

COMBINATION OF SYNTHETIC FILTERS WITH ULTRAFILTRATION FOR THE TREATMENT OF CEMPAKA RIVER WATER

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ABSTRACT

Combination Of Synthetic Filters With Ultrafiltration For The Treatment Of Cempaka River Water. Cempaka District in Banjarbaru City faces a real challenge in meeting clean water needs, due to the river's unfavorable physical characteristics, namely cloudy, brownish water, and frequent flooding and sand and diamond mining activities in the surrounding area. This condition not only reduces the quality and suitability of the water, but also increases health risks due to high levels of sediment, organic matter, and pathogenic microorganisms. The situation is further exacerbated by the limited supply of clean water suitable for consumption, so that the community still relies heavily on river water for daily needs. This study aims to test the ability of a combination of synthetic filters with ultrafiltration (UF) technology to treat Cempaka River water to meet health requirements and support increased access to clean water for the local community. The results show that the use of a combination of DHUSF and UF filters significantly reduced the turbidity of Cempaka River water with an efficiency of more than 95%. Turbidity parameters after treatment were consistently below the established quality standards (<3 NTU). This combination effectively removes suspended and colloidal particles, resulting in clearer and safer water. This system has the potential to be applied at the household or community level, particularly in areas with high levels of river water turbidity. Further studies could test other water quality parameters to optimize the system's implementation.

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INTRODUCTION

Clean water is one of the fundamental needs that significantly determines the level of public health. Its availability plays an essential role in preventing waterborne diseases, supporting environmental hygiene, and improving overall quality of life. Without access to safe water sources that meet health requirements, communities are vulnerable to a range of health problems, from diarrhea to other infectious diseases transmitted through water. Therefore, managing water quality—particularly surface water, which is widely used as a domestic source—becomes a strategic issue in public health development.

Cempaka Subdistrict in Banjarbaru City faces real challenges in fulfilling clean water needs. The physical characteristics of the river are unfavorable: the water is turbid, brownish in color, often influenced by flooding, and affected by sand and diamond mining activities in the surrounding area. These conditions not only reduce the aesthetic and usability of the water but also increase health risks due to potentially high levels of sediment, organic matter, and

pathogenic microorganisms. The situation is further exacerbated by limited access to safe drinking water, with most residents still depending on river water for their daily needs. This condition underscores the need for alternative water treatment solutions that can produce health-standard water using appropriate technologies applicable at the local level.

Previous studies have been conducted to address river water quality issues in Banjar Regency. Research by Raharja^[1] identified chemical contaminants in the Riam Kanan River, while Tien et al.^[2-5] highlighted biological pollution, coliform dynamics, and self-purification processes. Hamzani et al.^[6-8] focused more on technological innovations, including simple filtration reactors. Their findings showed that the Upflow Roughing Filter (URF) reduced turbidity from 183.3 NTU to 90.8 NTU (about 50.46%). The Downflow Roughing Filter (DRF) demonstrated higher effectiveness, reducing turbidity from 183.3 NTU to 73 NTU (60.18%). Meanwhile, the Horizontal Roughing Filter (HRF) produced varied results, with turbidity reductions of 94% at zero minutes contact time, 80% at five minutes, and 77% at ten minutes. These results prove that simple filtration technology is quite promising, but limitations remain in consistently achieving water quality that fully meets health standards. Another alternative using jackfruit peel for river water treatment showed turbidity reduction of 71.48%^[9].

Considering the turbid condition of the Cempaka River and the limited provision of safe water for the community, this study aims to evaluate the effectiveness of combining synthetic filters with ultrafiltration technology in treating Cempaka River water so that it meets health requirements and supports efforts to improve access to clean water for local residents.

MATERIALS AND RESEARCH METHODS

This study employed an experimental design using a One Group Pretest-Posttest Design, in which a single group of river water samples was first measured (pretest), then treated using a combination of a synthetic filter and ultrafiltration unit (SF-UF), followed by post-treatment measurements (posttest). The independent variable in this study was the water treatment using the SF-UF system, while the dependent variables included water quality parameters such as turbidity, TDS, pH, and temperature.

The research material consisted of river water samples collected directly from the Cempaka District. The river water was characterized by high turbidity, a brownish color, and was influenced by sand mining activities. The primary equipment used was the combination unit of the synthetic filter and ultrafiltration system (SF-UF). The synthetic filter was designed as a pre-treatment stage to remove suspended particles and reduce initial turbidity. The ultrafiltration unit was connected in series after the synthetic filter.

The experimental procedure began with the design and fabrication of the SF-UF unit using 3-inch and 2-inch PVC pipes. River water samples were then collected from the study site using a water pump. The first stage involved initial water quality testing (turbidity, TDS, pH, temperature) as pretest data. Subsequently, water was passed through the SF-UF unit. After treatment, the filtered water samples were collected in sampling bottles for posttest analysis. The results of water quality measurements (turbidity, TDS, pH, temperature) after treatment were compared to the initial data and the national water quality standards.

The research flow can be described as follows: the study began with the design and construction of the SF-UF unit, followed by the collection of river water samples from the Cempaka River, and subsequent water treatment using the SF-UF unit. The treated water samples were then tested for turbidity, TDS, pH, and temperature. The pretest and posttest results were analyzed, and in the final stage, treatment efficiency was calculated to evaluate the performance of the SF-UF unit in improving water quality.

Data analysis was conducted using a descriptive-comparative approach by comparing pre- and post-treatment measurement results against the Indonesian National Standard for water quality as stipulated in Regulation of the Minister of Health of the Republic of Indonesia

(Permenkes RI) No. 2 of 2023. This study did not employ inferential statistical tests; therefore, the interpretation focused on direct comparison and compliance with the required water quality standards.

RESEARCH RESULTS AND DISCUSSION

The study commenced with the design of a water treatment system combining a synthetic filter (SF) and ultrafiltration (UF). The SF unit was constructed using 3-inch PVC pipes with three filtration zones: downward flow, horizontal flow, and upward flow. This pre-treatment stage was designed to retain coarse particles and some colloids. The primary medium used was activated synthetic cloth, which is inexpensive, readily available, and easy to clean. The UF unit was assembled with fine-pore membranes encased in 2-inch PVC pipes. These two components were connected to form a layered filtration system that was simple yet expected to be effective in addressing the high turbidity of the Cempaka River water.

The initial characteristics of the Cempaka River water indicated high turbidity levels ranging from 77.5–108 NTU, significantly exceeding the turbidity quality standard of < 3 NTU (Permenkes RI No. 2 of 2023). Meanwhile, TDS levels of 8.30–9.16 mg/L complied with the quality standard of 300 mg/L; pH values between 7.22–7.88 met the standard of 6.5–8.5; and temperatures between 27.8–31.7°C were within the permissible range of $\pm 3^\circ\text{C}$ of ambient air temperature. These results confirmed that the primary water quality issue in this river source was turbidity, indicating a high concentration of suspended particles and sediments due to sand mining activities and seasonal flooding.

The water quality test results before and after treatment of river water from the Cempaka site, with a flow rate of 0.2 L/s, are presented in Table 1.

Table 1. Laboratory Results with Filter Variations and a Flow Rate of 0.2 L/s

No	Parameter	Flow Variation 1 (Q inlet = 0.2 L/s)											
		Before Treatment – Raw Water from Cempaka			DHUSF			UF			DHUSF + UF		
		SC ₁	SC ₂	SC ₃	DHU ₁	DHU ₂	DHU ₃	UF ₁	UF ₂	UF ₃	K ₁	K ₂	K ₃
1	Turbidity	99,3	37,3	37,2	37,3	37,2	38,1	12,0	11,4	10,3	1,90	2,50	2,60
2	TDS	8,30	8,48	8,38	8,48	8,38	8,52	8,46	8,54	8,50	8,50	8,50	8,50
3	pH	7,32	7,41	7,45	7,41	7,45	7,37	7,35	7,34	7,36	7,43	7,41	7,36
4	Temperature	31,7	30,8	31,4	30,8	31,4	30,7	30,5	30,5	30,3	31,3	31,3	31,2

Notes:

SC₁₂₃ = Water Quality before Treatment at the Cempaka Site

DHU₁₂₃ = Water Quality after Treatment using Downflow–Horizontal Flow–Upflow Synthetic Filtration

UF₁₂₃ = Water Quality after Treatment using Ultrafiltration

K₁₂₃ = Water Quality after Treatment using a Combination of DHUSF + UF

Drinking Water Quality Standards = Turbidity < 3 NTU; TDS ≤ 300 mg/L; pH = 6.5–8.5; Temperature = $\pm 3^\circ\text{C}$ of ambient air temperature

In Table 1, at a flow rate of 0.2 L/s, the treatment results of Cempaka River water show that the only filter variation producing significant outcomes in meeting the turbidity quality standard of < 3 NTU was the Type 3 DHUSF + UF filter. The turbidity parameter decreased from 99.3 – 37.3 – 37.2 NTU to 1.90 – 2.50 – 2.60 NTU, with respective treatment efficiencies of 98.09% – 93.30% – 93.01%.

Meanwhile, the Type 2 UF filter reduced turbidity from 99.3 – 37.3 – 37.2 NTU to 12 – 11.4 – 10.3 NTU, with efficiencies of 87.92% – 69.44% – 72.31%, which still did not comply with the turbidity standard of < 3 NTU. The Type 1 DHUSF filter only reduced turbidity from 99.3 – 37.3 – 37.2 NTU to 37.3 – 37.2 – 38.1 NTU, with respective efficiencies of 62.44% – 0.27% – (–2.42%), indicating no compliance with the quality standard.

In contrast, treatment results for TDS, pH, and temperature parameters did not show statistically significant differences but still met the required quality standards.

Subsequently, the water quality test results before and after treatment of Cempaka River water at a flow rate of 0.6 L/s are presented in Table 2:

Table 2. Laboratory Results with Filter Variations and a Flow Rate of 0.6 L/s

No	Parameter	Flow Variation 1 (Q inlet = 0.2 L/s)											
		Before Treatment – Raw Water from Cempaka			DHUSF			UF			DHUSF + UF		
		SC ₁	SC ₂	SC ₃	DHU ₁	DHU ₂	DHU ₃	UF ₁	UF ₂	UF ₃	K ₁	K ₂	K ₃
1	Turbidity	107	104	108	43,6	43,4	45,3	0,16	0,27	0,15	0,48	0,26	0,18
2	TDS	8,36	8,38	8,36	8,45	8,48	8,46	8,41	8,46	8,48	8,28	8,30	8,33
3	pH	7,22	7,26	7,23	7,30	7,33	7,32	7,36	7,31	7,32	7,51	7,51	7,47
4	Temperature	31,2	31,0	31,2	31,1	31,2	31,2	31,1	30,9	30,9	31,8	31,7	31,5

Notes:

SC123 = Water Quality before Treatment at the Cempaka Site

DHU123 = Water Quality after Treatment using Downflow–Horizontal Flow–Upflow Synthetic Filtration

UF123 = Water Quality after Treatment using Ultrafiltration

K123 = Water Quality after Treatment using a Combination of DHUSF + UF

Drinking Water Quality Standards = Turbidity < 3 NTU; TDS ≤ 300 mg/L; pH = 6.5–8.5; Temperature = ±3 °C of ambient air temperature

In Table 2, at a flow rate of 0.6 L/s, the treatment results of Cempaka River water showed that significant outcomes in meeting the turbidity quality standard of < 3 NTU were achieved by the Type 2 UF filter and the Type 3 DHUSF + UF filter. The turbidity parameter decreased from 107 – 104 – 108 NTU to 0.16 – 0.27 – 0.15 NTU with respective efficiencies of 99.85% – 99.74% – 99.86% for Type 2 UF, and from 107 – 104 – 108 NTU to 0.48 – 0.26 – 0.18 NTU with efficiencies of 99.55% – 99.75% – 99.83% for Type 3 DHUSF + UF. Meanwhile, the Type 1 DHUSF filter reduced turbidity only from 107 – 104 – 108 NTU to 43.6 – 43.4 – 45.3 NTU, with efficiencies of 59.25% – 58.27% – 58.06%, which did not meet the turbidity standard of < 3 NTU. Treatment results for TDS, pH, and temperature parameters were not significant, although they remained within the permissible limits.

The performance testing of the filtration units demonstrated varying effectiveness across filter types. At a flow rate of 0.2 L/s, the DHUSF + UF combination reduced turbidity from an initial level close to 100 NTU to the range of 1.9–2.6 NTU, achieving efficiencies above 93%, which met the quality standard. In contrast, the UF filter alone reduced turbidity only to 10–12 NTU with efficiencies of 70–88%, which did not meet the standard. The DHUSF alone showed inconsistent reductions, with low and variable efficiencies, and in some cases did not demonstrate any meaningful improvement. At a higher flow rate of 0.6 L/s, however, the performance of both DHUSF + UF and UF alone improved significantly, achieving turbidity reductions of > 99% and producing water with turbidity below 1 NTU. This finding suggests that an increased flow rate may enhance UF membrane efficiency, likely due to a more uniform pressure distribution across the membrane.

Theoretically, these differences in effectiveness can be explained by the fundamental principles of filtration. According to^[10,11], synthetic cloth filters are more effective at removing larger particles but tend to allow fine particles or colloids to pass through. This explains why DHUSF alone could not achieve turbidity levels below 3 NTU. In contrast, UF systems, as reported by^[12–15], are capable of filtering micro-scale particles approaching the nanometer range, making them highly effective for turbidity reduction. However, without pre-treatment, UF membranes are prone to fouling, which rapidly decreases efficiency. The findings of this study reinforce that UF performance was unstable at lower flow rates. With the addition of DHUSF as a pre-treatment, the suspended solids load was reduced, enabling UF to operate more optimally and consistently produce water with turbidity below 3 NTU.

Analysis of TDS, pH, and temperature parameters showed no significant changes after treatment. This is consistent with^[16–18], who state that layered filtration systems and UF membranes primarily target suspended particles, whereas dissolved substances (such as ions contributing to TDS) remain largely unaffected. This indicates that the technology is effective for improving water clarity and physical appearance, though not designed to alter dissolved content. Nevertheless, since the initial TDS, pH, and temperature of the Cempaka River already complied with quality standards, this was not a major limitation.

The DHUSF + UF combination proved to be the most effective configuration for treating Cempaka River water at both low and high flow rates. This technology consistently produced water quality that complied with Permenkes RI No. 2 of 2023, particularly with regard to turbidity. While UF alone remains a potential option, pre-treatment is required to ensure stable performance. DHUSF alone, on the other hand, is not recommended as a primary method and should be considered only as a supporting stage before UF. These findings support the argument that layered filtration systems are an appropriate solution for areas with high turbidity levels, aligning with other studies on the effectiveness of roughing filters and simple filtration technology combination^[19-21].

From an application perspective, the DHUSF + UF (SF-UF) configuration is highly suitable for the Cempaka River, which experiences high turbidity due to flooding and sand/diamond mining activities. The DHUSF stage reduces suspended solids, thereby minimizing UF membrane fouling, maintaining stable flow rates, and ensuring consistent compliance with turbidity standards, without altering dissolved parameters such as TDS or pH, which already met the standards. This principle of layered pre-treatment is also recommended by national studies on roughing filters for turbid river water and is consistent with international recommendations that membrane systems perform optimally when solid loads are reduced first^[22-24].

From a cost perspective, the SF casing can be constructed from inexpensive PVC pipes and cloth media, which are locally available. Modifications of roughing filters using local materials have proven cost-effective in turbidity reduction. Meanwhile, according to^[25], UF membranes can be cleaned and reused, reducing operational costs. This study suggests that with proper regulation of flow rates and backwashing, the system can be used for long-term operation. The DHUSF + UF combination is particularly relevant for areas experiencing seasonal turbidity surges, with DHUSF acting as a buffer during such events and UF ensuring consistent water quality that complies with the turbidity standard.

CONCLUSIONS AND RECOMMENDATIONS

The DHUSF + UF combination filter proved effective in significantly reducing turbidity in Cempaka River water, achieving consistent turbidity reduction efficiencies above 95% and meeting the water quality standard of < 3 NTU.

The use of the DHUSF + UF combination filter can be applied at household or community scales, particularly in areas relying on highly turbid river water sources. For further development, additional testing should be conducted to include broader water quality parameters.

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