Tikrit Journal of Engineering Sciences (2025); 32(1): 1606
DOI: http://doi.org/10.25130/tjes.32.1.23

IRAQI Academic Scientific Journals

ISSN: 1813-162X (Print); 2312-7589 (Online)

Tikrit Journal of Engineering Sciences

available online at: http://www.tj-es.com

TJES Tikrit Journal of Engineering Sciences

Iraqi Drinking Water Quality Standards (IQS 417/ 2009) – Revisited

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Keywords:

Drinking water network specification; Frost zone; Heat zone; Iraq drinking water quality standards; Pipe depth; Tap water temperature.

Highlights:

- *Tigris water temperature variations mimic ambient air temperature variations.*
- *The drinking water standards (IQS/417/2009) should be revised to include the recommended numerical limit on water temperature of less than 25 °C.*
- *From April through October, the drinking water temperature at the source, treatment plant, and customer, such as tap water, exceeded 25 °C.*

ARTICLE INFO

Article history:

Received	29 Aug. 2023
Received in revised form	20 Sep. 2023
Accepted	11 Feb. 2024
Final Proofreading	21 Aug. 2024
Available online	25 Mar. 2025

Citation: Abbas HA. **Iraqi Drinking Water Quality Standards (IQS 417/ 2009) – Revisited**. *Tikrit Journal of Engineering Sciences* 2025; **32**(1): 1606.
http://doi.org/10.25130/tjes.32.1.23

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Abstract: Iraq was one of the first developing countries to specify standard limits on drinking water quality. In 1967, (Law No. 25/1967) was issued. In 2001, new standard specifications of drinking water quality were issued (IQS/ 417/2001) and revised in 2009. These revisions did not significantly change the numerical limit values of major water quality parameters to reflect any major technological advancement in water quality sciences and epidemiological studies. The aim of this study is to set a numerical limit value for the drinking water temperature parameter to be promulgated and added to law IQS/ 417. Field water samples were collected from different sites in Baghdad. The water source in this study was the Tigris River from three water treatment plants and customer taps at selected districts whose water supplies were fed from these three water treatment plants. These samples' temperatures were measured by a good-grade mercury-filled Celsius thermometer on site. A literature survey on drinking water temperatures was conducted to collate as much relevant information as possible from countries in the Middle-Eastern region and Europe to compare them with the present results. It was found that the drinking water supply temperature in Baghdad was impacted by the temperature of the water supply source and the pipe distribution network. High averages of drinking water temperature prevailed during the summer season. It is recommended that a temperature limit value for potable water at customer taps should be below 25 °C, based on health aspects. This recommendation should be promulgated and included in law (IQS/ 417), depending on the public health requirements.

إعادة النظر بقانون معايير مياه الشرب العراقي (IQS 417/2009)

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الخلاصة

يعتبر العراق من اوائل الدول النامية التي وضعت وشرعت معايير لمياه الشرب. ففي عام ١٩٦٧ صدر القانون (١٩٦٧/٢٥) والذي تضمن تحديد مواصفات مياه الشرب في الدولة العراقية. في عام ٢٠٠١ تمت مراجعة القانون اعلاه حيث تم تعديل محددات بعض الملوثات لمواكبة التقدم التكنلوجي الذي حدث في مجال فحوصات مياه الشرب وعليه صدر التعديل الاول للقانون (IQS417/2001). وفي عام ٢٠٠٩ جرى تعديل آخر لمواصفات مياه الشرب بالقانون (IQS 417/2009). إن هدف الدراسة هو مراجعة آخر محددات نوعية مياه الشرب المثبتة بقانون IQS 417/2009 والتأكيد على أهمية درجة حرارة مياه الشرب لما لها من دور كبير في التأثير على التفاعلات الكيميائية والبيولوجية والتي بدورها تؤثر بشكل مباشر على المواصفات الفيزيائية لمياه الشرب وبالتالي الصحة العامة وتحاشي العديد من الامراض، وتمت دراسة المعلومات الخاصة بدرجات حرارة مياه الشرب لمدينة بغداد. حيث تم جمع المعلومات الخاصة بدرجات حرارة مياه الشرب ابتداءً من مياه المصدر (نهر دجلة) ومروراً بمراحل تصفية مياه الشرب لثلاثة مشاريع تصفية في بغداد وذلك بقياس درجات الحرارة للنماذج موقعياً، كما وتم جمع معلومات خاصة بدرجات حرارة مياه الشرب عند المستهلك ولمواقع سكنية تتم تزويدها بمياه الشرب من هذه المحطات وتم جمع معلومات خاصة لمياه الشرب لدول أوربية عند مستوى المستهلك لمقارنتها مع ما لدينا في بغداد وكذلك محددات درجة حرارة مياه الشرب لبعض الدول العربية، استنتج من هذه الدراسة بأن معدل درجة حرارة مياه الشرب عند المستهلك تتأثر بدرجة حرارة مياه المصدر ودرجة حرارة الماء داخل شبكات توزيع مياه الشرب. يوصي البحث باعتماد محدد لدرجة حرارة مياه الشرب عند المستهلك بحيث تكون تحت درجة 25 ˚C ضمن التعديل القادم لقانون (IQS 417/2009) وذلك بناءً على متطلبات الصحة العامة.

الكلمات الدالة: مواصفات شبكات مياه الشرب، منطقة الصقيع، منطقة الحرارة، معايير جودة مياه الشرب في العراق، عمق الانبوب، درجة حرارة ماء الصنبور.

1.INTRODUCTION

In 1914, the American Public Health Service (APHS) set the first established for the bacteriological qualities of drinking water [1]. The World Health Organization (WHO) issued its first edition of the international standards for drinking water back in 1958. The second and third editions were published in 1963 and 1971, respectively. The fourth edition, Guidelines for Drinking Water Quality, was issued in March 2022. This edition incorporated the first and second addenda [2]. In both international and American Guidelines or standards for drinking water quality, there is no mention of numerical value limits on drinking water temperature parameters. Piper [3] found that the water temperature positively influenced water use because high ambient air temperatures lead to more outdoor watering and drinking. Agudelo-Vera et al. [4] constructed a mathematical model to predict the drinking temperature of water inside the water distribution system for a Dutch city during a warm summer in 2006. The model used weather forecast data to predict the drinking water temperature in water distribution pipes. The model had an absolute error of less than 1°C. Agudelo-Vera et al. [5] presented forecasted models of maximum drinking water temperatures using meteorological data. Two forecast models were derived: the first used the last day's data to forecast the next coming two-day climatic data. The forecasted results of the maximum water temperature had an absolute maximum error of 0.3 °C. This study was conducted in a Dutch city over two months in the summer of 2006. The forecasted values were used in an early warning system. In 2018, Sunny et al. [6] investigated the effect of seasonal drinking water temperature variations on water discoloration risk. They showed that seasonal temperature variation in three trunk mains supplied from a single water source affected parameters critical for creating discoloration risk and material accumulation processes. Agudelo-Vera et al. [7] presented an excellent paper that addressed potential health issues related to the rise of drinking water temperature in public water supply networks conducted in nine countries. They presented tables showing drinking water temperatures in public water supply networks. In addition, they presented the maximum limit values at the tap for these countries. Mohammed and Tornyeviadzi et al. [8] conducted their study on the water supply distribution networks of Alesund in Norway at seven different locations. Water quality data and drinking water temperature were measured at these locations. The temperature of drinking water and water age were identified as the main factors controlling the microbiological stability of water in pipe distribution. Onyotha and Kwio–Tamal [9] presented a review of the literature of 87 papers on residual chlorine concentration, which, according to WHO, should be in the range of 0.2-5 mg/l. They reported that water temperature and pH are the main drinking water parameters contributing to chlorine decay. Aloraimi et al. [10] investigated the effect of water temperature and pipe material on the growth of microbial flora of water in a pipe network made of three materials, i.e., PEX, Galvanized steel, and Copper. Six models of pipe networks were constructed. The water temperatures in three of the pipe networks were kept at 22 °C, while the other three were operated at a water temperature of 32°C. The experimental models operated at high temperatures had well-defined microbial clusters. Legionellaceae and Mycobacteriaceae were prevalent at higher temperatures. Hence, they stated warmer water highly impacted microbiome growth than pipe materials. In 2006, the WHO issued its document entitled "Compendium of Drinking Water Quality Standards in the Eastern Mediterranean Region," which gave clear details and assessment of existing water quality guidelines or standards of different countries in the region. Iraq water quality standard was included in this document. Valuable recommendations were reached in the WHO study and presented as annotations concerning the available standards on drinking water quality in the region. One annotation strongly recommended that countries conduct a comprehensive review of existing national drinking water quality standards and benefit from the latest WHO guidelines for drinking water quality. Furthermore, it stated that promulgated standards should be revised every 3-5 years or as often as needed, accounting for new scientific advancement in the field [11].

1.1.Aim of the Present Study

The aim of this study is to set a numerical limit value for drinking water temperature parameters due to their importance in biochemical reactions in aquatic mediums and their role in disease transmission, such as Legionella infection, a severe form of pneumonia-lung inflammation caused by inhaling the bacterium Legionella from water or soil. Another reason for conducting this research is that maximum air temperatures during the summer could soar above 50 °C in Iraq, affecting the temperatures of all public water sources. A careful and comprehensive review of Iraq water quality standards IQS 417/2009 was conducted. A few important shortcomings were recognized, one of which is associated with drinking water temperature parameter that significantly influences biochemical reactions, disinfectant byproducts, and dissolved oxygen content ratio in water [12]. It is not feasible to alter the temperature of water treatment plants by active conventional water-cooling methods, but it could be done by passive methods. Hence, water temperature is better controlled by the selected raw water source and by the depth at which the pipe distribution network is buried. In Iraq, water distribution pipes are buried at depths of about one meter (measured from natural ground level). The novelty of this study is setting a numerical limit value for drinking water temperature at customers' taps in Iraq due to the lack of such limit value despite the importance of drinking water temperature in public health.

1.2.Motives for Conducting the Research

Iraq is one of the first developing countries to specify standards for drinking water quality; it dates back to 1967, i.e. (Law No. 25/1967). In 2001, new standard drinking water quality and analysis specifications, i.e., Standard No. 417, were issued. Despite the huge advancement in water quality treatment and measurement techniques, there was almost no difference in the numerical values of limits of the most important water quality parameters that affect public health. Most international institutions concerned with drinking water quality and human health, such as WHO [11], called for revising existing drinking water quality standards or guidelines every 3 to 5 years. In 2009, (IQS/ 417/2009) was adopted to revise 2001's version. This revision, again, did not contain any significant change in the numerical values of major water quality parameter limits to reflect any major technological advancement in water quality sciences or epidemiological studies.

2.METHODOLOGY OF DATA ACQUISITION

Two methods were used in the data acquisition phase of the study. Firstly, a survey was conducted to monitor water temperature variation at surface water sources, the operating water treatment plants, and the customer taps at selected sites within the capital city of Baghdad. Secondly, a literature review on drinking water temperature was performed to gather data on many Arab and international water supply schemes [11].

2.1.Survey of Local Water Treatment Plants

Daily water temperature variation data were collected from three water treatment plants in Iraq's capital, Baghdad. The three water treatment plants (WTP) are Al-Quadisia, Al-Wyhda, and Al-Rasheed. Al-Quadisia WTP is on the west bank of the Tigris River, while the other two plants are on the east bank. The data covered the temperature of the influent stream into each plant, which was the surface water source, i.e., the Tigris River for the three plants. Then, the temperature of the plant effluent water streams of the three plants and the temperature of the tap water at the customer level were recorded. The three studied WTPs are rather old and way past their design period. For example, Al-Wyhda WTP's first streamline was commissioned in 1951, while its second was added in 1958. The three studied WTPs were rehabilitated more than once. In 2009, the total design capacity of the three WTPs amounted to about 11% of the total design capacities of all WTPs serving Baghdad. Over 68% of all design capacities in 2009 were contributed by two major WTPs, i.e., the Karkh and the East Tigris plants [13]. In 2016, a mega WTP was commissioned, namely the Al-Rassafa plant. Al-Rassafa WTP added 916,000 m^3/day to the existing production in 2016. According to the records of the water supply department of the mayoralty of Baghdad, water loss was about 35% of the actual production, while the actual production of water supplies was about 76% of the design capacity in service [14]. Figure 1 shows the locations of the three studied water plants on the banks of the Tigris River in the south of Baghdad City.

Fig. 1 Site of Water Treatment Plants (S Denotes Site of Tap Water Sampled Area).

3. RESULTS AND DISCUSSION

3.1. Drinking Water Temperature

Despite the importance of temperature on water quality, almost all countries in the region, including Iraq, lack a clear strategy for setting a numerical limit for drinking water temperature as a water quality parameter. Only three Arab countries, namely Lebanon, Palestine, and Syria, set an upper limit value of 25 °C. Table 1 shows that this value seems reasonable based on the potential negative effects of high drinking water temperatures, considering the existing physical conditions on the ground and seasonal temperature variations coupled with cost consideration.

3.2. Overview of Recorded Water Temperature in Water Supply Schemes in Iraq and other Countries

Table 2 summarizes recorded drinking water temperatures at the source, water treatment plants, and consumer taps for selected areas within Baghdad. Similar corresponding data on drinking water temperature for some international water supply schemes, mainly in different European countries, are also included in Table 2.

Table 1 Supplied Drinking Water Temperature Upper Limit for Ten Arab Countries, Including Iraq [11].

Parameter	WHO guidelines	Reasons for consumer complaint	Egypt	Iraq	Jordan	Oman	Lebanon	Morocco	Pales tine	Sudan	Syrian Arab Republic	Tunisia
Temperature	–	–	–	–	–	--	25 °C	–	8–25 °C	Acceptable	8–25 °C	–

Table 2 Overview of Recorded Drinking Water Temperatures in Iraq and European Countries, i.e., SW = Surface Water, GW = Ground Water, MW = Mix of GW and SW, and RDT: Random Day Time [7].

Country	Source	Water Treatment Plant	At the Customer
Iraq, Al-Quadisia water supply plant	SW 10.5-33 °C	SW 10.5- 33 °C	11.5 – 35 °C
Iraq, Al-Wyhda water supply plant	SW 10.5–34.5 °C	SW 9- 33.5 °C	10.5 – 35 °C
Iraq, Al-Rasheed water supply plant	SW 11-36 °C	SW 10 - 34 ° C	RDT: 10 - 34.5 °C
Colombia	13–28 °C	16–26 °C	25–28 °C
Czech Republic	GW: 6–15 °C	SW: 4–11 °C	MW: 2–24 °C
France		GW: 12 °C	RDT: 10 <25 °C
Italy		6–15 °C	
Netherlands		SW: 2–23 °C GW: 12–13 °C	RDT: 4–25°C
Serbia		9–16 °C SW: 6–27 °C GW: 12–18 °C	5–18°C
South Africa		10–28 °C	20.5–24.5 °C
Spain		10–29 °C	10–29 °C
United Kingdom	SW: 1–21 °C	SW: 2–26 °C GW: 10–18 °C MW: 2–23 °C SW: 3–24 °C GW: 11–12 °C MW: 6–22 °C	SW: 3–25 °C GW: 4–27 °C MW: 4–26 °C

3.2.1. Drinking Water Temperature at the Source

Table 2 shows that the drinking water temperature at sources for Iraqi treatment plants and nine other countries ranged between 1 to 36 °C. The highest recorded source water temperatures were observed for the Tigris River at Baghdad. High values systematically happened during the sweltering hot days of the summer period. This period starts from April to October, i.e., the air temperatures were above 25 °C and into the 30 °C. Figure 2 shows the average maximum and minimum ambient air temperature in Baghdad. It is observed that Tigris water temperature variations mimicked ambient air temperature variations.

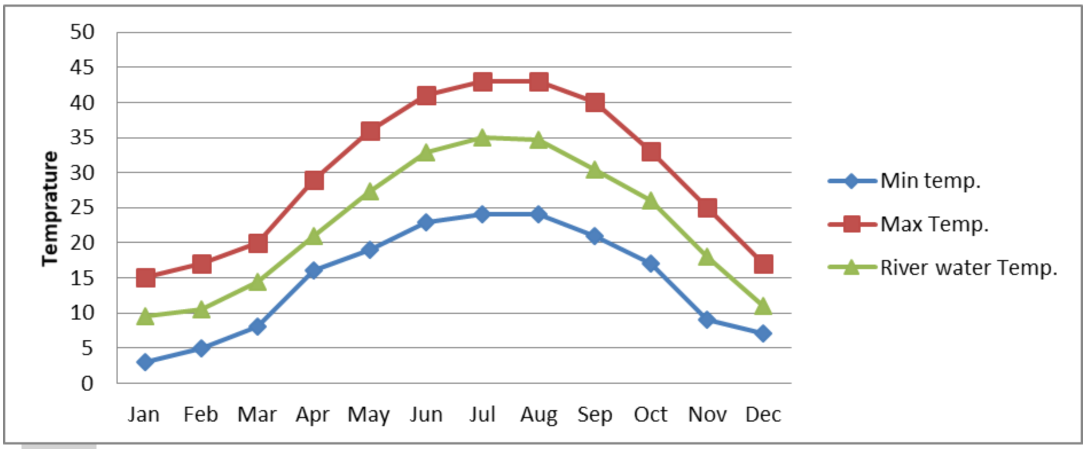

Fig. 2 Annual Averages of Ambient Air and Tigris River Water Temperature at Baghdad.

Al-Sudany et al. [15] studied the effect of annual ambient air temperature variations on underground soil temperature variations at different depths throughout the year for different locations over Baghdad. Diurnal fluctuations were also observed. They reported that underground soil temperature variation for shallow depths mimicked the ambient air temperature variation, diurnally and annually. Diurnal fluctuations disappeared rapidly with increasing depths. Such that the temperature values at depths of 10 meters and beyond stabilized and became constant. The amplitude of the annual wave temperature of the underground soil diminished with increasing soil depths, too. However, at a rather slower pace than the diurnal wave amplitude. Average underground soil temperature was almost equal to the annual mean ambient air temperature at a depth of about 10 meters, i.e., about 24 °C. These relatively high values of the Tigris River water temperature could be ascribed to the shallow water depth of the river during the summer season, coupled with the rather large width of the Tigris River at Baghdad. In addition, all this happens during the sweltering hot days of summer. Such high-water temperatures deplete the residual chlorine content of water and, as such, increase the potential for the proliferation of pathogens, such as Legionella spp. The WHO report states that to prevent legionella infection, the recommended temperature for storing and distributing cold water should be below 25 °C and ideally 20 °C [11].

3.2.2.Drinking Water Temperature at Treatment Plants

Table 2 shows an overview of the water temperature variation within the three water supply plants on both banks of the Tigris River. The recorded water temperature values mimicked the source (the Tigris River). Hence, the source water temperatures clearly impacted the water temperatures within the treatment plants. Here again, recorded water temperatures over the sweltering hot summer of about six months were above 25 °C. Such high-temperature values seriously impacted water treatment, one of which is chlorination. More chlorine must be added during the warmer season to offset its high depletion rate and ensure an acceptable residual disinfectant level in the pipe distribution system [12].

3.2.3.Drinking Water Temperature at the Tap

In Baghdad, tap water temperatures are not monitored by the water or health authorities. Other tests were monitored. The monitoring is usually random, and samples are collected at customers' taps. The results are discrete data and very temporally and spatially dispersed all over Baghdad. These water tests included turbidity, Al, Cl_2, Coliform Count/100 ml at 35 °C for 24 hours, E. Coli/ 100ml at 44 °C for 24 hours, and plate count/ml [4]. All these tests were temperature-dependent [12]. In Iraq, river water temperatures are measured and recorded by research academia [16-20]. However, tap water temperatures are rarely studied. Figure 1 shows the sites of areas where tap water samples were taken. The sites are denoted by the letter S. Table 2 shows clearly that in Baghdad, drinking water temperature at the taps (customers) is mainly influenced by the underground soil temperature throughout the year, which agrees with the findings of [7]. Regarding the tap water temperature in many European countries, they reported that only underground soil temperature influenced the tap water temperature. However, in Baghdad, it can be stated that during the long, hot summer days, in addition to the underground soil temperature levels, the temperature levels of the water source also come into play alongside and increase the levels of tap water temperature.

4.CONCLUSIONS

Based on the results of this study, the following conclusions are drawn:

- The governing parameter influencing tap water temperature levels within Baghdad was the water source temperature, i.e., the

Tigris River, and the underground soil temperature from April through October of each year. Outside this period, the underground soil temperature was the only controlling factor of the tap water temperature.

- The drinking water temperature at the source, treatment plant, and customer tap water exceeded 25 °C for about six months every year, i.e., from April to October.
- It is well known that the most widespread health risk associated with drinking water is microbial contamination. The consequences of this are serious, and its control must always be paramount. It is well documented that the temperature of drinking water below 25 °C can be used to control the growth of pathogens. Knowing that controlling drinking water temperature outside the critical range of 25-50 °C can prevent Legionella infection. Therefore, it is advised that the Iraqi standards on drinking water should include a limit value for the water temperature parameter. It is, therefore, recommended that for cold drinking water, the temperature of supplied tap water should be less than 25 °C, while for hot water, the temperature of water should be more than 50 °C to prevent Legionella infections. Hence, the drinking water standards (IQS/417/2009) should be revised to include the recommended numerical limit on water temperature of less than 25 °C. This limit should be promulgated.

5.RECOMMENDATIONS

Since the rather high drinking water temperature levels in Baghdad water supplies are mainly impacted by harsh climatic conditions during the summer season, to alleviate such a problem, a new holistic water supply engineering practice is required to cool down the temperature of the furnished water so as not to exceed 25 °C. The following passive methods are recommended as a solution in future new drinking water supply schemes or expansions of existing schemes:

1- All existing 104 compact water treatment units within the mayoralty of Baghdad should be phased out because compact units were made from metallic parts and erected aboveground, contributing greatly to a temperature rise of the finished water.

2- All future water storage concrete tanks to be constructed within each water treatment plant should be buried deeper than 10 meters from the natural ground level at the site to the ceiling of the roof of the tank level to evade heat depth.

3- Increase the number of district boosting stations all over Baghdad. Again, large storage concrete tanks should be buried deeper than 10 meters. This practice will decrease the water travel time "Water age," ensuring a proper chlorine residual inside the pipe distribution network. Proper chlorine residual is made possible by keeping the water as cool as possible, achieved by laying distribution pipes at a minimum depth of 2.5 meters from the upper border of the distribution pipe to escape the upper part of the “heat depth." The current Iraqi practice of laying drinking water distribution pipes at a depth of 1 meter should be ended.

ACKNOWLEDGEMENTS

The author would like to thank the staff of the Civil Engineering Department at the University of Technology for their continuous support and encouragement.

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