Advances in Health Sciences Research, volume 49
International Conference on Health and Well-Being (ICHWB 2021)

Comparison of Microbiological Quality of Well Water and Contaminated River Water in Open Defecation Area

[*1]Mitoriana Porusia, [1]Rezania Asyfiradayati, [1]Shesa Ratna Suryaning Putri, [1]Sarsa Shahila Dwinanda

[1]*Public Health Dept. Universitas Muhammadiyah Surakarta Jl. A Yani Tromol Pos. Pabelan Kartasura Kab. Sukoharjo Indonesia*
**corresponding author: mp781@ums.ac.id*

ABSTRACT

Introduction: At the end of 2019, Mulyoharjo village in Pemalang regency, Indonesia, had not reached an Open Defecation Free (ODF) status and diarrhea was frequent in the area. Some houses located by the river have no septic tank and dispose of the stool to the river. The local river water was contaminated, however, the quality of well water was not fully understood. Therefore, the quality of both water sources is required to be understood for the local community safety. **Objectives**: This study aims to determine and compare the microbiological quality (*Escherichia coli*) of well water and river water contaminated with stool in Mulyoharjo Village, Pemalang regency. **Method**: Seven houses were located next to the river (<20 m) and had dug well (depth 8-10 m). Four of seven houses had a septic tank while three houses had not. Both water sources from each house were collected using a weighted water sample bottle. *E.coli* presence was determined using the compact dry EC plates. **Results:** The result showed the river water had higher contamination (>1800 CFU/100ml) than well water (0-1125 CFU/100ml) (p=0.000, 95%). A difference was also found between the number of *E.coli* colonies in well water between houses with septic tanks and those without septic tanks (p=0.001). **Conclusion**: The contaminated river has a higher number of *E.coli* than well water. However, the houses with septic tanks tend to have well water with high *E.coli* compared to those who have no septic tank. It is assumed that the presence of septic tanks around the wells was too closed and caused contamination.
Keywords: *Escherichia coli*, contamination, well water, river water,

1. INTRODUCTION

Inadequate sanitation is a factor in the transmission of various diseases such as diarrhea, cholera, dysentery, hepatitis A, typhoid, polio, stunted growth, and causes of death in children under five [1]. Open defecation is an example of unhealthy behavior like disposing feces in fields, forests, bushes, rivers, beaches, or other open areas and allowing them to spread to contaminate the environment, soil, air, and water. Human waste contains pathogenic organisms that are carried by water, food, flies into diseases such as salmonella, *Vibrio cholera*, dysentery, diarrhea, and others [2]. Stool contains infectious agents that enter the digestive tract. One of many pathogens that indicate stool contamination is *Escherichia coli*, therefore *E.coli* should be absent from the drinking water and water for hygiene sanitation needs. The contaminated water that is used to process food can cause food contamination as well, such as in ice cream and street foods [2], [3]. Some cities in Central java province, Indonesia, have not achieved open defecation-free (ODF) status. It means that some people still conduct open defecation. Pemalang is one of a district that has this typical problem. According to data from the Pemalang Regency Health Office, in 2019 approximately 72,898 households were free from open defecation. However, some villages in the city were not free from open defecation such as Mulyoharjo village. According to data from the Mulyoharjo Health Center in 2019, approximately 25 families in the Mulyoharjo village still practice open defecation in the river, because they do not have latrines with septic tanks or some houses located by the river have no septic tank and dispose the stool to the river. The local health worker in Mulyoharjo said that there were more than 10 people who complain of diarrhea, both parents and toddlers, some have even been treated in 3 hospitals because of diarrhea in 2019.

Mulyoharjo village is trying to achieve ODF status with all efforts, but the quality of water that was contaminated with open defecation needs to be

checked as a control measure for diarrheal disease. Some residents in Mulyoharjo still use well water for their daily needs, the quality of this well water source has never been tested for its feasibility concerning the impact of open defecation in the river which allows contamination of river water and residents' well water. This research is important considering that the well water used by residents may be contaminated with fecal coliform bacteria that cause diarrhea [5]. Therefore, the quality of both water sources is required to be understood as a consideration of the safety and feasibility of consuming water for the local community. This study aims to determine and compare the microbiological quality (*Escherichia coli*) of well water and river water contaminated with stool in Mulyoharjo Village, Pemalang District. This research is very important to do considering the high incidence of diarrhea in Mulyoharjo Village (>10 cases) at the end of 2019. If this research can show the presence of contamination factors for well water originating from polluted river water, this finding can be considered by the parties. The output to take follow-up actions to eradicate open defecation in Mulyoharjo Village, Pemalang regency.

2. METHODS

2.1 Taking Sample

The location of water sampling was obtained using purposive sampling where the point of the river is near the houses of residents who have wells. Seven houses were located next to the river (<20 m) and had dug well (depth 8-10 m). Four of seven houses had a septic tank while three houses had not. the location of the river and wells allows for water sampling, the point of the river is close to the residents' wells, the point of the river is close to the houses of residents who do not have septic tanks or discharges sewage into the river and the location of the river is close to the homes of residents who have septic tanks. The samples used were river water and resident well water. Water samples from the river were taken with a 100 ml x 3 using a weighted sample bottle (glass-made) and transferred to a sterile bottle by the aseptic method while water samples from the well were taken by entering the water from the tap (well-pump) or taking it from the good bucket aseptically into a sterile bottle. The sampler bottle is always rinsed with water at that point 2 times before being used to take water samples. This is to avoid contamination from previous water sampling. While at the location, several questions will be asked to the house owner to obtain information such as the location (Figure 1) and distance of the septic tank, the use of the well water, the ownership of the latrine, how deep the well is, and the distance from the well to the river.

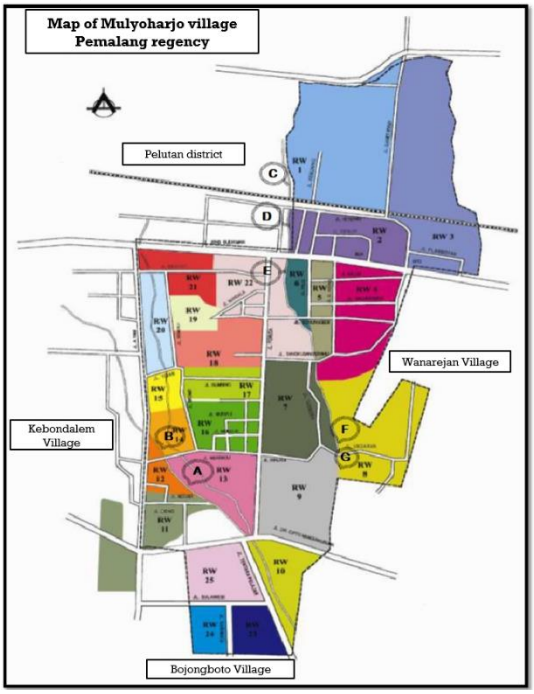

Figure 1. Map of Mulyoharjo Village Pemalang Indonesia

2.2 Laboratory Test

The variable in this study was the number of *E.coli* colonies detected in the compact dry EC plates. The use of compact dry EC plates is a simple and safe test procedure for the determination and quantification of coliform and *E. coli* bacterias [6]. The ready-to-use plate consists of a special 50 mm diameter petri dish containing a special nutrient detector pad. The water samples were brought and examined at the Microbiology Laboratory of the UMS Faculty of Health Sciences. Every 100 ml of water was filtered through a water filter membrane and the water membrane was placed in a compact dry EC plate aseptically. Each sample from each location will be repeated 3 times. The compact dry EC plates were then put into an incubator at 37^{o}C for 24 hours. The purple *E.coli* colonies were then counted and recorded. Observational data were analyzed statistically using SPSS version 21 software. The research data will be compared using a comparative statistical test (T-test) with a significance of 95% and compared with Indonesian water quality standards in Health regulation of Indonesia no 32 of 2017 concerning environmental health quality standards for water media for sanitation hygiene purposes. Other factors observed

during sampling as well as brief interviews with residents will serve as supporting information in writing scientific articles and suggestions for overcoming water pollution.

3. RESULT

Mulyoharjo Village is a village located in the center of Pemalang City. This village is crossed by several rivers which are also the boundary with other Villages. Previously, Mulyoharjo Village had problems with residents who still defecated in the river using an open toilet in the river or commonly called "helicopters". To get to open defecation-free (ODF), the river latrine was demolished to avoid the habit of defecating in the river. However, even though residents no longer defecate in river latrines, some houses near the river have latrines but do not have septic tanks, so they throw their defecation into the river. On the other hand, some residents have septic tanks that are placed too close to the well or make the well too close to the river. Of the 7 houses taken, 3 houses do not have a septic tank and defecate directly into the river. 4 houses do not have a septic tank and defecate directly into the river. Although these houses all have toilets, some houses do not have septic tanks. There is a medium river (3-4 meters wide) and a very small river with a width of 1 meter and a depth of <30 cm. The available well water is used mostly for sanitation purposes, such as bathing, toilet cleaning, washing clothes and dishes, but some also use it as drinking water through a cooking process.

Based on Table 1, it can be seen the difference between *E.coli* in well water and river water. There was a difference in the number of *E.coli* colonies examined between well water and river water (p=0.000). Colonies in river water are more numerous and reach 1800 to 3000 colonies. There was also a difference between the number of *E.coli* colonies in well water between houses with septic tanks and those without (p=0.001). The houses with septic tanks tend to have more contaminated well water than those that do not have septic tanks. The number of *E.coli* in well water in houses without septic tanks tends to show a higher *E.coli* CFU (167-663) compared to well water in homes with septic tanks (0-12).

Table 1. *E.coli* in well and river water

House code	Septic tank	Well to the septic tank (meter)	Well to the river (meter)	Well water use	*E.coli* in well water (CFU/100ml)	*E.coli* in river water (CFU/100ml)
A	No	-	8	Washing	8	2410
B	No	-	5	Drinking, washing	0	2505
D	No	-	20	Drinking, washing	12	2443
C	Yes	2	10	Drinking, washing	663	1856
E	Yes	5	10	Washing	167	3214
F	Yes	13	10	Washing	192	2379
G	Yes	8	20	Drinking, washing	1125	3520

4. DISCUSSION

In this study, houses in Mulyoharjo, which did not have a septic tank and disposed of sewage directly into the river, had lower contaminated *E.coli* well water compared to houses with septic tanks. However, river conditions in Mulyoharjo became very high for *E.coli* as well. The close distance between the septic tank and the well also increases the tendency for high contamination of well water. Yuniarno stated that residents of houses with wells and septic tanks <11 meters risk 2.36 times greater than respondents who have wells and septic tanks >11 meters [7]. There is a very significant relationship between the number of *E.coli* in dug well water and the distance from the dug well to the septic tank, in Tuminting village, Manado city. Septic tank waste greatly affects the pollution of dug wells [8]. Sapulete states that the closer the pollutant source is to the dug well, the more the presence of Coliform and *E.coli* in dug

wells is getting higher. Sapulete concluded that there was a relationship between the distance of the well and the septic tank with the content of *E.coli*. The horizontal distance between the septic tank and the well is 11 meters [9].

Sapulete suggests that the distance between the septic tank and the water source should be 11-15 meters [9]. This distance does not guarantee or ensure that the water source is not polluted but reduces the risk of pollutant factors entering and damaging the water quality of the dug well. At location F, although the distance between the well and the septic tank is >11 meters, *E.coli* contamination still occurs. The dug well construction that is not covered with bricks, or cracked can increase coliform contamination. Sudiartawan [10] states that dug wells without cracks and permanent well covers are made of concrete and use a suction pump, the distance from the septic tank is >11 meters and there is no domestic waste around the well making the well less likely to be contaminated with coliform bacteria. Research conducted by Rahmawati concluded that the high number of total coliforms was caused by well construction that did not meet the requirements, especially if the dug well as close to a pollutant source [11].

Although in Mulyoharjo, some houses near the river have latrines inside their houses, the disposal is not in the septic tank but directly into the river. Many previous studies have stated that latrines that do not meet the criteria/healthy can increase the number of *E.coli* in water bodies, even though what causes bacteriological pollution is not the condition of the latrine but the sewerage system. Disposal of septic tank waste and animal waste should not be disposed of directly into rivers, because rivers are still often used as a water source in several places. Water is a vital need for humans. Many daily activities and business activities are located near springs to support these activities, but human activities and life are often felt to have negative repercussions for the environment and for other humans. Among the many microorganisms of fecal origin that cause outbreaks of water-borne diseases are *Salmonella typhi* (typhoid fever), *Shigella spp* (Shigellosis), *Salmonella paratyphi* (Salmonellosis), *Vibrio cholerae* (cholera), *Camphylobacter jejuni* (dysentery) and pathogenic *Escherechia coli* (diarrhea) [2].

In this study it can be seen that at location D, although the distance between the well and the river is 20 meters, *E.coli* contamination is still detected (12 CFU/100 ml) and at location F with the same conditions but has a septic tank, *E.coli* is also detected (1125 CFU/ 100ml). Even though it is far from the river, there are still several other factors that become contaminants. Daramusseng investigated the presence of *E.coli* in the Karang Mumus river, Samarinda City which showed *E.coli* 30-2100 CFU / 100 ml. The presence of *E.coli* in the river exceeds the quality standard of the sling quality standard for water media for Sanitary Hygiene [12]. Based on Daramusseng's observations around the location of the Mumus river, there are traditional markets, animal markets, hotels, and a high density of houses along the river which creates a lot of domestic waste. There were also latrines located at several points above the Mumus river, thereby increasing *E.coli* contamination in the river. Daramusseng said that 75 houses have latrines above the river or throw their feces directly into the river. The existence of a septic tank needs to be arranged so that it is not too close to a well or river so that it does not pollute the two water sources [12].

Yuniarno stated that the standard distance between the well and the river to limit bacteriological contamination to the soil is 11 meters [7]. Based on Yuniarno's research results, it was found that residents whose wells and rivers are too close (<11 meters) tend to increase the risk of diarrhea incidence 2.02 times higher than those who have wells far from the river (>11 meters). Although most residents use their well water for their daily needs, the condition of the well which is quite close to the river can increase river water intrusion where river water can enter the soil pores and penetrate the well, especially during the dry season when the well water level decreased [7].

Based on Permenkes number 32 of 2017 it is stated that the quality standard for the presence of *E.coli* in water media for Sanitary Hygiene is 0 CFU/100 ml, while for public bathing water is 126 CFU/100 mL for the geometric mean and statistical limits. reached 410 CFU/100 ml [1]. Of the 7 well locations, only location B met the requirements with an *E.coli* content of 0 CFU/100 ml, while the other locations still had high *E.coli*. Efforts that can be done are divided into 2, namely short-term efforts and short-term efforts long term effort. Short-term efforts can be in the form of filtering and cooking well water that is used for consumption. The Mulyoharjo sub-district government can also disseminate the use of well water for consumption. According to the Director-General of Communicable Disease Eradication and Residential Environmental Health of the Indonesian Ministry of Health, clean water is water used for daily needs whose quality meets health

requirements and can be drunk when cooked. In the long term, in stages, the Mulyoharjo village government can rebuild a commuter septic tank that is used simultaneously from several houses that do not yet have a septic tank. People who are going to build new septic tanks and wells, should consider the location of the septic tank in the surrounding area.

The results of previous studies have shown that several locations of rivers or wells in Indonesia are contaminated with coliform bacteria above the national quality standard threshold. Adrianto's research found that river waters in Lampung Province have passed the threshold (8,564-25,394 JPT/100mL) [13]. In Muara Kali Wiso, Jepara Regency, it was also reported to have been contaminated with coliform bacteria and *E.coli* above the threshold [14]. On the other hand, Ariani *et al* explained that well water near the Ciliwung river was also reported to have a high number of coliforms [15]. Khomariyatika *et al* revealed that wells 11-20 meters away had a lower number of coliform bacteria than other areas [16]. The long-distance between the river and the well is believed to be a factor in preventing the contamination of coliform bacteria from the river to the well. Coliform is a microorganism that is commonly used as an indicator of pollution. These bacteria can be a sign to determine a water source has been contaminated by pathogens. These spoilage bacteria also produce various toxins such as indole and skatole which can cause digestive tract diseases such as diarrhea if the amount is in excess in the body. Coliform bacteria can be used as an indicator because their density is directly proportional to the level of water pollution. These bacteria can detect pathogens in water such as viruses, protozoa, and parasites. In addition, these bacteria also have a higher resistance than pathogens and are easier to isolate and grow. Research in Malaysia also shows that there is coliform bacterial contamination that exceeds the threshold and there is a relationship between total coliform, (TC), fecal coliform (FC), fecal streptococcus (FS), and colifaj [17].

5. CONCLUSION

In conclusion, the river water had a higher contamination (>1800 CFU/100ml) than well water (0-1125 CFU/100ml) (p=0.000, 95%). A difference was also found between the number of *E.coli* colonies in well water between houses with septic tanks and those without septic tanks (p=0.001). The houses with no septic tanks tend to have well water with high *E.coli* compared to those who have no septic tank. It is assumed that the presence of septic tanks around the wells was too closed. In the short term, socialization regarding well water treatment for consumption needs to be done to avoid diarrhea. The Mulyoharjo local government and residents can support ODF's efforts by constructing communal septic tanks that meet the prerequisites so that there is no *E.coli* contamination in the river.

ACKNOWLEDGMENT

Thank you to Universitas Muhammadiyah Surakarta for funding this research and to Mulyoharjo village for supporting the implementation of this activity.

AUTHOR CONTRIBUTION

All authors contributed to the development of the article, research, and methodology.

REFERENCES

[1] Indonesian Health Minister. Regulation no 32 year 2017 about environmental health quality standards for water media for sanitation hygiene purposes. BN.2017/NO.864, kemkes.go.id. 2017

[2] N. J. Ashbolt. Microbial contamination of drinking water and disease outcomes in developing regions. Toxicology. Vol 198, Issues 1–3, 20 May, Pages 229-238. 2004

[3] A. M. Putri and P. Kurnia, “Identifikasi Keberadaan Bakteri Coliform Dan Total Mikroba Dalam Es Dung-Dung Di Sekitar Kampus Universitas Muhammadiyah Surakarta (Identification of Coliform Bacteria and Total Microbes in Dung-Dung Ice Around the Universitas Muhammadiyah Surakarta),” *Media Gizi Indones.*, vol. 13, no. 1, p. 41, 2018, doi: 10.20473/mgi.v13i1.41-48.

[4] D. L. Wardani and Z. Setiyaningrum, “Identifikasi Bakteri Escherichia coli pada Saus Makanan Jajanan Di Sekitar Kampus Universitas Muhammadiyah Surakarta (Identification of Escherichia coli in Snack Food Sauce Around the Universitas Muhammadiyah Surakarta),” *J. Kesehat.*, vol. 12, no. 2, pp. 91–101, 2019.

[5] T.L. Mumbi, C. Wilberforce. An assessment of open defecation among residents of Thika East Sub-County, Kiambu County, Kenya. *International Journal of Medicine Research*. Volume 2; Issue 3; May 2017; Page No. 09-20

[6] A.T.S. Lopes, G.R. Albuquerque, B.M. Maciel. Multiplex Real-Time Polymerase Chain Reaction for Simultaneous Quantification of Salmonella spp., Escherichia coli, and Staphylococcus aureus in Different Food Matrices : Advantages and Disadvantages. *Food Microbiology*. Vol September 2018

[7] S. Yuniarno, S. Sulistyani, & M. Raharjo. Hubungan Kualitas Air Sumur Dengan Kejadian Diare Di Das Solo (The Relationship between Well Water Quality and Diarrhea in the Solo River Basin). *Jurnal Kesehatan Lingkungan Indonesia*, *4*(2), 65–70. 2005

[8] H. Nazar. Kebijakan Pengendalian Pencemaran Sumber Air Bersih Perumahan Sederhana di Kota Pekanbaru (Kasus di Kecamatan Tampan) (Clean Water Source Pollution Control Policy for Simple Housing in Pekanbaru City (Case in Tampan District). *Environmental Science*, *1*(4), 63–80. 2010

[9] M.R. Sapulete. Hubungan Antara Jarak Septic Tank Ke Sumur Gali Dan Kandungan Escherichia Coli Dalam Air Sumur Gali Di Kelurahan Tuminting Kecamatan Tuminting Kota Manado (Content Of Escherichia coli in the Dug Well Water In Tuminting Village, Tuminting District, Manado City). *Jurnal Biomedik (Jbm)*, *2*(3), 179–186. 2013

[10] I. Sudiartawan, I.P.A. Bawa, & N.K. Juliasih. Uji Cemaran Coliform dan Escherichia coli pada Air Sumur Gali disekitar Tempat Pemotongan Ternak Banjar Keden Desa Ketewel Kecamatan Sukawati Kabupaten Gianyar (Coliform and *Escherichia coli* Contamination Test in Dug Well Water around the Banjar Keden Slaughterhouse, Ketewel Village, Sukawati District, Gianyar Regency). *Jurnal Widya Biologi*, *11*(01), 20–29. 2020

[11] J.O. Rahmawati & I. Nurhayati. Pengaruh Jenis Media Filtrasi Kualitas Air Sumur Gali (Effect of Types of Filtration Media on Dug Well Water Quality). *WAKTU: Jurnal Teknik. UNIPA*, *14*(2), 32–38. 2016

[12] A. Daramusseng, & S. Syamsir. Studi Kualitas Air Sungai Karang Mumus Ditinjau dari Parameter *Escherichia coli* untuk Keperluan Higiene Sanitasi (Study of water quality of Karang Mumus River in terms of Eschercia coli parameters for sanitary hygiene needs). *Jurnal Kesehatan Lingkungan Indonesia*, *20*(1), 1–6. 2021

[13] R. Adrianto, Rizki. Pemantauan Jumlah Bakteri Coliform di Perairan Sungai Provinsi Lampung (Monitoring the number of coliform bacteria in river waters in Lampung Province). *Majalah Teknologi Agro Industri*. Vol 10 no. 1 Juni. 2018

[14] W. Widyaningsih, Supriharyono. Widyorini, N. Analisis Total Bakteri Coliform di Perairan Muara Kali Wiso Jepara (Analysis of Total Coliform Bacteria in the Waters of the Wiso River Estuary, Jepara). *Diponegoro Journal of Maquares*. vol 5 no 3, pp 157-164. 2016

[15] F. Ariani, R.L. Puspitasari, T.W. Priambodo. Pencemaran Coliform Pada Air Sumur Di Sekitar Sungai Ciliwung (Coliform pollution in well water around the Cilliwung river). *Jurnal Al-Azhar Indonesia Seri Sains dan Teknologi*, Vol. 4, No. 3, Maret. 2018

[16] T. Khomariyatika, E. Pawenang, & Tunggul. Kualitas Bakteriologis Air Sumur Gali (Bacteriological Quality of Dug Well Water). *Kemas: Jurnal Kesehatan Masyarakat*, Vol. 7, No. 1, Pp. 63-72, July. Issn 2355-3596. 2011

[17] A. Hamzah, S.H. Kipli, S.R. Ismail, R. Una, S. Sarmani. Microbiological Study in Coastal Water of Port Dickson, Malaysia. *Sains Malaysiana* 40(2)(2011): 93–99. 2011