EVALUATION OF SURFACE WATER QUALITY IN AL KUFA RIVER STATION

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ABSRACT

The principal reason for monitoring water quality has been, traditionally, the need to verify whether the observed water quality is suitable for intended uses. The present study was conducted on Al Kufa river in Al-Kufa city in the aim of studying the concentration levels of some water quality parameters (BOD, PO_4, NO_3, pH, TU, Cl, and dust particles).

Samples of raw water were collected and analyzed from Kufa river station during a period of eight months, starting from November until June 2010. The purpose is to assess the level of parameters measured and their effects on the river. Statistical analysis used to describe the relations between parameters of water quality with regression analysis done by using "Data Fit" program version 9.0 software.

This study showed that the discharging of domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water from adjacent areas causing some contaminants increased.

It was noticed that the NO_3 has highest positive correlation with PO_4 and pH has highest negative relation with PO_4 and NO_3,

Finally, precipitated dust particles have highest negative correlation with pH as a result of acidic chemicals in dust particles.

Keywords: Water Quality, Turbidity Unit, BOD, Phosphate, Nitrate, Hydrogen Ion Concentration, Chloride, Dust Particles, Regression Models.

تقييم نوعية المياه السطحية الخام في محطة شط الكوفة

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الموجز

ان مراقبة نوعية المياه والتأكد من صلاحيتها للاستخدام يعتبر الدافع الأول لعمليات ودراسات نوعية المياه، هذه الدراسة اختصت بدراسة مستويات بعض الملوثات (المتطلب الحيوي للاوكسجين، الفوسفات، النترات، أيون الهيدروجين، العكورة، الكلورايد، الغبار المتساقط) في نهر الكوفة في مدينة الكوفة.

تم أخذ عينات ومن ثم تحليلها من مياه النهر من محطة الكوفة وبواقع نموذجين شهريا من تشرين الثاني وحتى شهر حزيران في العام 2010. الهدف لمعرفة تأثير تلك الموثات على

مياه النهر من خلال التحليل الاحصائي لمعرفة درجة الارتباط فيما بينها وباستخدام برنامج "Data Fit" program version 9.0 software .

بينت الدراسة بان تصريف بعض مياه الصرف والمنظفات ومصرفات الزراعة مع بعض الأسمدة والمياه الصناعية من المناطق المجاورة للنهر لها دور في زيادة بعض تراكيز الملوثات. كما وأوضحت الدراسة بوجود ارتباط إحصائي موجب مع الفوسفات، وكذلك بين أيون الهيدروجين وكل من الفوسفات والنترات ولكن بارتباط سالب. أخيرا بينت الدراسة وجود ارتباط سالب مع ايون الهيدروجين كنتيجة لوجود بعض المواد الكيميائية في دقائق الأتربة المتساقطة على النهر.

كلمات رئيسية: نوعية المياه، العكورة، المتطلب الحيوي للاوكسجين، الفوسفات، النترات، أيون الهيدروجين، الكلورايد، دقائق الغبار، نمذجة الانحدار.

1.INTRODUCTION

Water is vital for life. Not only do we need water to drink, to grow food and to wash, but it is also important for many of the pleasant recreational aspects of life. Each different use has its own requirements over the composition and purity of the water and each body of water to be used will need to be analyzed on a regular basis to confirm its suitability (**Reeve, 2002**).

Aside from the very important issue of clean drinking water, why care about clean water? Clean water and enough of it is essential to any and all life, animals, plants, and microbes. Indeed, there are places in the world where the water is so polluted that fish have disappeared. In many other places fish or shellfish survive, but are not safe to eat because their flesh is contaminated. Humans enjoy being around water, but contamination with infectious organisms makes swimming unsafe; or if water has obnoxious odors or scum, being near it is not pleasant. Clean water is vital (**Hill, 2004**).

Historically, the environmental engineer has found ways and means to provide ample quantities of quality drinking water for domestic use as well as quality water for commercial and industrial uses. Water supply issues include demand projections, quality requirements, surface water and groundwater source evaluations, groundwater production, surface water collection, surface water treatment, saline water treatment, no conventional water production, and treated water distribution (**Corbitt, 2004**).

Water pollutants are categorized as *point* source or *no point* source, the former being identified as all dry weather pollutants that enter watercourses through pipes or channels. Storm drainage, even though the water may enter watercourses by way of pipes or channels, is considered non point source pollution. Other non point source pollution comes from agricultural runoff, construction sites, and other land disturbances (**Weiner and Matthews, 2003**).

Water, of course, is used for many purposes associated with human activity. In its natural state it occurs in and on the ground in subsurface and surface reservoirs. The quality and reliability of a source of water will vary considerably, both in time and space. This means that characteristics (chemical, physical, and biological) will differ greatly depending upon the location and type of source. It also means that a given source may vary over the seasons of the year (**Pfafflin and Ziegler, 2006**).

Many studies were carried out for different rivers in the world in different forms. **Bhargava (1983)** studied the quality of Ganga and Yamuna rivers. He found that the assimilation of biochemical oxygen demand (BOD) after the waste outfalls at the urban centers along these rivers was found to be exceedingly fast. During the two stage BOD removal in these streams, the early reaches, resulted from bioflocculation of waste colloidal matter with river.

Morrison, 1987, showed that heavy metals in natural waters may occur as organic and inorganic complexes of varying sizes, or be associated with colloidal or particulate material of a heterogeneous nature.

Euphrates river has a large importance for Iraqi environment researchers because of the detrimental effect of pollutants resulting from treated and untreated domestic wastewater, treated and untreated industrial wastewater and farming and agricultural pollutants.

Chabuk, 2009, studied the Evaluation of selected trace elements in Shatt Al - Hilla river a branch of Euphrates river. He showed There is a slight variation in the concentration of trace metals between the selected locations in his study. This may be attributed to the movement of pollutants along the river and the similarity of human activities and agricultural wastes disposed to these locations.

Obais, 2010, studied Water Quality Assessment in Middle-Euphrates Region in Iraq with various locations and different water bodies such as rivers, lake, and drains , showed an environmental assessment procedure is necessary to further characterize conditions of water quality in the middle Euphrates region.

2. OBJECTIVES

The objectives of the study are:

i. To characterize the water quality of Shatt Al Kufa station
ii. To identify the effects of some pollutants discharged by different sources on river.

3. STUDY AREA

Kufa is a city in Iraq, about 170 kilometres (110 mi) south of Baghdad (capital of Iraq), and 10 kilometres (6.2 mi) northeast of Najaf. It is located on the banks of the Euphrates River. Euphrates river branches after Al-Kifil town directly about (1Km) to two branches (first one is Shatt Al Kufa and another branch named Al Abbasia river). The main source of water for this river is rain water, stored water as lake and reservoirs.

Al Kufa station is located on the river Euphrates / Shatt al-Kufa, near the Al Kufa water treatment plant for surface water monitoring, at coordinates (E044.4075, N32.03941). The water level at the station is not stable at a certain depth, according to the season of the year, in the summer decline is attributed to its lowest level so that the bottom of the river can be seen in some areas near the station, and even in winter the water levels are not rising as required, and the center of the river is not covered with water even in winter and the rainy season (**Figure 1**).

The nature of the land surrounding the station is agricultural land, with some residential buildings at a distance (100 m to the south) and farming land on the other side.

Al Kufa River passes through many towns and villages thus it represents the main source for different uses such as**:**

a. Water supply systems: The River represents the supply source for many water treatment plants such as Al-Najaf and Al-Kufa water treatment plants.
b. Irrigation: The River is the main source of the irrigation for large agricultural areas locating on both sides of the river.
c. Industrial purposes: The river represents the main source for all industrial activities in the area.

In addition to these main uses, the river receives many pollutants discharged by different sources, including:

a. Municipal wastes: Municipal wastes are discharged from Northern drainage of Al Kufa) 2 km / north) and raw waste water discharged from Al Jimaah zone at 1 km / north of station.
b. Careless use of pesticides can contaminate water sources and make the water unsuitable for drinking. Wastes of animals and plants from agricultural areas are discharged to the river on both sides.
c. Industrial wastes: Many industries discharge wastewater to the river such as soft drink factory and many private industries.

4. WATER QUALITY PARAMETERS USED

This research covers the study and analysis of monthly water quality parameters which are listed in **Table 1** of surface water for river (Euphrates/ Shatt Al Kufa). The water quality parameters used in present study will be described below:

4.1 BOD

The amount of oxygen required o oxidize a substance to carbon dioxide and water, and if the oxidation of an organic compound is carried out by microorganisms using the organic matter as a food source, the oxygen consumed is known as biochemical (biological) oxygen demand (BOD) (Davis and Cornwell, 2008).
The BOD determination has been standardized and measures the amount of oxygen utilized by microorganisms in the stabilization of water for five days at 20 °C. For domestic sewage the 5-day value or BOD_5 represents approximately 2/3 of the demand which would be exerted if all the biologically oxidizable material were, in fact, oxidized (**Steel and McGhee, 1979**).

4.2 Phosphate

Nutrients are chemicals, such as nitrogen, phosphorus, carbon, sulfur, calcium, potassium, iron, manganese, boron and cobalt that are essential to the growth of living things. In terms of water quality, nutrients can be considered as pollutants when their concentration is sufficient to allow excessive growth of aquatic plants, particularly algae (**Lal, 2009**).

Phosphorus is present in fresh waters mostly in inorganic forms such as phosphates. However, being an important constituent of biological system, it may also present in the organic form. The major sources of phosphorus are domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water. Higher concentration of phosphorus, therefore, is indicative of pollution (**Duggal, K.N., 2008**).

4.3 Nitrate

The two nutrients of importance in water/wastewater are nitrogen and phosphorus. They are both essential nutrients for plant and organism growth, but in excess they can be undesirable, often leading to eutrophication. Nitrogen cycles present in inorganic and organic forms. The inorganic form of nitrogen of key interest is: N_2, NH_3, and NO_3^- The organic forms of nitrogen of interest are: NH_3, NO_2^-, and NO_3^-. Plants have the ability to fix N_2 and convert it to nitrates. Animals cannot utilize inorganic nitrogen or nitrogen from the atmosphere, unless it is first converted into its organic form. Nitrates in drinking water are harmful, and upper limit values of 40 mg/l are typical for drinking water (**Kiely, 1997**). Excessive nutrients often lead to large growth of algae, which in turn become oxygen-demanding material when they die and settle to the bottom (**Davis and Masten, 2004**).

4.4 pH

It is the logarithm to the base 10 of reciprocal of hydrogen ion concentration expressed in gms./litre. The pH value of neutral (pure) water is 7.0 and when it is less than 7.0 it is acidic in nature while above 7.0 is alkaline in nature. Too low or too high pH values are both undesirable an hence it is imperative to have the pH value of the water around neutral value. The pH of natural waters depends upon the CO_2 equilibrium and lies between 7.0 and 8.0 to 8.5. The pH of distilled water may be 6.5 or lower, because of CO_2 solution in it (**Lal, 2009**) .

4.5 Turbidity

Turbidity is measured in units that relate the clarity of the water sample to that of standardized suspension of silica. The interference in the passage of light caused by suspension of 1 mg/l of silica is equivalent to one turbidity unit (TU). To interpret turbidity data, it is useful to be familiar with the typical ranges that occur. Turbidity in excess of 5 TU is just noticeable to the average person, most people do not complain about the clarity of the water at TU values less than 5. Turbidity in what most people would consider to be a relatively clear lake may be as high as 25 TU. In muddy water, turbidity generally exceeds 100 TU. Modern water treatment plants can routinely produce crystal water with turbidities of less than 1 TU (**Nathanson, 2000**).

4.6 Chloride

Chloride in natural water results from the leaching of chloride-containing rocks and soils with which the water comes in contact and in coastal areas from saltwater intrusion. In addition, agricultural, industrial, and domestic wastewaters discharged to surface waters are a source of chlorides (**Metcalf & Eddy, 2004**). Chlorides found in domestic sewage is derived from kitchen wastes, human faces and urinary discharges etc., human excreta, for example, contains about 6 g of chlorides per person per day (**Punmia and Jain, 1998**).

4.7 Precipitated dust particles

Airborne particulate matter represents a complex mixture of organic and inorganic substances. Particulate matter is emitted in urban areas from power plants, industrial processes, vehicular traffic, domestic coal burning and industrial incinerators (**Kiely, 1997**), also particles in the atmosphere can come from windblown dust (**Boubel et. al., 2008**).

Water quality managers are concerned with knowing how water quality is affected by natural factors such as the geometry of the terrain, and the climate of the region (**Davis and Masten, 2004**).

Hence, present study considered the precipitated dust particles in study area in order to identify its effect on the water quality and relations between parameters involved through statistical analysis.

5. MODEL FORMATION

Data of water quality of the Euphrates River (at Kufa river station) are being analyzed monthly, and the pollution levels are being determined.

In present study the statistical models are described the relations between parameters of water quality. The regression analysis was done by using "Data Fit" program version 9.0 software.

Also, two statistical methods were utilized for analyzing data collected from the sampling site: correlation analyses, regression variable (t-ratio and Prob(t)), and Variance analyses (Prob(F)). Correlation analyses were performed on the individual water quality parameters to identify relationships between them. Variance analyses to determine the overall significance of the regression model

Accordingly, multiple non-linear regression models in three forms were used for each design requirements to choose which form gives the best fitting of data. The regression models that were proposed and investigated can be seen in **Table 2**.

6. Data Analysis

Data for Euphrates river in Al Kufa station were collected, from the period extended from November to June 2010. These data represent the Phosphate (PO_4), Nitrate (NO_3), Hydrogen Ion concentration (pH), turbidity unit (T.U.), Chloride (Cl), precipitated dust particles (PM, g/m^2) as independent variables, and Biological Oxygen Demand (BOD), as dependent variable, as shown in **Table 3**.

Table 4 shows the data statistics of water quality parameter used, while the correlation matrix is shown in **Table 5**.

The optimum correlation equation from rank A in an exponential form with coefficient of determination R^2 equal to 0.2465 was shown in **Table 6**, and **Table 7** shows regression variables results and 95% confidence intervals. Finally, (ANOVA) analysis is shown in **Table 8**.

Fig 2 shows the plot model of Euphrates River at Al Kufa station.

7. DISCUSSION

From **Table 5** BOD in station has poor negative relation with turbidity unit and poor positive relation with phosphate, while NO_3 has highest positive correlation with PO_4, because of they are together represent major nutrients found in domestic sewage that discharged to Al Kufa river from Northern drainage of Al Kufa (2 km/north) and raw waste water discharged from Al Jimaah zone at 1 km / north of station .

pH has highest negative relation with PO_4 and NO_3, apparently as a result of discharging of domestic sewage mentioned above and the wastewater effluent from the water softening factory precede the station causing altering the concentration in the Kufa water body.

Negative correlation between turbidity and phosphate was found, this results can be explained by considering the discharging domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water from adjacent areas which represent major sources of phosphates that affecting turbidity value with considering tiny fragments of organic matter with clay and silt cause turbidity.

Precipitated dust particles have highest negative correlation with pH as a result of acidic chemicals in dust particles resulting from gases emitted from numerous illegal private brick factories.
Some chemical substances exist as dry particles in the air while others enter water body as wet particles such as rain, snow, sleet, hail dew or fog (**Meenambal et. al., 2005**). Particles may be precipitated directly to the river or indirectly, such as with rain that falls on land is drained through the sewage system eventually make their way into river. The introduction of these acids and chemicals into river causes a sudden drastic change in the pH value.
Figures 3 and 4 show the variation of BOD and phosphate levels in the river water during the period of the study. All values measured are below the allowable Iraqi limits for rivers, less than 5 mg/l and 3 mg/l respectively (values detailed in table 4).
Figures 5 and 6 illustrate nitrates and pH; also, all values are at acceptable limits.
Figure 7 shows the turbidity concentration during period of study, highest value occurs in June was 47.7 NTU, while Iraqi standard is (10- 18 NTU), all measured values were allowable.
Chloride values throughout the period of the study shown in **Figure 8**, values ranged between (153.8-236.9 mg/l), highest level was at May, as a result of pesticides used for agriculture in adjacent land while Iraqi standard is 200 mg/l.
Table (9) shows the allowable limits of water quality parameters in river water body and drinking water according to IRAQI, WHO, US EPA, and CANADIAN standard.
Most values measured agreed well with the limits given in **Table 9**.

8. CONCLUSIONS

The following conclusions are drawn on the basis of the results obtained from the present analysis:
- It was found, BOD and chloride have poor relation with other parameters used, also, it was noted that moderate existence of its concentration in Kufa station compared with local and international allowable limits of water quality parameters.
- it was found that there is highest positive correlation between NO_3 and PO_4. Also, pH has highest negative relation with PO_4 and NO_3, these results can be explained by considering the discharging of domestic sewage and the wastewater effluent from some industrial activities to the river.
- Negative correlation between turbidity and phosphate was found.
- it was found that there is a negative relation between dust concentration and hydrogen ion, agreed well with Obais, 2010, and also with nitrates, while poor relation was found with phosphate, turbidity and chloride.

9. RECOMMENDATIONS

-Environmental monitoring programs to control the water quality of Al Kufa river, and how they are affected by various environmental factors.

-Further studies on other potential pollutants in Al Kufa River and the hydrocarbon compounds such as pesticides and other residues in the river water and sediment.

-More studies on the relationships between air pollution from industrial and traffic sources, and trace elements concentration within river water and sediment.

-Conduct more studies on the relationships between different types of pollutants and human and animal health.

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Table 1 Water quality parameters which are used in this study

Parameter	**Symbol**	**Unit**
Biological Oxygen Demand	BOD	mg/ L
Phosphate	PO_4	mg/ L
Nitrate	NO_3	mg/L
Hydrogen Ion concentration	pH	Hydrogen Ion concentration
Turbidity	TU	NTU
Chloride	Cl	mg/ L
Precipitated dust particles	PM	g/m^2/month

Table 2 The proposed models.

Rank	Equation Description
A	$y = \exp(ax_1 + bx_2 + ... + j_k x_k + M)$
B	$y = ax_1 + bx_2 + ... + j_k x_k + M$
C	$y = a\ x_1 + b\ x_2 + ... + j_k x_k$

Where;
y = dependent variables.
$x_1, x_2, \ldots, x_k$ = the independent variables.
a, b, c, …j_k = are model coefficients,
and M = model constant term.

Table 3 Description of independent and dependent variables in Al Kufa river station.

Type of variables	*Variables*	*Detail*
Independent	x_1	Phosphate (PO_4, mg/L)
	x_2	Nitrate (NO_3, mg/L)
	x_3	Hydrogen Ion concentration (pH)
	x_4	Turbidity unit (T.U., NTU)
	x_5	Chloride (Cl, mg/L)
	X_6	Precipitated dust particles(PM, g/m^2/month)
Dependent	Y	Biological Oxygen Demand (BOD), mg/L)

Table 4 Data Statistics of variables in Al-Kufa station

Variable	X1	X2	X3	X4	X5	X6	Y
Number of Points	8	8	8	8	8	8	8
Missing Points	0	0	0	0	0	0	0
Maximum Value	0.17	11.1	8.5	47.7	236.9	197.5	1.56
Minimum Value	0.05	7.9	7.3	5.9	153.8	15.33	0.91
Range	0.12	3.2	1.2	41.8	83.1	182.17	0.65
Average	0.105625	8.8425	7.76875	14.9375	200.65	108.3575	1.215
Standard Deviation	0.042881689	0.963190383	0.382601527	14.00121806	25.38948039	67.33670486	0.193316912

Table 5 Correlation matrix of variables in Al-Kufa station

Correlation Matrix							
	X1	X2	X3	X4	X5	X6	Y
X1	1						
X2	0.57894986	1					
X3	-0.5754979	-0.557396	1				
X4	-0.3047245	-0.217717	0.079453	1			
X5	-0.0964742	-0.235383	0.072612	-0.083726	1		
X6	-0.0976143	-0.304151	-0.448784	0.143449	-0.12878	1	
Y	0.07884085	0.21083	-0.368425	-0.120786	0.173557	0.163968	1

Table 6 Model Selected of variables in Al-Kufa station

Model	Std. Error	Residual Sum	Residual Avg.	RSS	R^2
exp(a*x1+b*x2+c*x3+d*x4+e*x5+f*x6+g)	0.44396	0.00262	0.00033	0.1971	0.2465

Table 7 Regression coefficients results and 95%confidence intervals

Regression Variable Results				
Var.	**Value**	**Standard Error**	**t-ratio**	**Prob(t)**
a	**-1.15428204598879**	**4.63880197013395**	**-0.24883193**	**0.84474**
b	**2.57272568082175E-02**	**0.306630909038197**	**0.083903012**	**0.94671**
c	**-0.210957288638414**	**0.890306811982229**	**-0.236948977**	**0.85189**
d	**-1.57638676748872E-03**	**1.07365540860054E-02**	**-0.146824275**	**0.90719**
e	**1.06726909016662E-03**	**6.44172699694457E-03**	**0.165680584**	**0.89547**
f	**4.60759543139453E-05**	**4.17928764012567E-03**	**0.011024834**	**0.99298**
g	**1.52921066131658**	**10.4046948661851**	**0.146973139**	**0.9071**

95% Confidence Intervals				
Var.	**Value**	**95% (+/-)**	**Lower Limit**	**Upper Limit**
a	**-1.15428204598879**	**58.941545592916**	**-60.0958276389048**	**57.7872635469272**
b	**2.5727256808E-02**	**3.89611365642113**	**-3.87038639961292**	**3.92184091322935**
c	**-0.21095728863841**	**11.3124164144086**	**-11.523373703047**	**11.1014591257702**
d	**-1.576386767E-03**	**0.136420803527602**	**-0.13799719029501**	**0.134844416760114**
e	**1.067269090E-03**	**8.184987156857E-02**	**-8.0782602478E-02**	**8.29171406587E-02**
f	**4.6075954313E-05**	**5.310286461296E-02**	**-5.3056788658E-02**	**5.3148940567E-02**
g	**1.52921066131658**	**132.204133908722**	**-130.674923247405**	**133.733344570038**

Table 8 Variance analysis of variables in Al-Kufa station

Variance Analysis					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Ratio**	**Prob(F)**
Regression	**6**	**6.449608182228E-02**	**0.01074934697038**	**0.054536445**	**0.99481**
Error	**1**	**0.19710391817772**	**0.19710391817772**		
Total	**7**	**0.2616**			

Table 9 Allowable limits of water quality parameters in river water body and drinking water according to IRAQI , WHO, US EPA, and CANADIAN standards

parameter	**Unit**	**water standards**				
		Iraqi* drinking water standards	**Iraqi * river water stand.**	**WHO* * drinking water standards**	**U.S. ** Envir. Protection Agency, 1994 drinking water stand.**	**CANADIAN * * Guidelines For Drinking Water Quality (1987)**
BOD	mg/ L	None	< 5	None	None	None
PO_4	mg/ L	……	< 3	…….	……	…….
NO_3	mg/L	0 - 40	50	10	10	10
pH	Hydr-ogen Ion conce	6.5-8.5	6.5-8.5	6.5-8	6.5-8.5	6.5-8.5
TU	NTU	< 10	10-18	5-25	1	1
Cl	mg/ L	200	200	250-600	250	< 250

* *Source:* Iraqi environmental legislations book
** *Source:* (Liu , 1999)

Figure 1 Map of the studying area in the national context.

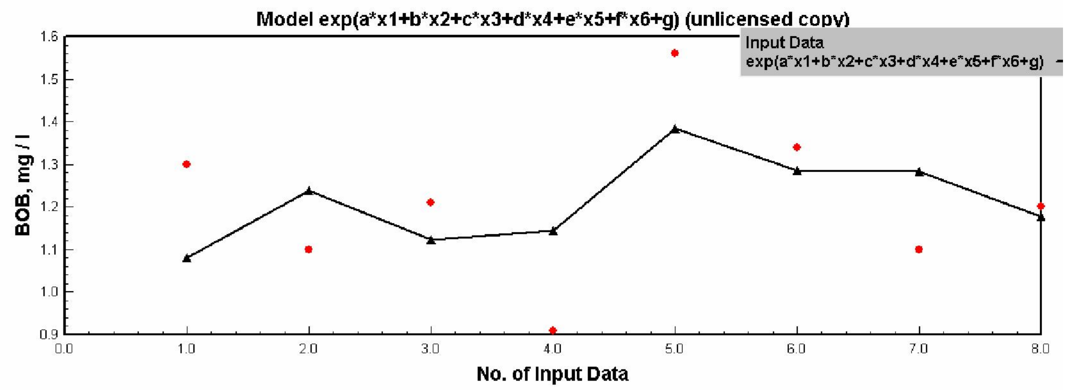

Figure 2 Plot model of water in AL Kufa station

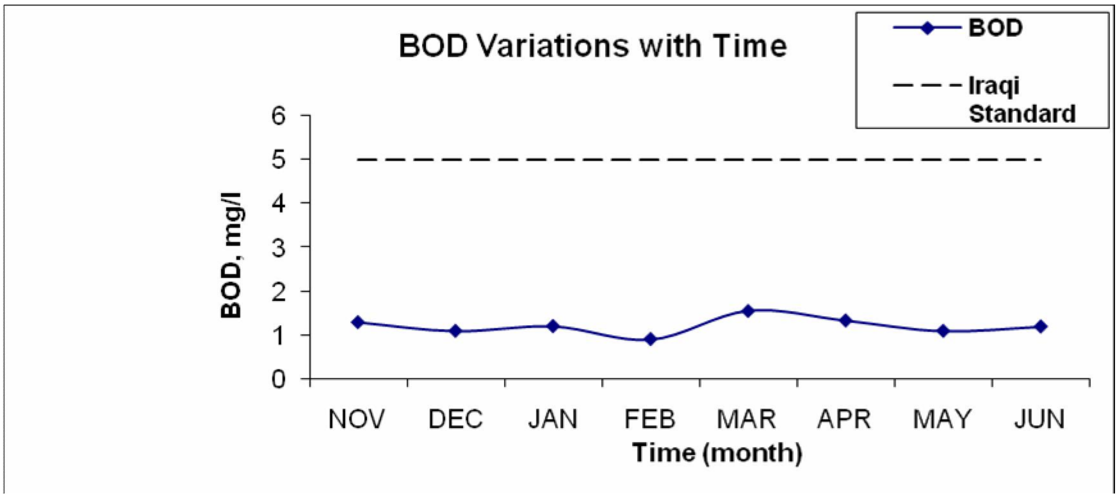

Figure 3 Variations of BOD with Time

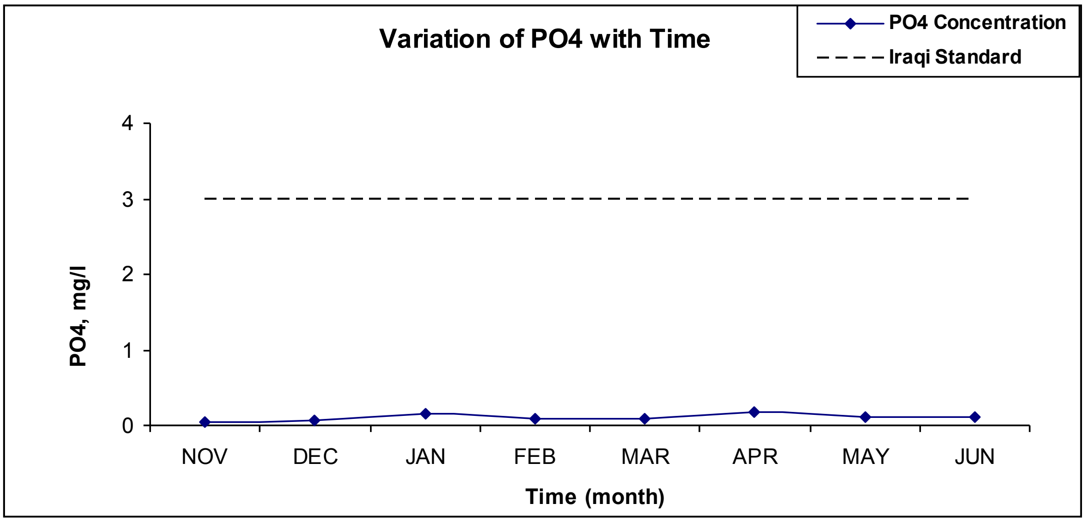

Figure 4 Variations of PO_4 with Time

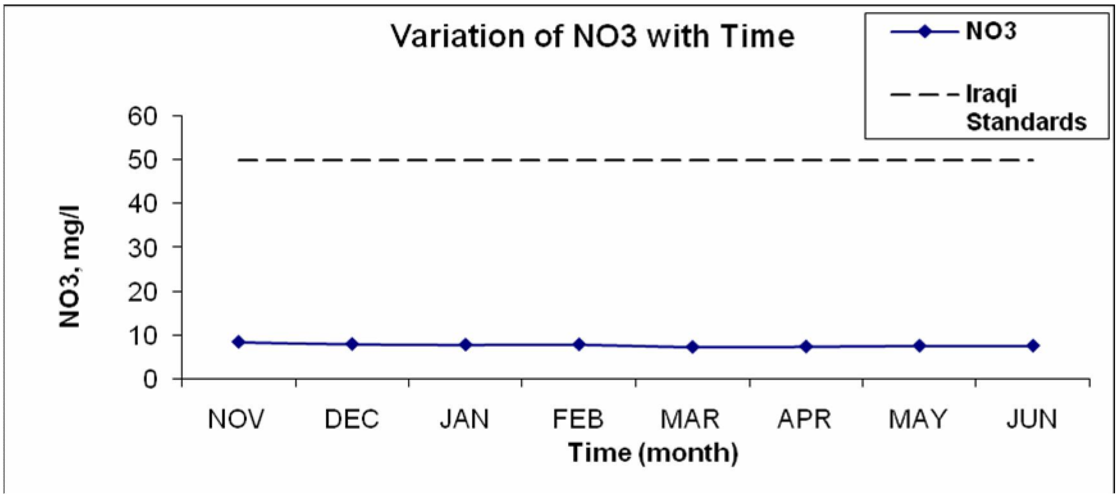

Figure 5 Variations of NO_3 with Time

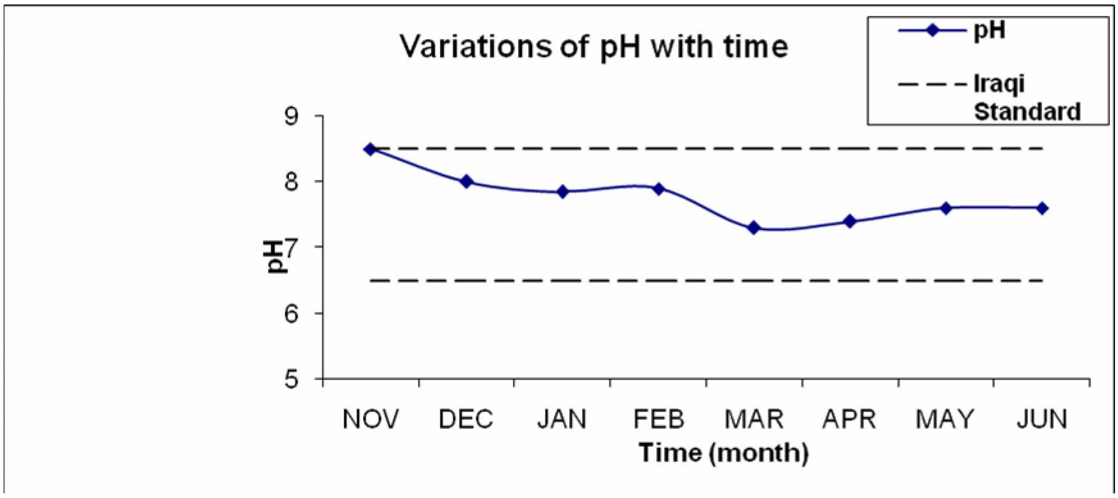

Figure 6 Variations of pH with Time

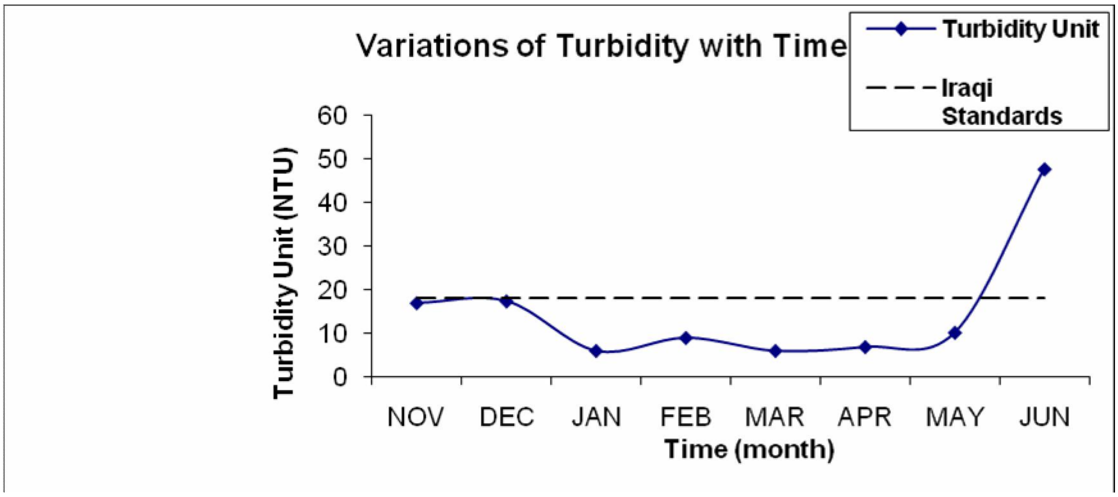

Figure 7 Variations of Turbidity with Time

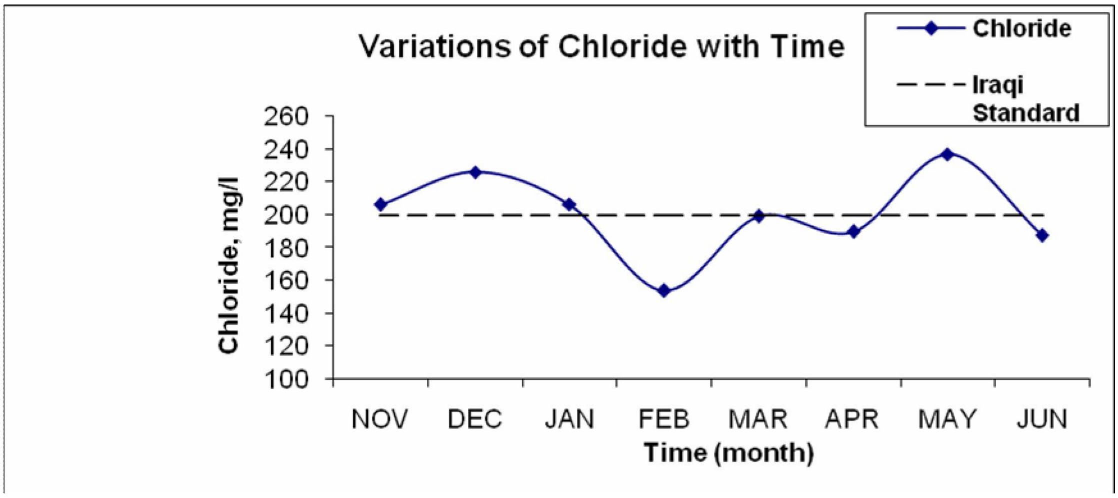

Figure 8 Variations of Chloride with Time