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Properties and Optimisation of Selected Operational Factors on the Performance of Household Water Treatment Techniques

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Abstract

Household Water Treatment Techniques (HWTTs) are essential for improving drinking water quality, particularly in low- and middle-income countries where centralized water treatment infrastructure is inadequate or unavailable. Common household treatment technologies include fibre filtration, chlorination, solar disinfection, ceramic filtration, bio-sand filtration, coagulation-flocculation, membrane filtration, and ultraviolet (UV) disinfection. However, the performance of these technologies is strongly influenced by operational factors that govern contaminant removal efficiency, treatment capacity, user acceptability, and system durability. This study evaluated the effects and optimization of four critical operational parameters—influent turbidity, number of filters, treatment time, and coagulant dose—on the performance of household filtration systems. Raw surface water samples were collected from the Opa River and treated using three filtration media: ceramic, fibre, and activated carbon filters. Process optimization was carried out using the Taguchi L943 orthogonal array experimental design. Individual and overall treatment performances were assessed to identify the optimum operational conditions for maximum filtration efficiency. The results showed mean overall treatment efficiencies of 88.24%, 88.27%, and 89.15% for the ceramic, fibre, and activated carbon filters, respectively. Corresponding performance ranges were 78.67–93.86%, 78.77–93.81%, and 77.73–93.85%, indicating consistently high contaminant removal efficiencies across the evaluated filtration systems. The optimized operational conditions were an influent turbidity of 1080 NTU, two filters, a treatment time of 12.8 minutes, and a coagulant dose of 135 mg/L. The findings demonstrate that optimizing these operational parameters significantly enhances household water treatment performance, thereby improving drinking water quality, protecting public health, and promoting the long-term sustainability and effectiveness of household water treatment interventions in resource-constrained communities.

Keywords

Household water treatment,
Filtration,
Turbidity,
Operational factors,
Drinking water quality,
Bio-sand filter,
Ceramic filter,
Pathogen removal.

Abbreviations

UV stands for Ultraviolet
SODIS stands for solar disinfection
WHO stands for World Health Organization
UNICEF stands for United Nations Children's Fund
HWTT stands for Household Water Treatment Techniques
MDPI stands for Multi Digital Publication Institute
WoS stands for Web of Science
RSC stands for Royal Society of Chemistry
L943 stands for nine experiments, 4 factors and 3 levels
AWWA stands for American Water Works Association
ORP stands for Oxidation Reduction Potential
COD stands for Chemical Oxygen Demand
TOC stands for Total Organic Carbon
CU stands for colour unit
NTU stands for Nephelometric Turbidity Unit
ACF stands for activated carbon filter
FF stands for fibre filter
CF stands for ceramic filter

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INTRODUCTION

Access to safe drinking water remains a global challenge, particularly in rural and underserved communities (Fasun et al., 2025; Isukuru et al., 2024; Ataley et al., 2024; Figure 1). According to the World Health Organization WHO and UNICEF (2023), approximately 2.2 billion people worldwide lack safely managed drinking water services. Household Water Treatment Techniques (HWTT) have emerged as effective point-of-use technologies capable of reducing waterborne diseases by improving microbiological and physicochemical water quality (Elliot et al., 2008; Murphy et al., 2010; Clasen, 2015, Latif et al., 2025).

Household water treatment technologies function through one or more of the following mechanisms, such as physical processes (filtration, sedimentation, and straining), chemical processes (chlorination, coagulation, and oxidation), biological processes (biofilm activity, biological degradation), and photochemical processes (ultraviolet disinfection and solar disinfection) (Hijnen et al., 2024; Idigbe et al., 2024; Aladekomo, 2025; Laouane et al., 2026).

Common household treatment technologies are bio-sand filtration, activated carbon filtration, ceramic filtration, fibre and cloth filtration, membrane filtration, chlorination, solar disinfection (SODIS), coagulation-flocculation-disinfection techniques, coagulation-flocculation-sedimentation Techniques, Ultraviolet (UV) and coagulation-flocculation-filtration treatment techniques (Koul et al., 2022; AWWA, 2017; Lantagne et al., 2021; Worku and Alemu, 2025; Aladekomo, 2025). Figure 2 shows the comparative performance of fibre, biosand ceramic and membrane filters.

The performance of these technologies depends significantly on operational conditions. Several studies have demonstrated that changes in influent water characteristics, turbidity, pH, environmental conditions, temperature, hydraulic loading rate, contact time, filter media characteristics, microbial load, maintenance practices, user behaviours, and practices can substantially affect treatment efficiency (Ajibola et al., 2024; Sobsey et al., 2008; Brown and Clasen, 2021; Iturralde Carrera et al., 2025). With all these updates, information and data on the effects of other operational factors such as stages or number of filters, and pore size of the filter are limited in the literature (Figures 3 and 4). The main objectives of this study are to evaluate the effects of selected operational factors on some HWTT and optimise these selected factors

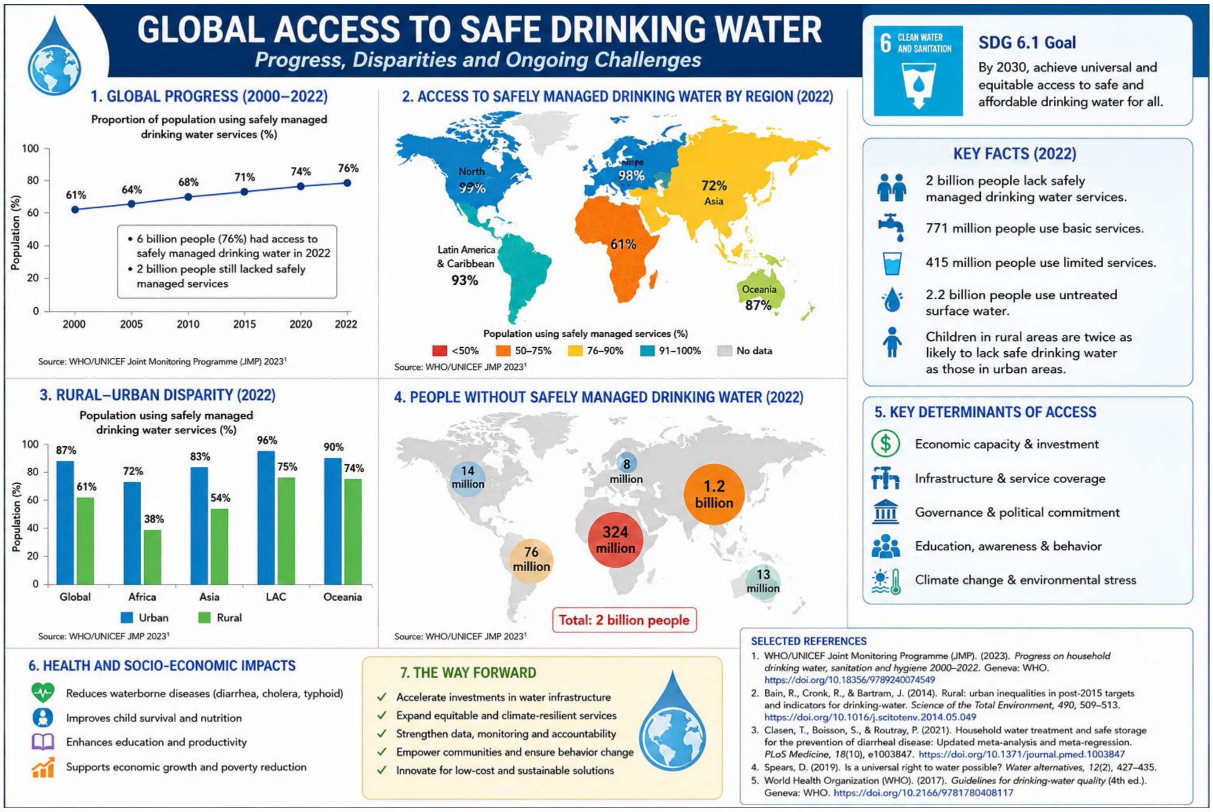

Figure 1: Global Access to safe drinking water with progress, disparities and ongoing challenges. (Adopted from Abeje and Yihun, 2024, WHO and UNICEF, 2023)

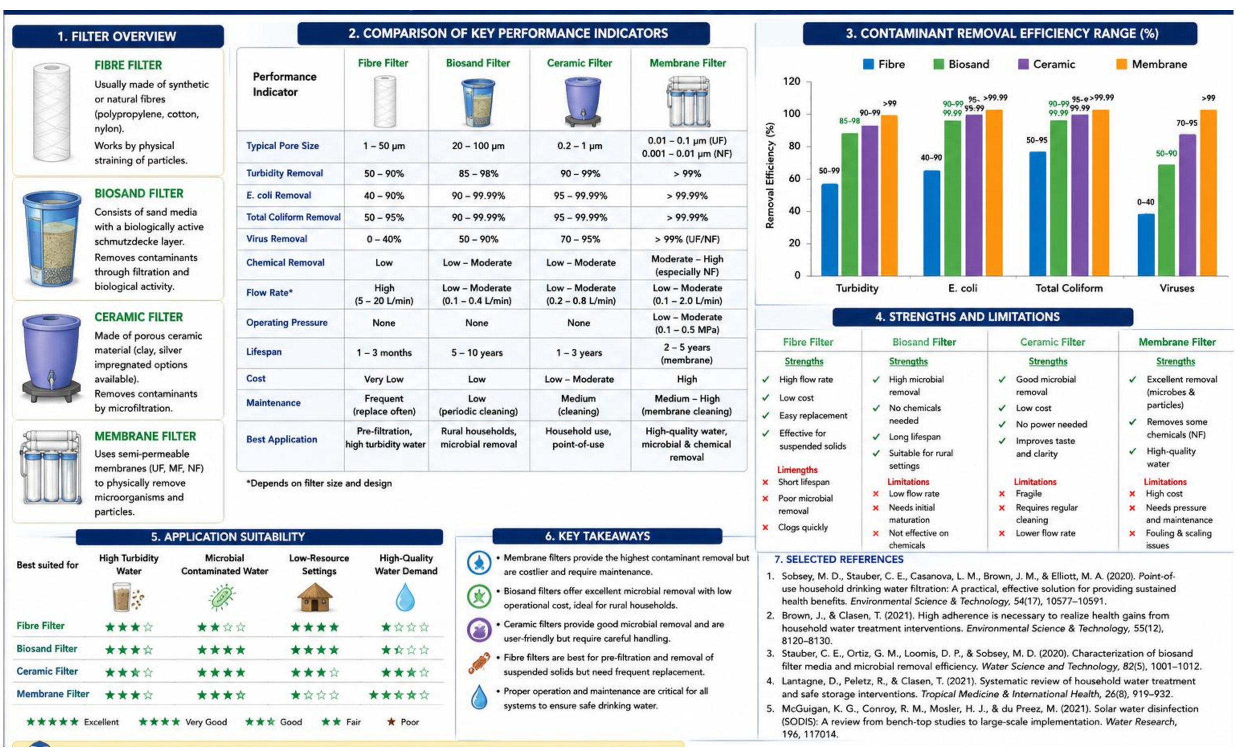

Figure 2: Comparative performance of fibre, biosand ceramic and membrane filters, a review of key characteristics, removal efficiency and operational performance. (Adopted from Sobsey et al., 2008; Brown and Clasen, 2021)

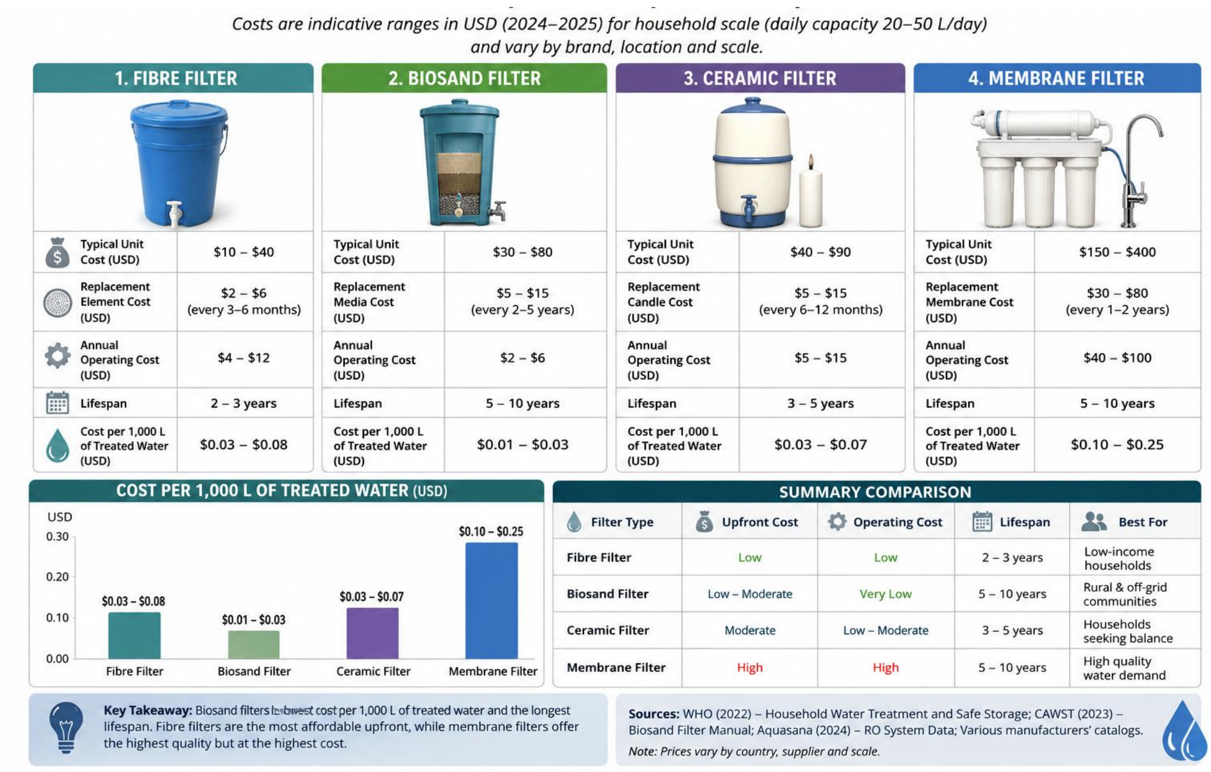

Figure 3: Cost comparative of fibre, biosand, ceramic and membrane filter. (Adopted from Baumgartner et al., 2007; Logsdon et al., 2002, Sobsey et al., 2008; Jellali et al., 2024)

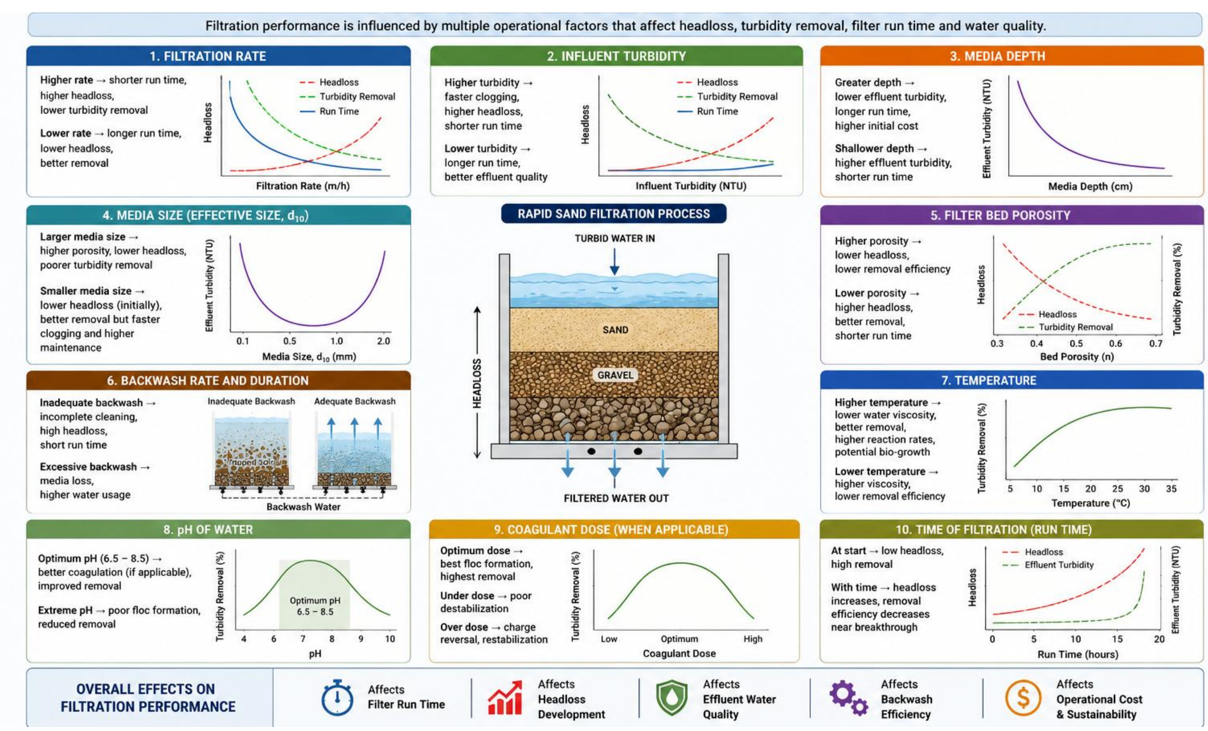

Figure 4: Effects of selected operational factors on filtration of turbid surface water. (Adopted from Bwapwa et al., 2024; Idigbe et al., 2024; Laouane et al., 2026)

MATERIALS AND METHODS

In this study on household water treatment techniques, the issues and challenges related to potable water production problems were explored. Recent and relevant information and data such as numerical values, figures and images were mined and composed from relevant databases utilizing several search engines and links such as PubMed link; Taylor and Francis Online link, ScienceDirect link, Scopus link, Google Scholar link, Web of Science (WoS) link, Wiley Online Library link, Elsevier link, SpringerLink, American Chemical Society Publications link, Magiran link, Multi Digital Publication Institute (MDPI) link, Frontiersin link, and Royal Society of Chemistry (RSC) Publishing link utilising the keywords such as potable water, household treatment, drinking water, water demand, water stress, water scarcity, water supply progression, trend of water supply, contaminated water, communicable disease, water borne diseases and water based disease, individually and in combination.

In summary, a desktop review was conducted using these keywords. Specific options were selected (any publication time, any article type, including patient articles and citations), and for publication growth, the selected options include relevance, any time, patient articles, review articles, and citations. In addition, selected operational factors (number of filters, type of filter (Ceramic filter CF, Fibre filter FF, and Activated Carbon Filter, ACF) alum dosage, turbidity of the raw water, and settling time after coagulation) that impacted the performance of household water treatment were studied and optimised using Taguchi techniques ($L_9\,4^3$, Table 1) and typical surface water collected from Opa River (Aladekomo et al., 2025). These water samples were mixed with coagulant rapidly and slowly, and allowed to settle for the settling time (Wang et al., 2021; Adejuwon et al., 2025). Figure 5 presents the location of sampling points. Figure 6 shows the laboratory setup. The outcomes of the literature search, data, and household treatment performance were analysed statistically using Microsoft Excel, and the effects of selected factors on the system's performance trend were identified and quantified. The performance (individual and overall) of HWTT based on the ability to remove selected pollutants (Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Colour, and Turbidity) was computed as follows (equations 1 and 2):

$$P_i = 100\left(\frac{Y_i - Y_f}{Y_i}\right) \quad (1)$$

$$P_a = \left(\prod_{i=1}^{n} P_i\right)^{\frac{1}{n}} \quad (2)$$

RESULTS AND DISCUSSIONS

Results from this study are discussed in the following categories: desktop review on household water treatment Techniques, publications on household water treatment techniques globally, publications on household water treatment Techniques at the national level, and performance of selected household techniques.

a) **Desktop Review on Household Water Treatment Techniques:** Figures 7 and 8 show the results of the desktop review of household water treatment techniques with specific attention to the keywords individually and in combinations. These figures revealed that there are three stages of publication on this subject matter. The first stage was between 1850 and 1925, the second stage, between 1925 and 1990, and the third stage, between 1990 and 2025, which can be described as an exponential trend.

b) **Publications on Household Water Treatment Techniques Globally:** Figure 9 presents the growth of publications on household water treatment techniques globally. The figure reveals that these publication trends were in three stages or phases. The first stage was between 1850 and 1925, which was a linear or logarithmic trend. The trend can be attributed to initial and rapid awareness of the vital role of household water treatment Techniques in the elimination of water-borne diseases. The second stage, between 1925 and 1990, which can be described as a semi-logarithmic trend. This trend can be attributed to the utilization of combined techniques as a household system. The third stage, between 1990 and 2025, can be described as an exponential trend. This trend can be attributed to the utilization of a combination of physical and chemical techniques as an effective and perfect household system.

c) **Publications on Household Water Treatment Techniques in Nigeria:** Figure 10 presents the growth of publications on household water treatment techniques at the national level. The figure reveals that the publication trend was in two stages or phases. The first stage was a linear or logarithmic trend. The trend can be attributed to initial and weak awareness of the vital role of household water treatment Techniques in the elimination of water-borne diseases. In addition, it can be associated with the dependency of the country on groundwater as the main water supply system. The second stage was exponential, which can be attributed to the effects of climate change on water level or contamination of surface water.

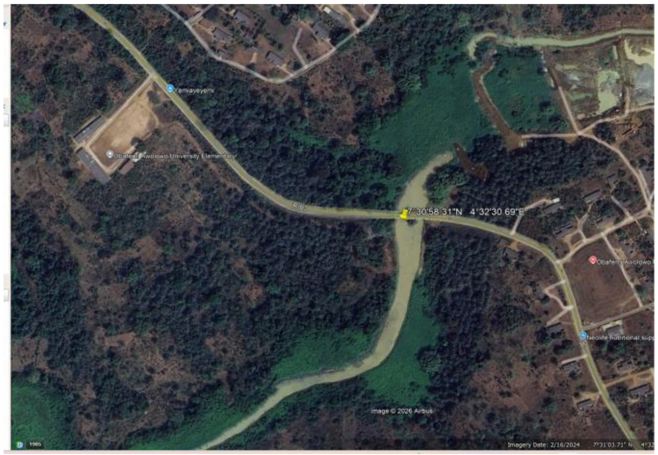

Figure 5a: An aerial view of the location for sampling point A

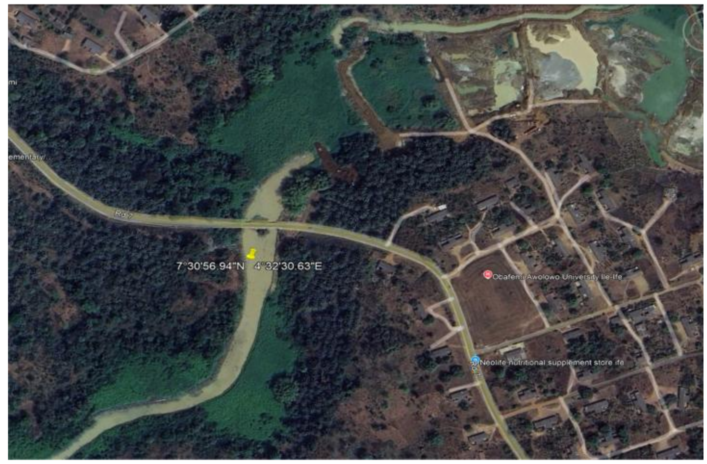

Figure 5b: An aerial view of the location for sampling point B

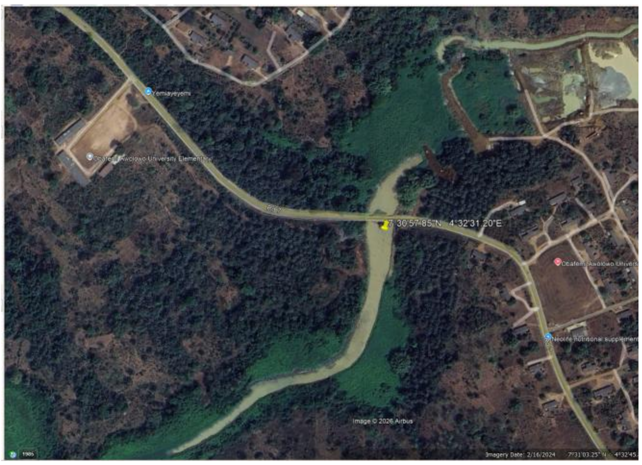

Figure 5c: An aerial view of the location for the sampling point


Figure 6a Laboratory Set-up for Ceramic Filtration Unit

Figure 6b: Laboratory Set-up for Activated Carbon Filtration Unit

Figure 6c: Laboratory Set-up for fibre filtration unit

Figure 6: Laboratory Set-up for - filtration units

Table 1: Taguchi $L_9 4^3$ Orthogonal Array for Experimental Design

Experiments	Factors and Levels				Factors and Values			
	A (No of filter unit)	B (Turbidty)	C (Alumn Dose)	D(Settling Time)	A (No of filter unit)	B (Turbidty, NTU)	C (Alumn Dose, mg/l)	D(Settling Time, minutes)
1	1	1	3	1	1	500	200	5
2	2	3	3	2	2	2000	200	10
3	3	3	3	1	3	2000	200	5
4	1	1	2	3	1	500	120	15
5	3	2	1	1	3	1500	80	5
6	3	3	1	3	3	2000	80	15
7	1	2	2	2	1	1500	120	10
8	2	2	1	2	2	1500	80	10
9	2	1	2	3	2	500	120	15

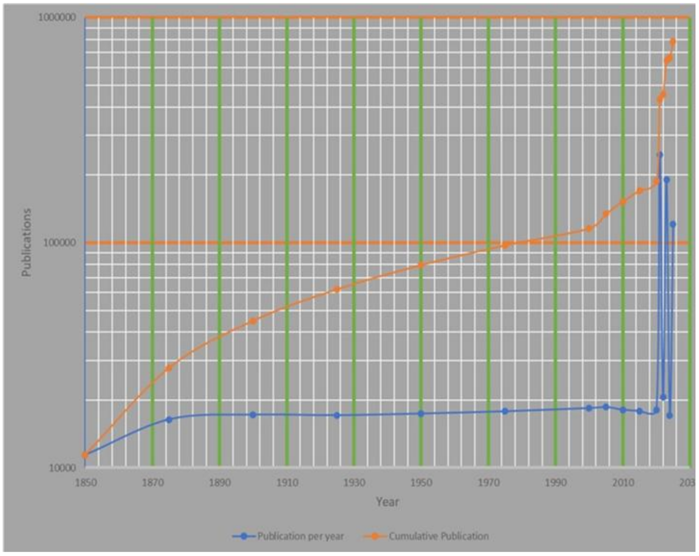

Figure 7: Results of the desktop review based on the year

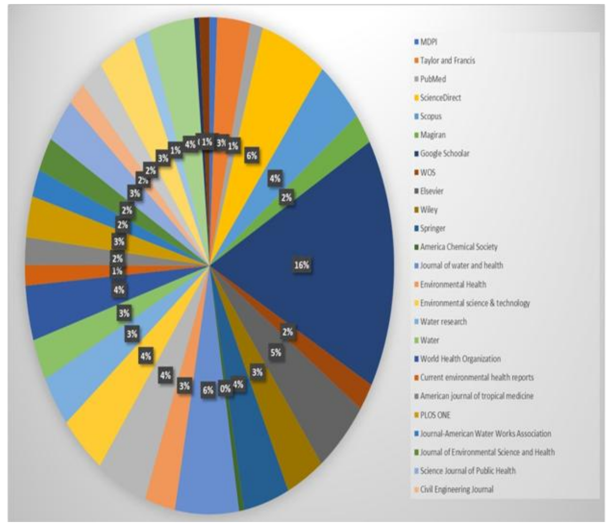

Figure 8: Results of the desktop review based on the journals

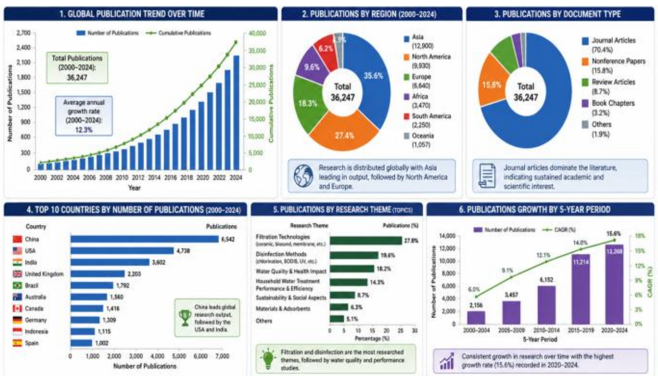

Figure 9: Global Publication trend and pattern between 2000 and 2024 on HWTT(Adopted from Bwapwa et al., 2024; Idigbe et al.,

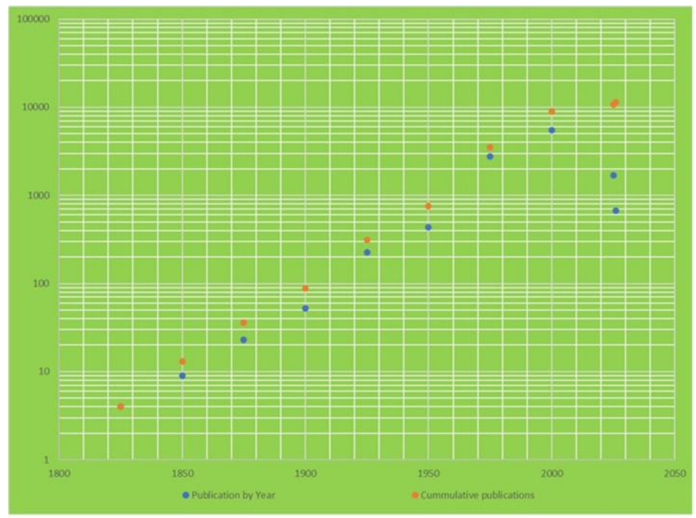

Figure 10a: Results of the desktop review in Nigeria based on the

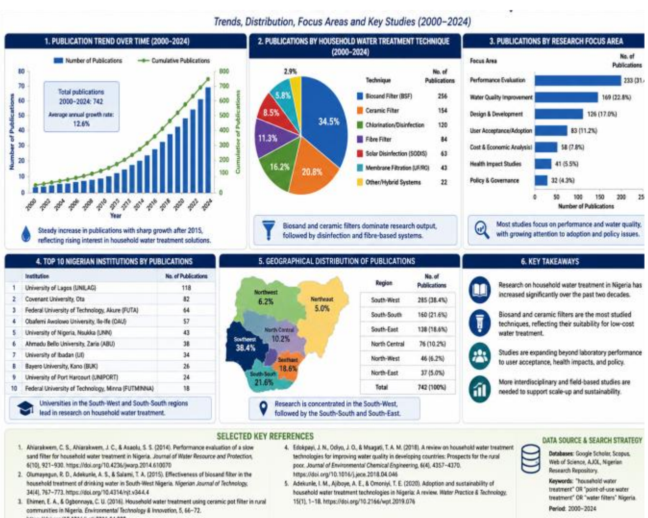

Figure 10c: Publications on HWTT in Nigeria (Adopted from Bwapwa et al., 2024; Idigbe et al., 2024; Laouane et al., 2026)

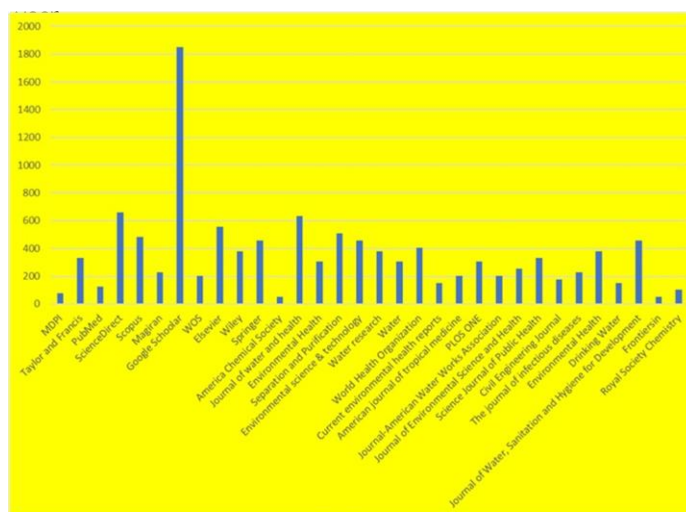

Figure 10b: Results of the desktop review in Nigeria based on the

e) Performance of Selected Household Techniques

Table 2 presents the effects of selected factors on the performance of household water treatment techniques, which is discussed as follows:

i. **Performance of Ceramic Filter (CF):** The overall performance average of the ceramic filter was 88.24 % with a range of between 78.67 and 93.86 %. The lowest performance of the ceramic filter in removing turbidity from raw surface water occurred in experiment 3 when the number of filters was at the highest level (3), turbidity of the raw water was at the peak (highest level 3), the alum dose was also at the highest level 3(200 mg/l) and the settling time was at the lowest level (5 minutes).

The highest performance of the ceramic filter in removing turbidity from raw surface water occurred in experiment 6 when the number of filters was at the highest level (3), turbidity of the raw water was at the peak (highest level 3), the alum dose was also at the lowest level 1(80 mg/l) and the settling time was at the highest level (15 minutes). This result revealed that settling time and alum dose is a vital factor in removing turbidity from surface water, a finding attributable to floc formation and sedimentation processes. The lowest performance of the ceramic filter in removing COD from raw surface water occurred in experiment 4 when the number of filters was at the lowest level (1), turbidity of the raw water was at the lowest (level 1), the alum dose was also at the medium level 2 (120 mg/l), and the settling time was at the highest level (15 minutes).

The highest performance of the ceramic filter in removing COD from raw surface water occurred in experiment 5 when the number of filters was at the highest level (3), turbidity of the raw water was at the moderate level 2, the alum dose was also at the lowest level 1(80 mg/l), and the settling time was at the lowest level (5 minutes). This result revealed that the number of filters, turbidity, alum dose and settling time are vital factors in removing COD from surface water, a finding attributable to floc formation, addition of coagulants and sedimentation processes. The lowest performance of the ceramic filter in removing TOC from raw surface water occurred in experiment 4 when the number of filters was at the lowest level (1), turbidity of the raw water was at the lowest level (3), the alum dose was also at the medium level 3(120 mg/l) and the settling time was at the highest level (15 minutes). The highest performance of the ceramic filter in removing TOC from raw surface water occurred in experiment 5 when the number of filters was at the highest level (3), turbidity of the raw water was at the medium level (2), the alum dose was also at the lowest level 1(80 mg/l) and the settling time was at the lowest level (5 minutes).

This result revealed that the number of filters, turbidity, alum dose and settling time are vital factors in removing COD from surface water, a finding attributable to floc formation, addition of coagulants and sedimentation processes. The lowest performance of the ceramic filter in removing TDS from raw surface water occurred in experiment 3 when the number of filters was at the highest level (3), turbidity of the raw water was at the highest (level 3), the alum dose was also at the highest level 3 (200 mg/l), and the settling time was at the lowest level (5 minutes).

The highest performance of the ceramic filter in removing turbidity from raw surface water occurred in experiment 7 when the number of filters was at the lowest level (1), turbidity of the raw water was at the moderate level 2, the alum dose was also at the medium level 2 (120 mg/l), and the settling time was at the medium level (10 minutes). a finding attributable to floc formation, addition of coagulants and sedimentation processes.

ii. **Performance of Activated Carbon Filter (ACF):** The overall performance average of the activated carbon filter was 89.15 % with a range of between 77.73 and 93.85 %. The lowest performance of the activated carbon filter in removing turbidity from raw surface water occurred in experiment 1 when the number of filters was at the lowest level (1), turbidity of the raw water was at the lowest level (1), the alum dose was at the highest level 3 (200 mg/l) and the settling time was at the lowest level (5 minutes).

The highest performance of the activated carbon filter in removing turbidity from raw surface water occurred in experiments 3 and 6 when the number of filters was at the highest level (3), turbidity of the raw water was at the peak (highest level 3). In experiment 3, the alum dose was at the highest level 3 (200 mg/l) and the settling time was at the lowest level (5 minutes), whereas in experiment 6, the alum dose was at the lowest level 1 (80 mg/l) and the settling time was at the highest level (15 minutes). This result revealed that settling time had little influence on turbidity removal by the activated carbon filter. The lowest performance of the activated carbon filter in removing COD from raw surface water occurred in experiment 2 when the number of filters was at the medium level (2), turbidity of the raw water was at the highest level (3), the alum dose was also at the highest level 3 (200 mg/l), and the settling time was at the medium level (10 minutes). The highest performance of the activated carbon filter in removing COD from raw surface water occurred in experiment 1 when the number of filters was at the lowest level (1), turbidity of the raw water was at the lowest level (1), the alum dose was also at the highest level 3 (200 mg/l), and the settling time was at the lowest level (5 minutes). This result revealed that raw water turbidity, settling time and number of filters are vital factors in removing COD from surface water. The lowest performance of the activated carbon filter in removing TOC from raw surface water occurred in experiment 4 when the number of filters was at the lowest level (1), turbidity of the raw water was at the lowest level (1), the alum dose was at the medium level 2 (120 mg/l), and the settling time was at the highest level (15 minutes). The highest performance of the activated carbon filter in removing TOC from raw surface water occurred in experiment 1 when the number of filters was at the lowest level (1), turbidity of the raw water was at the lowest level (1), the alum dose was at the highest level 3 (200 mg/l), and the settling time was at the lowest level (5 minutes). This result revealed that alum dose and settling time are vital factors in removing TOC from surface water. The colour removal performance remained constant at 95 % in all the experimental runs, indicating that the number of filters, raw water turbidity, alum dose, and settling time had no significant effect on colour removal by the activated carbon filter.

iii. **Performance of Fibre Filter (FF)**: Performance of Fibre Filter (FF): The overall performance average of the fibre filter was 88.27 % with a range of between 78.77 and 93.81 %. The lowest performance of the fibre filter in removing turbidity from raw surface water occurred in experiment 1 when the number of filters was at the lowest level (1), turbidity of the raw water was also at the lowest level (500 NTU), the alum dose was at the peak level (200 mg/l) and the settling time was at the lowest level (5 minutes). The highest performance of the fibre filter in removing turbidity from raw surface water occurred in experiment 7 when the number of filters was at the lowest level (1), turbidity of the raw water was at the medium level (1500 NTU), the alum dose was also at the medium level (120 mg/l) and the settling time was also at the medium level (10 minutes).

This result revealed that turbidity, alum dose and settling time are vital factors in removing turbidity from surface water, a finding attributable to floc formation and sedimentation processes. The lowest performance of the fibre filter in removing COD from raw surface water occurred in experiment 4 when the number of filters was at the lowest level (1), turbidity of the raw water was also at the lowest (500 NTU), the alum dose was at the medium level (120 mg/l), and the settling time was at the highest level (15 minutes). The highest performance of the fibre filter in removing COD from raw surface water occurred in experiment 5 when the number of filters was at the highest level (3), turbidity of the raw water was at the moderate level (1500 NTU), the alum dose was at the lowest level (80 mg/l), and the settling time was also at the lowest level (5 minutes). This result revealed that all the factors (number of filters, turbidity, alum dose and settling time) are vital in removing turbidity from surface water.

The lowest performance of the fibre filter in removing TDS from raw surface water occurred in experiment 4 when the number of filters was at the lowest level (1), turbidity of the raw water was also at the lowest (500 NTU), the alum dose was at the medium level (120 mg/l), and the settling time was at the highest level (15 minutes).

The highest performance of the fibre filter in removing TDS from raw surface water occurred in experiment 1 when the number of filters was at the lowest level (1), turbidity of the raw water was also at the lowest level (500 NTU), the alum dose was at the peak level (200 mg/l) and the settling time was at the lowest level (5 minutes). This result revealed that alum dose and settling time are vital factors in removing turbidity from surface water, a finding attributable to floc formation and sedimentation processes. The lowest performance of the fibre filter in removing colour from raw surface water occurred in experiment 9 when the number of filters was at the medium level (2), turbidity of the raw water was at the lowest level (500 NTU), the alum dose was at the medium level 2 (120 mg/l), and the settling time was at the highest level (15 minutes). The highest performance of the fibre filter in removing colour from raw surface water occurred in experiment 5 when the number of filters was at the highest level (3), turbidity of the raw water was at the moderate level 1 (1500 NTU), the alum dose was at the lowest level (80 mg/l), and the settling time was also at the lowest level (5 minutes). This result revealed that all the factors (number of filters, turbidity, alum dose and settling time) are vital in removing turbidity from surface water.

Table 2: Taguchi $L_9 4^3$ Orthogonal Array for Experimental Design and Performance of the Treatment Technique

Activated Carbon Filter

Experiments	Factors and Levels				Individual Performance					Overall Performance
	A (No of filter unit)	B (Turbidty)	C (Alumn Dose)	D(Settling Time)	Turbidity% Performance	Colour % Performance	COD % Performance	TOC % Performance	TDS % Performance	
1	1	500	200	5	67	95	115	91	94	91.06
2	2	2000	200	10	93	95	89	69	89	86.45
3	3	2000	200	5	94	95	100	78	89	90.88
4	1	500	120	15	70	95	108	52	76	77.73
5	3	1500	80	5	90	95	110	87	89	93.85
6	3	2000	80	15	94	95	100	78	87	90.47
7	1	1500	120	10	92	95	105	83	88	92.31
8	2	1500	80	10	92	95	105	83	89	92.52
9	2	500	120	15	73	95	111	88	74	87.10
									Average	89.15

Ceramic Filter

Experiments	Factors and Levels				Individual Performance					Overall Performance
	A (No of filter unit)	B (Turbidty)	C (Alumn Dose)	D(Settling Time)	Turbidity% Performance	Colour % Performance	COD % Performance	TOC % Performance	TDS % Performance	
1	1	500	200	5	64.34	95.00	101.00	79.00	84.00	83.65
2	2	2000	200	10	89.15	95.00	104.00	82.00	85.00	90.70
3	3	2000	200	5	51.16	95.00	107.00	84.00	69.00	78.67
4	1	500	120	15	72.61	95.00	95.00	74.00	84.00	83.56
5	3	1500	80	5	91.29	95.00	111.00	88.00	86.00	93.86
6	3	2000	80	15	94.55	95.00	108.00	79.00	85.00	91.78
7	1	1500	120	10	91.62	95.00	106.00	83.00	88.00	92.41
8	2	1500	80	10	91.23	95.00	107.00	85.00	87.00	92.73
9	2	500	120	15	74.51	95.00	109.00	86.00	74.00	86.74
									Average	88.24

Fibre Filter

Experiments	Factors and Levels				Individual Performance					Overall Performance
	A (No of filter unit)	B (Turbidty)	C (Alumn Dose)	D(Settling Time)	Turbidity% Performance	Colour % Performance	COD % Performance	TOC % Performance	TDS % Performance	
1	1	500	200	5	66.29	93.50	98.58	138.51	95.43	87.39
2	2	2000	200	10	84.82	93.57	90.15	325.46	86.96	88.82
3	3	2000	200	5	89.59	93.46	94.29	254.32	90.11	91.84
4	1	500	120	15	68.64	93.42	75.43	567.83	79.59	78.77
5	3	1500	80	5	90.68	93.80	100.74	128.86	90.40	93.81
6	3	2000	80	15	90.78	93.50	87.46	375.09	88.55	90.04
7	1	1500	120	10	91.36	93.46	86.76	386.67	88.40	89.96
8	2	1500	80	10	91.05	93.53	87.40	377.30	90.66	90.63
9	2	500	120	15	72.57	93.38	87.92	351.10	80.37	83.19
									Average	88.27

f) **Optimization of the selected factors:** Figures 11, 12 and 13 present the optimisation of selected factors with respect to the filters and performance of household water treatment techniques, which is discussed as follows:

   a. **Performance of Activated Carbon Filter (ACF):** Figure 11 presents the optimisation of selected factors with respect to the Activated Carbon Filter (ACF) and performance of household water treatment techniques. The optimum values of the selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of turbidity were 1550 NTU, 2, 9.8 minutes and 123 mg/l, respectively. The optimum values of the selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of COD were 1650 NTU, 2, 10.5 minutes and 115 mg/l, respectively. The optimum values of the selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of TOC were 1480 NTU, 2, 9 minutes and 125 mg/l, respectively. The optimum values of the selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of TDS were 1360 NTU, 2, 9.5minutes and 115 mg/l, respectively.

   b. **Performance of Ceramic Filter (CF):** Figure 12 presents the optimisation of selected factors with respect to the ceramic filter and performance of household water treatment techniques. The optimum values of these selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of turbidity were 95 NTU, 2, 11.2 minutes and 140 mg/l, respectively. The optimum values of these selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of COD were 1690 NTU, 2, 8.5 minutes and 138 mg/l, respectively. The optimum values of these selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of TOC were 1550 NTU, 2, 9.0 minutes and 125 mg/l, respectively. The optimum values of these selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of TDS were 1550 NTU, 3, 10.5 minutes and 145 mg/l, respectively.

   c. **Performance of Fibre Filter (CF):** Figure 13 presents the optimisation of selected factors with respect to the fibre filter and performance of household water treatment techniques. The optimum values of these selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of turbidity were 1650 NTU, 3, 9.6 minutes and 131 mg/l, respectively.

The optimum values of these selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of COD were 1625 NTU, 2, 10 minutes and 120 mg/l, respectively. The optimum values of these selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of TOC were 1590 NTU, 2, 10 minutes and 117 mg/l, respectively. The optimum values of these selected factors (influent turbidity, number of filters, treatment time, and coagulant dose) for the removal of TDS were 1610 NTU, 2, 10 minutes and 125 mg/l, respectively.

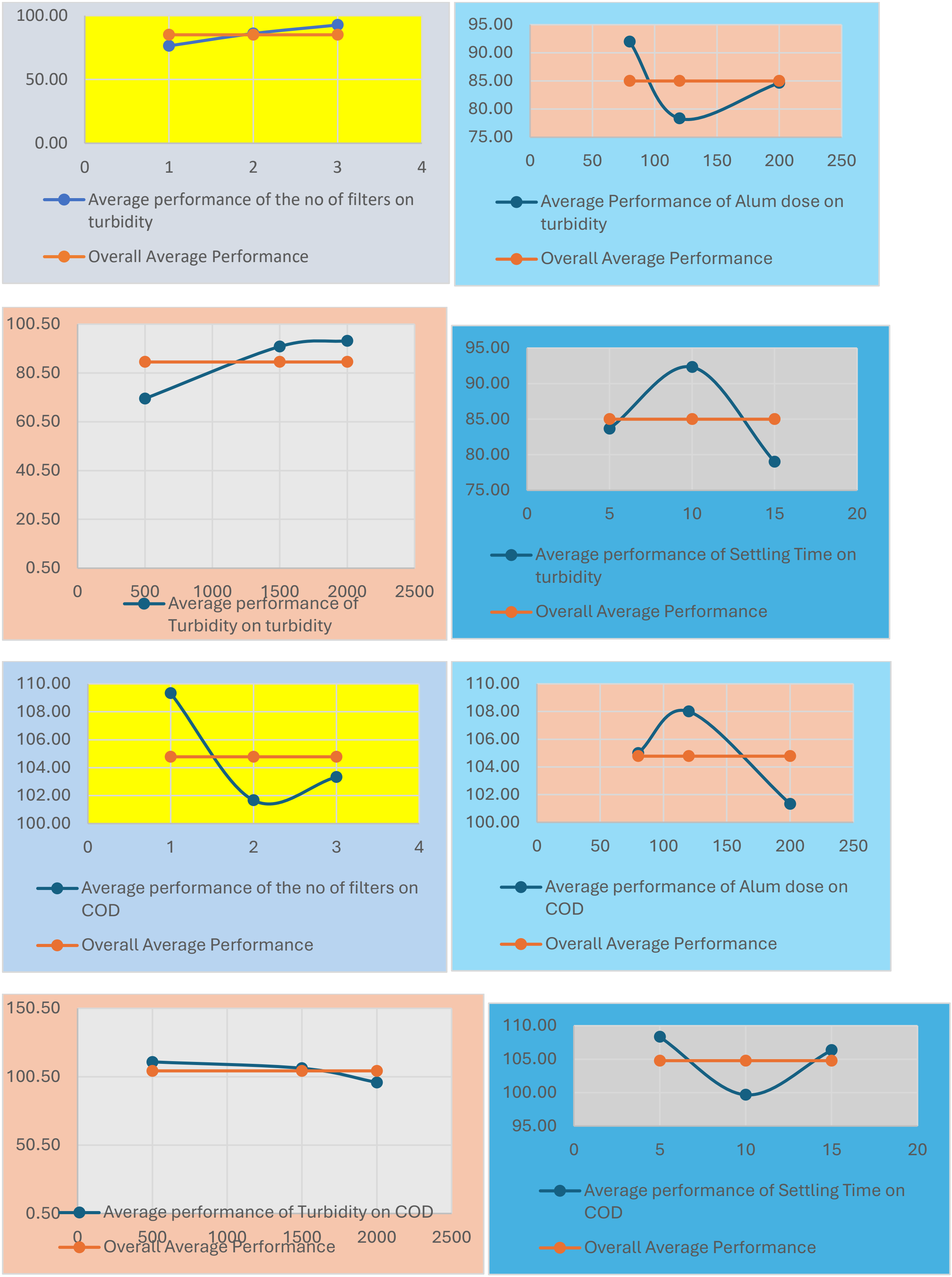

Figure 11a: Optimization of the selected factors in removing selected pollutants using activated carbon filter

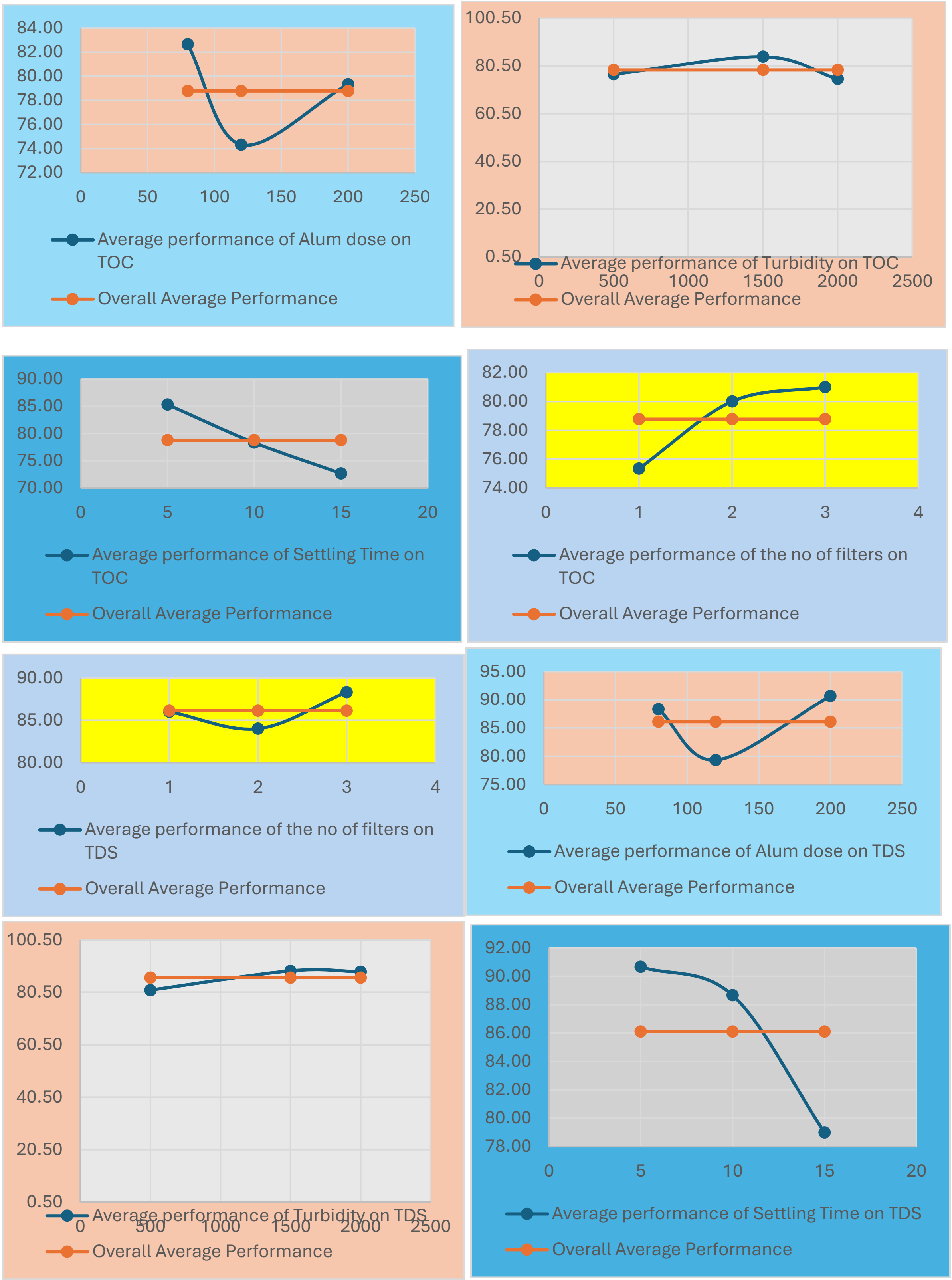

Figure 11b: Optimization of the selected factors in removing selected pollutants using activated carbon filter

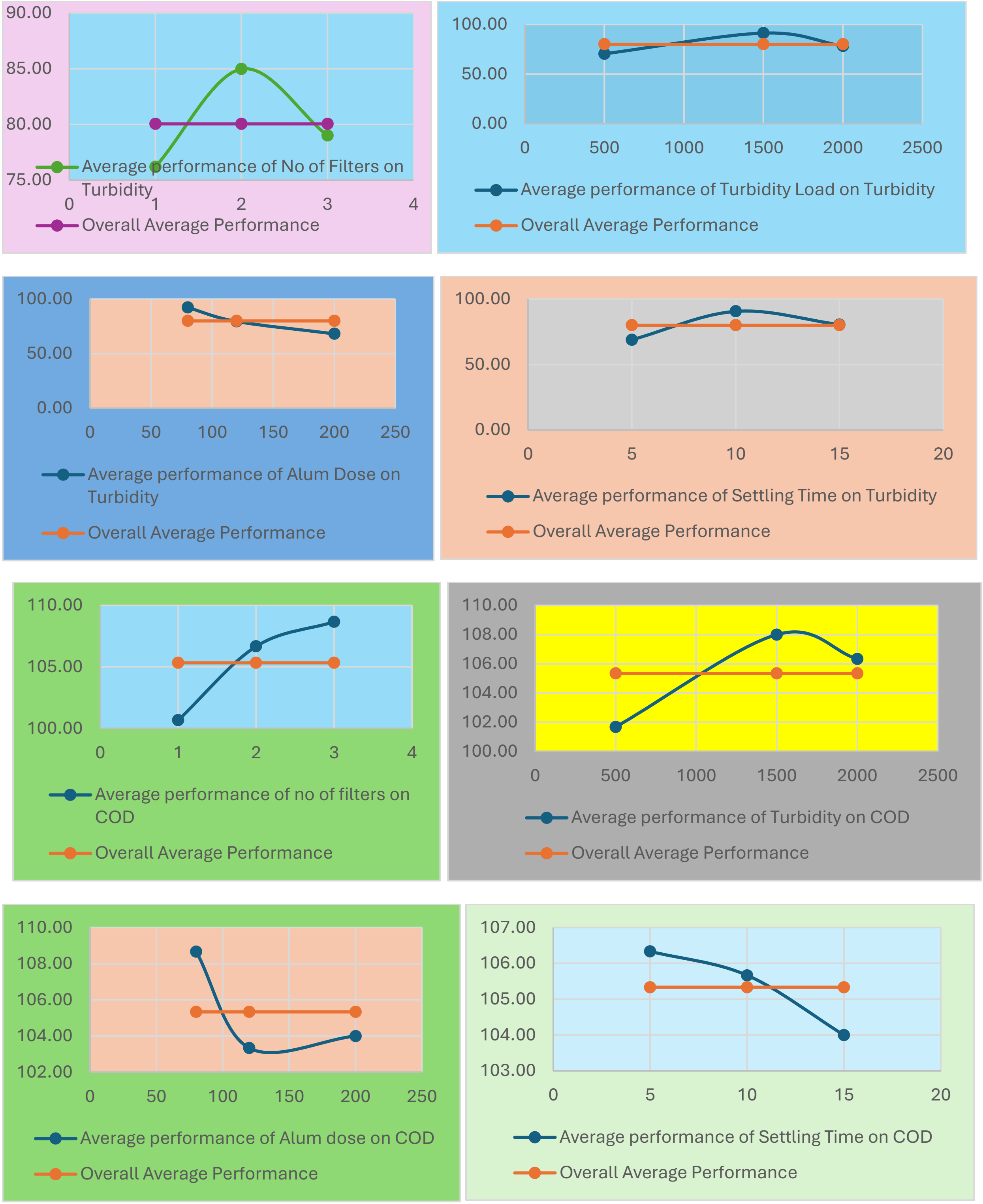

Figure 12a Optimization of the selected factors in removing selected pollutants using ceramic filter

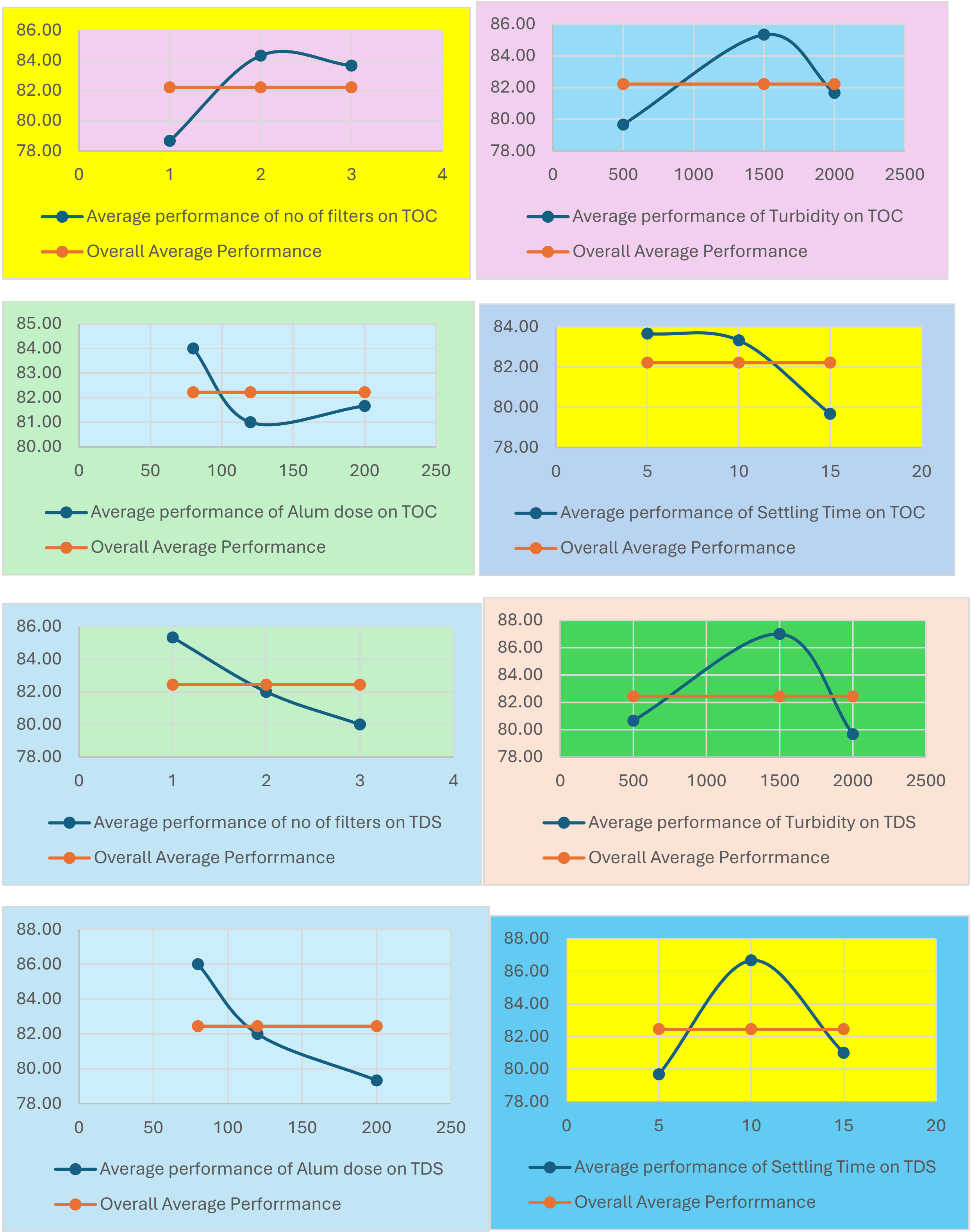

Figure 12b: Optimization of the selected factors in removing selected pollutants using ceramic filter

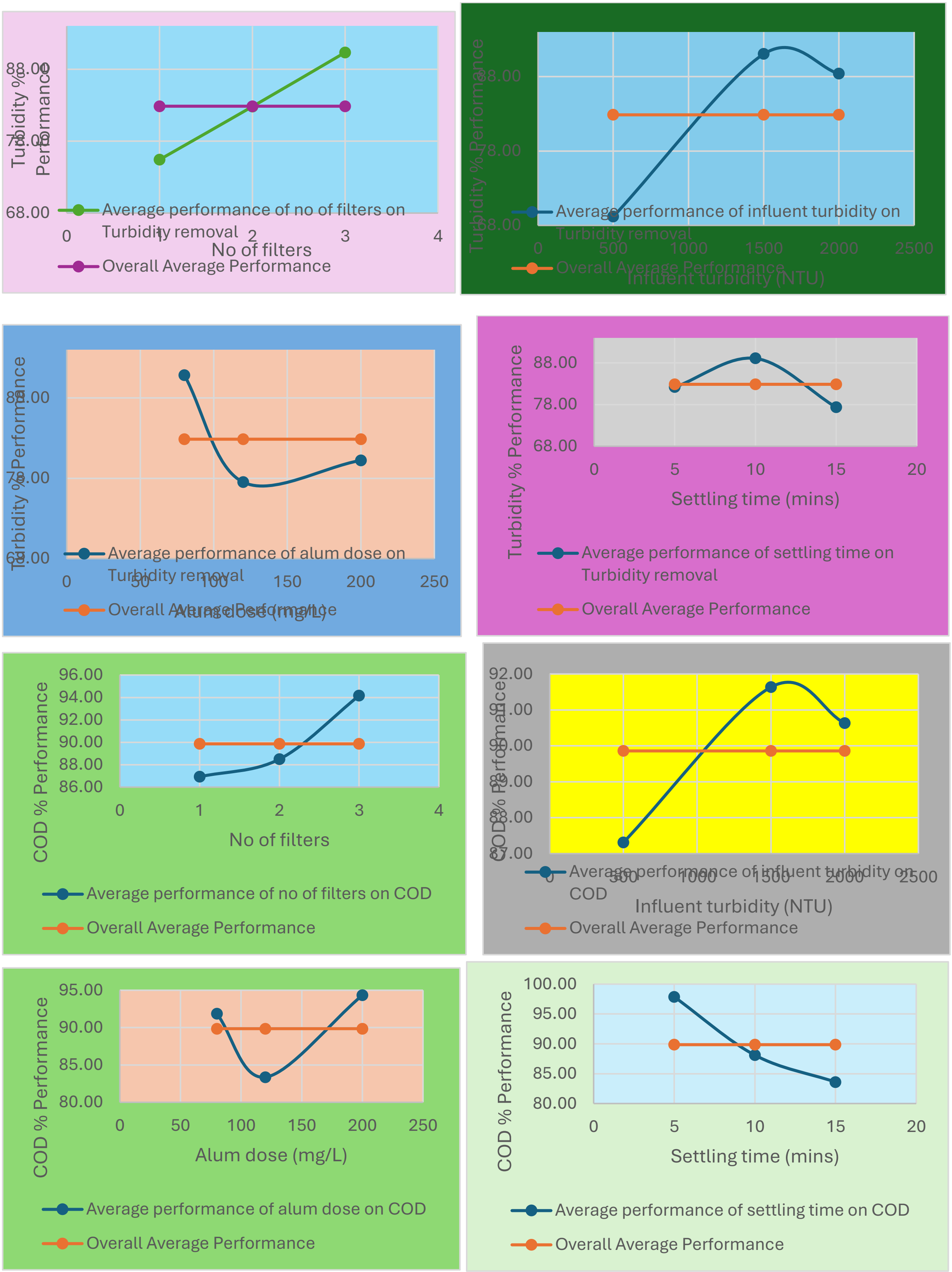

Figure 13a: Optimization of the selected factors in removing selected pollutants using fibre filter

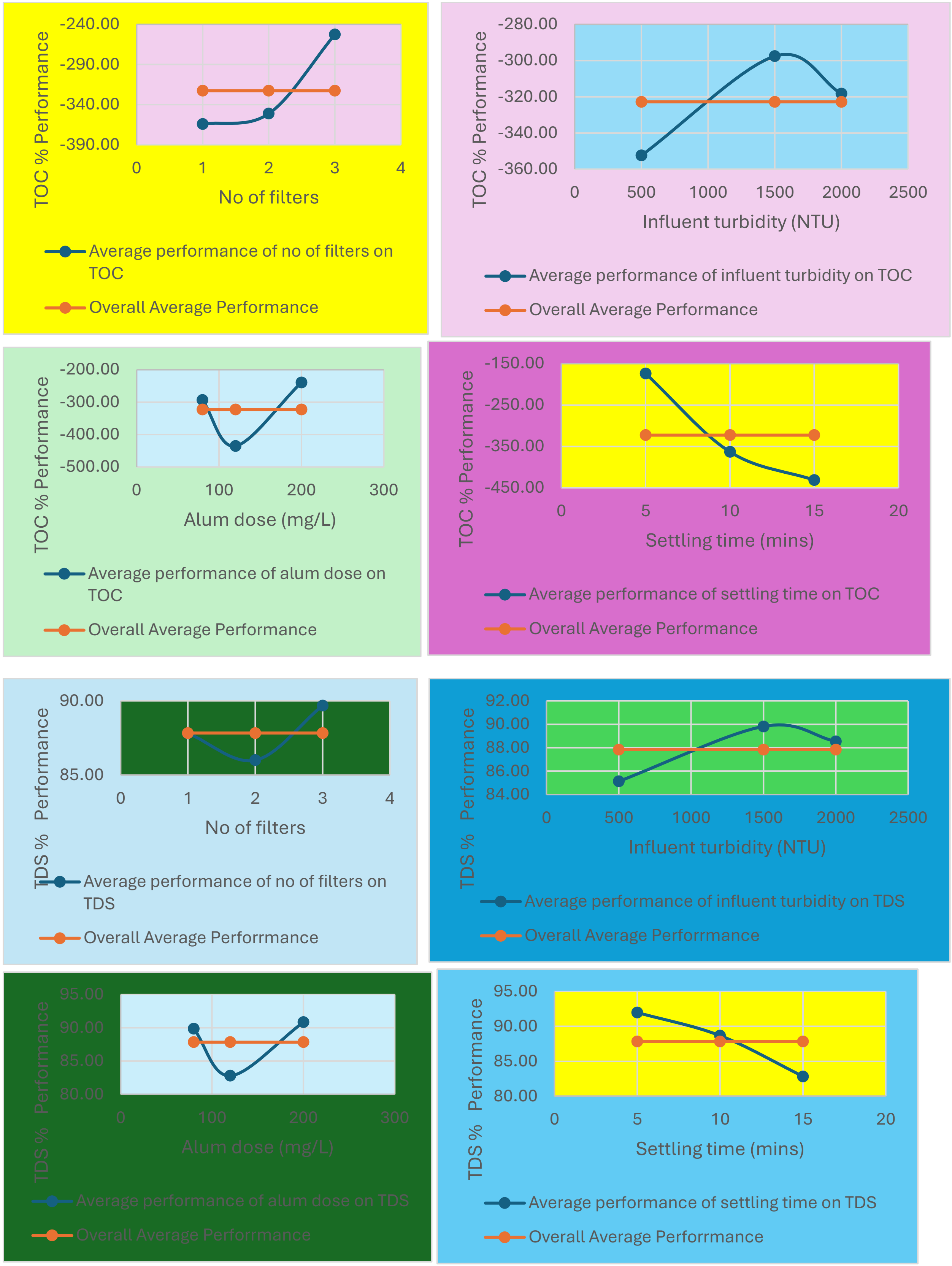

Figure 13b: Optimization of the selected factors in removing selected pollutants using fibre filter

CONCLUSION

This desktop review demonstrates the growing global research interest in household water treatment techniques (HWTT), reflecting their increasing importance in providing safe and reliable drinking water, particularly in regions where centralized water treatment systems are inadequate or unavailable. The review further highlights the effectiveness of household filtration technologies in improving drinking water quality and reducing the risk of waterborne diseases.

The performance evaluation showed that the average treatment efficiencies of the selected household filtration systems were 88.24%, 88.27%, and 89.15% for ceramic, fibre, and activated carbon filters, respectively. The corresponding performance ranges were 78.67–93.86% for ceramic filters, 78.77–93.81% for fibre filters, and 77.73–92.52% for activated carbon filters, indicating consistently high treatment efficiencies across varying operating conditions. Among the evaluated systems, activated carbon filters exhibited the highest overall average performance, although all three technologies demonstrated comparable and effective contaminant removal capabilities.

Optimization analysis identified the optimum operating conditions as an influent turbidity of 1080 NTU, two filter units, a treatment time of 12.8 minutes, and a coagulant dose of 135 mg/L. These parameters provide a practical framework for maximizing treatment efficiency while maintaining operational simplicity at the household level.

Overall, the findings underscore that influent turbidity, number of filters, treatment time, and coagulant dosage are critical factors influencing the performance of household water treatment systems. A comprehensive understanding and optimization of these parameters are essential for improving contaminant removal efficiency, enhancing public health outcomes, supporting evidence-based design and operation of household treatment systems, and promoting the long-term sustainability, affordability, and widespread adoption of household water treatment interventions, particularly in low- and middle-income countries.

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