EFFECT OF STORAGE TIME AND TEMPERATURE ON DRINKING WATER CHARACTERISTICS

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Abstract

Filter membrane technology is known to remove turbidity, colour and microorganisms in water. However, the stability of these parameters during storage is still being determined. This research was conducted to determine changes in pH, turbidity, and total coliform of water treated using membrane filter technology and stored at room temperature and in the refrigerator. Water stored at room temperature increases the pH more easily during storage time. On the other hand, there was no significant difference between changes in the turbidity value of water stored at room temperature and in the refrigerator. Closed storage at room temperature and refrigerators can also protect water from the growth of total coliform. Water treated using membrane filter technology is proven to be stored at room temperature or in the refrigerator without experiencing significant changes in pH, turbidity, and total coliform.

Keywords: *drinking water, pH, turbidity, total coliforms, filter membranes, storage*

Introduction

Water is an abiotic component that is very influential in the life of living things on earth, other compounds cannot replace its role, and most importantly, its function is as drinking water. Water must be fit for consumption, meet health requirements, and comply with government regulations referring to PERMENKES NO. 492 of 2010 concerning requirements for drinking water quality include bacteriological, chemical, radioactive, and physical requirements. For the parameter requirements of pH 6.5 – 8.5, turbidity parameter of 5 NTU and drinking water bacteriology, including contamination level of 0 CFU/100 mL for the presence of Coliform bacteria and Escherichia coli (E. coli), these standards refer to PERMENKES regulation No 492 of 2010.

The acidity level of pH is an essential factor in determining water quality because it affects the biological and chemical processes in it (Hasrianti & Nurasia, 2016). Drinking water generally has a neutral pH (pH 7). In principle, pH can control the balance of water's carbon dioxide and carbonate and bicarbonate content. The higher the turbidity level of drinking water, the higher the effect on human health risks (Park et al., 2020). The pH parameter affects human health if the water is used as drinking water

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(Shah et al., 2023). Besides pH, turbidity also plays an essential role in determining drinking water quality. Good drinking water generally does not have turbidity and does not have suspended particles in it. However, production water from drinking water treatment plants (IPAM) often has turbidity that exceeds the threshold (Nie et al., 2021).

E. coli bacteria are indicators of water pollution because they indicate contamination or contamination from human waste (Savitri, 2014). Coliform is a group of intestinal bacteria which live in the human digestive tract. Coliform bacteria in food and beverages also indicate the possibility of enteropathogenic and toxigenic microbes that harm health (Subroto et al., 2022). It is possible that drinking water can be polluted by E. coli and Coliform bacteria. It was proven by Wahyu et al.'s research in 2018 conducted on samples of drinking water in restaurants and cafes in the city of Padang. The samples tested were 16 samples of drinking water, and the analysis results showed 13 samples of drinking water contaminated with Coliform using the MPN analysis method.

Membrane filter technology is a technology that is known to be effective in removing suspended particles which cause turbidity and changes in pH (Moriera et al., 2021; Prayogo et al., 2023). Membrane filters are a high-turbidity water treatment solution that consumes less energy (Park et al., 2020). Membrane technology also removes microorganisms well from water (Park et al., 2020). When water is passed through these membranes under pressure, the larger microorganisms such as bacteria, protozoa, and some larger viruses are physically blocked and cannot pass through the membrane. The smaller pore sizes of membrane also prevent the passage of smaller microorganisms, like viruses.

Water storage duration can affect drinking water quality (Yao et al., 2022). This research was conducted to determine changes in the pH, turbidity, and growth parameters of Escherichia coli and Coliform sp bacteria using the Most Probable Number (MPN) method in drinking water filter membrane technology with variations in temperature and storage time. This study informs readers about the importance of physical (turbidity), chemical (pH), and microbiological characteristics when water is held for an extended period.

Research Methodology

Sample

Water samples were taken from a membrane filter outlet at a company engaged in food manufacturing located in Purwakarta, West Java. Sampling for research on membrane filter drinking water is in 4 points outside the production area with codes 1-4 (AM 1 L, AM 2 L, AM 3 L, and AM 4 L) and 2 points in the production area (AM 5 D and AM 6 D) according to Figure 1.

Analysis Techniques

Analysis of pH was carried out using a pH meter (Eutech pH 300), which had been calibrated using a buffer solution of pH 4, 7 and 10 which was carried out at room temperature, with time measurement variations of 1 hour, 24 hours, 48 hours, and 72 hours at room temperature storage of 18-25˚C and storage temperature of 0-4˚C in the refrigerator. Turbidity analysis was carried out using the turbidimetric method using a turbidimeter following SNI 3554:2015 point 3.4. Before testing the sample tool, it is first calibrated using a standard solution. In the measurement process, it is ensured that the tube containing the sample is clean and that there is no fat attached, so it must be wiped first using a tissue.

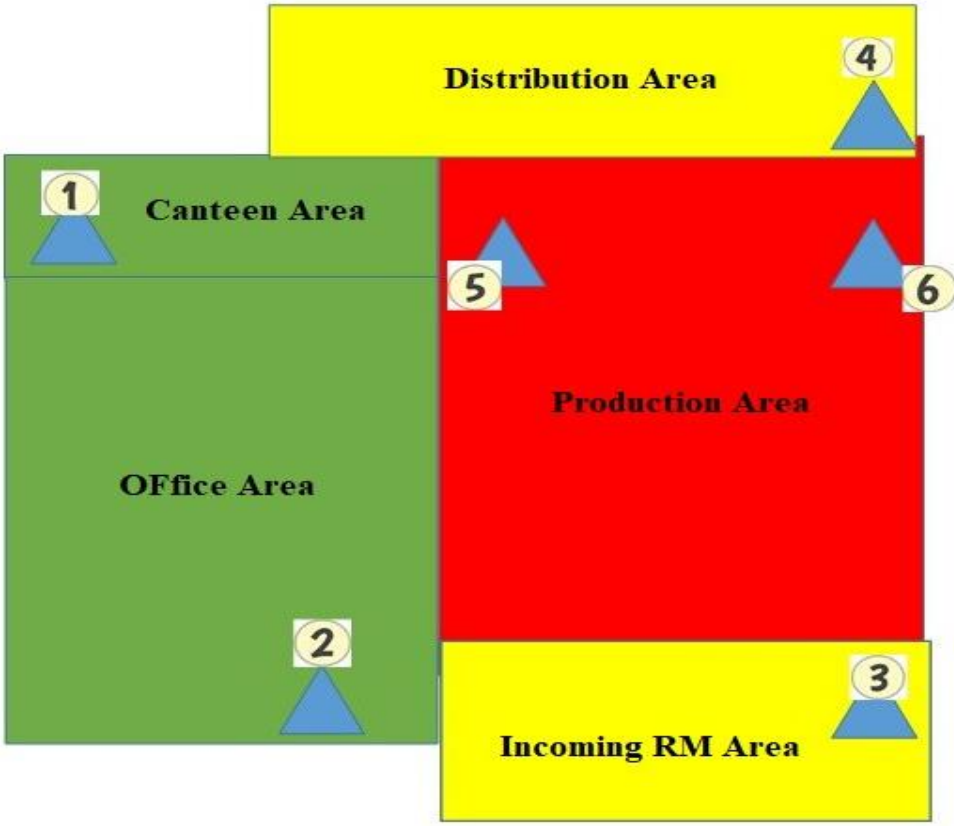

Figure 1. Sampling point plan

Result and Discussion

Figure 2 shows the change in water pH after being stored for 1 hour, 24 hours, 48 hours and 72 at room temperature and in the refrigerator. The results of the pH analysis of filter membrane drinking water at room temperature storage (Figure 1a) increased with time. For drinking water samples with filter membranes at room temperature storage from 1 hour to 72 hours of storage, two samples experienced the most significant increase, namely samples AM 2 L and AM 3 L, with an increase of 0.09. Samples of filter membrane drinking water at refrigerator temperature storage experienced a relatively high increase in pH with increasing storage time. The highest increase in pH was 0.44 in the AM 3 L sample. Temperature plays a vital role in changes in water pH (Peng et al., 2021). Lower temperatures can maintain the presence of dissolved carbon dioxide, thereby increasing the alkalinity of the water (Zhang et al., 2021; Purwanti et al., 2022).

The results of the research on the pH parameters of all filter membrane drinking water samples at room temperature storage conditions with a variation of 1 hour, 24 hours, 48 hours and 72 hours, the pH value obtained was 6.81 - 7.33 and the refrigerator temperature with a variation of 1 hour. 24 hours, 48 hours, and 72 hours the pH values obtained were 6.58 – 7.21, meaning that all samples met the standards referring to PERMENKES No. 492 of 2010 where the conditions for acceptance of pH were 6.5 – 8.5. The longer the storage of pH results, the greater it is caused by several factors, namely the concentration of CO_2 in water, temperature, carbonate, and bicarbonate concentrations and finally, the process of decomposition of organic matter (Wibowo & Ali, 2019).

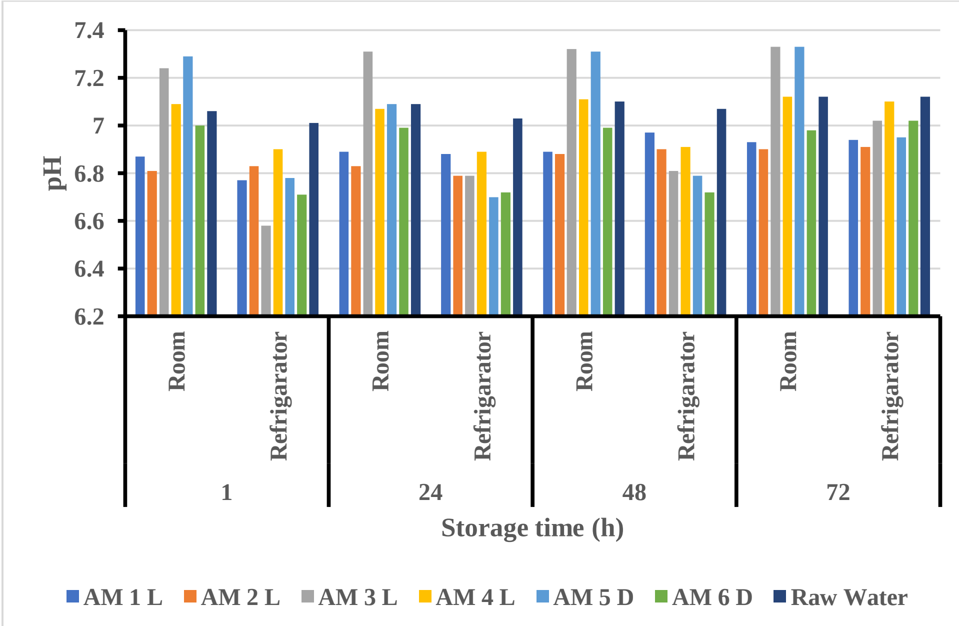

Figure 2. Effect of storage at room temperature and refrigerator on water pH

The degree of acidity describes the activity of the hydrogen contained in the water. Several aspects, such as temperature, biological activity, oxygen content, and other ions, influence water pH. The pH of the water is said to be acidic. If the pH value is <7, the taste of the water will taste sour, and the corrosion properties will be high. If the pH value of the water is >7, then it is called alkaline; with the taste of the water will be bitter, the texture of the water will be slightly slippery, the corrosion properties are low, tend to form scale and less effective in killing bacteria, and if the pH = 7 then it is called neutral, tasteless water and effectively kills bacteria (Rosita, 2014). It was shown by Nita Rosita's research in 2014, which analyzed the quality of refilled drinking water with a total sample of 12 sampling points, and 6 of them were positive for Coliform sp and Escherichia coli bacteria. The positive samples had a pH towards acid 5.67 – 6.50 (Rosita, 2014).

Turbidity change

Figure 3 shows the results of measuring the turbidity parameter in water samples of filter membranes stored in the refrigerator temperature with variations of 1 hour, 24 hours, 48 hours, and 72 hours. In testing the turbidity parameter in drinking water filter membranes at room temperature (Figure 3a) 18-25˚C with a variation of 1 hour, 24 hours, 48 hours, and 72 hours, it increased according to the checking time. The highest increase was in the AM 1 L sample, which was 0.09 NTU. In the sample storage refrigerator, the temperature increased with increasing storage time. The highest increase was in the AM 5 D sample, which was 0.08 NTU.

Turbidity in water is caused by the suspension of dissolved substances which can give a muddy or dirty colour (Awfa et al., 2022). The things that affect the turbidity of drinking water are the primary source of the water and the drinking water treatment method, where the filter membrane sample water goes through several stages of filtering, one of which is filtering using an RO filter so that it has minimal turbidity. The turbidity value is affected by colloids from small particles or the growth of microorganisms in the water. Hence, the turbidity measurement results are more significant (Rosita, 2014). There are several impacts on health if drinking water does not meet standards or has a high turbidity value, namely causing gastrointestinal diseases, especially it will attack people who have low immunity because this is caused by viruses or bacteria attached to suspended solids (Pramesti & Puspitakawati, 2020).

In this study, the results of the turbidity analysis on filter membrane drinking water under storage conditions at room temperature and refrigerator temperature with time variations of 1 hour, 24 hours, 48 hours and 72 hours, all samples met the standards set by PERMENKES No. 492 of 2010 with test results 0.20 – 0.39 NTUs. From the results of the turbidity test, we can see that the drinking water has many bacteria. It is evidenced by Nita Rosita's research in 2014, which showed that drinking water samples with turbidity measurements of 3.8-4 NTU had more microbial content than those with turbidity results of 3.2 NTU (Rosita, 2014), which is minimal because one source of food for bacteria is the organic matter with the results of the turbidity test entering the standard, so the organic matter contained in the drinking water sample of the filter membrane is low. Organic materials can be used as a source of energy by microbes such as bacteria, fungus, and algae for their metabolic processes. They can grow and create microbial colonies in water when they break down organic substances. Monitoring the amount of organic matter in drinking water can act as a warning sign for possible microbial contamination. The existence of bacteria or their metabolites may be suggested by elevated amounts of organic matter, which may call for additional testing or treatment.

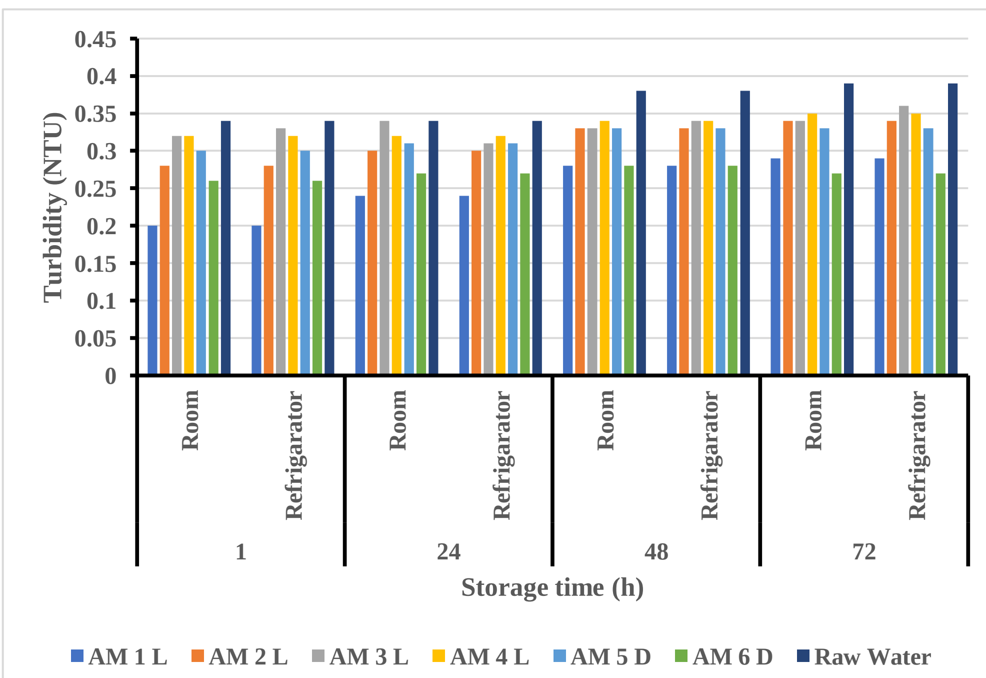

Figure 3. Effect of storage at room temperature and refrigerator on turbidity

Total coliforms

In the research results of the Coliform sp parameter, the Most Probable Number (MPN) method on filter membrane drinking water samples with time variations of 1 hour, 24 hours, 48 hours and 72 hours at room temperature storage 18-25˚C and storage temperature 0-4˚C cupboard temperature cooler. The results of the analysis of drinking water filter membrane samples on double-strength LSTB media for 10-

1 dilution and single-strength LSTB for 10-2 and 10-3 dilutions after incubation for 48 hours at 37˚C did not form gas. The media was not cloudy, indicating that Coliform sp bacteria in filter membrane drinking water samples stored for 1 hour, 24 hours, 48 hours and 72 hours at room temperature and refrigerator did not grow with 0 MPN/100 mL.

Statistic Analysis

1) pH

The results of measuring the pH of filter membrane drinking water were statistical tests using two-factor ANOVA data analysis with replication. The analysis of sample variable data shows that F count is 114.683 > from F table 2.44, so the average pH between filter membrane drinking water samples at room temperature storage of 18-25˚C is significantly different, so H_1 is accepted, and H_0 is rejected. Long storage variable F count 180.196 > from F table 2.95, then the average pH based on storage time is significantly different then H_1 is accepted H_0 is rejected.

Table 1. ANOVA measurement of pH at room temperature

Source of Variation	SS	df	MS	F	P-value	F crit
Sample	0.44849	6	0.07475	114.683	<0,05	2.44526
Variabel Lama Penyimpan	0.35235	3	0.11745	180.196	<0,05	2.94669
Interaction	0.18026	18	0.01001	15.365	<0,05	1.98678
Within	0.01825	28	0.00065			
Total	0.99936	55				

The sample variable data analysis results show that the F count is 1312.76 > from F table 2.44, so the average pH between drinking water samples of filter membranes at 0-4˚C cold storage is significantly different, so H_1 is accepted, and H_0 is rejected. Long storage variable F count 81.50 > from F table 2.95, then the average pH based on storage time is significantly different then H_1 is accepted H_0 is rejected.

Table 2. ANOVA pH measurement refrigerator temperature storage

Source of Variation	SS	df	MS	F	P-value	F crit
Source of Variation	SS	df	MS	F	P-value	F crit
Sample	1.378396	6	0.229733	1312.759	< 0,05	2.445259
Variabel Lama Penyimpan	0.042786	3	0.014262	81.4966	<0,05	2.946685
Interaction	0.083489	18	0.004638	26.50454	<0,05	1.986785
Source of Variation	SS	df	MS	F	P-value	F crit

2) Turbidity

The results of the turbidity test of filter membrane drinking water at room temperature were performed statistical tests using two-factor ANOVA data analysis with replication. The results of the sample variable data analysis show that F count is 114.17 > from F table 2.45, so the average turbidity between drinking water samples of filter membranes at room temperature storage of 18-25˚C is significantly different, so H_1 is accepted, H_0 is rejected. Long storage variable F count 44.12 > from F table 2.95, then the average turbidity based on storage time is significantly different then H_1 is accepted H_0 is rejected. The following Table 4.12 contains the results of measuring the turbidity parameter in drinking water samples of membrane filters stored in the refrigerator temperature with variations of 1 hour, 24 hours, 48 hours, and 72 hours.

The sample variable data analysis results show that F count is 72.93 > from F table 2.45, so the average turbidity between drinking water samples of filter membranes at 0-4˚C refrigerator temperature storage is significantly different, so H_1 is accepted, and H_0 is rejected. Long storage variable F count 44.12 > from F table 2.95, then the average turbidity based on storage time is significantly different then H_1 is accepted H_0 is rejected.

Table 3. ANOVA room temperature storage turbidity parameter

Source of Variation	SS	df	MS	F	P-value	F crit
Source of Variation	SS	df	MS	F	P-value	F crit
Sample	1.378396	6	0.229733	1312.759	< 0,05	2.445259
Variabel Lama Penyimpan	0.042786	3	0.014262	81.4966	<0,05	2.946685
Interaction	0.083489	18	0.004638	26.50454	<0,05	1.986785
Source of Variation	SS	df	MS	F	P-value	F crit

Table 4. ANOVA parameter of turbidity storage refrigerator temperature

Source of Variation	SS	df	MS	F	P-value	F crit
Source of Variation	SS	df	MS	F	P-value	F crit
Sample	1.378396	6	0.229733	1312.759	< 0,05	2.445259
Variabel Lama Penyimpan	0.042786	3	0.014262	81.4966	<0,05	2.946685
Interaction	0.083489	18	0.004638	26.50454	<0,05	1.986785
Source of Variation	SS	df	MS	F	P-value	F crit

Conclusions

When water is kept at room temperature, the pH can be raised more easily. The turbidity value of water kept at ambient temperature and in the refrigerator, on the other hand, did not significantly alter over time. Refrigerators and closed storage at room temperature can both stop total coliform growth in water. It has been demonstrated that water that has undergone membrane filter treatment can be kept at room temperature or in the fridge without experiencing appreciable changes in pH, turbidity, or total coliform.

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