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THE EFFECT OF DOMESTIC WATER FILTER TYPES ON THE QUALITY OF DRINKING WATER

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Abstract

Water pollution and contamination give rise to significant health risks for humanity. As the global population swells and industries expand, the demand for safe drinking water continues to flow. Water filtration systems, such as reverse osmosis filters, effectively eliminate contaminants from the water. During an experimental study, we assessed and compared four widely-used brands of home water filters (reverse osmosis systems). Each home water filter system was subjected to analysis across seven parameters. In the majority of cases, the physicochemical parameters examined remained within acceptable limits as agreed by the World Health Organization. This study included the measurement of various parameters, including hydrogen ion potential, temperature of water, water turbidity, color, specific conductance, total dissolved solids, and total hardness. These measurements were taken both before and after the application of the filters to all samples. The percentage reduction in each parameter was calculated by comparing the readings before and after treatment. Among the four brands examined in this research, the RO_1-CLASS and RO_2-PURERITEK brands exhibit greater performance in the context of reverse osmosis membrane purification systems, particularly those employing six-stage filter media.

Keywords: Water quality, Reverse Osmosis, Filtration system, Physicochemical parameters, Pollutants.

تأثير أنواع مرشحات المياه المنزلية على جودة مياه الشرب

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الخلاصة

يؤدي تلوث المياه وتلوثها إلى مخاطر صحية كبيرة على البشرية. مع تضخم عدد سكان العالم وتوسع الصناعات، يستمر الطلب على مياه الشرب الآمنة في التدفق. تعمل أنظمة تنقية المياه، مثل مرشحات التناضح العكسي، على إزالة الملوثات من الماء بشكل فعال. خلال دراسة تجريبية، قمنا بتقييم ومقارنة أربع علامات تجارية مستخدمة على نطاق واسع لمرشحات المياه المنزلية (أنظمة التناضح العكسي). تم إخضاع كل نظام لتصفية المياه المنزلية للتحليل عبر سبع معايير. وفي معظم الحالات، ظلت المعايير الفيزيائية والكيميائية التي تم فحصها ضمن الحدود المقبولة على النحو المتفق عليه من قبل منظمة الصحة العالمية. تضمنت هذه الدراسة قياس عوامل مختلفة، بما في ذلك جهد أيون الهيدروجين، ودرجة حرارة الماء، وتعكر الماء، واللون، والتوصيل النوعي، والمواد الصلبة الذائبة الكلية، والصلابة الكلية. تم أخذ هذه القياسات قبل وبعد تطبيق المرشحات على جميع العينات. تم حساب النسبة المئوية للتقليل في كل معاملة من خلال مقارنة القراءات قبل وبعد العلاج. من بين العلامات التجارية الأربع التي تم فحصها في هذا البحث، اظهرت العلامات التجارية RO_1–CLASS و RO_2–PURERITEK أداءً أكبر في سياق أنظمة تنقية غشاء التناضح العكسي، لا سيما تلك التي تستخدم وسائط مرشح سداسية المراحل.

كلمات مفتاحية: نوعية المياه، التناضح العكسي، نظام الترشيح، المعايير الفيزيائية والكيميائية، الملوثات.

Introduction

Water is a vital element for human survival, agriculture, and industry (15). Unfortunately, the pollution of both surface and groundwater has increased due to various human activities, such as agriculture, urbanization, and industrialization (1). The water we consume daily must be devoid of any pollutants, including chemicals or organisms that could impact our health and overall quality of life (16). In recent years, consumers have focused on the security of their tap water due to the increasing number of grumbles of water contamination. In the past, consumers utilized the provided water without any doubts. A domestic water purification system is necessary for consumers to enhance public health and relate to pollution of water (5). A filter of water is an instrument than removes contaminants from water by method of a good physical obstruction, chemical operation and/or biological process. The predominant and extensively employed method for water purification is the Reverse Osmosis (RO) technique, which employs a semi-permeable membrane to eliminate ions, molecules, and larger particles from water sources. The reverse osmosis purified water is employed for drinking, cooking, and ice-making, resulting in enhanced flavor and health advantages (2). Reverse osmosis technology proves highly effective in the removal of water pollutants. Currently, this technology provides a guarantee in numerous magnitudes of drinking water safety, encompassing factors like water quality, water quantity, and emergency water supply (8). In the recent past, due to its compact nature, simplicity, and improved effluent quality, reverse osmosis has emerged as a favorable option for small and medium-sized water treatment facilities (processing 50-1000 m^3 d^{-1}). It is being increasingly chosen for treating surface water contaminated with poisonous substances and underground water sources with elevated iron content and hardness. Numerous have been researches conducted to assess the overall performance of water filtration systems and these studies have shown high removal rates of water quality parameters (4, 7, 9, 11 and 12). The objectives of this study were to investigate how four different brands of Reverse Osmosis (RO) systems affect the removal of various impurities, differentiate purified water based on physicochemical parameters using sensory evaluation techniques, and assess consumer acceptance of the purified water.

Materials and Methods

Collection of water samples: The investigation was conducted on water samples obtained from four different domestics from one region with four different brands of Reverse osmosis (RO) systems includes RO_1 (CLASS-Brand) 6-stage filtration technology, RO_2 (PURERITEK-Brand) 6-Stages with stand and Gauge meter, RO_3 (DOW-Brand) 6-Stage water filter reverse osmosis RO and RO_4 (COMTECH WATER SYSTEM-Brand) 6-Stage mineral under-sink reverse osmosis. The water used in the filtration system is derived from both tap water and well water sources. The sample R_1, R_3, and R_4 were collected from tap water while, only one sample (R_2) was collected from well water. Two type of water samples was tested which are ((original water) the tap water before entering the filter system, and the filtered water). A total of eight water samples were collected from four dissimilar households (located in Sulaymaniyah city, specifically Bazyan, Twymalek, Bakrajo, and Shary Spy) during July 2023. These samples included four collected before passing through the RO filtration process and four collected after. Water is permitted to run for a few minutes before collecting the sample. One-liter quantities of both treated and untreated water samples were collected and placed into either plastic bottles (polyethylene) or glass bottles that had undergone two prior rinses with deionized water. These samples were then stored in an icebox to sustain a temperature of approximately 4 $^{\circ}$C. Following the collection process, the samples were promptly transported to a laboratory. Subsequent analyses were conducted at the soil chemistry laboratory, which is part of the College of Agricultural Engineering Sciences within the Department of natural resources.

Method of test and analysis instruments: We measured the physical and chemical characteristics of water samples both before and after employing filters. The specific parameters we examined involved hydrogen ion potential (pH), temperature of water, water turbidity, color, specific conductance (EC), total dissolved solids (TDS), and total hardness. We followed the guidelines outlined in the "standard methods for the examination of water and wastewater" (10) for the procedures related to sampling, preservation of sample, and laboratory analysis. Table 1 provides a comprehensive list of the methods and equipment utilized during the water sample testing.

Percentage removal: Based on the result obtained, the percentage removal was calculated by using the following formula.

$$\text{Percentage removal} = \frac{\text{Value befor treatment} - \text{Value after treatment}}{\text{Value befor treatment}} * 100$$

Table 1: Apparatus utilized in the research.

Apparatus	Model	Analysis
pH meter	Metrohm, pH Lab 827	pH measure
EC meter	LF318	Measure of EC and temperature
Turbidity meter	PHoto Flex Turb.	Turbidity measure
photo Lab spectral	82362 Weilheim	Measure of color and total hardness

Results and Discussion

The results obtained from the physicochemical analysis of domestic water samples, both before and after employing filtration systems, are presented in (Table 2).

pH is a significant parameter in various applications and industries. In terms of water quality, pH can affect the taste, corrosion potential, and effectiveness of disinfection processes. It also plays a role in the health and survival of aquatic organisms. The pH values of water samples before filtration ranged from 6.83-6.98. After filtration, the pH values in the water samples varied between 7.16-7.62. The observed increase in pH is likely a result of removing certain impurities that contribute to acidity and the dynamic interplay of the carbon dioxide-bicarbonate-carbonate equilibrium system, which is a common occurrence in many natural water treatment processes (6). The World Health Organization (17) recommended a pH range of 6.5-8.5 as the guideline for pH values in drinking water.

The value of water temperature in the water samples is observed between 19-20.5 ^{o}C before filtration. Whereas, after using water filters, the water temperature values varied between 19-20 ^{o}C. Water temperature can significantly impact various natural processes and ecosystems. It influences the distribution of aquatic species, affects the rate of chemical reactions in the water, and plays a crucial role in weather patterns. Additionally, water temperature is essential for understanding aquatic habitats and the overall health of aquatic environments. In the aquatic environment, temperature plays a vital role, exerting significant influence based on physicochemical and biochemical characteristics (13). Temperature has a predominant influence on nearly all biological reactions and physicochemical equilibriums, as highlighted by (3).

The color values of water samples ranged from 5-14.4 Hazen units before filtration. After using water filters, the color values varied between 0.2-4.1 Hazen units. Following the World Health Organization (17), color levels below 15 true color units (TCU) are generally considered acceptable to consumers.

The visual appearance of water, determined by dissolved or suspended substances, is referred to as its color. It plays a vital role as an indicator of water quality since particular colors can reveal the presence of pollutants or natural substances. Regularly monitoring and analyzing water color is vital for assessing the well-being of aquatic ecosystems and establishing whether the water is fit for drinking, recreation, and industrial uses. While the presence of color in drinking water may have indirect associations with health, its primary significance in drinking water relates to aesthetic considerations. Coloration can arise from natural geological sources or serve as a potential indicator of drinking water contamination.

Table 2: Values of the physicochemical parameters of the water analyzed.

Parameters	Filter name	Before filtration	After filtration	% Removal	WHO standard (17)
pH	RO_1 (CLASS water purifier)	6.98	7.62	-	6.5-8.5
	RO_2 (PURERITEK)	6.92	7.25	-	
	RO_3 (DOW)	6.83	7.16	-	
	RO_4 (COMTECH WATER SYSTEM)	6.94	7.21	-	
Temperature (ºC)	RO_1 (CLASS water purifier)	20.5	20	-	25
	RO_2 (PURERITEK)	19	19	-	
	RO_3 (DOW)	20.4	20	-	
	RO_4 (COMTECH WATER SYSTEM)	20	20	-	
Color (Hazen unit)	RO_1 (CLASS water purifier)	5	0.2	96	15
	RO_2 (PURERITEK)	14.4	0.2	98.61	
	RO_3 (DOW)	6.2	0.2	96.77	
	RO_4 (COMTECH WATER SYSTEM)	7.2	4.1	43.05	
Turbidity (NTU)	RO_1 (CLASS water purifier)	0.35	0.01	97.14	5
	RO_2 (PURERITEK)	0.41	0.01	97.56	
	RO_3 (DOW)	0.24	0.01	95.83	
	RO_4 (COMTECH WATER SYSTEM)	0.15	0.01	93.33	
EC (μS cm^{-1})	RO_1 (CLASS water purifier)	370.91	8.6	97.68	1500
	RO_2 (PURERITEK)	344.89	46.39	86.55	
	RO_3 (DOW)	357.91	60.72	83.03	
	RO_4 (COMTECH WATER SYSTEM)	343.9	107.1	68.86	
TDS (mg L^{-1})	RO_1 (CLASS water purifier)	366	9	97.54	1000
	RO_2 (PURERITEK)	356	45	87.36	
	RO_3 (DOW)	362	61	83.15	
	RO_4 (COMTECH WATER SYSTEM)	360	108	70	
Total Hardness (mg L^{-1})	RO_1 (CLASS water purifier)	169	60	64.5	500
	RO_2 (PURERITEK)	151	46	69.54	
	RO_3 (DOW)	165	34	79.39	
	RO_4 (COMTECH WATER SYSTEM)	175	39	77.71	

The current study's results revealed differences in color removal among the four different brands of RO filters (Table 2) and Figure 1. The RO_2 (PURERITEK-Brand) demonstrated the highest performance in color removal, achieving an impressive

98.61% removal from the well water sample, providing colorless drinking water suitable for human consumption. The RO_3 (DOW-Brand) filter exhibited good color removal, reaching 96.77%, followed by the RO_1 (CLASS-Brand) filter at 96% for tap water samples. However, the RO_4 (COMTECH WATER SYSTEM-Brand) filter showed poor performance in color removal, with less than 50% efficiency.

Turbidity refers to the cloudiness or haziness of a liquid due to the presence of suspended particles, including fine sediment, clay, silt, organic matter, and microscopic organisms. It quantifies the way light is scattered and absorbed by these particles in the water. In water treatment plants, turbidity can be eliminated through processes like filtration, sedimentation, and clarification. These methods help ensure cleaner and clearer water for various applications. Prior to filtration, the water samples had turbidity levels ranging from 0.15-0.35 NTU. Nevertheless, after undergoing filtration, both the treated well water and tap water showed a remarkable decrease in turbidity, reaching a consistent measurement of only 0.01 NTU across all four filters tested. All treatment methods exhibited excellent turbidity removal, with all achieving above 90% removal. Among them, the RO_2 (PURERITEK-Brand) proved to be the most effective, achieving a remarkable 97.56% turbidity removal from the well water sample. The RO_1 (CLASS-Brand), RO_3 (DOW-Brand), and RO_4 (COMTECH WATER SYSTEM-Brand) filters also showed positive results, removing turbidity at rates of 97.14%, 95.83%, and 93.33% respectively. As a result of these filtration methods, the turbidity in all filtered water samples, including tap water and well water, was reduced to less than 0.01 NTU, which aligns with the acceptable drinking water quality standards set by WHO at 5 NTU. Figure 2 graphically displays the turbidity removal efficiencies of the four filters tested, revealing that all four filters performed similarly in effectively removing turbidity.

Water's electrical conductivity (EC) pertains to its capacity to conduct an electric current, which is determined by the presence of dissolved ions, minerals, and other substances. This property measures the water's ability to carry electrical charges, and it is influenced by the concentration and mobility of charged particles within the water. The conductivity of water samples without water filters ranged from 343.90-370.91 $\mu S\ cm^{-1}$, while with water filters, it varied between 8.60-107.10 $\mu S\ cm^{-1}$. Elevated EC levels may indicate the presence of increased concentrations of dissolved salts, minerals, or pollutants in the water. The decrease in EC levels observed in this study can be ascribed to the reduction of water ions during the reverse osmosis treatment process. The results from this study revealed discrepancies in the removal of EC among various brands of RO filters. However, the RO_1 (CLASS-Brand) filter demonstrated an impressive removal rate of 97.68% of EC in tap water (Table 2) and Figure 3. In comparison, the RO_2 (PURERITEK-Brand) achieved 86.55% EC removal from the well water sample, followed by the RO_3 (DOW-Brand) system at 83.03%, and the RO_4 (COMTECH WATER SYSTEM-Brand) filter at 68.86% removal.

Total Dissolved Solids (TDS) typically refers to the quantification of all inorganic and organic components present in a liquid solution, typically water. It includes the collective sum of ions, minerals, salts, metals, and other dissolved substances present in the water. Before filtration, the water samples exhibited a maximum TDS value of

366 mg L^{-1} and a minimum value of 356 mg L^{-1}. However, after filtration, the TDS values in the study area ranged from (9-108) mg L^{-1}. All samples showed a TDS level lower than the WHO standard of 1000 mg L^{-1}. The results of this investigation demonstrate that the RO_1 (CLASS-Brand) and RO_2 (PURERITEK-Brand) exhibit the highest percentage removal of TDS in both tap water and well water samples, indicating their larger performance. RO_1 (CLASS Model) is the most effective treatment method in removing TDS from water at 97.54%. This is followed by RO_2 (PURERITEK-Brand), RO_3 (DOW-Brand) system, and RO_4 (COMTECH WATER SYSTEM-Brand) at 87.36%, 83.15%, and 70% removal respectively Figure 4.

The presence of calcium and magnesium causing hardness is typically evidenced by the formation of soap scum and the requirement for an excessive amount of soap to attain effective cleaning (17). The hardness of water primarily depends on the presence of calcium, magnesium salts, or a combination of the two. The assessment of total hardness (TH) in the water under investigation revealed values ranging from 151-175 mg L^{-1} before filtration, as indicated in (Table 2) and Figure 5. However, after filtration, the TH values within the research area ranged from 34-60 mg L^{-1}. Low levels of hardness are not suitable for drinking water; however, they are highly suitable for industrial applications. The mineral content in hard water can readily contribute to the formation of calculi and other related health issues. The values for all samples were below the recommended limit of 500 mg L^{-1} set by the WHO. The results from the current study demonstrate that the removal efficiency of total hardness by four different brands of RO filter drinking water treatment systems was as follows: 64.5%, 69.5%, 79.4%, and 77.7%, respectively (Table 2). All brands of RO filters give a good percentage removal of TH at above 50% removal. RO technology can effectively remove hardness. A proposed elucidation regarding hard water is that the heightened usage of soap in such water leads to the deposition of detergent salt remains or metal on the skin (or on garments). These residues are resistant to thorough rinsing and consequently contribute to skin irritation upon contact, as observed by (14). Furthermore, the decrease in TH values within the water sample could be attributed to the adsorption of calcium and/or magnesium ions by various brands of RO filters, as suggested by (18).

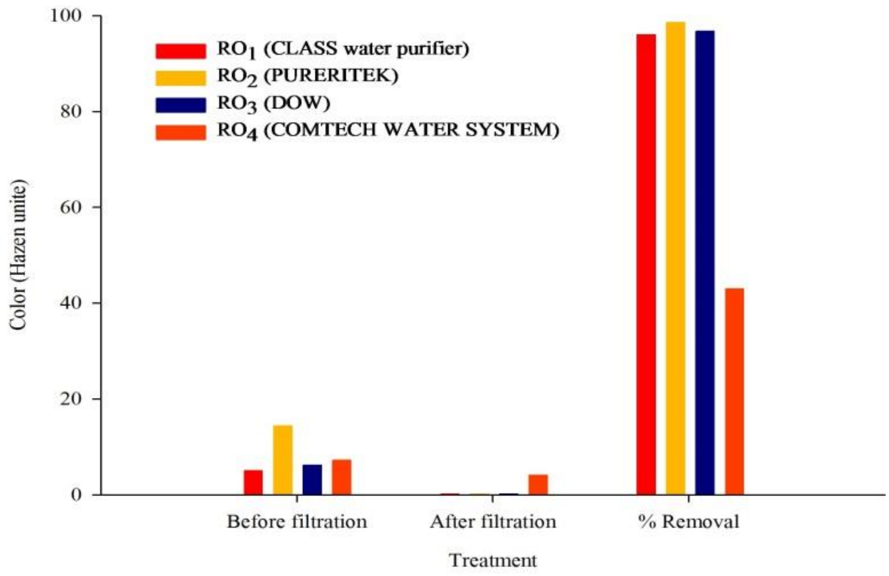

Figure 1: Percentage removal of color for different brands of RO filters.

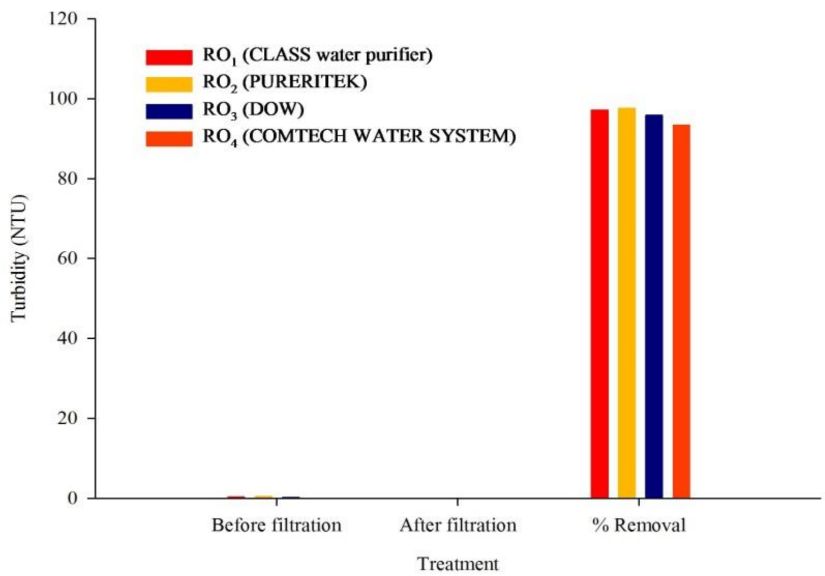

Figure 2: Percentage removal of Turbidity for different brands of RO filters.

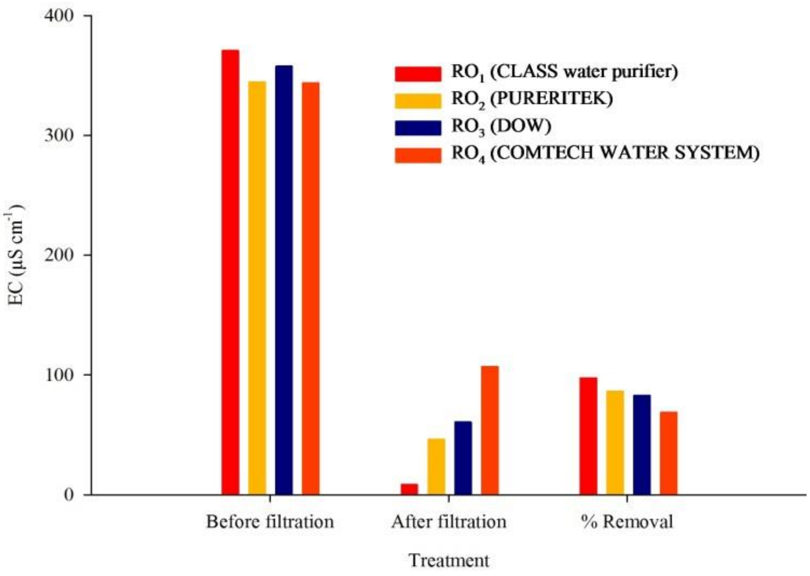

Figure 3: Percentage removal of EC for different brands of RO filters.

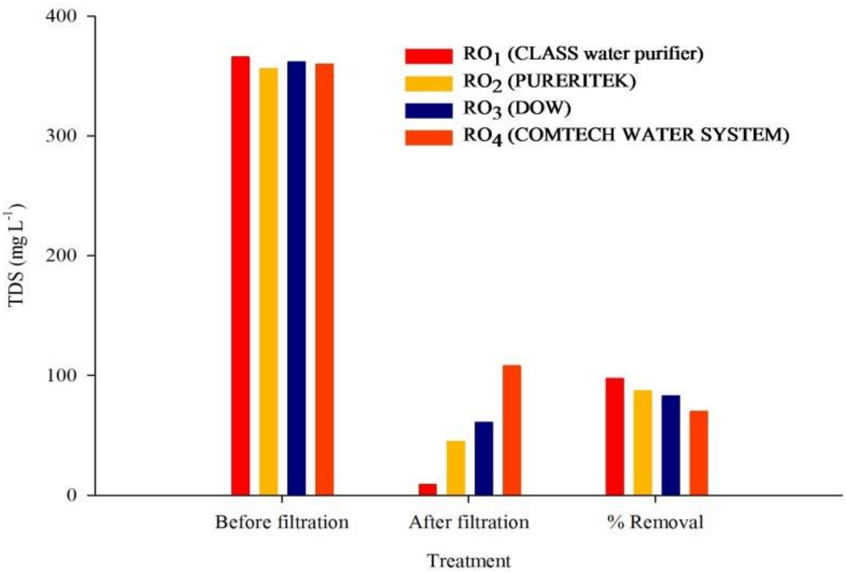

Figure 4: Percentage removal of TDS for different brands of RO filters.

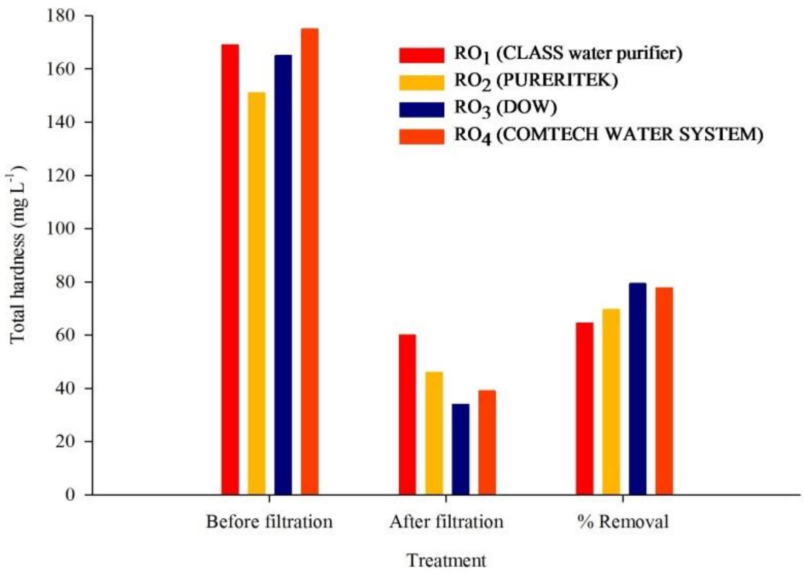

Figure 5: Percentage removal of total hardness for different brands of RO filters.

Conclusions

The operation of reverse osmosis membrane segregation technology for drinking water serves as an effective solution to alleviate the pressure stemming from water pollution and resource scarcity. In the contemporary landscape, a significant number of consumers express dissatisfaction with the quality of tap water provided, largely due to pervasive water contamination issues across the country. Numerous consumers encounter challenges such as turbidity, discoloration, and unpleasant taste and odor. Among the four brands examined in this research, the RO_1-CLASS and RO_2-PURERITEK brands exhibit greater performance in the context of reverse osmosis membrane purification systems, particularly those employing six-stage filter media. The evaluation of each household water filter system's quality and efficiency can be deduced from the utilization patterns of the filter media within each system.

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Author 1; methodology, writing—original draft preparation, Author 2 writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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