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Comparison And Assessment for Major Anions In Tigris River at Mosul District

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Abstract

Four major anions (nitrate, phosphate, sulfate and chloride) are measured in Tigris river at Mosul in six locations since Sept.2005 to June 2006. The same 4 anions are measured previously by researches or thesis, so their results are added to the former one for comparison. The variation of flow is also reported for the whole period in order to study the concentration-flow relationship. The nitrate and phosphate concentrations are increasing with the river flow increase and decreasing with its decrease for most periods, (reaching up to1.05mg/l at June for nitrate and 0.482mg/l at April for phosphate) .The lowest concentrations are observed (as low as 0.285 mg/l at Dec. for nitrate and 0.07mg/l at Jan for phosphate). Sulfate and chloride concentration are varying oppositely to the river flow for most periods, both showing their peaks at Jan. and their lowest at June (reaching up to 170 mg/l for sulfate, and 33.4 mg/l for chloride) while the minimum values are 68mg/l for sulfate, and 15.6 mg/l for chloride. The data of the previous years are not complete and data for only 8 years are available. It indicates that the anions concentrations variation corresponding to the river flow is similar to that of the studied years. However the data with equal flow rate only are used for comparison purposes to achieve correct results. All of the studied anions are increasing since 1982-2006 in different percentages except the phosphate. The 4 major anions are lower than the standards and MCL for the recent and previous studies.

Key words : Tigris River, Nitrate, Phosphate, Sulfate, Chloride, River Flow Variation

مقارنة وتقييم للايونات السالبة الرئيسية في نهر دجلة ضمن مدينة الموصل

الخلاصة

تم قياس تراكيز اربعة ايونات سالبة في نهر دجلة ضمن مدينة الموصل وهي كل من النترات والفوسفات والكبريتات والكلوريدات وذلك للفترة الواقعة بين ايلول 2005 وحزيران 2006 وفي ستة مواقع مختلفة على النهر. تم قياس تراكيز هذه الأيونات في عدة بحوث واطاريح للسنين السابقة ومنذ عام 1982 وقد استخدمت هذه البيانات في هذا البحث لمقارنة نتائج هذه الدراسة معها. اضافة الى ذلك فقد تم تسجيل معدل جريان النهر لايجاد العلاقة بين تركيز الأيونات ومعدل الجريان. خلصت الدراسة بان تراكيز ايونات النترات والفوسفات تتزايد مع تزايد معدل جريان مياه نهر دجلة وتتناقص مع تناقصها لاغلبية الاشهر وقد بلغت التراكيز أقصى قيمة مقدارها 1.05 ملغم/لتر في حزيران و0.482 ملغم/لتر في نيسان أما القيم الدنيا فبلغت 0.285 ملغم/لتر في كانون الاول و0.07 ملغم/لتر في كانون الثاني لكل من النترات والفوسفات على التوالي . أما تراكيز الكبريتات والكلوريدات فكانت تتغاير عكسيا مع معدل جريان مياه النهر بغالبية الاشهر مسجلة اعلى القيم في شهر كانون الثاني واوطأها في حزيران لكلا الايونين. بلغت القيم العليا 170 ملغم/لتر و33.4 ملغم/لتر أما القيم الدنيا فكانت 68 ملغم/لتر

و 15.6 ملغم/لتر لكل من الكبريتات والكلوريدات على التوالي. توفرت بيانات لثمان سنين سابقة فقط ضمن الفترة بين 1982–2006 وقد تبين بان تغاير التراكيزمع الجريان كان متشابها لجميع السنين المدروسة. هذا وقد ركزت الدراسة على مقارنة السنين التي تساوت معدلات جريان المياه فيها فقط لكي تصح المقارنة وخلصت النتائج الى أن تراكيز الايونات السالبة المدروسة قد ازدادت جميعها منذ عام 1982 وبنسب مختلفة باستثناء الفوسفات. أخيرا فقد قورنت جميع القيم لكافة السنين السابقة والحالية بالمعايير العالمية ومحدداتها وكانت اقل منها على الدوام .

الكلمات الدالة : نهر دجلة ، النترات ، الفوسفات ، الكبريتات ، الكلوريدات ، تغاير معدل جريان النهر.

Abbreviations

MCL :Maximum Contaminant Level .
X_{max} : maximum value.
$X_{min.}$: minimum value.

S.D: Standard Deviation.
N: number of samples.
C.V: Coefficient of Variation= S.D/ $X_{average.}$

Introduction

Tigris river is the main and the only source of water supply for Mosul city. Mosul depends on Tigris river for its supply of water for domestic, municipal, industrial, agricultural, and other purposes. On the other hand, it receives all wastewater resulting from various activities from many point and non point sources of discharge without any preliminary treatment.

The inorganic anion pollution of rivers mainly nutrients (i.e: nitrate and phosphate) as well as sulfate and chloride may arise from domestic and industrial sewage discharges beside exessive fertilization of farm lands [1] .

Nutrient status is one of four aspects of water quality measured by the environmental agency in the general quality assesment "GQA" Scheme. Nutrient concentrations have increased substantial in the world since the mid of the 19th century [2] due to the change of agricultural practices, such as using nitrogen and phosphate fertilizers to grow higher yielding crops. Nutrient concentration fluctuate from year to year and even seasonaly but their is no distinct trends[3]. As more nutrients are put onto the land, more become washed away into river. Excessive amounts of nitrates and phosphates in surface water can lead to eutrophication, a condition of superfluous algal growth that reduces the amount of free oxygen in the water which is harmful to the environment.. Nitrate converted to nitrite in the body, causes two chemical reactions that can cause adverse health effects: induction of methemoglobinemia, especially in infants under one year age, and a potential formation of carcinogenic nitrosamides and nitrosamines[1].

Sulfates are not considered toxic to plants or animals at normal concentrations. In humans, concentrations of 500 - 750 mg/l cause a temporary laxative effect. However, doses of several thousand mg/l did not cause any long-term ill effects.. Problems caused by sulfates are most often related to their ability to form strong acids which changes the pH. Sulfate ions also are involved in complexing and precipitation reactions which affect solubility of metals and other substances.

Chlorides are not usually harmful to people, but it can corrode metals and affect the taste of food products. Therefore, water that is used in industry or processed for any use has a recommended maximum chloride level. Chlorides can contaminate fresh water streams and lakes. Fish and aquatic communities cannot survive in high levels of chlorides. Small amounts of chlorides are required for normal cell functions in plant and animal life.

Review of Literatures

Nutrient associated problems in water quality were a matter of concern all over the world since 1965. A task group[4] concluded that more than half of the surface water supply in the U.S. are believed to be affected in some way and to varying degrees by nutrients, in future, however greater problems can be expected.

A statistical analysis has been carried out by Casey and Clarke [5] on 11 years (1965-1976) for weekly data of nitrate concentration of River Frome (Dorset). The results have shown a trend over the 11-year period with nitrate concentration per year. The mean predicted nitrate concentration of 3.37± 0.136 mg NO_3-N^{-1} was very close to the observed 3.44 mg NO_3-N^{-1} .

A study of six years analysis of water quality data was conducted by Maclead and Whitfield [3]. Samples were collected every four weeks from Columbia River at Reverlstoke to determine the process controlling water quality. The presence or absence of trends was also determined by plots of water quality versus time. Hysteresis diagrams (which is the log-log plots of water quality versus discharge for a typical year) were used to describe processes affecting water quality variables through the relationship of water chemistry. The major ions exhibited distinct seasonality and these ions varied inversely with discharge. Other variables didn't exhibit seasonality. Only one monitoring station was constructed for this study with 21 variables. No trend over time was found for the studied variables

A review of the historical data (water quality records) for 13 Kansas streams [6] was made to determine whether an increase in the NO_3 or PO_4 concentrations of these streams has occur, the rate of increase and whether the data can be used to provide a guide for future trends. The results suggested that future rates of NO_3 and PO_4 increase should not exceed those presently observed, which were around 0.02 ppm and 0.06 ppm per year respectively.

Many similar and more studies were conducted for nutrient variation all over the world[7,8,9,10] since nutrients will be increased directly with population increase as well as industrial and agricultural activities.

In Mosul, many thesis and researches were accomplished for Tigris River water quality in different directions [11-18] Table 1 summarizes some of their data description and period of these studies briefly. Part of the results had been used as a complementary data for the recent research to achieve an assessment of the four major anions in Tigris river since 1982 till mid of 2006. The collected data were insufficient to represent a trend or a representative statistical analysis since results of only 8 years are available. Moreover, many years are uncovered, however this study deals with the available data .

The continuing population increase and industrial expansion beside the intensification of agriculture indicate that significant increase in pollution by nutrients will occur. These nutrients will stimulate the growth of aquatic plants and other organism so that the problems which they cause will increase in frequency and severity .

One of the most expensive prblems caused by nutrient enrichment is the increased treatment required for drinking water due to filter clogging with algae beside contribution to the corrosion of intake pipes[8].

Continuous monitoring of all impurities in Tigris River is a necessity which should be practiced by the Iraqi authorities or government to prevent the deterioration of its quality and to manage this resource successfully. Tigris river is deteriorated by its quantity of its flowing water as can be seen from variation of the flow through the last 23 years and even by the naked eye, so at least its quality should be preserved and protected from further deterioration. The lack of water indicates that the pollution as well as treatment problems will increase. On the other hand, the lack of security caused the closure or shutoff of all industrial activities which is a good sign only from the environmental point of view, as it provides protection of the surrounding fields of air and water from further pollutants discharge.

Objectives of the Study

1. To document the concentration of four major anions which are nitrate and phosphate (nutrients) in addition to sulfate and chloride since 1982.
2. To evaluate their seasonal variation and their relation with changing river flow and time.
3. To determine specific causes.

Sampling and Experimental Description

Six locations were chosen along Tigris River starting from north of the city (i.e.: upstream the river) represented by location 1 near darnagogh, toward last location 6 near Albuseef south of the city (downstream the river). Figure 1 illustrates the 6 locations clearly.

These locations were chosen according to the suitability of sample collection. These samples are taken from each location monthly from September 2005 till mid June 2006 (i.e:10 months). Each sample was analyzed for the four main anions. Samples collection, preservation and analysis were conducted according to APHA, AWWA, and WPCF, (1992) [19] .

Results and Discussion

Table (2) represents ranges of concentrations for the four major anions, statistical parameters of monthly values for the studied period (2005-2006) are listed. The details of these results are plotted for 6 locations as shown in Figures (2,3,4 and 5). Each Figure represent the variation of one anion along the studied period beside the flow variation of Tigris river for the same period.

Tables (3,4,5and6) represent variation of each of the major anions for the previous studies since 1982 to July 2006. Table (7) represents the variation of Tigris river flow for the previous studies also.

The discussion will be divided into two parts; the first deal with the results of this study, while the second will summarize results of the previous researches since 1982 in order to compare the effect of time on Tigris river water quality.

Nitrates

Figure 2 shows the variation of nitrate concentration in Tigris River since mid Sept.2005 till mid June 2006. The flow variation with time was also plotted in the same Figure

Nitrate is one of the major anions in natural waters, it originates from a variety of sources include nitrogen fertilizer, animal manure, mineralization of soil nitrogen, and nitrogen fixing crops. Other sources include human waste from sewage treatment plants, septic systems and land fills. Rainfall also contributes some nitrate-N [20].

One way to determine the major source of nitrate concentrations is to look at its relationship to stream flow. In general, where pollutants are derived from non point sources, their concentrations increase with increasing flow. Where pollutants are derived from point sources , their concentrations increase as stream flow decrease due to dilution factor. Generally point sources, such as municipal sewage treatment plant discharge pollutant at relatively constant rates[21].

The variation of nitrate concentration for the studied period can be described in four portions as follows:

1. The nitrate concentrations decreased with the river flow decrease since Sept. till Dec. This indicates that the non point sources are the controlling factor here and no pollutants are introduced here within the river flow accept the point sources which is discharged in a relatively constant rate[21].
2. The nitrate concentration increased with the river flow decrease since Dec. till Feb. Here it is evident that nitrate concentrations increase within the low range of river flow [21]. This suggests that point sources also contribute nitrate to the river with appreciable concentration here.
3. The river flow start to increase rapidly from 300m^3/s at Feb. to 1500 m^3/s at April. The nitrate concentrations also increase here. This indicates that nitrate are introduced from non point sources as its concentrations increases with the flow increase .The same rainfall runoff that increase flow carries the pollutants from land surfaces and tile flow into the river. It also washes out the river banks near farm, all of which are rich with fertilizers and animal wastes, which is rich with nitrate. Here in spite of dilution effect of river flow, the nitrate concentration increased to show that the nonpoint sources predominates the dilution effect at this period.
4. For the last period between April-June, the river flow start to decrease while the nitrate concentration continues to increase. This mean that the rainfall effect disappears while the dilution effect predominates, so less water introduced higher concentrations of nitrate here. The nitrate reaches its highest concentration of 1.05 mg/l at June for location No.6.which is much less than the MCL(10mg/l)[1], and the MCL(40mg/l) according to the Iraqi regulations for drinking water,law No.417(1998).

Phosphates

Figure 3 illustrates the variation of phosphate concentration and river flow.

The main source of phosphates is due to erosion, the chemical and mechanical weathering of rocks. The second most important source is the human excreta and detergents. The third and last main source is agriculture and other land uses. This includes the leaching and drainage of fertilizers and other soil nutrients and the removal of soil particles [2].

Phosphate variation as shown in figure 3 kept changing almost similar to the river flow for most of the studied period. This indicates that the phosphate source is the most effective and the predominant factor always in spite of the dilution factor of the river flow. The phosphate is carried within the incoming flowing water continuously from 3 sources:

1. The breakdown of rock and soil minerals upstream the river (especially underneath the dam) which is 60 km north of Mosul.

2. The discharges of the polluted water from three valleys, Al-baqaq, Fayda, and Dohuk which are expanding continuously[14].

3. The uptake of fertilizers from the surrounding fields.

Thus the increase of river flow means more dissolution of phosphates beside the mentioned point sources which provides a continuous supply of phosphates as it carries human excreta, animal wastes, and detergents. The MCL for phosphate is 2.0 mg/l. Here it fluctuates between a minimum value of 0.07mg/l at Nov. to a maximum value of 0.482 mg/l at April. Both are within the acceptable limit (MCL (2.0 mg/l) [1]).

Sulfates

Figure 4 represent the variation of sulfate concentration and river flow.

Sulfate is a naturally occurring anion and it is present in the gypsum rocks dissolving underneath Mosul Dam north of the river before entering the city. Rainfall season also represent another source which may be induced to the river as a result of fuel combustion during cold weather especially for the heavily populated area [22].

The sulfate concentrations are increasing with the flow decrease since Sept.-Jan. This indicates that the point source here predominates increasingly with the flow decrease. Then the flow increases to reach its highest rate accompanied with sulfate decrease due to the dilution effect which appears clearly here. For the last two months (May and June) which are the beginning of summer and non rainy period in Iraq. Sulfate concentration continued decreasing in spite of the rapid flow decline. This behavior is related to the ending of rain period after April which means less dilution effect and lesser dissolution of air pollutants by storm periods[22].

The sulfate concentration varied between a minimum value of 68 mg/l at June to a maximum value of 170 mg/l at January which is still less than the MCL (250 mg/l) [1], and the MCL (400mg/l) according to the Iraqi regulations for drinking water, law No.417 (1998). This characteristic is similar and agree with other researches[5]. However this is a high concentration compared with other rivers around the world[5].

Chlorides

Chloride is found either from halite or rainfall in the catchments area of the river in addition to point sources which produces concentrations depending on population growth and their activities[2].

The variation of chloride concentration and river flow is shown in Fig.5. The chloride concentration doesn't show any distinguished manner at the beginning, but after Feb. chloride concentrations decreased with increasing flow due to the dilution effect. For the last two months, the flow decreases and the chloride continued to decrease but with less rate. This may be related to the rainfall shortage at this period. This means that the rainwater contributes to the chloride variation here.

The chloride concentrations varies between a minimum value of 15.6mg/l at June to a maximum of 33.4 at Jan. which is the same as sulfate variation described above and still far away from the MCL of (250 mg/l) [1], and the MCL (200mg/l) according to the Iraqi regulations for drinking water, law No.417(1998) .

Effect of Change of Sampling Locations

The effect of change of sampling locations inside Mosul district could clearly be shown for each of nitrate, phosphate, and chloride on Figs. (2, 3 and 5). The highest concentrations were always downstream the city (location 6)

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since the effect of all point and non point sources of pollution had been added to the flowing water. Sometimes there is an interaction of lines at specific months. This is related to the contribution of point and non point sources quantities and qualities which may appear at any specific time and location. However for the phosphate, location no.4 shows extra concentrations for many months, it even exceeds the last location most of the times; this appears since this location is nearby a domestic wastes disposal point collected from a heavily populated area (thus heavily pollution) and rich with detergents such as foams which appears even to the naked eyes. Thus the change of locations is not characterized by the same arrangements as with nitrates.

Unlike other anions, Figure 4 clearly demonstrates that sulfate concentrations are almost coincides for all locations with slight difference in the peaks only. Also the lowest concentrations were observed at the last location (no.6), while the highest appeared at the upstream locations, opposite to the previous discussed anions. This appeared because of the origin of sulfate was either from the gypsum rocks or the sulfur springs which is distributed upstream the river and discharged at Badoosh dam project. Thus it will be introduced increasingly toward the river corresponding to the river flow rate decline. Flowing toward the city didn't deteriorate its concentration, on the contrary it decreased the sulfate . This can be related to the dissociation of sulfate to H_2S or SO_3 due to the effect of sulfate bacteria with the inflowing river water. This also mean that point sources is not contributing for sulfate concentration such that the last location which is characterized by the lowest values compared with other locations. Table 2 shows the coefficient of variation C.V (the standard deviation divided by the average value) for the studied variables. The C.V. are 64.3%, 37.26%, 27.46%, 24.25%, and 18.57% for river flow, phosphate, nitrate, sulfate, and chloride respectively. This means that the highest fluctuating variable is the river flow followed by the phosphate and so on to end with chloride. This also indicates that the river flow is highly affected by the seasonality and the phosphate is the second variable affected and so on to end with chloride which is the least anion affected by seasonality.

Anions Variation for the Period 1982-2006

The second part of this study deals with the available data collected from previous studies, but data for many years are missing. However, this part will deal with the available data in order to estimate the effect of time passing over concentrations of the four major anions. Tables (3, 4, 5, and 6) summarized the available data which are plotted on Figs. (6, 7, 8, and 9).

Investigation of the variation of the anions upon year passing didn't give any distinct trend. The capability of rivers to export nutrients is controlled by water discharge, which in turn is a function of climate and other factors of which seasonality is one of them. Neither time series plots nor Box-Jenkins time series models could be used for the analysis of the collected data. Indeed results of only 9 years since 1982 were available out of 24 years (with many missing months also). It is decided that the best way to discuss the available results is to compare the anions variation for the years with complete data and which are characterized by a close values of the river flow which are for the years 1987, 1998, 2006 only with an average flows of 841.8, 882.8, 753 m^3/s

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respectively. This will represent a more reliable and logical comparison. Results of the remaining years were tabulated and plotted but will not be included in the discussion due to the sharp variation of flow between them as clarified in Fig.(10) and Table (7).

Table (3) and Fig.(6) show the variation of nitrate for the previous period. It is clearly clarified that year 1998 represents the highest concentrations of nitrate (maximum concentration of 1.33mg/l) followed by the year 2006 (maximum concentration of 1.05 mg/l) then 1987 (maximum concentration of 1.0 mg/l). This is proportional to the maximum flow for these years, but their average concentrations are (0.792, 1.086, 0.72) mg/l for the years 1987, 1998, 2006 respectively which indicates an increase among passing of time.

Table (4) and Fig.(7) represent the previous years variation of phosphate. It indicates that the average phosphate concentration are 0.488, 0.425 mg/l for the years 1987 and 1998 which are close, but they are overlapped within months variation. The average concentrations for the year 2006 represent lower values of 0.3mg/l, almost 60% of the previous years. This indicates an improvement.

Table (5) and Fig.(8) indicate the sulfate variation through the previous years. It is shown that the concentrations for the year 1987 are varying between 27 and 87 mg/l with an average of 59.1mg/l, but for the next years between 1998 and 2006 the average sulfate concentrations shows close values for both (100.7 ,116)mg/l, the year 2006 is almost around 16% more only.

Finally Table (6) and Fig.(9) show the chloride variation for the previous years. The chloride concentration is almost doubled for 1998, their average concentrations are (10.96, 19.3) mg/l, but at 2006 the concentration increased by 20% only to reach 24.2 mg/l.

Generally for sulfates and chlorides the wet periods which include Jan., Feb., March, April, Nov and Dec. shows higher concentrations than the dry periods, May, June, July, Aug., Sept., and Oct. as can be seen from Figs. (8) and (9). This is confirmed with the general seasonality variation for the available references also [3,9]. On the other hand, nitrate and phosphate behaved in a puzzled manner with respect to seasonality.

Generally the C.V for the studied variables demonstrate that the river flow shows the highest seasonality among others since it varies between 6.454% and 85.89%. This is a very wide variation. The phosphate is the second variable which shows seasonality variation followed by nitrate then sulfate. The chloride shows the lowest C.V. It can be said that it was the anion which shows the lowest seasonality .

Conclusions and Recommendations:

1. The concentrations for each of nitrates and phosphates are decreasing with the flow decrease and increasing with flow increase of Tigris river, while sulfates and chlorides concentrations are changing oppositely to the Tigris river flow most of the time.
2. Tigris river flow shows the highest seasonality variation followed by phosphates then nitrates and sulfates, while the chlorides showed the lowest seasonality variation as confirmed from their coefficient of variation (C.V). This is true for the recent and the previous studies also.
3. Flowing of Tigris water inside Mosul city had deteriorated its quality corresponding to the nitrate and phosphate concentrations which are increased by 20-50% due to the point

sources of pollution inside the city. Chlorides concentrations are increasing by 50% at rainy periods while it is not changing for the remaining periods.

4. Sulfates concentrations are almost not changing inside the city for most of the locations.

5. The average phosphate concentration was decreasing since 1983.

6. The average concentration of sulfates and chlorides are increasing continuously, but sulfates show concentrations higher than that of any other studied area in the world.

7. Sulfates and chlorides concentrations show higher values at the wet periods and lower values at the dry periods, but nitrates and phosphates didn't show any distinguished pattern.

8. All of the studied anions concentrations are within the Iraqi and the USEPA MCL

9. It is recommended to construct a monitoring station upstream of Mosul city to provide a continuous data of Tigris River water quality which could help to predict an exact model and time series analysis.

10. Regulations and laws should be established to control fertilizer application as well as industrial and municipal wastes disposal to avoid Tigris water deterioration.

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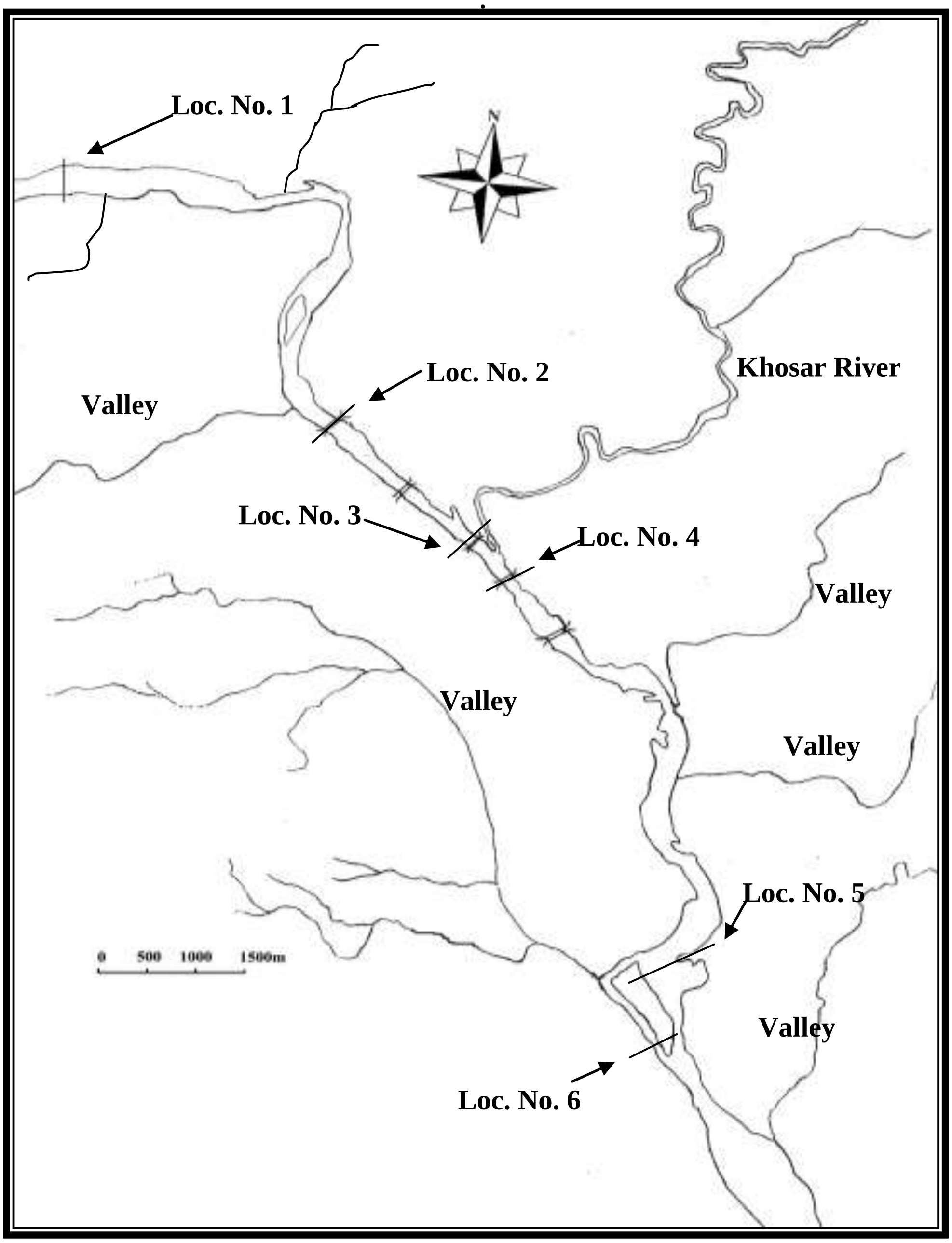
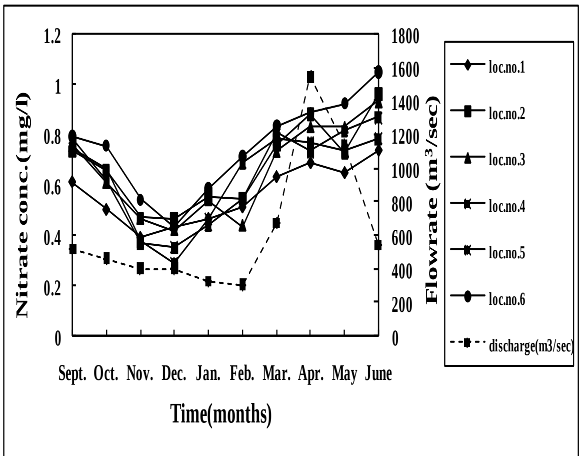
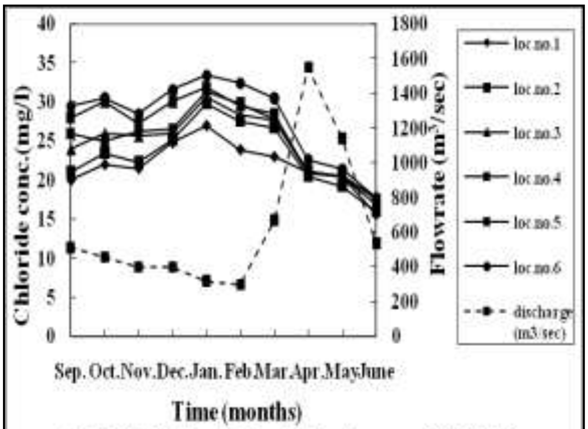


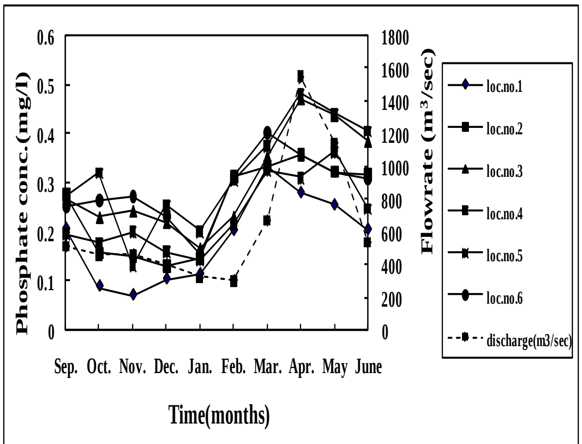
Fig. (1) Location of sampling points



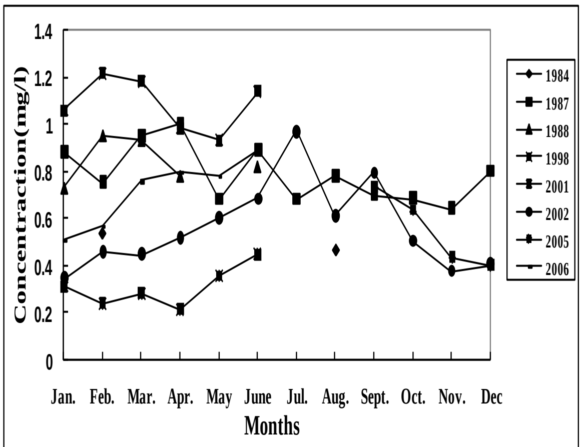
(Fig.2)Variation of nitrate for the year 2005-2006



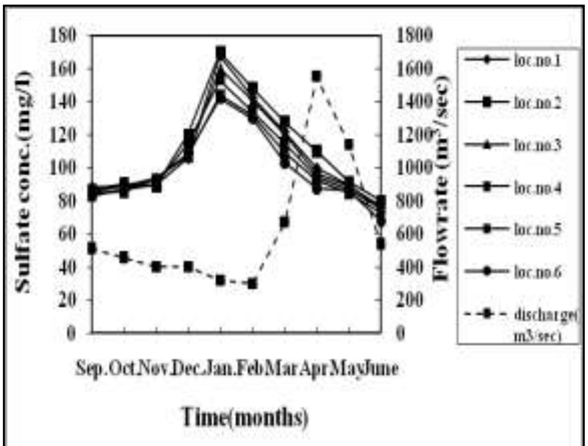
(Fig.5)Variation of chloride for the year 2005-2006



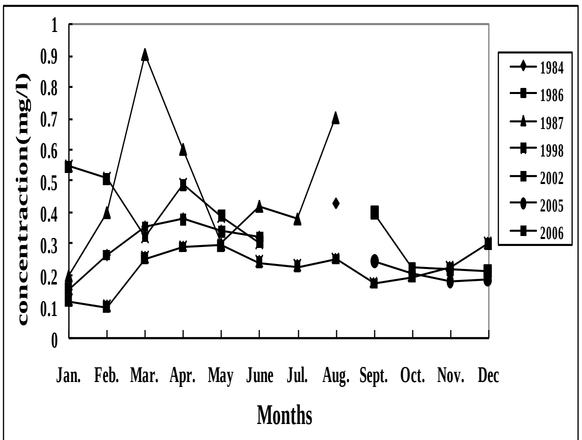
(Fig.3)Variation of phosphate for the year 2005-2006



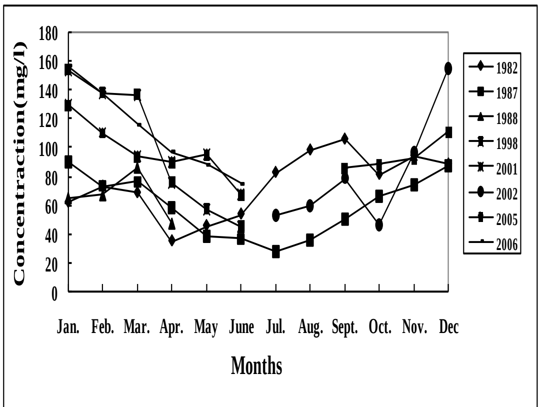
(Fig.6) Variation of nitrate for the previous studies



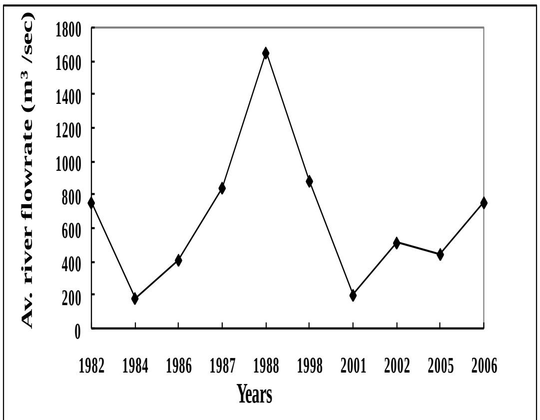
(Fig.4)Variation of sulfate for the year 2005-2006



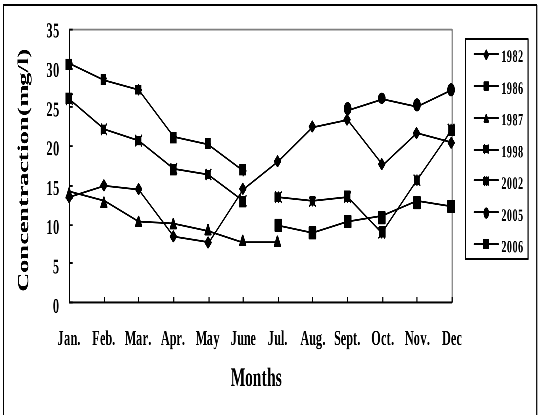
(Fig.7)Variation of phosphate for the previous studies



(Fig.8)Variotion of sulfate for the previous studies



(Fig .10) Variation of Av.river flow rate



(Fig.9)Variation of chloride for the previous studies

Table(1) Summary of Data for the previous years

Ref no.	No. of locations and variables studied	Period of the study
11 (Tali,A.Z.)	7 locations, 12 variable	Jan.-Dec. 1982
12 (Nao'm,J.Z.)	12 locations, 19 variable	Only Feb. and Aug. 1984
13 (Al-layla, et al.)	Only one location,10 variable	Aug.1986-Aug.1987
14 (Kharrufa, et al.)	2 locations only,15 variable	Oct .1987-June 1988
15 (Mohammad, M.H.)	16 locations, 16 variable	Jan. 1998-June 1998
16 (Mohammad, F.I.)	6 locations, 12 variable	Jan. 2002-June 2002
17 (CERCP)	12 variable	July2002-Dec. 2002
18 (Abdulwahed, S.S)	12 variable	Jan .2002-Oct. 2002

Table (2) Ranges of the major anions for the studied period 2005-2006

Variable	Units	$X_{average}$	Standard*	X_{max}	X_{min}	$X_{max} - X_{min}$	S.D	C.V
Nitrate	(mg/l)	0.6508	10	1.05	0.285	0.765	0.1787	27.46%
Phosphate	(mg/l)	0.2611	2	0.482	0.07	0.412	0.0973	37.26%
Sulfate	(mg/l)	104.48	400	170	68	102	25.334	24.25%
Chloride	(mg/l)	24.87	250	33.4	15.6	17.8	4.62	18.57%
Flow	(m3/s)	628.8		1550	300	1250	404.28	64.30%

*USEPA National primary and secondary drinking water contaminant standards 1994[1]

Table (3) Variation of nitrate concentration (mg/l) for the previous studies

Years	N	$X_{average}$	$X_{max.}$	$X_{min.}$	$X_{max}-X_{min}$	S.D	C.V
1983	-	0.503	0.71	0.22	0.49	0.159	31.64%
1986	12	0.615	0.7	0.5	0.2	0.1012	16.45%
1987	33	0.792	1.00	0.64	0.36	0.1213	15.28%
1988	15	0.843	0.96	0.78	0.18	0.0966	11.47%
1998	36	1.0864	1.33	0.78	0.55	0.1653	15.20%
2001	35	0.3	0.47	0.185	0.285	0.0854	28.56%
2002	62	0.57	1.37	0.177	1.193	0.233	41.07%
2005	72	0.55	0.7931	0.285	0.508	0.1576	28.61%
2006	108	0.72	1.05	0.383	0.667	0.1616	22.54%

Table (4)Variation of phosphate concentration (mg/l) for the previous studies

Years	N	$X_{average}$	$X_{max.}$	$X_{min.}$	$X_{max}-X_{min}$	S.D	C.V
1983	-	0.428	0.82	0.23	0.59	0.272	63.61%
1986	12	0.262	0.4	0.2	0.2	0.0926	35.44%
1987	24	0.488	0.9	0.2	0.7	0.2297	47.13%
1998	36	0.425	0.757	0.261	0.496	0.11997	28.23%
2002	62	0.23	0.9		0.9	0.1367	59.94%
2005	72	0.203	0.32	0.07	0.25	0.06745	33.23%
2006	108	0.30	0.482	0.103	0.379	0.0954	31.8%

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Table (5)Variation of sulfate concentration (mg/l) for the previous studies

Years	N	$X_{average}$	$X_{max.}$	$X_{min.}$	X_{max}-X_{min}	S.D	C.V
1982	55	74.65	108.6	26.91	81.69	2.7	30.40%
1986	12	56.25	65	50	15	6.5	11.56%
1987	33	59.1	87	27	60	21.34	36.11%
1988	15	62.1	86	45	41	16.65	26.82%
1998	36	100.7	168	40.5	127.5	44.33	40.02%
2001	35	95.26	138	60	78	20	21%
2002	22	83.98	185	38.5	146.5	41.5	49.40%
2005	72	93.9	120	83	37	10.48	11.2%
2006	108	116	170	68	102	29.62	26.54%

Table (6)Variation of chloride concentration (mg/L) for the previous studies

Years	N	$X_{average}$	$X_{max.}$	$X_{min.}$	X_{max}-X_{min}	S.D	C.V
1982	56	16.56	24.7	7.17	17.53	5.06	30.52%
1986	12	10.12	11	9	2	0.854	8.433%
1987	27	10.96	14.2	7.9	6.3	2.298	20.97%
1998	36	19.3	30	11.6	18.4	4.6808	24.26%
2002	22	14.7	28	5.5	22.5	5.574	37.95%
2005	72	25.88	31.5	20	11.5	3.167	12.24%
2006	108	24.2	33.4	15.6	17.8	5.315	21.96%

Table (7)Variation of Tigris river flow(m^3/s) for the previous studies

Years	$X_{average}$	$X_{max.}$	$X_{min.}$	X_{max}-X_{min}	S.D	C.V
1982	752.7	2265may	170 Sept	2095	646.52	85.89%
1984	177.5	240	115	125	88.38	49.80%
1986	407.5	430 Nov	370 Sept	60	26.3	6.454%
1987	841.8	1630 May	270 Aug	1360	501.6	59.50%
1988	1654	3130 April	800 Feb	2330	881.2	53.50%
1998	882.8	1960 April	311.7 Jan	1648.3	601.285	68.11%
2001	196.5	420 June	100 April	320	108.2	55.07%
2002	511.3	1010 May	240 Dec	770	216.06	42.30%
2005	442.5	513 Sept	400 Dec	113	54.13	12.24%
2006	753	1550 April	300 Jan	1250	496.2	65.90%