Using of Index Approach to Assess Water of Tigris River as a Source to Water Treatment Plants in Salah-AlDin Province, Iraq.

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Abstract

Water quality degradation in the Tigris River would occur in the last two decades, since pollutant loads from agriculture drainages, municipal wastewaters, and industrial wastewaters are not envisaged to be handled effectively. This will face the problems of water quality status which is used for multiple purposes, and drinking is one of these. This study used the Bhargava Water Quality Index (WQI) method as a tool to assess the water quality status of Tigris River as a source of raw water for water treatment plants within Salah-Alddin Province. For this purpose, six sectors along the main stream were chosen to take water samples from January 2010 until December 2010. The study had shown that the stream WQI lies between 2^{nd} class (good -84.31) to 5^{th} class (poor - 39.73). Decline of WQI values had appeared at all sectors in (January and February 2010) and improved after February 2010. The median values of WQI for Balad sector were the lowest in comparison with other sectors due to the effect of human, animal and agricultural activities, whereas, the median values of WQI for Al-dour sector was the highest because the strong hydraulic mix in addition to high water velocity.

Keywords: Water Quality index (WQI), Drinking, Bhargava, Salah-alddin, Iraq

الخلاصة

إن تردي نوعية مياه نهر دجلة ظهر خلال العقدين الماضيين، وبما أن أحمال الملوثات الناتجة من المبازل الزراعية ومياه الفضلات المدنية والصناعية لم يتم قياسها بدقة لكي تتم معالجتها بشكل فعال. لذا سوف تبرز مشاكل في حالة نوعية المياه للجسم المائي الذي يستعمل لعدة أغراض ومياه الشرب واحدة منها. في هذه الدراسة تم أستعمال طريقة مؤشر نوعية مياه (Bhargava WQI) كأداة لتقييم حالة نوعية مياه نهر دجلة كمصدر للمياه الخام لعدد من محطات الإسالة ضمن محافظة صلاح الدين. ولأجل هذا الغرض تم أختيار ست مقاطع على طول المجرى الرئيسي لنهر دجلة لأخذ العينات منها للفترة الممتدة من شهر كانون الثاني ولغاية كانون الأول للعام 2010. أظهرت الدراسة بأن قيمة مؤشر نوعية المياه لنهر دجلة صنف مابين الفئة الثانية (جيد-84.31) و الفئة الخامسة (ضعيف-39.73). أنخفضت قيم المؤشر في جميع المقاطع في شهري (كانون الثاني وشباط) وتحسن بعد شهر شباط. كانت قيمة الوسيط لمؤشر نوعية المياه في مقطع بلد أكثر إنخفاضا مقارنة بالمقاطع الأخرى نتيجة تأثره بالفعاليات البشرية والحيوانية والزراعية، بينما كانت قيمة الوسيط لمقطع الدور الأكثر إرتفاعا بسبب المزج الهيدروليكي السريع.

Introduction

Globally, there is an increasing awareness that water will be one of the most critical natural resources in future. Water scarcity is increasing worldwide and pressure on the existing water recourses is increasing due to the growing demands in several sectors such as, domestic, industrial, agriculture, hydropower generation, etc. Therefore, the evaluation of water quality in various countries has become a critical research topic in the recent years[1]. The quality of drinking water is closely associated with human health, and providing safe drinking water is one of important public health priorities. Estimated 80 per cent of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water, and on an average as much as one tenth of each person's productive time is sacrificed to water-related diseases[2,3]. Drinking water quality has become a critical issue in many countries and Iraq is no exception, especially due to concern that fresh water will be a scarce resource in the future, in addition to disposal of untreated wastewater into natural water bodies. So a water quality monitoring program is necessary for the protection of fresh water resources [4,5]. Political decision-makers, non-technical water managers, and the general public usually have neither the time nor the training to study and understand a traditional, technical review of water quality data. There is a further need to translate the water quality monitoring data into a form that is easily understood and effectively interpreted. A water quality index (WQI) plays an important role in such a translation process. It is a communication tool for transfer of water quality data[6]. The concept of indices to represent gradations in water quality was first proposed by Horton [7]. The need for such readily understood evaluation tool was ultimately realized, several researchers [8-18] have developed their own rating schemes. This study aimed to assess water quality of Tigris River for drinking purpose. Bhargava WQI method was used to find overall WQI along the stretch of the river basin within Salah-Alddin province in Iraq.

Materials and Methods

Study area the study area consists of six sectors distributed along Tigris river within Salah-Alddin Province as illustrate in figure(1). Meaningful and reliable sampling assures the validity of analytical findings. Therefore, most care was exercised to ensure that the analyses were representative of the actual composition of the water samples. The samples from different locations were collected in sterilized bottles and prior to filling the sample bottles were rinsed two to three times with the water to be collected. Collected samples were promptly carried to Tikrit treatment plant laboratory and almost the important water quality parameters were measured within four hours of collection. Samples were taken thrice per month during 2010. The samples were analyzed for six parameters which were Turbidity, Total Dissolved Solid (TDS), Potential of Hydrogen (pH), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5), and *fecal Coliform* using standard procedures recommended by APHA: AWWA: WEF[19]. Detail methodologies are described in Table (1). After determining field parameter (pH, DO., Turbidity and TDS), all the samples were kept in the dark at a cool temperature before being transported to a laboratory for quantification of other parameters [BOD_5, *Fecal Coliform*]. In the laboratory, all the samples were kept in a refrigerator at a temperature below 4ºC.

Bahragava WQI model

There are various water quality indices (WQI) to compare various physico–chemical and biological parameters such as Hortons Method, Brown, et al. method, Delphi Method… etc[20]. Among them the Bhargava Method was adopted because of the simplicity involved in handling small to large data for various beneficial uses[17]. The simplified model for WQI for a beneficial use is given by:

$$WQI = \left[\prod_{i=1}^{n} f_i(P_i)\right]^{\frac{1}{n}} \times 100 --- (1)$$

Where n is the number of variables considered more relevant to use and $f_i(P_i)$ is the sensitivity function of the ith variable which includes the effect of weighting of the ith variable in the use. The sensitivity function values for the different concentration of the variables quality are shown in the figure (2,a–f). Based on this figure(2,a–f) and the above model can be calculated the water quality index for the various beneficial uses of Tigris Rivers. Based on a classification system, wherein, classes I, II, III, IV and V respectively as shown in table (2).

Results and Discussion

The values, percentiles, minimum, maximum and median of collected samples for all sectors are presented in figure (3 and 4).

Turbidity

The maximum value of turbidity (93.87 NTU) was founded in a water sample collected from Aldour sector at February 2010, while the minimum of turbidity (10.4NTU) was founded in Baijy sector at November 2010. The turbidity more during the months (February, April, May and June 2010) at various sampling stations as shown in figure (3), this can be caused by flood, soil erosion, waste discharge, urban runoff, algal growth etc. The median's value of turbidity was observed to increase in Balad sector as shown in figure (3-a), due to agricultural activity and type of the soil (clay, sandy) which erosion and introduced to river basin [21].

Potential of Hydrogen pH

Hydrogen ion concentration (pH) of water is an important indicator of the chemical condition of the environment. In the present study at different sampling stations of Tigris river, the pH marked the variation from (7.2–8.5) as shown in fig(5). During monsoon and flood season, water showed an alkaline character, whereas, during of the other months it slightly alkaline pH, this can be caused by rain fall or flood that eroded of soil (gypsum, calcite) [21,22]. The median's value of pH had observed to increase in middle and south of the study area due to drainage of agricultural activity and geological formation (Al-fatha formation) in addition to interfere with groundwater started in Al-Dour sector [23] as illustrate in figure (3-d).

Total Dissolved Solids (TDS)

The spatial distribution of total dissolved solids (TDS) measured in samples collected from 6 sectors is presented in figure (3-e). It can be seen from the figure, that TDS values are observed to cover a wide range from 196 mg/L measured at Al-Sharqat and Samarra sectors in (September 2010) to 442 mg/L measured at Samarra sectors in (February 2010). This study showed that the concentration of TDS was increased during monsoon and flood season (January, February, March, April and December) which result increased in river water level that leads to dissolution of minerals from lithological composition[24] in addition to wash the soil top of agriculture land. These results are corresponding with the study of [21,22,25]. Also the TDS values were increased in (July, 2010) due to evaporation factor and to the drainage of municipal, industrial and agriculture activities[26]. High Median values of TDS concentration observed in Samarra sector as shown in figure (3), because drainage of agricultural activity at the north of this sector, also due to interference with groundwater [23].

Dissolved Oxygen DO

The concentrations of dissolved oxygen were ranged from (6mg/L)(February 2010) at Baijy sector to (10.4 mg/L)(May2010) at Tikrit sector as shown in figure(4). High levels of DO were appeared in spring and at the beginning of summer season, as a result of lower temperature, increase water level, increase turbulence, and rain fall. These results were corresponding with the study of [27]. The poor flow in the other months coupled with deterioration of water quality in addition to increased temperature resulted in the depletion of DO. Beside these, the mixing of organic wastes might had led to drop the oxygen level [27,28].

High values of median were appeared in Al-dour sector because of the violent mixing of water which leads to be saturated with dissolved oxygen, but Al-Sharqat sector was showed lower median value because affected by municipal and agricultural drainage as shown in fig (4-a).

Biochemical Oxygen demand BOD

Variations of BOD5 along the Tigris River were ranged between (0.6-4.9) mg/L as shown in figure (4-b). BOD values for all sectors increased in winter and spring seasons because rain fall addition to flood which lead to increase in water river level that eroded surface soil of river banks which include organic matter and debris by municipal, industrial and agricultural activities that disposal near river banks. Therefore, high content of oxygen in water will help the organisms to oxidize organic matter [29].

Al-dour sector median had decreased in comparison with remaining sectors as illustrate in figure (12), due to high velocity of Tigris River that remove contaminated sediment which responsible for depleting dissolved oxygen from water. While the median value for Balad sector was increased because of agricultural activity and feedlots and corrals of animals in each river banks that introduced to river by drainage canal or run-off.

Fecal coliform Bacteria

In the present study at different sampling stations of Tigris River, the *fecal coliform* marked the variation from (50-1800) MPN/100ml as illustrated in fig (13). The *fecal coliform* was increased in (January, February and March 2010) due to rain fall and flood that will increase the turbidity of river water, this turbidity became a good surface to adsorption food for microorganisms [30].

A little sector in temple areas of the river is clean and transparent at Tikrit and Samarra sectors as shown in figure (4-e), whereas the median values for these sectors are low, because of less agricultural land or municipal and industrial discharge north of these sectors. Nevertheless, the median value in Balad sector was rise in comparison with other sectors due to the effect of organic fertilizer which using in agricultural land at both banks in addition to animal corral and feeding.

Drinking Water Quality Index (DWQI)

The water quality of Tigris River was fall within the 2nd class (good - 84.31) to 5th class (poor -39.73) by using Bhargava water quality index method as illustrated in figure (4-f). At January 2010 the WQIs in all the sectors seen to be fair, and in February, ranged between fair to poor. While during (March, April, August, October and December) was ranged good to fair. Nevertheless, the WQI for remaining months was good.

Based on the WQI values for various beneficial uses of the Tigris River may be identified for purposes of quality improvement with respect to any beneficial uses. A general decline in WQI values at all sectors during months (January, February) because of increase Turbidity, Total dissolved solids, BOD and *fecal coliform*. Quality of Tigris River became better after February because of increased in river water level which sweeping of municipals, industrial and agricultural sediment from river bed.

The present study was showed that the median value of WQI for Balad sector was lowest in comparison with other sectors as illustrated in figure (16), due to the effect of human, animal and agricultural activities, where the data reveals to increase in Turbidity, BOD and *fecal coliform* in this sector. Whereas, the median values of WQI for Al-dour sector was high as a result of strong hydraulic mix where the aeration process in river will increase lead to oxidized the organic matter in water body. Also the high water velocity will wash the river bed from all sediments.

As a result of this study the water quality of Tigris River within Salah Alddin province is not suitable for drinking use unless treated by WTPs.

Conclusions

The Bhargava WQI is an effective tool to assess the water quality status of Tigris River as a supply raw water source for WTPs. This tool converts the water quality data into usable information which express the level of water quality degradation in Tigris River.

The status of water quality expressed in terms of the WQI, which concluded that the stream water is lie between 2nd class (good -84.31) to 5th class (poor -39.73). The decline of WQI values were appeared at all sectors during (January, February) due to increase Turbidity, Total dissolved solids, BOD and *fecal coliform*. Quality of Tigris River was improved after February because of increase in river water level which sweeping of municipals, industrial and agricultural sediment from river bed. Also, this study was showed that the median values of WQI for Balad sector was lowest in comparison with other sectors due to the effect of human, animal and agricultural activities, whereas, the median values of WQI for Al-dour sector was high because of strong hydraulic mix in addition to high water velocity.

This study recommends to the government of Salah-alddin province including all the stakeholders to envisage as first priority the problems of river pollution. This suggests the need to install the WWTPs for each city of the entire the Tigris River basin catchment area to reduce the pollutants of microorganisms and suspended particles.

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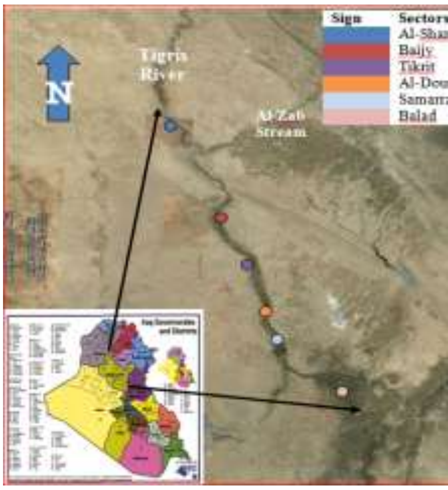

Figure (1): Location map of studying area

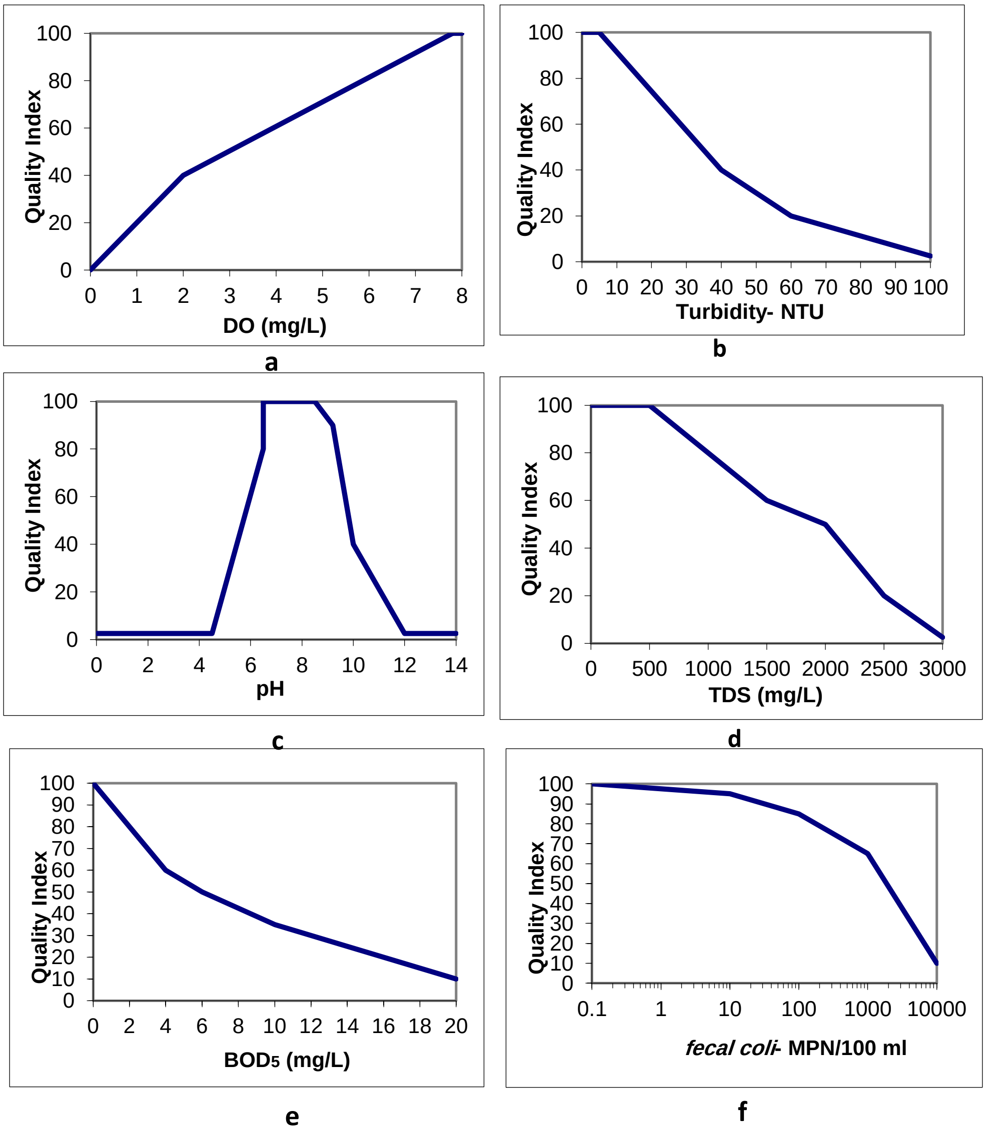

Figure (2): Rating curve for water quality index versus various parameters based on IQS[31] and (WHO,2006).

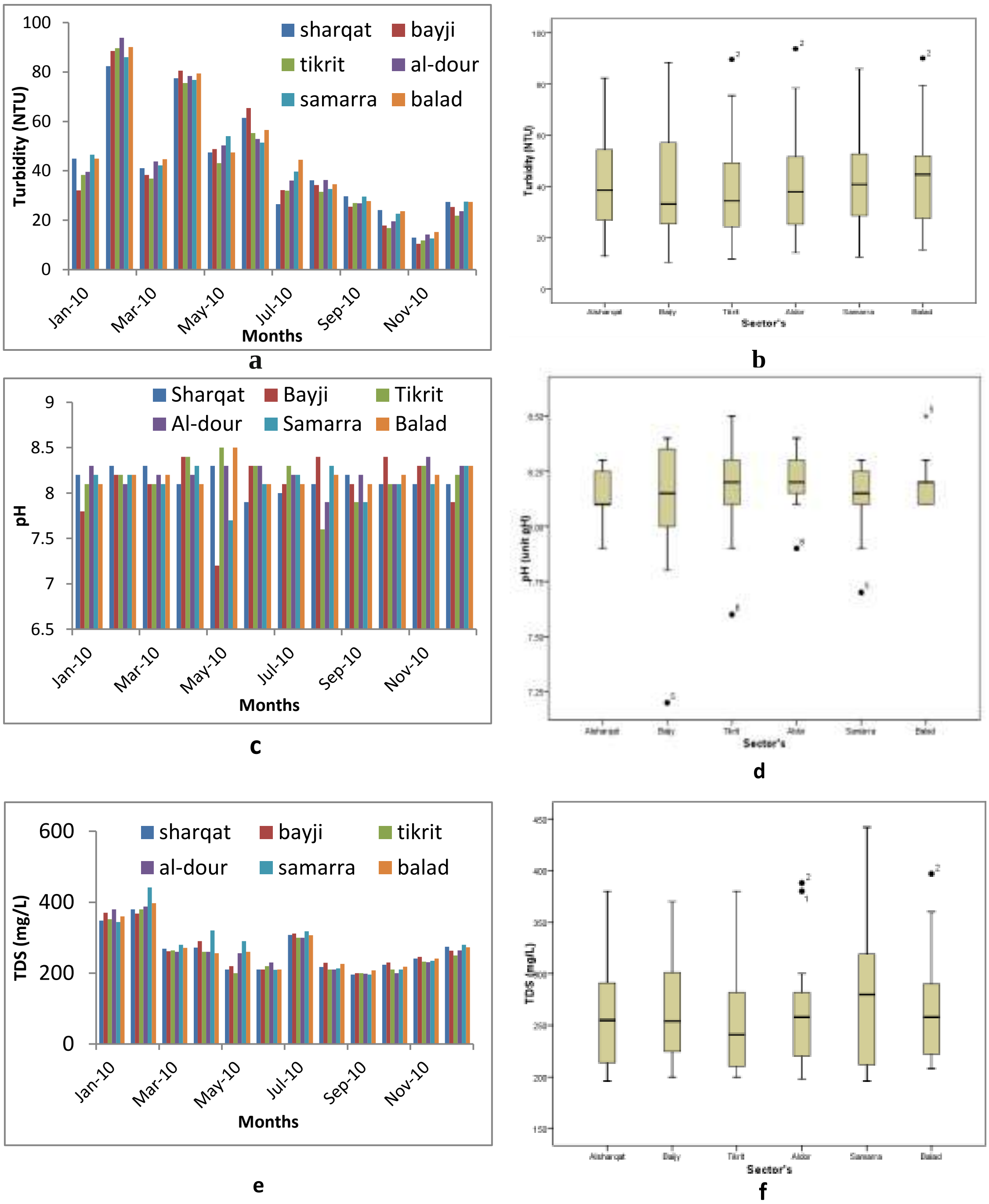

Figure (3) Values, Percentiles and medians for different water quality parameters.

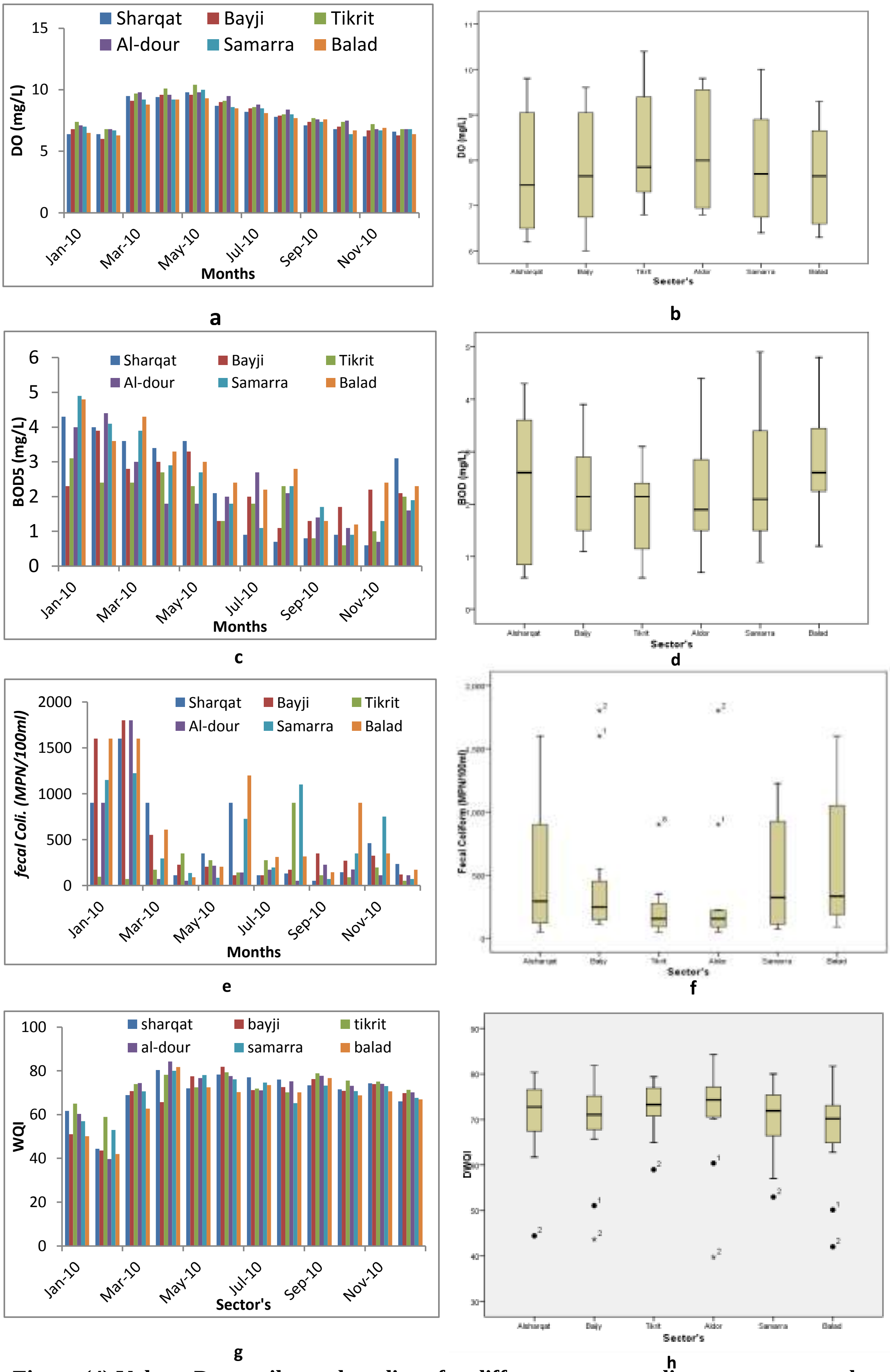

Figure (4) Values, Percentiles and medians for different water quality parameters and WQI during 2010.

Table (1):Water quality parameters, units and analytical methods used for Tigris River

Parameter	Abbreviation	Units	Analytical methods	Methods and Instruments
Turbidity	Turb.	NTU	Instrumental	(APHA:AWWA:WEF,1998)part(2550B.). HACH Laboratory Turbidi-meter 2100A
Total dissolved solids	TDS	mg /L	Instrumental	Mettler Toledo MX300
Dissolved Oxygen	DO	mg/L	Instrumental	(APHA:AWWA:WEF,1998)part(4500-O G.) Mettler Toledo MX300
Biochemical Oxygen Demand	BOD	mg/L	Instrumental	(APHA:AWWA:WEF,1998)part(5210 B.) Mettler Toledo MX300
Potential of Hydrogen	pH		Instrumental	(APHA:AWWA:WEF,1998)part(4500-H^+ B.) Mettler Toledo MX300
Fecal Coliform	*f.c.*	MPN/ 100ml	Multiple-tube fermentation method	(APHA:AWWA:WEF,1998)part(2340 C.)

Table (2): Rating scale for WQI (Bhargava WQI method)

Class	Range	Water Quality
I	91-100	Excellent
II	71-90	Good
III	51-70	Fair
IV	41-50	Marginal
V	≤40	Poor