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Original Research Article

Parametric evaluation of water quality from water purification systems in Saudi Arabia

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ABSTRACT

The use of point-of-use household drinking water purification systems has gained popularity as a means to empower communities and individuals without access to clean water to treat their own water at home. This study evaluated the effectiveness of point-of-use systems in improving Saudi Arabia's water quality by assessing parameters such as treated water color, odor, pH, total dissolved solids, electrical conductivity, total hardness, free chlorine, anions (chloride and sulphate), and cations (sodium). The physiochemical properties of six widely used point-of-use systems were examined, including polypropylene cotton filters, activated carbon filters (granular activated carbon and carbon block), and reverse osmosis membranes. The results for purified drinking water showed the following characteristics: The pH of the purified water ranged from 7.24 to 7.84, with electrical conductivity between 34.63 and 49.30 µS cm^{-1}, total dissolved solids from 16.33 to 24.33 mg L^{-1}, and total hardness from 0.45 to 2.84 mg L^{-1}. Sodium levels ranged from 6.50 to 11.07 mg L^{-1}, sulphate from 0.03 to 0.55 mg L^{-1}, free chlorine from 0 to 0.03 mg L^{-1} Cl_2, and chloride from 7.65 to 17.27 mg L^{-1}. The removal efficiencies for specific contaminants were as follows: sodium, sulphate, chloride, conductivity, and total hardness removal ranged from 92% to 99%. Activated carbon filters demonstrated a high efficiency in removing free chlorine, with a removal rate of 94% to 100%. This study concludes that point-of-use systems can effectively enhance water quality in Saudi Arabia. The choice of purification system should depend on the specific water quality concerns and the user's individual needs, as each system offers distinct advantages and limitations. Polypropylene cotton, activated carbon, and reverse osmosis membranes serve different roles in addressing water purification challenges.

KEYWORDS

Water purification systems, water quality, filters, membranes, activated carbon, reverse osmosis, Saudi Arabia.

INTRODUCTION

Maintaining high-quality water through physical and chemical treatments is essential for human survival [1]. Drinking water is a source of essential minerals for human health [2]. However, harmful chemicals such as organic pollutants and heavy metals can also be present in water, even in trace amounts, posing significant health risks [3]. The growing societal awareness of the dangers associated with drinking water toxins has increased the demand for

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household water treatment systems to improve water quality. Consequently, this demand has led to the proliferation of diverse types and a substantial quantity of household water treatment systems in the market [4].

In Saudi Arabia, various water treatment systems have been developed, designed to employ effective treatment methods and materials such as polypropylene (PP), carbon block (CTO), secondary chlorination, ultraviolet (UV) irradiation, and activated carbon (AC) adsorption [5]. Notably, one of the most widely used domestic treatment systems in Saudi Arabia combines air conditioning with reverse osmosis (RO) membrane filtration. RO-based filter systems account for approximately 38% of the market share, while filter systems equipped with hollow fibre ultrafiltration (UF) membranes represent 18% [6].

Currently, residential water filters are widely available and commercially accessible. Each filter includes a replaceable element that is compatible with different systems. Consumers often use point-of-use (POU) water treatment systems to effectively eliminate contaminants from drinking water. These systems utilize various purification methods, including adsorption, membrane filtration, chlorination, and UV sterilization [7]. Laboratory studies on POU systems have demonstrated high pollutant removal efficiencies [8]. According to the World Health Organization (WHO), POU water purification is a cost-effective approach compared to alternative methods [9].

Poor water quality has been linked to various health issues, such as tooth decay, cardiovascular problems, gastrointestinal disorders, kidney failure, and high blood pressure [10], [11]. A common symptom of inadequate water quality, particularly in developing countries, is gastrointestinal illness [12]. Improving water treatment systems has the potential to significantly reduce the prevalence and severity of these conditions [13]. The UN World Water Development Report 2019 highlights the critical role of clean water and sanitation in ending global poverty and fostering peaceful societies [14].

Water filters are essential for removing sediments, unpleasant tastes and odors, hardness, and other impurities from water before use in households or industries [15]. Studies on water quality and treatment systems in Saudi Arabia have identified various challenges and potential solutions. For instance, an evaluation of drinking water purification plants in Al-Hassa demonstrated high contaminant removal efficiency and compliance with international standards, while emphasizing the need for continuous monitoring and optimization [16]. Research on water treatment plants in Riyadh applied Quality Tools to address inefficiencies, such as excessive energy consumption in pumps, resulting in improved energy efficiency and cost-effectiveness [17]. Similarly, a Water Quality Index (WQI) assessment in Riyadh revealed acceptable overall quality but suggested improvements in reducing bacterial and chemical impurities [18]. In Jeddah, study on domestic water quality found significant microbial contamination, with over 60% of samples containing coliform bacteria [19]. POU systems, particularly those using UV sterilization, effectively reduced microbial contaminants and enhanced water safety.

These studies highlight the need for targeted interventions, advanced filtration technologies, and operational improvements to ensure a sustainable and safe water supply across Saudi Arabia. Despite existing local studies, gaps remain in understanding the operational performance and efficiency of water filtration systems. Global research has shown that POU systems, such as RO membranes and activated carbon filters, are highly effective in removing contaminants like pharmaceuticals, pesticides, and heavy metals. However, their efficiency depends on water quality and operational conditions [20].

Low-cost POU technologies, such as ceramic filters, activated carbon filters, and chlorination, have proven effective in reducing microbial contamination, especially in developing communities [21], [22]. Nonetheless, their limitations in addressing emerging contaminants remain a concern. Further research on POU systems, including RO membranes and activated carbon filters, has demonstrated their ability to remove emerging pollutants [23]. Although global studies confirm the efficacy of RO membranes and activated carbon filters under real-world conditions, their application in Saudi Arabia's unique climatic and hydrological context remains underexplored.

This study aims to bridge this gap by providing localized data on the performance of household water treatment systems in Saudi Arabia. It evaluates the sensory, physical, and chemical parameters of treated drinking water, quantifies contaminant removal efficiencies of different filtration methods, compares the performance of activated carbon filters and RO membranes, and assesses the physicochemical properties of treated water to ensure compliance with WHO standards.

MATERIALS AND METHODS

The study explored the characteristics and quality of water in Saudi Arabia based on the requirements set by WHO [24]. This investigation aimed to identify regional variations affecting water quality parameters relevant to household purification. Consequently, a multi-stage household water purification system was designed to more effectively address water quality concerns in Saudi Arabia compared to existing alternatives, considering contaminant removal, efficiency, and cost-effectiveness. The key water quality parameters evaluated in this study included color, odor, pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), free chlorine, anions (chloride and sulphate), and cations (sodium).

Filter and membrane elements

Six commercial POU systems were examined in this study. Figure 1 presents the materials used in point-of-use household water purification systems by filter type (GAC, CTO, and RO membranes). The selected systems included PP cotton filters, which are made from soft, flexible polypropylene plastic and purify water by removing sediments such as dust, clay, mud, and sand. Common types of PP cotton filters include pleated, string-wound, and melt-blown/spun. These filters are often used in multi-stage filtration processes to protect the primary filtration stages [25].

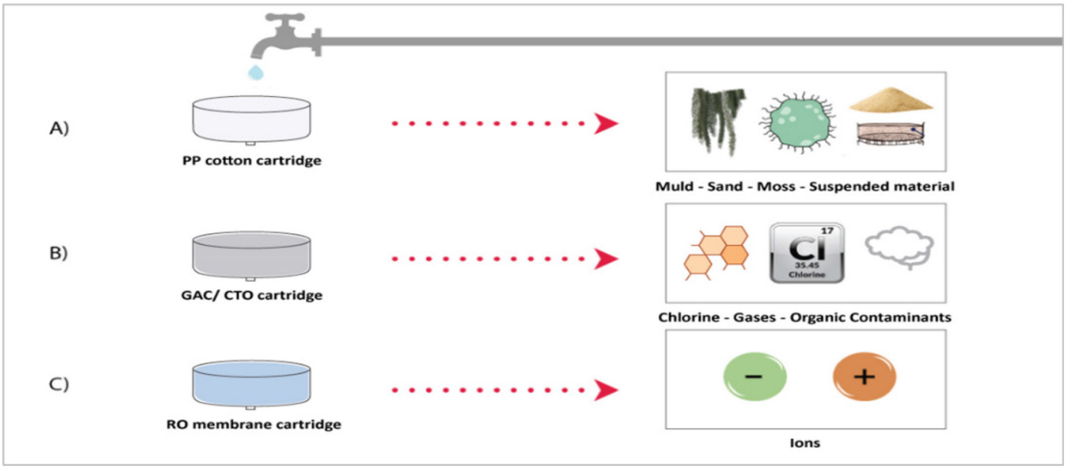

Figure 1. Graphical diagram showing the various materials of the point-of-use household water purification systems studied by type of element

GAC filters, known for their porous structure and significant internal surface area, were evaluated for their ability to remove various contaminants. Manufactured from materials such as bituminous coal, lignite coal, peat, wood, and coconut shells, GAC filters are effective in eliminating substances responsible for taste and odor, natural organic matter, volatile organic compounds, synthetic organic compounds, and disinfection byproduct precursors [26].

CTO filters, which also utilize activated carbon, were assessed for their efficiency in removing impurities and contaminants from water. These filters work through adsorption, a process in which organic compounds adhere to the surface of the activated carbon. CTO filters are capable of removing chlorine, tastes, odors, sediment, turbidity, iron, lead, bacteria, and other contaminants, depending on their type and quality [27].

RO membranes, the final filtration type studied, employ a semipermeable membrane with a pore size of less than one nanometer to filter nearly all inorganic contaminants, including dissolved solids such as salts [28].

The selection of these filters and membranes was based on the criteria that each product should be widely used in Saudi Arabia and affordable for a large portion of households. Each commercial system was sourced from a different company and consisted of a four-stage filtration process: a PP cotton filter in the first stage, two types of activated carbon (GAC and CTO) in the second and third stages, and an RO membrane in the fourth stage. Key performance characteristics of the chosen filters, including surface area, porosity, and effectiveness, are summarized (**Table 1**).

Table 1. Performance index characteristics of selected filters

Filter Type	Surface Area	Porosity (Pore Size)	Effective for
PP Cotton	0.5 to 3 square meters	1 to 100 micrometres	Large particles (sediment, rust, sand)
Granular Activated Carbon	500 to 1,500 m^2 g^{-1}	Micropores (< 2 nm), mesopores (2–50 nm)	Organic compounds, chlorine, VOCs
Activated Carbon Block	500 to 1,000 m^2 g^{-1}	0.5 to 10 micrometres	Chemicals, VOCs, particulates
RO Membrane	0.5 to 2 square meters (spiral-wound design)	~0.0001 micrometres (100 nanometers)	dissolved salts

Experiment and Study Area

The tap water used as a reference, along with household water purification system components, including filters and membranes, was collected in Jeddah City in western Saudi Arabia (**Figure 2**). The PP cotton filters were installed in a user-friendly and easily maintained household water purification system and labelled as I, II, III, IV, V, and VI. The activated carbon filters (GAC and CTO) from each brand were labelled VII, VIII, IX, X, XI, and XII, with one label assigned to each water purification system. The RO membranes were labelled XIII, XIV, XV, XVI, XVII, and XVIII.

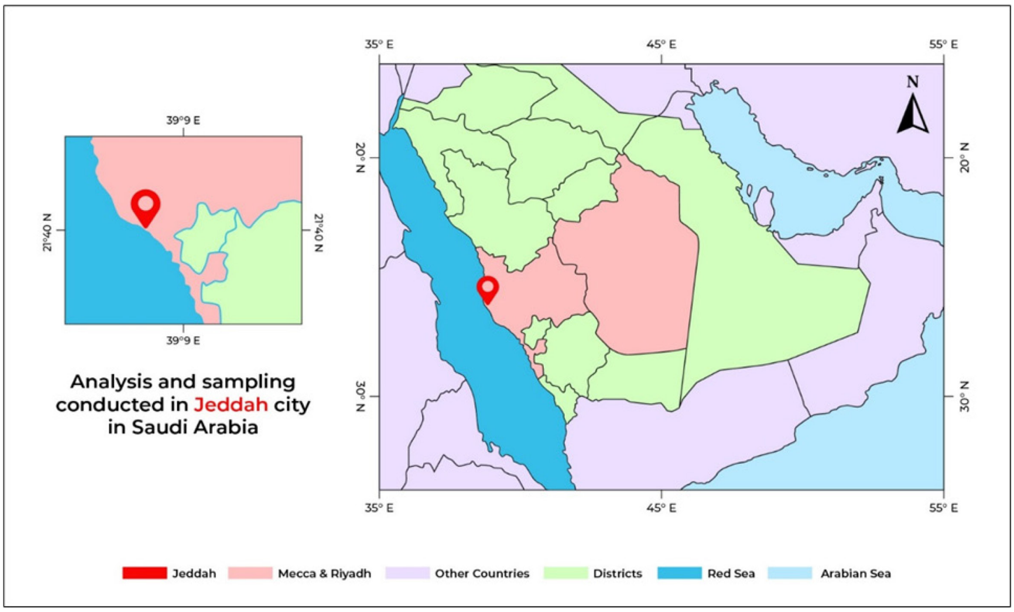

Figure 2. Location of sampling and experiment: Jeddah city, Saudi Arabia

A water system was designed to enable controlled water flow and separation of the three filtration phases, as illustrated (**Figure 3**). In the first phase, the PP cotton filter was tested independently. The second and third phases involved the combined testing of GAC and CTO filters. Finally, the RO membrane was evaluated in the fourth phase.

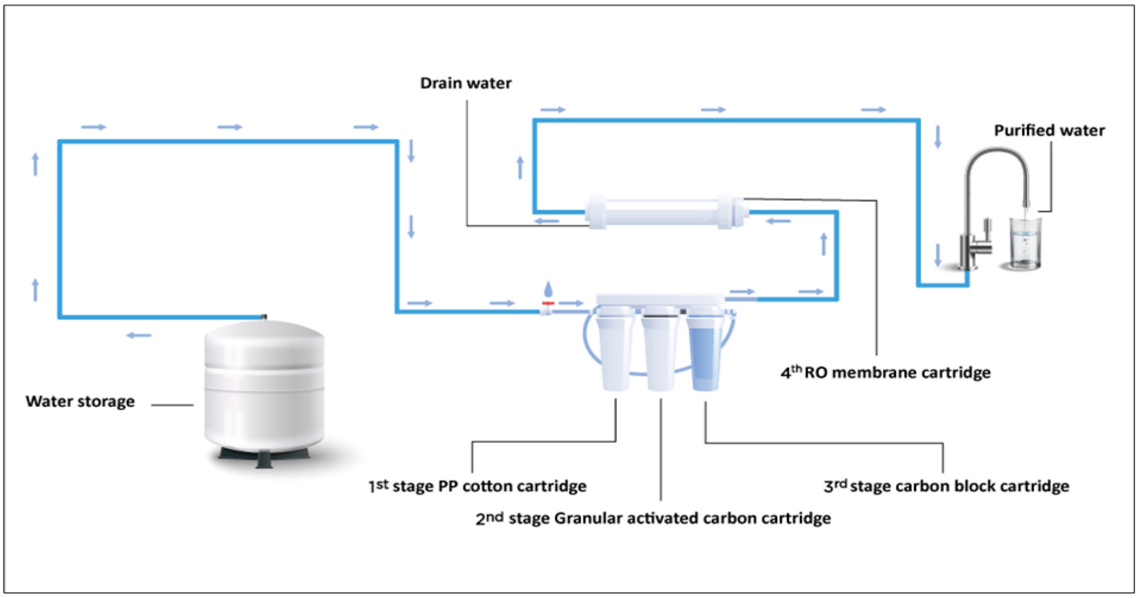

Figure 3. Schematic diagram depicting the setup of the point-of-use system

The experiments were conducted at an operating pressure of 4.14 bars, with water filtration temperatures ranging from 20 to 25°C. A mobile tank with a capacity of 80 liters was used to control the reference water quantity (2 liters per sample). Water samples with known concentrations were filtered using the designated filtration systems. Samples were collected in triplicate for each system and brand over a period from April 2023 to September 2023 to assess the impact of seasonal variations on water quality parameters.

Determination of physiochemical parameters

The physicochemical attributes of the water samples, including parameters such as pH, TDS, EC, anions (chloride and sulphate), cations (sodium), and free chlorine, were determined using various analytical techniques (**Table 2**). The pH levels, EC, and TDS were measured using the Hanna Environmental Probe (H Series). TH was calculated following the methodology outlined by the American Society for Testing and Materials (ASTM) [29]. The concentration of free chlorine was analyzed using an N, N-diethyl-p-phenylenediamine (DPD) colorimeter [30]. Anions and cations were quantified using an ion chromatography system, specifically the Thermo Scientific™ Dionex™ ICS-6000 [31], [32].

Table 2. Physicochemical parameters assessed for filters and membranes

Test Parameter	Color	Odor	pH	TDS	Conductivity	TH	Free Chlorine	Chloride	Sulphate	Sodium
PP Cotton Filter	√	-	-	-	-	-	-	-	-	-
Activated Carbon Filters (GAC and CTO)	√	√	-	-	-	-	√	-	-	-
RO Membrane	-	-	√	√	√	√	-	√	√	√

This comprehensive analytical approach provided detailed insights into the multifaceted physicochemical composition of the water samples, offering valuable information on their environmental quality and suitability for various applications.

Statistical analysis

The physicochemical characteristics of purified and unpurified drinking water collected from six POU systems were analyzed statistically to determine whether there was a significant difference between the two types of water samples. The data were subjected to an independent Student's t-test using Minitab. The student's t-test is a statistical method used to evaluate the significance of differences in means between two groups of data. Essentially, it is a mathematical technique used to analyse the relationship between two or more variables.

Using this method, the t-value was calculated. A null hypothesis (H_0) was established for the test, asserting that there is no statistically significant difference between the two datasets. The critical value was determined using a t-table, based on the probability value (p-value) and the degrees of freedom. The p-value for the t-test was set at 0.05. If the calculated t-value exceeded the critical value, the null hypothesis (H_0) was rejected, indicating a statistically significant difference between the means of the two datasets—unpurified and purified drinking water.

Additionally, the accuracy of the target ion measurements obtained using ion chromatography systems was evaluated by calculating the coefficient of determination (r^2 statistic) from calibration curves. This comprehensive analysis confirmed the reliability of the data and provided meaningful insights into the differences between purified and unpurified drinking water.

RESULTS AND DISCUSSION

A sensory assessment of tap water and various commercially available PP cotton and activated carbon filters was conducted using human evaluators as sensors. The evaluation revealed the absence of discernible color and odor in both unpurified and purified drinking water. The chloride content of commercial brands using RO membranes is presented in **Figure 4**. The mean chloride concentration in tap water samples was determined to be 254.42 mg L^{-1}, whereas the chloride levels in water purified using RO membranes ranged from 7.65 to 17.29 mg L^{-1}. According to WHO standards, the allowable limit for chloride is 250 mg L^{-1}, and all purified water samples had chloride concentrations well below this limit. Chloride is essential in water to help inhibit bacterial growth [32].

Figure 4 also presents the pH values of tap water and water purified using RO membranes. The pH of unpurified drinking water was 7.94, while purified samples exhibited pH levels ranging from 7.24 to 7.84. Notably, the purified samples showed slightly lower pH levels compared to tap water, indicating that RO membranes reduce pH during filtration. The WHO standard for pH is 6.5–8.5, and all purified water samples fell within this range.

EC data for RO membrane-based commercial brands are also **Figure 4**. Unpurified water samples had an average EC of 1032.24 µS cm^{-1}, whereas purified water samples ranged from 34.63 to 49.30 µS cm^{-1}. The average TDS concentration in unpurified drinking water was 506.30 mg L^{-1}, while purified samples ranged between 16.33 and 24.33 mg L^{-1}. All purified samples met the WHO TDS standard of less than 1000 mg L^{-1}. The reduced EC and TDS levels in purified water confirm the efficiency of RO membranes in removing dissolved solids.

Figure 4 illustrates the sodium and TH levels for RO membrane brands. The mean sodium and TH concentrations in tap water were 146.07 mg L^{-1} and 82.26 mg L^{-1}, respectively. In purified samples, sodium levels ranged from 6.50 to 11.07 mg L^{-1}, and TH ranged from 0.45 to 2.84 mg L^{-1}. All purified samples complied with WHO limits for sodium (200 mg L^{-1}) and TH (500 mg L^{-1}). The use of RO membranes proved highly effective in significantly reducing these parameters.

The sulphate concentrations for different brands are depicted in **Figure 4**. The mean sulphate concentration in unpurified water samples was 15.57 mg L^{-1}, while purified samples ranged from 0.03 to 0.55 mg L^{-1}. All purified samples met the WHO sulphate standard of 500 mg L^{-1}. Elevated sulphate levels above this limit can lead to dehydration, particularly in infants [33].

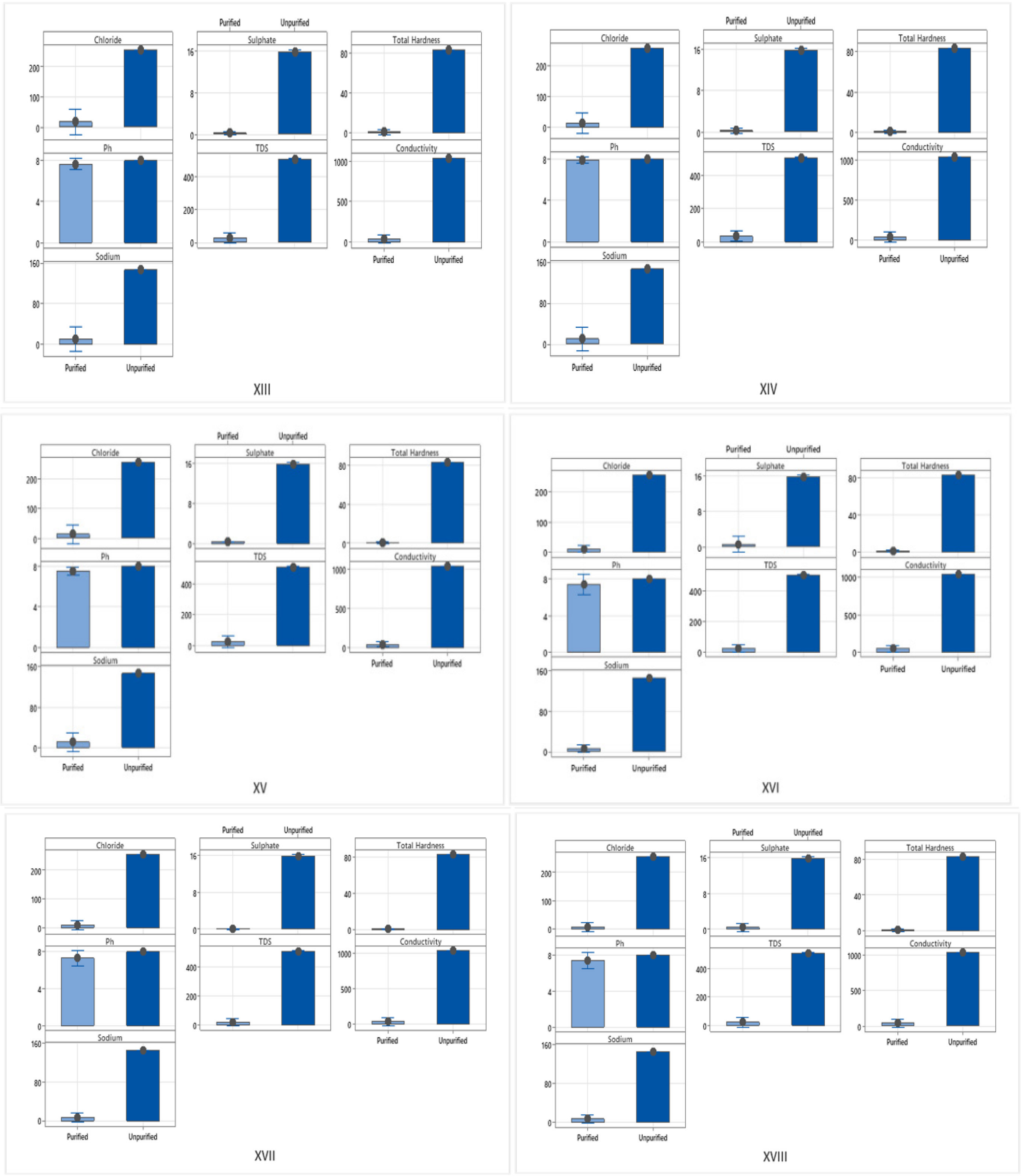

Figure 4. parameters (Chloride, pH, Sodium, Sulphate, TDS, TH, and EC) of unpurified tap water and water purified using RO membranes and water purification systems XIII, XIV, XV, XVI, XVII, and XVIII; The units for all these properties—chloride, sodium, sulphate, TH, and TDS—are expressed in mg L^{-1}, while conductivity is expressed in µS cm^{-1}

Figure 5 shows the free chlorine concentrations in water treated with activated carbon filters. Tap water had a mean free chlorine concentration of 1.00 mg L^{-1}, while purified samples ranged from 0 to 0.03 mg L^{-1} CL_2. All purified samples complied with WHO standards, which require free chlorine levels to remain below 5 mg L^{-1} CL_2. Monitoring free chlorine concentrations using suitable devices is essential for ensuring safe water [34].

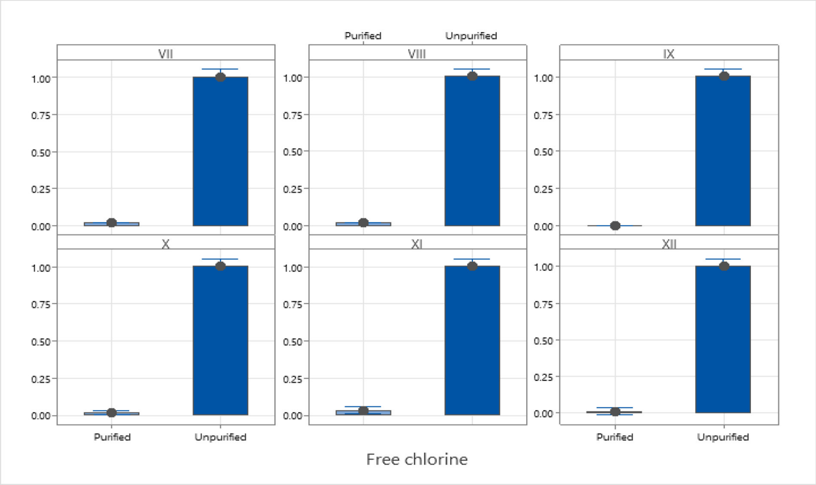

Figure 5. Free chlorine concentration in unpurified tap water and water purified using activated carbon filters VII, VIII, IX, X, XI, XII; free chlorine unit is expressed in (mg L^{-1}Cl$_2$)

PP cotton and activated carbon filters, such as GAC and CTO, are cost-effective but have limitations in removing minerals and dissolved organic matter. In contrast, RO membranes, while more expensive and requiring high water pressure, effectively removed sodium, sulphate, chloride, and total hardness. Removal efficiencies for these contaminants ranged from 92.42% to 99.80%, as shown in **Figure 6**, highlighting the superior purification capability of RO membranes. The effectiveness of activated carbon filters in removing free chlorine is depicted in **Figure 7**, with removal efficiencies ranging from 94% to 100%.

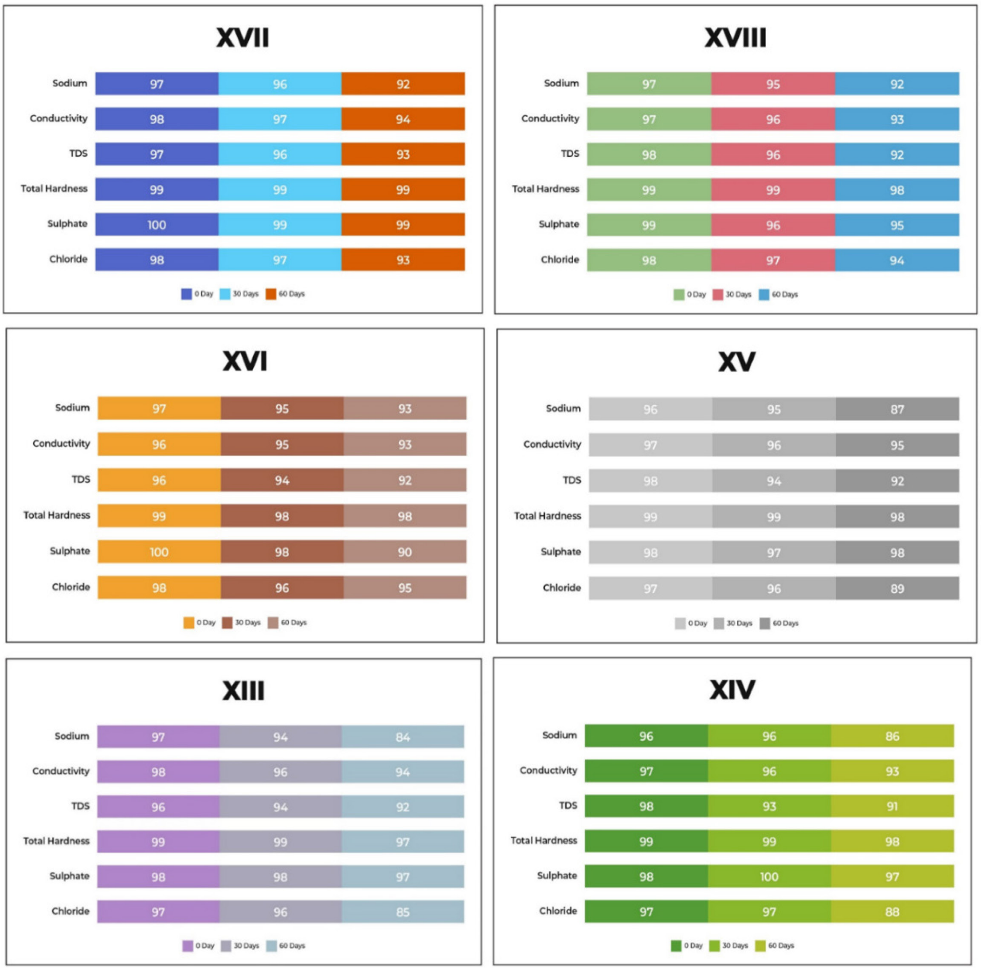

Figure 6. Removal efficiency of sodium, sulphate, chloride, TDS, TH, and EC from tap water using RO elements XIII, XIV, XV, XVI, XVII, and XVIII; The units for all these properties—chloride, sodium, sulphate, TH, and TDS—are expressed in mg L^{-1}, while conductivity is expressed in µS cm^{-1}

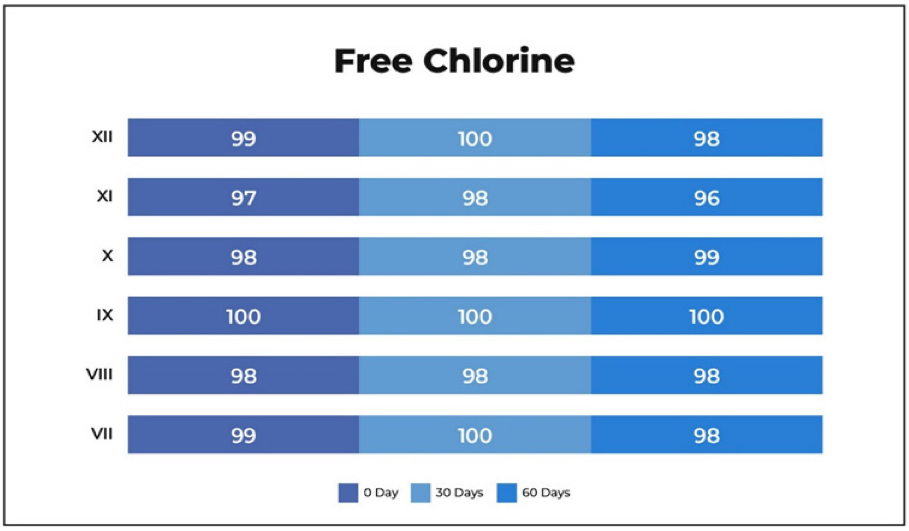

Figure 7. Purification efficiency of GAC and CTO elements from tap water; free chlorine unit is expressed in (mg $L^{-1}Cl_2$)

RO membranes are semi-permeable, with pore sizes less than 0.0001 micrometers (or less than 1 nanometer), allowing them to filter out dissolved salts and microorganisms [35]. Activated carbon filters, with surface areas ranging from 300 to 2000 m^2/g and pore sizes from 0.5 nm to several hundred nm, effectively reduce contaminants through adsorption. This process removes undesirable taste, odor, and color, as well as common disinfection byproducts (THMs), organic contaminants like chlorinated solvents, and other industrial pollutants [36].

These characteristics illustrate the unique strengths of each filtration method. Activated carbon filters are particularly effective at adsorbing larger organic contaminants, while RO membranes excel at removing dissolved salts and small charged molecules [37].

Chlorine removal is essential for improving the taste and odor of treated water. Activated carbon filters achieve this by reacting with chlorine molecules to form chloride ions, thereby eliminating residual chlorine. The process is rapid but requires a large surface area to maintain efficiency and prevent premature clogging, which would necessitate early filter replacement [38].

By efficiently removing impurities such as bacteria, chlorine, salts, sulphate, and dissolved solids, residential water filtration systems help prevent waterborne diseases. This study confirms that these systems adhere to WHO standards for drinking water, demonstrating their effectiveness in reducing chemical contaminants and improving water quality [38], [39].

For the statistical analysis presented in Table 3, a student’s t-test was applied to the means of two data groups to determine whether the differences between the data were significant. The analysis, conducted using Minitab, compared purified and unpurified water. The results revealed that all physicochemical parameters of the purified water were significantly improved compared to the unpurified water, confirming the effectiveness of household water filtration system components in reducing and eliminating organic contaminants. Overall, the Minitab analysis demonstrated that purified water was significantly cleaner, affirming its safety over unpurified water.

T-testing was not conducted for free chlorine samples (Membrane IX) due to equivalent standard deviation values in the purified water data, rendering the test inapplicable. Additionally, t-testing was not performed on the free chlorine sample (Membrane IX) because the purified water data consistently showed a value of zero, resulting in a predetermined significant outcome. A comparison between the raw data and the student’s t-test results further confirmed that purified water is superior to unpurified water.

Table 3. T-test values for the filters and membranes tested

Type	Properties	Unpurified Mean	Purified Mean	T-value	Data significance	Significant/Not significant
Membrane XIII	**chloride**	254.42	11.69	24.77	0.002	Significant
	sodium	146.07	8.60	24.13	0.002	Significant
	sulphate	15.57	0.28	131.15	<0.001	Significant
	TH	82.26	1.70	143.92	<0.001	Significant
	TDS	505.9	28.7	67.44	<0.001	Significant
Membrane XIV	**chloride**	254.05	14.00	31.99	0.001	Significant
	sodium	146.14	9.94	26.06	0.001	Significant
	sulphate	15.73	0.18	110.99	<0.001	Significant
	TH	82.38	0.46	285.32	<0.001	Significant
	TDS	505.9	32.00	64.50	<0.001	Significant
Membrane XV	**chloride**	254.05	13.80	34.05	0.001	Significant
	sodium	146.14	10.49	32.34	0.001	Significant
	sulphate	15.73	0.31	150.70	<0.001	Significant
	TH	82.38	0.53	340.60	<0.001	Significant
	TDS	505.9	24.70	54.80	<0.001	Significant
Membrane XVI	**chloride**	254.05	8.59	97.30	<0.001	Significant
	sodium	146.14	6.51	84.67	<0.001	Significant
	sulphate	15.7	0.56	34.10	0.001	Significant
	TH	82.38	0.72	256.70	<0.001	Significant
	TDS	505.9	29.00	84.40	<0.001	Significant
Membrane XVII	**chloride**	254.05	8.78	70.94	<0.001	Significant
	sodium	146.14	6.87	66.30	<0.001	Significant
	sulphate	15.7	0.03	150.46	<0.001	Significant
	TH	82.38	0.18	601.28	<0.001	Significant
	TDS	505.9	20.00	85.06	<0.001	Significant
Membrane XVIII	**chloride**	254.05	7.66	69.46	<0.001	Significant
	sodium	146.14	6.75	73.39	<0.001	Significant
	sulphate	15.73	0.41	68.09	<0.001	Significant
	TH	82.38	0.60	236.98	<0.001	Significant
	TDS	505.9	21.70	62.70	<0.001	Significant

Type	Membrane Properties	Unpurified Mean	Purified Mean	T-value	Data Significance	Significant/Not significant
Filter VII	**Free chlorine**	1	0.02	N/A	N/A	N/A
Filter VIII			0.02	N/A	N/A	N/A
Filter IX			0	N/A	N/A	N/A
Filter X			0.01	88.68	<0.001	Significant
Filter XI			0.03	80.61	<0.001	Significant
Filter XII			0.01	82.26	<0.001	Significant

* The units for all these properties—chloride, sodium, sulphate, TH, and TDS—are expressed in mg L^{-1}, while free chlorine is expressed in mg $L^{-1}Cl_2$.

The results of this study were compared with those obtained in other regions, as shown in **Table 4**, and were found to align with WHO standards. This alignment underscores the high efficacy of the POU systems examined in removing contaminants from drinking water in Saudi Arabia.

Moreover, the coefficient of determination (r^2) for the target ions exceeded 0.995, demonstrating excellent linearity in accordance with analytical method validation principles. These principles, such as those outlined in the International Conference on Harmonisation (ICH) Q2(R1) guideline, emphasize the importance of high correlation coefficients to establish method suitability [40].

Table 4. Comparison of findings with previous international studies

City/Country	Parameters and Results	Reference
China	pH: (6.50–7.86) DO: 4.62–5.58 mg L^{-1} Mean value of hardness: 74.54 mg L^{-1} Hardness removal rates: > 97% Mean conductivity: 254.5 µS cm^{-1}	[41]
Iran	pH: (0.2–1.9) Hardness: (28–115) mg L^{-1} Sodium: (20–160) mg L^{-1} Chloride (30–200) mg L^{-1} Sulfate: (20–100) mg L^{-1}	[42]
Kerman	pH: (6.60) Sodium: 28 mg L^{-1} Chloride: 12.01 mg L^{-1} Sulphate: 0.3 mg L^{-1}	[8]
Saudi Arabia	pH: (7.24–7.84) Hardness: (0.45–2.84) mg L^{-1} Chloride: (7.65–17.29) mg L^{-1} Sodium: (6.50–11.07) mg L^{-1} Sulphate: (0.037–0.55) mg L^{-1}	**[Present study]**

FUTURE WORK

This study acknowledges several limitations. A notable constraint is the exclusive focus on POU household water purification systems, without incorporating UV treatment, which is highly effective in eliminating the majority of waterborne viruses and bacteria. Additionally, the research was conducted using a limited sample size, focusing on high-quality cotton, activated carbon, and reverse osmosis filters. While the sample size is small, the findings of this study are robust enough to provide valuable insights and a comprehensive overview of POU systems.

Further research is recommended to optimize filter designs and materials for more efficient and cost-effective removal of contaminants prevalent in Saudi Arabia's water sources. Moreover, future studies should investigate the long-term impact of filter usage on performance and the potential leaching of contaminants.

CONCLUSIONS

This study investigated the efficacy of commercially available PP cotton, activated carbon (GAC/CTO) filters, and RO membranes in improving the quality of household drinking water in Saudi Arabia, considering sensory, physical, and chemical parameters. The findings demonstrated that activated carbon filters effectively removed free chlorine from tap water, achieving removal efficiencies exceeding 94%. Additionally, RO membranes significantly reduced levels of several key contaminants, including chloride, sodium, sulphate, and total hardness, with removal efficiencies exceeding 92%.

Tap water subjected to filtration with both activated carbon and RO membranes exhibited no discernible color or odor. However, RO membranes were found to lower the pH of purified water compared to tap water. While activated carbon filters are cost-effective, their effectiveness is limited to the removal of free chlorine and some dissolved organic matter. In contrast, RO membranes, though more expensive and requiring high water pressure, provide superior contaminant removal capabilities.

The findings of this study highlight the effectiveness of commercially available filters in addressing specific water quality concerns in Saudi Arabia. Activated carbon filters are particularly effective for chlorine removal, while RO membranes offer a broader spectrum of purification, significantly reducing contaminants such as chloride, sodium, sulphate, and total hardness. By carefully selecting and maintaining appropriate filters based on specific water quality concerns, households can significantly enhance the safety and palatability of their drinking water.

The adoption of POU systems has gained popularity as a practical solution for communities and individuals without access to clean water, enabling them to purify water at home. These systems are compact, easy to install, and user-friendly.

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NOMENCLATURE

Abbreviations	Definition
AC	Activated carbon
DPD	N, N-diethyl-p-phenylenediamine
EC	Electron conductivity
ICS	Ion chromatography system
MF	Microfiltration
NF	Nanofiltration
pH	Power of hydrogen
PP	polypropylene
POU	Point of use
RO	Reverse osmosis
TDS	Total dissolved solids
TH	Total hardness
THMs	Trihalomethanes
UF	Ultrafiltration
VOCs	Volatile organic compounds
WQI	Water Quality Index
WHO	World health organization

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