BIO Web of Conferences **223**, 02003 (2026) https://doi.org/10.1051/bioconf/202622302003
ICFTN 2025

Improving The Quality of Drinking Water for The Community with Membrane and Ultraviolet Filtration Technology

Dikianur Alvianto[1]*, Taufikkilah* Romadhon[1], and *Panggulu Ahmad Ramadhani* Utoro[1,*]

[1]Department of Agricultural Product Technology, Mulawarman University, Jl. Tanah Grogot Kampus Gunung Kelua, Indonesia, 75119, Indonesia

Abstract. Access to safe drinking water remains a critical public health priority. This study evaluates the effectiveness of a combined membrane and ultraviolet (UV) filtration system in improving water quality parameters to meet the Indonesian Ministry of Health standards No.2 2023. Raw water samples (A) and treated water samples (B) were analyzed for TDS, turbidity, color, pH, nitrate, and nitrite using standardized methods (SNI). Results showed substantial reductions in TDS from 172 mg/L to 122 mg/L, turbidity from 136 NTU to 11 NTU, and color from 36.4 PtCo to 12.2 PtCo. pH improved from 5.85 to 6.26, approaching the acceptable range of 6.5–8.5. Nitrate and nitrite concentrations remained well below maximum limits, with slight variations after treatment (nitrate: 0.495 to 0.658 mg/L; nitrite: 0.375 to 0.071 mg/L). The membrane filtration effectively removed suspended solids and reduced turbidity, while UV treatment provided microbial disinfection without altering chemical composition. These findings confirm that integrating membrane and UV technologies can significantly enhance the physicochemical quality of drinking water, making it safer for community consumption. The approach offers a practical, scalable solution for rural and peri-urban areas with limited access to centralized water treatment facilities. Future research should support broader implementation.

1 Introduction

Access to safe drinking water is universally acknowledged as a fundamental human right and a cornerstone of sustainable development. Despite global commitments to the Sustainable Development Goals (SDG 6), which emphasize universal access to clean water and sanitation, more than two billion people worldwide still lack safely managed drinking water services (1). Unsafe water remains a leading cause of preventable diseases, particularly diarrheal illnesses, which disproportionately affect children under five years old and contribute significantly to global morbidity and mortality (2). Beyond health, inadequate access to potable water undermines education, economic productivity, and gender equity, as women and children often bear the burden of water collection in resource-limited settings

---

[*] Corresponding author: panggulu@unmul.ac.id

(3). In Indonesia, the challenge is particularly acute in rural and peri-urban areas, where communities frequently rely on untreated surface water, shallow wells, or rainwater harvesting systems that are highly vulnerable to contamination (1). These conditions underscore the urgent need for innovative, affordable, and sustainable water treatment technologies that can be deployed at the community level.

The importance of addressing water quality is further emphasized by the complex array of contaminants commonly found in untreated water sources. Physicochemical parameters such as turbidity, color, total dissolved solids (TDS), and pH, as well as chemical pollutants including nitrates, nitrites, and detergents, often exceed permissible limits in rural water supplies (4). Elevated turbidity and color not only reduce the aesthetic acceptability of water but also interfere with disinfection processes, shielding microorganisms from inactivation (5). High TDS levels, while not always directly harmful, can impart undesirable taste and may indicate the presence of harmful ions such as chlorides or sulfates (6). Nitrate and nitrite contamination, frequently linked to agricultural runoff, pose significant health risks, including methemoglobinemia in infants and potential carcinogenic effects (7). Moreover, microbial pathogens such as *Escherichia coli*, *Cryptosporidium*, and enteric viruses remain prevalent in untreated water, contributing to outbreaks of gastrointestinal illness (8). Climate change and extreme weather events further exacerbate these risks by altering hydrological cycles, increasing the frequency of floods and droughts, and thereby destabilizing water quality and availability (9).

The central research problem addressed in this study is the inadequacy of conventional water sources in meeting national and international drinking water standards. In many Indonesian communities, raw water exhibits turbidity, color, and TDS levels that exceed permissible limits, rendering it unsafe for direct consumption. Conventional centralized water treatment systems, while effective, are often inaccessible or unaffordable for rural populations due to high infrastructure and operational costs (10). As a result, communities are left with limited options, relying on boiling or chemical disinfection methods that may be insufficient, costly, or unsustainable in the long term (11). The challenge, therefore, lies in identifying and implementing decentralized water treatment solutions that are both technically effective and socially acceptable.

General solutions to this problem have focused on point-of-use and community-scale technologies that can improve water quality at the household or village level. These include ceramic filters, biosand filters, chlorination, solar disinfection, and membrane-based systems (12). Each approach has advantages and limitations. For example, chlorination is inexpensive and effective against bacteria but less so against protozoa and viruses, and it may produce disinfection by-products. Solar disinfection is low-cost but dependent on weather conditions and requires long exposure times (13). Membrane technologies, while more effective in removing a broad range of contaminants, face challenges related to fouling, maintenance, and cost (14). These considerations underscore the need for integrated approaches that combine complementary technologies to maximize effectiveness while minimizing limitations. Recent assessments of mobile point-of-use membrane-based appliances in Indonesia have shown promising results in reducing nitrate, nitrite, ammonia, and fluoride levels, while maintaining stable flow rates and low fouling, making them suitable for low-income communities (15).

Broader spatial analyses also show that well water quality in Jakarta is strongly influenced by topography, population density, and flood-related factors, underscoring the importance of local context in water safety strategies (16).

One promising solution is the integration of membrane filtration with ultraviolet (UV) disinfection. Membrane filtration, including microfiltration and ultrafiltration, provides a physical barrier to suspended solids, turbidity, and pathogens, significantly improving the physical and aesthetic quality of water (17). Ultrafiltration membranes, in particular, are effective in removing bacteria, protozoa, and some viruses, while also reducing turbidity and color (12). However, membranes alone may not fully address microbial risks, especially viruses and bacteria that can pass through or proliferate in storage systems. UV disinfection complements membrane filtration by inactivating microorganisms through DNA damage, preventing replication and infection (18). Importantly, UV treatment does not alter the chemical composition of water, making it suitable for integration with membrane systems.

Previous studies have demonstrated the effectiveness of membrane-UV systems in improving water quality. (19) reported that combined systems achieved significant reductions in microbial contamination and improved physicochemical parameters in decentralized applications. Similarly, studies in rural and peri-urban contexts have shown that membrane-UV integration can provide safe drinking water with relatively low energy requirements and minimal chemical inputs (10,12). Nevertheless, challenges remain, particularly in contexts where raw water exhibits extremely high turbidity or color, which can reduce UV effectiveness and accelerate membrane fouling (14). These findings suggest that while membrane-UV systems hold promise, their performance must be empirically evaluated under specific local conditions to determine feasibility and sustainability.

The literature on decentralized water treatment highlights both the potential and the limitations of membrane-UV systems. While numerous studies have documented improvements in microbial safety and reductions in turbidity and TDS, fewer have examined the performance of these systems in Southeast Asian contexts, particularly in Indonesia. Moreover, existing research often focuses on laboratory or pilot-scale studies, with limited data on real-world community applications (19). This gap is significant, as local environmental conditions, water quality characteristics, and community practices can greatly influence system performance and sustainability (9). Addressing this gap requires empirical studies that evaluate membrane-UV systems under field conditions, providing evidence to inform policy and practice.

The objective of the present study is to evaluate the effectiveness of a combined membrane and UV system in improving drinking water quality in an Indonesian community context. The novelty of this research lies in its empirical assessment of system performance under real-world conditions, focusing on key physicochemical parameters such as TDS, turbidity, color, pH, nitrate, and nitrite. The hypothesis is that the integration of membrane filtration and UV disinfection will significantly improve water quality, bringing most parameters within the limits set by the Indonesian Ministry of Health Regulation No. 2 of 2023. The scope of the study includes systematic sampling of raw and treated water, laboratory analysis of key parameters, and comparison with national standards. By addressing a critical gap in the literature and providing context-specific evidence, this study contributes to the broader discourse on decentralized water treatment and supports efforts to achieve universal access to safe drinking water.

2 Methods

This chapter outlines the methodological framework employed in the study evaluating the effectiveness of a combined membrane and ultraviolet (UV) filtration system for improving drinking water quality in rural Indonesian communities. The methodology is structured to ensure clarity, reproducibility, and alignment with national and international standards for water quality assessment. The study was carried out in a rural community in East Kalimantan, Indonesia, where access to centralized water treatment facilities is limited.

2.1 Research Design

The study adopted an experimental research design with a comparative approach. Raw water samples (Sample A) were collected from local community sources, while treated water samples (Sample B) were obtained after processing through the integrated membrane and UV filtration system. The design allowed for direct comparison of physicochemical parameters before and after treatment. The membrane and UV-based membrane filtration tool is a modification of research (15) and can be seen in (Figure 1).

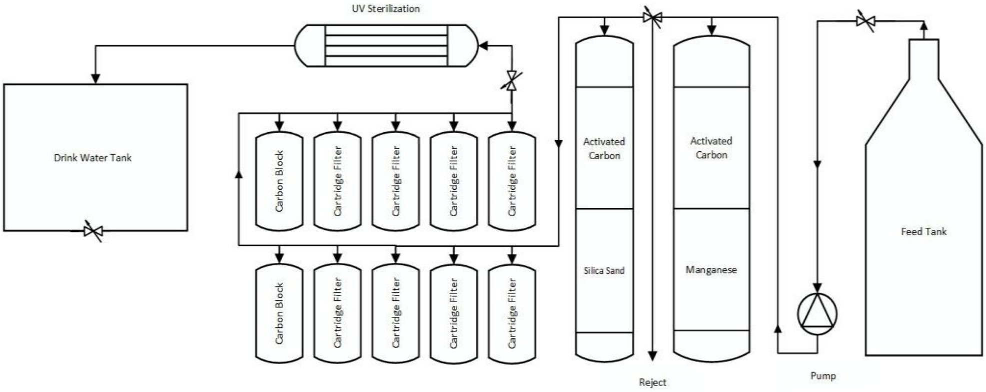

Fig. 1. The membrane and UV-based membrane filtration tool

The filtration unit employed a Polypropylene (PP) sediment filter cartridge (microfiltration) as the primary barrier for suspended solids. The filter had a pore size rating of 0.1–1 μm to effectively retain particulate matter and turbidity prior to UV disinfection. The filtration process operated at a constant flow rate of 8–10 L/minute driven by a feed pump pressure of 0.2–0.3 MPa. This configuration was selected for its cost-effectiveness and chemical inertness, providing a robust pre-treatment stage to ensure optimal UV transmittance (15,20). This configuration was selected for its ability to remove suspended solids, turbidity, bacteria, and protozoa. The UV unit was installed downstream of the membrane filter. It consisted of a low-pressure mercury vapor lamp emitting at 254 nm, a wavelength proven effective for microbial inactivation. The UV dose was maintained at >40 mJ/cm², sufficient to inactivate bacteria, viruses, and protozoa. The membrane and UV units were integrated in series, with the membrane serving as a pre-treatment step to reduce turbidity and suspended solids, thereby enhancing UV penetration and disinfection efficiency.

2.2 Analytical Procedure

Parameters were selected based on their relevance to both aesthetic and health-related aspects of drinking water quality, as defined by the Indonesian Ministry of Health Regulation No. 2 of 2023 (21). All analyses were conducted using standardized methods from the Indonesian National Standard (SNI). Six key water quality parameters were analyzed.:

- Total Dissolved Solids (TDS) : Gravimetric method (SNI 6989.27:2019)
- Turbidity : Nephelometric method (SNI 06-6989.25-2005)
- Color : Platinum-Cobalt method (SNI 6989.80:2011)
- pH : Electrometric method (SNI 6989.11:2019)
- Nitrate (NO_3^-) : Spectrophotometric method (SNI 19-6964.7-2003)
- Nitrite (NO_2^-) : Spectrophotometric method (SNI 06.6989.9-2004)

2.3 Data Analysis

The results of raw and treated water samples were compared against the permissible limits specified in the Indonesian Ministry of Health Regulation No. 2 of 2023 (21). To ensure the reliability of results, several quality assurance measures were implemented: calibration of instruments before each measurement session, use of blanks and standards to validate analytical accuracy, triplicate measurements for each parameter, and cross-checking results with certified reference laboratories when necessary. These measures align with best practices in water quality monitoring and ensure that the findings are robust and reproducible (22).

3 Result and Discussion

This chapter presents the findings of the study on the effectiveness of a combined membrane and ultraviolet (UV) filtration system in improving drinking water quality in a rural Indonesian context. The results are organized according to the key physicochemical parameters measured total dissolved solids (TDS), turbidity, color, pH, nitrate, and nitrite. The discussion is structured inductively, beginning with parameter-specific analyses and culminating in a synthesis of the system's overall performance, its potential for scalability, and its contribution to the discourse on decentralized water treatment technologies. The results of water testing from sample A and B can be seen in Table 1.

Table 1. Physicochemical Water Quality Parameters of Raw and Treated Water

Parameter	Unit	Quality Standard*	A (Raw Water)	B (Treated Water)	Method
TDS	mg/L	<300	172	122	SNI 6989.27:2019
Turbidty	NTU	<3	136	11	SNI 06-6989.25-2005
Color	PtCO	10	36.4	12.2	SNI 6989.80:2011
pH	-	6.5-8.5	5.85	6.26	SNI 6989.11:2019
Nitrate (NO_3^-)	mg/L	20	0.495	0.658	SNI 19-6964.7-2003
Nitrite (NO_2^-)	mg/L	3	0.375	0.071	SNI 06.6989.9-2004

* Indonesian Ministry of Health, No.2 of 2023

3.1 Total Dissolved Solids (TDS)

The raw water sample exhibited a TDS concentration of 172 mg/L, which was reduced to 122 mg/L after treatment (Table 1). Both values fall below the maximum permissible limit of 300 mg/L set by the Indonesian Ministry of Health (21). The reduction of approximately 29% demonstrates the membrane's capacity to remove dissolved inorganic and organic matter, including salts, minerals, and trace contaminants.

High TDS levels are often associated with undesirable taste, scaling in household appliances, and potential health risks when dominated by harmful ions such as nitrates, sulfates, or chlorides (4). The observed reduction aligns with findings from other studies that report ultrafiltration membranes as effective in lowering TDS within acceptable ranges for drinking water (12). The results suggest that the system is capable of maintaining TDS within safe limits, thereby improving both the aesthetic and functional quality of water. However, the relatively modest reduction indicates that while membranes are effective, they may not be sufficient in contexts where raw water exhibits extremely high TDS, such as in coastal or industrially impacted areas (23).Captions should be typed in 9-point Times. They should be centred above the tables and flush left beneath the figures.

3.2 Turbidity

Turbidity decreased significantly from 136 NTU in raw water to 11 NTU after treatment (Table 1). Although this represents a reduction of more than 90%, the treated water still exceeded the permissible limit of 3 NTU. Turbidity is a critical parameter because it not only affects the aesthetic quality of water but also interferes with disinfection processes by shielding microorganisms from UV exposure (5).

The persistence of turbidity above the standard highlights the limitations of the membrane system in handling highly turbid raw water. Similar findings have been reported in studies where ultrafiltration alone was insufficient to reduce turbidity to acceptable levels without pre-treatment steps such as coagulation or sedimentation (14). This result underscores the importance of integrating additional pre-treatment processes in areas where raw water turbidity is extremely high. For instance, coagulation-flocculation followed by sedimentation has been shown to enhance membrane performance and extend operational lifespan by reducing fouling (24).

3.3 Color

The color of raw water was measured at 36.4 PtCo, which decreased to 12.2 PtCo after treatment (Table 1). While this represents a substantial improvement, the treated water still slightly exceeded the permissible limit of 10 PtCo. The color of well water samples in several locations exceeded the permissible limits, indicating possible contamination from organic matter and surrounding environmental conditions. Similar findings were reported in Semau Island, where dug wells showed poor physicochemical and bacteriological quality due to proximity to pollution sources and lack of protective structures. Color in water is typically caused by dissolved organic matter, iron, manganese, and other trace metals (25).

The reduction in color demonstrates the membrane's ability to remove suspended and colloidal particles, while UV treatment had little direct effect on this parameter. Similar outcomes have been reported in studies where ultrafiltration reduced color but required complementary adsorption processes, such as activated carbon, to achieve compliance with drinking water standards (26). The persistence of color above the standard suggests that additional treatment steps, such as granular activated carbon or advanced oxidation processes, may be necessary to fully meet regulatory requirements in contexts with high levels of dissolved organic matter.

3.4 pH

The pH of raw water was 5.85, which increased to 6.26 after treatment (Table 1). Although this represents an improvement, the value still falls slightly below the acceptable range of 6.5–8.5. Low pH in drinking water can lead to corrosivity, leaching of metals from pipes, and undesirable taste (6). The modest increase in pH suggests that the membrane-UV system has limited capacity to adjust acidity. This finding is consistent with previous studies that emphasize the need for pH adjustment through chemical dosing (e.g., lime or sodium carbonate) in cases where raw water is naturally acidic (9). The implication is that while the system improves pH, additional interventions are required to ensure compliance with standards and to prevent long-term infrastructure damage due to corrosive water

3.5 Nitrate

Nitrate concentrations increased slightly from 0.495 mg/L in raw water to 0.658 mg/L after treatment (Table 1). Both values are well below the maximum permissible limit of 20 mg/L. The slight increase in nitrate concentration observed (from 0.495 to 0.658 mg/L) is likely attributed to the oxidation of nitrite (NO^2) to nitrate (NO^3) during UV treatment, as well as the release of nitrogenous compounds from biofilm or trapped organic matter on the membrane surface. Biological activity within the membrane module can facilitate nitrification, converting residual nitrite or ammonia into nitrate (27), while UV irradiation has been shown to induce transformations of nitrogen species in the presence of organic constituents (28). Nitrate contamination is a major concern in agricultural regions, where fertilizer runoff often leads to elevated concentrations in groundwater (7) Chronic exposure to high nitrate levels has been linked to methemoglobinemia and potential carcinogenic effects. The low levels observed in this study indicate that nitrate is not a significant concern in the study area.

The findings align with other studies showing that ultrafiltration and UV treatment have limited direct impact on nitrate removal, as these technologies primarily target suspended solids and microorganisms. Nitrate contamination in groundwater remains a major concern, and various removal technologies have been developed, including biological denitrification, ion exchange, and membrane-based processes. Recent studies highlight that bioelectrochemical systems can significantly enhance nitrate removal efficiency in waters with low organic carbon concentrations, offering a sustainable alternative to conventional denitrification (29).

In addition, low-carbon biological technologies such as sulfur- and hydrogen-autotrophic denitrification, as well as emerging photoelectrotrophic processes, are increasingly recognized as promising approaches for sustainable nitrate removal in wastewater treatment (30). Complementary findings also show that denitrifying membrane bioreactors (DNMBRs) can achieve high nitrate removal while the choice of carbon source and C/N ratio strongly influence both nitrogen removal efficiency and membrane fouling behavior (31).

3.6 Nitrite

Nitrite concentrations decreased from 0.375 mg/L in raw water to 0.071 mg/L after treatment, both well below the maximum permissible limit of 3 mg/L (Table 1). The reduction indicates that the system is effective in lowering nitrite levels, which is significant given that nitrite is more toxic than nitrate and can cause acute health effects even at low concentrations (32). The observed reduction may be attributed to adsorption onto the membrane surface or transformation during UV exposure. Similar findings have been reported in studies where UV irradiation facilitated the breakdown of nitrite into less harmful compounds (33). This result highlights the added value of UV treatment in addressing nitrite contamination, even though it is not the primary target of the technology.

4 Conclusion

This study confirms that integrating microfiltration with UV treatment significantly improves drinking water quality in community settings, effectively reducing total dissolved solids, turbidity, color, and nitrite while maintaining safe nitrate levels. Although the system shows promise as a decentralized solution, residual turbidity, color, and low pH values indicate that complementary pre-treatment steps, such as coagulation or activated carbon, are necessary for full regulatory compliance. Beyond its technical performance, the system offers a cost-effective alternative to centralized infrastructure, featuring low capital and operational costs with simple maintenance requirements suitable for local operators.

The research provides critical field-based evidence of membrane-UV performance in Indonesia, enriching the knowledge base for technology developers and policymakers regarding decentralized water treatment. While the current configuration successfully mitigates microbial risks and suspended solids, future work must focus on optimizing hybrid systems and assessing long-term stability to handle variable raw water conditions. Ultimately, this work underscores the technology's potential as a scalable, sustainable pathway to improve water access in underserved regions, provided that operational limitations are addressed through adaptive system design.

References

1. WHO, UNICEF, *Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs*. Joint Water Supply & Sanitation Monitoring Programme (2021)
2. A. Prüss-Ustün, J. Wolf, J. Bartram, T. Clasen, O. Cumming, M.C. Freeman, et al., Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low- and middle-income countries. Int. J. Hyg. Environ. Health **222**, 765–777 (2019). https://doi.org/10.1016/j.ijheh.2019.05.004
3. C.C. Vassella, J. Koch, A. Henzi, A. Jordan, R. Waeber, R. Iannaccone, et al., From spontaneous to strategic natural window ventilation: Improving indoor air quality in Swiss schools. Int. J. Hyg. Environ. Health **234**, 113746 (2021). https://doi.org/10.1016/j.ijheh.2021.113746
4. V. Kothari, S. Vij, S. Sharma, N. Gupta, Correlation of various water quality parameters and water quality index of districts of Uttarakhand. Environ. Sustain. Indic. **9**, 100093 (2021). https://doi.org/10.1016/j.indic.2020.100093
5. M.W. LeChevallier, Water Treatment and Pathogen Control: Process Efficiency in Achieving Safe Drinking-water. Water Intell. Online **12** (2013). https://doi.org/10.2166/9781780405858
6. WHO, *Guidelines for drinking-water quality: Fourth edition incorporating the first addendum*, (World Health Organization, 2017)
7. I. Otero, M.J. Nieuwenhuijsen, D. Rojas-Rueda, Health impacts of bike sharing systems in Europe. Environ. Int. **115**, 387–394 (2018). https://doi.org/10.1016/j.envint.2018.04.014
8. N.J. Ashbolt, Microbial Contamination of Drinking Water and Human Health from Community Water Systems. Curr. Environ. Heal. Reports **2**, 95–106 (2015). https://doi.org/10.1007/s40572-014-0037-5
9. M. Tuninetti, L. Ridolfi, F. Laio, Charting out the future agricultural trade and its impact on water resources. Sci. Total Environ. **714**, 136626 (2020). https://doi.org/10.1016/j.scitotenv.2020.136626

10. T. Clasen, Household Water Treatment and Safe Storage to Prevent Diarrheal Disease in Developing Countries. Curr. Environ. Heal. Reports **2**, 69–74 (2015). https://doi.org/10.1007/s40572-014-0033-9
11. D. Lantagne, T. Clasen, Point-of-use water treatment in emergency response. Waterlines **31**, 30–52 (2012). https://doi.org/10.3362/1756-3488.2012.005
12. A. Campisano, D. Butler, S. Ward, M.J. Burns, E. Friedler, K. DeBusk, et al., Urban rainwater harvesting systems: Research, implementation and future perspectives. Water Res. **115**, 195–209 (2017). https://doi.org/10.1016/j.watres.2017.02.056
13. K.G. McGuigan, R.M. Conroy, H.J. Mosler, M. du Preez, E. Ubomba-Jaswa, P. Fernandez-Ibañez, Solar water disinfection (SODIS): A review from bench-top to roof-top. J. Hazard. Mater. **235–236**, 29–46 (2012). https://doi.org/10.1016/j.jhazmat.2012.07.053
14. W. Guo, H.H. Ngo, J. Li, A mini-review on membrane fouling. Bioresour. Technol. **122**, 27–34 (2012). https://doi.org/10.1016/j.biortech.2012.04.089
15. Y. Wibisono, R.V. Astuti, G. Djoyowasito, A.W. Putranto, N. Izza, D. Alvianto, et al., Assessment of Point-of-Use Membrane-Based Drinking Water Appliance for Local Community. J. Eng. Sci. Technol. Rev. **14**, 1–7 (2021). https://doi.org/10.25103/jestr.145.01
16. A.H. Ashillah, Z. Zakianis, H. Kusnoputranto, E.P. Fitratunnisa, S. Fauzia, F. Lestari, et al., Linking Urban Sustainability and Water Quality: Spatial Analysis of Topographic, Sociodemographic, and Flood-Related Factors Affecting Well Water in Jakarta (2017–2019). Sustain. **17**, 1–19 (2025). https://doi.org/10.3390/su17083373
17. M.A. Shannon, P.W. Bohn, M. Elimelech, J.G. Georgiadis, B.J. Mariñas, A.M. Mayes, Science and technology for water purification in the coming decades. Nature **452**, 301–310 (2008). https://doi.org/10.1038/nature06599
18. W.A.M. Hijnen, E.F. Beerendonk, G.J. Medema, Inactivation credit of UV radiation for viruses, bacteria and protozoan (oo)cysts in water: A review. Water Res. **40**, 3–22 (2006). https://doi.org/10.1016/j.watres.2005.10.030
19. Q. Qin, H. Lu, Z. Zhu, Y. Qiu, X. Liu, D. Yin, Safety and security of household water purifiers against pathogenic microbial contamination and bio-risk evaluation of their microbial community structures. Sep. Purif. Technol. **357**, 130012 (2025). https://doi.org/10.1016/j.seppur.2024.130012
20. M. Shatat, S.B. Riffat, Water desalination technologies utilizing conventional and renewable energy sources. Int. J. Low-Carbon Technol. **9**, 1–19 (2014). https://doi.org/10.1093/ijlct/cts025
21. Indonesian Ministry of Health, Permenkes No. 2 Tahun 2023, Indones. Minist. Heal. **55**, 1–175 (2023)
22. APHA, *Standard methods for the examination of water and wastewater*, 23rd ed. (American Public Health Association, 2017)
23. E.H. Koh, E. Lee, K.K. Lee, Application of geographically weighted regression models to predict spatial characteristics of nitrate contamination: Implications for an effective groundwater management strategy. J. Environ. Manage. **268**, 110646 (2020). https://doi.org/10.1016/j.jenvman.2020.110646
24. J. Liu, K. He, S. Tang, T. Wang, Z. Zhang, A comparative study of ferrous, ferric and ferrate pretreatment for ceramic membrane fouling alleviation in reclaimed water treatment. Sep. Purif. Technol. **217**, 118–127 (2019). https://doi.org/10.1016/j.seppur.2019.01.040
25. K. Kusmiyati, F.W.F. Waangsir, E.M. Mauguru, M.K. Tokan, Bacteriological quality and environment risk of water pollution of dug wells on Semau Island, Indonesia. Int. J. Health Sci. (Qassim) **6**, 732–746 (2022). https://doi.org/10.53730/ijhs.v6nS9.12324

26. H.N. Tran, S.J. You, A. Hosseini-Bandegharaei, H.P. Chao, Mistakes and inconsistencies regarding adsorption of contaminants from aqueous solutions: A critical review. Water Res. **120**, 88–116 (2017). https://doi.org/10.1016/j.watres.2017.04.014
27. K. Pullerits, S. Chan, J. Ahlinder, A. Keucken, P. Rådström, C.J. Paul, Impact of Coagulation–Ultrafiltration on Long-Term Pipe Biofilm Dynamics in a Full-Scale Chloraminated Drinking Water Distribution System. Environ. Sci. Water Res. Technol. **6**, 3044–3056 (2020). https://doi.org/10.1039/D0EW00622J
28. Y. Sato, M. Ishihara, K. Fukuda, S. Nakamura, K. Murakami, M. Fujita, et al., Behavior of Nitrate-Nitrogen and Nitrite-Nitrogen in Drinking Water during UV Irradiation. Biocontrol Sci. **23**, 139–143 (2018). https://doi.org/10.4265/bio.23.139
29. R. Lust, J. Nerut, K. Kasak, Ü. Mander, Enhancing nitrate removal from waters with low organic carbon concentration using a bioelectrochemical system-a pilot-scale study. Water (Switzerland) **12**, 516 (2020). https://doi.org/10.3390/w12020516
30. R. Zheng, K. Zhang, L. Kong, S. Liu, Research progress and prospect of low-carbon biological technology for nitrate removal in wastewater treatment. Front. Environ. Sci. Eng. **18**, 89 (2024). https://doi.org/10.1007/s11783-024-1840-3
31. Z. Wang, P. Gao, L. Yan, C. Yin, S. Li, Enhanced nitrate removal and fouling behavior in a denitrifying membrane bioreactor: Impacts of carbon source and c/n ratio. Desalin. Water Treat. **207**, 86–98 (2020). https://doi.org/10.5004/dwt.2020.26421
32. W. Cao, X. Liu, X. Liu, Y. Zhou, X. Zhang, H. Tian, et al., Perfluoroalkyl substances in umbilical cord serum and gestational and postnatal growth in a Chinese birth cohort. Environ. Int. **116**, 197–205 (2018). https://doi.org/10.1016/j.envint.2018.04.015
33. T. Rasheed, K. Rizwan, M. Bilal, F. Sher, H.M.N. Iqbal, Tailored functional materials as robust candidates to mitigate pesticides in aqueous matrices—a review. Chemosphere **282**,131056 (2021). https://doi.org/10.1016/j.chemosphere.2021.131056