Water Quality Evaluation of Potable Water Supply Network in Al-Dura, Baghdad City, Iraq

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Abstract

The aim of this study is to determine the quality of drinking water in Al-Dura southern Baghdad City and comparing with the Iraqi standards (IQS) and World Health Organization (WHO) standards, then calculated by using a quality index which provides a single value to express overall quality based on twelve variables that were determined during the period between November 2016 to February 2017, samples were taken from twelve sites. The parameters used: pH, heavy metals (lead, cadmium and iron), chlorides, total hardness (TH), turbidity, dissolved oxygen (DO), total dissolved solid (TDS), alkalinity, electrical conductivity (EC) and free chlorine. The study showed that the range of water quality index for drinking water are lying between (0-25) and can be classified as an excellent water and Suitable for drinking.

Keywords: Iraqi standards, World Health Organization standards, Water Quality Index, Drinking Water, Al- Dura Baghdad city

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تقييم نوعية المياه في شبكة مياه الشرب في مدينة الدورة / مدينة بغداد باستخدام مؤشر جودة المياه

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الخلاصة

الهدف من هذه الدراسة هو لتقييم نوعية مياه الشرب في منطقة الدورة جنوب مدينة بغداد ومقارنتها بالمواصفات القياسية العراقية (IQS) ومواصفات منظمة الصحة العالمية (WHO) لمياه الشرب، ثم حساب نوعية مياه الشرب باستخدام مؤشرجودة المياه من خلال أعطاء قيمة واحدة للتعبير عن الجودة الشاملة بناءً على اثني عشر متغيراً تم تحديدها خلال الفترة من شهر تشرين الثاني 2016 الى شهر شباط 2017، تم أخذ عينات من اثني عشر نقطة في المدينة. والخصائص المستخدمة هي: الاس الهيدروجيني والعناصر الثقيلة (رصاص، كادميوم والحديد)الكلوريدات، التوصيلية الكهربائية، العسرة الكلية، العكارة، الاوكسجين المذاب، المواد الصلبة الذائبة والكلور الحر والقاعدية .وأظهرت الدراسة أن نطاق مؤشر جودة المياه يقع بين (0-25) وتصنف على انها مياه عالية الجودة وصالحة لاستخدامات الشرب

الكلمات المفتاحية: المواصفات القياسية العراقية، مواصفات منظمة الصحة العالمية، مؤشر جودة المياه، مدينة الدورة في بغداد.

Introduction

Water is a dynamic renewable natural resource. It's availability with good quality and adequate quantity is very important for human life and other purposes. In general, the quality of water is equally important as the quantity. Therefore, water quality is considered as an important Factor judge environmental changes which are strongly associated with social and economic development [1]. Drinking water is considered as an important topic that has been receiving a Great attention due to the high demand of human consumption used daily, as water is an essential element of life and plays an important role in the development process. Drinking water must be free from components which may adversely affect the human health. Such components include minerals, organic substances and disease-causing micro-organisms and having an acceptable quality in terms of physical, chemical, and biological parameters so that it can be safely used for drinking, cooking and other domestic applications [2, 3]. Due to the high population in the world quality of potable water have become critical issues in many countries;

so that water quality monitoring program is necessary to evaluate the performance of the water. Water quality index (WQI) is an important method in assessing it means summarizing large amounts of water quality data in simple terms, it gives a general idea of the water quality in a particular region to find the solution to treat the water if it's not good for drinking water for example [4]. The aim of this study is to evaluate the water quality of potable water network in Al- Al-Dura, Baghdad City and comparing with the Iraqi standards (IQS (2001)) and World Health Organization standards (WHO (2006)) for drinking water and calculate water quality index (WQI) by measurement: pH, heavy metal, chlorides, total hardness, turbidity, dissolved oxygen, total dissolved solids, free chlorine, alkalinity and electrical conductivity.

Study Area

The study area is located in Al-Dura city in the southern part of Baghdad City, it lies between latitude 33° -15′ 5″ N and longitude 44°- 23′ 31″ E. This city characterized by high population density and the main source of its surface water is Tigris River.

Materials and Methods

1. Data collection and analysis

(96)-water samples were collected in a clean plastic bottles of 1 liter and analyzed for water quality parameters. Water samples are collected twice in a month from twelve sites in Al-Dura Baghdad city as shown in Figure (1), during the period extended from the November 2016 to February 2017. In this study the evaluation of the water quality index of the potable water network were chosen for twelve parameters namely: pH, heavy metal, chlorides, total hardness, turbidity, dissolved oxygen, total dissolved solid, free chlorine, alkalinity and electrical conductivity were determined with portable Multi-meter ISOLAB, Turbidity was measured by Turbidity meter (Thermo Orion AQ4500), Dissolved oxygen was measured by Lovibond meter (senso direct oxi 200), Chloride and Total hardness were determined by titration [5] and heavy metals (iron (Fe), lead (Pb) and cadmium (Cd) were analyzed by flameless atomic absorption spectrometry (Shimadzu AA-6300).

Figure 1: Sampling points in Al- Dura- Baghdad City.

2. Application Water quality index

Water quality index (WQI) of potable water was calculated considering twelve important physic-chemical parameters using WHO (2006) and the Iraqi standards (IQS417 (2001)) for drinking water. For assessing the Water quality index, we used the next steps:

Firstly, unit weight (Wn) for all parameters is inversely proportional to the recommended standard (V_S) for the corresponding parameter. W_n values were calculated by using the equations [6]:

$$W_n = \frac{K}{V_S} \quad (1)$$

Where K = proportionality constant, V_S= drinking water quality standard. The constant of proportionality K in the above equation determined by the Following equation:

$$K = \frac{1}{\sum_{n=1}^{n=n} \frac{1}{V_S}} \quad (2)$$

Secondly, Quality rating (Qn) is calculated as

$$Q_n = 100\left[\frac{V_a}{V_s}\right] \quad (3)$$

While, the quality rating for PH and Dissolved oxygen ($Q_{pH,DO}$) was calculated on the basis of

$$\boldsymbol{Q_{Ph,Do} = 100\left[\frac{(V_a - V_n)}{(V_S - V_n)}\right]} \quad \textbf{(4)}$$

Where, V_a = is the monitored value at the lab.

V_n= the ideal value of pH considered as equal to (7.00) and for DO considered as equal to 14.6(mg/l).

V_s = value of the Iraqi water quality parameter obtained from recommended standard of corresponding parameter.

Table (1) shown the Water quality index scale. Then, the overall WQI was calculated on the basis of weighting and rating of all parameters, as follows [7,8]:

$$\boldsymbol{WQI = \sum_{n=1}^{n=n} W_n Q_n} \quad \textbf{(5)}$$

Table1: Water quality index scale [9].

WQI	0-25	26-50	75-51	76-100	>100
Water Quality	Excellent	Good	Poor	Very Poor	Unsuitable

Results and Discussion

1. Physical-Chemical Parameters

The physical and chemical parameters of analyzed potable water is summarized at twelve sites in Al- Al-Dura Baghdad city in figures (2-13) Compares between months we took average value of parameter in each month

pH: The values of pH at twelve sampling sites are shown in Figure (2). The results revealed that values of pH at November 2016 in some sites are slightly higher, reaching the highest value 8.92 in site No.1, December and January give a good value within limits of WHO (2006) and IQS-417-(2001) standards. While the minimum values of pH were in February in all sites but still in the lower limits, the lowest value 6.55 in site No1**.**

Electrical Conductivity (EC) and Total Dissolved Solid

have been shown in Figures (3, 4). Values of EC at all sampling locations were gave a good result when compared with WHO-(2006) and IQS-417- (2001) guidelines for drinking water

and the maximum values were observed in January at the site No.10 is that 1087(µS/cm), while the minimum values of EC in February at the site No.11 the value was 727 (µS/cm). The results of TDS showed a good value for all sites excepted some point was low than acceptable limits in site No.5 in January 494 (mg/l), site No.7 in January and February and site No .12 were shown the lowest value (404 mg/l) in December. The maximum values were observed in January at site No.10 (715 mg/l).

Turbidity and Dissolved Oxygen

The values of turbidity and Dissolved oxygen at all sampling locations have been shown in Figures (5, 6). For turbidity the values were good and below the upper acceptable limits at all months, except in site No 1 in November was 5.08 (NTU) and the highest value in January was 6.72, and site No.9 in January was 5.75(NTU). The lowest value was 0.5 NTU in January at site No. 12. for DO the results showed a good value in November its gradually rise in December then increased in January and February and reached more than upper acceptable limits, reaching the highest value for the DO concentrations 7.93 mg / l in site No.8 in February, while the lower value of DO concentration was 2.25 mg/l at the site No.10 in December.

From these results we found that there was a problem in the maximum limits and these caused health problems over a long term.

Free chlorine

The results of free chlorine at all sampling points have been shown in Figure (7). Shows that the values of some site were high than acceptable limit and the highest value was 3.08(mg/l) in site No.11 in December. lower value of the free chlorine concentration was 0.35 (mg /l) in November at site No. 8. From these values it can be concluded that there was a problem in the minimum percentage required to provide free chlorine in drinking water.

Chloride ion (Cl-1) and Total Hardness (T.H)

The results of chloride ion (Cl-1) and total hardness at all sampling points have been shown in Figures (8, 9). Values were giving a good results when compare with limits of WHO (2006)

and IQS 417(2001) guidelines for drinking water. The highest value of Chloride 219.97 (mg/l) in November at site No.5 and the lowest value 79.9 (mg/l) in January at site No.2.

Alkalinity

Alkalinity at all sampling locations have been shown in figure (10). The results showed good values at all sites in all months except in December at three sites were highest than limits, that's value 280 (mg / l) in site No.2, 280 (mg / l) in site No.8 and 300 (mg / l) in site No.12. The lower value of the alkalinity concentration in some sites was 40 mg / l.

Heavy Metals (Iron (Fe), Lead (Pb) and Cadmium (Cd))

Figures (11, 12 and 13) showed the results of heavy metals, Cd, Fe and Pb in all months were good as drinking water in all sites except site No.1 in November that have a concentration of Pb 0.008 (mg/l)

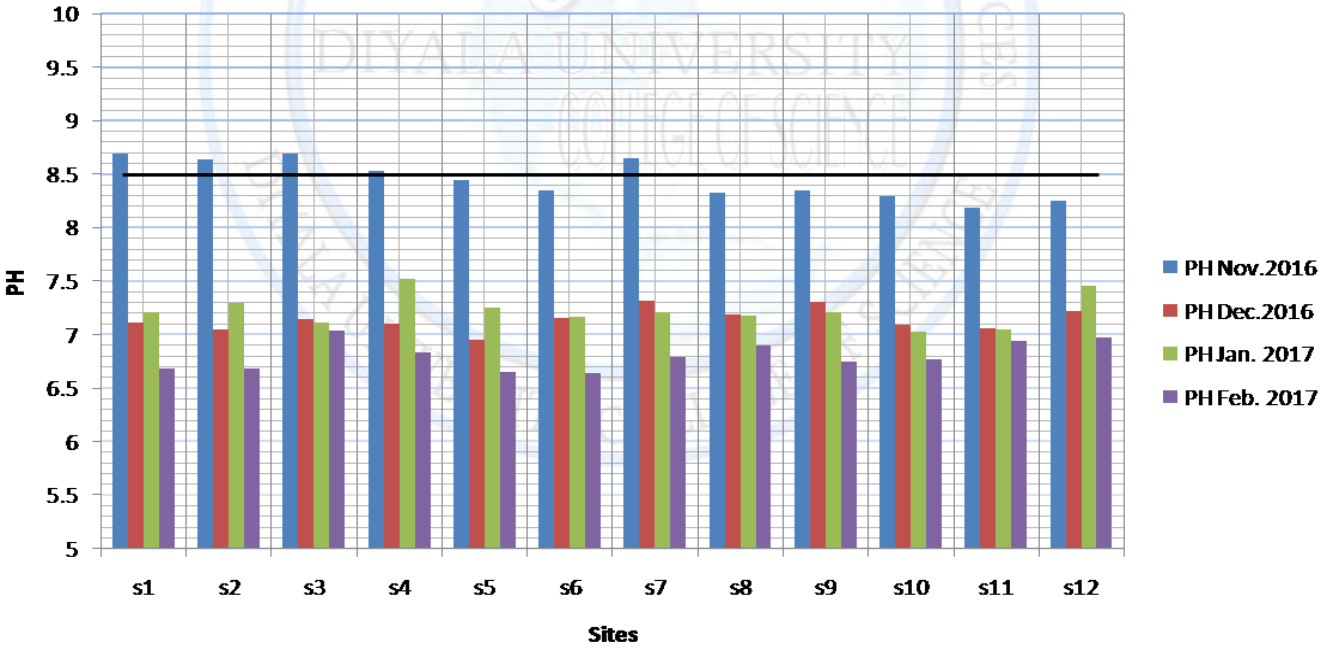

Figure 2: pH values

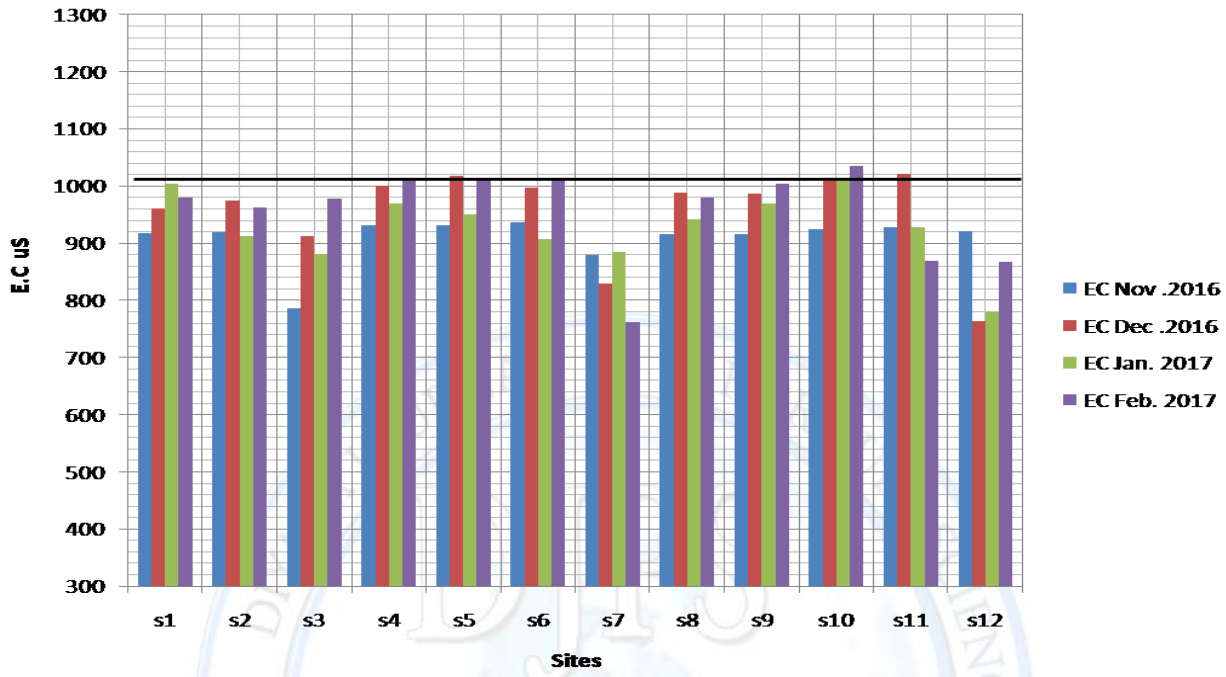

Figure 3: Electrical conductivity values

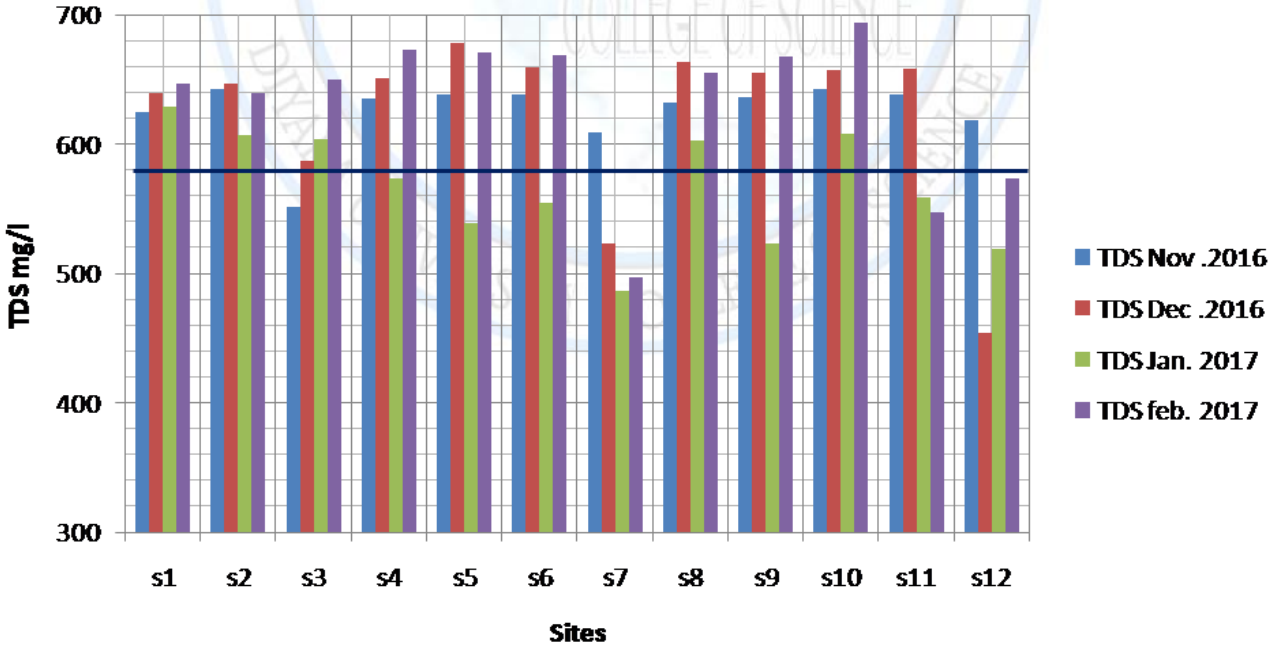

Figure 4: TDS values

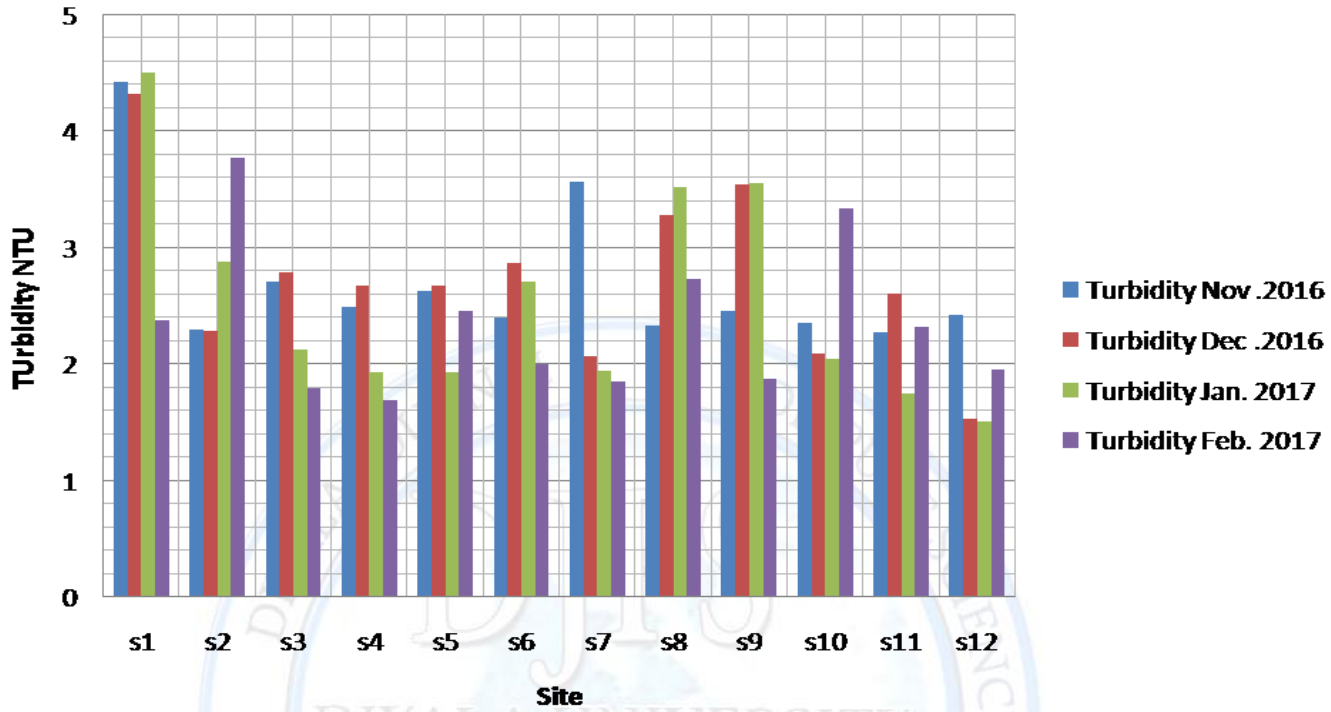

Figure 5: Turbidity values

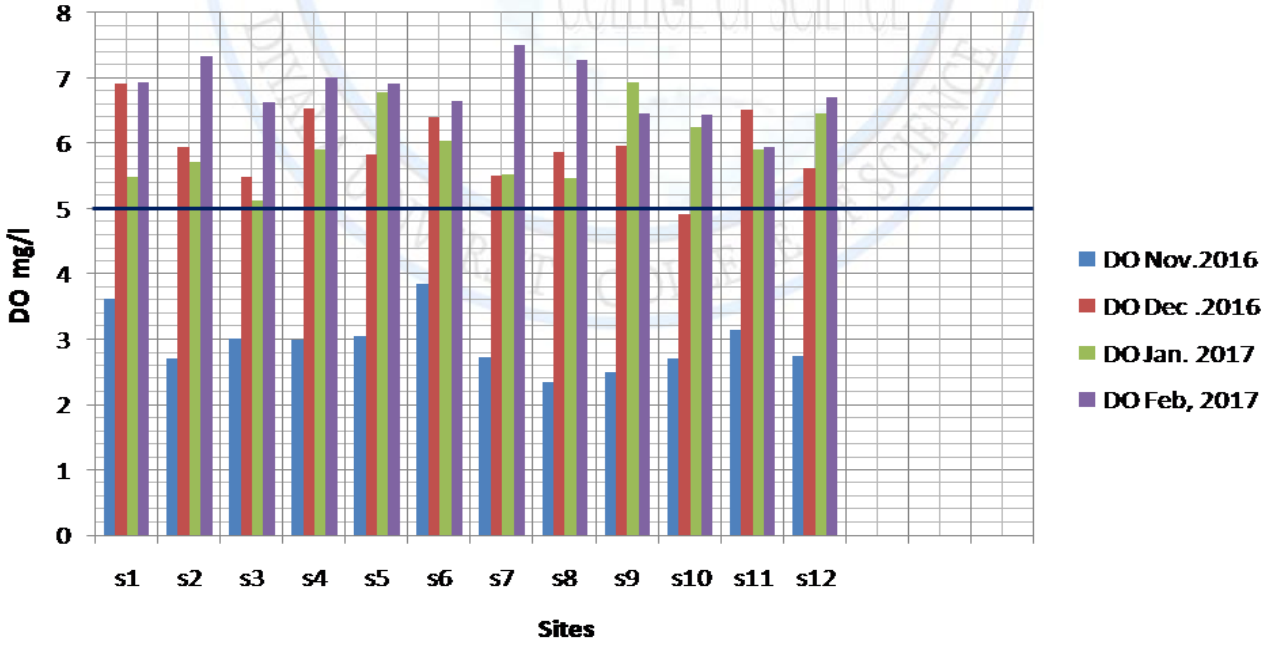

Figure 6: DO values

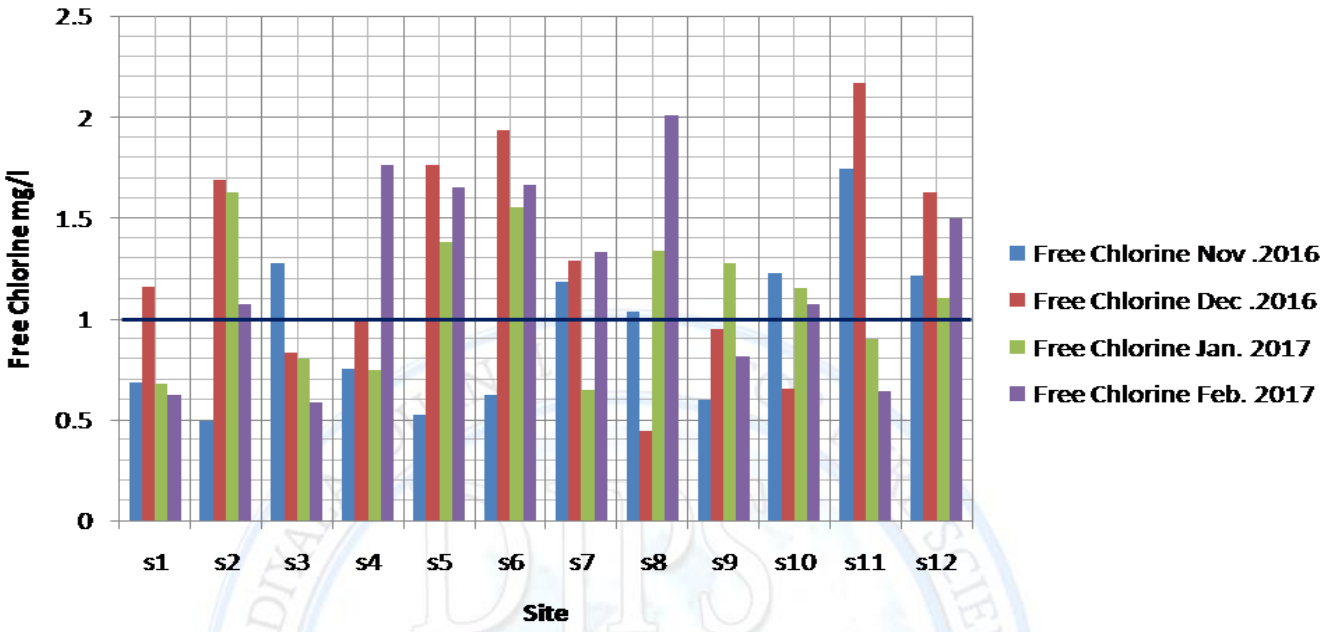

Figure 7: Free chlorine values

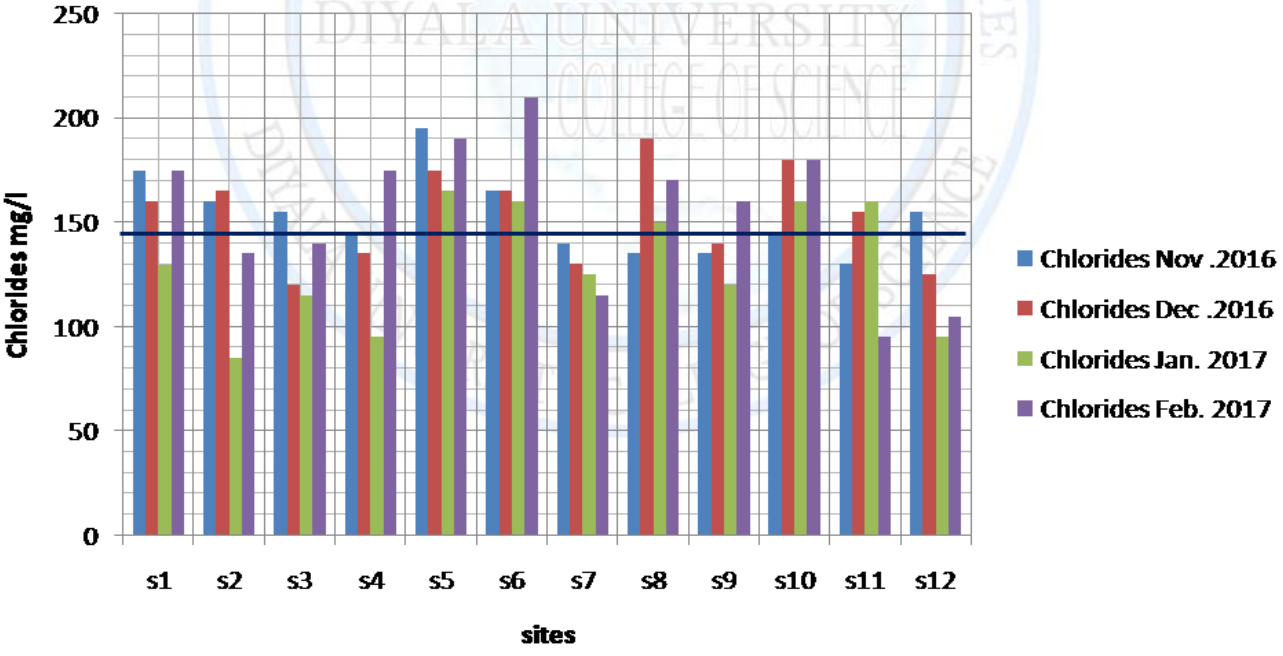

Figure 8: Chlorine values

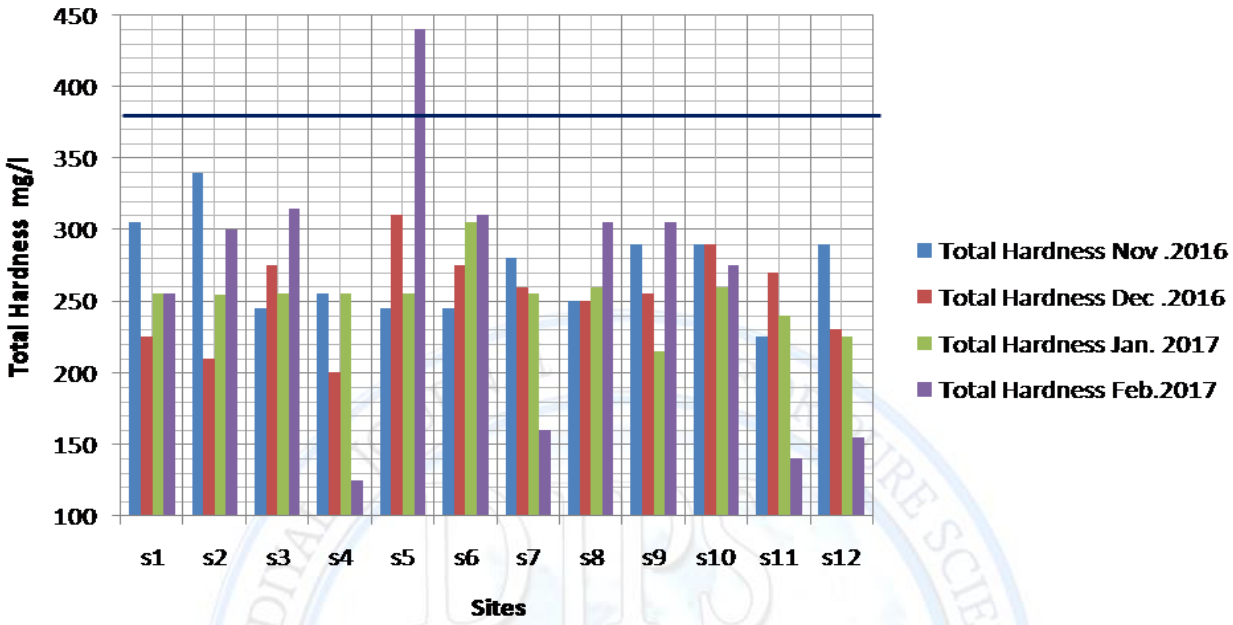

Figure 9: Total Hardness values

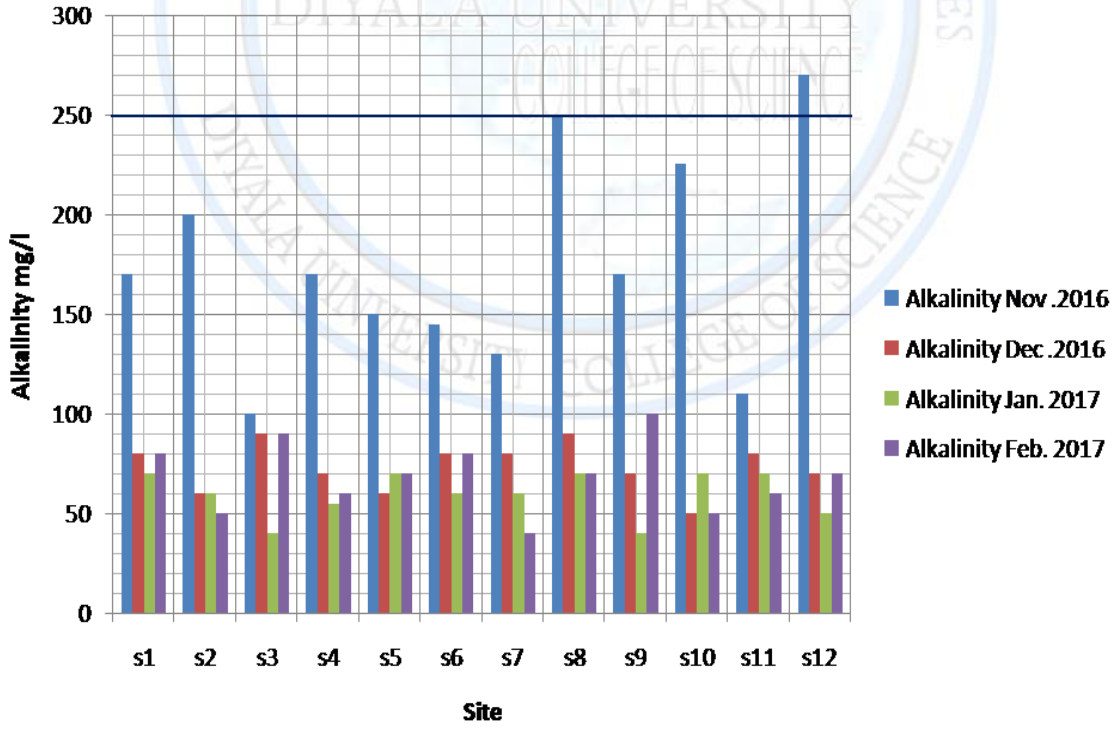

Figure 10: Alkalinity values

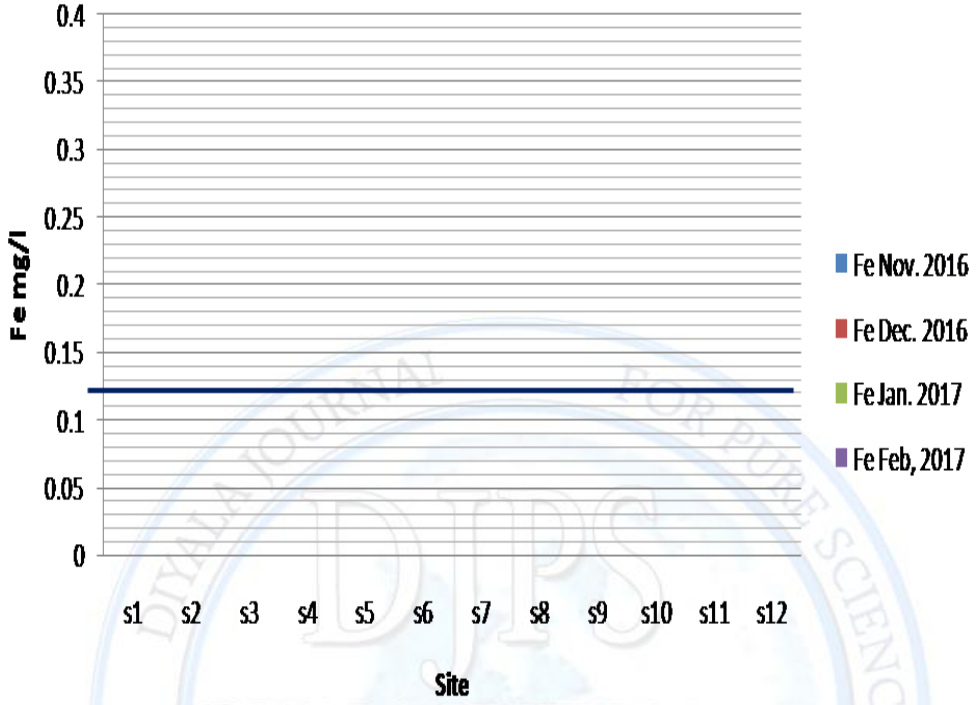

Figure 11: Fe values

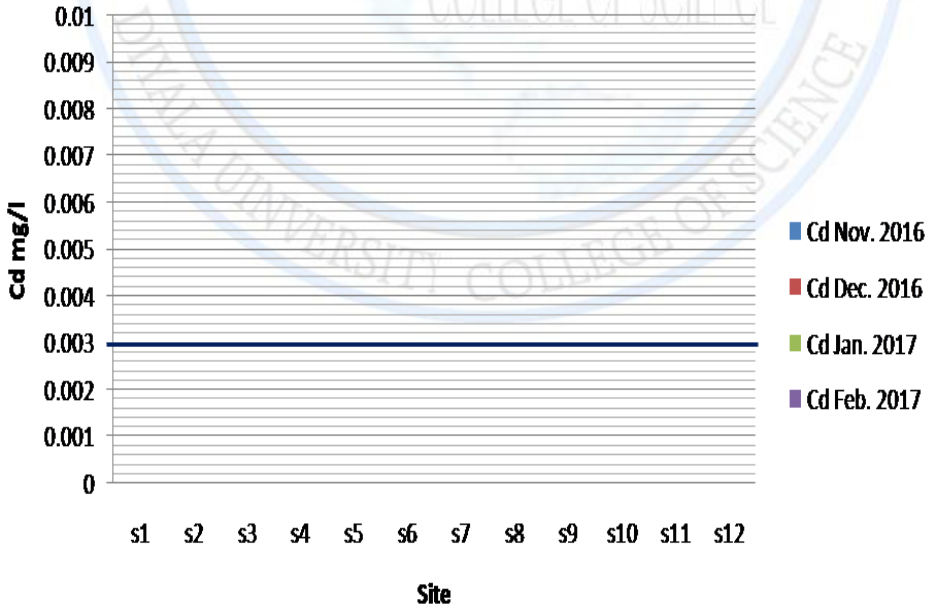

Figure 12: Cd values

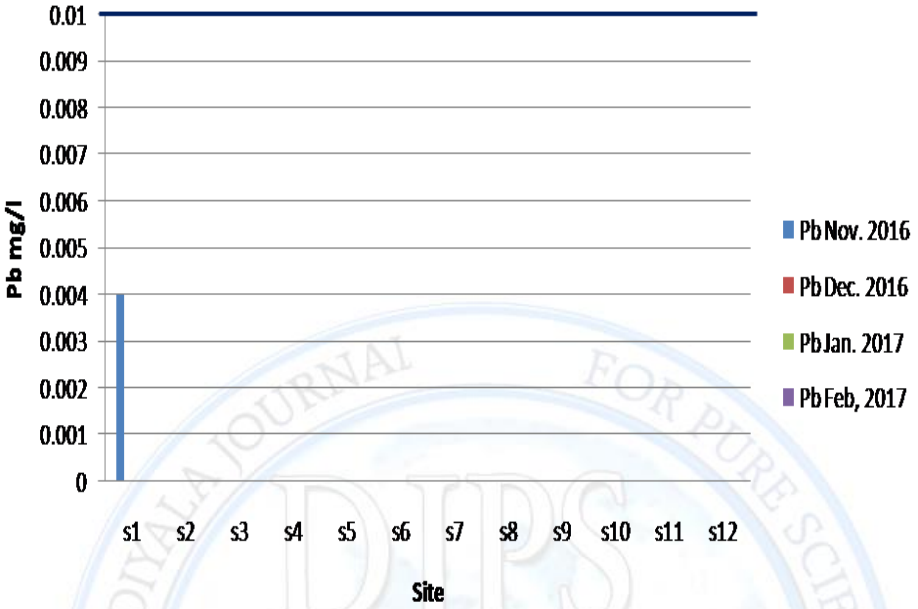

Figure 13: pb values

Water Quality Index (WQI):

The physico-chemical parameters with the WHO (2006) and IQS 417 (2001) standards, and weights for parameters are listed in Table (14). Water samples are collected twice in a month so that for water quality index we take the average for the month, the water quality index that was found in Four months for twelve sites have been listed in Table (15) and figure (14). The WQI results obtained for the different sampling sites were fall under the class of excellent water quality (0- 25). These index values revealed that the status of the drinking water samples were suitable for drinking at all sampling.

Table 2: The physico-chemical parameters compared WHO and IQS standards with weight of parameters

Parameter	IQS417, (2001) [10]	WHO (2006) [11]	Weight
pH	6.5-8.5	6.5-8.5	0.000268786
Dissolved Oxygen (DO) mg/l	5	6.5	0.000456937
Turbidity (NTU)	5	5	0.000456937
Chloride (Cl) mg/l	250	250	9.13874E-06
Total hardness as CaCO3 mg/l	100-500	500	4.56937E-06
Electrical conductivity (EC) µS/cm	1000	1500	2.28468E-06
Total Dissolved Solid (TDS) mg/l	500-1000	1000	9.13874E-06
Free chlorine mg/l	0.3-2	0.3	0.001142342

Alkalinity as CaCO3 mg/l	250	250	4.56937E-07
Iron (Fe) mg/l	0.3	0.3	0.007615613
Cadmium (Cd) mg/l	0.003	0.003	0.761561333
Lead(pb) mg/l	0.01	0.01	0.2284684

Table 3: The water quality index (WQI)

Sites	Average WQI 1 NOV. 2016	Average WQI 2 DEC. 2016	Average WQI 3 JAN. 2017	Average WQI 4 FEB. 2017
S1	9.312548817	0.146363438	0.129033306	0.053726503
S2	0.13752664	0.161586521	0.168224689	0.126558175
S3	0.185018582	0.120680948	0.113921129	0.090485113
S4	0.150623969	0.122785648	0.112624598	0.15137477
S5	0.137126343	0.16809719	0.140101587	0.149313731
S6	0.135258794	0.180713286	0.158932112	0.147034508
S7	0.188450058	0.143088551	0.103120614	0.124346756
S8	0.165162904	0.10253767	0.120857401	0.174963208
S9	0.140802571	0.135161695	0.147053461	0.100098061
S10	0.173792873	0.106311762	0.126957119	0.128314256
S11	0.19838557	0.189327299	0.111462611	0.099391551
S12	0.173130114	0.155084599	0.12539421	0.141920784

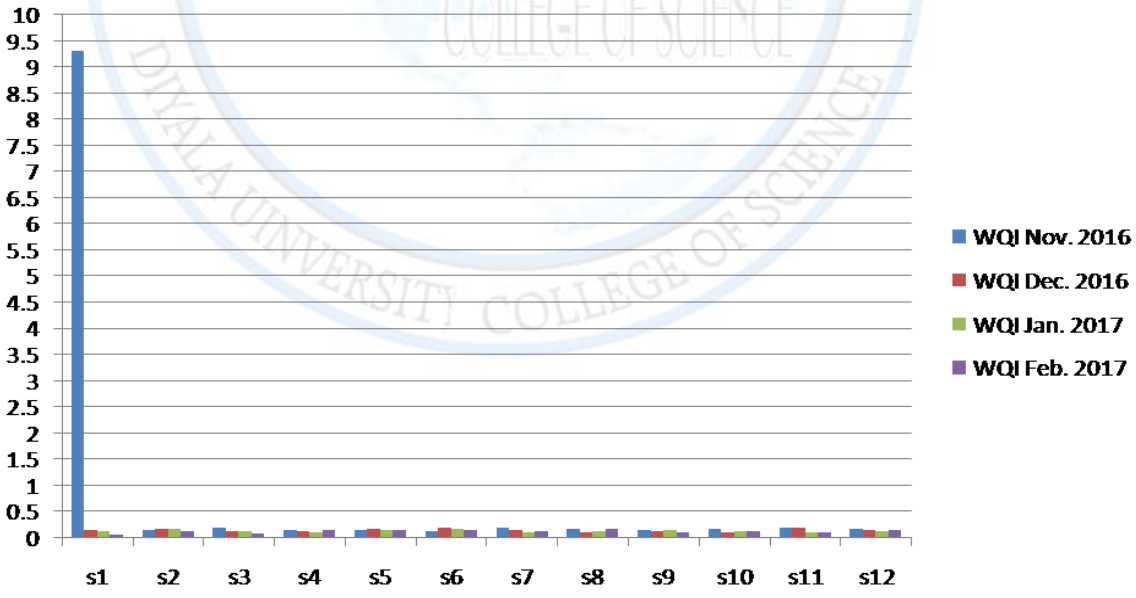

Figure 14: The water quality index

Conclusions

In general, WQI showed that water quality was classified as an excellent water type and was suitable for drinking in Al-Dura area; pH, dissolved oxygen, turbidity, free chlorine and alkalinity were slightly higher than the standard in some samples, total dissolved solid at some point was lower than acceptable limits, and the other parameter gave good results.

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