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Comparison of Reverse Osmosis and Non Reverse Osmosis Disinfection Methods for Drinking Water Depot

Muhamad Iqbal[1*], Ruslan La Ane[2]
[1]Department of Environmental Health, Bandung Health Polytechnic, Bandung, Indonesia
[2]Department of Civil and Environmental Engineering, Faculty of Engineering, Ehime University, Matsuyama, Japan
[*]Authors Correspondence: muhamadiqbal@staff.poltekkesbandung.ac.id/0882001236953

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ABSTRACT
Drinking Water Depot (DWP) offers cheap and affordable drinking water, so it becomes an option for the society. However, the large number of public interest is not accompanied by qualified water quality. The test result by Bandung Public Health Office on DWP quality indicated that 55.22% were not eligible. The study aimed to determine the effective disinfection method to reduce microbiology in Reverse Osmosis (RO) and Non-RO methods. It was an analysis with a cross-sectional design. The population was all DWPs in Bandung and obtained 659 DWPs as samples. Sampling used two different tests and obtained 30 samples consisting of 30 DWP using RO and 30 Non-RO in average. Data analysis was done through univariate and bivariate using Wilcoxon Rank Sum test. The analysis result showed that polluted water raw quality was 48.33%; the bacteria reduction by RO method was 100% and Non-RO was 43.33%. The bivariate analysis result indicated that p-value was 0.033 which means that there was a difference between disinfection method using RO and Non-RO with the coliform presence. The RO disinfection is the best method which was able to be used by DWP owners. Thus, the society is suggested to choose DWP using RO disinfection method which verified by Public Health Department.

INTRODUCTION

Drinking Water Depot (DWP) is a business entity that manage drinking water for society's needs in bulk. DWP was established during economic crisis in 1998 to answer the problem of high demand for bottled drinking water. The society began to seek the alternative source of cheap water to meet the drinking water needs. DWP has grown rapidly and reached 659 DWPs in Bandung since 2017. The result of test conducted by Bandung Public Health Department indicated that from 134 DWPs, there were 74 DWPs (55.22%) contaminated with coliform and E. Coli.[1]

Several factors affecting DWP drinking water quality are sanitation hygiene, raw water, and disinfection method. The hygiene standard is influenced by DWP location which must be pollution free, the quality of DWP equipment, clean and healthy behavior as well as procedures of DWP processing conducted.[2]

The treatment process determines the water quality which will be consumed, except water spring. DWP processing includes filtration and disinfection.[3] Filtration is a separating process of suspended contamination and colloidal mixture including microorganisms. Meanwhile, disinfection is to eradicate pathogens. There are several methods used by DWP including using ozonation, ultraviolet, and reverse osmosis. Disinfection using ozone (O_3) takes place in the ozone mixing tank at least 0.1 ppm and the residual ozone immediately after filling is 0.06-0.1 ppm. Oxidizing ability of Ozone can kill various microorganisms, such as Escherichia bacteria, Salmonella enteritidis, and other pathogenic bacteria. Ozone will destroy as well as kill the outer microorganism cells (cell lysis).[4]

In addition to using ozone, disinfection is able to be conducted by Ultraviolet (UV) with a wavelength of 254 mm or a power of 2.537 degrees Angstrom can eradicate microorganism in 1 second. The disinfection quality using UV is strongly influenced by the water speed, the capacity or UV volume and the lamp intensity.[5]

Reverse Osmosis (RO) is the most promising membrane technology in reducing organic micro pollutant from drinking water treatment. RO filter becomes one of the most reliable filters. This process is able to remove about 80 to 99.8% of contaminants contained in water. RO process uses high pressure, so the water can pass through the membrane. The RO membrane density is 0.001 micrometer.[6] The osmotic pressure used in combination with other technology enables the water filter to produce the best healthy water. However, there is still thing that make it less effective in terms of time. Since the membrane in this technology is micro, the water which came out is also small. So, clogged membrane, dirty membrane, and broken membrane often occur.[7]

As demand for drinking water increases, the society takes advantage of DWP existence. In addition to being efficient and easy to get, the price is also affordable. The poor quality of treated water at the drinking water depot will affect the health status of people in the drinking water depot environment. So, it is the background for the growth and development of DWP, especially in Bandung city. The purpose of this study was to analyze the quality of the raw water sources used by drinking water depots, determine the most effective disinfection method to reduce coliform bacteria and provide advice to drinking water depot entrepreneurs regarding the selection of disinfection method.

MATERIAL AND METHOD

The study used quantitative with a cross sectional design to find out the comparison of using RO and Non-RO method on microbiological quality at DWPs. It was carried out at all Public Health Center in Bandung. There were 659 drinking water depots registered in all public health centers as the populations.

Samples were obtained through the results of calculation using the two-average difference test formula, then obtained sample size of 30 samples which consist of 30 DWPs using the RO disinfection method and 30 non-RO DWPs. The inspection method used was a membrane where the raw water and drinking water were passed into a membrane filter for 100 ml. The analysis technique used Wilcoxon Rank Sum Test.

Data were obtained by taking samples of raw water and water from the DWP processing process and then taking them to the laboratory for immediate examination. Water sample taken was 100 ml using sterile plastic. Then, laboratory test was done using membrane method,

namely raw water or drinking water was passed into a membrane filter. After that, it was incubated for 24 hours at 37°C. Laboratory measurement data were analyzed with application computer using Wilcoxon Rank Sum Test analysis and presented in the table. The use of Wilcoxon Rank Sum Test as statistical analysis is because the data is not normally distributed and the measurement results for the independent variables contain categorical data and there is numerical data for the dependent variable. It was conducted from July to August 2020 in Bandung City.

RESULTS

The field observation result showed that average number of DWP employees were 2-3 people with percentage of 66.67%. It indicated that DWPs in Bandung did business for a long time which is 7% DWP have operated more than 10 years. There are 3 types of raw water sources, namely spring, *Perusahaan Daerah Air Minum (PDAM)*, and well water (Table 1). Most owners of DWP used spring water (76.67%), but laboratory result showed *Perusahaan Daerah Air Minum (PDAM)* has the best quality (Table 2). The lack of DWP oversight by related offices is indicated with business license ownership by 35%, proper hygiene sanitation issued by public health department or local port health office by 30%, an overview of DWP production flow by 30%. The owner compliance levels in checking DWP microbiological quality every 3 months are 30% and 6 months is 41% (Table 1).

The laboratory examination result presents that microbiology in DWP raw water with spring is 56.67%, well water is 100%, and PDWP is 75% (Table 2). Then, DWP examination indicates that it used RO disinfection method and it is 100% eligible, while DWP using Non-RO is only 43.33% qualified (Table 3). The bivariate analysis result indicates that p-value is 0.033 for coliform which means that there is a difference disinfection method using RO and Non-RO on bacteria of 60 samples which have been tested in laboratory (Table 4).

Table 4 indicates the result of two different tests of average between Drinking Water Depot using RO and Non-RO disinfection method in reducing microbiological numbers in drinking water. The p-value for the presence of coliform and E. coli are 0.000. it can be concluded that there is a significant difference between Drinking Water Depot using RO and Non-RO disinfection method.

Table 1. Characteristics of Drinking Water Depot (DWP)

Characteristic	RO	Non-RO	%
Number of Employees			
1 Person	0	9	15
2 People	22	18	66.67
>3 People	8	3	18.33
Business Length (Years)			
<5	17	12	48.33
5 – 10	11	13	24
> 10	2	5	11.66
Raw Water Source			
PDAM	9	3	20
Spring Water	19	27	76.67
Well	2	0	4
Ownership			
Business License	14	7	35
Sanitary Hygiene Certificate	10	8	30
Standard Operational Procedure	2	5	11.67
Production Flow	10	8	30
Laboratory Test			
Last 3 Months	10	8	30
Last 6 Months	16	9	41
Information			
Participate Counselling	19	16	58.33
Get Guidance	16	13	48.33
Drinking Water Depot Management	18	18	60

Source: Primary Data, 2020

Table 2. Raw Water Quality

Indicator	*Perusahaan Daerah Air Minum (PDAM)*		Spring Water		Well Water	
	n = 12		n = 46		n = 2	
	n	%	n	%	n	%
Qualify	9	75	26	56.52	0	0
Not Qualify	3	25	20	43.48	2	100

Source: Primary Data, 2020

DISCUSSION

The disinfection process aimed to eliminate microorganism in raw water. UV rays, ozone, and reserve osmosis can be used to kill microorganism in DWP raw water.[8] The result indicated that coliform bacteria was still found in drinking water by Non-RO (UV and ozone), while RO did not contain pathogenic bacteria. The result of study is in line with Tomonic that RO disinfection method has a better quality in reducing microorganism than Non-RO method.[9]

The measurement in laboratory found that Non-RO disinfection method was still found microbiology. It is in line with Naratinova who stated that coliform is found in UV lamps which do not change > 36 months or 3 years.[5] It is not in line with Jarvis who stated that UV-LED can reduce microbiology in water above 97% at wavelength of 275 nm by considering exposure time, lamp position, light intensity, and the resistance between light and water surface.[10] The treated water quality in this study found that unqualified water was 56.7%. Several factors caused the poor quality of treated water using UV disinfection method was the contact time less than 1 second, so UV rays did not reach the entire water surface.

This result is not in line with Ding's finding that there is a decrease in spore after given injection of 1.5mg/L ozone and killed 99% of bacillus spore.[11] The flow rate of 4.17 ipm and ozone content of 2.79 ppm can reduce coliform in filtration system by 100%.[12] UV and ozone disinfection methods are still considered ineffective if they are not accompanied with cartridge filtration since these methods do not completely reduce the microbiological presence level in drinking water.[13]

Table 3. Drinking Water Depot (DWP) Quality

Variable	RO	%	Non-RO	%
Qualify	30	100	13	43.33
Not Qualify	0	0	17	56.67

Source: Primary Data, 2020

Table 4. Two Different Tests of Average

Wilcoxon Runk Sum Test		
Indicator	**n**	***p-value***
Coliform	60	0.033

Source: Primary Data, 2020

RO is the most effective disinfectant method to degrade microbiology in drinking water. The laboratory measurement result showed that 100% of water processed by DWP had a qualified drinking water based on Minister of Health Regulation No. 492 of 2010 about Drinking Water Quality Requirements. The RO effectiveness in degrading microbiology is in line with Fujioka that RO with bacteria removal rate ranging from 2.6 to 3.1-log (average = 2.9-log) and can reduce all coliform bacteria. It indicates that it is the best method applied in treating drinking water.[14] The weakness of RO system is that the membrane is often clogged since the pore is tiny, so colloidal particles, suspended particle, bacteria, and virus cannot pass through the membrane pores. The blockage occurs in osmotic membrane because of deposition pores of membrane by organic substance with a low concentration of water salt.[15] It makes the membrane to work extra in filtering in order to lighten the membrane work. So, pre-treatment is needed. According to Cornellisen, the importance of pretreatment can reduce 10 times of dirt rate and eliminate blockage to membrane. So, it can reduce installation maintenance costs.[16]

Water source plays an essential role in water supply. According to Seo, water quality affects the coliform concentration which is mostly influenced by organic substance since good raw water quality optimizes the work of DWP equipment, so the water has good quality.[17] Based on the result of laboratory examination on coliform, the unqualified raw drinking water depots of 60 samples is 48.33%. Well water is the worst choice since 100% unqualified, while spring water is 43.5% and *PDAM* is 25% unqualified (Table 2). The best water sources is

from *PDAM* since it has processed before distributed to customers, while spring and well water have no treatment.

The guidance conducted by related offices is not optimal. There is only 58.33% of DWP owners who get counseling and 48.33% receive coaching (Table 1). According to Villafuerte, it is important to supervise the DWP in order to know whether the water consumed is safe and healthy. Monthly and annual training or seminar must be conducted in operating DWP in order to ensure that consumers get the quality product and service. Furthermore, permits from relevant office and laboratory measurement related to the treated water quality must be carried out before DWP starts operating as well as strict surveillance in order to avoid contamination.[18] If it is not supervised, a typical public health problem is going to arise.[19] The low compliance of owner is proved by business license ownership by 35% and sanitation hygiene certificate by 30% (Table 1). The establishment of DWP without recommendation and permit from the relevant offices makes Health Department/Port Health Office difficult to supervise. The supervision conducted makes people feel safe, comfortable, and get optimal benefits of DWP services. The reason is that drinking water is primary human need which is broad, so the slightest risk must be avoided.[20]

CONCLUSION AND RECOMMENDATION

The clean water treatment process is largely determined by the selection of the filtration method and the disinfection method. The method using Reverse Osmosis (RO) is the best method in reducing the presence of microbiology in drinking water compared to Non-RO methods. so it is recommended to every drinking water depot entrepreneur to use the reverse osmosis processing method.

Then for the Government, in this case the city health department, must monitor and evaluate the performance of the Drinking Water Depot, so that the quality of the treated water from the Drinking Water Depot can be maintained and ensure that the people who consume the water are not attacked by diseases originating from the Drinking Water Depot.

AUTHOR CONTRIBUTIONS

This article was written by MI in scientific paper writing; RLA proofreading and provided critical feedback of the manuscript. MI = Muhammad Iqbal; RLA = Ruslan La Ane.

CONFLICTS OF INTEREST

The author stated that there was no conflict of interest with funding sponsor and did not have role in study design; collection, analysis, or data interpretation, script writing, and decision to publish the result.

REFERENCES

1. Dinas Kesehatan. Laporan Tahunan Seksi Penyehatan Lingkungan. *Kota Bandung*. 2019.
2. Alfian AR, Firdani F, Sari PN. Why the Quality of Refill Drinking Water Depots is Bad (As a Qualitative Study). *J Kesehat Lingkung Indones*. 2022;21(1):106-110. https://doi.org/10.14710/jkli.21.1.106-110
3. Raksanagara AS, Fitriyah S, Afriadi I, Sukandar H. Aspek Internal dan Eksternal Kualitas Produksi Depot Air Minum Isi Ulang: Studi Kualitatif di Kota Bandung. *Maj Kedokt Bandung*. 2018;50(38):53-60. https://doi.org/10.15395/mkb.v50n1.1143
4. Sofia DR. Perbandingan Hasil Disinfeksi Menggunakan Ozon dan Sinar Ultra Violet Terhadap Kandungan Mikroorganisme pada Air Minum Isi Ulang. *Agroscience (Agsci)*. 2019;9(1):82. https://doi.org/10.35194/agsci.v9i1.636
5. Navratinova S, Nurjazuli N, Tarwatjo T. Hubungan Desinfeksi Sinar Ultraviolet (UV) dengan Kualitas Bakteriologis Air Minum pada Depot Air Minum Isi Ulang (DAMIU) (Studi di Kecamatan Pontianak Selatan Kota Pontianak). *J Kesehat Masy*. 2019;7(1):412-420. https://doi.org/10.14710/jkm.v7i1.23011
6. Ebrahimzadeh S, Wols B, Azzellino A, Martijn BJ, van der Hoek JP. Quantification and Modelling of Organic Micropollutant Removal by Reverse Osmosis (RO) Drinking

Water Treatment. *J Water Process Eng*. 2021;42(June):102164. https://doi.org/10.1016/j.jwpe.2021.102164

7. Hidayati FW, Jhoansyah D, Deni R, Danial M. Analisis Model Altman, Model Zmijewski dan Model Ohlson untuk Memprediksi Financial Distress. *J Indones Sos Sains*. 2021;2(2):230-240. https://doi.org/10.36418/jiss.v2i2.179
8. Mairizki F. Analisis Higiene Sanitasi Depot Air Minum Isi Ulang (Damiu) di Sekitar Universitas Islam Riau. *J Endur*. 2017;2(3):389-396. http://doi.org/10.22216/jen.v2i3.2428
9. Tominik VI, Hutabarat MSH. Analisis Uji Kualitas Bakteriologis Air Minum Isi Ulang (AMIU) Menggunakan Metode Mpn pada Pengolahan Air Sistem Reverse Osmosis (RO) dan Sistem Ultra Violet (UV). *Jurnal Kesehatan Saelmakers PERDANA* 2018;1:20-24. https://journal.ukmc.ac.id/index.php/joh/article/view/98
10. Jarvis P, Autin O, Goslan EH, Hassard F. Application of Ultraviolet Light-Emitting Diodes. Water 2019, 11, 1894. Published online 2019:15. https://doi.org/10.1016/j.watres.2016.03.003
11. Ding W, Jin W, Cao S, et al. Ozone Disinfection of Chlorine-Resistant Bacteria in Drinking Water. *Water Res*. 2019;160:339-349. https://doi.org/10.1016/j.watres.2019.05.014
12. Jannah FZ, Zuhri MS, Mulyadi E. Optimasi Kadar Ozon dalam Proses Disinfeksi Bakteri Optimization of Ozone Levels in the Process of Disinfection Coliform Bacteria in Drinking Water. *J Tek Kim*. 2021;15(2):59-65. 10.33005/jurnal_tekkim.v15i2.2567
13. Jones CH, Shilling EG, Linden KG, Cook SM. Life Cycle Environmental Impacts of Disinfection Technologies Used in Small Drinking Water Systems. *Environ Sci Technol*. 2018;52(5):2998-3007. https://doi.org/10.1021/acs.est.7b04448
14. Fujioka T, Makabe R, Mori N, Snyder SA, Leddy M. Assessment of Online Bacterial Particle Counts for Monitoring the Performance of Reverse Osmosis Membrane Process in Potable Reuse. *Sci Total Environ*. 2019;667:540-544. 10.1016/j.scitotenv.2019.02.339
15. Couto CF, Santos AV, Amaral MCS, et al. Assessing Potential of Nanofiltration, Reverse Osmosis and Membrane Distillation Drinking Water Treatment for Pharmaceutically Active Compounds (PhACs) Removal. *J Water Process Eng*. 2020;33(July 2019):101029. https://doi.org/10.1016/j.jwpe.2019.101029
16. Cornelissen ER, Harmsen DJH, Blankert B, Wessels LP, Van der Meer WGJ. Effect of Minimal Pre-Treatment on Reverse Osmosis Using Surface Water as a Source. *Desalination*. 2021;509(January):115056. https://doi.org/10.1016/j.desal.2021.115056
17. Seo M, Lee H, Kim Y. Relationship between Coliform Bacteria and Water Quality Factors at Weir Stations in the Nakdong River, South Korea. *Water (Switzerland)*. 2019;11(6). https://doi.org/10.3390/w11061171
18. Villafuerte LAJ, Vigonte F. Knowledge and Practices of Water Refilling Stations Owners and Operators: A Case Study. *SSRN Electron J*. Published online 2022. 10.47895/amp.v47i2.1360
19. Birawida AB, Selomo M, Mallongi A. Potential Hazards from Hygiene, Sanitation and Bacterium of Refill Drinking Water at Barrang Lompo Island (Water and Food Safety Perspective). *IOP Conf Ser Earth Environ Sci*. 2018;157(1):1-6. https://iopscience.iop.org/article/10.1088/1755-1315/157/1/012034
20. Suriata IN. Perizinan Usaha Industri Dagang Depot Air Minum di Kota Denpasar. *Public Inspir J Adm Publik*. 2021;6(1):42-54. doi:10.22225/pi.6.1.2021.42-54. https://doi.org/10.22225/pi.6.1.2021.42-54