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Characterizing of some hydrochemical parameters of Tigris River, Iraq, with the aid of GIS

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ABSTRACT

Nine stations along Tigris River in Iraq were selected to study the spatial and temporal changes of some selected parameters for the period 2009-2012. These parameters include discharge, Total Dissolved Solids,(TDS),NO_3,BOD and COD. Water type is of bicarbonate along the northern stations (Feshkhabour, Mosul, Sharkat and Samarra) and transforms into sulfate in the remaining central and southern stations. GIS was used to characterize the temporal and spatial changes of these parameters along the selected River Tigris stations. Discharges values of all stations show significant temporal decreasing patterns and spatial decreasing patterns along these stations were also noticed. TDS values show noticeable temporal changes for the present stations, whereas sharp increasing changes downstream direction were observed. NO_3, BOD and COD spatial and temporal changes show that their values show no indication on pollution and that their values for the high and low flow conditions are within the normal range values.

Keywords, discharge, water type, GIS, spatial analyses, temporal change, Tigris River, Iraq

1. INTRODUCTION

River chemistry is of vital importance in the studying the river catchment area, where the growing demand for the water resources, urged the hydrologist to characterize and monitor the spatial and temporal changes in the physical, chemical and biological properties of the rivers at specific location to detect the nature of the changes in these properties and determine the possible pollution sources. Nowadays, the information concerning the anthropogenic and natural effects and their extents are very important in implementing of any sustainable water use and treatment management plan. In Iraq River Tigris comprise with the Euphrates River, very important fertile plain called through centuries, the Mesopotamia i.e. Iraq is the country of the Two Rivers. River Tigris originates from Turkey and cross the Iraqi territories with a catchment area of above 400,000 Km and total length of 1410km. The river length inside Iraq is 1100 Km. (Al-Ansari et al, 1987). It has many tributaries with different contributions; they are originating from both Turkey and Iran except of Adhaim tributary which originates entirely in Iraq. Many hydraulic dams and barrages were established to regulate and manage the water quantities storage and release through the country. In addition to the importance of water quantities which subjected to significant decreasing due to the natural global warming and anthropogenic effects, water quality plays important role in restricting the water uses for the different purpose.

River Tigris is of critical importance since it is the prime source for drinking, agricultural and power generation uses along the country. Many studies dealing with the chemical, hydrological and environmental aspects of the River Tigris were achieved. Al-Ansari et al, 1986, 1987, Auad, 1997; Mahmood, 2013; and Ali et al 2014, are among others. The present study aims at evaluation of specific parameters for nine stations extending from the northern to the southern parts of the country. These parameters include discharges, TDS, NO_3, BOD and COD. Invers Distance Weight,(IDW), interpolation of Geographic Information System(GIS) was used to show the nature of some hydrochemical parameters of River Tigris throughout the country. The main task Inverse Distance Weight, (IDW) of the spatial interpolation is to predict a value for any unmeasured location where it uses the measured values surrounding the prediction location,(Michael et. el.,2012).

2. MATERIALS AND METHODS

2.1. Study area

The study area extends through the whole country where Tigris River originates from Turkey and passes through different Iraqi provinces,(Fig-1). It has many tributaries arising also from Turkey and Iran. Through its course inside Iraq, it passes through different geological formations and sediment of different ages. Calcareous formations of palaeozoic and cenozoic are exposed in the extreme northern parts of the country (Fig-2), (Jassim and Geoff,2006). In the central parts, clastic formations of Miocene ages are dispersed in the catchment area whereas in the southern parts, clastic and different types of recent sediments of Quaternary age are exposed. These sediments are composed mainly from flood plain deposits, river terraces, and back swamps sediments at sometimes (Buday, 1980).

***2.2.* Samples and stations**

In the present study 9 stations; Feshkhabour, Mosul, Sharkat, Samarra, Baghdad, Thiraa Dijla (Tigris arm), Kut, Ali Gahrbi and Amara were chosed to study the spatial variations of some selected chemical parameters (Fig-1). These parameters include River Tigris discharge, Total Dissolved Solids (TDS), NO3, BOD and COD. The above stations were selected to cover the entire catchment area of River Tigris in Iraq. The parameters include the monthly measurement for the period 2009-2012, it is provided by the National Center for Water Recourses Management, Ministry of Water Recourses .TDS was selected to explain the variation of the river salinity cross the country while NO_3, BOD and COD were selected to detect the probable river pollution along these stations. GIS techniques were used to characterized the present study parameters and exhibit the spatial and temporal variations along the River Tigris in Iraq. Arc GIS 9.3 software is used to prepare the maps of the study area, so the interpolation and extrapolation techniques were used to measure a specific parameter and the geo-statistical analysis was used to digitize the output layer statistically and spatially for of the selected parameters.

3 .RESULTS AND DISCUSSION

Table.1, explain the mean values of the present study variables for the period 2009-2012 in which significant spatial variation along the selected stations were observed. Piper plots of the present study readings,(Fig-3), show that the River Tigris has a bicarbonate type for the Feshkhabur, Mosul, Sharkat and Samarra, and transforms into Ca-SO_4 type for the remaining stations for the study period. This pattern of water type is highly related to the discharge quantities where the first four stations are characterized by high discharge values compared with the remaining stations. Sulfate type of water reflects, also, the effects of geological formations downstream direction. No significant temporal changes of water type for all the present stations could be detected. Controlling of discharges released from the dams and barrages may play an important role in reducing the difference between the high and low flow conditions for all the selected stations.

***3.1.*Discharges**

The temporal behavior of the river discharges for the selected stations,(Fig-4), shows similar patterns, where the highest values are for Feshkhabour and Sharkat stations. Discharges quantities decrease significantly downstream direction in which Ali Gharbi and Amara stations were characterized by the lowest values. Nature of the incoming quantities the released and storage behind the dams and barrages are the main controlling factors on the discharges patterns of the present stations. All of the selected stations show decreasing trends with time, In addition to the decrease patterns downstream direction.

3.2.TDS

Significant increasing spatial trends along the present study river stations can be noticed, (Fig-5).Thiraa Dijla has prominent highest values as compared with the other stations. This is due to the fact that Thiraa Dijla is linking the return water of Tharthar lake of the brakish nature to the main stem of Tigris River just little north of Baghdad. The increasing of salinity is also exhibited in the water type classification along the river, i.e. at Feshkhbour , Mosul Sharkat and Samara the type is bicarbonate and then transforms to sulfate type starting from Thiraa Dijla and extending to the southern stations, Amara and Ali Gharbi. The highest (April) and lowest (September) TDS values were 258 and 1246 ppm for Feshkhabour and Amara stations respectively. The nature of these trends changes is related to the geologic formations that the river passes through, where the Quaternary deposits of clastic nature with some salty sediment are predominant in the southern part. Increasing of human activities in an additional factor for the TDS increasing at these stations. Figure (6), shows the nature of TDS changes during the high and low flow conditions.

3.3.NO_3

Nitrate is derived from both natural and anthropogenic sources, it comes as products of industrial and agricultural sewage or from geologic formations containing soluble nitrogen compounds. It also produced by decomposition of organic matters by bacteria through nitrification process,(Diaz and Rosenberg,2005). Excess of nutrients may cause algal blooms, dramatic shift in trophic relationships and expansion of coastal hypoxic zone,(Romano and Zeng,2007). Fig (8) shows, the spatial variations of NO_3 of the present study stations. As appeared, the concentration of NO_3 starts to increase at Samara station towards the southern stations which, in general, show increasing trends. The minimum and maximum values of NO_3 were 1 and 8 for Feshkhabour and Amara stations respectively. Increasing of N-Based fertilizers in the southern parts of the country is the main source of NO_3 concentrations increasing. Concerning the temporal variations, there is no significant variation where the values of NO_3 of high and low flow are close to each other, Fig (7).Despite the above facts the concentration of NO_3 still below the acceptable limits for the two periods for all stations. Rational use of N-based fertilizers and contraction of agricultural lands in the last years are the main causes of the present patterns of NO_3 spatial and temporal changes.

3.4. BOD

It expresses the dissolved oxygen required by living organism for its metabolic activities of the organic matter decomposition in the water bodies. High levels of BOD refer to the advance of the organic matters that leads to the depletion of oxygen (Manahm, 2005, Patahak and Limaye, 2011). Figure (8) shows the spatial variation of BOD along the present study stations where the minimum and maximum values are 2.4 and 0.6 at both Sharkat and Kut and Thiraa Dijla stations respectively. The values of BOD of all the present stations show no indications of pollution and that they are within the normal limits. Figure (9) Shows that there are, slight differences in the BOD Values for both high and low flow conditions, but they still as stated, within the normal range.

3.5.COD

It is the amount of specific oxidant that reacts with the sample under controlled by strong oxidants, it is often used as an indicator of pollutions in natural and waste waters (Mamias et al, 1993).As appeared from Figure (8), there are an increasing trends along the river stations where the minimum and maximum values were 0.7 and 1.9 at Feshkhabor and Thiraa Dijla stations respectively. The highest values at Thiraa Dijla reflects effect of sewages as compared with the remaining stations. Comparison of high and low flow concentration, Fig (10) shows no significant temporal difference. The values of low and high flow conditions show that these are normal and no significant indications concerning the anthropogenic pollutions along the present study stations can be detected.

4. CONCLUSIONS

1- Significant spatial variations of discharges, TDS, NO3, BOD and COD along the present study stations were noticed.
2- Water type of the River Tigris changes from bicarbonate into sulfate indicating the increasing effects of geologic formations downstream direction as well as human activities increasing.
3- River Tigris salinity shows significant temporal and spatial changes for all the study stations where Feshkhabour and Amara stations are characterized by the lowest and highest values for all the selected variables.
4- Values of NO_3, BOD and COD show that no pollution indicators can be detected. However, due to the extensive establishment of water treatment plant and improper and an in-efficient operation of some of these plants, it is of critical importance to conduct a continuous monitoring program for the above indicators.

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Table 1: Mean values of the present study variables.

Stations	Mean concentration (ppm)			
	NO_3	TDS	COD	BOD
Feshkhabour **(2009)**	1.0	258	0.7	1.5
Mousl	2.3	290	0.9	2.1
Sharkat	1.7	311	1.3	2.4
Samarra	1.9	307	1.2	1.3
Thiraa Dijla	4.0	1241	1.4	1.7
Baghdad	4.1	547	1.2	1.1
Kut	2.9	728	1.1	1.4
Ali Gharbi	5.5	1075	1.6	1.4
Amara	7.5	1246	1.3	1.2
Feshkhabour **(2010)**	3.7	264	1.2	0.9
Mousl	2.6	634	1.5	1.1
Sharkat	2.7	382	1.2	1.1
Samarra	2.3	307	1.7	1.5
Thiraa Dijla	4.3	1170	1.9	0.6
Baghdad	4.7	526	1.1	1.4
Kut	3.3	612	1.2	2.3
Ali Gharbi	4.5	886	1.2	1.4
Amara	8.1	1019	1.2	0.8
Feshkhabour **(2011)**	2.6	322	0.8	1.8
Mousl	1.7	314	0.9	1.5
Sharkat	2.0	318	1.0	1.4
Samarra	2.9	352	1.7	1.5
Thiraa Dijla	2.5	1236	1.1	1.7
Baghdad	1.9	628	0.9	1.4
Kut	3.0	762	0.9	1.8
Ali Gharbi	3.5	1051	1.4	2.0
Amara	3.9	1177	1.5	2.1
Feshkhabour **(2012)**	4.1	299	1.3	1.6
Mousl	3.5	282	1.1	1.2
Sharkat	2.9	311	1.5	1.8
Samarra	3.2	334	1.4	1.1
Thiraa Dijla	2.3	1125	1.9	1.5
Baghdad	3.1	700	1.2	2.1
Kut	3.6	746	1.3	2.4
Ali Gharbi	3.8	1077	1.8	2.3
Amara	3.0	1158	1.6	2.2

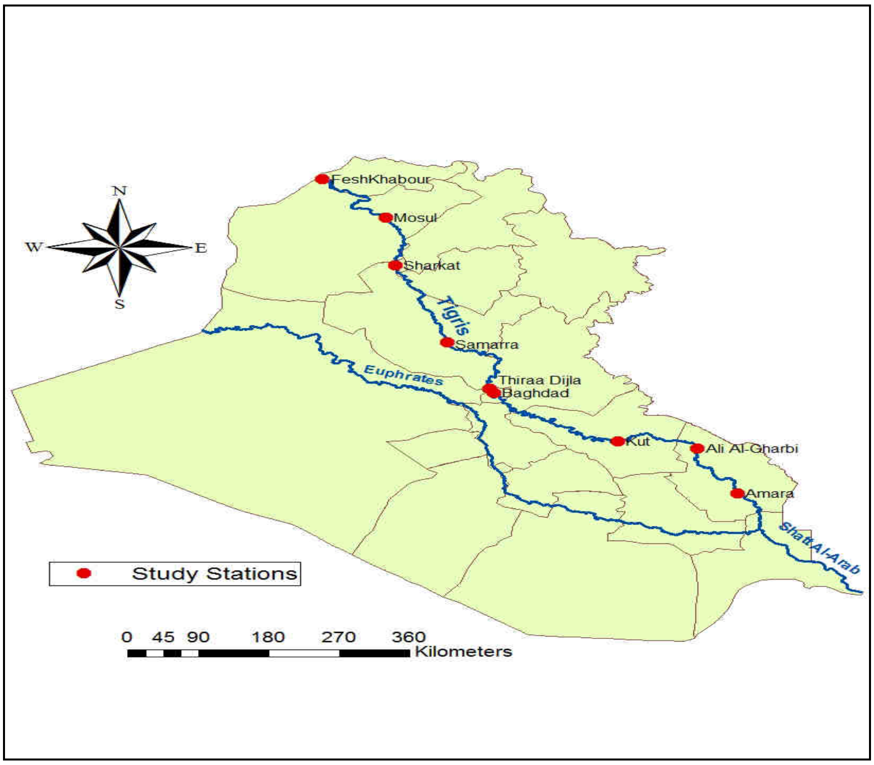


Fig. 1: location map of the present study stations.

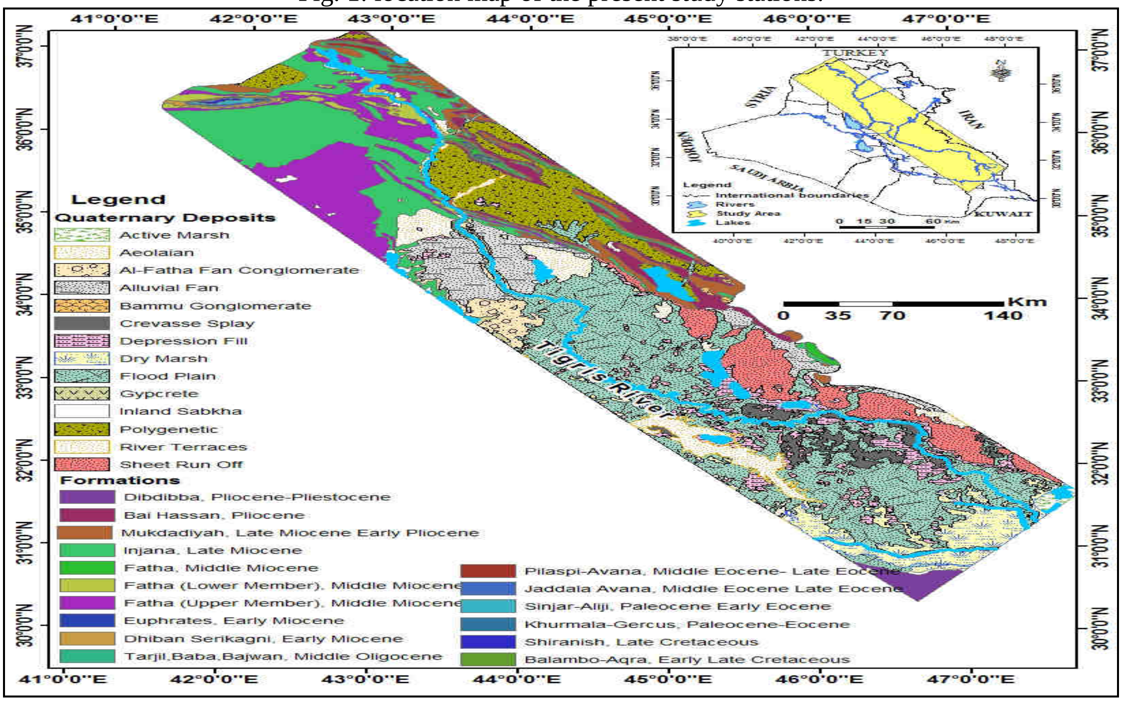
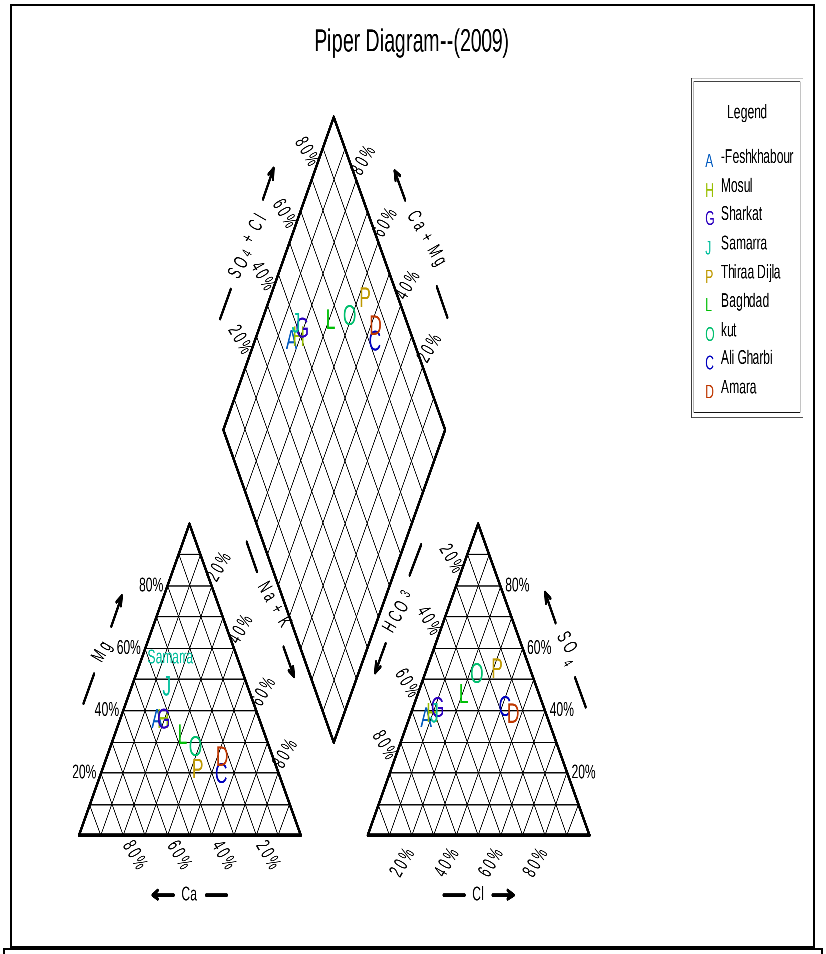
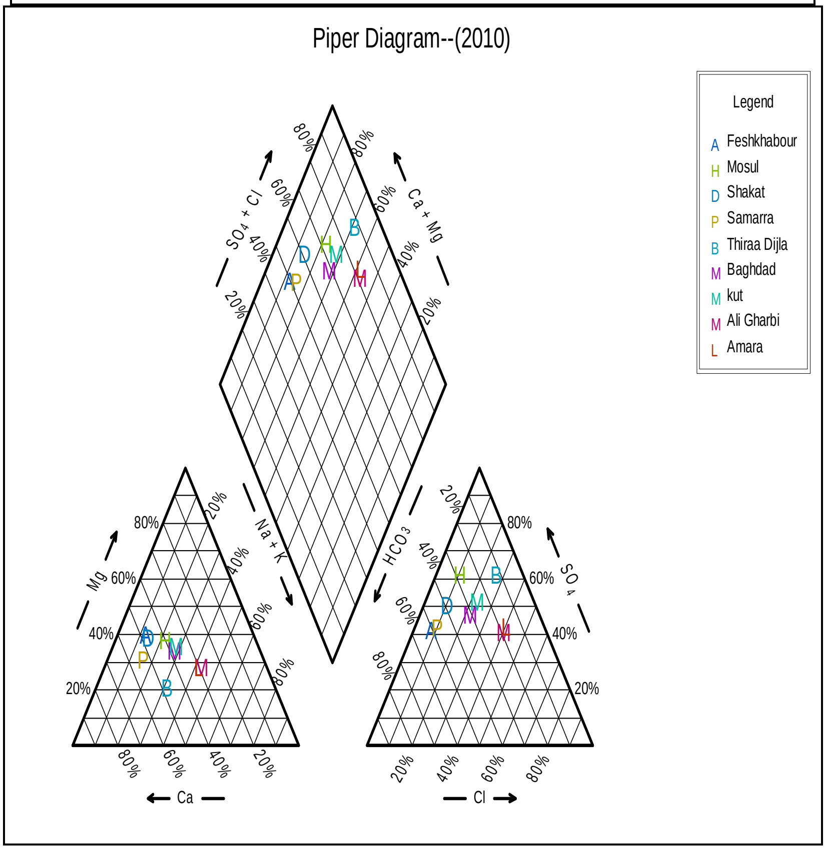


Fig. 2: Geological map of the study area.


Piper Diagram--(2009)
Legend
A -Feshkhabour
H Mosul
G Sharkat
J Samarra
P Thiraa Dijla
L Baghdad
O kut
C Ali Gharbi
D Amara
SO4 + Cl
Ca + Mg
Na + K
HCO3
Mg
SO4
Ca
Cl
Samarra
80%
60%
40%
20%


Piper Diagram--(2010)
Legend
A Feshkhabour
H Mosul
D Shakat
P Samarra
B Thiraa Dijla
M Baghdad
M kut
M Ali Gharbi
L Amara
SO4 + Cl
Ca + Mg
Na + K
HCO3
Mg
SO4
Ca
Cl
80%
60%
40%
20%

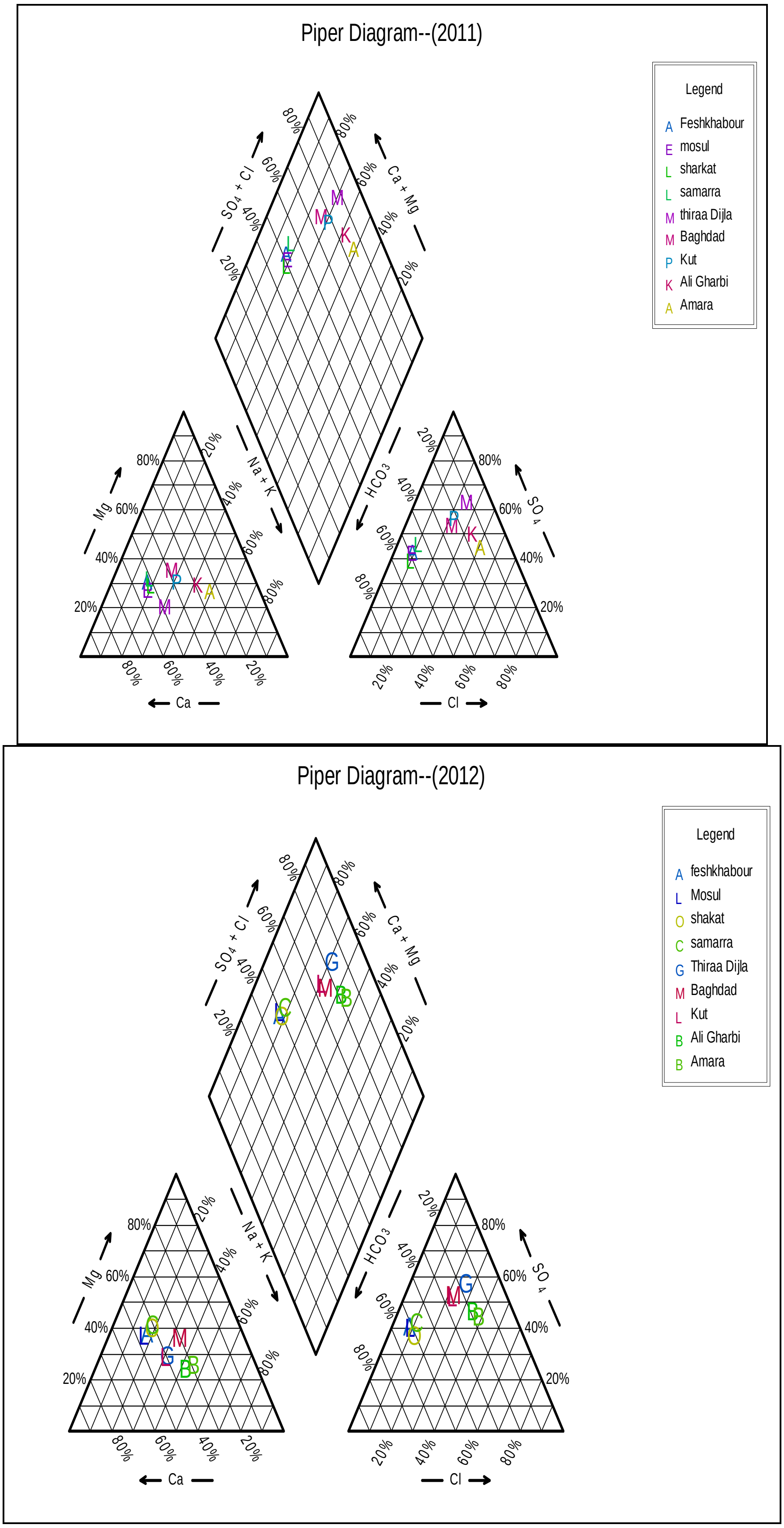
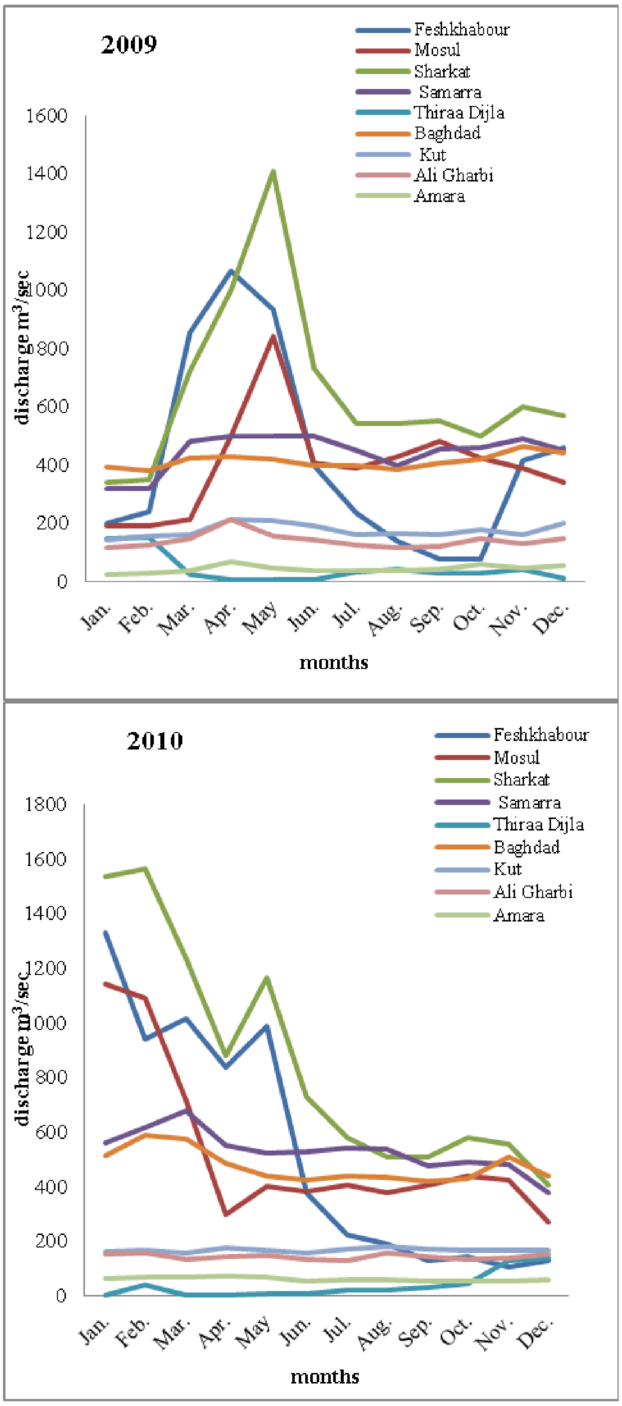


Fig. 3: Piper plots of the present study stations for the study periods.


2009
Feshkhabour
Mosul
Sharkat
Samarra
Thiraa Dijla
Baghdad
Kut
Ali Gharbi
Amara
1600
1400
1200
1000
800
600
400
200
0
discharge m3/sec
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Aug.
Sep.
Oct.
Nov.
Dec.
months
2010
Feshkhabour
Mosul
Sharkat
Samarra
Thiraa Dijla
Baghdad
Kut
Ali Gharbi
Amara
1800
1600
1400
1200
1000
800
600
400
200
0
discharge m3/sec
Jan.
Feb.
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May
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months

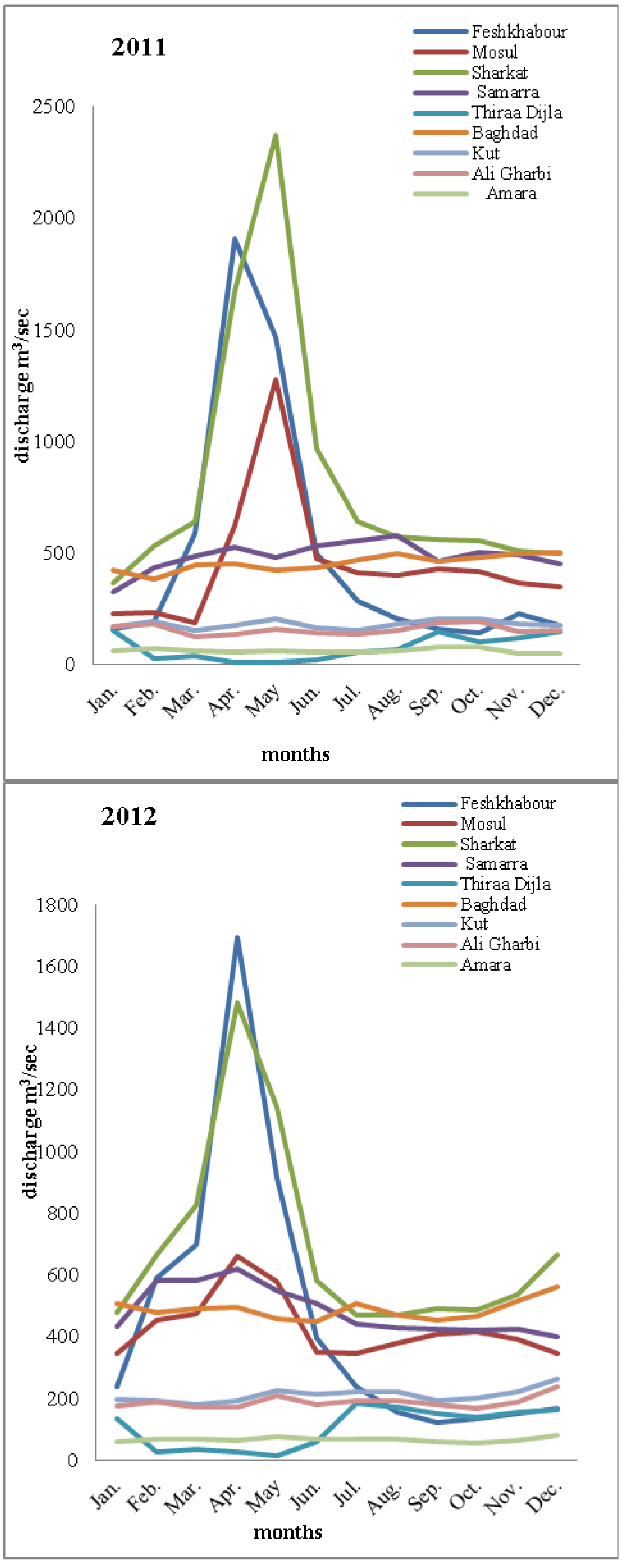

Fig. 4: Discharge variations along the selected stations for the study period.

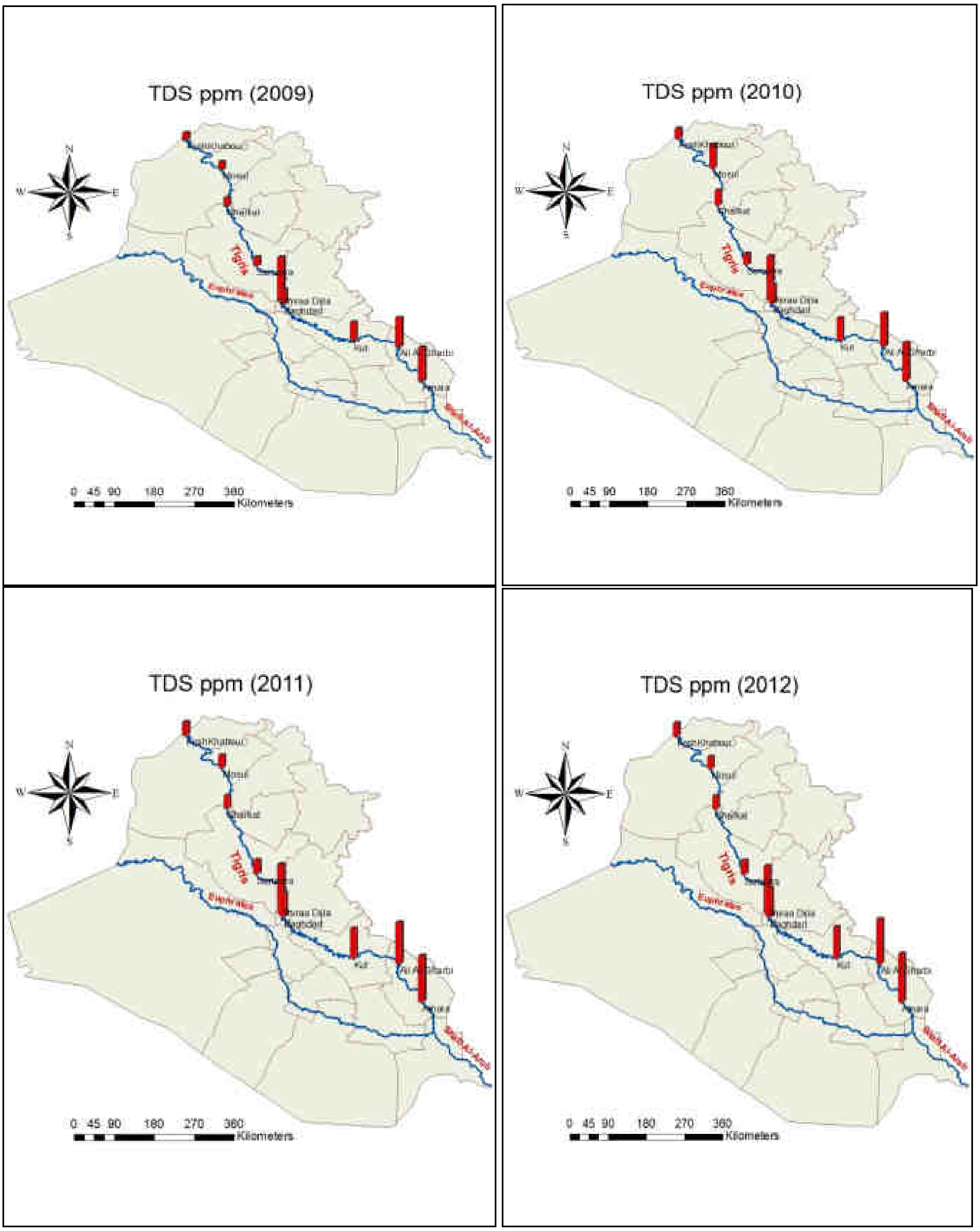

Fig.5 : Variations of TDS of the present stations for the study period.

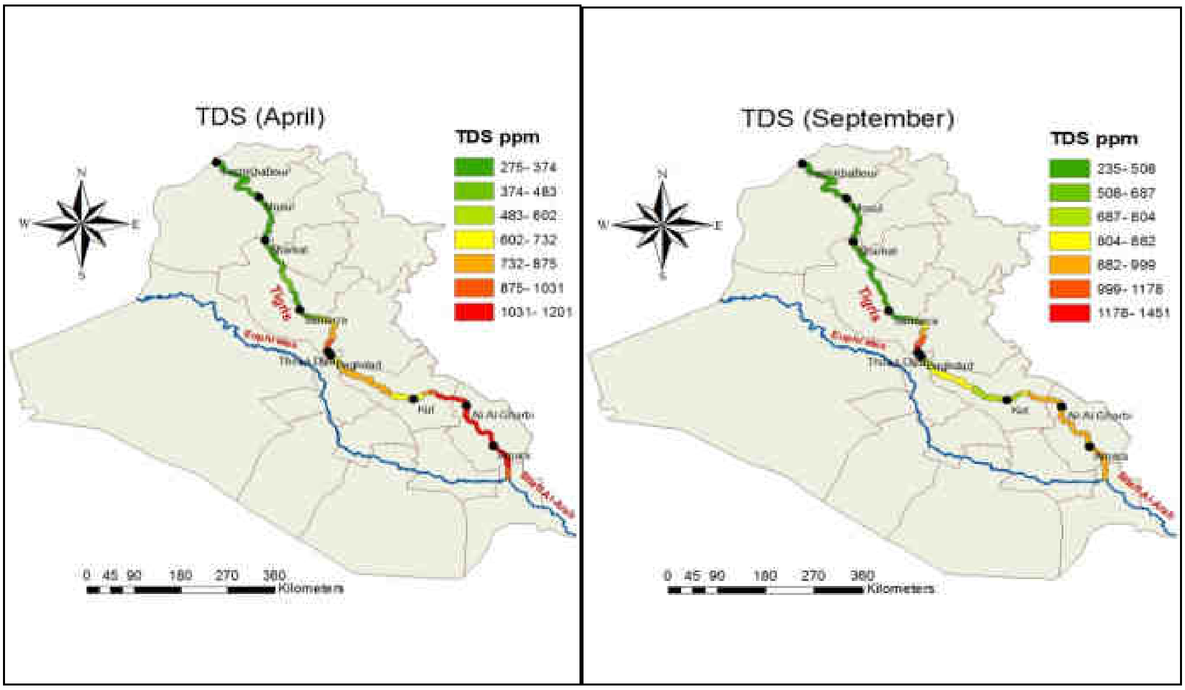

Fig. 6: TDS values of High flow (April) and low (September) for the study stations.

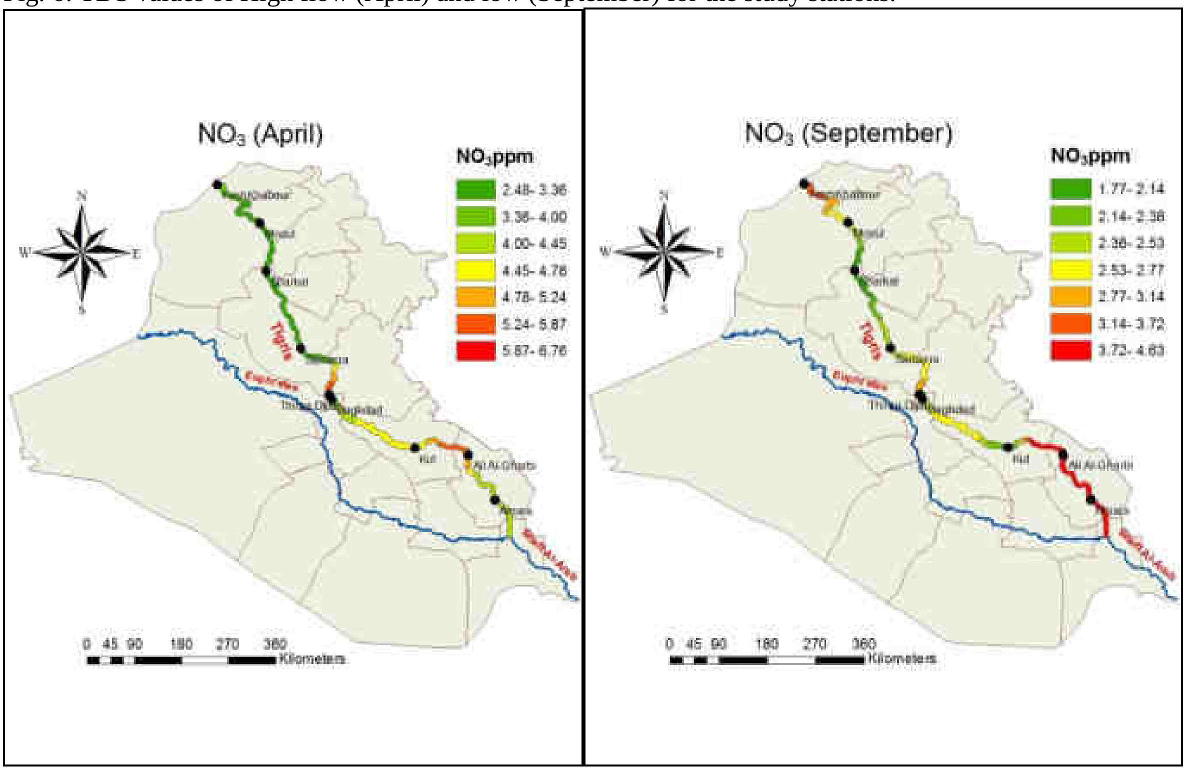

Fig. 7: NO_3 values of High flow (April) and low (September) for the study stations.

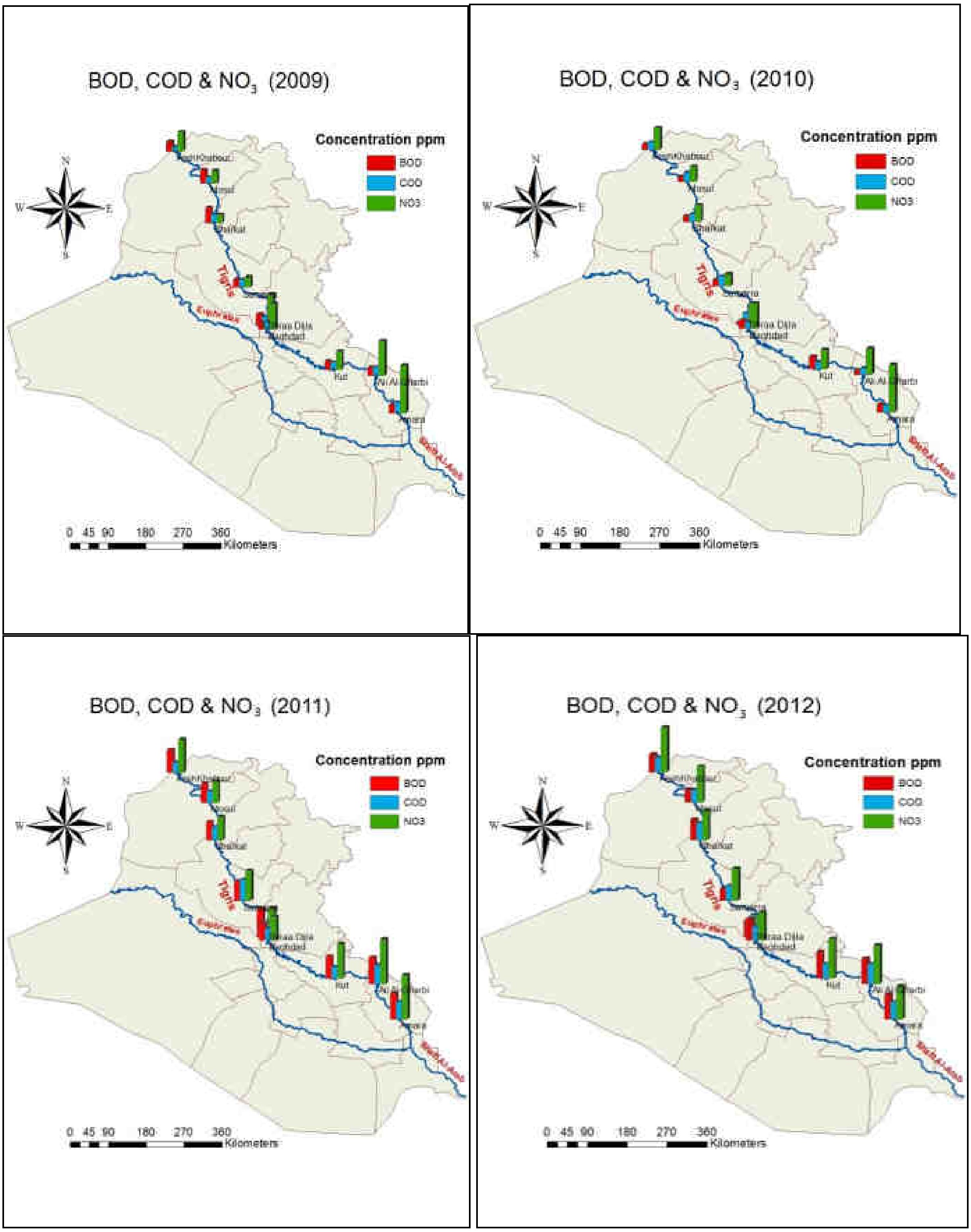

Fig.8 : Variations of NO_3,BOD and COD of the present stations for the study period.

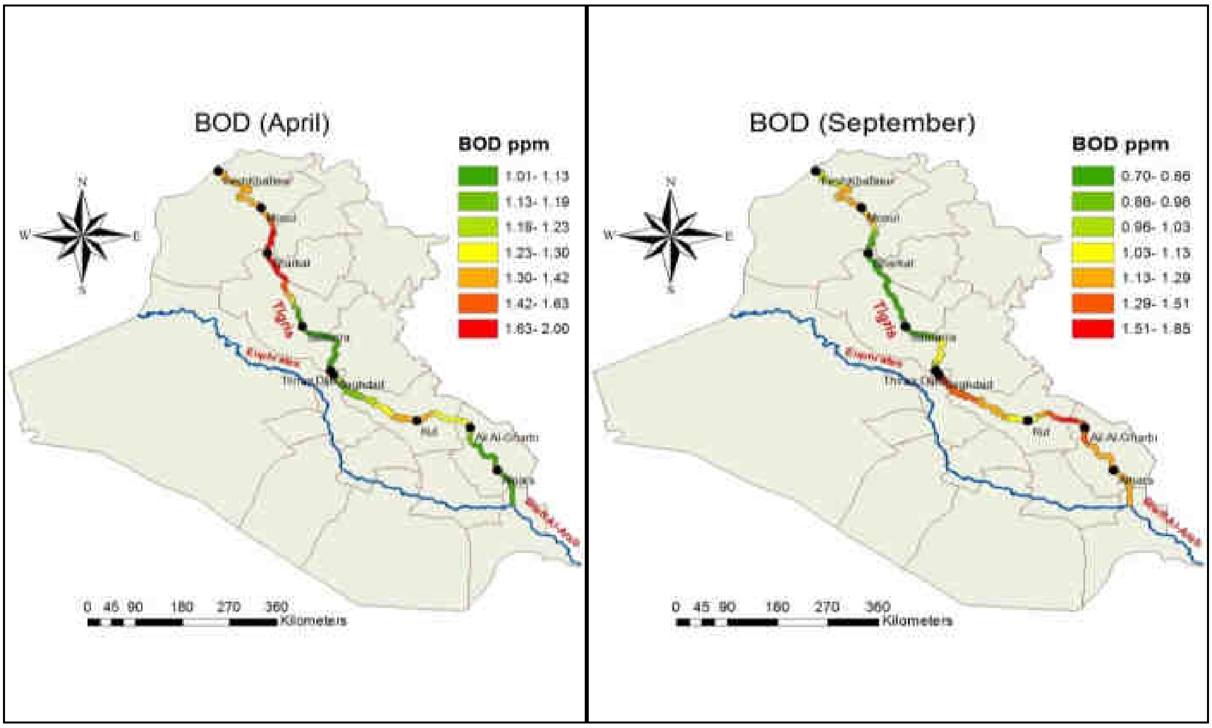

Fig.9: BOD values of High flow (April) and low (September) for the study stations.

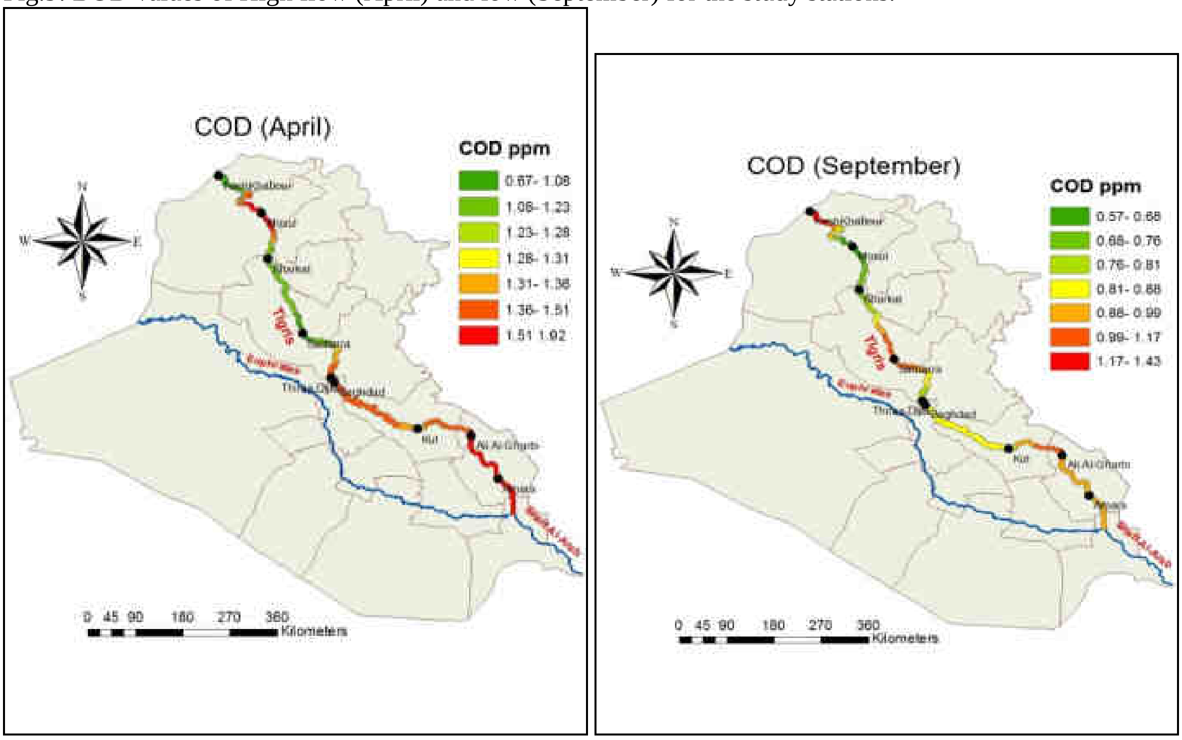

Fig.10: COD values of High flow (April) and low (September) for the study stations.