-1.16	-1.53	-1.69	-2.78	-1.98	-1.20
Pey Ghala	h9	-2.08	-2.39	-1.91	-1.14	0.82	2.00	-1.03	-1.53	-2.32	-2.43	-2.55	-2.50	-1.93
Naqade	h26	-2.94	-3.38	-2.00	-2.18	-1.71	-1.33	-1.24	-1.60	-2.19	-3.08	-3.34	-3.50	-2.17
Polebahramlo	h10	-2.39	-2.78	-1.61	-2.32	-2.03	-2.34	-2.73	-1.70	-2.69	-3.17	-1.77	-1.44	-2.18
Oshnaveyeh	h2	-2.38	-0.48	-1.01	-1.78	-1.95	-1.45	-1.99	-1.23	-1.89	-2.02	-1.94	-2.35	-1.69
Kotar	h8	-1.95	-1.94	-1.48	-2.15	-1.12	-1.31	-1.86	-2.51	-3.50	-2.55	-2.10	-2.41	-2.11
Gerdeyaghob	h25	-2.54	-1.87	-1.75	-2.37	-2.73	-2.51	-2.58	-3.00	-3.50	-2.31	-2.63	-2.68	-2.53
Tapik	h17	-1.19	-1.65	-1.54	-1.52	-1.45	-0.82	-1.25	-1.63	-1.73	-1.56	-1.31	-0.38	-1.60
Abajalo Sofla	h6	-1.95	-1.83	-1.76	-1.48	-1.49	-0.74	-2.05	-1.75	-1.78	-1.92	-1.97	-0.66	-1.78
Kalhor	h8	-2.84	-1.94	-1.51	-1.18	-1.62	-1.12	-2.09	-1.08	-1.11	-2.46	-2.23	-1.90	-1.75
Safakhaneh	h11	-2.35	-2.27	-2.14	-1.25	-1.93	-1.78	-2.00	-1.11	-2.12	-2.68	-2.38	-1.70	-1.89
Band	h5	1.86	-1.02	-1.99	-1.96	-2.42	-2.89	-2.10	-1.99	-1.96	-0.25	1.46	1.93	-1.90
Tazekand	h15	-3.03	-2.74	-1.90	-3.59	-3.23	-2.75	-2.32	-4.14	-4.76	-3.52	-3.63	-3.96	-2.44
Dashband	h13	-1.93	-3.01	-2.16	-2.32	-0.87	-1.80	-2.78	-2.35	-2.88	-3.01	-2.76	-3.26	-2.21
Simineh	h14	-3.15	-2.02	-1.99	-2.98	-1.41	-1.58	-2.84	-2.03	-2.38	-1.45	-1.48	-1.86	-2.09
Sari Ghamesh	h22	-1.48	-1.43	-1.62	-1.89	-1.66	-1.21	-1.03	-2.18	-1.18	0.38	0.90	-0.55	-1.95
Chehriq Olya	h23	-2.11	-1.39	-0.90	-1.59	-1.63	-1.37	-1.67	-1.78	-1.61	-1.83	-2.46	-1.91	-1.61
Yalghoz Aghaj	h1	-0.52	-1.34	-1.63	-1.78	-1.32	-1.75	-1.96	-2.42	-1.60	-2.14	-1.68	0.24	-1.90
Akhola	h18	-1.86	-2.93	-2.38	-2.11	-1.77	-1.69	-2.33	-2.14	-2.14	-1.50	0.79	0.92	-2.04
Shirinkand	h20	-1.78	-0.52	-1.03	-1.07	-2.30	-1.49	-1.44	-0.89	-1.14	-0.30	0.39	0.26	-0.76
Gheshlag Amir	h21	-1.98	-3.27	-2.11	-2.05	-3.25	-2.46	-1.50	-1.14	-1.50	-0.70	-1.57	-0.91	-1.55
Sofi	h19	-2.37	-1.14	-1.51	-2.89	-1.28	1.16	-2.43	-1.03	-2.21	-2.11	-1.57	-2.32	-2.18

3- 2- Results of the study of the time of change in the flow rates of river flow in the lake of Urmia

To study the time of changing of flow data in two monthly and annual scales of studied stations, the Pettitt test was done and the results of this test were presented in Figure 3.

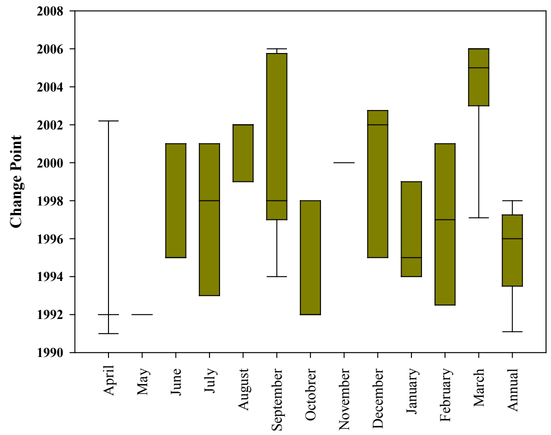

Figure 3. Box plots of data time changing of hydrometric stations in the Urmia Lake Basin

According to the results of the Pettitt test, we can see the time of trend change in the monthly and annual river flow. Also can be indicated from this fig, the trend change has often occurred between 1994 and 1998. In order to investigate the effects of the trend time changing of river flow data in the time changing of trend of water level of Urmia Lake, the time of changing the trend of water level of Urmia Lake was calculated using the Pettitt test and the results are presented in Figure 4.

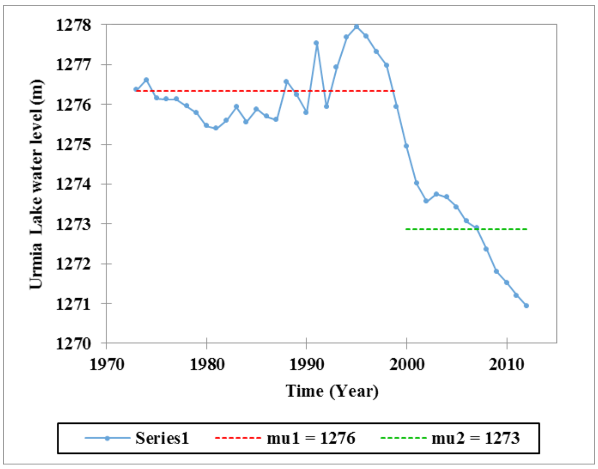

Figure 4. Results of the trend change point in Urmia Lake water level data

As shown in Figure 4, the time of the change in the time series of the yearly annual level of Urmia Lake water level begins in 1999, followed by a downward trend. According to Figure 3, the time of changing the annual flow of most of the hydrometric stations was occurred from 1994 to 1998. The results showed that the effect of changing the river flow data of the studied stations on the Urmia Lake water level appeared after one to two years. 93% of the studied months have a decreasing trend in flow data at hydrometric stations and about 7% of the months have an increasing trend.

On the other hand, previous studies [25-28] showed that there is an increasing trend in temperature in Iran, especially in cold months. Therefore, temperature variations can be considered as one of the reasons for the decrease in rainfall and consequently the decrease in discharge in the study area. Also, the results showed that rainfall reduction is in the direction of the continental polar mass with the origin of Europe, which is also mentioned in [8]. Fathian et al. (2015) also reported a decline trend in their study in the Urmia Lake Basin [29].

4- Conclusion

In this study, the trend of long-term (30 years) variations in the monthly and annual river flow in selected stations in the Urmia Lake basin using non-parametric Mann-Kendall test, after eliminating significant correlation was studied during the statistical period of 1984-2013. In summary, the results are as follows:

The affected areas of the Arctic Ocean - a continent with a European origin that originates from the Black Sea - include a downward trend in the rainforest. It seems that the accumulation of greenhouse gases, land use change and the global warming phenomenon in the Urmia Lake basin are among the factors that reduce the rate of flow in the region. Temperature variations can alter the structure of the climate and reduce the relative humidity by increasing the atmosphere's capacity to accept water vapor. Increasing the temperature in addition to the flow of rivers will also affect other variables such as precipitation, evaporation and relative humidity. The trend of decreasing the flow of rivers in the Urmia Lake basin can also be due to the reduction of rainfall in the region. The results of the study of river flow changes in the Urmia basin in the annual scale showed that there was a decreasing trend in all stations. The results of the study of the trend change time (Pettitt test) showed that the decreasing deflection in the river flow of the studied hydrometric stations affected the water level of Urmia Lake.

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