Envirotek : Jurnal Ilmiah Teknik Lingkungan
Vol. 8, No.1, Bulan April, 2026, pp. 10-19
Journal Home Page: http://envirotek.upnjatim.ac.id/
e-ISSN 26231336 p-ISSN 2085501X

The Effect of Pump Pressure in Improving the Quality of Peat Water Treatment Throught Nanofiltration: Effectiveness

Sriani[1*], Akhmad Yani[1], Gusti Z. Anshari[1]

[1] Master of Environmental Science Study Program· Tanjung Pura University, Pontianak, Indonesia

Correspondence Email (Author): Srianiyadi@gmail.com

Received: 7-10-2025
Accepted: 4-3-2025
Published: 30-4-2026

Keywords:
Peat water treatment; Nanofiltration; Presssure; Effectiveness

ABSTRACT

The study aimed to evaluate the effectiveness of nanofiltration at different pressures in reducing turbidity, colour intensity, organic matter, Fe, TDS, as well as Total Coliforms and Escherichia coli in peat water. This research employed a quasi-experimental design with a quantitative approach. The tested pressures were 30 psi, 40 psi, and 60 psi, each repeated 9 times, resulting in a total of 27 samples. The tested parameters included turbidity, colour intensity, organic matter, Fe, TDS, Total Coliform, and Escherichia coli. Sample analysis was conducted at the Laboratory of Standardisation and Industrial Service Agency in Pontianak, West Kalimantan. Data analysis was performed using One-Way ANOVA and Kruskal-Wallis tests. The effectiveness of nanofiltration, such as turbidity (98.98%) with a p-value of 0.539 > 0.05, TDS (92.04%) with a p-value of 0.0567 > 0.05, organic matter (97.18%) with a p-value of 0.808 > 0.05, and Fe (90.83%) with a p-value of 0.613 >0.05. Statistical tests indicate no significant difference between pressures (p-value 0.05). Variations in pump pressure have a significant effect on the quality of peat water in achieving clean water standards. To achieve drinking water standards, further processing such as reverse osmosis is needed.

1. INTRODUCTION

Peat water is naturally formed in peatland ecosystems and is characterised by a dark yellow to reddish-brown colour, high acidity, and elevated concentrations of dissolved organic matter, particularly humic and fulvic substances. It may also contain relatively high levels of certain elements such as Fe, Al, Na, S, and P, alongside various micronutrients. These characteristics reduce its suitability for direct use as drinking water, not only because of aesthetic problems such as colour, odour, and taste, but also because of potential health and operational concerns. Low pH can increase the solubility of metals and may contribute to corrosiveness, while high organic content can support microbial growth and, when chlorine is applied during treatment, may form harmful disinfection by-products such as trihalomethanes. Therefore, despite its abundance and strategic importance in peatland regions, peat water requires effective and appropriate treatment technology before it can be safely used as clean water or drinking water. In this context, membrane-based treatment—particularly nanofiltration—has emerged as a promising approach due to its ability to reduce colour, organic substances, dissolved contaminants, and microbial pollutants while supporting the production of water that meets quality standards .

Suppose chlorine is used as a disinfectant in peat water treatment. In that case, it will form trihalomethanes, such as chloroform, which can cause cancer (metal solubility in water is also higher at low pH). The presence of these pathogenic microbes certainly poses a health risk. Furthermore, failure to meet established standards can reduce public acceptance of the water, which may then encourage them to seek alternative, potentially less safe sources (S. Sutrisno, 1991). Peat water with a low pH produces a sour taste that can lead to tooth decay and digestive disorders (Notodarmojo, 1994).

A simple method exists for removing colour and organic matter from peat water: adding 0.10 grams of chlorine, 0.05 grams of quicklime, 0.30 grams of clay, and 0.40 grams of alum per 1,000 millilitres of peat water. Each addition is stirred manually for 30 seconds. Within 5 minutes, a clear solution forms, accompanied by a brown precipitate (Widiastuti & Latifah, 2017). Nanofiltration membranes play a crucial role in mitigating the degradation of dyes, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), turbidity, heavy metals, and dissolved solids (Rizza F.F, 2025).

Peat water treatment in West Kalimantan, aimed at producing clean water, requires rapid, efficient, and environmentally friendly processing methods. Considering the challenges of peat water treatment, it can be utilised as a raw material, providing not only clean water but also a natural alternative for drinking water. Nanofiltration membranes are a viable option for treating peat water. Addressing the challenges of clean water demand in West Kalimantan requires a sustainable water management approach (Khayan et al., 2022).

Nanofiltration membranes have a pore size of approximately 0.001 µm, enabling them to filter waste with a very high organic content. In solutions containing solid suspensions and polyvalent ions, the resulting permeate generally contains monovalent ions and low-molecular-weight organic solvents, such as alcohols. Nanofiltration is utilised for water softening, removal of micro-pollutants, and treatment of waste and water (Wenten et al., 2010).

Factors influencing the effectiveness of water pump pressures at 30 psi, 40 psi, and 60 psi for nanofiltration water treatment include: 1. Compression pressure, which is the pressure exerted by the water pump, is also related to the water flow rate through the nanofiltration membrane.2. At higher pressures, the water flow rate tends to be faster, which can affect the water residence time in the nanofiltration system.3. Organic matter retention: Higher pressures can increase the retention of organic matter and larger molecular compounds by the nanofiltration membrane (Agenson et al., 2003). This can help improve the effectiveness of removing these substances from peat water. 4. Capacity and energy consumption: A water pump with a pressure of 80 psi can provide a greater water purification capacity, but it requires more energy to operate. 5. Cavitation and pump damage: Excessive pressure can cause cavitation in water pumps, which can damage the pump and reduce overall system performance (Abdel-Fatah, 2018).6. Peat water characteristics: The properties of peat water, including organic matter content, colour, and other contaminants, can affect the effectiveness of nanofiltration at specific pressures.

Laboratory evaluations and field testing can help determine the optimal pressure for specific peat water conditions. One suitable membrane technology for treating natural organic matter (NOM) in water is nanofiltration (NF). NF membranes also utilise energy from driven forces. In this case, the membrane performance, including permeability and selectivity, is calculated for the treated water (Elma et al., 2023). Research conducted by Kiswanto et al. (2022) processed peat water into clean water using ceramic membrane nanofiltration technology with pressure settings of 1 bar, 1.5 bar, and 2 bar. A pressure difference of 2 bar provides the best results in reducing the levels of contaminant compounds contained in peat water with an average percentage of TSS reduction rejection of 91.89%, Fe 70%, Mn 93.2%, Zn 95%, NH_3 68.6%, NO_2 -70%, PO_4-3 38.14% and BOD_5 91.99%. The nanofiltration membrane process can remove suspended solids, natural organic matter, bacteria, viruses, salts, and divalent ions from water. Nanofiltration operates at a lower pressure than reverse osmosis, typically between 50 and 150 psi (Saiful et al., 2017). Nanofiltration is used for water softening and the removal of micro pollutants, such as those found in waste and water treatment (Wenten et al., 2010). More effective water treatment technologies, such as nanofiltration membranes, can produce water that meets health standards and is suitable for public consumption (Qadafi et al., 2023).The research aims to evaluate the effectiveness of pressure in the treatment of peat water using nanofiltration membranes, as well as the addition of lime ($Ca(OH)_2$) as a coagulant to stabilize the pH of peat water. This method is expected to be an effective solution to ensure that peat water meets the raw water quality standards or clean water standards stipulated in the Indonesian Minister of Health Regulation No. 2 of 2023 concerning Environmental Health.

2. METHOD

Nanofiltration membranes for drinking water production typically take the form of spiral-wound modules. A schematic of the spiral-wound module is shown in figure 1 (Chen et al., 2020).

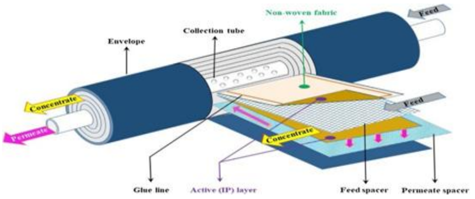

Figure 1. Spiral-wound Nanofiltration Membrane Module

This study is a quasi-experimental study, or a study that approaches a real experiment, but cannot control all relevant variables. It uses a quantitative method that shows the relationship between variables, theories, and seeks generalizations that have predictive value. The population in this study was peat water in the Nanas ditch, Siantan Hulu Village, North Pontianak District, West Kalimantan. Testing was carried out in a laboratory using a specific examination method and was carried out by the Pontianak Industrial Standardization and Services Center Laboratory. The sample in this study of peat water was based on the minimum amount obtained from the minimum sample calculation. The percentage of effectiveness of pump pressure using Nanofiltration in reducing pollutant parameters in processing peat water into clean water can be calculated using the following formula, Yahia, A, et al., (2025).

$$Ef = \frac{A-B}{A} \times 100\%$$

Description:
Ef = Effectiveness
A = nitial sample before treatment (control)
B = final sample after treatment

2.1 Tools And Materials

Three Vontron VNF1 4040 Nanofiltration Membranes, a water pump, a pressure gauge, a flow meter, a voltmeter, a filter cartridge, a 1000-litre water tank, a pH indicator, a 1-litre plastic dispenser, a 250-mL glass bottle, an oven, a Bunsen burner, alcohol, whiting, distilled water, label paper, indicator paper, and peat water.

2.2 Work Procedures

Peat water from the river is pumped into a 1,000-litre tank, and 200 grams of lime solution is added. The peat water in the holding tank also serves as the site for coagulation, flocculation, and sedimentation.

Then, the peat water from the storage tank is pumped with pressures of 30 psi, 40 psi, and 60 psi, respectively, through a microfilter/water filter cartridge to the Nanofiltration membrane. The processed water is then collected in a 1-litre jerrycan for laboratory examination. After the first sample is taken, a backwash is performed to clean the NF before taking the subsequent sample. For sampling, nine repetitions are carried out. Then, it is sent to an accredited laboratory for examination of drinking water parameters, as per the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Environmental Health (Permenkes RI No. 2 of 2023 concerning Environmental Health, 2023).

The data were analysed using a statistical method in the form of One-Way ANOVA Test using SPSS software version 25 was used so that researchers could measure the effectiveness of the treatment objectively, compare optimal conditions, and identify the relationship between operating variables and processing results and could determine the most efficient operating pressure based on laboratory and field data. The research flow illustrates the process of preparation as the basis for deciding filtration, absorption, and microfiltration, both methods and materials.

3. RESULTS AND DISCUSSION

3.1 Univariate Analysis

Table 1. Examination of initial peat water samples before and after being given lime, before being filtered with Nanofiltration.

Parameter	Peat water	Peat Water + Lime	Standards for Drinking Water: Regulation of the Indonesian Ministry of Health No. 2 of 2023	Standard Hygiene and Sanitation Regulation of the Indonesian Ministry of Health No. 32 of 2017
pH	5,13	8,04	6,5 – 8,5	6,5 – 8,5
Turbidity (NTU)	2,02	42,50	< 3	25
Color (TCU)	106,00	97,00	10	50
TDS (mg/L)	154,00	192,00	< 300	1000
Organic Substances (mg/L)	482,00	463,00		10
Fe (mg/L)	3,33	0,783	0,2	1
Total Coliform (CFU/100 mL)	245,00	240	0	50
Escherichia coli (CFU/100 mL)	98,00	95	0	0

Source: BSPJI Pontianak Test, 2024

Based on Table 1, the differences in peat water before and after lime addition are visible. There are changes in water parameters such as pH, turbidity, and TDS, which increased after lime addition. Meanwhile, after lime addition, the colour (97 TCU), organic matter (463 mg/L), Total *Coliforms* (240 CFU/100 mL), and *Escherichia coli* (95 CFU/100 mL) decreased.

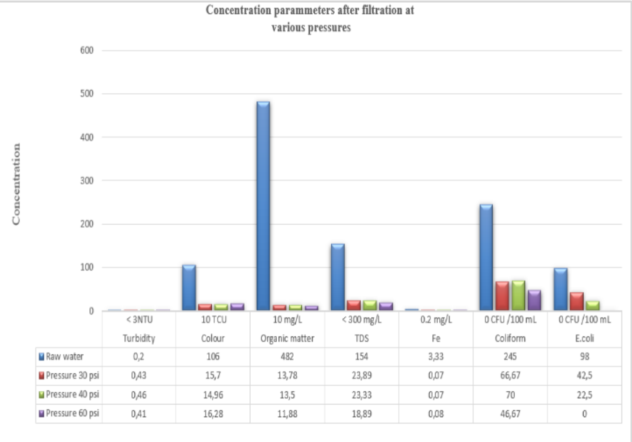

Figure 2. A decrease in the concentration of the parameters of turbidity, colour, organic substances, TDS, Fe, Total *Coliform* and *Escherichia coli* variations right from 30 psi, 40 psi and 60 psi.

Based on Figure 2, the differences in peat water after treatment using Nanofiltration with varying pressures are visible in the reduction of turbidity, colour, organic matter, TDS, Fe, Total *Coliforms*, and *Escherichia coli*. The average reduction in water parameters differs with each pressure variation.

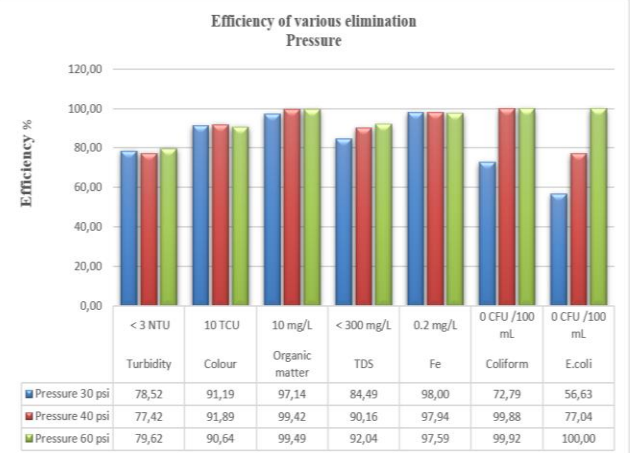

Figure 3. Effectiveness of parameters for turbidity, colour, organic substances, TDS, Fe, Total *Coliform* and *Escherichia coli* with right variations of 30 psi, 40 psi and 60 psi

Based on Figure 3, it can be seen that there is a difference in the effectiveness of pressure in peat water treatment using Nanofiltration with variations in pressure on the water parameters of turbidity, color, organic matter, TDS, Fe, Total *Coliform* and *Escherichia coli* with a percentage of > 90% of color, organic matter TDS, Fe, Total *Coliform* and *Escherichia coli.*

3.2 Bivariate Analysis

Bivariate analysis in this study used the one-way ANOVA test with a significance level of α=0.05, with the following results:

Table 2. . Results of One Way ANOVA Statistical Analysis of Turbidity, Color, Organic Matter, TDS, Fe, Total *Coliform*, and *Escherichia coli* Parameters

		F	**Sig.**
Turbidity	Between Groups	.674	.519
	Within Groups		
	Total		
Color	Between Groups	.080	.924
	Within Groups		
	Total		
Organic Substances	Between Groups	.215	.808
	Within Groups		
	Total		
TDS	Between Groups	.580	.567
	Within Groups		
	Total		
Fe	Between Groups	.499	.613
	Within Groups		
	Total		
Coliform	Between Groups	.398	.676
	Within Groups		
	Total		
E_coli	Between Groups	1.839	.181
	Within Groups		
	Total		

Source: SPSS 25, 2024

Table 3. Results of the statistical analysis of the Kruskal Wallis test

	Test Statistics[a,b]		
	Turbidity	**Color**	**E_coli**
Kruskal-Wallis H	1.237	0.177	5.305
df	2	2	2
Asymp. Sig.	0.539	0.915	0.07

a. Kruskal Wallis Test
b. Grouping variables: pressure

Based on Table 3, there is no significant difference between pressures, as evidenced by the significance results obtained (p-value > 0.05) in the parameters of turbidity, colour, and *Escherichia coli,* because this is likely caused by other more dominant factors, such as the characteristics of the Vontron VNF1-4040 membrane, which has a specific rejection limit for dissolved substances and colloids. In addition, initial water quality factors, such as turbidity levels, organic content, and ion concentration in peat water, can also significantly impact filtration efficiency beyond operating pressure (Kiswanto et al., 2022).

3.2.1 pH Parameters

The initial pH of the peat water was 5.13 after the addition of whiting lime to 8. After filtration with nanofiltration, the average pH value at 30 psi pressure was 5.78, at 40 psi pressure, the pH value was 5.88, and at 60 Psi pressure, the average pH value was 5.65, all of which decreased after filtration. The addition of whiting lime, which is alkaline, can also neutralize the pH of peat water, increasing the pH from 3.7 to 7 (Sisnayati et al., 2023). Judging from the laboratory results, the pH value remains below 6.5, so it still does not meet the requirements of the Indonesian Minister of Health Regulation No. 2 of 2023. Characteristics vary depending on the location, vegetation, type of soil where the peat water is located, the thickness of the peat, the age of the peat, and the weather (Sukiman Nurdin, 2011). Reactions with organic acids in peat water contain high levels of humic acid and fulvic acid, which cause the water to be acidic and brownish in colour. When $Ca(OH)_2$ is added to peat water, it reacts with the organic acids, neutralizing OH^- ions and forming compounds that can precipitate or dissolve, thereby rendering the pH-increasing effect unstable (Efendi et al., 2024). Betel lime ($CaCO_3$) can change into CaO and $Ca(OH)_2$ due to environmental factors. Its main component, calcium, plays a vital role in bone formation. In addition to water purification, betel lime offers various health benefits, including relief from coughs, mouth ulcers, swollen gums, boils, menstrual disorders, insect bites, and skin conditions such as tinea versicolor, ringworm, and scabies (Nurnabila, 2011).

3.2.2 Turbidity Parameters

According to Table 3, the statistical analysis shows no significant difference in pressure variations related to turbidity reduction (p-value > 0.539). Therefore, pressure is not a key factor in the nanofiltration process. Figure 1 shows that the turbidity of peat water after nanofiltration at varying pressures decreased significantly. This notable reduction in turbidity is attributed to the very small pore sizes of nanofiltration membranes (1–10 nm), which allow them to effectively retain colloidal particles, suspended solids, and some organic matter through size exclusion and electrostatic interactions (Wang et al., 2023).

Although nanofiltration is effective in reducing turbidity, the condition of the raw water remains a key factor in determining treatment efficiency (Liu et al., 2023). The use of nanofiltration technology in peat water treatment can also be combined with other methods, such as pretreatment (e.g. lime addition/peat softening) or integration with ultrafiltration. To improve performance, nanofiltration can be combined with pretreatment or other membrane processes. A study by Hilal et al. demonstrated that a membrane combination was capable of reducing turbidity to 0.03 NTU with high efficiency for hardness and organic matter, a finding reinforced by recent research on the importance of the integrated membrane system (Abdel-Fatah et al., 2023). The effectiveness of turbidity removal is influenced more by membrane characteristics than by operating pressure.(Liu et al., 2023; Zhang et al., 2023)

3.2.3 Color parameters

Table 3 shows that there is no significant difference between pressures, as evidenced by the significance results obtained (p-value > 0.915). Drinking water and clean water must meet physical standards, including colour, as it can indicate the presence of organic contaminants or unwanted substances. To overcome this, treatment processes such as filtration, the use of activated carbon, or chemical oxidation are typically employed to remove colour due to organic materials. One alternative for peat water treatment is the use of nanofiltration, which eliminates the need for chemicals. Nanofiltration membranes play an important role in reducing dyes, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), turbidity, heavy metals, and dissolved solids (Rizza, F. F, 2025). Nanofiltration is a relatively new membrane filtration technology that is often used for water with a low total dissolved solids content, particularly for softening purposes and removing disinfectant byproducts from both natural and synthetic organic substances. The peat water sources in West Kalimantan are dark brown to blackish in colour due to the high organic content (Syifa A. P. S, et al., 2022).

The adsorption process can occur both on the membrane surface and within its pores. This adsorption can form an additional layer (fouling layer) that functions as a secondary barrier, thereby consistently increasing dye retention even when the pressure changes. This is because the removal mechanism is dominated by adsorption interactions and membrane characteristics (Guo et al., 2025), with no significant difference between pressures. Filtration studies have shown that the removal of total organic carbon (TOC), an indicator of NOM, can achieve very high efficiencies, approximately 96%, for both tight nanofiltration (T-NF) and loose filtration (L-NF) membranes. This high NOM removal efficiency directly impacts the reduction in water color because color is highly correlated with the concentration of dissolved organic matter.

Therefore, higher NOM removal leads to a greater reduction in color intensity. Although there are differences in ion rejection characteristics between T-NF and L-NF, both exhibit nearly equal efficiency in removing NOM. Pressure variations do not significantly affect color. In other words, provided the membrane has sufficient capacity to retain NOM molecules, changes in pressure do not significantly increase color removal efficiency.

3.2.4 Organic Substance Parameters

Table 2 shows that there is no significant difference between pressures, as evidenced by the significance results obtained (p-value > 0.808). Meanwhile, the water standard, as per the Indonesian Minister of Health Regulation No. 492 of 2010, requires drinking water to have an organic matter value of 10 mg/L. The primary compounds in peat water are humic acid, fulvic acid, and humin, which serve as colouring agents. These three compounds come from the dissolution of humus in peatlands. Humic acid has a high molecular weight with a brown to black colour, while fulvic acid is soluble in water at various pH levels and is yellow-brown in colour. Humin, which is insoluble in water, is black. According to research (Ren & Wang, 2011), Nanofiltration membranes with a pore size of around 0.001 micrometres have limitations in processing raw water into drinking water. This membrane is effective in filtering dissolved solids, bacteria, viruses, and multivalent ions such as Ca^{2+} and Mg^{2+}, but cannot separate monovalent ions such as Na^+ and K^+. In addition, Nanofiltration can only be used to treat fresh water (Muliawati & Pengantar, 2012). Peat water contains dissolved organic compounds that cause the water to be brown and acidic, so it requires special treatment before it is ready for consumption. These organic compounds are composed of humic acids, including humic acid, fulvic acid, and humin (Nainggolan, 2011). Organic substances are substances that mostly contain carbon elements, such as benzene, chloroform, detergents, methoxychlor, and pentachlorophenol, which are found in water and are contaminated by waste that seeps into the water. Hence, it is not safe to use it as a source of drinking water (Tambunan, 2023). Natural organic matter (NOM) is a major contaminant in surface water, causing the formation of toxic disinfection byproducts. Therefore, removing natural organic matter is a crucial step in drinking water treatment (Yin et al., 2023). Nanofiltration is an effective method for removing natural organic matter (NOM) from surface water (Mallya et al., 2023).

3.2.5 TDS (Total Dissolved Solids) Parameters

Table 2 shows that there is no significant difference between pressures, as evidenced by the significance results obtained (p-value > 0.567). Drinking water standards according to the Indonesian Minister of Health Regulation No. 2 of 2023, where drinking water or clean water has a TDS value < 300 mg/L. Peat water processing into clean water uses ceramic membrane Nanofiltration technology with pressure settings of 1 bar, 1.5 bar and 2 bar (Kiswanto et al., 2022). A pressure difference of 2 bar provides the best results in reducing the levels of contaminant compounds contained in peat water with an average percentage of TSS reduction rejection of 91.89%, Fe 70%, Mn 93.2%, Zn 95%, NH_3 68, 6%, NO_2 - 70%, PO_4 -3 38.14%, and BOD_5 91.99%. Total Dissolved Solids (TDS) in peat water is typically high because it contains various dissolved substances, including minerals, organic matter, and other anions/cations derived from vegetation decomposition and soil dissolution processes. High TDS content in peat water can include compounds such as organic acids, humic substances, and minerals such as iron (Fe) and manganese (Mn). High TDS values in drinking water are considered inadequate to meet clean water standards, as they can affect the taste and safety of the water (Kiswanto et al., 2022).

Although nanofiltration is effective in reducing TDS to high levels, the accumulation of inorganic substances on the membrane causes long-term fouling, necessitating optimal pretreatment, such as pH adjustment with lime and coagulation, to minimize the TDS load and extend the membrane's operational life (Guo et al., 2024).

In pilot-scale tests, nanofiltration was highly effective at treating secondary effluent from a wastewater treatment plant (WWTP), yielding high-quality water. This performance was further improved by integrating advanced oxidation processes, which led to over 98% removal of contaminants and a reduction in Dissolved Organic Carbon (DOC) of up to 92% (Gouveia et al., 2023).

3.2.6 Fe (Iron) Parameters

Table 2 shows that there is no significant difference between pressures, as evidenced by the significance results obtained (p-value > 0.613). The drinking water standard, as per the Indonesian Minister of Health Regulation No. 2 of 2023, requires that drinking water have a Fe value mg/L of 0.2 mg/L. High levels of iron (Fe) in water need to be considered in providing clean water for the community. High Fe levels can reduce aesthetic value and inhibit the effectiveness of the disinfection process, because suspended particles can protect microbes. Water with high iron levels tends to be reddish brown and mixed with metal, which makes it less desirable for consumption (C. T. Sutrisno, 2010).

This indicates that within the pressure range used, pressure is not the primary factor affecting the efficiency of iron removal in the nanofiltration process. Metal ion removal by nanofiltration membranes is more influenced by membrane properties (pore size and charge) than operational pressure (Zhang et al., 2023; Liu et al., 2023). Figure 1 shows that the iron content in peat water after the nanofiltration process has met the drinking water standard according to the Indonesian Minister of Health Regulation No. 2 of 2023 of 0.2 mg/L. This reduction occurs through the size exclusion mechanism and the Donnan effect, where Fe ions and Fe-organic complexes are retained by the membrane (Labarca & Bórquez, 2020; Wang et al., 2023).

3.2.7 Total Coliform Parameters

Table 2 shows that there is no significant difference between pressures, as evidenced by the significance results obtained ((p-value > 0.676). The drinking water standard, as stipulated in the Indonesian Minister of Health Regulation No. 2 of 2023, requires that drinking water have a total coliform count of no more than 100 mL CFU/100 mL. *Coliform* bacteria serve as indicators for the presence of other pathogenic bacteria. Water contaminated with gastrointestinal pathogenic bacteria is highly hazardous to drink. This can be confirmed by the discovery of organisms present in human or animal feces that are never found in their free state in nature. The presence of several organisms included in this category, namely *coliform* bacteria (*Escherichia coli*), *Enterococci faecalis*, and *Clostridium sp*. In Indonesia, the indicator bacteria for contaminated water are *Escherichia. coli*. These coliform bacteria produce the substance ethionine, which, in research, has been linked to cancer. These putrefying bacteria also produce various toxins in the Indole series, skatol, which can cause disease if excessively present in the body (Ramadhani, 2020).

The decrease in the concentration of Total *Coliform* and *Escherichia coli* by using ceramic membranes also occurs due to the filtering and absorption process, where organic materials contained in wastewater are filtered and absorbed by the ceramic membrane under intense pressure, so that organic materials stick to the membrane wall, so that the water that comes out is cleaner (Siswoyo & Agustina, 2009). This suggests that an increase in pressure does not significantly impact the efficiency of microorganism removal. The elimination of bacteria in water treatment systems depends more on physical processes and the interactions between the filter medium and pollutants than on changes in pressure. This finding aligns with research on microbial flocculants (MBF), which indicates that microorganisms and contaminants are removed through flocculation—a process involving particle clumping and settling, thereby enabling effective separation from water. MBFs are highly effective at removing contaminants, including microorganisms and organic matter in wastewater. Consequently, the removal of bacteria such as Total Coliform and *Escherichia coli* can occur optimally when supported by an effective separation mechanism, whether through flocculation or membrane filtration (Yang et al., 2024).

3.2.8 Parameters of *Escherichia coli* (*E.coli*)

Table 3 shows that there is no significant difference in pressures, as indicated by the p-value obtained (p > 0.70). The filtered water still contains *Escherichia coli*. Meanwhile, the drinking water standard, as per the Indonesian Minister of Health Regulation No. 2 of 2023, requires drinking water to have an E. coli value of 0 CFU/100 mL. *Escherichia coli* bacteria are pathogenic and can also cause diarrhea or bloody diarrhea, abdominal cramps, nausea and malaise (Ramadhani, 2020). This bacterium is a gram-negative bacterium in the form of a short rod with flagella measuring 0.4-0.7 µm in diameter and 1.4 µm in length, and a ring. *Escherichia coli* grows well in almost all media, causing lactose fermentation and has aerobic properties. *Escherichia coli* infections that occur can cause complications in children under 5 years and the elderly. *Escherichia coli* has a size of 0.5-1 microns and can be filtered by a nanofiltration membrane, which has smaller pores of 1-5 nm, and can be filtered by a ceramic membrane, which has smaller pores than *Escherichia coli* (Siswoyo & Agustina, 2009). Field testing in Minnesota demonstrated that the system was capable of achieving Bacillus subtilis removal levels ranging from 4.3 logs to complete removal (> 6.9 logs). The ES404 membrane with a Molecular Weight Cut-Off (MWCO) of 4,000 Daltons performed very similarly to the more stringent CA2PF membrane (MWCO 2,000 Daltons) and the AFC30 membrane (MWCO 350 Daltons). Testing in Ohio of the ES404, CA2PF, and AFC30 membranes showed that all membranes performed similarly, with nearly all *Bacillus subtilis* being eliminated (>6.0 logs). This indicates that the ES404 membrane is quite effective for treating bacteria down to the size of B. subtilis. When tested with MS2 bacteriophage in Minnesota, the ES404 membrane demonstrated removal levels ranging from 4.1 logs to complete removal (> 5.3 logs), while the AFC30 membrane achieved removal levels of 4.2 logs (Patterson et al., 2012). Given that *Escherichia coli* cells typically measure between 0.5 and 1 µm—substantially larger than the nanofiltration membrane's pore size of 1–5 nm—it is theoretically possible for the membrane to retain these bacteria effectively (Liang & Zhou, 2022; Xu* & Xu, 2022; Yang et al., 2024). Overall, the findings from this study suggest that fluctuations in pressure do not have a substantial impact on the removal of *Escherichia coli*. Consequently, a more holistic strategy is required, which involves refining membrane properties, enhancing pre-treatment efficiency, and managing contamination both during and after the filtration process, to ensure that the treated water meets established quality standards.

3.2.9 Pressure Effectiveness

Fiqure 2 shows that nanofiltration can reduce contaminant parameters in peat water by over 90% at a pressure of 30 psi (91.19%), organic matter (97.14%), and Fe (98%). At a pressure of 40 psi, the colour (91.89%), organic matter (99.42%), TDS (90.16%), Fe (97.94%), and total coliform (99.88%). Meanwhile, at a pressure of 60 psi, colour (90.64%), organic matter (99.49%), TDS (92.04%), Fe (97.59%), total *coliform* (99.92%), and *Escherichia coli* (100%). The results of this study indicate that 60 psi is more effective in reducing these parameters in peat water.

Nanofiltration and Reverse Osmosis are used in various applications, such as drinking water purification (especially for seawater and brackish water desalination), pesticide reduction, and pure water production for industry and semiconductors. The use of Nanofiltration membranes is growing in wastewater and drinking water treatment. Applications in wastewater treatment account for 18.30% of the reviewed research, with other trends including pharmaceuticals and biotechnology (14.04%), economics and design (13.72%), membrane modification (12.83%), solvent nanofiltration (11.25%), membrane fabrication (10.52%), desalination (8.94%), fouling research (7.83%), modeling (6.78%), review (5.47%), and the food industry (2.52%) (Oatley-Radcliffe et al., 2017).

This research shows that peat water treatment with nanofiltration can produce water that meets the quality standards for clean water. Untreated peat water has the potential to contain hazardous substances, such as heavy metals, organic compounds, and pathogenic microorganisms, which can cause various health problems, including poisoning, infection, or digestive disorders if consumed or used daily. To avoid these risks, maintaining the quality of peat water or treating it before use is very important. In accordance with the Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023, drinking water and clean water must meet established standards, including physical, chemical, bacteriological, and radioactive aspects.

Nanofiltration can reject organic compounds with a molecular weight of 300-1000, while salt rejection is 15-90%. The larger the pore size of the membrane, the greater the organic compounds that can pass through the membrane. For organic compounds with a molecular weight greater than 1000, ultrafiltration can be used. Ultrafiltration has larger pores (Maryam H. et al, 2019). The use of appropriate pump pressure in peat water treatment is highly dependent on the scale of application: households utilise 40-60 Psi pressure pumps with NF or 100-200 psi for RO, and apply simple pre-treatment such as sedimentation and activated carbon to reduce pump load (Setiadi & Kristyawan, 2018). Water treatment with membrane technology has produced processed water with the required drinking water quality (7 critical parameters, namely pH, temperature, colour, turbidity, TSS, TDS and *Escherichia coli*) (Hidayah, 2018).

The Fyne nanofiltration process can be used in small-scale public drinking water supply systems (serving 25-500 people) to reduce colour and microbial pathogens in drinking water. Total Organic Carbon (TOC) removal by the nanofiltration membrane will also reduce the formation of disinfection byproducts after the chlorination process (Patterson et al., 2012). The results showed that variations in pressure of 30, 40, and 60 psi did not provide a significant difference in filtration effectiveness. This is likely due to other, more dominant factors, such as the characteristics of the Vontron VNF1-4040 membrane, which has a specific rejection limit for dissolved substances and colloids. In addition, initial water quality, such as turbidity levels, organic content, and ion concentrations in peat water, can also affect filtration efficiency more than just operating pressure. These factors can limit performance improvements even if the pressure is increased. Nanofiltration can operate under low-pressure conditions while maintaining effective separation performance (Cheng et al., 2023). Furthermore, the quality of the feed water—including turbidity levels, organic matter content, and ion concentrations in peat water—can influence filtration efficiency more significantly than operating pressure alone. These factors may restrict performance improvements, even when pressure is increased. This study focuses on the application of the Low-Temperature Interfacial Polymerization (LTIP) method to enhance the performance of nanofiltration membranes, specifically for drinking water treatment. The approach aims to achieve operation under very low pressure, provide good antifouling properties, and effectively reduce high levels of natural organic matter (NOM) while maintaining low salt rejection (Cheng et al., 2023).

4. CONCLUSION

Research shows that there is no significant difference between pressures in peat water treatment using nanofiltration. The effectiveness of pressure shows that nanofiltration can reduce contaminant parameters in peat water by a percentage above 90%. At a pressure of 30 psi, there was a decrease in colour (91.19%), organic matter (97.14%), and Fe (98%). At a pressure of 40 psi, there was a decrease in colour (91.89%), organic matter (99.42%), TDS (90.16%), Fe (97.94%), and total coliform (99.88%). Meanwhile, at a pressure of 60 psi, there was a decrease in colour (90.64%), organic matter (99.49%), TDS (92.04%), Fe (97.59%), total *coliform* (99.92%) and *Escherichia coli* up to (100%).

Nevertheless, the treated water still does not fully comply with the drinking water quality standards set by the Indonesian Ministry of Health Regulation No. 2 of 2023. Water processed through nanofiltration is suitable only as clean water for purposes such as washing and bathing. Therefore, nanofiltration cannot function as a standalone treatment technology; instead, it is more appropriately used as a pre-treatment step that requires additional processes like disinfection or reverse osmosis. From a practical standpoint, nanofiltration has the potential to be a relatively energy-efficient technology compared to high-pressure membrane systems. However, definitive conclusions about its cost-effectiveness cannot yet be drawn, as this study did not include an economic analysis.

Future research should focus on optimizing pre-treatment strategies—such as coagulation, adsorption, pH adjustment, and aeration—to enhance membrane performance, as well as exploring different types of membranes. Furthermore, a comprehensive economic feasibility assessment is necessary to support the widespread and sustainable implementation of nanofiltration technology.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to all parties who contributed to the completion of this research. Special thanks are extended to colleagues and discussion partners for their insightful exchanges and valuable input throughout the research process. The authors also wish to acknowledge the reviewers and editors for their constructive suggestions, which significantly enhanced the quality of this manuscript. Every form of assistance and support provided is greatly appreciated and has been instrumental in refining this work.

REFERENCES

Andi, S. P. (2025). Regulatory Influence on Sustainable Water Resources Accessibility in Indonesia, Journal Transformation of Mandalika. Vol. 6, No.6Dwee, D., Dion, H. B., & Brown, I. S. (2012). *Information behaviour concept: A basic introduction*. University of Life Press.

Abdel-Fatah, A. S., Tohamy, H. A. S., Ahmed, S. I., Youssef, M. A., Mabrouk, M. R., Kamel, S., Samhan, F. A., & El-Gendi, A. (2023). Anatase-cellulose acetate for reinforced desalination membrane with antibacterial properties. *BMC Chemistry*, *17*(1), 1–15. https://doi.org/10.1186/s13065-023-01013-1

Abdurrahman. (2023). Nanofiltration Technology Applied to Peat and Wetland Saline Water. In A. Ahmad & M. B. Alshammari (Eds.), Nanofiltration Membrane for Water Purification (pp. 217–245). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-5315-6_12

Agenson, K. O., Oh, J.-I., & Urase, T. (2003). Retention of a wide variety of organic pollutants by different nanofiltration/reverse osmosis membranes: controlling parameters of the process. Journal of Membrane Science, 225(1), 91–103. https://doi.org/10.1016/j.memsci.2003.08.006

Cheng, X., Lai, C., Zhu, X., Shao, S., Xu, J., Zhang, F., Song, J., Wu, D., Liang, H., & Luo, X. (2023). Tailored ultra-low pressure nanofiltration membranes for advanced drinking water treatment. *Desalination*, *548*, 116264. https://doi.org/10.1016/J.DESAL.2022.116264

Chen, B.-Z., Ju, X., Liu, N., Chu, C.-H., Lu, J.-P., Wang, C., & Sun, S.-P. (2020). Pilot-scale fabrication of nanofiltration membranes and spiral-wound modules. Chemical Engineering Research and Design, 160, 395–404. https://doi.org/10.1016/j.cherd.2020.06.011

Efendi, M., Sihombing, P., Rosmainar, L., & Carolius Angga, S. (2024). Analysis of Optimum Conditions of Calcium Ferrate (CaFeO4) Compounds as Oxidants to Reduce Colour Intensity in Peat Water in Palangka Raya City. Jurnal Cendekia Kimia, 02(02), 60–71.

Elma, M., Rahma, A., Mustalifah, F. R., Wahid, A. R., Lamandau, D. R., Fatimah, S., Huda, M. S., Alsiren, M. A., Nasruddin, Saraswati, N. K. D. A., Simatupang, P. F. A., Firdaus, M., & Abdurrahman. (2023). Nanofiltration Technology Applied to Peat and Wetland Saline Water. In A. Ahmad & M. B. Alshammari (Eds.), Nanofiltration Membrane for Water Purification (pp. 217–245). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-5315-6_12

Guo, H. yu, Wang, X. mao, Wang, K., & Liu, S. (2025). Adsorption of natural organic matter and divalent cations onto / inside loose nanofiltration membranes: Implications for drinking water treatment from rejection selectivity perspective. *Water Research*, *282*, 123660. https://doi.org/10.1016/J.WATRES.2025.123660

Gouveia, T. I. A., Gorito, A. M., Cristóvão, M. B., Pereira, V. J., Crespo, J., Alves, A., Pereira, M. F. R., Ribeiro, A. R. L., Silva, A. M. T., & Santos, M. S. F. (2023). Nanofiltration combined with ozone-based processes for the removal of antineoplastic drugs from wastewater effluents. *Journal of Environmental Management*, *348*(October), 119314. https://doi.org/10.1016/j.jenvman.2023.119314

Hidayah, M. (2018). Wastewater Treatment into Drinking Water by Removing Ammonium and E. coli Bacteria Through Nanofiltration Membranes. Walisongo Journal of Chemistry, 1(1), 6. https://doi.org/10.21580/wjc.v2i1.2668

Hilal, N., Al-Zoubi, H., Darwish, N. A., Mohammad, A. W., & Abu Arabi, M. (2004). A comprehensive review of nanofiltration membranes: Treatment, pretreatment, modelling, and atomic force microscopy. Desalination, 170(3), 281–308. https://doi.org/10.1016/j.desal.2004.01.007

Kiswanto, Wintah, Rahayu, N. L., & Sulistiyowati, E. (2022). Processing Peat Water into Clean Water Using Ceramic Membrane Nanofiltration Technology. In Journal of Industrial Research Dynamics (Vol. 33, Issue 1).

Khayan, K., Sutomo, A. H., Rasyid, A., Puspita, W. L., Hariyadi, D., Anwar, T., Wardoyo, S., Sahknan, R., & Aziz, A. (2022). Integrated water treatment system for peat water treatment. CLEAN–Soil, Air, Water, 50(2), 2100404. https://doi.org/10.1002/clen.202100404

Liu, L., Liu, Y., Chen, X., Feng, S., Wan, Y., Lu, H., & Luo, J. (2023). A nanofiltration membrane with outstanding antifouling ability: Exploring the structure-property-performance relationship. *Journal of Membrane Science*,*668*,121205. https://doi.org/10.1016/J.MEMSCI.2022.121205

Liang, J., & Zhou, Y. (2022). Iron-based advanced oxidation processes for enhancing sludge dewaterability: State of the art, challenges, and sludge reuse. *Water Research*, *218*,118499. https://doi.org/10.1016/J.WATRES.2022.118499

Labarca, F., & Bórquez, R. (2020). Comparative study of nanofiltration and ion exchange for nitrate reduction in the presence of chloride and iron in groundwater. *Science of The Total Environment*, *723*, 137809. https://doi.org/10.1016/J.SCITOTENV.2020.137809

Mallya, D. S., Abdikheibari, S., Dumée, L. F., Muthukumaran, S., Lei, W., & Baskaran, K. (2023). Removal of natural organic matter from surface water sources by nanofiltration and surface engineering membranes for fouling mitigation – A review. *Chemosphere*, *321*(November2022). https://doi.org/10.1016/j.chemosphere.2023.138070

Maryam Haddad, Benoit Barbeau (2019). Hybrid Hollow Fiber Nanofiltration–Calcite Contactor: A Novel Point-of-Entry Treatment for Removal of Dissolved Mn, Fe, NOM and Hardness from Domestic Groundwater Supplies, Membranes (Basel), Jul 19;9(7):90.

http://www.health.gov.au/hsdd/mentalhe/sp/nysps/about.htm

Nainggolan, H. (2011). Processing Plantation Industrial Wastewater and Peat Water into Clean Water. Medan USU Press. Pg.

Notodarmojo, S. (1994). Colored Water Treatment: A Review of Laboratory Studies. Colored Water Workshop Paper.

Nurnabila, N. (2011). Formulation of Ethanol Extract of Betel Leaf (Piper betle L.) and Betel Lime ($CaCO_3$) with Microcrystalline Cellulose (AVICEL) as a Binder and Its Effect on CD4 Levels in the Blood.

Oatley-Radcliffe, D. L., Walters, M., Ainscough, T. J., Williams, P. M., Mohammad, A. W., & Hilal, N. (2017). Nanofiltration Membranes and Processes: A Review of Research Trends Over the Past Decade. Journal of Water Process Engineering, 19, 164–171. https://doi.org/10.1016/j.jwpe.2017.07.02610.1016/j.jwpe.2017.07.026

Patterson, C., Anderson, A., Sinha, R., Muhammad, N., & Pearson, D. (2012). Nanofiltration Membranes for Removal of Color and Pathogens in Small Public Drinking Water Sources. Journal of Environmental Engineering, 138(1), 48–57. https://doi.org/10.1061/(ASCE)EE.1943-7870.0000463

Qadafi, M., Wulan, D. R., Notodarmojo, S., & Zevi, Y. (2023). Characteristics and treatment methods for peat water as clean water sources: A mini review. *Water Cycle*, *4*, 60–69. https://doi.org/10.1016/J.WATCYC.2023.02.005

Rizza Fadillah Fitri, (2025), "A Comprehensive Review of Produced Water Processing Technology in the Oil and Gas Industry", Journal of Scientech Research and Development Volume 7, Issue 2, December 2025 P-ISSN: 2715-6974 E-ISSN: 2715-5846

Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023 concerning Environmental Health (2023).

Ramadhani, I. (2020). Fundamentals of Microbiology Labs (N. Suharti, Ed.; Printed by Pe). CV. Pena Persada.

Rustanti, E. (2009). Study of Peat Water Treatment to Become Clean Water Using a Combination of Upflow Anaerobic Filter and Slow Sand Filter Processes. Journal of Environmental Engineering, 1–11.

Sisnayati, Komala, R., Intang, A., & Faizal, M. (2023). Application of Nanofiltration-Reverse Osmosis Membrane Technology for Clean Water and Drinking Water Production at the Kiai Marogan Islamic Boarding School, Palembang. Madaniya, 4(2), 443–452.

Setiadi, I., & Kristyawan, I. P. (2018). Technology for Processing Salty Peat Water into Drinking Water in Tanjung Tengah Village, Penajam, East Kalimantan. Indonesian Water Journal, 8. https://doi.org/10.29122/jai.v8i2.2376

Saiful, M., Shaleha, S., & Rahmi, F. (2017). Synthesis of Polyurethane Membranes Based on Natural Materials. Syiah Kuala University Press.

Sukiman Nurdin. (2011). Analysis of Changes in Water Content and Shear Strength of Gambutialombi Soil Due to the Influence of Temperature and Heating Time. Smartek Journal, 9, 88–108.

Siswoyo, E., & Agustina, R. A. (2009). The Use of Ceramic Membranes to Reduce *E. coli* Bacteria and Total Suspended Solids (TSS) in Kasam Surface Water. Environmental Science and Technology, 1(1), 77–85. https://doi.org/10.31237/osf.io/3jxc2

Sutrisno, S. (1991). Classical Malay Literature and Its Heirs. In Variation, Transformation and Meaning (pp. 37–52). BRILL. https://doi.org/10.1163/9789004454590_00410.1163/9789004454590_004

Tambunan, V. N. (2023). Analysis of Organic Substances in Well Water Dug by Residents in Kaliserayu Sientis Village, Percut Sei Tuan District, Deli Serdang Regency. Journal of Biology, 1, 1–25.

Wang, Q., Guan, Q., Sun, Y., Du, Q., Xiao, X., Luo, H., Zhang, J., & Mi, J. (2023). Simulation of future land use/cover change (LUCC) in typical watersheds of arid regions under multiple scenarios. *Journal of Environmental Management*, *335*, 117543. https://doi.org/10.1016/J.JENVMAN.2023.117543

Wang, F., Wang, H., Ma, H., Zhang, L., Sun, C., & Guo, Q. (2023). Radon dynamic adsorption coefficients of two activated charcoals at different temperatures in nitrogen environment. *Applied Radiation and Isotopes*, *191*. https://doi.org/10.1016/j.apradiso.2022.110564

Widiastuti, T., & Latifah, S. (2017). Empowering Peatland Farmers Through Peat Water Purification Process. JPPM: Journal Of Community Service And Empowerment, 1(2), 155. https://doi.org/10.30595/jppm.v1i2.175010.30595/jppm.v1i2.1750

Wenten, I., Khoiruddin, Aryanti, P. T. P., & Hakim, A. N. (2010). Introduction to Membrane Technology. In Chemical Engineering Dictate, Bandung Institute of Technology (September Issue). Chemical Engineering, ITB 2010.

Xu*, aiyan Y. M. W. L.-Z. G.-X. H. Z. W., & Xu, S. (2022). Removal and Inactivation of Virus by Ceramic Water Filters Coated with Lanthanum (III). *ACT Publication*. https://pubs.acs.org/doi/10.1021/acsestwater.2c00316

Yuksekdag, A., Korkut, S., Kaya, R., Emin Pasaoglu, M., Turken, T., Agtas, M., Evren Ersahin, M., Ozgun, H., & Koyuncu, I. (2023). Upgrading of conventional water treatment plant by nanofiltration for enhanced organic matter removal. *Separation and Purification Technology*, *325*, 124766. https://doi.org/10.1016/J.SEPPUR.2023.124766

Yahia Aedan, Ali Altaee, Ho Kyong Shon (2025). "Performance of pressure stimuli-responsive nanofiltration and cellulose acetate forward osmosis membranes for PFOA contaminated wastewater treatment", https://creativecommons.org/licenses/by/4.0/

Yang, Y., Jiang, C., Wang, X., Fan, L., Xie, Y., Wang, D., Yang, T., Peng, J., Zhang, X., & Zhuang, X. (2024). Unraveling the Potential of Microbial Flocculants: Preparation, Performance, and Applications in Wastewater Treatment. *Water (Switzerland)*,*16*(14). https://doi.org/10.3390/w16141995

Yin, J., Fidalgo, M., & Deng, B. (2023). Removal of NOMs by Carbon Nanotubes/Polysulfone Nanocomposite Hollow Fiber Membranes for the Control of

Disinfection Byproducts (DBPs). *Water (Switzerland)*, *15*(11). https://doi.org/10.3390/w15112054

Zhang, Y., Chen, Y., Wang, M., Su, W., Li, H., Li, P., & Zhang, X. (2023). Preparation of high temperature resistant polyamide composite nanofiltration membranes by thermally assisted interfacial polymerization. *Journal of Membrane Science*, *687*. https://doi.org/10.1016/j.memsci.2023.122020

Zhang, Y., Xin, J., Huo, G., Zhang, Z., Zhou, X., Bi, J., Kang, S., Dai, Z., & Li, N. (2023). Cross-linked PI membranes with simultaneously improved CO2 permeability and plasticization resistance via tunning polymer precursor orientation degree. *Journal of Membrane Science*, *687*, 121994. https://doi.org/10.1016/J.MEMSCI.2023.121994

Zhang, Y., Xin, J., Huo, G., Zhang, Z., Zhou, X., Bi, J., Kang, S., Dai, Z., & Li, N. (2023). Cross-linked PI membranes with simultaneously improved CO2 permeability and plasticization resistance via tunning polymer precursor orientation degree. *Journal of Membrane Science*, *687*, 121994. https://doi.org/10.1016/J.MEMSCI.2023.121994