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Assessment of variations in river discharge and sediment at some stations of Gorgan-Roud River, Golestan Province, Iran

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ABSTRACT: The main part of sediment in each river is formed of suspended load. In this investigation, to assess the relationship between sediment discharge and flow discharge in 14 hydrometer stations of Golestan Province, corresponding data of inventory years of 1971 to 2008 were received and analyzed. To do this, first the discharges and corresponding sediment data in different seasons were recognized and defined. To determine data trend, Mann-Kendall non parametric test was used. Considering that all of annual and seasonal series of observed discharge and sediment were not normal in all investigated stations, Mann-Kendall non parametric method was an appropriate method for determining time series in this study. Results of data trend evaluation showed that the trend of annual and seasonal discharge and sediment was descending in most of studied stations. Also, results showed that by dividing discharge and sediment data to sets and times, assessing the trend is of higher precision and sensitivity and better results could be obtained.

***Keywords**:* Flow Discharge, Sediment Discharge, Gorgan-Roud River, Data Trend, R

INTRODUCTION

The main part of transported sediment by most of the rivers is comprised of suspended load. So, determining amount of suspended load in river engineering studies is of high importance (Zoratipour et al., 2005). Suspended sediment load has an irregular and diffused nature varying spatially and temporally in different scales, especially at the time of shower (Sadegietal.,2005). In management watersheds, erosion, sediment transport, sedimentation, and water quality are of high importance. These issues could be addressed by creating and developing programs ofmeasuring transported sediment in rivers (Olive and Rigar, 1992). On the other hand, suspended load of a river largely represents upstream conditions. Many groups need these data. From these data, relationship between the processes ofbasin erosion and suspended sediment could be studied (Hiks et al., 2000). Thus, suspended sediment has a close correlation with soil erosion researches (Valingh, 1994). Since sediments are mainly transported in flood periods, to achieve an estimation of amount of transported sediments by rivers, simultaneously measured data of discharge-sediment in water and sediment-gauge stations and also statistical analysis of results are used (Saeedi and Sadeghi, 2009). This procedure leads to the high cost of sampling and in many cases makes it impossible. Applying indirect methods of sediment estimation including curves and measuring relations and using regression concept are the appropriate solution for solving existing problems in sampling multiplicity from a flood current or total sediment curve (Sadeghi, 2005).Fatahi and Moghadam (2009) assessed the trend of qualitative and quantitative changes of water resources in watershed of Ghom province. Their results showed that totally, trend of water resources in watershed of Ghom province is dropping both qualitatively and quantitatively. Horowitz (2002) used sediment measuring curve to estimate concentration of suspended load, and underestimating sedimentation using linear and non-linear regression was found. Ghazizadeh and Shahnizadeh (2008) assessed the trend of changes in Karkheh River. The results showed that upstream stations have desired quality but downstream stations have undergone loss quality because of some reasons such as natural condition of river, reduced river slope and entrance of municipal wastes in downstream. Zoratipour et al (2005) conducted a research on GlinkHydrometery Station in Taleghan watershed to determine the efficiency and assessment of current hydrological (statistical) methods for estimating suspended load and also to select the best method for sediment estimation. The results of this study showed that ultimately for all the data, the middle limit method with error 2170.6 tons per day and two-line method with error 2325.9 tons per day were the appropriate and the inappropriate methods, respectively.Harijani and Kouhestani (2007) conducted an investigation in Sajasroud watershed, Zanjan province to present a proper formula for estimating "sediment delivery ratio" and five-variable linear regression modelwith variables influencing on sedimentation coefficient was suggested for Sajasroud watersheds. In this study, the trend of changing discharge and sediment in different seasons and in all data of 14 hydrometery stations, Golestan province was evaluated.

MATERIAL AND METHODS

Gorganroud basin (watershed) with area 10197 km2is one of the basins in northeast of Iran that main part of it occurs in Golestan province. This basin is limited in 54° 10' E to 56° 26' E and 36° 35' E to 38° 15' N coordination's. Based on De Marton, Gorganroud basin occurs in humid, semi-humid, mediterranean, semiarid and arid climate classes. The most humid months in the study area include Azar, Dey, Bahman, and Esfand and the most arid month is Shahrivar. Mean precipitation in different places of Gorganroud basin varies significantly ranging from 202 mm in RobatGhareh to 903 mm in Pas Poshte (Sheikh et al, 2009). In this investigation 14 hydrometer stations of Gorganroud basin were selected based on 37 statistical years (1971-2008) and then the trend of sediment and flow discharge was determined(figure 1).

Selecting statistical test

There are many methods to recognize trend in time series of hydrological data. Statistical test for recognition of trend are included linear regression, Rho Spearman, Sent, Man Candle and seasonal Candle. Of these tests, the two tests namely simple linear regression and Man Candle test are used higher and more attentions directed to them than others (Sheikh et al, 2009). In this investigation the two tests linear regression and Man Candle test considered too. The former method is parametric but the latter is nonparametric, each of them has some advantages and disadvantages too. Linear regression is a parametric method based on student t test. The main point that has to be considered in application of student t test is that the dada should be independence and follow the normal distribution. For determining data independence generally autocorrelation coefficient (ACF) between consecutive data for different delay steps is calculated (Han, 2003).

$$\rho_m = \frac{\mathrm{Cov}^{(X_t,X_{t+m})}}{\mathrm{Var}(X_t)} = \frac{\frac{1}{n-m}\sum_{t=1}^{n-m}(X_t-\overline{X})(X_{t+m}-\overline{X})}{\frac{1}{n-1}\sum_{t=1}^{n}(X_t-\overline{X})^2}$$

X_t(t=1.2.3,…), tested time series, is the same X_{t+m}tested time serieswith m delay step, and $\overline{X}$is the average time series. Range P will be from -1 to +1.For quite random time series, p_m value for $m \neq 0$ is zero. If the series of autocorrelation coefficient values for all delay steps occurs in confidence interval 95%, series of studied data are independence in confidence level 95% (Han, 2003).

$$\frac{u}{1} = (-1 \pm Z_{1-\frac{a}{2}}\sqrt{n-2}/n-)$$

Where: n is the length of studied data series, 1 and u are the lower and upper limits of confidence interval, respectively, a is the confidence level (which is 5% here), and Z is the critical value of standard normal distribution in confidence level a. If time correlation of data is significance, or in other words if the data are dependent, time correlation effect should be removed or must be declined as low as possible prior to conducting any trend test.

One of the current methods to conduct it is pre-waiting method (Kaviani and Asakereh, 2005). Van Stouric (Van Stouric, 1995) has suggested the following relation for pre-waiting of time series with significant correlation with one Gan delay.

$$Y_t = X_t - \rho_1 X_{t-1}$$

$X_t$is the raw data series, X_{t-1} is the raw data series with one delay step, ρ_1 is the correlation coefficient between data with one delay step, and Y_t is the corected or treated data series.

Of course, it should be noted that conducted studies by Yu and Wang (27) show that providing being a trend in time series, the effect of temporal correlation on test trend depends on sample size (number of data), the value of temporal correlation and magitude or value of the trend. When number of data and magnitude of trend is high,temporal correlation does not significantly affect the test results. A variety of methods exist to test data normality. In this investigation Qqplot (a graphical method)and statistical method of shapiro-wilk test were used (11 and 23). In result section, some parts of results related to graphical method of Qqplot and all the results of shapiro-wilk test are presented. Statistical parameter of shapiro-wilk test is obtained from the following relation:

$$W = \frac{[\sum_{i=1}^{n} a_i X_i]^2}{\sum_{i=1}^{n} (X_i - \overline{X})^2}$$

$\mathbf{X_i}$is the related observed value in i thrank of arranged observation serias, n is the number of all observation, and $\mathbf{a_i}$ is a coefficient that is obtained from special table related to this test for each i th observation. In this method, if p value obtained for shapiro-wilk parameter (W) is higher than 0.05, we conclude thatdata series in confidence level 95% follow normal distribution. According to obtained results of this study, data series of discharge and sediment doen dot follow normal distribution both anually and seasonally. Thus, there is no requirement to use the linear regression method, and non-parametric test of Man Candle was used to evaluate data trend.

Man Candle test

One of the methods for evaluating changing data trend is non-parametric test of Man Candle. This method first was used in 1945 by Man, and Candle in 1975 obtained statistical distribution of this test. This method is one of the best methods to detect and determine data trend, and many researchers have used this method to detect the trend of climatic and hydrological parameters (Sheikh et al., 2009; Hejam et al, 2008).

Non-parametric test of Man Candle, in contrast to parametric test such as linear regression,does not suppose certain distribution function for data series. However, recognition ability of it equals parametric tests (Leten Meyer et al, 1994). For this reason,World Meteorological Organization, strictly suggest Man Candle test to evaluate and recognize the trend in temporal series (Michael et al, 1966).

In this method data are arranged according to occurrence time, and each datum is compared to all data after itself. Steps of conducting this test are as follow:

$$S = \sum_{i+1}^{n-1} \sum_{j=i+1}^{n} \mathrm{sign}(X_i - X_j)$$

$$\mathrm{sign}(\theta) = \begin{bmatrix} 1 & \text{if} & \theta > 0 \\ 0 & \text{if} & \theta = 0 \\ -1 & \text{if} & \theta < 0 \end{bmatrix}$$

For independent random and uniformly distributed variables and variable without node (two or more data with the same numerical value which are followed consecutive in an arranged series) the average and variance S are as following:

$$E(S) = 0 \quad \mathrm{Var}(S) = \frac{n(n1)(2n+5)}{18} = \sigma^2$$

If there is node in data series, the variance value is calculated from the following relation:

$$S = \frac{n(n-1)(2n-5)\sum_{i+1}^{n} t_i(i)(i-1)(2i-5)}{18}$$

Where: $\mathbf{t_i}$shows the number of nodes with capacity i. For example, if there are only two numbers with the same value in a data series, there will be a node with capacity 2 ($\mathbf{t_2 = 1}$).

If the number of data is higher than 10, S will follow the normal distribution, and the value of standard statistical measure (Z) will be as bellow:

$$Z_s = \begin{cases} \frac{s-1}{\sqrt{\mathrm{var}(s)}} & \text{if} \quad s > 0 \\ 0 & \text{if} \quad s = 0 \\ \frac{s+1}{\sqrt{\mathrm{var}(s)}} & \text{if} \quad s < 0 \end{cases}$$

Thus, in a two-way test, null hypothesis will be rejected for detecting the trend in confidence level a, if Z_s value is higher than (or equal to) Z. to evaluate the data trend in seasonal and annual series of discharge and sediment data, if absolute values of Z obtained from Man Candle test is higher than 1.96, data trend in level 5% is significant, and when Z value is higher than 2.56, it will be significant in level 1% too.

It should be mentioned that all the statistical analysis in this research were conducted in statistical and programming environment ofR.

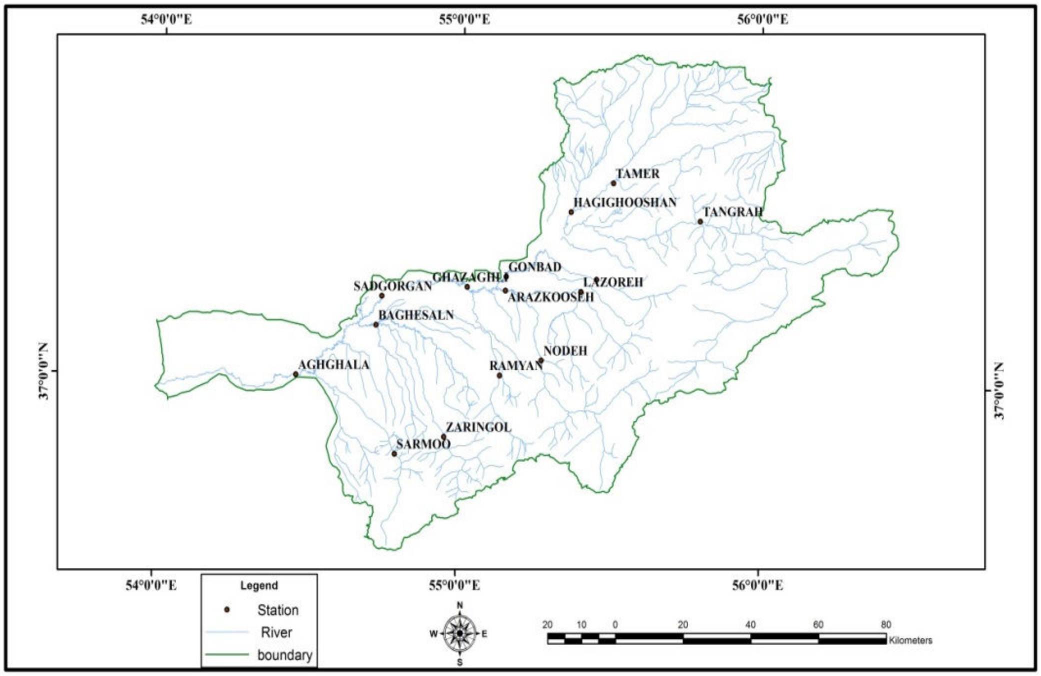

Figure 1. Location of evaluated stations in Golestan province map.

RESULTS

First, the independency and normality of data were tested separately in all the stations. To evaluate the independency of data, autocorrelation coefficients for different delay steps for each of observation series in all stations were calculated and then depicted on graphs of autocorrelation function (ACF).Results of calculations for all stations in discharge and sediment data series showed that for delay steps of 1-5 years, different temporal steps are independent. For example, ACF graphs of annual observed series of flow discharge in two stations of Ghazagholi and Bagheh are presented in figure 2. In this figure it is observed for observation series in both stations, autocorrelation coefficients of consecutive data with delay steps of 1-5 years occurs out of confidence level of 95%. Since the number of observation series in studied stations is lengthy and the value of observed trend observation series of number of rainy days is high for all stations and because in confidence level of 99% the observed trends are significant, the effect of autocorrelation coefficient on results of trend test was supposed negligible.

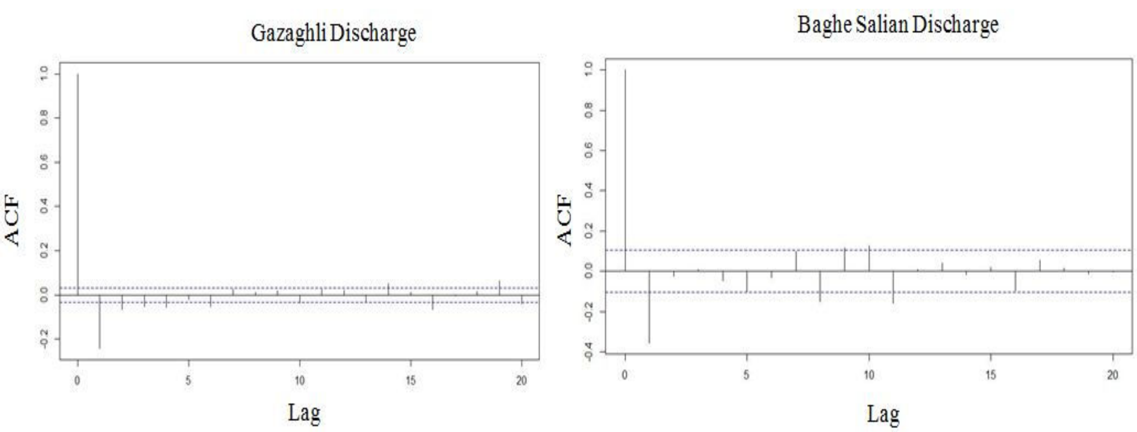

Figure 2. Diagram of autocorrelation coefficients of annual observation series related to flow discharge in two stations of Ghazagholi and Bagheh.

To evaluatethe condition of absence of data normality for using the Man Candle test, the results ofshapiro-wilk testare presented in figures 1 and 2. Results show that none of the assessed stations in observation series of discharge and sediment (both annually and seasonally) in confidence level of 99% does not follow normal distribution. Because, obtained p value for shapiro-wilk parameter was lower than 0.01. There are many statistical methods to test the normality of observation series, but most of experts use only QQplot graphical test (Hazleton,2003). In this investigation, comparing results of QQplot graphs with results of shapiro-wilk statistical test showed that when statistical test exhibit some observation series as abnormal, also QQplot graph confirms this situation. So, for abnormal observation series in begining and end of the graph, it shows very high skewness which exhibit data abnormality. To compare normal and abnormal series on QQplot graph, anuual discharge and sediment series of Ghazagholi station is presented in figure 2. As it is observed, a very high skewness is observed in begining and end of all QQplot graphs. For this station, also shapiro-wilk test confirms the abnormality of discharge and sediment distribution (tables 1 and 2). Since anuual and seasonal discharge and sediment series in all stations does not follow normal distribution, it could be concluded that use of nonparametric Man Candle test to analyze data trend of discharge and sediment is a proper method.

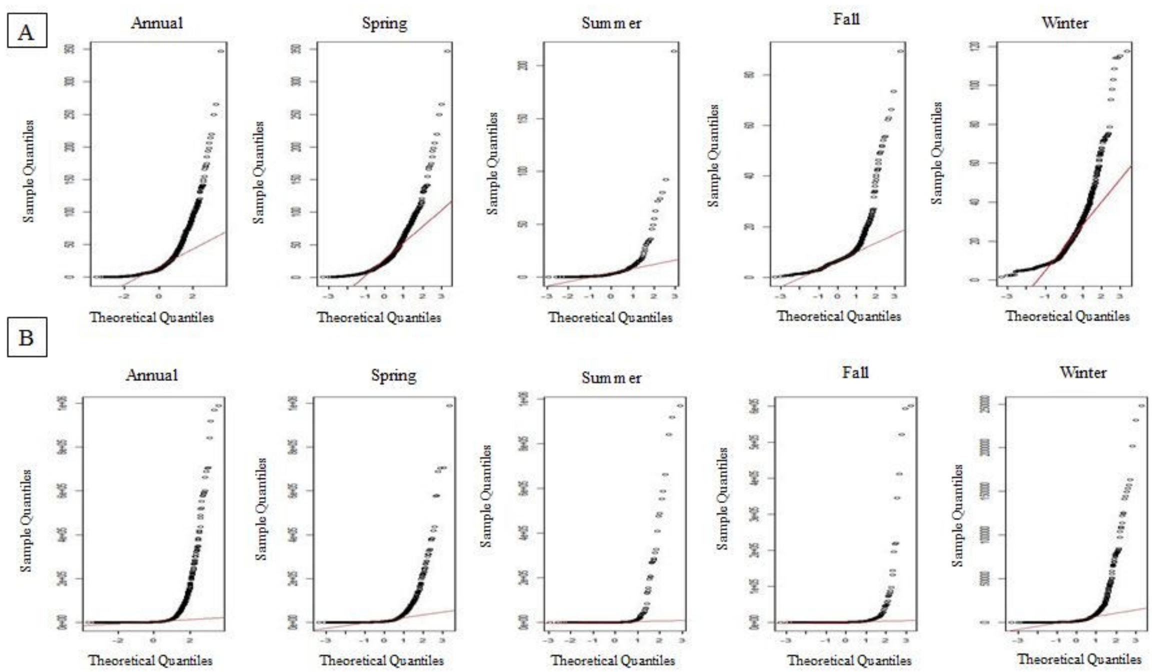

Figure 3. QQplot graphs (A: flow discharge, B: sediment) Ghazagholi station in annual and seasonal series.

Table 1. Results of shapiro-wilk to recognize normality and abnormality of discharge observation series in studied stations.

Station	annual		spring		summery		autumn		winter	
	P	W	P	W	P	W	P	W	P	W
Agh-Ghala	0.000	0.69	0.000	0.82	0.000	0.06	0.000	0.75	0.000	0.71
Araz-Kouseh	0.000	0.67	0.000	0.74	0.000	0.29	0.000	0.29	0.000	0.8
Bagheh-Salian	0.000	0.44	0.000	0.56	0.000	0.45	0.000	0.7	0.000	0.82
Gonbad	0.000	0.47	0.000	0.61	0.000	0.1	0.000	0.96	0.000	0.86
Lezoreh	0.000	0.71	0.000	0.87	0.000	0.83	0.000	0.88	0.000	0.74
Ramian	0.000	0.59	0.000	0.74	0.000	0.34	0.000	0.76	0.000	0.62
Ghazagholi	0.000	0.66	0.000	0.77	0.000	0.37	0.000	0.6	0.000	0.77
Haji-Ghochan	0.000	0.68	0.0001	0.88	0.000	0.59	0.000	0.86	0.000	0.82
Nudeh	0.000	0.42	0.000	0.44	0.000	0.51	0.002	0.96	0.000	0.75
Sarmo	0.000	0.71	0.000	0.91	0.000	0.59	0.000	0.57	0.000	0.85
Tangrah	0.000	0.55	0.000	0.7	0.000	0.76	0.000	0.63	0.000	0.78
Gorgandam	0.000	0.58	0.000	0.7	0.000	0.52	0.000	0.9	0.000	0.82
Tamar	0.000	0.65	0.000	0.67	0.000	0.32	0.000	0.8	0.000	0.76
Zarin-Gol	0.000	0.62	0.000	0.76	0.000	0.73	0.000	0.88	0.000	0.86

Table 2. Results of shapiro-wilk to recognize normality and abnormality of sediment observation series in studied stations.

Station	annual		spring		summery		autumn		winter	
	P	W	P	W	P	W	P	W	P	W
Agh-Ghala	0.000	0.11	0.000	0.14	0.000	0.14	0.000	0.41	0.000	0.15
Araz-Kouseh	0.000	0.16	0.000	0.17	0.000	0.13	0.000	0.15	0.000	0.23
Bagheh-Salian	0.000	0.07	0.000	0.18	0.000	0.17	0.000	0.34	0.000	0.59
Gonbad	0.000	0.34	0.000	0.49	0.000	0.14	0.000	0.28	0.000	0.24
Lezoreh	0.000	0.2	0.000	0.28	0.000	0.27	0.000	0.19	0.000	0.23
Ramian	0.000	0.08	0.000	0.16	0.000	0.15	0.000	0.38	0.000	0.26
Ghazagholi	0.000	0.26	0.000	0.37	0.000	0.3	0.000	0.13	0.000	0.36
Haji-Ghochan	0.000	0.19	0.000	0.47	0.000	0.21	0.000	0.3	0.000	0.35
Nudeh	0.000	0.08	0.000	0.13	0.000	0.11	0.000	0.43	0.000	0.42
Sarmo	0.000	0.19	0.000	0.32	0.000	0.39	0.000	0.13	0.000	0.33
Tangrah	0.000	0.09	0.000	0.21	0.000	0.13	0.000	0.16	0.000	0.38
Gorgandam	0.000	0.14	0.000	0.16	0.000	0.1	0.000	0.28	0.000	0.2
Tamar	0.000	0.16	0.000	0.24	0.000	0.2	0.000	0.09	0.000	0.06
Zarin-Gol	0.000	0.04	0.000	0.1	0.000	0.2	0.000	0.24	0.000	0.53

Statistical analysis of discharge data using Man Candle shows the significant decreasing trend in most of the studied stations at level of 1%. Only, station of Gonbad shows the significantincreasing trendat level of 5% for annual discharge observation, and there is no significant trendin stations Lezoreh, Ramian, Nudeh, and Tangrah. For seasonal discharges, in spring season most of stations show the decreasing trend. Stations Yagheh-salian, Gonbad, Ramian, Nudeh, Sarmo and Tangrah have not any trend in spring in the viewpoint of flow discharge, but other stations have significant decreasing trend. Also, in summer, autumn and winter most of stations show the significant decreasing trend in studied levels. In summer, stations Agh-ghola and Gonbad have significant increasing trend at confidence level of 99% and stations Araz-Kouseh, Bagheh-Salian, Lezoreh, Nudeh and Salian have not any significant trend. In autumn, stations Gonbad and Gharagholi have increasing trend and stations Sarmo and Tamr have significant decreasing trend at confidence level of 99%, station Haji-Ghochan has significant decreasing trend at confidence level of 95%. In this season, other stations do not show any significant trend in studied levels. In winter, stations Gonbad, Nudehand Gharagholihave significant increasing trendand stations Lezoreh, Ramian, Sarmo, Tangrah and Zarin-Gol have not significant trend. Other stations have significant decreasing trend (Table 3).

Assessing the trend of annual sediment series (similar to flow discharge)shows the significant decreasing trend for most stations. So, Ramian and Gharagholi have not significant trend but other stations show significant decreasing trend. Also, in assessing seasonal discharge there is a significant decreasing trend for most of the stations. Only station Gharagholi in autumn and winter, and station Gonbad in winter have shown significant increasing trend.

Table 3. results of Man Candle test to recognize data trends in discharge observation series in studied stations.

Station	annual		spring		summery		autumn		winter	
	P_valu	tau	P_valu	tau	P_valu	tau	P_valu	tau	P_valu	tau
Agh-Ghala	0.013	-0.04	0.001	-0.11	0.000	0.21	0.2	-0.005	0.86	0.006
Araz-Kouseh	0.000	-0.12	0.003	-0.1	0.08	-0.09	0.56	-0.02	0.000	-0.13
Bagheh-Salian	0.000	-0.15	0.13	-0.1	0.18	-0.1	0.14	-0.09	0.0001	-0.26
Gonbad	0.03	0.02	0.42	0.01	0.000	0.16	0.000	0.14	0.0003	0.07
Lezoreh	0.17	-0.04	0.7	-0.02	0.01	-0.12	0.38	-0.06	0.6	-0.03
Ramian	0.5	-0.02	0.69	-0.02	0.02	-0.18	0.66	-0.03	0.17	-0.08
Ghazagholi	0.05	-0.02	0.000	-0.1	0.006	-0.01	0.000	0.09	0.05	0.03
Haji-Ghochan	0.000	-0.3	0.003	-0.27	0.05	-0.25	0.02	-0.02	0.0001	-0.37
Nudeh	0.26	0.03	0.27	-0.05	0.52	0.03	0.49	-0.04	0.01	0.13
Sarmo	0.0002	-0.13	0.12	-0.11	0.01	-0.21	0.008	-0.2	0.62	-0.03
Tangrah	0.24	-0.03	0.56	0.03	0.76	0.02	0.32	-0.07	0.2	-0.08
Gorgandam	0.000	-0.08	0.000	-0.09	0.000	-0.13	0.25	-0.02	0.000	-0.12
Tamar	0.000	-0.23	0.000	-0.18	0.06	-0.1	0.000	-0.26	0.000	-0.18
Zarin-Gol	0.0003	-0.11	0.03	-0.12	0.005	-0.16	0.51	-0.04	0.14	-0.09

CONCLUSIONS

Based on obtained results of this investigation and other similar questions it could be suggested that possibility of parametric methods such as linear regression to study and assess the data trend is limited because of assumptions that are included in their application. In this study, it was recognized that none of the annual and seasonal observations related to discharge and sediment are not normal in any of assessed stations, whereas the condition of being normal is one of the prerequisites of linear regression method. Analysis of the trend of annual and seasonal discharge and sediment in assessed stations showed that in most stations the direction of trend is decreasing. Though the trend magnitude in different stations and seasons is diverse according to Tavo index, it could be concluded that the amount of river discharge and thereby the amount of transported sediment in rivers have decreasing trend in station locations. Results show that when we divide discharge and sediment to categories and some times, the trend assessment will be possible with greater sensitivity and accuracy and the better results could be attained. In assessing the variation trend in discharge and sediment data (both seasonally and categorized), effect of lower points will be decrease and estimation of sedimentation in very high discharges could be improved. Also, categorizing discharges to different classes allows measuring more properly the effect of high and low discharges on sediment rating curve. Additionally, the effect of high and flood discharges (which their multitude islow) on sediment rating curve is low,if discharge is not classified according to classes and seasons with frequent normal and low discharges. Generally, it could be suggested that for assessment variability of discharge and suspended load, use of categorized data in specific values or use of temporal periods for assessment relationship sediment discharge and flow could leads to better results.

Table 4. results of Man Candle test to recognize data trends in sediment observation series in studied stations.

Station	annual		spring		summery		autumn		winter	
	P_valu	tau	P_valu	tau	P_valu	tau	P_valu	tau	P_valu	tau
Agh-Ghala	0.000	-0.17	0.000	-0.25	0.001	-0.16	0.12	0.06	0.021	-0.09
Araz-Kouseh	0.000	-0.24	0.000	-0.29	0.000	-0.22	0.71	0.01	0.000	-0.26
Bagheh-Salian	0.000	-0.14	0.37	-0.06	0.17	-0.19	0.22	0.08	0.000	-0.29
Gonbad	0.000	-0.08	0.0002	-0.07	0.89	0.004	0.8	-0.007	0.000	0.16
Lezoreh	0.0004	-0.12	0.65	0.034	0.006	-0.21	0.025	-0.16	0.035	-0.14
Ramian	0.12	0.052	0.37	0.05	0.11	-0.12	0.08	0.11	0.46	0.04
Ghazagholi	0.11	-0.01	0.000	-0.15	0.44	-0.02	0.000	0.07	0.000	-0.09
Haji-Ghochan	0.000	-0.03	0.08	-0.27	0.03	-0.25	0.81	-0.2	0.0009	-0.37
Nudeh	0.000	-0.15	0.002	-0.16	0.0001	-0.21	0.24	-0.07	0.001	-0.18
Sarmo	0.014	-0.09	0.18	-0.09	0.24	-0.1	0.014	-0.18	0.22	-0.09
Tangrah	0.000	-0.16	0.72	-0.02	0.025	-0.16	0.000	-0.34	0.019	-0.15
Gorgandam	0.000	-0.12	0.000	-0.2	0.000	-0.21	0.03	-0.05	0.000	-0.13
Tamar	0.000	-0.24	0.000	-0.26	0.003	-0.16	0.0002	-0.19	0.000	-0.16
Zarin-Gol	0.000	-0.21	0.001	-0.18	0.000	-0.3	0.0003	-0.22	0.0002	-0.22

REFRENCES

Fattahi M, Moghaddam R.2009. Trend analysis of quantitative and qualitative Water resources changes in Qom watershed. Fifth National Conference on Science and Watershed Engineering of Iran, Gorgan. 12 pp.

Ghazizadeh N, Sahnizadeh B.2009. Trend analysis of qualitative changes in 2006-2007 years in Karkheh River. Tertiary National Conference Water Resources Management of Iran, Tabriz. 6 pp.

Haan CT.2003. Statistical methods in hydrology. Second ed., Blackwell Publishing.

Harijani F, Kohestani N. 2007.Suggestion of appropriate equation to estimate of sediment transport rate in Sajarood Watershed, Zanjan Province. FourthNational Conference on Science and Watershed Engineering of Iran, Tehran. 8 pp.

Hazelton ML.2003. A graphical tool for assessing normality. The American statistician,vol.57, 285- 288.

Hejam S, Koshkho Y, Shamsoddinvandi R.2008. Trend analysis of annual seasonal precipitation changes using the non-parametric methods in several stations, central Iran basin. Geographical Research Quarterly. No, 64. 12 pp.

Hicks DM, Gomez B, Trustrum NA.2000. Erosion Thresholds and Suspended Sediment Yields, Waipaoa River Basin, New Zealand, Water Resources Research, 36(4), 1129-1142.

Horowitz AJ.2002. The use of rating (Transport) curves to predict suspended sediment concentration: ammeter of temporal resolution, turbidity and other sediment surrogates workshop.

Kaviany MR, Asakereh H.2005. Statistical Study of Annual Precipitation Trend in Isfahan. Vol. 18, 20 pp.

Lettenmaier DP, Wood EF, Wallis JR.1994. Hydro-climatological trends in the Continental United States, 1948-88. Journal of Climate, 7: 586-607.

Mitchell JM, Dzerdzeevskii B, Flohn H, Hofmeyr WL, Lamb HH, Rao KN, Wallen CC.1966. Climate change. WMO Technical Note No. 79. World Meteorological Organization. 79pp.

Olive LJ, Reiger WA.1992. Stream Suspended Sediment Transport Monitoring – Why, How and What IS Being Measured? IAHS Public, No: 210.

Sadeghi SHR, Tofighi B, Mahdavi M.2006. Sediment Estimation Modeling in Zarrinderakht Watershed. Iranian J. Natural Res., Vol. 58, No. 4. 9pp.

Sadeghi SHR.2005. Development of Sediment Rating Curve Equations for Rising and Falling Limbs of Hidrograph Using Regression Concept. Jornal of Iran-Water Resources Research. Volume 1, No 1.

Sheikh V, Babaei A, Moshakhian Y.2009. Trend Analysis of precipitation Regime in the Gorganroud Basin. Iran-Watershed Management Science & Engineering. Vol. 3, No. 8. 11 pp.

Von Storch H.1995. Misuses of statistical analysis in climate research. In: Von Storch, H. & Navarra (Eds.), Analysis of Climate Variability: Applications of Statistical Techniques, Springer, Berlin.

Walling DE.1994. Measuring Sediment Yield From River Basins, in: R. Lal (Edd.), Soil Erosion Research Methods, Soil and Water Conservation Society. Pub 1,2nd edition, 39-83.