Gaziosmanpaşa Üniversitesi Ziraat Fakültesi Dergisi
Journal of Agricultural Faculty of Gaziosmanpasa University
http://ziraatdergi.gop.edu.tr/

Araştırma Makalesi/*Research Article*

JAFAG
ISSN: 1300-2910
E-ISSN: 2147-8848
(2017) 34 (1), 33-37
doi:**10.13002/jafag1100**

Variability Analysis on Water Quality of Streamflow from Yesilirmak Basin in Turkey

Kadri YUREKLİ[1]*

[1]Gaziosmanpasa University, Agriculture Faculty, Department of Biosystem Engineering, Tokat-Turkey
*e-mail: kadriyurekli@yahoo.com

Alındığı tarih (Received): 15.08.2016 Kabul tarihi (Accepted): 03.03.2017
Online Baskı tarihi (Printed Online): 13.03.2017 Yazılı baskı tarihi (Printed): 02.05.2017

Abstract: In this paper, variability in monthly water quality records at Durucasu monitoring station on the Yeşilırmak River was analyzed by considering the Mann-Kendal (MK) and Theil-Sen Slope estimator (TSE) statistical approaches to detect the direction and magnitude of an available monotonic trend in any given data. The pH, chlorides, sulfates and SAR data sequences for some months had statistically significance upward trend when there was a decreasing trend in streamflow data of the nine months. The largest percent change in streamflow data was found as 153% in November, whereas July in the pH, June in chlorides and January in sulfates and SAR had the maximum percent change.

Keywords: Yesilirmak, water quality, Mann-Kendal, Theil-Sen Slope estimator

Türkiye'de Yeşilırmak Havzasından Elde Edilen Akımın Su kalitesi Üzerine Değişkenlik Analizi

Öz: Bu çalışmada, Yeşilırmak nehri üzerindeki Durucasu su kalite ölçüm istasyonunun aylık su kalite değerlerindeki değişkenlik, Mann-kendal ve Theil-Sen eğim tahmin istatistik yaklaşımları kullanılarak mevcut verideki doğrusal trendin yön ve büyüklüğünü ortaya çıkarmak amacıyla analiz edildi. Bazı ayların pH, klor, sülfat ve SAR verilerinde istatistiki anlamda önemli artan trend, dokuz ayın akım değerlerinde ise azalan trend bulundu. Akım verisindeki en büyük yüzde değişim Kasım ayında % 153 olarak saptandı, bununla birlikte Temmuz ayında pH, Haziran ayında klor, Ocak ayında sülfat ve SAR verisi maksimum yüzde değişime sahip oldu.

Anahtar Kelimeler: Yesilirmak, su kalitesi, Mann-Kendal, Theil-Sen Eğim Tahmini

1. Introduction

Freshwater rivers represent an essential and integral component of the natural source of the world in terms of quantity and quality. But, among the most important issues facing civilization in the 21st century is the growing scarcity of fresh and clean water. Maintaining and improving the quality and quantity of freshwater has long-term economic, health, and ecological implications. In a broad term, water quality refers to the physical, biological and chemical statues of the water body. The quality of life is often judged on the availability of pristine waters. Therefore, water quality is important not only because of its linkage to the availability of water for various uses and its impact on public health, but also because water quality has an intrinsic value. Also, the presence, abundance, diversity and distribution of aquatic species in surface waters are depended upon a myriad of physical and chemical factors, such as temperature, electrical conductivity, suspended solids, nutrients, chemicals, and in-stream and riparian habitats (Kurunc et al 2005).

Non-parametric approaches by researchers on the subject in many countries are widely used in the analysis of changes in hydro-climatic variables. Some of the studies related to water quality are: Kalaycı ve Kahya (1998) used the four different non-parametric test (Sen's S, Spearman's Rho, Mann-Kendall and Seasonal

Kendall) to detect linear trend in water quality data of Susurluk Basin. Antonopoulos et al. (2001) tested monotonic trend in nine water quality parameters by using some statistical approaches. Kisi and Ay (2014) analyzed 10 water quality parameters and streamflow data recorded at five stations on Kizilirmak river basin by using the new technique proposed by Sen and Mann-Kendall test.

The study was aimed to detect variation in streamflow and eight water quality parameters from Durucasu monitoring station on Yesilirmak River by using Mann-Kendall test.

2. Material and Methods

The Yeşilırmak Basin is one of the major basins in Turkey. The water of the Yeşilırmak is mostly used for irrigation in agriculture in addition to drinking, bathing, propagation of fisheries and wildlife, etc. Due to population explosion and rapid industrialization the river has been indiscriminately polluted and misused (Kurunc et al 2005).

The river flows approximately 519 km and reaches to the Black Sea. It drains an area of 38,730 km^2 which is about 5% of Turkey's surface area. The basin of the river is bounded 39º 30' and 41º 21' N latitudes, 34º 40' and 39º 48' E longitudes. The land rises from an altitude of the sea level to 2800 m. In terms of land use, there are about 39% forest regime, 39% cropland and 19% pasture land in the basin (Anonymous 1970; Munsuz and Ünver 1983). The major tributaries to the Yeşilırmak River are Kelkit, Çekerek, Çorum Çat and Tersakan Streams.

In Durucasu monitoring station, water flow is measured and water samples are taken for once every month by the General Directorate of State Hydraulic Works (DSI). The geographic coordinate of this water quality monitoring station is 40º 44' 40" N latitudes and 36º 06' 43" E longitudes. The drainage area of the monitoring station is about 21,650 km^2. Figure 1 shows the location map of the monitoring station.

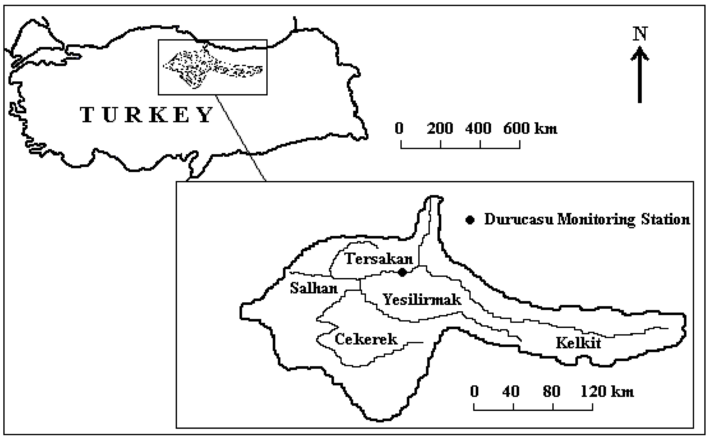

Figure 1. Location of Drucasu monitoring station in the Yeşilırmak River Basin

In addition to streamflow (Q) in m^3/s, among the water quality constituents measured by DSI at Durucasu monitoring station are water specific conductivity (EC) in dS/m, temperature (T) in ^{o}C, sodium (Na^+), potassium (K^+), calcium+magnesium (Ca^{2+}+Mg^{2+}), chlorides (Cl^-) and sulfates (SO_4^{2-}) in mg/l and pH. In addition to these water quality constituents, calculated sodium adsorption rate (SAR) is also used in this study. The records for these constituents available for the analysis as presented in this paper are on a monthly basis for the period 1984–2002. Yenilmez et al. (2011) applied Mann-Kendal test to time series concerning with four water quality parameters from Eymir Lake in Ankara province. Zhai et al. (2014) analyzed spatio-temporal variations of three key water quality elements in Huai river basin by seasonal Mann-Kendal and

Moran's I methods. Naddeo et al. (2013) used Mann-Kendal approach to detect the change in water quality parameters from 13 Southern Italiy rivers.

2.2. Testing change in the data

Variation in water quality variables in the study has been analyzed by non-parametric approach (Mann-Kendall, MK), which is commonly used in many areas. The method was given in Yurekli (2015) as detailed. In this study, only test statistic (Z_{MK}) of the MK was presented as follows:

$$Z_{MK} = \left\{ \frac{S-1}{\sqrt{\sigma_S^2}} \text{ if } S>0,\ 0 \text{ if } S=0, \frac{S+1}{\sqrt{\sigma_S^2}} \text{ if } S<0 \right\} \quad (1)$$

In the equation, S is total value based on positive and negative differences among observations. It is assumed that the statistic S is approximately normally distributed with the mean zero. In case where the sample size n >10, the σ_S^2 is its variance.

The Z_{MK} test statistic is evaluated to according to the standard normal distribution. This value is compared to the value of $Z_{1-\alpha/2}$ from standard normal distribution table at 5% significance level. The null hypothesis associated with no trend is accepted if the Z_{MK} test statistic is smaller than the critical value of the standard normal distribution at the significance level of α. The Z_{MK} test statistic having a positive or negative value signifies an increasing or decreasing trend.

In this study, Theil-Sen's estimator (TSE) (Sen 1968; Theil 1950) was taken into account when specifying the magnitude and direction of variation in water quality data. The brief descriptions of the statistical method are as follows:

(I) The slope estimates (Q_k) of N pairs of data series are first computed by sorting data in ascending order:

$$Q_k = \frac{x_j - x_i}{j-i} \text{ for } k = 1,...,N \quad (2)$$

(II) If N is odd or even, the median concerning with the Q_k is obtained from:

$$Q_{med} = \begin{cases} Q_{\left[(N+1)/2\right]} & \text{if N is odd} \\ 2^{-1}\left\{Q_{\left[(N)/2\right]} + Q_{\left[(N+2)/2\right]}\right\} & \text{if N is even} \end{cases} \quad (3)$$

The percent change of the upward and downward trend in water quality data is found by the following equation given in Yue and Hashino (2003).

$$\%\,PC = \frac{Q_{med} \times t}{\bar{x}} \quad (4)$$

Where t is data analysis period (years), the $\bar{x}$ is mean of the data.

3. Results and Discussions

Variation in streamflow, the water quality constituents and sodium adsorption rate (SAR) was tested by Mann-Kendall (MK) in the study. The MK results related to the mentioned data were given in the Table 1. As can be seen the table, the streamflow data sequences of the remaining months had significance downward trend except streamflow data of April, May and June. As for pH, there were upward trend in eight months while the four months (February, Marc, December and November) had statistically insignificance trend. Additionally, an increasing trend was detected in chlorides data sets of January and June. Besides, sulfates and SAR data sequences for January had also upward trend. But, the data sequences concerning with water specific conductivity, temperature, sodium, potassium, calcium+magnesium had statistically significance monotonic trend in none of all months. Theil-Sen's estimator results of streamflow and water quality constituents with monotonic trend at Durucasu monitoring station are in the Table 2.

According to the Equation 4, the percent change of the downward trend in streamflow data varied between 68% (July) and153% (November), whereas the percent change for the upward variation of the pH was between 3.8% (April) and 13.1% (July). The percent change for chlorides data sets of January and June months were 39.4% and 44.5%, respectively. As for sulfates and SAR data sequences for January, The percent change was calculated as 50.3% and 27.3%, respectively.

Table 1. Mann-Kendal test results for Durucasu monitoring station

Months	Q	T	pH	EC	Na	K	Ca+Mg	Cl	SO_4	SAR
1	-3.08*	-0.46	2.39*	0.42	1.58	1.58	0.28	2.21*	2.77*	2.24*
2	-2.80*	0.25	0.84	1.12	0.91	0.98	1.37	1.12	1.61	0.77
3	-1.82*	0.28	0.35	0.46	0.35	-0.54	1.44	0.11	0.53	0.35
4	-1.26	-0.57	1.77*	0.56	0.39	-1.27	0.14	0.14	-0.32	0.42
5	-0.37	0.42	2.59*	0.04	0.87	0.46	-0.12	0.04	0.95	1.24
6	-1.21	-1.05	2.47*	0.23	1.18	0.12	-0.11	2.39*	1.21	1.44
7	-2.38*	1.07	5.00*	-0.14	1.40	0.35	-0.14	0.67	1.61	1.61
8	-1.94*	-0.04	2.06*	0.87	1.20	0.21	1.07	0.54	1.44	1.11
9	-2.51*	1.25	2.53*	1.03	1.15	-0.54	0.50	1.03	1.32	1.11
10	-3.43*	1.34	1.70*	-0.29	0.00	-0.50	-0.08	0.37	0.12	0.95
11	-3.43*	0.78	1.24	-0.82	0.00	-0.79	-0.78	0.25	-0.62	0.37
12	-3.29*	-0.46	0.70	0.70	0.99	1.20	0.33	1.45	0.78	1.44

Table 2. The TSE results for Durucasu monitoring station

Constituents	1	2	3	4	5	6	7	8	9	10	11	12
Q	-4.1	-3.9	-4.3				-1.0	-1.2	-1.5	-2.0	-1.8	-4.0
pH	0.04			0.02	0.02	0.03	0.06	0.03	0.02	0.02		
Cl	0.47					0.47						
SO_4	2.46											
SAR	0.01											

4. Conclusion

i. As mentioned above, at Durucasu monitoring station on Yesilirmak river, monthly data sets of streamflow and water quality constituents in some months showed a monotonic trend in the sense of upward or downward. The reason of this variation may be explained by some socio-economic evolution in the Yesilirmak river basin. The cause of pollution is the increase in industrialized and urbanized areas, animal husbandry without any wastewater treatment and the development of roads and airports. Besides, extreme use of mineral fertilizers, soil degradation and rotation cropping system were very impact on water quality in the basin and have led to variation in concentration of some water quality.

References

Anonymous (1970). Soils of Yeşilırmak Basin. General Directorship of Soil-water publications, 241, Ankara-Turkey, 141 pp. (in Turkish).

Antonopoulos VZ, Papamichail DM and Mitsiou KA (2001). Statistical and trend analysis of water quality

and quantity data for the Strymon River in Greece. Hydrology and Earth System Sciences, 5: 679-691.
Kalaycı S and Kahya E (1998). Detection of water quality trends in the rivers of the Susurluk Basin. Turkish Journal of Engineering and Environmental Science, 22: 503-514.
Kisi O and Ay M (2014). Comparison of Mann–Kendall and innovative trend method for water quality parameters of the Kizilirmak River, Turkey. Journal of Hydroloy, 513: 362-375.
Kurunc A, Yurekli, K and Cevik O (2005). Performance of two stochastic approaches for simulating river water quality and streamflow. Environmental Modeling & Software, 20: 1995-2000.
Munsuz N and Ünver I (1983). Waters of Turkey. University of Ankara, Agricultural Faculty Publications, 882, Ankara-Turkey, 392 pp. (in Turkish).
Sen PK (1968). Estimates of the regression coefficient based on Kendall's tau. Journal of the American Statistical Association, 63: 1379–1389.
Naddeo V, Scannapieco D, Zarra T and Belgiorno V (2013). River water quality assessment: Implementation of non-parametric tests for sampling frequency optimization. Land Use Policy, 30: 197-205.
Theil H (1950). A Rank Invariant Method of Linear and Polynomial Regression Analysis, part 3. Netherlands Akademie van Wettenschappen, Proceedings, 53, pp. 1397–1412.
Yenilmez F, Keskin F and Aksoy A (2011).Water quality trend analysis in Eymir Lake, Ankara. Physics and Chemistry of the Earth, 36: 135-140.
Yue S and Hashino M (2003). Long term trends of annual and monthly precipitation in Japan. Journal of the American Water Resources Association, 39: 587–596.
Zhai X, Xia J and Zhang Y (2014). Water quality variation in the highly disturbed Huai River Basin, China from 1994 to 2005 by multi-statistical analyses. Science of Total Environment, 496: 594-606.
Yurekli K (2015). Impact of climate variability on precipitation in the Upper Euphrates–Tigris Rivers Basin of Southeast Turkey. Atmospheric Research, 154: 25-38