*Available online www.jocpr.com*

**Journal of Chemical and Pharmaceutical Research, 2016, 8(3):541-547**

**Research Article**

**ISSN : 0975-7384**
**CODEN(USA) : JCPRC5**

# Discharge changes and the impact on water quality in Karoon River, Iran

**Dariush Rahimi* and Ali Baratian**

*Physical Geography Department, Geographical Science Faculty, University of Isfahan, Isfahan, Iran*

---

**ABSTRACT**

*Quality of water is gaining great importance with the rising pressure on industry's and agriculture and rise in standard living. The Karoon sub-river systems, located in the south west Iran, have been considered as an important water source for people in the area southwards. The Karoon River originals from the Zagros Mountain range and the Kohrang River joins it and form a great river called the North Karoon. We used data samples water quality (SAR, Cation$^+$, Anion$^-$, EC, TDS and $P^H$) and discharge at 1983-2013 period. The results M-k test show that SAR, Cation$^+$, Anion$^-$, $P^H$, EC and TDS have upper ward but discharge has downward trend at period(1982-2013). Other results show that the calculated Z element SAR, Cation$^+$,Anion$^-$,$P^H$,EC and TDS are $z \geq + 1.96$ that these amounts show elements have upper ward. There is enough evidence to determine that there is an upper ward trend. The calculated z discharge is -1.2 that it was $\geq$ - 1.96. Discharge has down ward trend. There is not enough evidence to determine that there is a downward trend. The results show that elements chemistry have upward trend but discharge has downward trend at Armand station.*

**Key word**: Karoon River, Discharge, Water Quality, PH, EC.

---

## INTRODUCTION

Water quality is assuming great importance with the rising pressure on industries and agriculture and rise in standard of living [15]. The quality of water is a subject of continuing concern and because of inextricably linked to water quantity, it is very important for the hydrologist to understand the significance of developing and modeling techniques that can accommodate both the features. The assessment of long-term water quality changes is also a challenging problem. Water quality has been rapidly declining worldwide particularly in developing countries due to natural and anthropogenic processes [26]. During the last decades, there has been an increasing demand for monitoring water quality of many rivers by regular measurements of various water quality variables. The major chemical elements of many world's major rivers have been studied, especially the East China [13], the Amazon [27, 28, 29], the Lena [12, 8]. The study of stream geochemistry reveals the pattern and linkage between evaporation, chemical weathering, precipitation and anthropogenic impacts [21].

Changes in air temperature and rainfall could affect river flows and, hence, the mobility and strength of contaminants. With increased flows, there will be changes in stream power and, hence, sediment loads with the potential to alter the morphology of rivers and the transfer of sediments to lakes, thereby impacting freshwater habitats in both lake and stream systems. Storms that terminate drought periods will flush nutrients from urban and rural areas or generate acid pulses in acidified upland catchments [24].

The results of these studies compiled as reliable long-term water quality records and the examination of this data for long-term trends [6]. Quantifying the major ion composition of stream waters also has broad implications, i.e., water quality type, hydrogeology characteristics, weathering processes and rainfall chemistry [2, 3]. The researchers [1] used such databases for research and water quality and quantity from 38 rivers out of 25 watersheds from 1995 to 2002 in Turkey. The researchers [4,13and14] were also studied geochemistry and heavy metal of the upper Han River basin and Yellow River to determine the spatial patterns of major ion composition, and to identify their sources and controlling factors. The results studied [4, 26] relationship with runoff and sediment load from 1983 to 2011 in Yellow River Delta. The results shows that the Yellow River experienced progressively severe droughts that reduced both runoff and sediment load to its delta lobe. Naddafi et.al and Karamoua *et.al*, studied about water quality in south Karoon(from Gotevand to Khorramshahr staions).They showed that drainage network, petroleum industrial and food industrial reason decreasing water quality this part of Karoon[16,22]. The furthermore; the population of North Karoon basin is about 5,000,000 persons. In fact, this river has important role supply water for Khuzestan province in south west of Iran. This regional is one of the industrial and agriculture in Iran. The Karoon river water is collecting behind Karoon1, 2,3and 4Dams for use drinking water, Industrials and agriculture in south west of Iran [18, 26 and 30].

## EXPERIMENTAL SECTION

**Material:**

The North Karoon basin with a 10500-km2 area is a sub basin of ground Karoon River located in south west of Iran. The origin of Karoon River is in the Zagros Mountain range and the Kohrang River joins it, and they south form a great river called the North Karoon[23] (Fig.1).

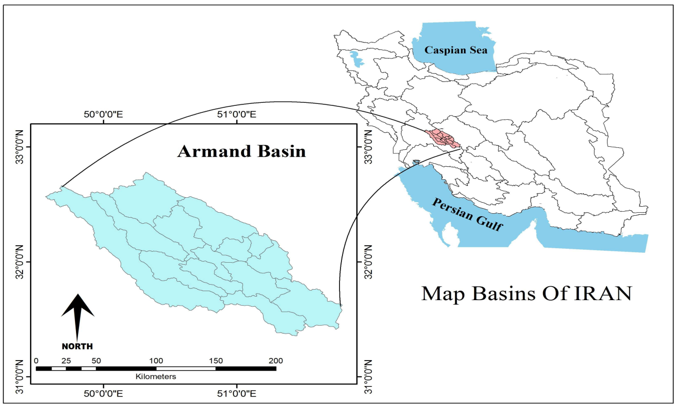



**Fig.1. The location of North Karoon basin and Armand station**

The samples are 455 that they collected by Chaharmahal and Bakhtiari Regional Water (CBRW) (Table.1)from October 1981 to September 2013.The samples collected do analysis by CBRW. This data are monthly in the time series 1980 to 2013.Monthly measurements of the discharge and water quality variables were obtained, and monitored the Armand station (include branch Sarab, Kohesookhteh, Dehcheshmeh and Kharaji) of the Karoon River by CHRW (Table 1). We used this data in two separate times (monthly and yearly) [18, 30].

**Table 1. Characteristics of the main Stations in North Karoon**

| Station | longitude° | latitude° | Rainfall mean(mm) | Elevation (m ) |
|---|---|---|---|---|
| Sarab | 50-28 | 32-20 | 820 | 2200 |
| Darkesh | 50-38 | 32-02 | 750 | 1850 |
| Jonghan | 50-39 | 32-07 | 730 | 1930 |
| Kharvrood | 50-50 | 32-19 | 340 | 1980 |
| Kohesookhteh | 50-39 | 32-06 | 360 | 2030 |
| Dehcheshmeh | 50-33 | 32-13 | 560 | 2050 |
| Kharaji | 50-50 | 32-04 | 430 | 2070 |
| Beheshtabad | 50-38 | 32-03 | 650 | 1650 |
| Armand | 50-46 | 31-41 | 800 | 900 |

The following variables are measured by CBRW: above (Q) as m3/s, pH, electrical conductivity (EC) as µs/cm, Total dissolved solid (TDS), chlorides ($Cl^-$) ($Anion^-$), $Cation^+$ include elements: (sodium ($Na^+$), potassium ($K^+$), Magnesium ($Mg2^+$), calcium (Ca2+)) , Sodium Absorption Ratio (SAR), temporary hardness and total hardness as meq/l at the above stations (Table1). The monitoring data of these variables are available for the analysis as presented in this paper on monthly and yearly basis for the period of 1981-2013.

**Methodology:**

Monthly average and yearly of the data time series have analyzed by statistical methods. Parametric and non-parametric statistical methods were use correlation (Pearson (Ш), Mann-Kendall (MK) [17, 19].The significance level in this study was $p < 0.05$.To evaluated the impact of discharge on water quality by correlation coefficient and trend analysis by Mann-Kenddal test. In this study are used correlation Pearson (Ш), multivariable linear model and Man-Kendal Model for determined trend. Equation 1

$$r = \frac{\sum_{i=1}^{n}(x_i - \overline{x})(y_i - \overline{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \overline{x})^2 \sum_{i=1}^{n}(y_i - \overline{y})^2}}$$

An aspect of technical analysis that tries to predict the future movement of a stock based on past data. Trend analysis based on the idea that what has happened in the past gives traders an idea of what will happen in the future. A trend can be creating as the general movement over time of a statistically detectable change [9].The MK test, usually used to assess the trend of a time-series. The purpose of the Mann-Kendall (MK) test [17,19,10] is statistically assess if there is a monotonic upward or downward trend of the variable of interest over time. A monotonic upward (downward) trend means that the variable consistently increases (decreases) through time, but the trend may or may not be linear. The MK test is using to in place of a parametric linear regression analysis, which is used to test if the slope of the estimated linear regression line is different from zero [11, 5, and 7]. A trend can be creating as the general movement over time of a statistically detectable change [9]. If the calculated $z \geq +1.96$ there is an upward and or $z \leq -1.96$ there is downward trend at alpha $\geq 0.05$.The regression analysis requires that the residuals from the fitted regression line be normally distributed; an assumption not required by the MK test, that is, the MK test is a non-parametric (distribution-free) test (Equation 2, 3, and 4).

(2) $$Z_c = \begin{cases} \frac{S-1}{\sqrt{\mathrm{var}(s)}}, & S > 0 \\ 0, & S = 0 \\ \frac{S+1}{\mathrm{var}(s)}, & S < 0 \end{cases}$$ Where: (3) $$S = \sum_{i=k}^{n-1} \sum_{k=i+1}^{n} sgn(x_k - x_i),$$

(3) $$sgn(x_k - x_i) = \begin{cases} 1, & x_k > x_i \\ 0, & x_k = x_i \\ -1, & x_k < x_i \end{cases}$$

In which the $x_k$, xi are the sequential data values, n is the length of the data set, t is the extent of any given tie, and $\sum$ denotes the summation over all ties.

## RESULTS AND DISCUSSION

This basin has an important role in drinking water supply. Geology formations, industrial, agriculture and humans actives have the main role in decreasing water quality in this basin. The annual precipitation mean in this basin is 770 mm with an annual water volume of 2.1 billion m3. Geology formations, industrial and agriculture actives have the main role in decreasing water quality in this basin.

The formation of this basin is sedimentary. Lithologies of the rocks are limestone, marl, sandstone, dolomite and gypsum. In addition, formation of Hormuz complex contain salt red, marl, sandstone and red shale with an igneous composition. In terms of tectonic, North Karoon affected by Dopolan fault. This fault is parallel to main Zagros fault direction. Geologically, Hormmoz Formation is the oldest known formation in this area with an age from pre Cambrian to middle Cambrian. The type of Hormmoz formation consists of salt, prêt marls with interlayer lime, sandstone and marl. Due to its salt formation feature in the direction of Dopolan Fault, the Hormmoz formation has cut the younger formations and reached the surface, and its facials are Hormmoz formation with northeast-southwest direction.

**Quality analyses:**
Table 2 shows that statistical profile of the North Karoon River. SAR values vary from 0.06 to 6.90. Cation values vary from 10.60 to 0.01. The pH values and anions concentration changed from 7.0 to 9.1 and 0.6 to 8.8, respectively. This appeared to be a significant difference in EC among the winter, summer and transition (April and October) months ($P<0.05$). Between May and December, an increase was observed in EC occurred from 146 to 859 µohm cm−1.Increases from 0.01 to 1.6 meq l−1 in K between January and October (Table 2).

**Table2. Mean annual values of water quality characteristics of North Karoon Basin in Armand station**

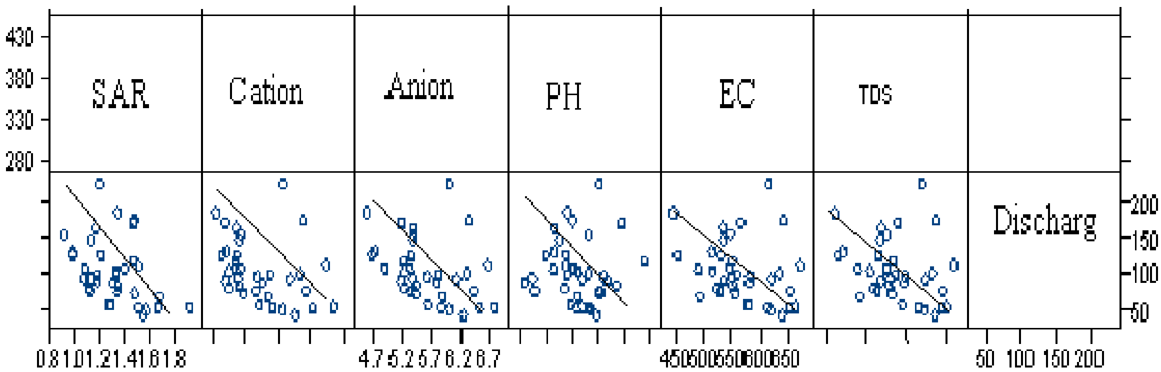
| Element | N | Mean | Standard | Max | Min | Range | Skw | kurt |
|---|---|---|---|---|---|---|---|---|
| SAR | 1078 | 0.66 | 0.89 | 6.90 | 0.06 | 6.84 | 4.59 | 22.96 |
| Cation$^+$ | 1104 | 4.45 | 1.36 | 10.60 | 0.01 | 10.59 | -0.73 | 2.24 |
| Anion$^-$ | 1104 | 4.40 | 1.34 | 8.80 | 0.20 | 8.60 | -0.66 | 1.25 |
| PH | 1104 | 7.97 | 0.32 | 9.10 | 7.00 | 2.10 | -0.04 | 0.68 |
| EC | 1104 | 451.31 | 107.79 | 859.00 | 146.00 | 713.00 | 0.26 | -0.02 |
| TDS | 1104 | 293.44 | 70.28 | 558.00 | 95.00 | 463.00 | 0.27 | 0.01 |
| Discharge | 1102 | 109 | 120.34 | 1061 | 54 | 1007 | 3.86 | 21.15 |

The results of simple correlation applied between each water quality variables concentration and the discharge (Annual mean and Monthly mean) monitored at the Armand stations of the Karoon River give in Table 3.

Among the test stations, the max concentration was determined in Armand station (r=-0.40). Anions (So4-2, Cl, HCO3-, CO3-2) concentration increased in discharge in the station (r=0.48). Therefore, the concentrations the Cation and Anion increased in these samples. SAR showed decrease during increased discharge. EC (r=-0.3), pH (r=-0.01) and TDS (r=-0.3) were increased during increased discharge (Table 3, Annual Discharge). In addition, there is an inverse relationship between the discharge and the concentration of chemical factors(Table 3).SAR(-0.63),cation(-0.75),Anion(-0.75), pH(-0.05),EC(-0.76)and TDS(-0.76) were decrease chemical during increased discharge(Table3,Graph1).

**Table3. The correlation between discharge and chemical elements in Armand station**

| | SAR | Cation | Anion | pH | EC | TDS |
|---|---|---|---|---|---|---|
| Disc(annual) | -0.40 | -0.33 | -0.35 | -0.01 | -0.29 | -0.29 |
| Disc(Monthly) | -0.63 | -0.75 | -0.75 | -0.05 | -0.76 | -0.76 |




**Graph1.Matrix correlation between chemical elements and discharge in Armand station**

**Trend analysis:**
Trend analysis is based on the idea that what has happened in the past gives traders an idea of what will happen in the future[5,7]. The results M-k test show that SAR, Cation$^+$,Anion$^-$,P$^H$,EC and TDS have upper ward but discharge has downward trend at period(1982-2013).Other results show that the calculated Z element SAR, Cation$^+$,Anion$^-$, P$^H$, EC and TDS are $z \geq + 1.96$ that these amounts show elements have upper ward(graph2,3,4,5,6 and 7). There is enough evidence to determine that there is an upper ward trend. The calculated z discharge is -1.2 that it was $\geq$ -1.96. Discharge has down ward trend (graph.8) there is not enough evidence to determine that there is a downward trend. The results show that elements chemistry have upward trend but discharge has downward trend at Armand station Table .4.

**Table4. Mann-Kendall Trend Test by Normal Approximation in Armand station**

| Mann-Kendall | SAR | Cation | Anion | pH | EC | TDS | Discharge |
|---|---|---|---|---|---|---|---|
| The calculated z | 3 | 4.43 | 4.3 | 2 | 5.9 | 5.78 | -1.2 |
| P-value | 0.01 | 0.004 | 0.008 | 0.02 | 0.001 | 0.001 | 0.01 |

The calculated z > + 1.96 and -1.96, For Ha: Upper and Down ward trend, at alpha = 0.05, there is enough evidence to determine that there is an upward trend.

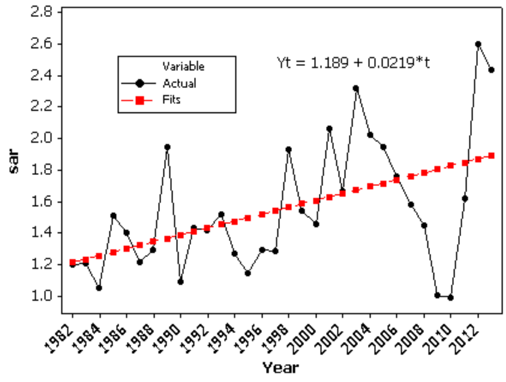



**Fig2.Time series and trend line Cation[+](Armand)**

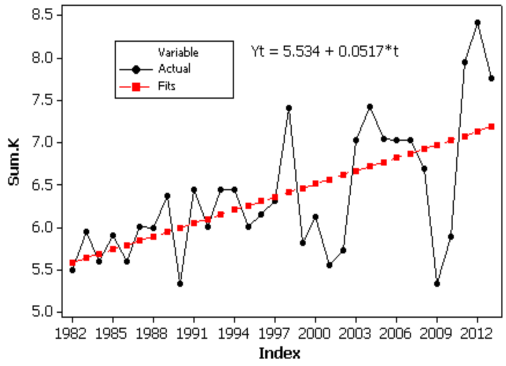



**Fig3.Time series and trend line SAR (Armand)**

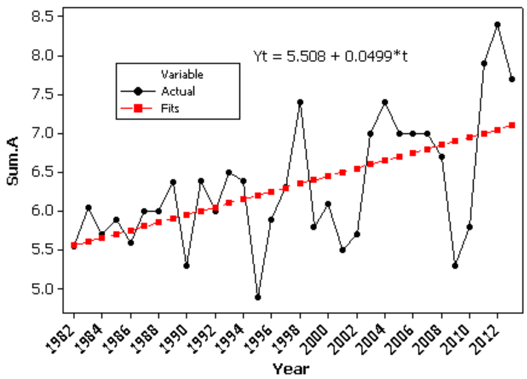



**Fig4.Time series and trend line P[H] (Armand)**

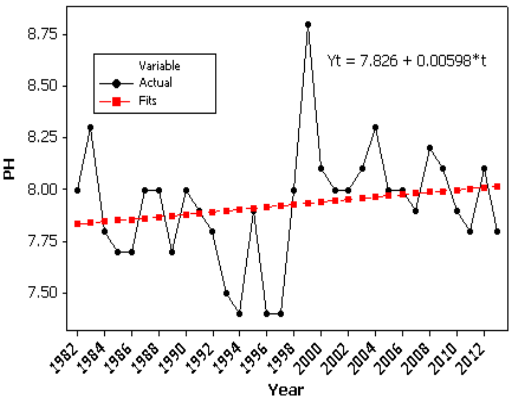



**Fig5. Time series and trend line Anion[-](Armand)**

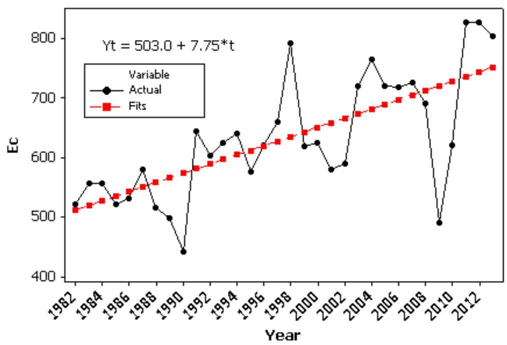



**Fig6.Time series and trend line TDS (Armand)**

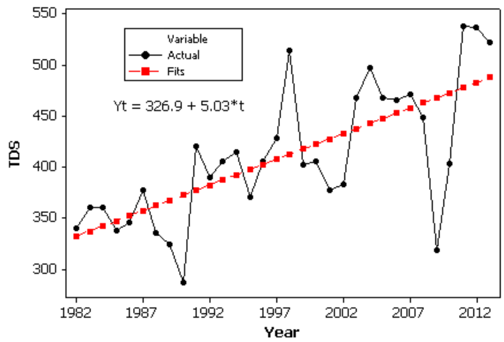



**Fig7. Time series and trend line EC(Armand)**

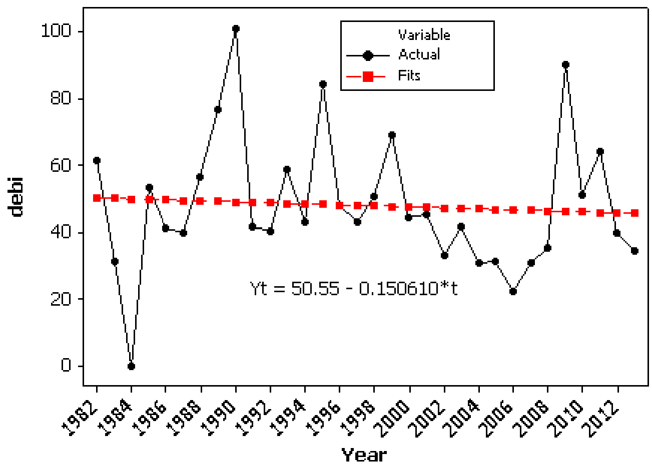



**Fig8.Time series and trend line Discharge (Armand)**

The results showed that the discharge rate change was effective on the water quality in Karoon River. Therefore, droughts, overharvesting and transportation among water basins increase the concentration of $Cations^+$,$Anion^-$ ,SAR,$P^H$,EC and TDS. Increased use of chemical fertilizers, destruction of vegetation and pastures, decrease runoff, salt formation and dissolution of maximum discharge rain is more anion concentrations PH ,TDS and EC.

In all samples, water PH is intermitted rates, 6.5 to 8, range and it observed acidic and base feature of water. By comparing the results of analysis, the water PH is in permitted limit and the Hormmoz formation just makes Karoon River pollute locally. However, the juncture of access branches to the river make it dilute and cleanse water salinity in low positions. After joining Hormmoz formation with Karoon River, just their TDS, EC, $anion^-$ and $cations^+$ increases and the river did not become salty.

## CONCLUSION

The results of upper points of Karoon River with the salt Formation and low positions samples in the route of the river showed that, because of much entering dissolved materials from the salt dome to the river, only river water TDS, EC and PH increases and the river did not become salty. Based on the calculations made on the spot, the SAR, $Cation^+$,$Anion^-$ ,TDS, EC and PH volumes have increased at Armand station. This increase is because the river runs over the Hormoz salt formations in the region and down warn trend discharge. This increase in the concentration of diluted chemicals in the water is in direct relation with the decrease in discharge volume. Another fact that makes the river water quality low is the presence of discharged agricultural, industrial and residential wastewater entering the river when the river water level is low. In fact, the discharge fluctuation of the river under increasing condition, which increases the Hormoz salt formation erosion, leads to the intensity in the water basin lime formations that increase the chemical substance concentrations. However, along the river, the salt dome make the spring salty locally. If we have added down ward trend discharge, drought, consumption increasing and climate change on discharge change in Karoon River; thus, water quality will be very bad in Karoon River. So, the project of inter basin transition water from Karoon River to Zayandehrood River (Behesht Abad Tunnel), drought events and the decrease of discharge rate in future, threaten the river water quality a lot.

**Acknowledgment**
The authors gratefully acknowledge the IWRMC (Iran Water Resources Management Company) and CBRW (Chaharmahal & Bakhtiari Regional Water) for financial support.

## REFERENCES

[1] Berkant, O., & Fatih, E., (**2007**). *Journal of Environ Monit Assess* 133:215–229.
[2] Brennan S.K., & Lowenstein, T.K., (**2002**). *Journal of Geochim. Cosmochim. Acta* 66: 2683–2700.
[3] Cruz J.v, and Amaral C.S., (**2004**). *Journal of Appl. Geochem*. 19: 445–459.
[4] Dongxian Konga, ,Chiyuan Miaoa, b,Alistair G.L. Borthwickc, Qingyun Duana, Hao Liud,Qiaohong Suna, Aizhong Yea, Zhenhua Dia,Wei Gonga,(**2015**), *Journal of Hydrology*, Volume 520, 2015, Pages 157–167.
[5] Esterby, S.R.(**1998**), *Hydrological Processes* 10:127-149.
[6] Hirsch, R.M., J.R. Slack, and R.A. Smith. (**1982**), *Water Resources Research* 18(1):107-121.
[7] Hirsch, R. M., Alexander, R. B., & Smith, R. A.,(**1991**), *Journal of Water Resources Research*, 27: 803–813.
[8] Huh, Y., Panteleyev, G., Babich, D., Zaitsev, A., Edmond, J.M.,(**1998**), *Geochim. Cosmochim. Acta* 62, 2053–2075.
[9] Gary Benattar_ and Philippe Trebuchet,(**2011**), Trend Analysis in Polls, Topics, Opinions and Answers, HAL Id: hal-00601261.
[10] Gilbert, R.O. (**1987**), Statistical Methods for Environmental Pollution Monitoring, Wiley, NY.
[11] Gibbons, J.D, and S.Chakraborti,(**2003**),Nonparametric Statistical Inference, Marcel Dekker,NY.
[12] Gordeev, V.V., Sidorov, L.S,(**1993**), *Mar. Chem*. 43, 33–45.
[13] Jiabo Chen, Jun Lu,(20**14**), *PLOS ONE* , **2014**, Volume 9,Issue 8.
[14] Junhong Baia, b,Qingqing Zhaoa,Qiongqiong Lua, Junjing Wanga, K. Ramesh Reddy,(**2015**), *Journal of Hydrology*, Volume 520, 2015, Pages 186–192.
[15] R. K. Isaac · T. K. Khura · J. R. Wurmbrand ,(**2009**), *Environ Monit Assess* (2009) 159:465–473.
[16] Karamouz, M., Mahjouri, N., & Kerachian, R, (**2004**), *Journal of Environmental Engineering and Science*, 1(2): 15–21.
[17] Kendall, M.G. **1975**. Rank Correlation Methods, 4th edition, Charles Griffin, London.
[18] Management and planning organization (Chaharmahal&Bakhtiari province), (**2005**),The report of economic and social water resources sector.
[19] Mann, H.B. (**1945**), *Econometrica* 13:163-171.
[20] Meteorology organization (Chaharmahal&Bakhtiari province), annual calendars of stations.

[21] Meybeck, M.,(**1987**), *Am. J. Sci*. 287, 401–428.
[22] Naddafi, K., Honari, H., & Ahmadi, M,(**2007**), *Journal of Environ Monit Assess* 134:305–312.
[23] N. C. C., (**1984**), Topography maps, s. 1/50000
[24] P. G. Whitedhead, R. L. Wilby, R. W. Battarbee, M. Kernan&A. J. Wade, (**2009**), *Hydrological Sciences–Journal–des Sciences Hydrologiques*, 54(1) 2009.
[25] Planning and Budget (Chaharmahal&Bakhtiari province),(**2001**),The review of comprehensive plan of water resources.
[26] Siyue Li., Quanfa Zhang., (**2008**), *Journal of Applied Geochemistry* 23: 3535–3544.
[27] Stallard,R.F., Edmond, J.M.,(**1981**), *J. Geophys. Res*. 86, 9844–9858.
[28] Stallard, R.F., Edmond, J.M.,(**1983***), J. Geophys. Res*. 88, 9671–9688.
[29] Stallard, R.F., Edmond, J.M., (**1987***), J. Geophys. Res*. 92, 8293–8302.
[30]Water Resources of Chaharmahal&Bakhtiari Company, (**2008**), the appearance of water resources of province, studies and planning sector.