Spectral analysis of some selected hydrochemcial parameters of lower diyala river

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ABSTRACT

Many hydrochemcial parameters of Lower Diyala river including electrical conductivity (EC), Ca^{+2}, Mg^{+2}, SO_4^{-2}, Cl^{-1}, HCO_3^{-1} and total hardness (TH) were analysed for their periodicities using monthly measurements for the period 1983-1987. Results showed significant autocorrelation for all the studied series and therefore they subjected to the spectral (Fourier) analysis to investigate the main periodicities that contribute to the total variance of the observed data. Most of the selected parameters have strong (less frequent) semi-annual and biannual cycle as well as seasonal cycle for Mg^{+2}, Cl^{-1} and total hardness. These results reveal the variation of the factors affecting the river water quality including hydrological and meteorological conditions as well as the impact of human activities through the river catchment area.

ا لاصة

حللت العديد من ا عاملات ا يدروكيميائية لنماذج مآخوذة من ر ديا الاسفل بشكل شهري لغرض ديد الدورية للفترة من 1983-1987. لت ا عاملات ا يدروكيميائية التوصيلية ا يدروليكية والكالسيوم وا غنيسيوم والك يتات والكلور والبيكاربونات فضلاً عن العسرة الكلية. بينت نتائج اليل العينات ا أخوذة وجود ارتباط ذا معنوي لكل سلاسل بيانات ا عاملات ا يدروليكية ا قاسة، لذا حللت هذه السلاسل باستخدام التحليل الطيفي(فورير) للتحري عن ا ركبات الدورية الرئيسة وال تساهم التباين الكلي للمعاملات ا قاسة. اغلب ا عاملات ا ختارة لغرض التحليل بينت وجود دورية من النوع الشبة ا و ي والثنائي ا و ي (اقل تكراراً) اضافة ا الدورية من النوعي ا و ي للمغنيسيوم والكلور والعسرة الكلية، وهذا يؤكد على ان العوامل ال تسبب تغ نوعية ا ياه ذا النهر تتضمن الظروف ا يدرولوجية وا ناخية بالاضافة ا تأث الانسان من خلال تغ حوض التصريف ذا النهر.

INTRODUCTION

Diyala river is one of the most important tributaries of river Tigris in Iraq. It drains an area of abut 32600 km lying across Iraqi- Iranian frontiers. The river basin is widely varied through the entire catchment area from semi-arid plain north of Baghdad to mountainous area of western Iran (Al-Ansari and Al-Jabbari, 1987). The river catchment were divided into four parts, above Derbendikhan, Upper Diyala, Middle Diyala and Lower Diayala, each of these have different characteristics and different contribution to the main river flow. Form geological view point, river catchment have different geological units; Above Derbendikhan the catchment lies within thrust zone and the exposed rocks are of Jurrasic age, whereas the Upper and Middle Diyala lie within the folded zone in which the createaceous strata are exposed, as well as Mukdadiya, Fatha formations and Quaternary terraces are dispersed. Lower Diyala is covered mainly by recent alluvium and lies within the unfolded zone (Al-Ansari et al., 1987). Climate conditions are very so much in the river catchment in which the rainy season starting form November to April, the amount of precipitation varies from 800 mm near the northern parts to 250 mm near southern limits of the basin. The annual evaporation rate may reach as high as 2000 mm (Al-Jiboury, 1999). These conditions have clear effects on alteration of wet and dry years and then the variation of river water quality. Many hydrochemical studies were achieved showing that water chemistry of the river are varied both spatially and temporally for the above river parts. Ansari et al., 1987; Al-Sinawi, 1986; and Al-Adili, 1992, are among others.

The present study aim to investigate the periodicity behavior of some selected parameters of Lower Diyala river downstream Hemrin dam, using Spectral (Fourier) analysis depending upon the monthly measurements for the period (1983-1987) available from the state of irrigation projects operations and maintenance (Al-Adili, 1992). These include electrical conductivity (EC), Ca^{+2}, Mg^{+2}, SO_4^{-2}, Cl^{-1}, HCO_3^{-1} and total hardness (TH). Due to the incomplete and disturbed record of river discharge at the study location, therefore it was excluded from the present study through its importance for comparison purposes with the used parameters.

ANALYTICAL PROCEDURE

Autocorrelation:

Autocorrelation can be defined as the measure of time dependence of a given time series for different lags. The values of autocorrelation coefficient for different lags and given confidence limit could be schematically shown using correlation which indicates series trend and periodicity. Serial autocorrelation take the following form (Fuller, 1976):

$$r_L = \frac{Cov|Y_i(i+L)}{[VarY_i \cdot VarY(i+L)]^{0.5}} \qquad \text{………………..(1)}$$

It can also be expressed using serial covariance as:

$$r_L = \frac{Serial\,Cov(C_L)}{Serial\,Cov\,at\,Lag(C_\circ)} \qquad \text{………………… (2)}$$

Where Y= average; 0 < L < N; L = lag (represent the shift between any two compared series.

Spectral Analysis:

Spectral (Fourier) analysis is used for describing the structure of time series and explains the main components that contribute to the total variance in the observed data and defining the behavior using spectral density function. This function is the Fourier transformation of the serial covariance as: (Fuller, 1976)

$$\gamma(L) = \int e^{inv} df(w) \quad \text{……………………..(3)}$$

For continuous series

$$\gamma(L) = \int e^{inv} f(w) dw \quad \text{…………………..(4)}$$

where $\gamma(L)$: variance at lag L, $f(w)$: spectral density distribution function, w: angular frequency, t: time, $i = \sqrt{-1}$.

Fourier transform is the method of transforming any function in terms of time $Y(t)$ to another function in term of frequency $f(w)$, where the latter function gives independent values with different frequencies as compared with time function which are strongly correlated leading to interpretation difficulties.

RESULTS AND DISCUSSION

Monthly readings of the selected parameters were plotted to define their trends, figures 1-4. As revealed by these figures, all the above parameters show decreasing trends except of Cl^{-1} which have noticeable increasing trend. EC, HCO_3^{-1}, and SO_4^{-2} have slight decrease trends as compared with Ca^{+2}, Mg^{+2}, and total hardness. Significant trends have clear effect on the analysis of time series especially if these series were taken on the basis of shorter period and less frequent sampling (Feng *et al.*, 2004). Accordingly, they should be removed before carrying out the spectral analysis.

Correlogram of 95% confidence limit of the studied hydrochemical parameters (Figures 5-8) show clear periodicities (cycles), but they differ in their amplitude of the main components that contribute to the total variance of the observed data. Periodogram of the above parameters can be used to examine the main periodicities and their frequencies. According to the periodograms of the current data as depicated in the figures (9-12), it is clear that there exist significant differences among the appeared periodicities. These periodicities can be classified as: strong clear (less frequent), clear, and moderately clear (more frequent). Concerning EC, biannual cycle (5.2) months, and the cycle of (15.3) months which can called as (semi-annual) cycle are the most clear whereas the other cycles are not clear, figure ( ). Other ions and total hardness have strong clear semi-annual cycle but with less frequent occurrence Ca^{+2}, Mg^{+2}, SO_4^{-2}, Cl^{-1}, HCO_3^{-1} and TH have clear biannual cycle as well as seasonal cycle for Mg^{+2}, Cl^{-1}, HCO_3^{-1} and TH.

Most likely, the biannual cycle reflects the effect of time lag between the rainy and snow melt periods in the upper parts of the river catchment. Seasonal cycle reflects the impact of meteorological conditions on flow behavior whereas the semi-annual cycle exhibits the effect the overall natural conditions plus discharges release control through the dams installed upstream.

According to the aforementioned results there are significant variations in the periodicities of the studied parameters, however, it should be stressed here that the current results are restricted for the study period only and the real behavior of the river may be more clear if the measurements were taken for longer periods on the weekly or daily basis.

CONCLUSIONS

Slight decreasing trends in the studied hdyrochemical parameters were noticed and high autocorrelation of the analysed series were observed indicating existence of different periodicities.

1. Semi-annual, biannual and seasonal cycles were found to be the most prominent periodicities contributing to the total variance of the observed data.
2. Semi-annual cycle reflects the effect of wet and dry years fluctuation

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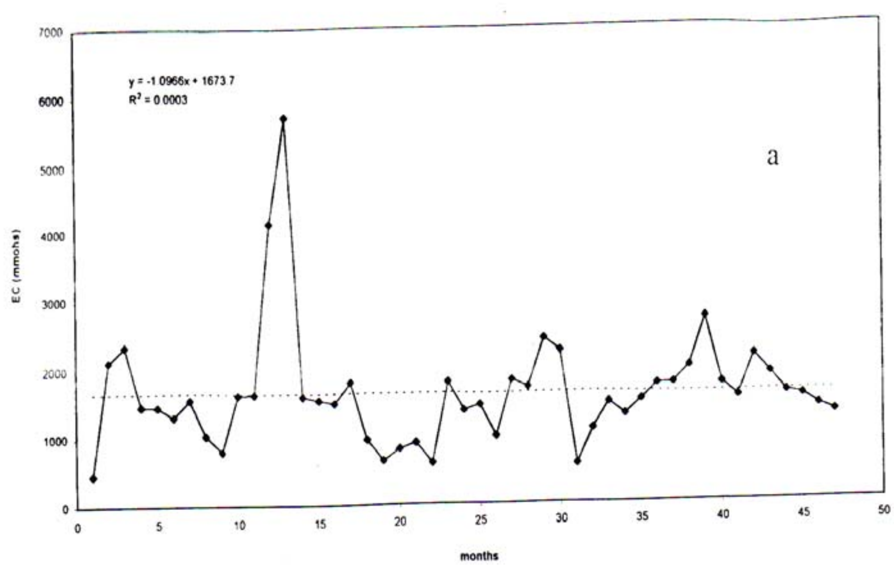


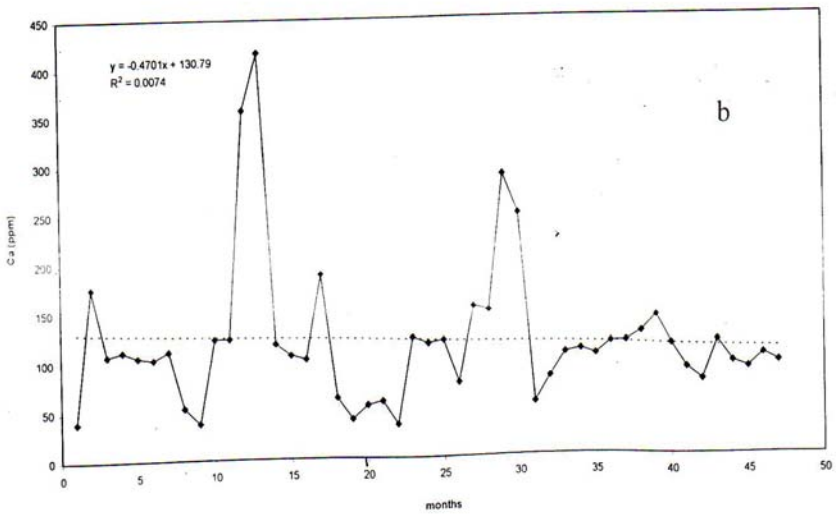
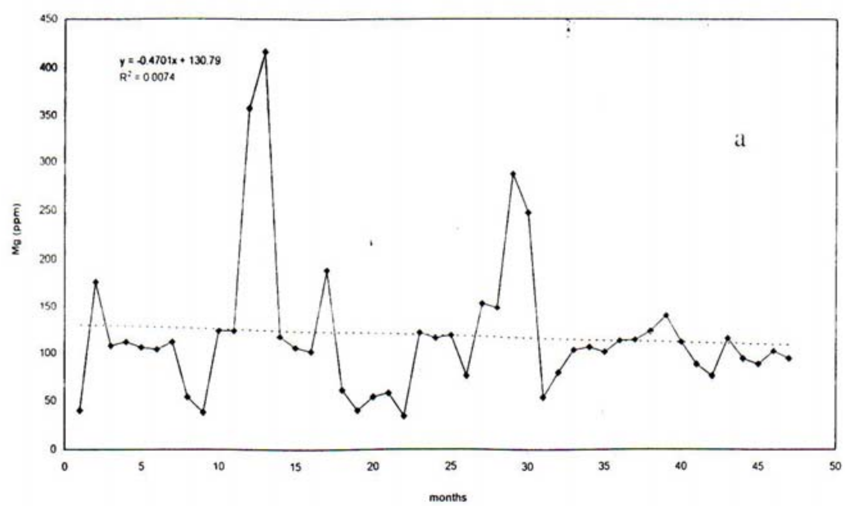
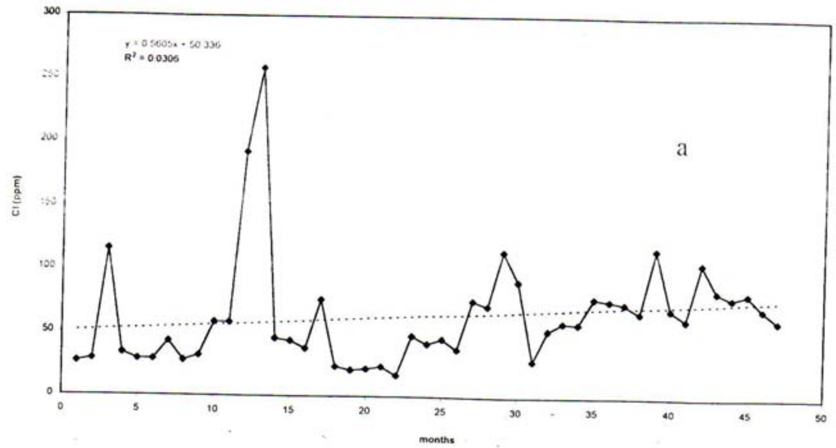


Fig. 1: Variation of EC(a) and Ca(b) with time of Lower Diyala river for the period 1983-1987





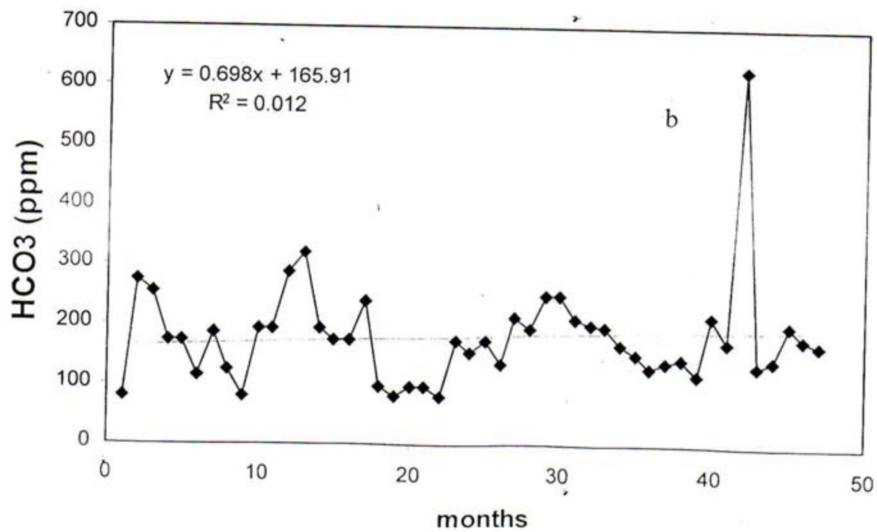


Fig. 3: Variation of Cl(a) and HCO3 (b) with time of Lower Diyala river for the period 1983-1987

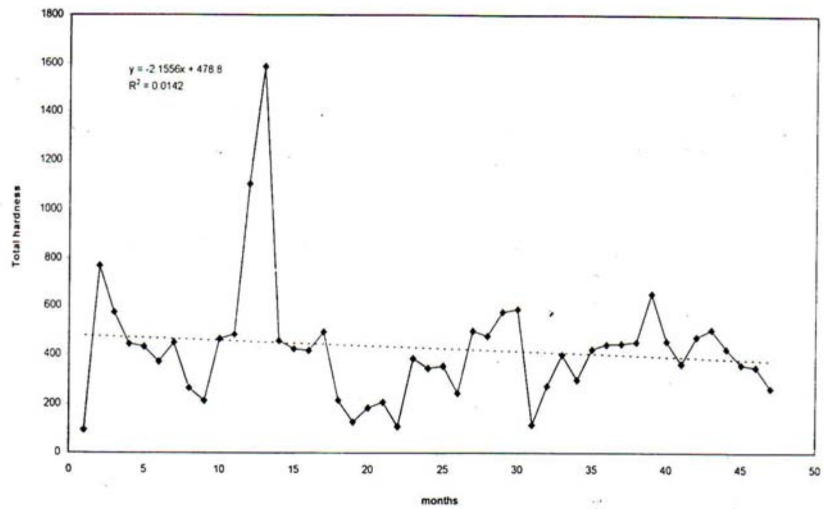
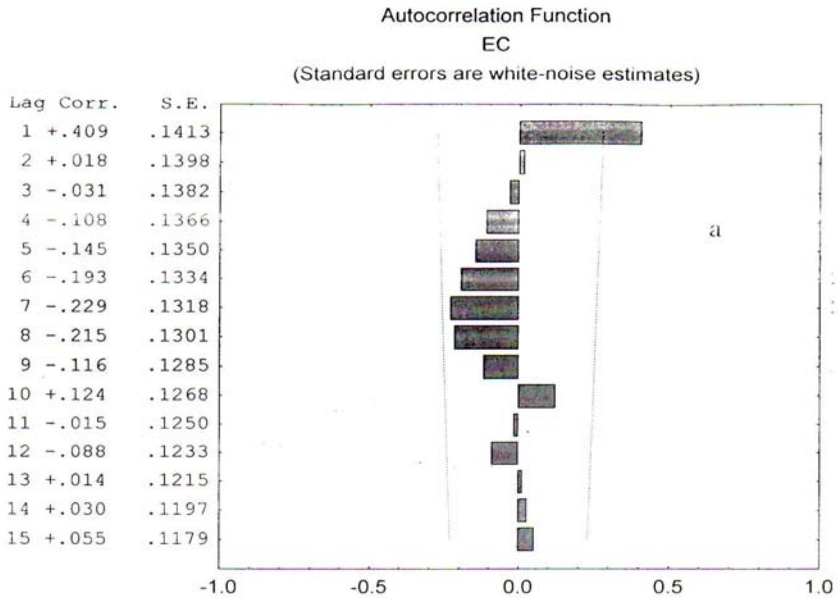
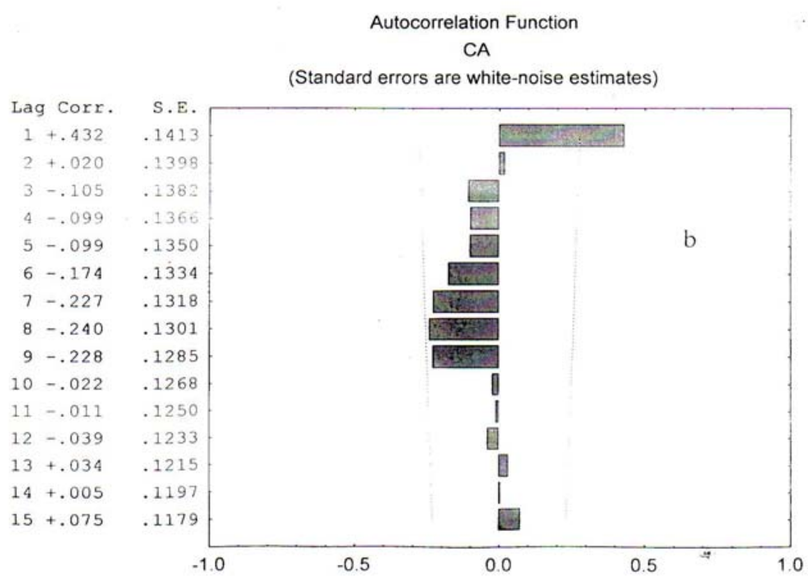
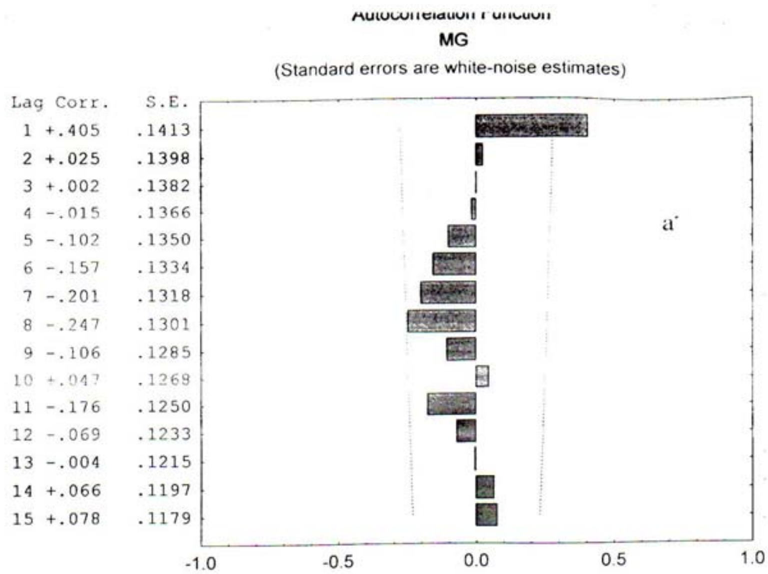


Fig. 4: Variation of TH. with time of Lower Diyala river for the period 1983-1987





]Fig. 5 : Correlogram(95% confidence limit) of EC(a) and Ca (b) for Low river



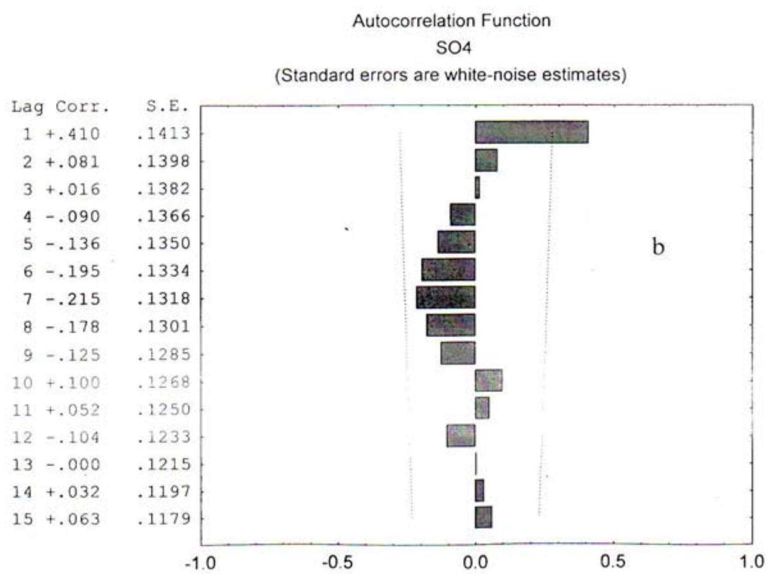


Fig. 6 : Correlogram(95% confidence limit) of Mg(a) and SO4 (b) for Lower Diyala river

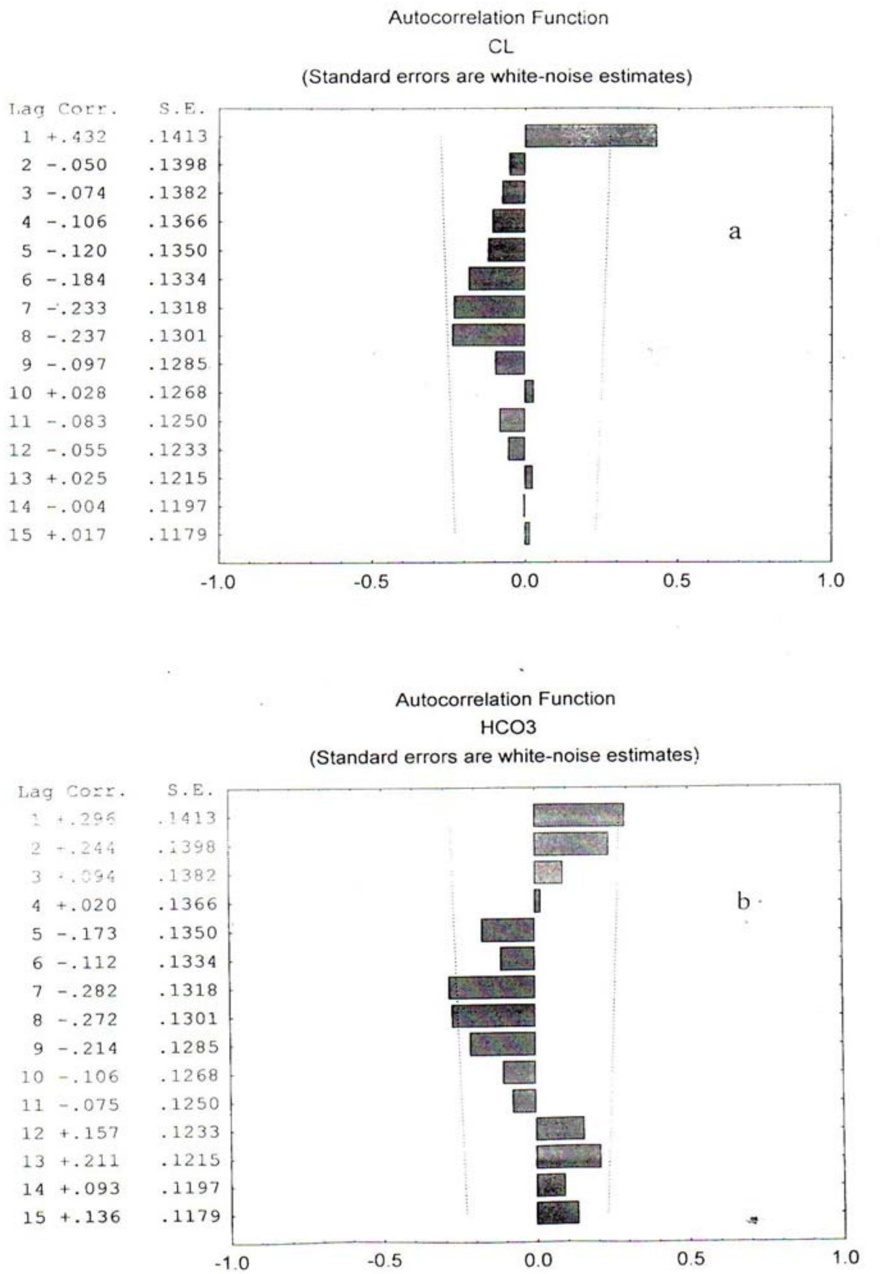


Fig. 7 Correlogram(95% confidence limit) of Cl (a) and HCO3 (b) for Low
river

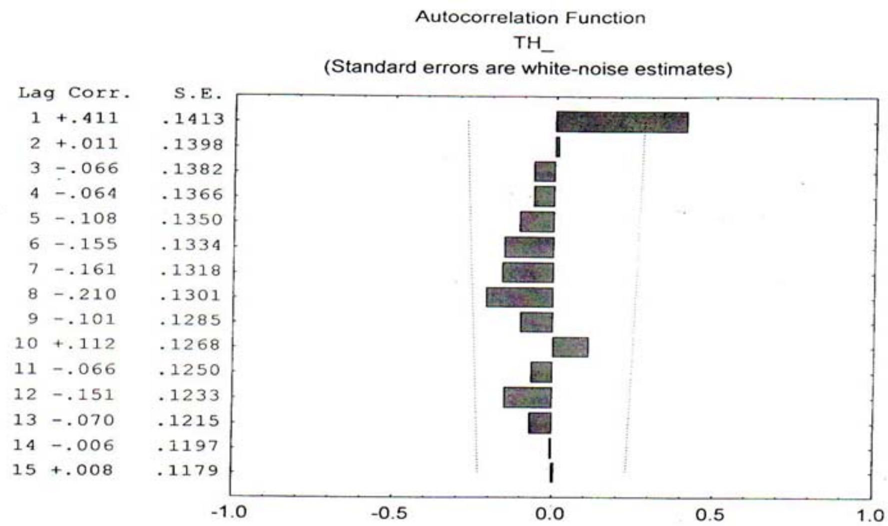
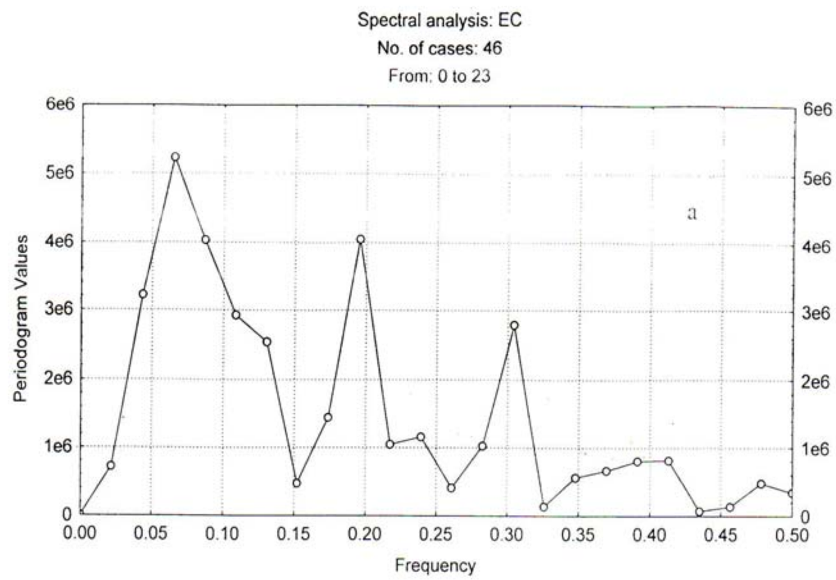


Fig. 8 : Correlogram(95% confidence limit) of TH. for Lower Diyala river.



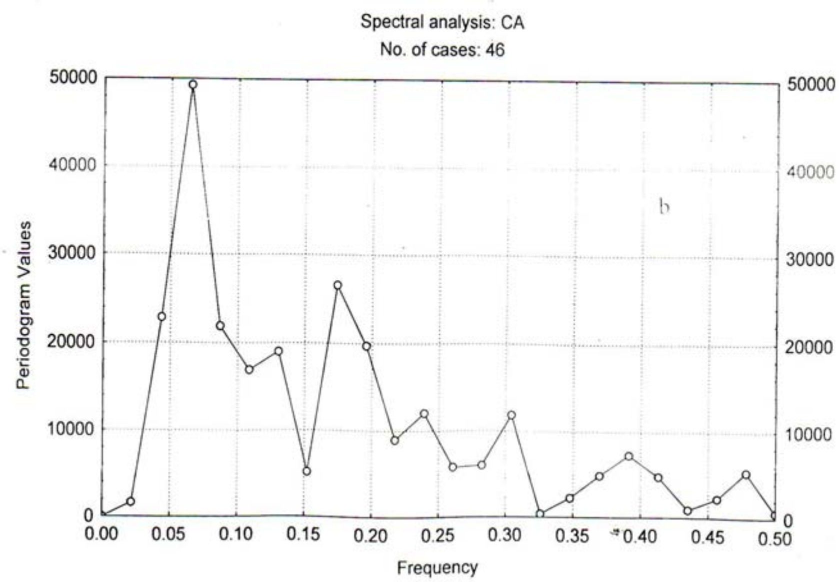
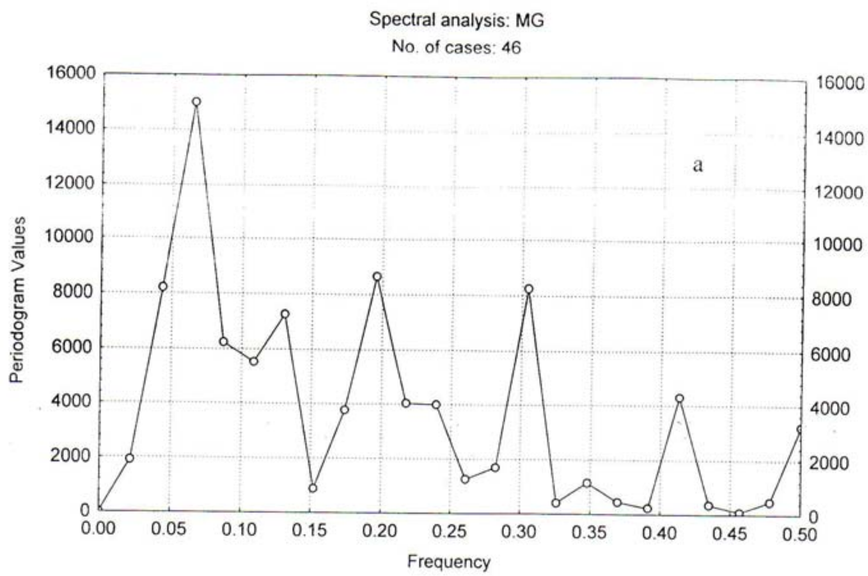


Fig. 9 : Periodogram of EC (a) and Ca(b) for Lower Diyala river.



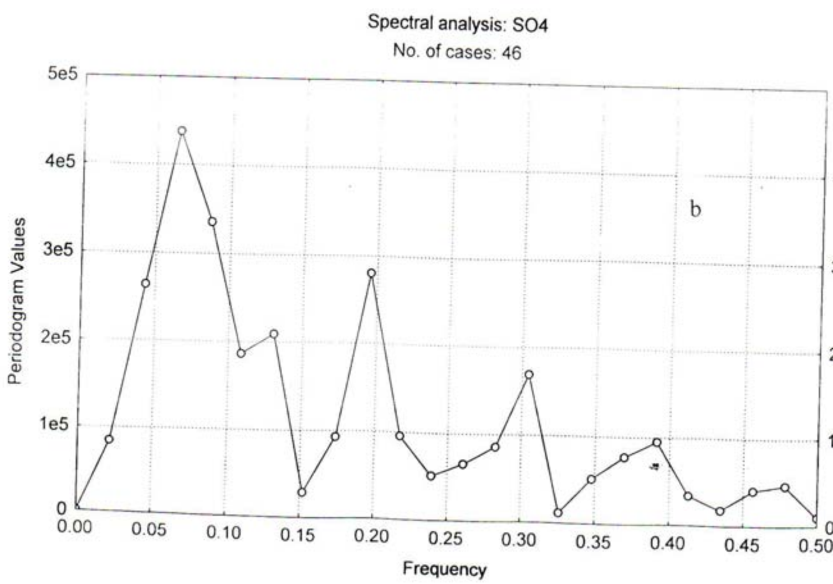
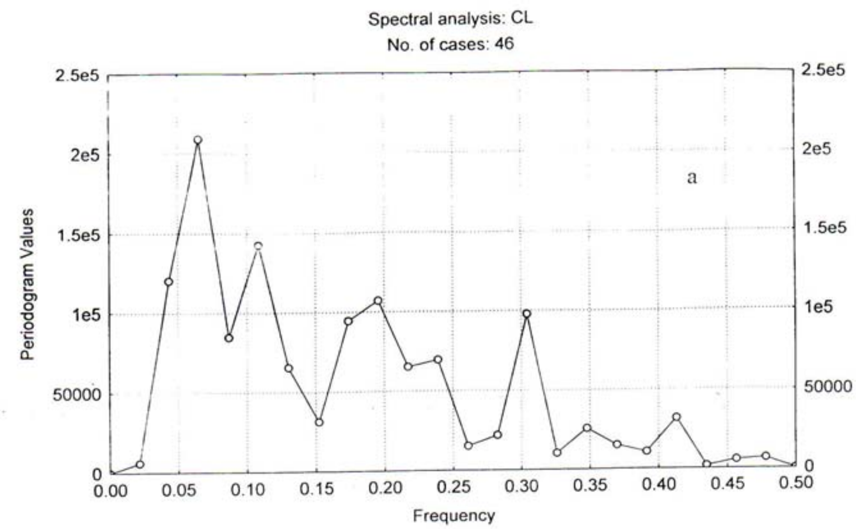


Fig. 10 : Periodogram of Mg (a) and SO4 (b) for Lower Diyala river.



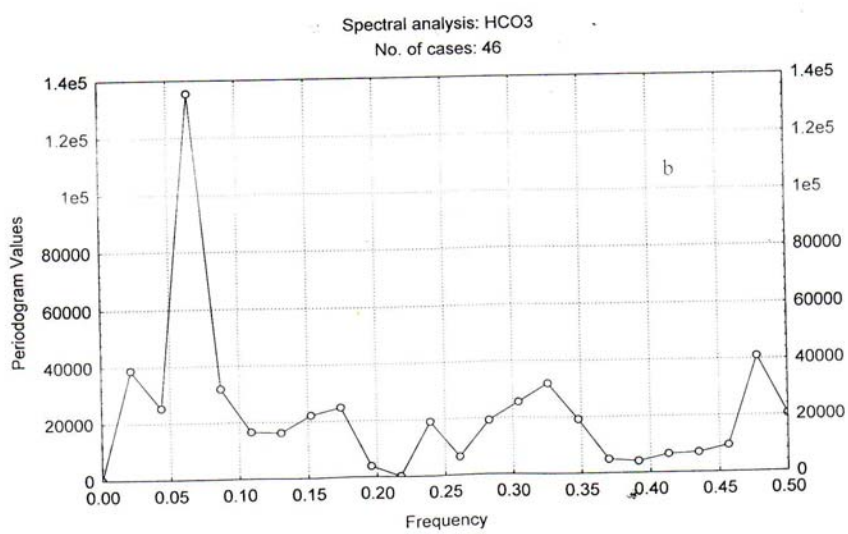


Fig. 11 : Periodogram of Cl (a) and HCO3 (b) for Lower Diyala river.

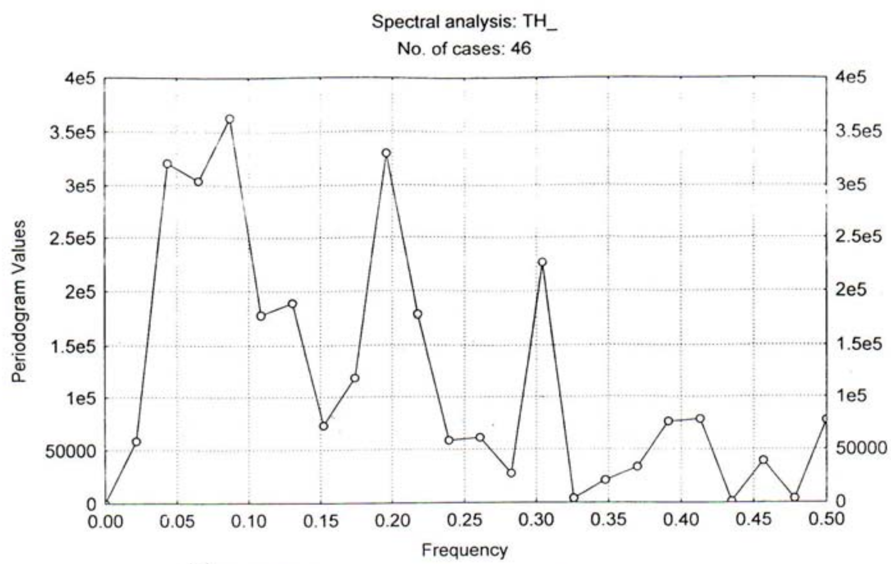


Fig. 12 : Periodogram of TH. for Lower Diyala river.

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