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Monitoring and assessment of water quality in Tehran city using physicochemical and microbial indexes

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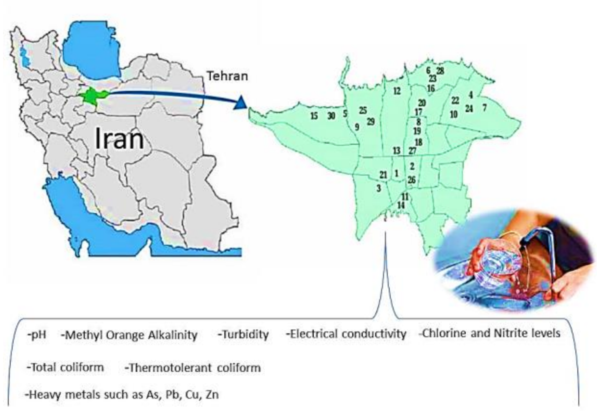
GRAPHICAL ABSTRACT



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ABSTRACT

Drinking water is one of the main factors for health maintenance and sustainable development of communities and its quantity and quality are so important. The aim of present study is random sampling of drinking water in 30 regions of Tehran city during 2 months in summer of 2020 to determine physicochemical attributes, microbial quantity and heavy metal levels according to national standard guidelines. Tests such as pH, alkalinity, turbidity, electrical conductivity, chloride, nitrite level, total and thermotolerant coliforms, and also heavy metals (arsenic, copper, zinc and lead), were performed in three replications. The pH (6.50 to 7.81), turbidity (0.011 to 2.983 NUT), chloride level (240.42 to 321.34 mg/L) and nitrate value (7.21 to 20.04 mg/L) were in allowable ranges. The phenolphthalein alkalinity was not found and methyl orange alkalinity was detected in the range of 31.54 to 147.22 (mg/L) in samples. The electrical conductivity (1401.7 to 1972.1 µs/cm) and thermotolerant coliforms were found higher than allowable range in some samples. The range of heavy metals was represented by following trend in Tehran: arsenic (0.85 to 15.90 µg/L), cooper (0.04 to 3.38 mg/L), zinc (0.16 to 3.80 mg/L), lead (0.001 to 0.031 mg/L) and some ranges were not within the national standard guidelines. The present study illustrated that quality of drinking water was in line with World Health Organization, while microbial quantity, electrical conductivity and some impurities (Cu and Pb) were higher than standard in some regions, so more arrangements should consider for increasing of drinking water quality in Tehran.

1. Introduction

Water is the most abundant liquid on the planet and is essential element for survival of all known organisms (Ahmed et al. 2020). Drinking water is one of the prominent factors for wellbeing and human health and is considered as a restriction on productivity, economic improvement, healthy ecosystems and environment (Amouei et al. 2017). Also, drinking water is suitable for human consumption and all household appliances and is available in sufficient quantity and quality for community (Wen et al. 2020).The management of demand is a necessary factor for provision assessment and water resources development (Khoshakhlagh et al. 2002).

Safe drinking water is not indicated any considerable risk to human over consumption, as expressed by the Guidelines and all attempts should be considered to obtain safe sample (WHO 2011). Access to safe water is the most important criterion for health promotion and disease prevention. Nowadays, water is widely applied in distinct fields such as drinking, agriculture, animal husbandry, and power generation, industrial and urban applications (Cremades et al. 2018).

Physiochemical and microbiological attributes are major parameters for investigating agriculture, domestic and industrial water (Cosgrove and Loucks. 2015). Quality of water is influenced by deforestation activities such as removal of riparian vegetation all over the world. Urban rivers and reservoirs affect more on quality because of improving exploitation (Yousefi and Hojati Bonab et al. 2020). The degradation of water quality was occurred by agricultural activities, application of pesticides, uncontrolled fertilizers and heavy metals (Liu et al. 2009).

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Heavy metals are expressed as elements with a special density of higher than 5 g cm^{-3}. The major threats to health care from these metals are related with exposure to elements such as arsenic, copper, zinc and lead and so on (Saleem et al. 2015).

Water can be a vital factor of infection, contamination and many of the waterborne diseases that may be transmitted by food intake, droplets and aerosols (WHO 2011). Hygienic water includes microbial pathogens when consumed and high population of microorganisms is considered more in distribution network or consumption because of affecting human health (Khoshakhlagh et al. 2002). Unfortunately, majority of the diarrheal deaths and waterborne diseases among children are related to unsafe drinking water and poor hygiene all over the world every year (Chang et al. 2018). The *Escherichia coli* bacteria in drinking water are recognized as a main and prominent factor for deterioration of microbiological attributes (Wen et al. 2020).

Regarding to the role of water for health care, the aim of present research is to measure physicochemical, microbial and heavy metals of drinking water during 2020 summer in 30 regions of Tehran city.

2. Materials and methods

2.1. Sampling

The 30 regions of Tehran city including Azadegan, Ekbatan, Bumehen, Pardis, Tajrish, Javadiyeh, Chitgar, Holy Shrine, Hakimiyeh, Darband, Darvazeh Dowlat, Damavand, Rudehen, Shahre Rey, Sanat Square, Shush, Sadeghiyeh, Tarasht, Abdol Abad, Ali Abad, Qolhak, Karaj, Kahrizak, Moniriyeh, Mosalla, Mofateh, Molavi, Mirdamad, Nemat Abad and Vardavard were selected in present study during summer of 2020. Fig. 1 (map of Tehran city) is outlined all studied regions in present research. Samples were collected randomly in accordance with standard conditions to prevent secondary contamination using sterile sampling containers from public places such as parks, subway stations and passages, as well as tap water without hose and apparent contamination, and then samples were transferred shortly to laboratory.

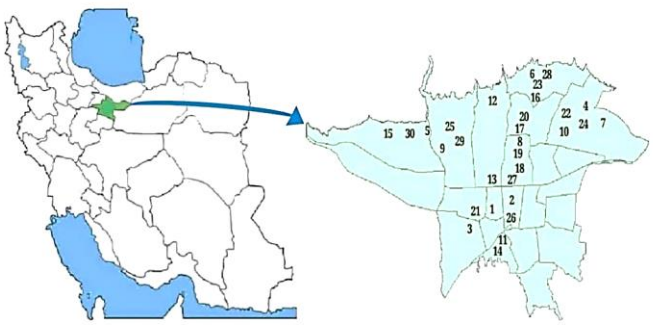

Fig. 1. Surveyed regions of Tehran province in present study

2.2. Physicochemical tests

In present study, pH, alkalinity, turbidity were measured by pH meter model 827, titration procedure and a nephelo turbidity meter, respectively. The other tests were also determined such as electrical conductivity (EC) using EC 712 Metro device from Switzerland, chloride level by iodometry technique and nitrite through DR 2000 Hach device. The mentioned tests were performed with three replications according to national and international standard water and wastewater guidelines (ISO 2010, WHO 2011).

2.3. Estimation of “total” and “thermotolerant” coliform bacteria

Coliform bacteria (total and thermotolerant) were assessed using spread plate technique. Concisely, 0.1 mL of 10^{-1} to 10^{-6} dilutions in peptone water was diffused on MacConkey agar for drinking water samples. The incubation was done for total and thermotholerant coliforms at 37 and 44 ºC about 48 h, respectively. Total and thermotolerant coliforms were represented by colonies (pink to dark red) on agar and after that were enumerated as CFU mL^{-1} (Obiri-Danso et al. 2003).

2.4. Determination of some heavy metals

In present study, stock samples of arsenic (As), copper (Cu), zinc (Zn) and lead (Pb) were prepared using arsenic nitrite, copper nitrite, zinc nitrite and lead nitrite, respectively. Heavy metals were determined using atomic absorption spectroscopy (Shimadzu, 6200) in samples (Kumar et al. 2020).

2.5. Statistical analysis

Water samples were randomly selected from 30 areas and the tests were conducted in three replications. The normality analysis was performed for all data, which was examined by factorial arrangement in a completely randomized model with mean and standard deviations. Finally, data were statistically analyzed using SPSS 24 software and Duncan's mean comparison at 0.05 % level.

3. Results and discussion

Water quality and hygiene are the most prominent challenges of treatment and distribution systems.

3.1. Physicochemical aspects

The pH of drinking water was observed 6.50 and 7.81 in Sanat Square and Bumehen regions, respectively (Table 1). There was a significant difference at 95 % level between the results, while optimum pH of drinking water was found between 6.5 and 8.5, which was within the national (ISO 2010). Previous research expressed that pH of drinking water was detected from 7.6 to 7.8 in Tehran, which was in line with Environmental Protection Agency and national standard (Yazdanbakhsh et al. 2009). The pH was in the range of 6.8 to 7.89 drinking water (54 samples) collected in spring and autumn from Babol, northern Iran (Amouei et al. 2017). The mean level of this factor was indicated 7.56, which was within the range of national and international standards in 13 different districts of Sindh, Pakistan (Khan et al. 2018). No specific standard was represented for water alkalinity, but there is a direct correlation between water alkalinity and pH. Phenolphthalein alkalinity was not observed in each sample and its number was zero, which was not depicted in Table 1. A significant difference of methyl orange alkalinity was observed between samples (p<0.05), which was varied from 31.54 mg/L (Holy Shrine) to 147.22 mg/L (Damavand), as represented in Table 1.

Total alkalinity ranged from 322.9 to 396 mg/L in drinking water samples collected from Babol, northern Iran (Amouei et al. 2017). The minimum level of total alkalinity was found and phenolphthalein alkalinity was observed in the range of 1.66 to 4.06 (mg/L) for Navsari District in Gujarat and India (Vaidya and Gadhia, 2012). The performed experiments on alkalinity indicated that phenolphthalein alkalinity was determined negative for drinking water samples (Odiongenyi et al. 2015).

The turbidity changed from 0.011 to 2.983 NTU and slight values were found in most samples (Table 1). In 100 % cases, turbidity results were completely in accordance with the maximum level (5 NTU) of national standard (ISO 2010). The average of water turbidity was significantly increased in Karaj compared to others (p<0.05). The minimum and maximum turbidity were reported as 0.32 to 1 NTU for drinking water sources in Villages of Saqqez, Iran, which was in desired and permissible range of national standard (Yousefi and Hojati Bonab et al. 2020).

In present study, EC of samples was belonged 1401.4 and 1972.1 (µs/cm) for Rudehen and Ekbatan, respectively (Table 1), and also EC standard is 1500 (µs/cm) as represented in WHO, 2011. Some regions had a higher level such as Chitgar (1510.3 µs/cm), Molavi (1547.1 µs/cm), Damavand (1550.2 µs/cm), Qolhak (1557.3 µs/cm), Bumehen (1611.0 µs/cm), Shush (1742.3 µs/cm), Sadeghiyeh (1746.7 µs/cm), Karaj (1907.0 µs/cm), Kahrizak (1865.1 µs/cm), Holy Shrine (1945.1 µs/cm) and Ekbatan (1972.1 µs/cm). Zones could indicate inorganic contaminants with highest mean EC that import through sewage leakage and agricultural runoff from huge drains, as the same results were demonstrated in drinking water of Pakistan (Ahmed et al. 2020). The mean EC level of samples was ranged from 187.80 and 68.80 µs/cm, which was exceeded than standard value in South Eastern Nigeria (Odiongenyi et al. 2015).

As depicted in Table 2, the highest and lowest chloride were belonged to Vardavard (321.34 mg/L) and Qolhak (231.14 mg/L), respectively, so these levels were in the standard range and the maximum permissible is 400 mg/L (ISO 2010). High chloride caused flavor in drinking water and a slightly unpleasant odor was felt from sample of Vardavard region in control experiment, which is probably due to more chloride presence compared to others. Chloride was observed from 37.52 to 112.56 (mg/L) for drinking water supply sources in Villages of Saqqez, Iran (Yousefi and Hojati Bonab et al. 2020). In South Eastern Nigeria, the range of this index was detected from 5.50 to 7 (mg/L) for distinct samples, which was within the standard (Odiongenyi et al. 2015).

Table 1. The mean results of physicochemical for drinking water samples (mean ± standard error).

No.	Samples	pH	Methyl Orange Alkalinity, mg/L	Turbidity, NTU	Electrical conductivity, μs/cm
1	Abdol Abad	6.62^{a}±0.25	46.20^{b}±2.36	0.012^{a}±0.002	1420.1^{a}±10.2
2	Ali Abad	7.43^{c}±0.22	44.01^{b}±1.71	0.080^{c}±0.003	1500.2^{b}±7.1
3	Azadegan	6.85^{a}±0.21	43.52^{b}±1.50	0.013^{a}±0.002	1450.4^{ab}±9.0
4	Bumehen	7.81^{d}±0.07	145.01^{d}±1.25	0.031^{ab}±0.002	1611.0^{c}±13.0
5	Chitgar	7.62^{c}±0.39	45.02^{b}±1.24	0.022^{a}±0.002	1510.3^{b}±9.4
6	Darband	6.52^{a}±0.06	45.53^{b}±1.45	0.012^{a}±0.001	1462.1^{ab}±10.2
7	Damavand	7.74^{d}±0.01	147.22^{d}±4.22	0.043^{b}±0.001	1550.2^{b}±7.3
8	Darvazeh Dowlat	7.17^{b}±0.02	45.05^{b}±1.20	0.022^{a}±0.002	1401.7^{a}±8.4
9	Ekbatan	7.63^{d}±0.30	45.04^{b}±1.97	0.011^{a}±0.001	1972.1^{f}±12.2
10	Hakimiyeh	7.71^{d}±0.10	133.30^{c}±3.33	0.041^{b}±0.004	1493.2^{b}±11.0
11	Holy Shrine	7.22^{b}±0.15	31.54^{a}±0.32	0.012^{a}±0.001	1945.1^{f}±12.0
12	Sanat Square	6.50^{a}±0.25	46.02^{b}±1.87	0.113^{d}±0.017	1487.3^{b}±10.1
13	Javadiyeh	6.81^{a}±0.22	44.06^{b}±2.62	0.011^{a}±0.001	1423.4^{a}±11.0
14	Kahrizak	7.12^{b}±0.09	33.11^{a}±0.60	0.042^{b}±0.001	1865.1^{e}±9.3
15	Karaj	7.41^{c}±0.07	46.55^{b}±1.41	2.983^{f}±0.003	1907.0^{f}±5.0
16	Mirdamad	7.20^{b}±0.30	44.03^{b}±1.92	0.074^{c}±0.005	1508.2^{b}±7.0
17	Mofateh	6.74^{a}±0.04	44.52^{b}±2.35	0.113^{d}±0.007	1474.3^{b}±8.0
18	Molavi	7.40^{c}±0.12	32.24^{a}±3.64	0.031^{ab}±0.004	1547.1^{bc}±7.2
19	Moniriyeh	7.12^{b}±0.08	44.02^{b}±2.79	0.012^{a}±0.001	1501.3^{b}±10.2
20	Mosalla	6.83^{a}±0.05	46.13^{b}±1.21	0.214^{e}±0.002	1504.0^{b}±14.9
21	Nemat Abad	7.23^{b}±0.34	46.04^{b}±1.34	0.152^{d}±0.001	1467.1^{a}±17.0
22	Pardis	7.63^{c}±0.05	143.23^{d}±1.60	0.053^{b}±0.001	1403.4^{a}±8.4
23	Qolhak	7.32^{bc}±0.03	45.52^{b}±1.85	0.151^{d}±0.009	1557.3^{bc}±11.3
24	Rudehen	7.63^{c}±0.07	129.11^{c}±2.01	0.042^{b}±0.001	1401.4^{a}±10.4
25	Sadeghiyeh	7.51^{c}±0.20	44.12^{b}±1.41	0.011^{a}±0.001	1746.7^{de}±11.9
26	Shahre Rey	7.31^{bc}±0.04	40.05^{ab}±4.33	0.032^{ab}±0.002	1509.5^{b}±13. 7
27	Shush	7.42^{c}±0.12	45.83^{b}±1.80	0.012^{a}±0.001	1742.3^{d}±12.6
28	Tajrish	6.52^{a}±0.11	45.04^{b}±2.75	0.041^{b}±0.003	1407.8^{a}±9.9
29	Tarasht	7.60^{c}±0.13	44.25^{b}±1.27	0.012^{a}±0.002	1488.2^{b}±12.0
30	Vardavard	6.95^{ab}±0.61	45.05^{b}±1.97	0.142^{d}±0.002	1404.3^{a}±15.5

$^{a-f}$ Significant differences in each column

The nitrate content was ranged from 7.21 to 20.04 (mg/L) according to No^{-3} (Table 2). The highest value was belonged to Javadieh (20.04 mg/L) compared to others, and Ali Abad (7.21 mg/L) had the lowest level (p<0.05), which was in the rage of 50 (mg/L) as a standard level (ISO 2010). The highest concentration of nitrate was found 20.66 (mg/L) in drinking water sources of Amol, which reduced by increasing depth of well (Yousefi and Naeij, 2007). In South Eastern Nigeria, this level was distinguished in the range of 0.10 to 0.18 (mg/L) according to NO^{-2}, which was lower than standard (Odiongenyi et al. 2015).

3.2. Microbial contamination

The highest level (6.76 CFU/mL) of total coliforms was detected for Molavi, but the lowest (0.22 CFU/mL) was observed in Tajrish among 30 regions, as illustrated in Table 2. All drinking water samples should be free of thermotolerant coliform (ISO 2007). The highest level (4.11 CFU/mL) of thermotolerant coliforms was found in Kahrizak. The general results of microbiological contamination showed that thermotolerant coliforms of drinking water were higher than allowable range, but in some regions were not detected such as Bumehen, Darband, Damavand, Hakimiyeh, Mirdamad, Mofateh, Pardis, Qolhak, Rudehen, Sadeghiyeh and Tajrish. The microbial quality of drinking water was lower than national standard in terms of thermotolerant coliforms (ISO 2007) for the other areas (Abdol Abad, Ali Abad, Azadegan, Chitgar, Darvazeh Dowlat, Ekbatan, Holy Shrine, Sanat Square, Javadiyeh, Kahrizak, Karaj, Molavi, Moniriyeh, Mosalla, Nemat Abad, Shahre Rey, Shush, Tarasht, Vardavard). Microbial quality (total coliforms) of drinking water was investigated in rural areas from central part of Boyer-Ahmad city, which was in standard range (Shirazi et al. 2012). A microbiological water quality indicator is generally one specific species or group of microorganisms, which can enter into water via fecal matter, but is easy to measure than the full spectrum of microorganisms that pose a risk to human health (Wen et al. 2020). Total coliforms were detected from 7 to 18 (CFU/mL) by influencing of household filter types on quality of drinking water (Alsulaili et al. 2020). Also, deterioration of urban water distribution had the largest share in microbial contamination of drinking water. Therefore, several efforts should be conducted to reduce pollution of available safe water (John et al. 2014), so these arrangements must also be taken in the undesirable areas of Tehran.

Table 2. The mean results of chloride and nitrite levels and microbial parameters, for drinking water samples (mean ± standard error).

NO.	Samples	Chloride level, mg/L	Nitrite level :NO^{-}_{3}, mg/L	Total coliform, CFU/mL	Thermotolerant coliform, CFU/mL
1	Abdol Abad	302.41^{d}±7.02	11.20^{b}±2.00	3.63^{bc}±0.14	1.81^{b}±0.02
2	Ali Abad	240.43^{a}±6.85	7.21^{a}±1.30	4.28^{c}±0.06	2.00^{c}±0.03
3	Azadegan	300.22^{d}±5.12	18.20^{e}±1.22	4.21^{c}±0.020	1.80^{bc}±0.01
4	Bumehen	291.51^{d}±3.22	11.22^{b}±1.34	1.22^{a}±0.35	ND^{a}
5	Chitgar	282.92^{c}±4.20	9.23^{b}±1.66	2.13^{b}±0.09	0.80^{b}±0.03
6	Darband	301.33^{d}±5.01	13.25^{c}±1.20	0.34^{a}±0.01	ND^{a}
7	Damavand	263.35^{b}±2.39	9.01^{b}±1.22	0.50^{a}±0.01	ND^{a}
8	Darvazeh Dowlat	250.21^{ab}±4.60	9.02^{b}±1.34	3.51^{bc}±0.03	1.70^{b}±0.05
9	Ekbatan	280.22^{c}±3.24	10.11^{b}±2.00	4.80^{c}±0.11	1.32^{b}±0.02
10	Hakimiyeh	275.33^{c}±4.57	9.53^{b}±1.80	0.92^{a}±0.02	ND^{a}
11	Holy Shrine	280.01^{c}±4.23	8.32^{b}±1.72	2.91^{b}±0.11	0.91^{b}±0.02
12	Sanat Square	274.24^{c}±5.02	10.50^{b}±2.10	4.70^{c}±0.12	1.22^{b}±0.03
13	Javadiyeh	270.71^{bc}±2.34	20.04^{f}±1.90	2.80^{b}±0.15	0.21^{b}±0.01
14	Kahrizak	282.52^{c}±6.34	8.33^{a}±1.05	6.40^{d}±0.21	4.11^{d}±0.02
15	Karaj	275.51^{c}±5.21	8.24^{a}±1.03	4.36^{c}±0.05	2.41^{c}±0.04
16	Mirdamad	290.04^{cd}±6.01	11.54^{b}±1.34	0.62^{a}±0.01	ND^{a}
17	Mofateh	310.22^{d}±3.98	12.00^{b}±1.06	0.42^{a}±0.20	ND^{a}
18	Molavi	295.23^{d}±3.84	11.32^{b}±1.13	6.76^{d}±0.31	2.20^{c}±0.02
19	Moniriyeh	280.04^{c}±5.21	9.24^{b}±0.98	3.75^{bc}±0.31	1.40^{b}±0.01
20	Mosalla	300.30^{d}±4.30	11.32^{b}±1.07	4.14^{d}±0.21	2.50^{c}±0.05
21	Nemat Abad	295.12^{d}±5.23	12.81^{c}±1.20	3.18^{bc}±0.07	1.00^{b}±0.00
22	Pardis	304.43^{d}±3.41	12.80^{c}±2.40	2.71^{b}±0.22	ND^{a}
23	Qolhak	231.14^{a}±3.17	7.32^{a}±1.04	1.15^{a}±0.09	ND^{a}
24	Rudehen	275.22^{c}±3.11	9.24^{b}±1.30	0.71^{a}±0.05	ND^{a}
25	Sadeghiyeh	278.51^{c}±4.00	9.42^{b}±1.34	1.82^{b}±0.04	ND^{a}
26	Shahre Rey	240.42^{a}±4.31	8.33^{b}±1.64	3.42^{bc}±0.02	1.41^{b}±0.06
27	Shush	270.23^{bc}±3.98	9.35^{b}±1.60	5.34^{cd}±0.09	1.43^{b}±0.02
28	Tajrish	295.54^{d}±3.54	19.31^{f}±1.78	0.22^{a}±0.34	ND^{a}
29	Tarasht	280.22^{c}±6.12	8.33^{b}±1.36	4.92^{c}±0.03	1.30^{b}±0.01
30	Vardavard	321.34^{e}±4.39	13.34^{c}±1.36	5.89^{cd}±0.12	3.40^{cd}±0.31

$^{a-f}$ Significant differences in each column
ND: not detected

3.3. Concentration of heavy metals

Heavy metals are chiefly detected in water body and knowing their spatial pattern could be a critical matter on regional position for policymakers in health care, contamination source, and risk mitigation (Machado et al. 2017). The permissible levels of As 0.01 (mgL^{-1}), Cu 2 (mgL^{-l}) and Pb 0.01 (mgL^{-1}) are detected in drinking water according to national standard (ISO 2010). The mean values were observed for heavy metals such as As, Cu, Zn and Pb in Tehran (Table 3).

There was a significant difference between contaminated regions in terms of As concentration. The mean results of 30 regions illustrated that As levels were in the standard range in all samples (p<0.05) and the highest and lowest levels were observed for Vardavard (1. 59 μgL^{-1}) and Ekbatan (0.08 μgL^{-1}), respectively. Cu level was calculated in the range of 0.02 (mgL^{-1}) to 3.38 (mgL^{-1}) and all samples were close to standard range except Pardis (2.04 mgL^{-1}), Kahrizak (2.05 mgL^{-1}), Karaj (2.44 mgL^{-1}), Tajrish (2.55 mgL^{-1}), Sadeghiyeh (2.75 mgL^{-1}) and Mosalla (3.38 mgL^{-1}). There is no limit for Zn by national standard, but all samples are permitted and close to 3 (mgL^{-l}) as optimum range (ISO 2010). The amount of Zn was in the range of 0.14 (mgL^{-l}) for Moniriyeh to 3.82 (mgL^{-l}) for Darvazeh Dowlat. The results of Pb level indicated that this factor was obtained in the range of 0.001 to 0.031 (mgL^{-1}) and Darband (0.011 mgL^{-1}), Molavi (0.012 mgL^{-1}), Sadeghiyeh (0.013 mgL^{-1}), Moniriyeh (0.014 mgL^{-1}), Ekbatan (0.016 mgL^{-1}), Qolhak (0.020 mgL^{-1}), Bumehen (0.023 mgL^{-1}) and Holy shrine (0.031 mgL^{-1}) were higher than national standard.

High As of drinking water have resulted in symptoms of As contamination specifically in developing countries, where millions people are critical at risk assessment. Nevertheless, polluted groundwater with As was not just restricted to developing countries (Machado et al. 2017). A study in China represented that As level was in the range of 0.001 to 0.05 (mgL^{-1}) for source of water in springs (Liu et al. 2009). The research demonstrated that 8.4 % tube wells of pollution water included higher 0.3 (mgL^{-1}) As in Bangladesh (KhalidHasan et al. 2019). The exceeded levels of heavy metals such as Pb, Cu, and Zn were also more polluted the water body (Kumar et al. 2020). The Pb contribution (30.73 mgL^{-1}) was noticeably high in Mangla Lake, Pakistan and could be because of traffic conditions (Saleem et al. 2015). Highways, road dust, traffic conditions, and main roads can be regarded as the major contamination of heavy metals such as Pb and Zn (Kumar et al. 2020).

Table 3. The mean results of heavy metals level in drinking water samples (mean ± standard error).

No.	Samples	As, µg/L	Cu, mg/L	Zn, mg/L	Pb, mg/L
1	Abdol Abad	$0.51^{b}\pm0.03$	$0.14^{b}\pm0.11$	$1.02^{b}\pm0.23$	$0.002^{a}\pm0.000$
2	Ali Abad	$0.60^{b}\pm0.11$	$0.04^{a}\pm0.03$	$2.10^{c}\pm0.30$	$0.001^{a}\pm0.000$
3	Azadegan	$0.09^{a}\pm0.07$	$0.22^{b}\pm0.07$	$0.18^{a}\pm0.02$	$0.010^{b}\pm0.001$
4	Bumehen	$0.10^{a}\pm0.06$	$0.15^{b}\pm0.03$	$0.17^{a}\pm0.14$	$0.023^{c}\pm0.014$
5	Chitgar	$0.44^{b}\pm0.17$	$0.90^{bc}\pm0.11$	$1.73^{bc}\pm0.21$	$0.001^{a}\pm0.000$
6	Darband	$0.50^{b}\pm0.02$	$1.31^{c}\pm0.13$	$2.04^{b}\pm0.75$	$0.011^{b}\pm0.005$
7	Damavand	$0.52^{b}\pm0.31$	$0.77^{bc}\pm0.10$	$3.04^{c}\pm0.40$	$0.002^{a}\pm0.000$
8	Darvazeh Dowlat	$0.38^{b}\pm0.13$	$1.02^{c}\pm0.07$	$3.82^{c}\pm0.33$	$0.002^{a}\pm0.001$
9	Ekbatan	$0.08^{a}\pm0.00$	$0.72^{bc}\pm0.05$	$0.16^{a}\pm0.05$	$0.016^{b}\pm0.005$
10	Hakimiyeh	$0.37^{b}\pm0.24$	$1.33^{c}\pm0.03$	$1.06^{b}\pm0.09$	$0.007^{a}\pm0.002$
11	Holy Shrine	$0.59^{bc}\pm0.15$	$0.20^{b}\pm0.02$	$1.83^{bc}\pm0.11$	$0.031^{d}\pm0.011$
12	Sanat Square	$0.48^{b}\pm0.03$	$0.67^{c}\pm0.22$	$0.98^{b}\pm0.22$	$0.004^{a}\pm0.001$
13	Javadiyeh	$0.27^{a}\pm0.13$	$0.95^{bc}\pm0.07$	$0.50^{a}\pm0.04$	$0.001^{a}\pm0.000$
14	Kahrizak	$0.75^{c}\pm0.10$	$2.05^{d}\pm0.35$	$2.44^{c}\pm0.30$	$0.004^{a}\pm0.002$
15	Karaj	$0.62^{bc}\pm0.25$	$2.44^{d}\pm0.21$	$2.38^{c}\pm0.11$	$0.008^{a}\pm0.001$
16	Mirdamad	$1.06^{cd}\pm0.30$	$1.87^{cd}\pm0.09$	$3.73^{d}\pm0.42$	$0.003^{a}\pm0.002$
17	Mofateh	$0.94^{c}\pm0.43$	$0.72^{bc}\pm0.10$	$3.01^{cd}\pm0.52$	$0.001^{a}\pm0.000$
18	Molavi	$1.44^{d}\pm0.21$	$1.42^{c}\pm0.07$	$2.52^{c}\pm0.70$	$0.012^{b}\pm0.010$
19	Moniriyeh	$0.99^{cd}\pm0.03$	$0.09^{ab}\pm0.03$	$0.14^{a}\pm0.52$	$0.014^{b}\pm0.012$
20	Mosalla	$0.51^{b}\pm0.30$	$3.38^{e}\pm0.51$	$3.80^{d}\pm0.81$	$0.010^{b}\pm0.011$
21	Nemat Abad	$0.72^{c}\pm0.15$	$0.08^{a}\pm0.04$	$0.72^{a}\pm0.43$	$0.010^{b}\pm0.003$
22	Pardis	$0.28^{a}\pm0.05$	$2.04^{d}\pm0.32$	$0.94^{ab}\pm0.12$	$0.009^{a}\pm0.002$
23	Qolhak	$0.31^{ab}\pm0.27$	$0.81^{bc}\pm0.13$	$0.25^{a}\pm0.02$	$0.020^{c}\pm0.004$
24	Rudehen	$0.46^{b}\pm0.15$	$1.44^{c}\pm0.09$	$3.02^{cd}\pm0.30$	$0.010^{b}\pm0.030$
25	Sadeghiyeh	$0.57^{bc}\pm0.22$	$2.75^{d}\pm0.82$	$1.53^{bc}\pm0.14$	$0.013^{b}\pm0.010$
26	Shahre Rey	$0.38^{b}\pm0.13$	$0.93^{c}\pm0.60$	$0.90^{ab}\pm0.07$	$0.010^{b}\pm0.005$
27	Shush	$0.73^{c}\pm0.26$	$1.47^{cd}\pm0.36$	$1.52^{b}\pm0.19$	$0.010^{b}\pm0.012$
28	Tajrish	$0.34^{b}\pm0.20$	$2.55^{d}\pm0.41$	$2.31^{c}\pm0.13$	$0.010^{b}\pm0.013$
29	Tarasht	$0.68^{bc}\pm0.12$	$0.02^{a}\pm0.01$	$1.42^{bc}\pm0.37$	$0.002^{a}\pm0.001$
30	Vardavard	$1.59^{d}\pm0.37$	$1.46^{cd}\pm0.02$	$2.73^{cd}\pm0.24$	$0.010^{b}\pm0.002$

$^{a-d}$ Significant differences in each column

4. Conclusions

The results demonstrated that water qualities such as pH, turbidity, chloride and nitrate of distinct regions were within acceptable level. Chemical pollution can potentially be caused by dispersion of surface water, transfer and storage of water in low rainy season, air pollution and their precipitation during rainfall on catchment surfaces and the microbial quality and EC of drinking water was lower than national standards in some regions. Tehran residents are probably at risk of distinct waterborne diseases through consumption of piped drinking water. Cu and Pb concentrations were higher than national standard in some regions. Therefore, it is necessary to be more careful and sensitive about providing safe drinking water in accordance with national standard, so that polluted water is not distributed in urban population of Tehran.

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