DOI: https://doi.org/10.21323/2618-9771-2024-7-1-137-143

Received 13.09.2023
Accepted in revised 23.03.2024
Accepted for publication 26.03.2024

Available online at https://www.fsjour.com/jour
Original scientific article
Open access

CHEMICAL AND MICROBIOLOGICAL ASSESSMENT OF HOUSE-FILTERED WATER PRODUCED BY HOUSEHOLD WATER FILTRATION SYSTEMS

Abdalla S. M. Ammar [1,3,]* Mohamed G. El-Zeiny[2,3], Ahmad I. Al-Turki[3]

[1] Faculty of Agriculture, Cairo University, Giza, Egypt
[2] Faculty of Agriculture, Alexandria University, Alexandria, Egypt
[3] College of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia

KEY WORDS:
House-water filters, filtered water, chemical and microbiological quality, water safety

ABSTRACT

Chemical characteristics and microbiological quality of filtered water generated from municipal water using mono-, di- and penta-stage (5-stage) filters, as well as disposed drain water were investigated. With the application of the household water penta filters, the total dissolved solids (TDS) of the filtered water were highly reduced (0.04–0.07 g/L) and, consequently, electrical conductivity also decreased. Furthermore, total hardness was completely removed (0–2 mg $CaCO_3$/L), as well as the chloride content. In the same manner, the nitrate content in the filtered water resulted from the household water penta filters decreased significantly (0.5–0.9 mg/L). Cations, such as Na^+ and K^+, in the filtered water were greatly affected and were 18–28 and 2 mg/L, respectively. Filtered water generated from the house-water penta filters was not in compliance with the daily amounts of F, Na and K necessary for teenagers and kids, and it might cause a risk of deficiencies. From the microbiological point of view, the penta-stage filter effectively removed total bacterial counts and total coliforms from water making it completely safe for potable and other domestic uses. The home water mono- and di- filters had low effectiveness of contaminant removal.

FUNDING: This study has been financially supported by Deanship of Scientific Research, Al-Qassim University, Al-Qassim, Saudi Arabia under grant No. SR-D-009-023

ACKNOWLEDGEMENTS: The authors thank Deanship of Scientific Research, Al-Qassim University, Al-Qassim, Saudi Arabia, for financial support.

Поступила 13.09.2023
Поступила после рецензирования 23.03.2024
Принята в печать 26.03.2024

https://www.fsjour.com/jour
Научная статья
Open access

ХИМИЧЕСКАЯ И МИКРОБИОЛОГИЧЕСКАЯ ОЦЕНКА ФИЛЬТРОВАННОЙ ВОДЫ, ПОЛУЧЕННОЙ С ПОМОЩЬЮ ДОМАШНИХ СИСТЕМ ФИЛЬТРАЦИИ ВОДЫ

Аммар А. С. М.[1,3]*, Эль-Зини М. Г.[2,3], Аль-Турки А. И.[3]

[1] Сельскохозяйственный факультет, Каирский Университет, Гиза, Египет
[2] Сельскохозяйственный факультет, Александрийский университет, Александрия, Египет
[3] Колледж сельского хозяйства и ветеринарной медицины, Университет Кассим, Саудовская Аравия

КЛЮЧЕВЫЕ СЛОВА:
домашние фильтры воды, фильтрованная вода, химическое и микробиологическое качество, безвредность воды

АННОТАЦИЯ

Поведено исследование химических характеристик и микробиологических показателей фильтрованной воды, полученной из муниципальной воды с использованием одно-, двух- и пяти-стадийных фильтров, а также удаляемой сточной воды. При применении домашних пяти-стадийных фильтров, общее количество растворённых в воде веществ (TDS) в фильтрованной воде было существенно снижено (0,04–0,07 г/л) и, следовательно, также была снижена электропроводность. Кроме того, общая жесткость была полностью удалена (0–2 мг $CaCO_3$/л), также как и содержание хлоридов. Аналогичным образом, содержание нитратов в фильтрованной воде, полученной от домашних пяти-стадийных фильтров воды, значительно уменьшилось (0,5–0,9 мг/л). Большое влияние было оказано на катионы в фильтрованной воде, такие как Na^+ и K^+, которые были на уровне 18–28 и 2 мг/л, соответственно. Фильтрованная вода, полученная от домашних пяти-стадийных фильтров воды, не соответствовала суточным количествам F, Na и K, необходимым подросткам и детям, что может представлять риск дефицита. С микробиологической точки зрения домашние пяти-стадийные фильтры воды эффективно удаляли общие количества бактерий и общие колиформы из воды, что делало её полностью безопасной для питья и другого домашнего использования. Домашние одно- и двухстадийные фильтры воды имели низкую эффективность удаления контаминантов.

ФИНАНСИРОВАНИЕ: Данное исследование было финансово поддержано деканатом научных исследований, Университет Кассим, Эль-Касим, Саудовская Аравия, грант No. SR-D-009-023.

БЛАГОДАРНОСТИ: Авторы выражают благодарность деканату научных исследований, Университет Кассим, Эль-Касим, Саудовская Аравия, за финансовую поддержку.

1. Introduction

Water, the source of life, is one of the main fuels for economic and social development. Water is subject to different pollution sources, i. e., domestic, industrial and agricultural wastes, and becomes contaminated with pollutants beyond safe limits for use by humans. The point-of-use (POU) and point-of-entry (POE) filtration systems are commonly used to remove or at least reduce the contaminants to safe levels. US-EPA [1] defined POU as a filtration system connected to one tap or more taps to treat water for human purposes (drinking and cooking), while POE are devices fixed to the main water line to treat all water for a single house,

FOR CITATION: **Ammar, A. S. M., El-Zeiny, M. G., Al-Turki, A. I.,** (2024). Chemical and microbiological assessment of house-filtered water produced by household water filtration systems. *Food Systems,* 7(1), 137–143. https://doi.org/10.21323/2618-9771-2024-7-1-137-143

ДЛЯ ЦИТИРОВАНИЯ: **Аммар, А. С. М., Эль-Зини, М. Г., Аль-Турки, А. И.** (2024). Химическая и микробиологическая оценка фильтрованной воды, полученной с помощью домашних систем фильтрации воды. *Пищевые системы*, 7(1), 137–143. https://doi.org/10.21323/2618-9771-2024-7-1-137-143

hospital, restaurant and commercial building. Therefore, POU drinking water treatment is rising quickly due to the high risk of exposure to various contaminants in drinking water [2]. Household water filtration systems have recently been used in many houses to enhance the potable water quality [3]. Home water filters have become a new market that has been discovered by manufacturers to improve drinking water quality and remove contaminants from water [4]. Asia is expected to be the largest market for POU devices in the coming decades, followed by the United States and Canada, then by Europe [5]. The performance of POU activated carbon block filters in removing Pb contents was tested by Bosscher et al. [6]. They found that activated carbon filters were very effective in removing soluble Pb from tap water. It is reported that home water purification systems significantly decreased the fluoride concentration in purified water, which became as low as zero in some cases [7].

The main physicochemical characteristics affecting contaminant removal from water using filtration systems can be summarized as follows [8,9,10]: pore size, presence of surface charges (molecular charges and/or membrane charges), particle size and surface area, adsorption affinity, differences in concentrations (ionic strength), pressure, water temperature, water pH and osmotic pressure.

Household filtration systems have proved to separate a lot of pollutants [11]. Due to its ability to absorb a variety of contaminants found in water, activated carbon is a material that is frequently used in water filtration systems [12,13]. Activated carbon is a multifunctional porous adsorbent material (hydrophobic and lipophilic) and has a large surface area and adsorption affinity where contaminants are attracted and attached to the particle surface by Van der Waals forces and /or chemical adsorption. There are two types of activated carbon: granulated activated carbon and block activated carbon. Block carbon has smaller particles and smaller pore size than granular activated carbon [10]. The mean particle size of the commercial powdered activated carbon adsorbent ranges between 1 and 150 µm and surface area ranges from 736 to 2869 m^2/g. Although trace organic and inorganic pollutants are adsorbed to the pores and surfaces of the activated carbon [9], limited numbers of contaminants will be eliminated. A reverse osmosis (RO) filter contains the semipermeable membrane between two phases. Ions and biomolecules can be separated from water through the semipermeable membrane using higher external pressure than the osmotic pressure; water is forced to move against the osmosis phenomenon [10].

The general public is aware of the fact that drinking water safety and quality remain to be a major public health concern [14]. Thus, household water filtration systems are commonly used in rural and urban regions in Saudi Arabia for ensuring water safety and quality. Although there are local and international organizations (i. e. NSF International) that develop public health standards for products, filters have no strict scientific evidence for continuous use, effectiveness, positive health effects, and negative impacts. Also, all cations and anions, regardless of whether they are beneficial or harmful, are removed from water treatment devices due to the absence of a selective removal system [15]. Research on how domestic house water filters affect the quality of water is currently lacking. Therefore, the objectives of this study were to determine the physical (i. e., total dissolved solids, electrical conductivity), chemical (i. e., total hardness, chlorides, anions, cations) and microbiological (i. e., total count, total coliforms, fecal coliforms, mold and yeast) properties of filtered water obtained from house water filters (mono-, di- and penta-filter systems) as well as chemical and physical properties of drain water.

2. Materials and methods

2.1. Plan of the study

A model of a water purification system was designed at a pilot scale to resemble a household system. Domestic household water purification systems included mono (1 stage), di (2 stages) and penta (5 stages) filters with the inlet connected to city tap water and the outlet connected to 500-liter capacity polypropylene tanks. Filters and tanks were purchased from Buraidah, KSA local markets (Figure 1 and Figure 2).

2.2. Filter specifications

House water filters used in this study included:

a – Mono-filter containing one stage of high efficiency polypropylene (pp) filter. A polypropylene filter is capable of filtering down to five microns (i. e. silt, scales, sediments, coarse and fine sands),

b – Di-filter comprising of two-stages: the pp sediment filter and the second-stage carbon block filter (reduces cloudiness, volatile organic carbons, Cl_2, organics, off-odors and unusual tastes) and

c – Penta-filtration system (5-stage filter) containing three pre-filters (pp, carbon block and granular activated carbon filters) to remove large contaminants and protect reverse osmosis (RO) membrane, the RO-filter to remove contaminants, metals and salts, and in the last stage, there is the fine granular activated carbon (GAC) filter to provide final polishing to the purified water.

All solvents and chemicals used in analysis were of analytical grade and purchased from Sigma-Aldrich (Missouri, USA). Microbiological media (SPC, VRB-MUG and PDA) were bought from Biolife (Milan, Italy).

2.3. Sampling

Water samples were collected according to the WHO recommendations and the Standard Methods for the Examination of Water and Wastewater as reported by APHA, AWWA and WPCF [16]. Filtered water samples were collected in sterile two-liter glass bottles. All sample bottles were kept refrigerated (4 °C) during transport to the lab inside an insulated ice box. Microbiological samples were withdrawn under sterilized conditions and the rest of the samples were kept for physical and chemical analyses. Microbiological analyses were done at the same day of sampling, while chemical analyses were performed within 24 h of sampling.

To simulate the practical uses in a household, samples were withdrawn from water purification filters (mono, di and penta) immediately after filtration (A-F) in a quantity of 100, 200, 300, 400 and 500 liters in sterile bottles and kept under refrigeration (4 °C) until microbiological analysis within 24 hrs. Control samples were withdrawn directly from tap water without filtration. Duplicated samples were withdrawn as mentioned previously and refrigerated (4 °C/24 h) for chemical analyses. Samples were taken from the drain line of the penta-filter (this line runs from the outlet end of the RO membrane to the drain and is used to discharge contaminants and impurities found in the incoming water source).

Figure 1. **House water mono, di and penta filters used in the experiments**
Рисунок 1. **Домашние одно-, двух- и пяти-стадийные фильтры для воды, использованные в экспериментах**

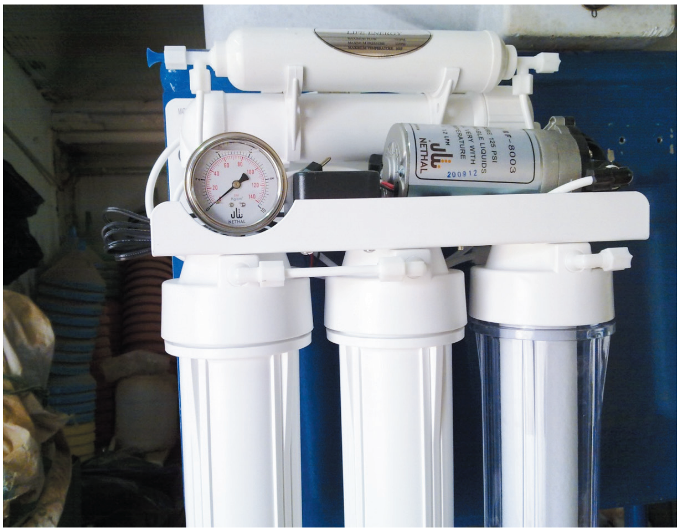


Figure 2. **House water penta filter used in the experiments**
Рисунок 2. **Домашний пяти-стадийный фильтр, использованный в экспериментах**

2.4. Analysis

Chemical tests were carried out according to the Standard Methods for the Examination of Water and Wastewater [16] as follows:

- Total dissolved solids (TDS) and electrical conductivity (EC) were determined using a conductivity/TDS meter (TDS meter, Model 76, Engineered systems and Designs, USA).
- Total hardness (Ca + Mg) was determined using titration with ethylene diamine tetra acetic acid disodium (Na_2 EDTA) in the presence of eriochrome black T as an indicator.
- Chloride determination was done by titration with 0.0141 N silver nitrate in the presence of potassium chromate as an indicator.
- Nitrates were determined by a spectrophotometer (Jenway, USA) using NED dihydrochloride N-(1–naphthyl)-ethylenediamine dihydrochloride.
- Fluorides were determined colorimetrically by using the SPADNS method (4,5 dihydroxy-3-(p-sulfophenylazo)-2,7-naphthalenedisulfonic acid trisodium salt).
- Sodium and potassium were determined using an atomic absorption spectrophotometer (AAS) (Shimadzu 6800, Japan). Required standards of Na and K were prepared daily by appropriate dilution of the stock solution.

Microbiological analyses included total bacterial counts (filtration method, ISO 6222:1999) [17] using the Aerobic Standard Plate Count Agar medium and incubation at 37 ± 1 °C for 24h. The membrane filtration method was used to determine the total coliform group using the VRB-MUG medium (incubation at 37 ± 1 °C for 24h) and fecal coliform according to ISO 9308–1 [18] using the VRB-MUG medium (incubation at 44 ± 1 °C for 24h), and yeast and mold counts [19] using the Potato Dextrose Agar medium and incubation at 25 ± 1 °C for 72 h.

2.5. Statistical analyses

Data were statistically analyzed using one-way analysis of variance, ANOVA [20].

3. Results and discussion

In the present study, physical, chemical and microbiological characteristics of the filtered water resulted from the household water filters (either mono, di or penta filters) were determined to evaluate its suitability for potable and industrial uses. Fresh filtered water should not contain health hazards, such as pathogens, toxic chemicals and carcinogenic compounds, during its direct consumption as drinking water or as industrial use.

3.1. Physical properties of the filtered water

Physical characteristics of the filtered water, i. e. total dissolved solids (TDS) and electrical conductivity (EC), were determined as presented in Figure 3 and Figure 4.

The results shown in Figure 3 indicate that physical characteristics of the filtered water varied according to the house water filter type used to produce the filtered water. The TDS values of raw water samples (control) ranged between 1.42 and 1.49 g/L. The TDS of the filtered water slightly decreased due to treatment processes via house water mono and di filters. The TDS values of the filtered water resulted from the house water mono filters ranged from 1.27 to 1.49 g/L. Likewise the TDS values of the filtered water obtained from the house water di filters were between 1.30 and 1.48 g/L. Using the house water penta filters highly reduced TDS of the filtered water. The TDS levels ranged between 0.04 and 0.07 g/L. Thus, using the house water penta filter had a significant ($P \leqslant 0.05$) positive effect on TDS values in the filtered water. Recently, Khanal et al. [21] reported that only RO-UV led to a significant reduction of TDS levels resulting in the average and maximum removal rates of 73.8 and 97.8%, respectively. The obtained TDS values of the filtered water were within the allowed limits (1000 mg/L) required by the Egyptian Standards [22].

The results presented in Figure 4 show the electrical conductivity values of the filtered water. The EC values of the filtered water resulted from the house water mono or di filters were slightly affected (812.8–972.2 mmhos/cm) compared to the control water samples (908.8–953.6 mmhos/cm). On the other hand, the EC values highly decreased in the filtered water obtained from the house water penta filters (25.6–44.8 mmhos/cm). EC is a measure of the anions and cations present in water samples, the conductivity increases with an increase in the ion content [23]. EC values significantly ($P \leqslant 0.05$) and highly decreased in the filtered water obtained from the house water penta filters. The EC values are in agreement with those found by Al-Oud et al. [24] and Królak et al. [3].

3.2. Chemical characteristics of the filtered water

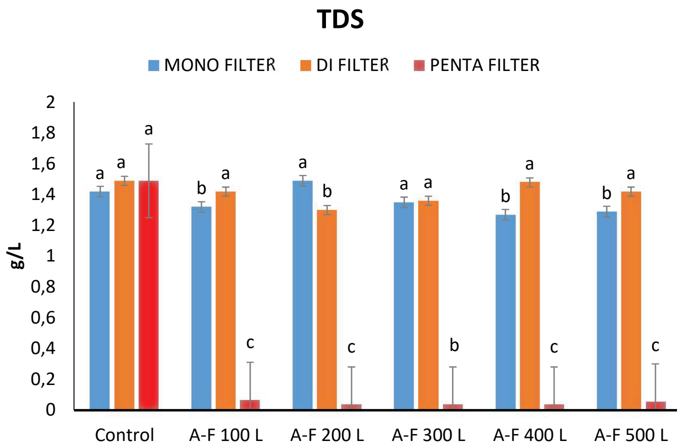
Chemical characteristics of the filtered water i. e., total hardness, nitrates, chlorides, cations, and anions were determined.

3.2.1. Effect of the home water filters on total hardness (TH) and total chlorides

The results presented in Figure 5 show water hardness values in the filtered water obtained from the house water filters. Total hardness of the filtered water was slightly affected by using the house water mono or di filters (213–233 mg $CaCO_3$/L) compared to the water control samples (233 mg $CaCO_3$/L). Total hardness was completely removed in the filtered water resulted from the house water penta filters (0–2 mg $CaCO_3$/L). The sources of TH in water are dissolved ions from rocks, seepage, and runoff from soils [23]. It is of interest to report that there were significant differences ($p \leqslant 0.05$) between TH values in the filtered water resulted from the penta filters and mono and di filters. These results are in agreement with those obtained by Jaafari-Ashkavandi and Kheirmand [25] and Królak et al. [3]. Generally, TH of the filtered water withdrawn from different types of the house water filters was within the permissible limits (500 mg/l) required by Egyptian Standards [22].

It can be noticed from the results in Figure 6 that the chloride content of the filtered water obtained from the house water mono or di filters ranged from 186.9 to 207.4 mg/L. The chloride content of the filtered water resulted from the house water penta filters was completely removed. Using the house water penta filter had a significant ($P \leqslant 0.05$) positive effect on the chloride content in the filtered water (Figure 6). These results are in agreement with those reported by Królak et al. [3].

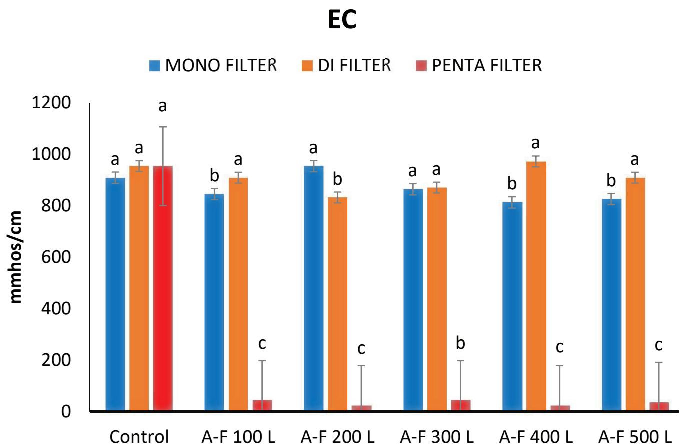
The obtained chloride content of the filtered water was found to be within the permissible limits (250 mg/L) required by Egyptian Standards [22].



Different letters indicate significant differences ($P \leqslant 0.05$).
A-F = After Filtration.

Figure 3. **Effect of the home water filters on TDS (g/L) in the filtered water**

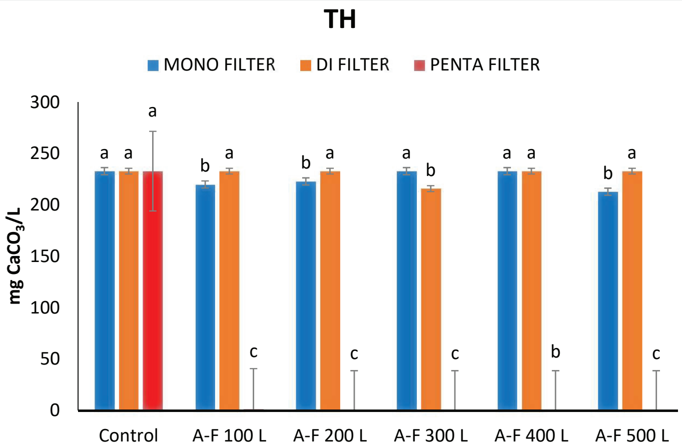
Рисунок 3. **Влияние домашних фильтров для воды на TDS (г/л) в фильтрованной воде**



Different letters indicate significant differences ($P \leqslant 0.05$).
A-F = After Filtration.

Figure 4. **Effect of the home water filters on EC (mmhos/cm) in the filtered water**

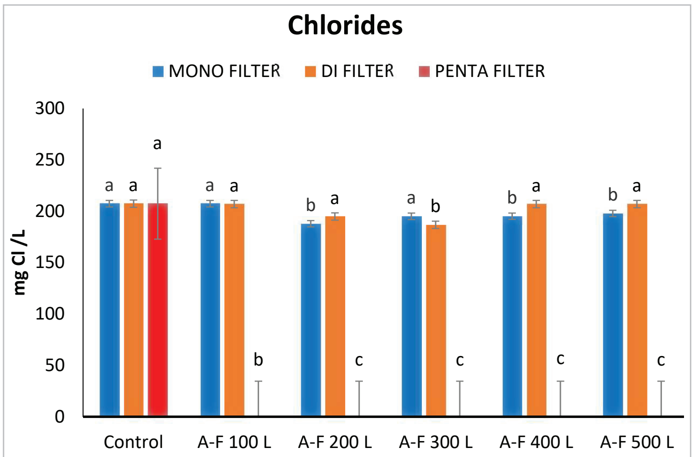
Рисунок 4. **Влияние домашних фильтров для воды на электропроводность (мкО/см) в фильтрованной воде**



Different letters indicate significant differences (P ⩽ 0.05).
A-F = After Filtration.

Figure 5. **Effect of the home water filters on total hardness (mg $CaCO_3$/L) in the filtered water**

Рисунок 5. **Влияние домашних фильтров для воды на общую жесткость (мг $CaCO_3$/л) в фильтрованной воде**



Different letters indicate significant differences (P ⩽ 0.05).
A-F = After Filtration.

Figure 6. **Effect of the home water filters on the total chloride content (mg Cl/L) in the filtered water**

Рисунок 6. **Влияние домашних фильтров для воды на содержание общих хлоридов (мг Cl/л) в фильтрованной воде**

3.2.2. Effect of the home water filters on anions and cations

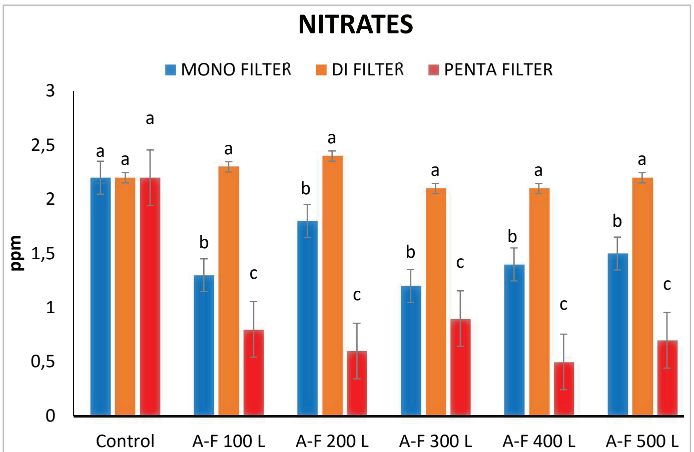
It can be noticed from Figure 7 that the nitrate content of the filtered water resulted from the house water mono filter ranged from 1.20 to 1.80 mg/L. The nitrate content slightly decreased in the filtered water after using the house water mono filter compared to the control samples. Also, the house water di filter did not affect the nitrate content of the produced water (Figure 7). The nitrate content of the filtered water resulted from the house water penta filters (Figure 7) was significantly (P ⩽ 0.05) and highly reduced (0.5–0.9 mg/L) compared to the control water samples (2.2 mg/L). Reverse osmosis is a physicochemical process that is highly practical for removing nitrate [15]. These results are in agreement with those reported by Królak et al. [3]. JECFA [26] and Commission Regulation [27] established the Acceptable Daily Intake of NO_3 ranged from 0 to 3.7 mg/kg body weight. The recorded values of nitrates were within the allowed and recommended levels according to Egyptian standards (45 mg/L) [22] and WHO guidelines (50 mg/L) [28] indicating relevant safety of such water as reported by Al-Redhaiman and Abdel Magid [29].

The fluoride content in the filtered water obtained from the house water filters is shown in Figure 8. The fluoride content in the filtered water obtained from the house water mono filters was found to be similar to its level in the control water samples (0.18 and 0.23 mg/L). Likewise, the house water di filters did not affect the fluoride content in the filtered water (0.21–0.25 mg/L). On the contrary, the fluoride content in the filtered water produced using the house water penta filters was highly affected (0.04–0.08 mg/L) compared to the control water samples (0.23 mg/L). Using the house water penta filter had a significant (P ⩽ 0.05) negative effect on the fluoride content in the filtered water. Also, Jaafari-Ashkavandi and Kheirmand [25] and Eftekhar et al. [7] reported that the filtration of water using home water purification systems significantly decreased its fluoride content. These recorded results are lower than those required by Egyptian Standards (0.8 mg/L) [22] and the WHO guidelines (1.5 mg/L) [28] for drinking water.

Generally, water contains different types of cations, i. e. Ca, Mg, Na and K, in varying amounts [30]. Among the salts that are crucial to the flavor of water are sodium and potassium [15]. The results in Figures 9 and 10 show the content of cations Na^+ and K^+, respectively, in the filtered water as affected by using the household water filters. It can be concluded that using the house water mono or di filters led to the slightly decreased cation contents. On the contrary, cations, i. e. the Na^+ and K^+ contents, in the filtered water were greatly affected by using the house water penta filter. The Na^+ and K^+ contents were 18–28 and 2 mg/L, respectively, in the filtered water generated from the house water penta filter. Thus, using the house water penta filter had a significant (P ⩽ 0.05) negative effect on the Na^+ and K^+ contents in the filtered water. The obtained Na values of the filtered water were within the allowed limits required by the Egyptian Standards (200 mg/L) [22] and the WHO guidelines (50 mg/L) [28] for drinking water.

3.2.3. Physical and chemical characteristics of drain water resulted from the home water penta filters

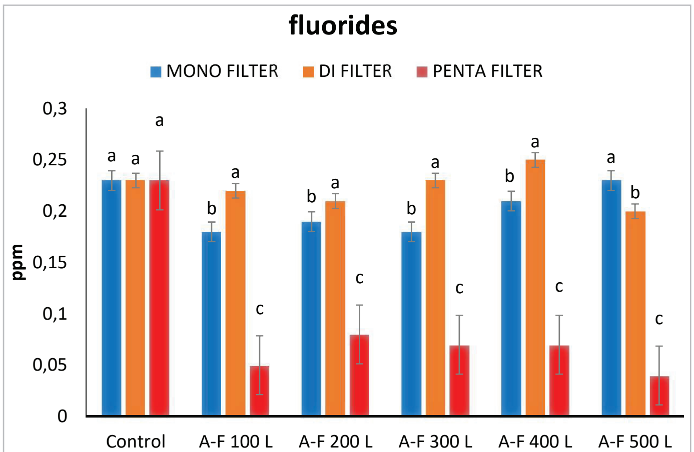
Drain water runs from the outlet end of the RO membrane hosing to the sewer system. It contains salts, contaminants and impurities found in the incoming water source. Drain water resulted from the house water penta filters was physically and chemically evaluated (Table 1). Drain wa-



Different letters indicate significant differences (P ⩽ 0.05).
A-F = After Filtration.

Figure 7. **Effect of the home water filters on the nitrate content (ppm) in the filtered water**

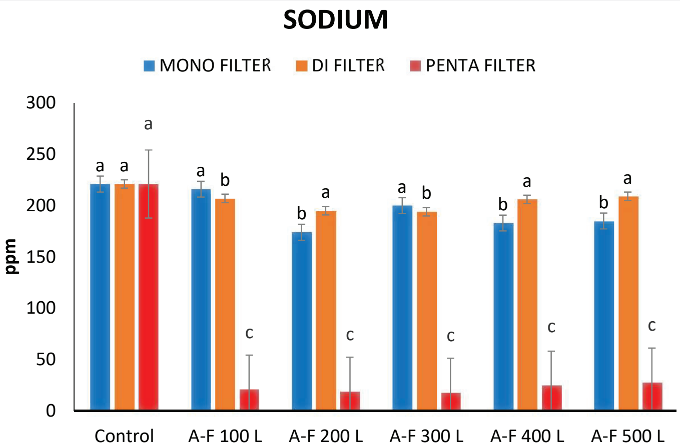
Рисунок 7. **Влияние домашних фильтров для воды на содержание нитратов (ppm) в фильтрованной воде**



Different letters indicate significant differences (P ⩽ 0.05).
A-F = After Filtration.

Figure 8. **Effect of the home water filters on the fluoride content (ppm) in the filtered water**

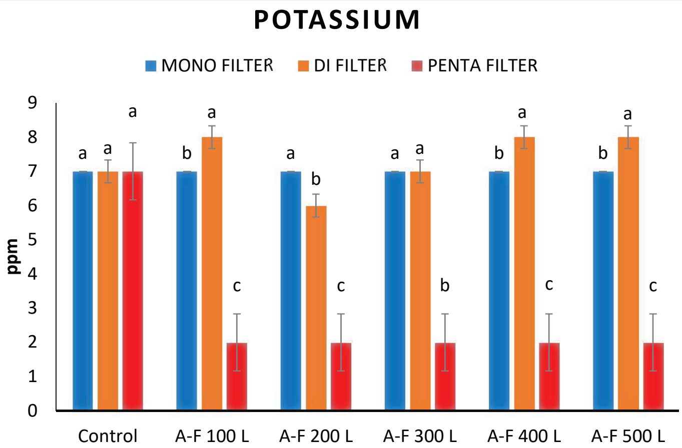
Рисунок 8. **Влияние домашних фильтров для воды на содержание фторидов (ppm) в фильтрованной воде**



Different letters indicate significant differences (P ⩽ 0.05).
A-F = After Filtration.

Figure 9. **Effect of the home water filters on the sodium content (ppm) in the filtered water**

Рисунок 9. **Влияние домашних фильтров для воды на содержание натрия (ppm) в фильтрованной воде**



Different letters indicate significant differences (P ⩽ 0.05).
A-F = After Filtration.

Figure 10. **Effect of the home water filters on the potassium content (ppm) in the filtered water**

Рисунок 10. **Влияние домашних фильтров для воды на содержание калия (ppm) в фильтрованной воде**

ter disposed from the house water penta filter ranged from 15 to 18 liters per 100 liters from incoming water. Drain water became hard water, which had total hardness ranged between 330 and 332 mg $CaCO_3$/L. Furthermore, it contained the high chloride concentration being 349 mg/L. Also, TDS increased in drain water (1.98 g/L) compared to the control water samples (1.49 g/L). Likewise, drain water had higher EC values (1267.2 mmhos/cm) than those reported in the control water samples.

Table 1. **Physical and chemical characteristics of drain water resulted from the home water penta filters**

Таблица 1. **Физические и химические характеристики сточной воды, полученной от домашних пяти-стадийных фильтров**

Sample	Drain water/100L	TH (mg $CaCO_3$/L)	Cl^- (ppm)	TDS (g/L)	EC (mmhos/cm)
A-F 100 L	18	330	349.8	1.98	1267.2
A-F 200 L	18	332	349	1.98	1267.2
A-F 300 L	15	331	349	1.98	1267.2
A-F 400 L	15	330	349.5	1.98	1267.2
A-F 500 L	15	330	349.5	1.98	1267.2

A-F = After Filtration.

3.3. Microbiological characteristics of the filtered water

3.3.3. Effect of the home water filters on total counts, coliform, fecal coliform and yeast and mold counts

It is very clear that the microbiological examination of water is greatly important to assure its safety for potable and /or industrial uses. Therefore, the filtered water obtained from the house water filters was microbiologically examined for its total bacterial counts, total coliform, fecal coliform and yeast and mold counts in water samples withdrawn from different types of house water filters. The obtained results are presented in Tables 2, 3 and 4, which show that the filtered water resulted from all studied house water filters was completely free from yeast, molds and fecal coliforms. Total bacterial counts (at 37 °C) ranged between 3.0×10^3 and 2.9×10^4, 9.3 x10^2 and 3.3×10^4 CFU/ml in the filtered water resulted from the home water mono filters and di filters, respectively. Total coliforms ranged from 7.7×10^2 to 3.0×10^3 and 3.8×10^2 to 8.4×10^3 CFU/ml in the filtered water resulted from the home water mono filters and di filters, respectively. It can be concluded that total bacterial counts and total coliforms were slightly affected by using the home water mono filters and di filters. The results in Table 4 indicate that the house water penta filters totally removed the bacterial population, including total counts and total coliforms, from the produced water making it completely safe for potable and other uses. Consequently, to assure continuous safety of such water, house water penta filters should be used. The most effective method for improving water quality parameters is the reverse osmosis membrane purification system with five-stage filter media [31]. Generally, total bacterial counts and total coliforms in filtered water produced from the home water mono and di filters were higher than the allowed levels required by the Egyptian Standards (50 and 0 CFU/100 ml, respectively) [22], and the WHO guidelines [28] (0 CFU/100 ml) for total coliforms and fecal coliforms.

Table 2. **Effect of the home water mono filters on total counts, coliform, fecal coliform and yeast and mold counts (CFU/ml) in the filtered water**

Таблица 2. **Влияние домашних одно-стадийных фильтров на общие количества, количества колиформных бактерий, фекальных колиформных бактерий, дрожжей и плесеней (КОЕ/мл) в фильтрованной воде**

Sample	Total counts	Total coliforms	Fecal coliforms	Yeast and mold
Control	3.0×10^4	2.8×10^4	Nil	Nil
A-F 100 L	4.7×10^3	7.9×10^2	Nil	Nil
A-F 200 L	3.0×10^3	2.1×10^3	Nil	Nil
A-F 300 L	2.8×10^4	3.0×10^3	Nil	Nil
A-F 400 L	2.9×10^4	8.4×10^2	Nil	Nil
A-F 500 L	2.8×10^4	7.7×10^2	Nil	Nil

A-F = After Filtration.

Table 3. **Effect of the home water di filters on total counts, coliform, fecal coliform and yeast and mold counts (CFU/ml) in the filtered water**

Таблица 3. **Влияние домашних двух-стадийных фильтров на общие количества, количества колиформных бактерий, фекальных колиформных бактерий, дрожжей и плесеней (КОЕ/мл) в фильтрованной воде**

Sample	Total counts	Total coliforms	Fecal coliforms	Yeast and mold
Control	3.4×10^4	2.5×10^4	Nil	Nil
A-F 100 L	3.3×10^4	8.4×10^3	Nil	Nil
A-F 200 L	5.3×10^3	8.2×10^2	Nil	Nil
A-F 300 L	1.8×10^3	3.8×10^2	Nil	Nil
A-F 400 L	1.8×10^3	8.4×10^2	Nil	Nil
A-F 500 L	9.3×10^2	7.0×10^2	Nil	Nil

A-F = After Filtration.

Table 4. **Effect of the home water penta filters on total counts, coliform, fecal coliform and yeast and mold counts (CFU/ml) in the filtered water**

Таблица 4. **Влияние домашних пяти-стадийных фильтров на общие количества, количества колиформных бактерий, фекальных колиформных бактерий, дрожжей и плесеней (КОЕ/мл) в фильтрованной воде**

Sample	Total counts	Total coliforms	Fecal coliforms	Yeast and mold
Control	3.4×10^4	2.5×10^4	Nil	Nil
A-F 100 L	Nil	Nil	Nil	Nil
A-F 200 L	Nil	Nil	Nil	Nil
A-F 300 L	Nil	Nil	Nil	Nil
A-F 400 L	Nil	Nil	Nil	Nil
A-F 500 L	Nil	Nil	Nil	Nil

A-F = After Filtration.

4. Conclusions

It can be concluded from the above-mentioned results that the penta filter used in the present study showed good purification capability of removing TDS, EC, TH, chlorides, nitrates, total bacterial counts and coliforms from water. On the contrary, the home water mono and di filters exhibited low effectiveness of contaminant removal. Therefore, consumers who primarily drink filtered water resulted from home water penta filters minimize risk of exposure to nitrates, heavy metals and microorganisms due to the presence of reverse osmosis, which has proven to be the most valid and effective technique to eliminate almost all contaminants. On the other hand, although this device has benefits in many cases, filtered water generated from those filters may pose an increased risk of deficiencies in F, Na, K and Mg for people. These elements are very important for the human body and their levels in filtered water can be lower than permissible limits set by local and international standards. Therefore, people should consume them from other food sources or use re-mineralization techniques to increase the nutrient content of filtered water. Drain water disposed from the house water penta filter contained high concentrations of contaminants and it needs further studies.

REFERENCES

1. EPA: United States Environmental Protection Agency (2006). Investigation of the Capability of Point-of-Use/Point-of-Entry Treatment Devices as a Means of Providing Water Security. EPA/600/R-06/012. Retrieved from http://www.aquanetto.ch/data/documents/ressources/EPA_PointofUsePointofEntry.pdf Accessed August 19, 2023
2. Wu J., Cao M., Tong D., Finkelstein Z., Hoek E. M.V. (2021). A critical review of point-of-use drinking water treatment in the United States. *npj Clean Water,* 4, Article 40. https://doi.org/10.1038/s41545-021-00128-z
3. Królak, E., Raczuk, J., Biardzka, E. (2015). Do water filters improve the quality of potable water? *Journal of Elementology*, 20(1), 149–159. https://doi.org/10.5601/jelem.2013.18.4.541
4. Daschner, F.D., Rtiden, H., Simon R., Clotten, J. (1996). Microbiological contamination of drinking water in a commercial household water filter system. *European Journal of Clinical Microbiology and Infectious Diseases,* 15(3), 233–237. https://doi.org/10.1007/BF01591360
5. March H., Garcia X., Domene E., Sauri D. (2020). Tap water, bottled water or in-home water treatment systems: Insights on household perceptions and choices. *Water,* 12(5), Article 1310. https://doi.org/10.3390/w12051310
6. Bosscher, V., Lytle, D.A., Schock, M.R., Porter, A., Del Toral, M. (2019). POU water filters effectively reduce lead in drinking water: A demonstration field study in flint, Michigan. *Journal of Environmental Science and Health, Part A,* 54(5), 484–493. https://doi.org/10.1080/10934529.2019.1611141
7. Eftekhar, B., Skini, M., Shamohammadi, M., Ghaffaripour, J., Nilchian, F. (2015). The effectiveness of home water purification systems on the amount of fluoride in drinking water. *Journal of Dentistry, Shiraz University of Medical Science,* 16(3 Suppl), 278–281.
8. Smith, S.C., Rodrigues, D.F. (2015). Carbon-based nanomaterials for removal of chemical and biological contaminants from water: A review of mechanisms and applications. *Carbon,* 91, 122–143. http://doi.org/10.1016/j.carbon.2015.04.043
9. Sangkarak, S., Phetrak, A., Kittipongvises, S., Kitkaew, D., Phihusut, D., Lohwacharin, J. (2020). Adsorptive performance of activated carbon reused from household drinking water filter for hexavalent chromium-contaminated water. *Journal of Environmental Management*, 272, Article 111085. https://doi.org/10.1016/j.jenvman.2020.111085
10. Singh, S.P., Agarwal, A.K., Gupta, T., Maliyekkal, S.M. (2022). New trends in emerging environmental contaminants. Springer Nature Singapore, 2022. https://doi.org/10.1007/978-981-16-8367-1
11. Alsulaili, A, Al-Harbi, M., Elsayed, K. (2020). The influence of household filter types on quality of drinking water. *Process Safety and Environmental Protection,* 143, 204–211. https://doi.org/10.1016/j.psep.2020.06.051
12. Wright, J., Gundry, S., Conroy, R. (2004). Household drinking water in developing countries: A systematic review of microbiological contamination between source and point-of-use. *Tropical Medicine and International Health*, 9(1), 106–117. https://doi.org/10.1046/j.1365-3156.2003.01160.x
13. Mecha, C. A., Pillay, V. L. (2014). Development and evaluation of woven fabric microfiltration membranes impregnated with silver nanoparticles for potable water treatment. *Journal of Membrane Science*, 458, 149–156. https://doi.org/10.1016/j.memsci.2014.02.001
14. Masoumi, S.J., Haghkhah, M., Mehrabani, D., Ghasempour, H.R., Esmaeelnejad, Z., Ghafari, N. et al. (2013). Quality of drinking water of household filter systems in Shiraz, Southern Iran. *Middle-East Journal of Scientific Research*, 17(3), 270–274. https://doi.org/10.5829/idosi.mejsr.2013.17.03.74121
15. Pourjamali, R, Sadrabad, E.K., Hashemi S. A., Shekofteh, H., Mokhtari, M., Heydariet, A. et al. (2018). Evaluation of point-of-use drinking water treatment systems efficiency in reducing or removing physicochemical parameters and heavy metals. *Journal of Environmental Health and Sustainable Development,* 3(4), 557–566. https://doi.org/10.18502/jehsd.v4i1.490
16. APHA, AWWA, WPCF (1985). Standard Methods for the Examination of Water and Wastewater. Sixteenth Edition. Port city press, Baltimore, Maryland, USA, 1985.
17. ISO 6222 Water quality — Enumeration of culturable micro-organisms — Colony count by inoculation in a nutrient agar culture medium (DS/EN ISO 6222:1999)
18. ISO 9308–1:2000 Standard. Water Quality — Detection and enumeration of Escherichia coli and coliform bacteria — Part 1: Membrane filtration method.
19. APHA (1998). Standard methods for examination of water and wastewater 20th ed., American Public Health Association Water Works Association, Water Environmental Federation Washington, DC.
20. Rao, V. N. M., Blane, K. (1985). PC-STAT, statistical programs for microcomputers. Version 1A. Department of Food Science and Technology, University of Georgia, Athens, GA, USA, 1985.
21. Khanal, S., Kazama, S., Benyapa, S., Takizawa, S. (2023). Performance assessment of household water treatment and safe storage in Kathmandu Valley, Nepal. *Water,* 15(12), Article 2305. https://doi.org/10.3390/w15122305
22. Egyptian Standards: ES:190–1(2007). Drinking water and ice standards. Part 1: Drinking water. Egyptian Organization for Standardization and Quality.
23. Rahman, I.M.M., Barua, S., Barua, R., Mutsuddi, R., Alamgir, M., Islam, F. et al. (2017). Quality assessment of the non-carbonated bottled drinking water marketed in Bangladesh and comparison with tap water. *Food Control,* 73, 1149–1158. http://doi.org/10.1016/j.foodcont.2016.10.032
24. Al-Oud, S.S., El-Nadi, A.H., Salad, S. (2000). Detection of organic aromatic polycyclic hydrocarbons in underground water of Al-Qassim region, central of Saudi Arabia. *The Journal of Agricultural Science, Mansoura University,* 25(7), 4709–4715.
25. Jaafari-Ashkavandi, Z., Kheirmand, M. (2013). Effect of home-used water purifier on fluoride concentration of drinking water in Southern Iran. *Dental Research Journal*, 10(4), 489–492.
26. Joint FAO/WHO Expert Committee on Food Additives (JECFA). (2003). Nitrate and potential endogenous formation of N-nitroso compounds. Chapter in Safety evaluation of certain food additives and contaminants. Geneva. Retrieved from https://inchem.org/documents/jecfa/jecmono/v50je01.htm Accessed August 25, 2023
27. EEA (2011). Commission Regulation (EU) No. 1258/2011 of 2 December 2011 amending Regulation (EC) No. 1881/2006 as regards maximum levels for nitrates in foodstuffs. *Official Journal of the European Union*, L 320, 15–17. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R1258&from=EN Accessed August 10, 2023
28. WHO (World Health Organization). (2017). Guidelines for Drinking-water Quality. 4th edition. Incorporating the first addendum. World Health Organization, Geneva.
29. Al-Redhaiman, K.N., Abdel-Magid, H.M. (2002). The applicability of the local and international water quality guidelines to Al-Gassim region of central Saudi Arabia. *Water, Air, and Soil Pollution*, 137(1), 235–246. https://doi.org/10.1023/A:1015550417199
30. Islam, M., Nasrin, T., Islam, M. (2021). Determination of surface water quality for irrigation in Dinajpur. *Turkish Journal of Agriculture — Food Science and Technology*, 9(10), 1782–1791. https://doi.org/10.24925/turjaf.v9i10.1782-1791.4208
31. Abd Rahim, N.S., Othman, N. (March 31, 2019). *Home water purification system in Malaysia: Qualitative and quantitative study.* IOP Conference Series: Materials Science and Engineering, Volume 601, Postgraduate Symposium in Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 2019. https://doi.org/10.1088/1757-899X/601/1/012011

AUTHOR INFORMATION	СВЕДЕНИЯ ОБ АВТОРАХ
Affiliation	**Принадлежность к организации**
Abdalla S. M. Ammar, Professor, Food Science and Technology Department, Faculty of Agriculture, Cairo University 1 Gamaa Street, Giza, 12613, Egypt Food Science and Human Nutrition Department, College of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia Tel.: +2–0101–997–17–99 E-mail: abdallaammar@agr.cu.edu.eg ORCID: https://orcid.org/0000-0002-9919-8760 * corresponding author	**Аммар Абдалла С. М.,** профессор, кафедра науки о питании и технологии, Сельскохозяйственный факультет, Каирский Университет 12613, Египет, Гиза, ул. Гамаа, 1 Факультет пищевых наук и питания человека, Колледж сельского хозяйства и ветеринарной медицины, Университет Кассима, Саудовская Аравия Тел.: +2–0101–997–17–99 E-mail: abdallaammar@agr.cu.edu.eg ORCID: https://orcid.org/0000-0002-9919-8760 * автор для контактов
Mohamed G. El-Ziney, Professor of Dairy Science and Technology, Dairy Science and Technology Department, Faculty of Agriculture, Alexandria University PO Box 21454 Alexandria, Egypt Food Science and Human Nutrition Department, College of Agriculture and Veterinary Medicine, Qassim University, Saudi Arabia Tel.: +2–0106–516–63–51 E-mail: elziney@yahoo.com ORCID: http://orcid.org/0000-0001-9082-4262	**Эль-Зини Мохаммед Г.,** профессор технологии молока, кафедра технологии молочной промышленности, сельскохозяйственный факультет, Александрийский университет 21454, Александрия, Египет Факультет пищевых наук и питания человека, Колледж сельского хозяйства и ветеринарной медицины, Университет Кассима, Саудовская Аравия Тел.: +2–0106–516–63–51 E-mail: elziney@yahoo.com ORCID: http://orcid.org/0000-0001-9082-4262
Ahmad I. Al-Turki, Professor of Environmental Microbiology, Plant Production and Protection Department, College of Agriculture and Veterinary Medicine, Qassim University PO BOX 6622, Buraydah 51452, Al-Qassim, Saudi Arabia Tel.: +966–0568–410–066 E-mail: trky@qu.edu.sa ORCID: http://orcid.org/0009-0006-8805-061X	**Аль-Турки Ахмад И.,** профессор экологической микробиологии, факультет растениеводства и защиты растений, Колледж сельского хозяйства и ветеринарной медицины, Университет Кассима 51452, Саудовская Аравия, Бурайда, п/о 6622 Тел.: +966–0568–410–066 E-mail: trky@qu.edu.sa ORCID: http://orcid.org/0009-0006-8805-061X
Contribution	**Критерии авторства**
Authors equally relevant to the writing of the manuscript, and equally responsible for plagiarism.	Авторы в равных долях имеют отношение к написанию рукописи и одинаково несут ответственность за плагиат.
Conflict of interest	**Конфликт интересов**
The authors declare no conflict of interest.	Авторы заявляют об отсутствии конфликта интересов.