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Short communication

Assessing tap water quality: comparative study of point-of-use water filters

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Introduction

In recent years, public awareness of the relationship between drinking water quality and health has led to increased use of different point-of-use filters such as household filtration systems (HFSs) and water filter jugs. These devices are very popular for improving water taste, color, and some physicochemical properties of tap water due to their affordability and ease of use (Domoń et al., 2023; Hazzazi et al., 2024). Several mechanisms are employed for water purification, namely ion-exchange and/or activated carbon, microfiltration (MF) and reverse osmosis (RO). While RO systems have been shown to markedly reduce conductivity, calcium, chloride content, and pH, devices using ion-exchange show more variable performance across brands and over filter lifetime (Hazzazi et al., 2024; Kim et al., 2021). Regardless the filter used, they suffer from several disadvantages such as unwanted demineralization, incomplete contaminant removal as well as high ongoing replacements costs. In addition, their effectiveness significantly varies depending on the filter type and the parameter evaluated (Zarębska et al., 2024). This study aimed to assess tap water quality before and after filtration treatment using various point-of-use filters.

Materials and methods

The tap water was collected from several locations in the water distribution network in Skopje. Four filtration mechanisms were employed: multi-stage RO filtration (sample 1 and 2), activated carbon MF (sample 3 and 4), MF (sample 5 and 6) and filter jug operating on activated carbon combined with ion-exchange resin filtration (sample 7 and 8). The even numbers represent the filtered samples whereas the odd number the respective unfiltered tap water control. Six physicochemical parameters (total hardness, calcium content, pH, chloride content, water conductivity and permanganate index) were measured in the filtered samples and their respective unfiltered controls at two time points: immediately after filtration (T 0h) and 20 hours later (T 20h). pH and electrical conductivity were measured using a Mettler Toledo SevenMulti meter (Switzerland). Total hardness and calcium content in the investigated samples were determined complexometrically. Chloride content was determined using the Mohr's method and the permanganate index was analyzed by the Kübel-Tiemann method.

Results and discussion

Conductivity and water hardness

The analysis of filtered and unfiltered samples revealed the most prominent difference regarding conductivity and water hardness. At T 0h filtered samples obtained by RO filtration (sample 2) and activated carbon combined with ion-exchange resin

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filtration (sample 8) had conductivity reduction by 77.8% and 20.7%, respectively, compared to their unfiltered controls. Also, these two systems substantially reduced water hardness, from approximately 19.7–20.0 °dH to 4.0 °dH and 3.8 °dH respectively, classifying the filtrate as soft water. Samples 4 and 6 showed no meaningful change in either parameter, consistent with the known limitations of activated carbon and microfiltration technologies, which are not effective at reducing dissolved mineral ions (Alsulaili et al., 2020; Kim et al., 2021).

Calcium content

Calcium levels were also significantly reduced in samples 2 and 8, by 51.7% and 81.5%, respectively. The obtained results reflect efficient cation removal via the semipermeable membrane and ion-exchange resin. The results obtained for samples 4 and 6 showed little to no reduction, consistent with the inability of carbon-based and microfiltration systems to alter mineral composition (Alsulaili et al., 2020; Kim et al., 2021).

Permanganate index

The analysis of the results obtained for the permanganate index revealed important differences between filtered and unfiltered samples. At T 0h, the values ranged 0.60–2.24 mg/L which is in accordance with the national regulatory limits (8 mg/L). Twenty hours later, permanganate index for sample 6 was 5.16 mg/L (+224% relative), while in its respective unfiltered tap control the value remained stable at 1.96 mg/L. At the same time point, this parameter for samples 4 and 8 was increased by 57.2% and 73.8%, respectively. Sample 2 remained nearly unchanged (+4.0%). The disproportionate rise in samples 4, 6 and 8, relative to their unfiltered controls suggests organic content originates from within the filtration system itself, as leaching of compounds from the cartridge may promote microbial proliferation upon storage (Domoń et al., 2023).

Chloride content

Chloride levels for all investigated samples were in accordance with the national regulatory limit of 250 mg/L at both time points (range: 15.98–25.74 mg/L). No meaningful differences were detected between filter types.

pH

pH remained within the WHO-recommended range of 6.5–9.5 across all samples and time points.

Conclusion

This study showed that the tap water quality filtered by point-of-use filters can be significantly lowered during storage. Twenty hours post filtration, reduced water hardness, calcium and chloride content, and conductivity were observed in sample 2 and a considerable increase of permanganate index in samples 4, 6, and 8. As presented, all recorded values are within national regulatory limits for water intended for human consumption. However, the investigated filters were able to modify some of the important quality parameters during storage which warrants attention from a public health perspective. It is therefore recommended that consumers utilizing HFSs, especially jug-type filtration systems consume filtered water promptly following filtration, rather than retaining it for prolonged periods at room temperature.

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