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EVALUATION OF ISTANBUL'S DRINKING AND CITY WATER ANALYSIS IN 2017

İstanbul İli 2017 Yılı İçme ve Kullanma Sularının Değerlendirilmesi

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Abstract

Istanbul is a city of 16 million, accounting for almost fifth of the population of Turkey, therefore providing quality drinking and use water is vital. To evaluate the results of drinking and city water analysis in Istanbul in 2017. This is a descriptive study using retrospective data. Inspection monitoring and control monitoring samples collected 748 monitoring points from 36 water plants around Istanbul in addition to Residual Chlorine measurement samples from 548 points. These samples were analyzed in Istanbul Public Health Reference Laboratories (HSL). Data analysis was carried in SPSS 21.0, statistical analysis were described as percentage, mean, standard deviation. Statistical significance was accepted as p<0.05 with 95% confidence interval. Mean pH level in İstanbul's drinking and usage water was 6.95±0.14 (min: 6,62-max:7,28); mean Coliform Bacteria levels were 17.09±99.47 (min:0.00-622.00) /100 ml; mean conductivity was 376.22±78.52 (min: 282.06-max:613.73) µS/cm; mean Escherichia coli per. 3.13±18.98 (min:0,00-max:118.60); mean iron levels were 34.39±18.81 (min:6,79-max:103.70) µg/L. 90.2% of inspection monitoring samples, 96.9% of control monitoring samples and 99.5% of residual chlorine analysis were in acceptable levels. Water quality analysis in Turkey is done by various organizations and multiple branches of government under national and international regulations. Monitoring and analysis procedures are independent of each other and currently no integrated monitoring strategies is at place, although several actions on this front has started. An integrated system of data collection and analysis between all stakeholders are needed to increase time and workload efficiency in water quality evaluation.

Keywords: Drinking water, public health, *Escherichia coli*.

Özet

İstanbul, Türkiye nüfusunun yaklaşık beşte birini oluşturan 16 milyonluk bir şehirdir, bu nedenle kaliteli içme ve kullanma suyu sağlamak hayati önem taşımaktadır. Bu çalışmada İstanbul ilindeki 2017 yılı içme kullanma sularının analiz sonuçlarının değerlendirilmesi amaçlanmıştır. Araştırma retrospektif verilerin kullanıldığı tanımlayıcı bir çalışmadır. İstanbul ilinde 36 noktada bulunan şebekelerden belirlenen 748 izleme noktasından Kontrol İzlem ve Denetim İzlem numunesi, 548 izleme noktasından Bakiye Klor Ölçümü numunesi alınarak, bir tanesi Anadolu yakasında iki tanesi Avrupa yakasında olmak üzere İstanbul Halk Sağlığı 1-2-3 No'lu Referans Laboratuvarlarında (HSL) analizleri yapılmaktadır. Veriler SPSS 21.0 paket programı ile değerlendirilmiş, istatistiksel analizlerde yüzde, aritmetik ortalama, standart sapma kullanılarak yorumlanmıştır. İstatistiklerde % 95 güven aralığı ve anlamlılık düzeyi p<0,05 olarak kabul edilmiştir. Araştırmada İstanbul ilindeki içme kullanma sularındaki ph değeri ortalaması 6,95±0,15 (min: 6,62-maks: 7,28); Koliform bakteri değeri ortalaması 17,09±99,47 (min:0,00-622,00) /100 ml; iletkenlik değeri ortalaması 376,22±78,52 (min: 282,06- maks:613,73) µS / cm; *Escherichia* coli miktarı ortalaması 3,13±18,98 (min:0,00-maks:118,60); demir miktarı ortalaması 34,38±18,81 (min: 6,79-maks: 103,70) µg/L olarak saptanmıştır. Araştırmada yapılan denetim izlem sonuçlarının %90,2'si, kontrol izlemlerinin %96,9'u ve bakiye klor ölçümlerinin %99,5'u uygun saptanmıştır. Ülkemizde su kalitesi izleme çalışmaları, çeşitli kurum ve kuruluşlar tarafından ulusal ve uluslararası sorumluluklar kapsamında yürütülmektedir. Çalışmalar birbirinden bağımsız olup, henüz entegre bir kirlilik izleme stratejisi uygulanmamaktadır. Bu konuda ortak paydaşlar ile çeşitli çalışmalar yapılmaktadır. Su kalitesi izleme çalışmalarını yürüten kurum ve kuruluşlar ile birbirine entegre ortak bir veri tabanı oluşturularak yapılan çalışmaların sonuçları paylaşıldığı takdirde zaman ve insan gücü kaybının da önüne geçilmiş olacaktır.

Anahtar kelimeler: İçme suyu, halk sağlığı, *Escherichia coli.*

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Introduction

Water covers 78% of the surface area of the world, however, suitable water for human use is much limited (1). Only 2.7-3.0% is freshwater (2). It is a vital material for all living organisms and plays an important role in all metabolic processes in the human body (3). It is a necessary source to maintain life (4-6). Therefore, it needs to be clear of pathogens, color, taste etc. and any other harmful substances. Therefore, the microbial quality of water is an important topic of interest and study for consumers, providers, regulators and public health authorities. Health authorities particularly have an important stake as it can carry a lot of pathologic materials (7).

Drinking and usage water analysis includes 'control monitoring analysis', 'inspection monitoring analysis' and 'residual chlorine analysis'. Inspection monitoring aims to provide data and compare them to the existing regulatory parameters. These parameters are collected under microbiological, chemical, physical and radioactivity groups (8).

Control monitoring analysis provides information about organoleptic and microbiological characteristics, and effectiveness of decontamination (especially disinfection) efforts and compares them to the existing regulatory parameters (8).

Water distribution of the city is done by Istanbul Water and Sewage Administration (İSKİ) in Istanbul while all of the monitoring analysis is undertaken by Istanbul Health Directorate Public Health Services. Surface water collected from Alibeyköy, Büyükçekmece, Darlık, Elmalı, Istırancalar, Kazandere, Ömerli, Papuçdere, Sazlıdere, Terkos dams and Melen, Yeşilçay, Yeşilvadi regulatory water basins in are then decontaminated Büyükçekmece, Cumhuriyet, Elmalı, İkitelli, Kağıthane, Ömerli ve Taşoluk decontamination centers and distributed to main water plants (9).

The water distribution line is approximately 18,821 km. and distributes 2,796,277 m^3 water daily. The Ministry of Health developed an online Environmental Health Information Management System to integrate to a Geographical Information System to track and monitor the drinking and usage of water. City health directorates started using this system in July 2010 (9). Istanbul is a city of 16 million, accounting for almost fifth of the population of Turkey, therefore providing quality drinking and use of water is vital. This study aims to evaluate the various quality analyses done in 2017.

Material and Method

This is a descriptive study using retrospective data. Inspection monitoring and control monitoring samples collected 748 monitoring points from 36 water plants around İstanbul in addition to Residual Chlorine measurement samples from 548 points. These samples were analyzed in Istanbul Public Health Reference Laboratories (HSL) 1, 2, and 3.

Microbiological samples were collected in sterile disposable plastic vials. Samples for chemical analysis were collected in disposable plastic vials. Samples for microbiological analysis are carried in special transportation containers with cold chains. For residual chlorine measurement and analysis, a comparator device that utilizes an o-tolidine solution as indicator for colour difference was used.

Data analysis was carried in SPSS v21.0, statistical analysis was described as percentage, mean, standard deviation. Statistical significance was accepted as $p<0.05$ with 95% confidence interval.

This study is approved by Istanbul University School of Medicine Clinical Research Ethics Board with decree number 2019/451. This research article has been written from the thesis.

Results:

Mean pH level in Istanbul's drinking and usage water was 6.95±0.14 (min:6.62-max:7.28); mean Coliform Bacteria levels were 17.09±99.47 (min:0.00-622.00) /100 ml; mean conductivity was 376.22±78.52 (min:282.06-max:613.73) µS/cm; mean *Escherichia Coli* per. 3.13±18.98 (min:0.00-max: 118.60); mean iron levels were 34.39±18.81 (min:6.79-max:103.70) µg/L. Mean values of chemical and microbiological parameter values for both control and inspection monitoring analysis are presented in Table 1.

Table 1: . Mean levels of chemical and microbiological parameters of Water Analysis in Istanbul in 2017.

Chemical and microbiological parameters	Number of districts	Minimum	Maximum	Mean	Standard deviation
Aluminium	39	12.5	70.1	37.9	14.5
Ammonia	39	0.0	0.0	0.0	0.0
Clostridium perfringens	39	0.0	0.4	0.0	0.0
Iron	39	6.7	103.6	34.3	18.8
Escherichia coli	39	0.0	118.5	3.1	18.9
Conductivity	39	282.0	613.7	376.2	78.5
Coliform bacteria	39	0.0	622.0	17.0	99.4
pH	39	6.6	7.2	6.9	0.1

Inspection monitoring analysis reveals that abnormal (unfit for drinking and use) samples were mostly in Autumn. Results are presented in Table 2.

Table 2: Fitness of drinking and usage water on inspection monitoring analysis according to the season.

Fitness of drinking and usage water	Season			
	Spring n(%)	Summer n(%)	Autumn n(%)	Winter n(%)
Suitable (n=167)	45(26.9%)	41(24.6%)	37(22.2%)	44(26.3%)
Not suitable (n=18)	2(11.1%)	5(24.8%)	7(38.9%)	4(22.2%)

Among parameters that were above acceptable levels in inspection monitoring analysis, 55.5% were chemical, 22.2% were microbiologic and 22.2% were physical parameters. Of the chemical parameters there were above the levels, 60% (n=6) were trihalomethane, 10% (n=1) were arsenic, 10% (n=1) were nitrate and 20% (n=2) were iron. In microbiological parameters that were above the acceptable levels, 25% (n=1) were Coliform Bacteria, 25% (n=1) were Enterococci, 25% (n=1) were *Escherichia coli* and 25% (n=1) were *Clostridium perfringens* In control monitoring analysis, the distribution of unacceptable levels in samples revealed that most of these samples were received in Autumn (Table 3).

Table 3: Fitness of drinking and usage water on control monitoring analysis according to the season.

Fitness of drinking and usage water	Season			
	Spring n(%)	Summer n(%)	Autumn n(%)	Winter n(%)
Suitable (n=9083)	2167(23.9%)	2641(23.6%)	2132(23.5%)	2143(29.1%)
Not suitable (n=286)	60(20.9 %)	74(25.8%)	85 (29.7%)	67(25.9%)

Among parameters that were above acceptable levels in control monitoring analysis 46.8% (n=134) were chemical, 51.3% (n=147) were microbiologic and 1.7% (n=5) were physical parameters.

In control monitoring analysis, 77.5% (n=114) of the inappropriate levels were Coliform bacteria, 5.4% (n=8) were *E. coli* and 17% (n=25) were *C. perfringens.*

Among above normal findings in chemical parameters, 21% (n=27) were aluminum, 0.1% (n=4) ammonia, 77% (n=96) were iron and 1.4% (n=7) were pH levels. Overall, 90.2% of inspection monitoring, 96.9% of control monitoring and 99.5% of residual chlor was found suitable for human use (Figure 1).

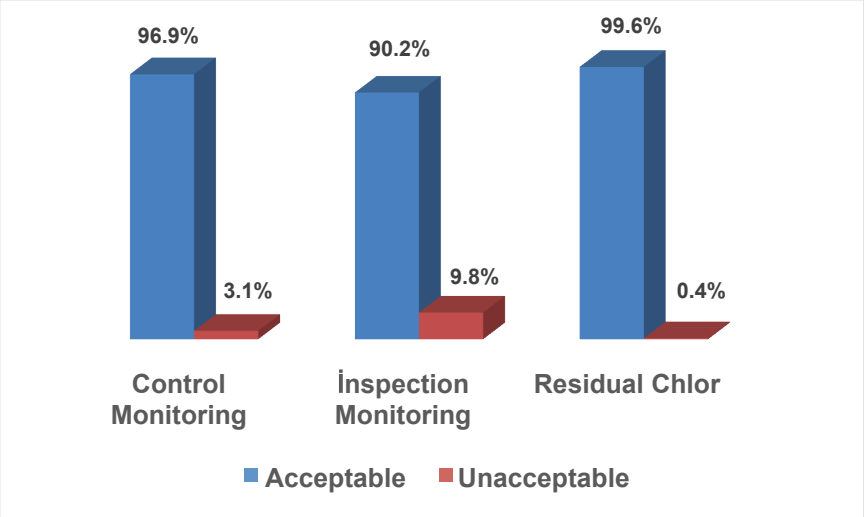

Figure 1: Overall suitability of different monitoring tests for human use of water.

Discussion

This study aims to evaluate the analysis of drinking and usage water of Istanbul in 2017. In terms of free residual chlorine maesurements performed the only 610 (0.04%) of them were below 0.2 ppm. 9,369 samples were collected for control monitoring while 286 (3.1%) of them were unfit / above regulation levels according to parameters set by Regulation for Consumption Water (8). Of the 286 values that were unfit for the parameters, 145 (50.7%) were microbiologic, 124 (43.4%) were chemical, 8 (8.2%) were physical, 5 (1.7%) were physical-chemical, 2 (0.7%) were chemical- microbiologic and 2 (0.7%) were physical- chemical- microbiological.

185 samples were collected for inspection monitoring while 18 (9.8%) of them were unfit / above regulation levels according to parameters set by Regulation for Consumption Water (8). Of the 18 values that were unfit for the parameters, 4

(22.0%) were microbiologic, 10 (55.5%) were chemical, 2 (11.5%) were physical, 1 (5.5%) were physical-chemical, 1 (5.5%) were chemical- microbiologic.

Mean pH level of the drinking water was 7.20±6.90 (min:6.6-max:7.2). The acceptable levels for pH is between 6.50 to 9.50 as per regulations (8). In a study in Southwest Nigeria, pH level in tap water was found to be 6.50±0.20 (5-10). Another similar study in India found the drinking water pH to be 7.07±0.20 (11), in Iran 7.60±0.21 (11). In the close geography, southeast Tunisia it was found to be 7.60±1.40 (12). In northern Pakistan, surface water pH was 7.00±0.02, while underground water pH was 6.90±0.07 (13). In Iraq, tap water pH was found to be 8.10 (min:7.70-max:8.50) (14). Studies looking at pH levels of water in Turkey revealed similar results. In the Bilecik Osmaneli region a study found it to be 7.60 (15) while another study in Van, it was 7.40 (16). Both of these studies found acceptable pH level measurements according to the regulations.

In the study, mean conductivity measure was 376.20±78.50 µS/cm (min:282.00-613.70). The study in northern Pakistan mentioned above found the surface water conductivity 659.20±97.50 µS/cm while underground water levels were 730.20±283.10 µS/cm (13). Study in Iraq also found the conductivity of tap water as 466.20 (min:431-max:554) (14). Results from Turkey, in Van were 578.70±32.80 µ S/cm for conductivity levels (16).

In the study, the value of Coliform bacteria was 17.0±99.4 (min:0-max:622.0). The regulation levels for Coliform bacteria in drinking and usage water is however zero (8). Studies in different parts of the world also revealed that usually reaching zero is heard: In India, it the fecal Coliform bacteria levels were 154.6±4.5 MPN/100ml; while total Coliform bacteria was 174.8±3.6 MPN/100ml (11). In Iran it was 9±5 (0-37) MPN/ (11) while in a different geography, Sweden it was found to be below 1 in 100 ml in all regions (17).

Mean *E. coli* level in our study was 3.1±18.9 (min:0.0-max:118.5). Same study from Iran found their levels to be 0.8±2.6 (min:0.0-max:4.0) (11), while in Sweden *E.coli* levels were below 1 in 100 ml (17).

Mean iron levels were 34.30±18.80 (min:6.70-max:103.60) in our study, which was below the regulation levels of below 200 µg/L (8) . In the study from Northwest Nigeria it was 0.07 mg/l (5-10). In India it was 0.09±0.01 mg/l in drinking water (11). In northern Pakistan which looked at surface and underground water separately, the iron levels were 158±39 µg/L, 50±45 µg/L consecutively (16). Sweden had the lowest measurement in mean iron 5.40±4.10 (13). Studies looking at Turkey, Bileck – Osmaneli Region and Van found their mean levels to be 1 µg/L (17) and 15.30±6.40 (15-16) consecutively.

Of the unfit samples in inspection monitoring 9.2% were in chemical parameters Trihalomethane which was the most frequent unfit parameter in samples making up 3.5% of all unfit results in all analyses conducted. Chlorination for disinfecting water sources are known to react with water to form trihalomethane (THM) and haloacetic acid (HAA) which are both carcinogenic (18). Therefore, THM in the water was interpreted as a result of the disinfection process.

Arsenic is known to increase the risk of cancers and vascular system pathologies (19). Abnormal (above regulation values) samples were only found once a year, and were not continuous and assessed as non-harmful for human health. In two districts, Silivri and Çatalca, agricultural lands were in close proximity to water plants. As the abnormal sample was received in May, which is the season of high agricultural spraying, it might be possible that the one-off sample was due to it. Impermeability areas around the water plants should regularly be controlled for such events.

Iron levels were found to be inappropriate the most, among other parameters in both monitoring analysis. Iron (Fe) and manganese (Mn) are among the most abundant elements in the world. Iron is found in rocks, soil and water in different forms. Existence of them in drinking water is regarded as nor a health risk for humans. However, high levels of iron or manganese

change the color and taste of the drinking water, and in fact can lead to doubts and insecurity in the quality and hygiene of water in end users (20).

Only in February 2017, the iron levels were above normal limits, which accounts for 1.1% of all samples. As it is not harmful to human health, this abnormal measurement is acceptable for quality.

Water quality analysis in Turkey is done by various organizations and multiple branches of government under national and international regulations. Monitoring and analysis procedures are independent of each other and currently no integrated monitoring strategies is at place, although several actions on this front have started. An integrated system of data collection and analysis between all stakeholders are needed to increase time and workload efficiency in water quality evaluation.

Another important point is ensuring the sustained quality of water. Most effective action for this is risk analysis, management and planning encompassing the process from the source to the end user. A Drinking and Usage Water Security Planning should be done by all partners in charge of distributing the water and should be updated and put into action yearly. This would also allow for a wholesome overview of the process, enabling understanding of the possible dangers and preventing it before it reaches the end user.

New settlements and factory sites that can cause waste mix in the drinking and usage of water should not be built near water plants and water transportation units or only built under highly restricted regulations in order to prevent water contamination.

In addition, farm spraying, pest control, fertilization and similar activities for farming areas in close proximity to these plants needs to be carefully undertaken with surveillance and inspection.

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