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Original Article

Evaluation of Multi-Coloured Filter Containers for Water Quality

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Abstract *- This study examines the effectiveness of multi-coloured filter containers, black (BK), blue (BL), and transparent (TR), in improving water quality, focusing on indicators such as turbidity, Total Suspended Solids (TSS), pH, electrical conductivity, total alkalinity, calcium, and iron. The investigation aims to determine whether container colour impacts filtration performance. Water samples were drawn from a shallow, untreated well at the Federal Polytechnic, Ado Ekiti, known for poor water quality and contaminant levels exceeding WHO standards, providing an ideal source for testing filtration efficacy. Identical filter media were installed in each container to ensure consistency, and samples were periodically tested over time. Results indicated that the blue (BL) container provided the most effective overall filtration, demonstrating superior turbidity reduction and stable water quality improvements. Black and transparent containers showed effectiveness in specific areas but were generally less consistent than blue ones. These findings suggest that container colour, likely influenced by factors such as light transmission, impacts filtration outcomes. The study concludes that blue containers offer the best performance for enhancing water quality, and future research should explore additional colours and materials to improve contaminant removal further and achieve reliable water quality standards.*

Keywords *- Multi-coloured containers, Filters, Filtration, NSDWQ.*

1. Introduction

Access to clean drinking water is essential for health, yet contaminants like heavy metals, bacteria, and chemicals threaten water quality worldwide. Growing awareness of pollutants has led more people to adopt home water filtration systems to ensure safer water [1], [2]. Water filtration systems ensure clean and safe drinking water in households. While their primary function is to purify, modern designs now emphasize aesthetics, making these systems a seamless addition to contemporary home settings. Multi-coloured filter containers, especially in black, blue, and transparent variants, enhance both functionality and visual appeal, creating a perfect balance between practicality and style. These containers come in a variety of hues to suit different tastes and settings. Black offers a sleek, minimalist look that complements modern and industrial décor styles. Blue adds a vibrant and refreshing touch, often associated with water and cleanliness, making it a popular choice for brightening up kitchens or utility spaces. Transparent containers allow users to view water levels and observe the filtration process, merging elegance with functionality. Whether used to match interior themes or to serve as eye-catching additions, these filter containers elevate the overall aesthetic of water filtration systems, making them both practical and stylish for everyday use.[3] [4]. Different colours can help distinguish between various filter types or stages of filtration (e.g., pre-filters, activated carbon, or reverse osmosis systems). This makes maintenance and troubleshooting more intuitive for users.[5]. For households with children, vibrant multi-coloured filters can make water filtration systems more engaging. They may foster curiosity about water cleanliness and environmental sustainability, making them ideal for households needing a user-friendly solution to maintain water quality [6]. Multi-coloured containers are often made from durable, BPA-free plastics or tempered glass with coloured coatings. These materials ensure longevity and resistance to wear while retaining their aesthetic appeal.[1], [7]. Modern designs often emphasize sustainability with eco-friendly materials and production methods. This research systematically evaluates three multi-coloured filter containers for their effectiveness in improving water quality. It analyzes key parameters, such as turbidity, total suspended solids, pH, and specific contaminants, before and after filtration. Testing over 45 days aims to assess both initial and sustained filtration performance. By using a controlled water sample, the study ensures consistent testing conditions across all containers, aiming to determine the optimal colour filter for effective water treatment. Water scarcity and contamination remain urgent global issues, with millions still lacking access to safe drinking water [8] [9]. The study is expected to significantly advance understanding of colour-based filtration container methods and their impact on water quality as there are relatively few studies on them. Studies investigating the impact of multi-colored filter containers on water quality are limited. These findings could inspire further research into alternative materials and filtration technologies, expanding the range of accessible water treatment options worldwide.

2. Theoretical Background

2.1. Previous Research on Water Quality and Filtration Effectiveness

Research on water filtration efficiency has extensively explored technologies aimed at improving water quality by removing contaminants like heavy metals, pathogens, and organic compounds[10], [11], [12]. These studies provide foundational insights into the strengths and limitations of different filtration materials and designs, guiding the development of more effective systems.

Activated carbon is widely recognized for its high efficacy in adsorbing organic compounds, chlorine, and VOCs, often responsible for unpleasant tastes and odors in water [13], [14]. Pandang et al. (2023) found that activated carbon filters can remove up to 95% chlorine and certain organics. However, they are less effective against heavy metals and nitrates, necessitating additional filtration stages.

Ceramic filters have proven highly effective in removing microbial contaminants such as bacteria and protozoa, particularly in rural areas [15], [16] Ko. (2021) found ceramic filters removed up to 99% of bacterial contaminants. However, they may not effectively capture viruses or chemicals, limiting their scope.

Reverse osmosis (RO) systems are among the most effective for removing a broad range of contaminants, including heavy metals and salts, with studies by Hama Salih & Ahmad (2024) showing up to 99% removal rates for lead, mercury, and arsenic. Nevertheless, RO systems are energy-intensive and produce significant wastewater, raising environmental concerns.

Multi-stage filtration systems, which combine activated carbon, ion exchange, and RO, have become popular for household use due to their comprehensive contaminant removal. Liu et al. (2018) showed that these systems effectively reduce heavy metals, sediments, pathogens, and chemicals, though they may increase costs and maintenance needs.

UV and chemical disinfection add an extra layer of safety, particularly in microbial contamination zones. Zhang and Wang (2021) found UV effective against bacteria and viruses, while chlorine is commonly used despite its impact on water taste. Colour-coded filtration systems remain under-researched, though Akhtar et al. (2022) suggest they may simplify maintenance, improving user compliance and filter longevity. Further studies are needed to confirm their long-term efficiency in diverse settings.

3. Materials and Method

3.1. The materials used for the research include:

3.1.1. Filter Containers

Three containers of different colours, black (BK), blue (BL), and transparent (TR) (1 foot long), were used to assess the impact of container colour on water quality improvement. Each container had the same volume and structural characteristics to ensure consistency across testing.

3.1.2. Uniform Filter Media

Identical layers of filter media (5-micron filter) were placed within each container. These layers were chosen for their effectiveness in removing particulates, reducing turbidity, and influencing other physicochemical properties of the water.

3.1.3. Water Sample Source

Water was collected from a shallow, covered well at the Federal Polytechnic, Ado Ekiti campus, known for its unhygienic condition, providing an ideal sample to test the filtration containers.

3.1.4. Measurement Instruments

- **pH Meter**: A calibrated digital Hanna pH meter was used to measure the acidity or alkalinity of each water sample.
- **Turbidity Meter**: A turbidity meter, HACH DR 900 Colorimeter, recorded the clarity of the water in FAU (Formazin Attenuation Unit (1 FAU= 1 NTU) (Nephelometric Turbidity Units).
- **Colourimeter (Hach DR 900)**: This device measured concentrations of specific chemicals, like iron, by adding reagents to each water sample.
- **TSS Analyzer**: A Total Suspended Solids (TSS) analyzer or filtration setup was used to determine the amount of solid particles left in the water after filtration.
- **Conductivity Meter**: This instrument measured electrical conductivity, providing information about the ion concentration in the water.

3.1.5. Reagents

Used with the colourimeter to test for specific chemical concentrations, such as iron, in each water sample.

3.2. Methods

For this research, three containers, black (BK), blue (BL), and transparent (TR), were selected to examine the effect of container colour on water quality improvement. Each container’s volume and structural characteristics were identical, ensuring consistency across conditions. Uniform filter media were installed in all containers, with layers chosen for their capacity to remove particulates, reduce turbidity, and influence various physicochemical parameters. All materials were bought at the open market within the Ado Ekiti Metropolis. Water samples were sourced from a shallow well on the Federal Polytechnic, Ado Ekiti campus.

This well, known for its poor water quality, provided a suitable test sample to evaluate the containers' effectiveness in enhancing water quality. Baseline measurements of pH, turbidity, Total Suspended Solids (TSS), conductivity, and specific contaminants like iron and calcium were recorded before filtration, serving as reference points for assessing improvements. A calibrated digital pH meter was used for acidity levels to measure these parameters, and a turbidity meter (nephelometer) recorded water clarity in NTU units.

The Hach DR 900 colourimeter measured chemical concentrations by adding reagents to each sample, while a TSS analyzer assessed the amount of solid particles remaining post-filtration. Electrical conductivity was measured to understand ion concentration. Following the initial assessment, equal volumes of water were filtered through each container, with samples collected at set intervals (Day 1, 7, 14, and 45) to observe changes over time. Laboratory equipment tested each post-filtration sample for pH stability, turbidity, TSS, conductivity, and iron levels, providing insights into the filtration efficiency of each container colour.

3.3. Sampling Procedure

The Record was made of the source water's initial water quality parameters (pH, turbidity, TSS, conductivity, and specific contaminants), as seen in Table 1. Equal volumes of water were passed through each coloured container. Filtrate was collected at predetermined intervals (e.g., Day 1, Day 7, Day 14, etc.) to observe changes over time. Laboratory instruments were used to test each sample post-filtration.

- For pH analysis: The pH of each sample was measured and recorded to determine if the container colour influences pH stability.

- Turbidity: The turbidity was assessed to determine the clarity and particulate removal efficiency of each container.

- TSS: The TSS was determined by filtering the sample and weighing the remaining solids.

- Conductivity: This was achieved to determine ion concentration, giving insight into the dissolved solids remaining after filtration. Iron and Other Chemicals: A HACH DR 900 Colourimeter was used to measure concentrations of specific chemicals, like iron, by adding reagents to each sample as needed.

Plate 1. Water filtration set-up

Plate 2. Source of water supply

Plate 3. Part of the laboratory analysis

3.4. Removal Efficiency Calculation

The Removal Efficiency in percentage (%) by the mathematical formula:

Removal Efficiency

$$RE = \frac{(C_O - C_e)}{C_O} \times 100\%$$

C_0 = The quality of the raw sample before filtration

C_e = The quality of the filtrate after passing through filters in containers of different colours (Method as adopted from [17]

4. Results and Discussion

4.1. Initial Water Quality Measurements

The initial water quality measurements provide a baseline assessment of key parameters in untreated water samples, establishing a foundation for analyzing the effectiveness of any filtration or treatment method applied. This baseline assessment includes turbidity, Total Suspended Solids (TSS), pH, Electrical Conductivity (EC), total alkalinity, calcium (Ca), and iron (Fe), among others, as indicators of water purity, chemical stability, and safety for consumption. The field turbidity value is 41 FAU, surpassing the NSDWQ (2007) guideline of 5.00–15.00 FAU [18]. This high turbidity suggests a substantial amount of suspended particles, possibly including contaminants, which reduces water clarity and may harbor pathogens.

The measured Total Suspended Solids (TSS) is 34 mg/L, below the WHO limit of 50 mg/L. TSS includes particles like sediment and silt. Though within the acceptable range, high TSS can affect aesthetics and filtration efficiency.The recorded pH is 6.7, fitting within the WHO-recommended 6.5–8.5 range, indicating acceptable acidity for drinking water without immediate risk of corrosion or imbalance. Electrical Conductivity (EC) is 2.5 µS/cm, slightly above the WHO standard of 2 µS/cm, suggesting minimal presence of dissolved salts, which may slightlyimpact taste. Total Alkalinity is 115 mg/L, within the WHO limit of 150 mg/L, reflecting stable pH and good buffering capacity.The calcium level is 132 mg/L, well above the WHO guideline of 0.003 mg/L, contributing to water hardness and potential scale buildup. Iron measures at 0.87 mg/L, exceeding the WHO limit of 0.3 mg/L, which can lead to discolouration, metallic taste, and staining and may also promote iron bacteria growth.

Table 1. Results of the raw well water quality before subject to treatment

S/n	Parameters	Unit	Field Values	WHO
1	Turbidity	FAU	41	5.00 – 15.00
2	TSS	mg/l	34	50
3	pH		6.7	6.5 – 8.5
4	EC	us/cm	2.5	2
5	T. Alkalinity	Mg/l	115	150
6	Ca	Mg/l	132	0.003
7	Fe	Mg/l	0.87	0.3

4.2. Water Quality Reaction in Different Containers Over Time

4.2.1. Turbidity Reaction in Containers Over Time

As Observed from Figure 1 above. Initially, all samples exceeded the standard, with BL at 25 NTU, BK at 41 NTU, and TR at 30 NTU. By Day 4, BL and BK reduce to 1 NTU, maintaining this level well within the standard for the entire period. TR reduces to 17 NTU by Day 4, reaching compliance by Day 7, but fluctuates slightly on Days 21, 25, 28, and 35. BL and BK demonstrate stable, consistent turbidity reduction, while TR shows effective but less consistent performance. Overall, all containers significantly improve turbidity over time.

From Figure 2, the initial TSS levels on Day 1 for BL, BK, and TR are 22 mg/L, 34 mg/L, and 28 mg/L, respectively, all below the NSDWQ limit. By Day 4, levels drop significantly to 1 mg/L for BL and BK and 8 mg/L for TR. From Day 7, BL and BK maintain 1 mg/L, while TR stabilizes around 1 mg/L with minor fluctuations on Days 21, 25, and 35, demonstrating effective TSS reduction across containers

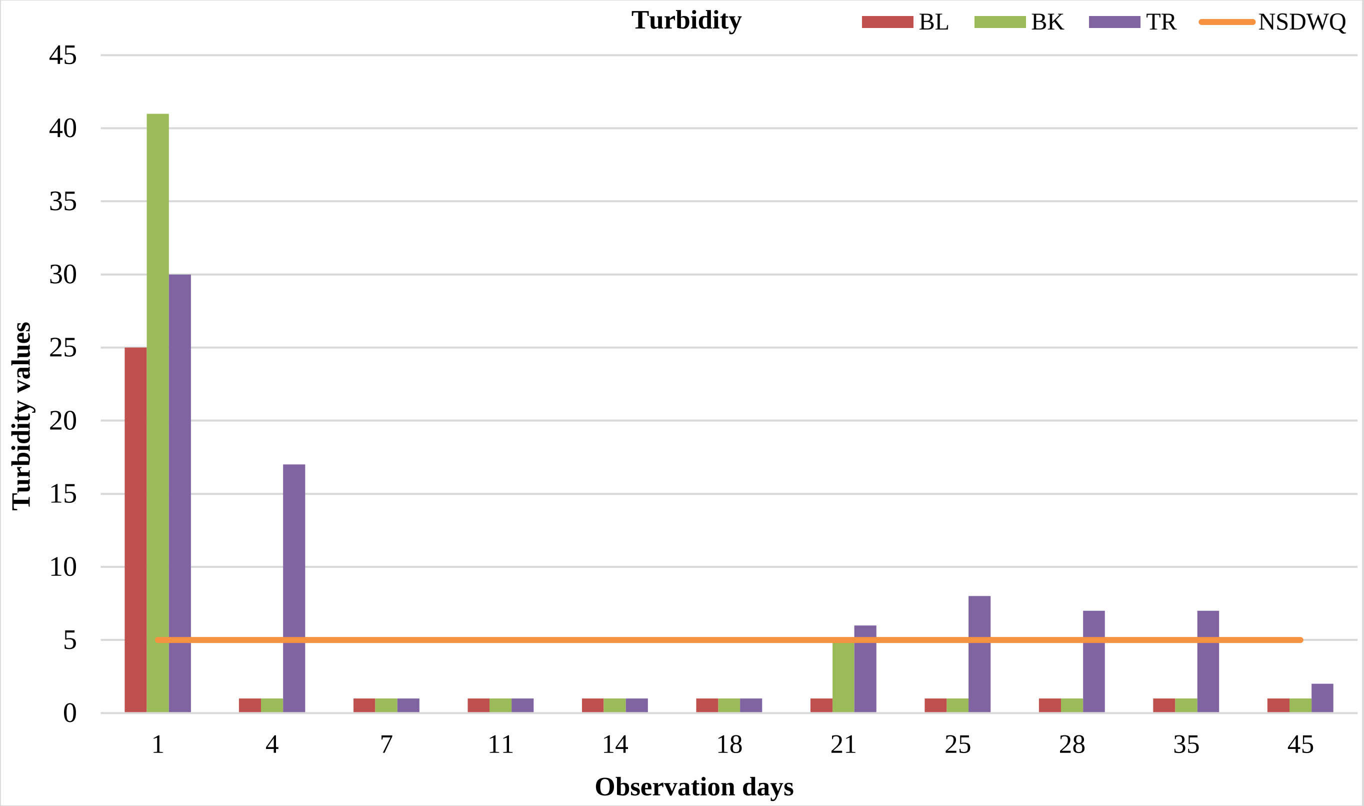

Fig. 1 Turbidity measurements over 45 days for water samples filtered through three coloured containers (BL, BK, and TR) against the NSDWQ

4.2.2. TSS Reaction in Containers Over Time

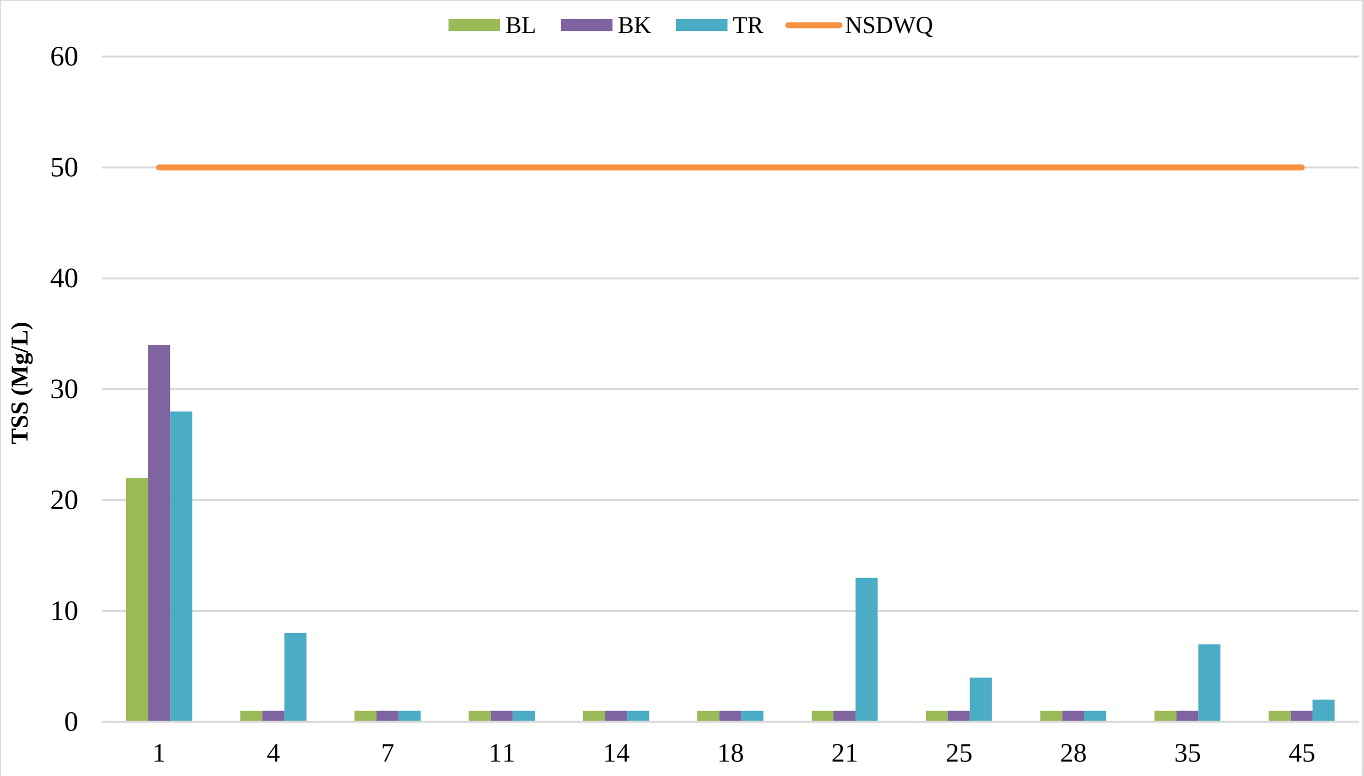

Fig. 2 Total Suspended Solids (TSS) levels over 45 days for water samples filtered through three containers (BL, BK, and TR) relative to the NSDWQ standard of 50 mg/L

As noted in Figure 3. At first, pH levels are near neutral, with BL and BK at 6.7 and TR at 6.9, all within the standard range. From Days 4 to 25, pH values stabilize around 7.3 to 7.5, indicating consistent water quality with minimal variation. By Day 28, pH levels rise slightly, reaching 7.5–7.6 for BL and BK and 7.5 for TR, further increasing by Day 45, bringing BL to 7.9 and BK and TR to 8.1. All samples remain within the NSDWQ pH standards throughout, demonstrating that the filters effectively maintain pH stability with only minor increases. On Day 1 (Figure 4), the initial EC levels for all samples are well below the NSDWQ threshold, with BL at 2.2 mS/cm, BK at 2.5 mS/cm, and TR at 2.3 mS/cm, indicating a low ionic content in the water filtered by each container. From Days 4 to 25, the EC values fluctuate slightly but remain stable, with BL generally between 2.2 and 2.5 mS/cm, BK around 2.2 to 2.6 mS/cm, and TR mostly at 2.3 to 2.5 mS/cm. This slight variability reflects consistent filtration with only minor changes in ion concentration levels. By Day 45, EC levels gradually increase, reaching 2.6 mS/cm for BL and 2.7 mS/cm for both BK and TR. Despite this slight rise, all samples stay well within the NSDWQ limit of 3.0 mS/cm, indicating no significant increase in ionic content. Over the entire 45-day period, all samples consistently comply with NSDWQ standards for EC, underscoring effective filtration that maintains safe levels of ionic content in the drinking water. The minor increases over time suggest a stable filtration process without significant performance degradation.

4.2.3. pH reaction in Containers Over Time

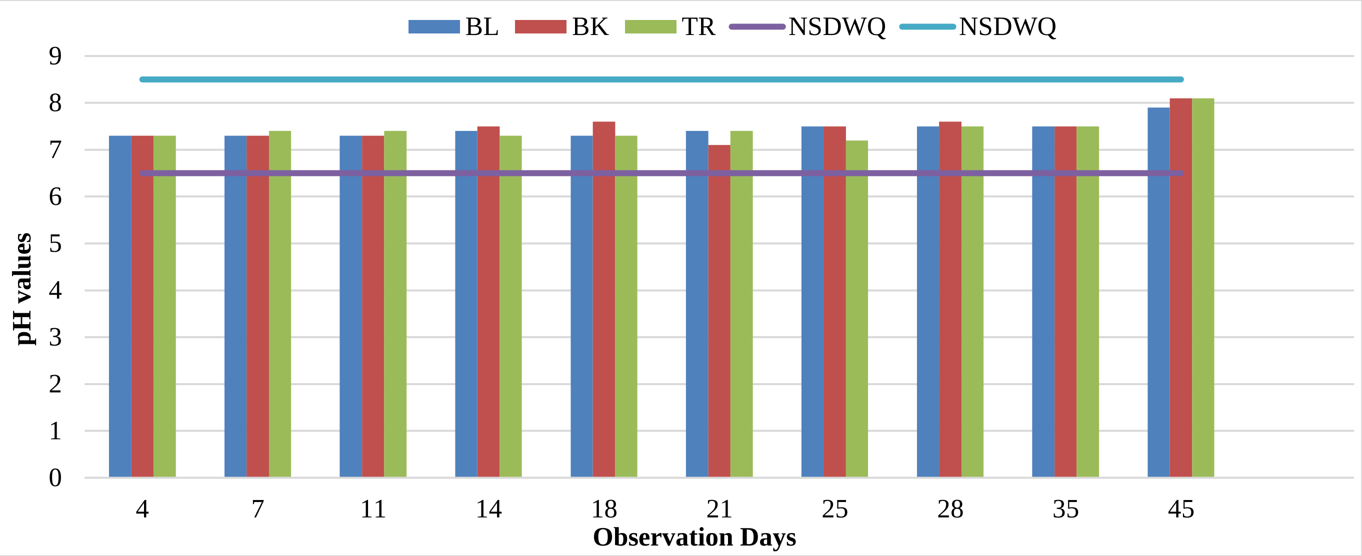

Fig. 3 pH measurements over 45 days for water samples filtered through three coloured containers (BL, BK, and TR), compared to the NSDWQ acceptable range of 6.5 to 8.5

4.2.4. EC Reaction in Containers Over Time

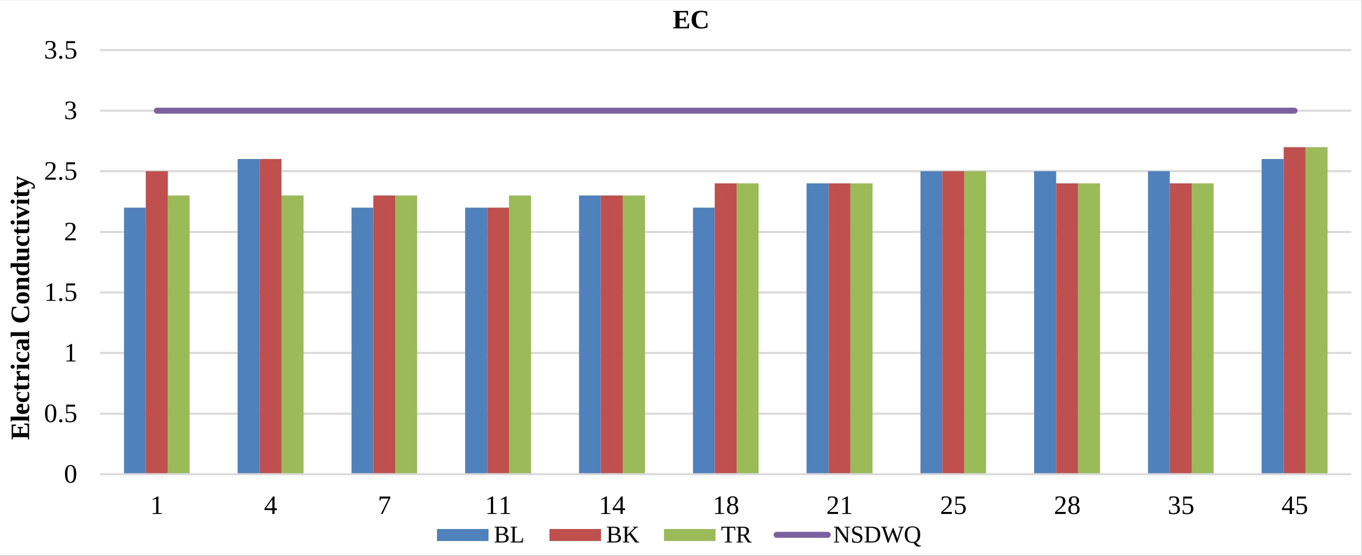

Fig. 4 Electrical Conductivity (EC) measurements over 45 days for water samples from three colored filter containers (BL, BK, and TR), compared to the NSDWQ limit of 3.0 mS/cm

As indicated in Figure 5. On Day 1, all samples start below 150mg/l, with BL at 89.6 mg/L and BK and TR at 115.2 mg/L, indicating safe initial alkalinity. From Days 4 to 35, alkalinity fluctuates. BL ranges between 76.8 mg/L and 140.8 mg/L, remaining within the limit, while BK occasionally exceeds it, reaching 166.4 mg/L on Days 4 and 14. TR also varies, peaking at 168.4 mg/L on Day 14 before stabilizing near 115.2 mg/L. By Day 45, BK experiences a sharp increase to 281.4 mg/L, surpassing the NSDWQ limit, while BL and TR remain below the standard at 102.4 mg/L and 166.4 mg/L, respectively. Overall, BL consistently meets the standard, whereas BK and TR show occasional excesses, indicating minor fluctuations in maintaining ideal alkalinity across all containers. Initial readings show high calcium levels above the limit, with BL at 132.8 mg/L, BK at 273.6 mg/L, and TR at 187.2 mg/L. Between Days 4 and 14, levels generally decrease, falling below 50 mg/L by Day 11, though BK and TR exceed this standard on Day 14. Significant spikes occur on Days 18 and 21, with calcium levels peaking at 382.4 mg/L for BL, 373.6 mg/L for BK, and 392 mg/L for TR. Following these peaks, levels decline but remain well above the NSDWQ limit, with Day 45 readings at 223.2 mg/L for BL, 281.4 mg/L for BK, and 254.4 mg/L for TR. Calcium concentrations consistently exceed the NSDWQ limit, showing marked fluctuations, especially around Days 18 and 21.

4.2.5. Total Alkalinity Reaction in Containers Over Time

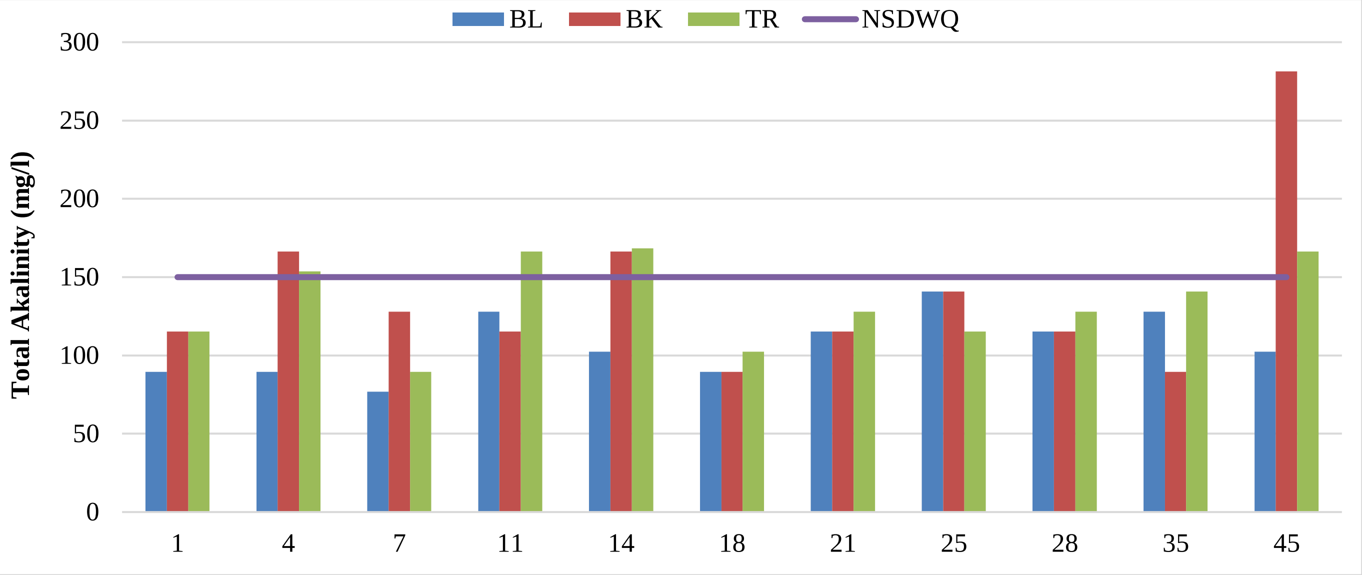

Fig. 5 Total Alkalinity (T. Alkaline) levels over 45 days for water samples in three filter containers (BL, BK, and TR), with the NSDWQ limit set at 150 mg/L

4.2.6. Calcium Hardness reaction in Containers Over Time

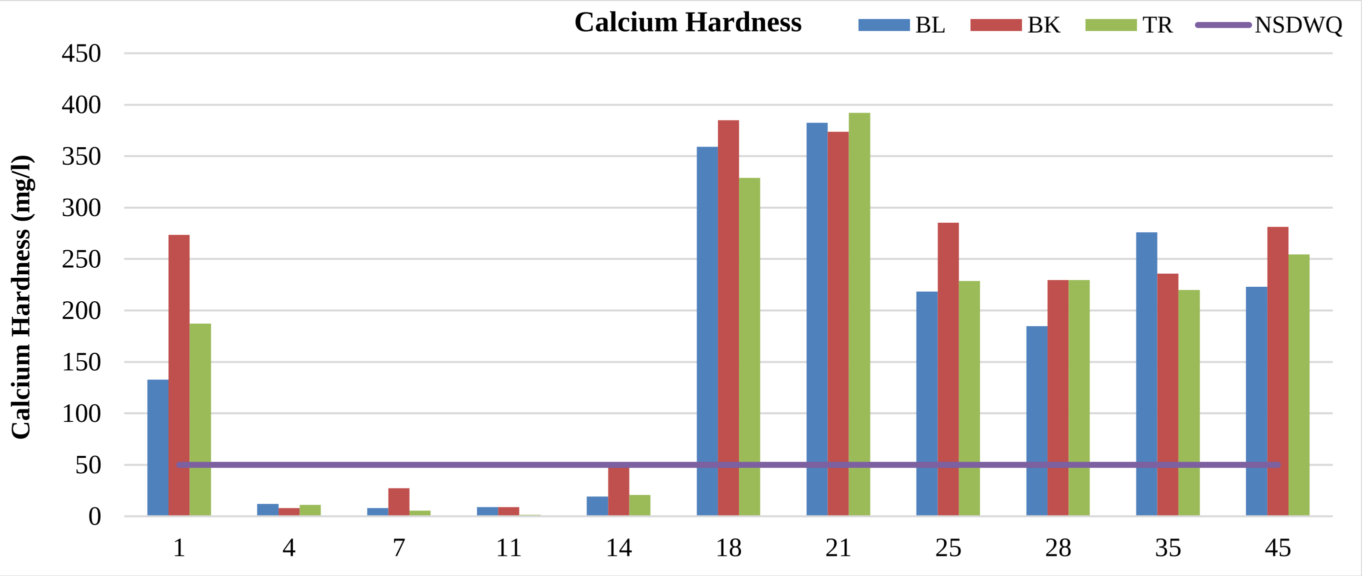

Fig. 6 Calcium concentrations over 45 days in three filter containers (BL, BK, and TR), compared to the NSDWQ limit of 50 mg/L

4.2.7. Iron (II) Oxide Reaction in Containers Over Time

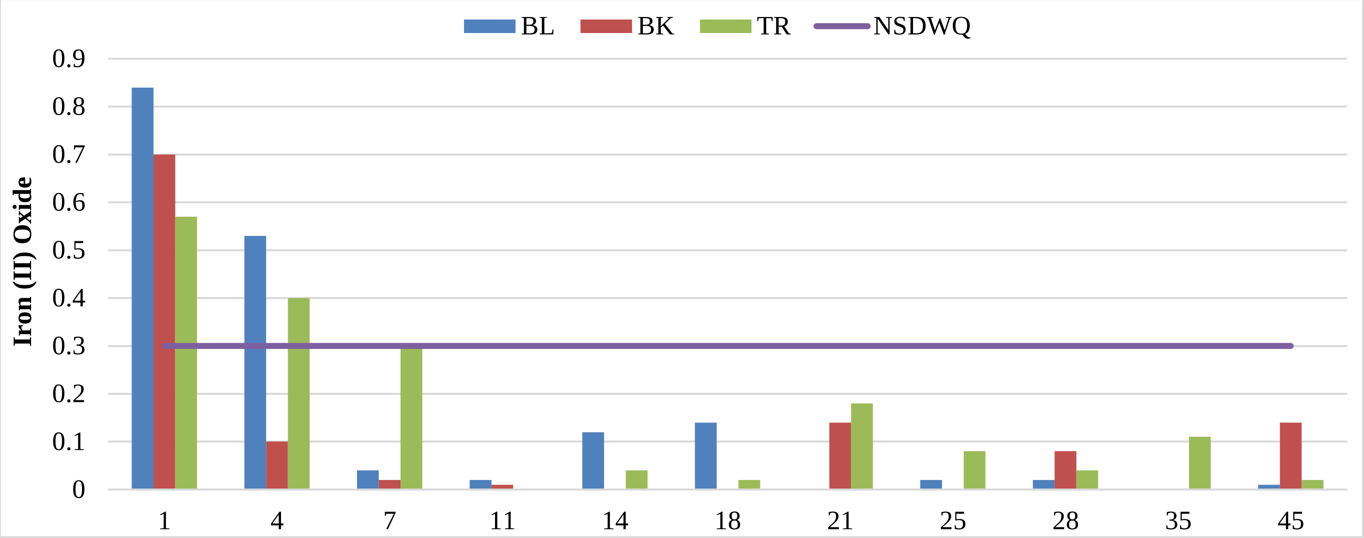

Fig.7 Iron (Fe) concentrations in three filter containers (BL, BK, and TR) over 45 days, compared to the NSDWQ limit of 0.3 mg/L

From Figure 7, all iron levels are first high, with BL at 0.84 mg/L, BK at 0.7 mg/L, and TR at 0.57 mg/L. From Day 4 to Day 11, iron concentrations decrease significantly, reaching 0.02 mg/L in BL and 0.01 mg/L in BK, both below the NSDWQ limit. Minor fluctuations occur between Days 14 and 21, with BK peaking at 0.14 mg/L on Day 21 but still within the standard. Between Days 25 and 45, slight variations persist, including spikes in BK at 0.14 mg/L on Day 45 and TR at 0.11 mg/L on Day 35, yet all remain under the limit. Iron levels consistently decline and stay within NSDWQ standards for most of the period, indicating effective reduction.

4.3. Removal Efficiency of Filters

4.3.1. Removal Efficiency of Filters on Turbidity

Figure 8 illustrates removal efficiency over time for blue, black, and transparent containers on the turbidity of the water samples. The blue container starts at 35% efficiency on Day 1, reaches 100% by Day 4, and maintains this level throughout, indicating stable filtration. The black container begins at 0% on Day 1, improves to 100% by Day 4, dips briefly to 74% on Day 21, and then stabilizes at 100%. The transparent container starts at 18% on Day 1, achieves 100% by Day 7, fluctuates with a drop to 62% on Day 21, and ends at 94% on Day 45. Overall, the blue container shows the most consistent performance in turbidity removal, while the black container is stable with one brief drop, and the transparent container, though variable, ends with high efficiency.

4.3.2. Removal Efficiency of Filters on TSS of water

Figure 9 illustrates the removal efficiency of blue, black, and transparent containers over time. The blue container starts at 35% efficiency on Day 1, reaches 100% by Day 4, and maintains this consistently throughout, indicating stable filtration. The black container starts at 0% on Day 1, improves to 100% by Day 4, briefly dips to 74% on Day 21, and then returns to full efficiency, showing one minor fluctuation. The transparent container begins at 18% on Day 1, reaches 100% by Day 7, but fluctuates with a drop to 62% on Day 21, ending at 94% on Day 45. Overall, the blue container demonstrates the most consistent filtration, the black container is stable with a brief drop, and the transparent container is more variable but effective by the end.

4.3.3. Removal Efficiency of Filters on T. Alkalinity of water

Figure 10 shows removal efficiency for blue, black, and transparent containers over the observation period. The blue container achieves and maintains 100% efficiency from Day 4 onward, indicating stable and effective filtration. The black container reaches 100% by Day 4, dips briefly to 74% on Day 21, and then resumes full efficiency, reflecting minor variability but generally high performance.

The transparent container starts at 18% on Day 1, increases to 100% by Day 7, but fluctuates on Days 21, 28, and 35, ending at 94% on Day 45, showing less stability. Overall, the blue container provides the most consistent filtration, while the black container is reliable with a small drop, and the transparent container is the least stable.

4.4.4. Removal efficiency of Filter on EC of water

Figure 11 shows that removal efficiency varies across the blue, black, and transparent containers. The blue container starts with the highest initial efficiency at 12% on Days 1, 7, 11, and 18, with slight dips like -4% on Day 4, but drops to 0% by Day 25 and ends at -4% on Day 45, indicating reduced performance. The black container maintains 12% efficiency through Day 11, declines gradually to 4% by Day 21, reaches 0% by Day 25, and falls to -12% by Day 45, showing the steepest loss. The transparent container begins at 8% from Days 1 to 14, drops to 4% by Day 18, and concludes at -8% on Day 45, reflecting a moderate decline. Overall, the blue container performed best initially, but all containers show efficiency loss by Day 45, suggesting the need for filter replacement.

4.4.5. Removal efficiency of Filter on Calcium Hardness of water

Observations from Figure 12 reveal the following: Positive changes are seen in all containers, with bars above zero indicating water quality improvements, likely reductions of 50–100%. Negative changes appear as bars below zero, with some values nearing -200%, suggesting worsened water quality for certain metrics post-filtration.

The "Black" container generally exhibits fewer extreme negative values than the "Blue" and "Transparent" containers. Each container shows strengths and weaknesses across metrics, indicating varied effectiveness in water quality improvement.

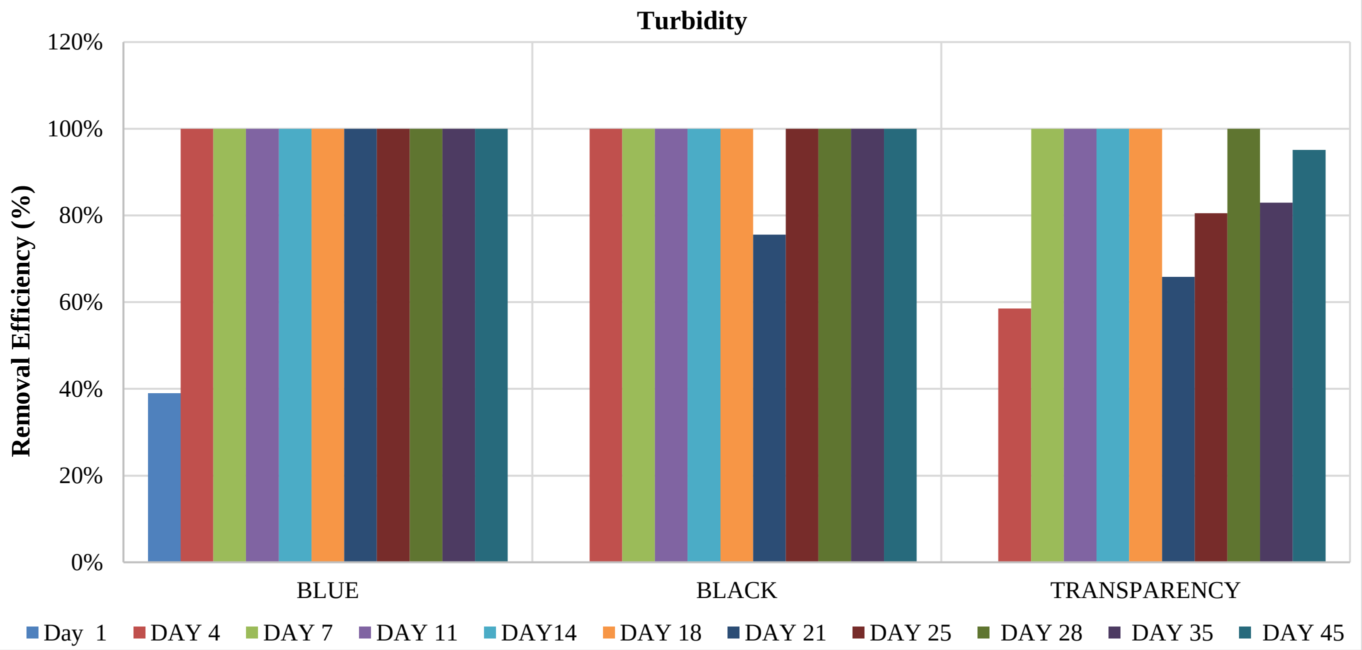

Fig. 8 Removal efficiency of filters on turbidity of water

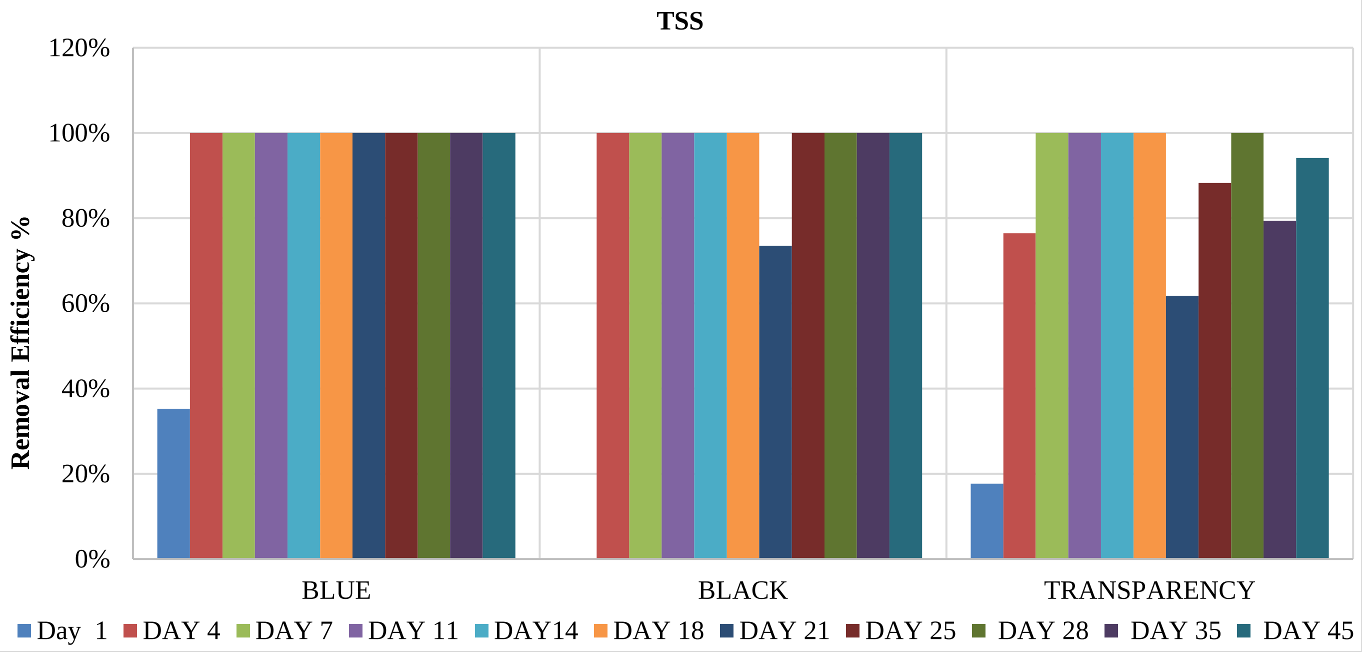

Fig. 9 Removal efficiency of filters on TSS of water

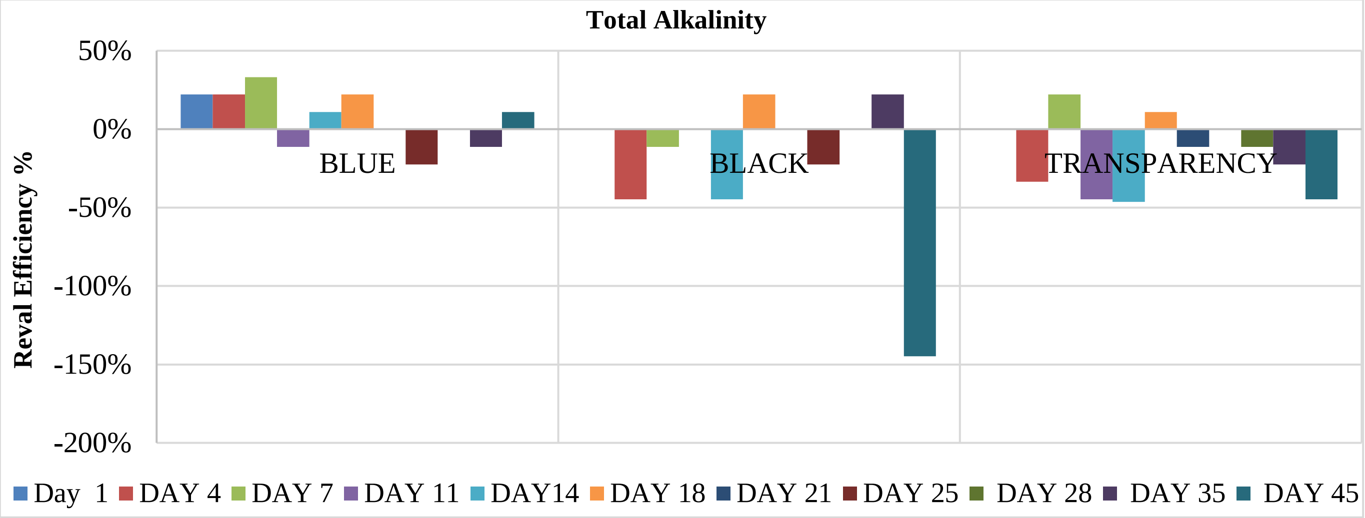

Fig. 10 Removal efficiency of FILTERS on T. Alkalinity of water

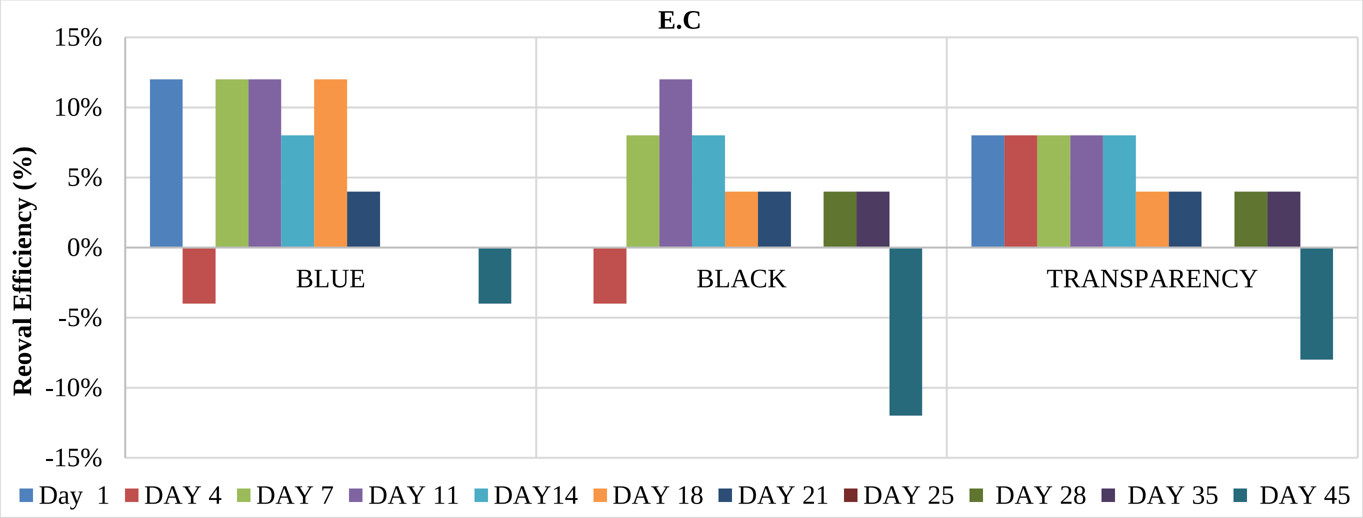

Fig. 11 Removal Efficiency of Filters on EC of water

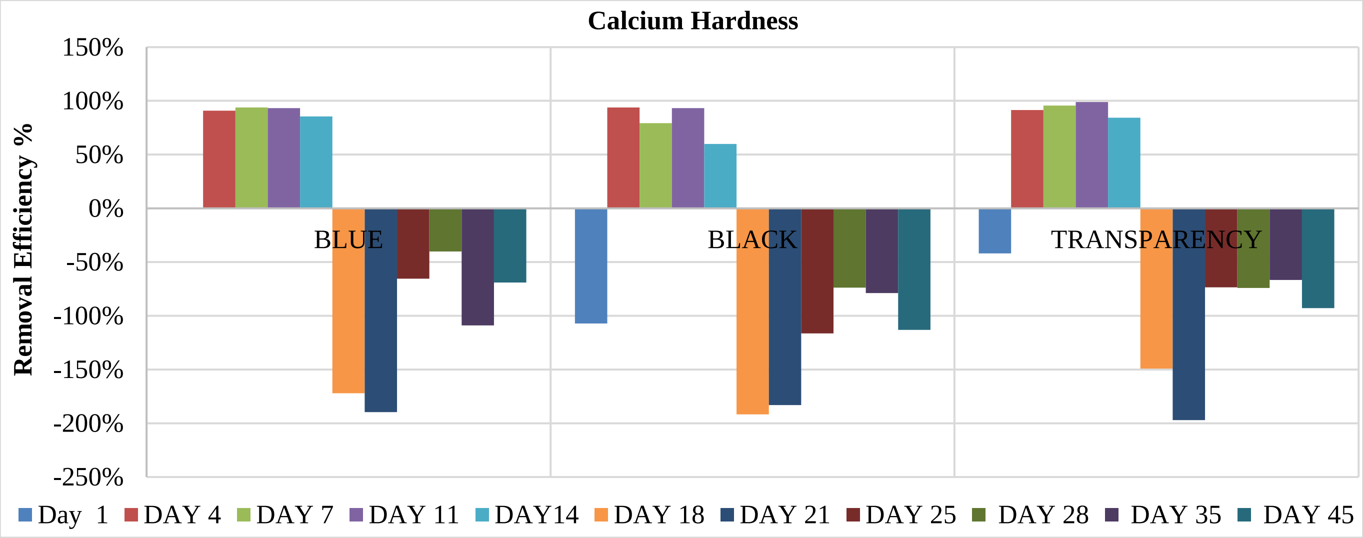

Fig. 12 Removal efficiency of filters on calcium hardness of water

5. Conclusion

Evaluating multi-coloured filter containers (BL, BK, and TR) provides valuable insights into their potential for improving water quality. The filters effectively reduced turbidity and Total Suspended Solids (TSS), nearing or meeting the NSDWQ turbidity benchmark of 5 NTU. This reduction enhances water clarity and minimizes microbial growth risk. TSS values also dropped well within acceptable limits, which is beneficial for public health, as suspended solids often carry contaminants.

Additionally, pH levels remained consistently stable across all containers, maintaining the NSDWQ range of 6.5 to 8.5, indicating minimal impact on chemical balance.Calcium concentrations fluctuated, often exceeding the NSDWQ limit of 50 mg/L, suggesting that while the filters reduce hardness somewhat, they struggle to meet standards for calcium consistently. Similarly, iron levels initially decreased but showed elevated readings in some containers (especially BK and TR) over time. These findings indicate that additional iron- and calcium-specific treatments may be required for full compliance with drinking water quality standards.Based on these results, the BL container performed best overall, showing superior turbidity reduction, TSS removal, and stable pH. However, we recommend further research to explore the influence of container materials and coatings on long-term filtration efficiency, as these factors could impact durability and performance.

Expanding testing to include other contaminants, such as bacteria and heavy metals, would also provide a more comprehensive understanding of each container's effectiveness. For practical use, especially in resource-limited areas, blue or black containers may serve as low-cost, effective options for improving basic water quality where advanced filtration is unavailable. Educating communities about the potential role of container colour in filtration effectiveness could also promote safer water practices in regions with limited access to clean water.In conclusion, while multi-coloured containers show promise for basic water treatment—particularly in reducing turbidity and TSS and maintaining stable pH—they may need to be integrated with additional filtration technologies to achieve full NSDWQ compliance across all parameters. Such integration could yield an accessible, effective solution for safe drinking water, especially in underserved areas.

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