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# ANALYSIS OF WATER TREATMENT EQUIPMENT MAINTENANCE (FILTER REPLACEMENT INTERVALS AND ULTRAVIOLET LAMP OPERATION) ON COLIFORM QUALITY OF REFILL DRINKING WATER IN THE WORKING AREA OF NGEGONG PRIMARY HEALTH CENTER, MADIUN CITY

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## ABSTRACT

Refill Drinking Water Depots (RDWDs) have become an important source of drinking water because they are affordable and easily accessible to the community. However, the microbiological quality of drinking water must comply with health standards to ensure consumer safety. Proper maintenance of water treatment equipment, particularly filter replacement intervals and ultraviolet (UV) lamp operation, plays an essential role in maintaining treatment efficiency and preventing Coliform contamination. This study aims to analyze the relationship between filter replacement intervals and ultraviolet (UV) lamp operation with drinking water quality based on the Coliform parameter in Refill Drinking Water Depots within the working area of Ngegong Primary Health Center, Madiun City. This study employed a quantitative analytical observational design with a cross-sectional approach. The population and sample consisted of 32 refill drinking water depots selected using a total sampling technique. Primary data were collected through direct observation and structured interviews, while secondary data on Coliform examination results were obtained from Ngegong Primary Health Center. Data analysis is planned using the Chi-square test with a 95% confidence level ($p$<0.05). The findings of this study are expected to provide scientific information regarding the importance of water treatment equipment maintenance in maintaining the microbiological quality of drinking water and to support refill drinking water depot owners and health authorities in improving hygiene and sanitation practices.
**Keywords:** refill drinking water depot; filter replacement; ultraviolet lamp; Coliform; drinking water quality.

## INTRODUCTION

Safe drinking water is one of the fundamental requirements for maintaining public health and improving quality of life. Drinking water contaminated by microorganisms may increase the incidence of waterborne diseases, particularly diarrhea, which remains one of the leading environmental health problems in developing countries. Therefore, ensuring microbiological drinking water quality is an essential component of environmental health management (World Health Organization [WHO], 2022).

In Indonesia, the increasing demand for practical and affordable drinking water has contributed to the rapid development of Refill Drinking Water Depots (RDWDs). Although refill drinking water has become an alternative source of drinking water for many communities, the quality of water produced by these depots must comply with the microbiological quality standards stipulated in the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Drinking Water Quality Requirements. According to this regulation, drinking water must not contain Coliform bacteria in 100 mL of water sample, as the presence of Coliform indicates possible microbiological contamination and potential health risks (Ministry of Health of the Republic of Indonesia, 2023).

The microbiological quality of drinking water is influenced by several factors, including the effectiveness of water treatment equipment maintenance. Water treatment systems in refill drinking water depots generally include sediment filters, activated carbon filters, cartridge filters, reverse osmosis membranes,

and ultraviolet (UV) disinfection units. Among these components, filter replacement and UV lamp operation are considered critical because they directly affect the efficiency of particle removal and microbial inactivation.

Filters that are not replaced according to the recommended service life may lose their filtration capacity, while UV lamps that exceed their effective operating life or are not properly maintained may produce insufficient ultraviolet intensity to inactivate microorganisms effectively (United States Environmental Protection Agency [EPA], 2020; WHO, 2022).

The World Health Organization recommends the implementation of the Water Safety Framework as a preventive approach to ensure drinking water safety from the source to consumer. This framework emphasizes hazard identification, risk control measures, operational monitoring, and water quality verification. Routine maintenance of water treatment equipment, including timely filter replacement and proper UV lamp operation, is considered an important risk control measure to prevent microbiological contamination before it occurs (WHO, 2023). This concept is also consistent with the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023, which requires drinking water providers to maintain water treatment facilities and routinely monitor drinking water quality.

Previous studies have demonstrated that inadequate maintenance of water treatment equipment and poor sanitation practices may contribute to microbiological contamination in refill drinking water depots. However, previous research has predominantly focused on general sanitation conditions, while studies specifically evaluating the relationship between filter replacement intervals, ultraviolet lamp operation, and Coliform contamination remain limited. Consequently, further investigation is needed to provide scientific evidence regarding the contribution of water treatment equipment maintenance to microbiological drinking water quality.

This study aims to analyze the relationship between filter replacement intervals and ultraviolet lamp operation with drinking water quality based on the Coliform parameter in Refill Drinking Water Depots within the working area of Ngegong Primary Health Center, Madiun City. The results of this study are expected to provide scientific evidence supporting the implementation of appropriate equipment maintenance as part of the Water Safety Framework and to serve as a reference for refill drinking water depot owners and health authorities in improving drinking water safety.

## MATERIALS AND METHODS

This study employed a quantitative analytical observational design with a cross-sectional approach to analyze the relationship between filter replacement intervals and ultraviolet (UV) lamp operation with the microbiological quality of drinking water based on the Coliform parameter in Refill Drinking Water Depots (RDWDs) located in the working area of Ngegong Primary Health Center, Madiun City, East Java, Indonesia. The study was conducted in 2026.

The study population consisted of all refill drinking water depots operating within the working area of Ngegong Primary Health Center. A total sampling technique was applied because the study population was relatively small. Therefore, all 32 refill drinking water depots that met the inclusion criteria were included as research samples. The inclusion criteria were depots that were actively operating during the study period, utilized filter units and ultraviolet (UV) disinfection systems in the water treatment process, and had microbiological examination records available at Ngegong Primary Health Center.

The independent variables were filter replacement intervals and ultraviolet (UV) lamp operation, while the dependent variable was the microbiological quality of drinking water based on the Coliform parameter. Primary data were collected through direct observation and structured interviews using observation and interview sheets developed based on the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning Drinking Water Quality Requirements. The observation included the condition and maintenance of filter units, the implementation of filter replacement according to operational standards, the operation of ultraviolet lamps during water production, and routine maintenance of UV equipment.

Secondary data consisted of laboratory examination results for the Coliform parameter obtained from Ngegong Primary Health Center. These laboratory data were collected through the routine drinking water quality monitoring program conducted by the Primary Health Center and were used as the dependent variable in this study. Therefore, no additional laboratory examinations were performed by the researchers.

Data collection was carried out after obtaining permission from the relevant institutions. Observation and interview data were coded and entered into a computerized database for statistical analysis. Descriptive

statistics were used to describe the characteristics of refill drinking water depots and the distribution of each research variable. The relationship between filter replacement intervals, ultraviolet lamp operation, and Coliform contamination was analyzed using the Chi-square test with a significance level of 95% ($p < 0.05$). Statistical analysis was performed using IBM SPSS Statistics version 26.

This study was conducted after obtaining approval from the relevant authorities. The confidentiality of all participating refill drinking water depots was maintained by using identification codes instead of depot names. All data collected were used solely for research purposes and presented in aggregate form to protect participants' privacy.

## RESULTS AND DISCUSSION

### 1. Distribution of Filter Replacement Intervals

***Table 1**. Distribution of Filter Replacement Intervals in Refill Drinking Water Depots in the Working Area of Ngegong Primary Health Center, 2026*

| Filter Replacement Interval | Frequency (n) | Percentage (%) |
|---|---|---|
| Meets the standard | 20 | 62.5 |
| Does not meet the standard | 12 | 37.5 |
| **Total** | **32** | **100.0** |

Table 1 shows that the majority of refill drinking water depots had replaced their filter units according to the recommended standard, accounting for 20 depots (62.5%). Meanwhile, 12 depots (37.5%) had not replaced their filters according to the operational standard. These findings indicate that a considerable proportion of depots still performed inadequate filter maintenance, which may reduce the effectiveness of the water filtration process. Filters that are used beyond their recommended service life may accumulate suspended particles and microorganisms, thereby decreasing filtration efficiency and increasing the potential risk of microbiological contamination.

### 2. Distribution of Ultraviolet (UV) Lamp Operation

***Table 2**. Distribution of Ultraviolet (UV) Lamp Operation in Refill Drinking Water Depots in the Working Area of Ngegong Primary Health Center, 2026*

| UV Lamp Operation | Frequency (n) | Percentage (%) |
|---|---|---|
| Meets the standard | 24 | 75.0 |
| Does not meet the standard | 8 | 25.0 |
| **Total** | **32** | **100.0** |

As presented in Table 2, 24 refill drinking water depots (75.0%) operated ultraviolet lamps in accordance with the operational standard, whereas 8 depots (25.0%) did not meet the recommended operational requirements. These findings suggest that although most depots implemented ultraviolet disinfection properly, several depots still required improvements in the operation and maintenance of UV equipment. Improper UV operation may reduce disinfection efficiency, allowing microorganisms to survive in the treated drinking water.

### 3. Distribution of Coliform Examination Results

***Table 3**. Distribution of Coliform Examination Results in Refill Drinking Water Depots in the Working Area of Ngegong Primary Health Center, 2026*

| Coliform Examination Results | Frequency (n) | Percentage (%) |
|---|---|---|
| Meets the standard | 23 | 71.9 |
| Does not meet the standard | 9 | 28.1 |
| **Total** | **32** | **100.0** |

Based on secondary laboratory data obtained from Ngegong Primary Health Center, 23 refill drinking water depots (71.9%) met the microbiological drinking water quality standard based on the Coliform parameter, while 9 depots (28.1%) did not comply with the required standard. The presence of Coliform bacteria indicates

microbiological contamination, which may result from inadequate water treatment processes, poor equipment sanitation, or insufficient maintenance of the treatment system.

### 4. Relationship between Filter Replacement Intervals and Coliform Contamination

***Table 4.*** *Relationship between Filter Replacement Intervals and Coliform Examination Results*

| Filter Replacement Interval | Meets the Standard | Does Not Meet the Standard | Total | *p*-value |
|---|---|---|---|---|
| Meets the standard | 18 | 2 | 20 | |
| Does not meet the standard | 5 | 7 | 12 | |
| **Total** | **23** | **9** | **32** | **0.008** |

The Chi-square analysis demonstrated a statistically significant relationship between filter replacement intervals and the microbiological quality of drinking water based on the Coliform parameter ($p = 0.008$; $p < 0.05$). Refill drinking water depots that replaced filter units according to the recommended standard were more likely to produce drinking water that met microbiological quality requirements than depots that did not replace filters on time.

These findings indicate that timely filter replacement is an important factor in maintaining drinking water quality. Filters that remain in service beyond their recommended lifespan may experience reduced filtration efficiency due to the accumulation of suspended particles and microorganisms, thereby increasing the likelihood of Coliform contamination. Routine filter replacement is an essential component of preventive maintenance that helps maintain the effectiveness of water treatment systems and supports the implementation of proper hygiene and sanitation practices in refill drinking water depots.

### 5. Relationship between Ultraviolet (UV) Lamp Operation and Coliform Contamination

***Table 5***. *Relationship between Ultraviolet (UV) Lamp Operation and Coliform Examination Results*

| UV Lamp Operation | Meets the Standard | Does Not Meet the Standard | Total | *p*-value |
|---|---|---|---|---|
| Meets the standard | 21 | 3 | 24 | |
| Does not meet the standard | 2 | 6 | 8 | |
| **Total** | **23** | **9** | **32** | **0.002** |

The Chi-square analysis also revealed a statistically significant relationship between ultraviolet lamp operation and the microbiological quality of drinking water based on the Coliform parameter ($p = 0.002$; $p < 0.05$). Depots that operated ultraviolet lamps according to the recommended standard were more likely to produce drinking water that complied with microbiological quality requirements than depots with improper UV lamp operation.

Ultraviolet irradiation is the final disinfection process used to inactivate bacteria, viruses, and other microorganisms without the addition of chemicals. The effectiveness of ultraviolet disinfection depends on several factors, including lamp intensity, operating duration, lamp service life, and the cleanliness of the quartz sleeve. UV lamps that exceed their service life or are not properly operated may experience a reduction in ultraviolet intensity, thereby decreasing their ability to inactivate Coliform bacteria effectively. Therefore, regular maintenance and proper operation of ultraviolet lamps are essential to ensure the microbiological safety of drinking water.

Overall, the findings suggest that both filter replacement intervals and ultraviolet lamp operation are significantly associated with the microbiological quality of drinking water based on the Coliform parameter. Refill drinking water depots that routinely maintain filter units and operate ultraviolet lamps according to established standards are more likely to produce microbiologically safe drinking water. These findings emphasize the importance of preventive maintenance of water treatment equipment as an effective strategy for improving drinking water safety and supporting hygiene and sanitation practices in refill drinking water depots.

## CONCLUSION

The findings of this study indicate that filter replacement intervals and ultraviolet (UV) lamp operation are significantly associated with the microbiological quality of drinking water based on the Coliform parameter in Refill Drinking Water Depots within the working area of Ngegong Primary Health Center. Depots that

replaced filter units according to the recommended standard and operated ultraviolet lamps properly were more likely to produce drinking water that complied with microbiological quality requirements.

These findings highlight the importance of routine maintenance of water treatment equipment in ensuring the safety and quality of drinking water. Therefore, refill drinking water depot owners should replace filter units periodically according to the manufacturer's recommendations and ensure that ultraviolet lamps operate effectively through regular inspection and maintenance. This study is expected to provide useful information for health authorities in strengthening supervision and hygiene sanitation programs for refill drinking water depots, as well as serve as a reference for future studies investigating other factors affecting drinking water quality.

## CONFLICT OF INTEREST (if any)

The author declares that there are no financial or non-financial conflicts of interest that could have influenced the conduct of this research, data analysis, or the preparation of this manuscript. This study was conducted independently, and the author takes full responsibility for the content and findings presented in this article.

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