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Determination of usage frequency of household type water purifiers and effects on drinking water quality in Meram

Meram ilçesinde ev tipi su arıtma cihazlarının kullanım sıklığının belirlenmesi ve içme suyu kalitesine etkisi

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ABSTRACT

Objective: In this study, it is aimed to determine usage frequency of household type water purifiers in Meram and their effects on microbiological and chemical quality of water.

Methods: This cross-sectional study was conducted in Meram of Konya province between the dates of 01 April - 01 June 2016. As the usage prevalence of household type water purifiers in Meram was not known, it was assumed as 50% with G-Power 3.1.9.2 software; sample size was calculated as 810 houses with 95% confidence interval (α=0.05), 7% derivation, 80% power and design effect as 2. 810 houses were selected which were sampled from the neighborhoods of Meram. A questionnaire was applied to the participants who agree to participate, by face to face interview. Water samples were taken from homes which were accesible, for microbiological and chemical analysis from the water network system and the household water purifier. Microbiological analysis was performed by membrane filtration method in Konya public health laboratory. Chemical analyses (pH, conductivity, free chlorine, ammonium, nitrite, fluoride, calcium, magnesium and total hardness) were carried out by the Hach Lange DR

ÖZET

Amaç: Bu çalışmada, ev tipi su arıtma cihazlarının Meram ilçesinde kullanım sıklığının tespit edilmesi ve bu cihazların içme suyunun mikrobiyolojik ve kimyasal kalitesine etkisinin saptanması amaçlanmıştır.

Yöntem: Kesitsel tipteki bu çalışma; 01 Nisan - 01 Haziran 2016 tarihleri arasında, Konya ili Meram ilçesinde yapılmıştır. Örneklem büyüklüğü G-Power 3.1.9.2 bilgisayar programı ile Meram ilçesinde ev tipi su arıtma cihazlarının kullanım prevalansı bilinmediğinden %50 alınarak %95 güven aralığında (α=0,05), %7 sapma, %80 güç ve desen etkisi iki olacak şekilde 810 haneye ulaşılmıştır. Meram ilçesindeki mahallelerden örnekleme seçilen 810 haneye ulaşılmıştır. Çalışmaya katılmayı kabul eden katılımcılara, yüz yüze görüşme yöntemiyle anket uygulanmıştır. Ev tipi arıtma cihazı kullanılan ve analiz için ulaşılabilen hanelerin şebeke sisteminden ve arıtma cihazlarından, mikrobiyolojik ve kimyasal analiz için su örnekleri alınmıştır. Mikrobiyolojik analizler membran süzme yöntemiyle Konya Halk Sağlığı Laboratuvarı'nda yapılmıştır. Kimyasal analizler olarak pH, iletkenlik, serbest klor, amonyum, nitrit, florür, kalsiyum, magnezyum ve toplam sertlik analizlerini Hach Lange DR 3900 UV

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3900 UV spectrophotometer and the Hach Lange HQ40D pH-conductivity instrument at Meram Medical Faculty Public Health Department.

Results: It is found that water purifiers are used in 67 out of 810 households (8,3%) that were interviewed. None of the samples taken from tap water before household type water purifiers were shown total coliform bacteria growth. In one sample taken from treated water thorough purifiers, 9 kob/100 mL total coliform growth was observed (2.5%). In analyses of free chlorine, pH, conductivity, fluoride, calcium, magnesium and total hardness, all parameters were confirmed to be significantly lower in treated water compared to municipal water, while in analysis of nitrite no significant difference was observed. Also, ammonium in samples was not detected.

Conclusion: Household type water purifiers were found not to be a healthy and high quality preference for drinking water, as a result of both hygienic risks and the fact that they significantly decrease water hardness and amounts of salubrious minerals like fluoride, calcium and magnesium in municipal water. Despite regular maintenance when good hygiene can not be provided they may cause the problem of public health in microbiological terms.

Key Words: Water purification, drinking water quality, consumer preference

spektrofotometresinde ve Hach Lange HQ40D pH-iletkenlik cihazında, Meram Tıp Fakültesi Halk Sağlığı Anabilim Dalı'nda analiz edilmiştir.

Bulgular: Görüşülen 810 hanenin 67'sinde (%8.3) su arıtıcılarının kullanıldığı tespit edilmiştir. Ev tipi su arıtma cihazlarının öncesinde musluk suyundan alınan örneklerin hiçbirinde toplam koliform bakteri üremesi görülmemiştir. Arıtılmış sudan alınan bir örnekte ise 9 kob/100 mL toplam koliform bakteri üremesi gözlemlenmiştir (%2,5). Serbest klor, pH, iletkenlik, florür, kalsiyum, magnezyum ve toplam sertlik analizleri şebeke suyuna kıyasla arıtılmış suda önemli ölçüde düşük olduğu tespit edilmiş; nitrit analizinde ise önemli bir farklılık gözlenmemiştir. Su örneklerinin hiç birisinde amonyum belirlenmemiştir.

Sonuç: Ev tipi su arıtma cihazlarının hem hijyenik açıdan hem de sağlık için faydalı olan florür, kalsiyum, magnezyum mineralleri ile suyun toplam sertliğini önemli ölçüde azaltmasından dolayı sağlıklı ve kaliteli bir içme suyu tercihi olarak bulunmamıştır. Düzenli bakım yapılmasına rağmen iyi hijyen sağlanamadığı durumlarda ev tipi su arıtma cihazları mikrobiyolojik açıdan halk sağlığı sorunu ortaya çıkmasına sebep olabilirler.

Anahtar Kelimeler: Su arıtma, içme suyu kalitesi, tüketici tercihi

INTRODUCTION

Water is essential for survival. Every person should be able to access sufficient and safe water resources (1). Access to water and sanitation are indispensable factors for maximizing health status (2). Water requirement may change by age, gender, body weight or physical activity level. European Food Safety Authority (EFSA) has set the daily water consumption requirement as two litres for women and two and a half litres for men (3, 4).

In terms of health, cleanliness of water is also as important as its quantity. Clean and healthy water is the kind that not harbouring disease-causing microorganisms and toxic chemicals as well as including required minerals in balanced ratios. Basic factors for determining water quality are ambient temperature, amount of dissolved oxygen, pH, mineral ingredients and organic/inorganic contaminants (5).

All over the world many activities are being undertaken for ensuring access to healthy and high quality drinking water. Although investments on municipal water systems have been increased,

problems faced during providing municipal water services create worries about cleanliness and safety of municipal water. Negative news about municipal water as well as advertisements about packaged water and water purifiers reinforce negative perceptions (6). In places where municipal water distribution system or municipal water quality is thought to be insufficient, a great majority of the households consume packaged water. For the same reasons, number of families that own water purifiers increase with every passing day (7-9).

Household type water purifiers have many types that use different methods such as mechanical filtration systems, softeners, anionic exchangers, ultraviolet disinfectors, reverse osmosis systems, ozonisers, chlorinators etc. It should not be forgotten about all these systems that no one treatment system can pose a solution for all water quality problems, and all systems has their own limitations and system lifecycles as well as a need for regular maintenance and monitoring. Water treatment systems should be chosen for the characteristics of the water that would be treated (10).

In conducted studies, it is suggested that household type water purifiers cause coliform growth and are also decreasing water hardness and mineral levels such as calcium, magnesium or fluoride (11, 12). Therefore, monitoring of drinking water quality from source to point-of-use is essential to ensure compliance with quality standards and to protect public health (13).

In this study, it is aimed to determine usage frequency of household type water purifiers in Meram and their effects on microbiological and chemical quality of water.

MATERIAL and METHOD

This cross-sectional study was conducted in Meram district of Konya province between the dates of 01st April - 01st June 2016. As the usage prevalence of household type water purifiers in Meram district was not known, it was assumed as 50% with G-Power 3.1.9.2 software; sample size was calculated as 810 houses with 95% confidence interval (α=0.05), 7% deviation, 80% power and pattern effect as 2 (14). 115 neighbourhoods in Meram was assumed as a cluster and 27 neighbourhoods selected into the cluster with simple random sampling. From each neighbourhood that selected into the cluster, 30 houses were added into the sample and therefore it reached to the total of 810 houses, with simple random sampling method, using the Municipal Information System of Konya Metropolitan Municipality. Households in the next door number have been included in the sampling when they refuse to participate in the study and are not available in the address. Using face-to-face interview method, a poll which had been prepared by the researchers, was conducted to every participant that gave verbal consent to partake in the study. No samples can be taken from a total of 28 household type water purifiers: 15 owners did not give permission for taking samples, nine owners could not be reached out at home, three owners have removed the devices and one owner was moved out. All 39 devices had reverse osmosis systems. Two separate samples from each of 39 houses were taken, one from tap water prior to go through purifier and one from water treated in the purifier. In sample-taking process, firstly taps were wiped with alcohol swabs, then water was moderately flushed for 2-3 minutes, then taps were closed and scorched with fire, then water was moderately flushed again for 2-3 minutes and finally the samples were taken into sample container. Water samples were taken into 500 mL sterilized sample containers for microbiological analysis and into 500 mL sample container for chemical analysis. Water samples were delivered through cold chain to Konya Public Health Laboratory for microbiological analysis and microbiological analysis was performed by membrane filtration. Chemically, analyses for pH, conductivity, free chlorine, ammonium, nitrite, fluoride, calcium, magnesium and total water hardness were conducted with Hach Lange DR 3900 UV spectrophotometer and

Hach Lange HQ40D pH-conductivity device in Public Health Department of Meram Medical Faculty. Free chlorine analyses were made with Hach Lange DR 3900 UV spectrophotometer at houses right after the samples were taken. Measurement range of chemical parameters: ammonium 0.015-2.0 mg/L, nitrite 0.002-0.300 mg/L, fluoride 0.1-2.5 mg/L, water hardness 1.78-35.6 °f, magnesium 3.0-50.0 mg/L, calcium 5.0-100.0 mg/L, free chlorine 0.02-2.0 mg/L, pH 2-14, conductivity 0.01 $\mu S/cm^{-1}$ - 200 mS/cm^{-1}. Values below measurement range in the spectrophotometer are assumed to be zero. Computerized data analyses were made with SPSS 24.0 packaged software. The descriptive data are given in median, interquartile range, number, percentage. The normality analyses of the data were tested with graphical and Shapiro-Wilk method. Wilcoxon signed rank test was used because the data were not normally distributed. The Chi-square test was used to compare proportions in different groups. For statistical significance, $p<0.05$ value was assumed. For the study to be conducted, a project was submitted to Necmettin Erbakan University Meram Medical Faculty Ethical Board for Non-Medicinal Researches and Researches without Medical Devices and an approval was obtained (Date: 18.12.2015 Number: 2015/384). The research funding was provided by Necmettin Erbakan University Scientific Research Projects Coordination Unit (Project No: 161518004).

RESULTS

It found that water purifiers are being used in 67 out of 810 households (8.3%) that were interviewed. Out of 67 participants who prefer household type water treatment, it is found that 39 (58.2%) think of tap water as dirty, 30 (44.8%) do not enjoy the taste of municipal water, 17 (25.4%) think of tap water as calcareous. 367 of the participants (45.3%) were found to have an income below 2000 TL. When compared income level with purifier usage, water treatment usage ratio was found to be significantly higher in participants with an income 2000 TL and over (13.1%), than participants with an income below 2000 TL (2.5%) (p=0.001).

Usage period median for household type water purifiers is found to be 48 months (36-84 months). 14 of the participants who use household type water purifiers (21.9%) have been using those devices between 0-24 months, 28 of them (43.7%) have been using those devices between 25-50 months, 22 of them (34.6%) have been using those devices for 61 or more months. 59 of the participants who use household type water purifiers (90.8%) stated that they carry out maintenance for their devices; 32 of whom (49.2%) for every six months and 24 of whom (36.9%) for every year. Last maintenance for household type water purifiers was determined to be done 6 months ago (2-10 months). None of the samples taken from tap water before household type water purifiers were shown total coliform bacteria (0 kob/100 mL) growth. In one sample taken from treated water thorough purifiers, total coliform bacteria (9 kob/100 mL) growth was observed (2.5%). Total coliform bacteria growth was observed in a device that was told to be maintained.

In analyses of free chlorine, pH, conductivity, fluoride, calcium, magnesium and total hardness, all parameters were confirmed to be significantly lower in treated water compared to municipal water, while in analysis of nitrite no significant difference was observed (Table 1). Also, ammonium in samples was not detected.

DISCUSSION

Water is one of the essential elements for vital activities to be realized in every period of human life. In this respect, existence and quality of water in habitats is extremely important. Water is needed to be distributed sufficiently, cleanly, healthily and safely with water supply systems (15). In some studies, it was carried out in several provinces in Turkey, usage ratios were found to be varied between 31.7-44.9%

Tablo 1. Comparison of physical and chemical analyses between treated water samples from household type purifiers and tap water samples - Meram/Konya, 2016

	Tap Water Median (25.-75. per)	Treated Water Median (25.-75. per)	p Value
pH	7.71 (7.49 - 7.85)	6.59 (6.37 - 6.87)	0.001
Conductivity (µS/cm^{-1})	436.00 (405.00 - 671.00)	52.40 (38.00 - 67.00)	0.001
Free Chlorine (mg/L)	0.58 (0.43 - 0.69)	0.02 (0.01 - 0.03)	0.001
Fluoride (mg/L)	0.157 (0.00 - 0.321)	0.00 (0.00 - 0.00)	0.001
Calcium (mg/L)	53.00 (42.60 - 71.40)	1.20 (0.00 - 3.75)	0.001
Magnesium (mg/L)	27.1 (22.30 - 47.40)	6.59 (3.02 - 10.70)	0.001
Total Hardness (°f)*	24.03 (20.64 - 38.98)	2.79 (1.79 - 4.71)	0.001
Nitrite (mg/L)	0.003 (0.002 - 0.003)	0.002 (0.000 - 0.003)	0.068

*Total hardness degree (°f): Calculated in French hardness degree

for tap water, between 13-54% for packaged water, between 6.3-25% for household type water purifiers, between 2.0-27.1% for spring water (6, 9, 15-17). In a study conducted in Iran, it is found that 12.8% of people prefer to use household type water purifiers (18). In this study, prevalence of household type water purifiers was 8.3%.

Many studies were conducted on factors that affect preferences about drinking water consumption. In these studies, many factors were found to affect drinking water preferences of individuals, such as personal ideas on health, habits, residential situation, socio-demographical factors (age, gender, income level, educational level etc.), quality parameters about tap water (taste, odour, mineral levels, pollution etc.), accessibility of drinking water sources and advertisements about packaged water and water treatments devices (7, 19-24). In a study carried out in Iran, participants who use household type water purifiers stated that they prefer to use these devices because of good taste, easy access, affordability and fewer side effects on health (18). In our study, it was determined that consumer had preferred household type water purifiers because of disliking the taste of municipal water and finding it to be polluted and/or calcareous. Effects of water-borne contaminants on human health can vary from gastroenteritis to serious diseases such as lethal diarrhoea, dysentery, hepatitis and typhoid fever (1). When it comes to studies on microbiological quality of treated water through household type water purifiers, in a study conducted in Ankara, microbiological samples were taken from 16 devices and coliform bacteria growth was identified in 62.5% of them (12). In a study conducted in Germany, in 24 out of 34 purifiers (70.5%) bacteria growth was observed (25). As for this study, in 1 out of 39 purifiers (2.5%) total coliform growth was observed, although its maintenance had been done timely. No growth was observed in samples taken from municipal water. Although less coliform

growth was observed in samples taken from devices compared with similar studies, even this constitutes an important hygiene and public health problem. Also the fact that less devices has shown total coliform growth in this study can be attributed to maintenance of most of the devices being done in a timely manner.

In terms of pH, nearly all purifiers were observed to decrease pH of tap water that they were connected with and pH values of one-third of the samples were even below 6.5. The pH value is suggested as 6.5-9.5 in legislation on water for human consumption (26). World Health Organization that there is no direct correlation between pH value of drinking water and human health. But it also points out that pH values affect disinfection efficiency, and low pH increases metal corrosion; therefore, pH values indirectly affect human health (27). On grounds of pH values of tap waters being observed as normal, local administrations who have the duty of providing healthy drinking water should occasionally utter the need of preferring municipal water for healthy life.

Free chlorine amount in tap water samples used in this study was 0.58 mg/L, while free chlorine amount in samples taken from treated water was 0.02 mg/L. Arranging proper chlorine level and chlorination would decrease the discomfort about taste and odour. Low level of chlorine in treated water can also lead to negative results in cases of potential device-based microbiological contamination. Failing to carry out maintenance of purifiers in a timely manner would increase the risk of microbiological contamination and as a result low level of free chlorine would cause a public health problem.

Fluoride amount in foods is low; therefore, its main source is water. Preferred fluoride value in drinking water is around 0.5-1.0 mg/L. Fluoride level below 0.5 mg/L leads to easier teeth decay, while fluoride level above 1.5 mg/L may cause teeth stains called fluorosis (28). In many studies conducted in Turkey on determining fluoride levels, fluoride concentrations found to be lower than 1.0 mg/L (29), while in a study carried out in Isparta fluoride value was 1.66 mg/L (28). In a study carried out in Konya, samples were taken from 50 different locations and 92% of the samples were found to have fluoride amounts around 0.15-0.30 mg/L (29). In a study made in Iran, it was shown that household type water purifiers completely filter fluoride in municipal water (11). Similarly, in this study, fluoride amount in samples taken from municipal water was found to be lower than preferred fluoride level with 0.157 mg/L, while the purifiers found to be completely filtering the fluoride in municipal water. As a result, usage of purifiers is thought to create risks on dental health.

Water hardness is a term for defining the number of ions and the amount of sulphate and carbonate salts of especially calcium and magnesium in water. Hard water contains minerals that needed to be taken daily, especially calcium and magnesium (30). Calcium and magnesium ions that abound in water can easily be absorbed in stomach and intestinal system (28). Magnesium taken from water can be more rapidly absorbed than food-based magnesium (31). It is stated that 700-1000 mg of calcium and 300-400 mg of magnesium is needed to be taken daily (32). There are many studies that state hard water is preventive against deaths from diseases like colon, rectum, pancreas, liver, breast and ovary cancer, as well as cerebrovascular and cardiovascular diseases (30, 32). In the water samples taken from different locations as a part of the study conducted in Isparta, Ca+2 levels varied between 51.24-92.15 mg/L, Mg+2 levels varied between 4.25-28.24 mg/L and total hardness values varied between 16.2-34.2 °f (28). In our study, calcium amount was 53.00 mg/L and magnesium amount was 27.10 mg/L in municipal water; while in the samples taken from household type water purifiers, calcium amount was 1.20 mg/L and magnesium amount was 6.59 mg/L. Water hardness was 24.03 °f in municipal water and 2.79 °f in samples taken from household type water purifiers. In a study carried out in Iran, it was also shown that these devices decrease amounts of calcium

and magnesium in municipal water (11). Water hardness is an aesthetic parameter about palatal delight. Obviating the hardness of water provided by municipalities through purifiers in households and preference of packaged soft water as drinking water in societies that are accustomed to the taste of soft water, means to be deprived of the benefits of hard water, in terms of public health (30).

To conclude, household type water purifiers were found not to be a healthy and high quality preference for drinking water, as a result of both hygienic risks and the fact that they significantly decrease water hardness and amounts of salubrious minerals like fluoride, calcium and magnesium in municipal water. Despite regular maintenance when good hygiene cannot be provided they may cause the problem of public health in microbiological terms. The limitation of our research is only questioning the income situation as a socio-economic variable.

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