Journal Home Page:
https://e-journal.unair.ac.id/JKL

Jurnal Kesehatan Lingkungan
Journal of Environmental Health
Vol. 15 No. 1
DOI: 10.20473/jkl.v15i1.2023.46-55
ISSN: 1829 - 7285 | E-ISSN: 2040 - 881X

ORIGINAL RESEARCH Open Access

EVALUATION OF FACTORS AND BIOLOGICAL PARAMETERS OF THE GROUNDWATER IN MAKASAR SUBDISTRICT, EAST JAKARTA

Diinii Haniifah[1]*, Tri Edhi Budhi Soesilo[2], Dwi Nowo Martono[2]

[1]Graduate School of Environmental Science, Universitas Indonesia, UI Campus Salemba, Jakarta 10430, Indonesia
[2]School of Environmental Science, Universitas Indonesia, UI Campus Salemba, Jakarta 10430, Indonesia

Corresponding Author:
*) diiniihaniifah95@gmail.com

Article Info

Submitted	: 21 November 2022
In reviewed	: 29 November 2022
Accepted	: 29 December 2022
Available Online	: 31 January 2023

Keywords : *Coliform content, Drainage system, Groundwater, Septic tanks*

***Published by** Faculty of Public Health Universitas Airlangga*

Abstract

Introduction: *People prefer to use groundwater for daily needs to piped water in Indonesia. However, population growth and the construction of residential homes can hugely affect the quality of groundwater. The study aims to examine the relationship between groundwater quality and its influencing factors.* ***Methods:*** *This study was conducted with a quantitative approach and a survey method. Primary and secondary data were required in this study. The variables examined in this study were groundwater quality as seen from its biological parameters and influencing factors which consisted of internal and external factors.* ***Results and Discussion:*** *The results show that the highest coliform bacteria content was found in Cipinang Melayu at 200 MPN/100 mL concentrations in 2019 and 2020, as well as 100 MPN/100 mL in 2021, followed by Pinang Ranti. The highest coliform content was discovered in Halim Perdana Kusuma well number 3 at 50 MPN/100 mL concentration. Groundwater contains coliform because of internal influencing factors as well as external factors. Coliform content and its influence factors were both significantly correlated with a P-value < 0.05 (correlation coefficient = 0.201 for internal factors; correlation coefficient = -0.144 for external factors). The groundwater quality and internal factors were correlated with a correlation coefficient of 0.634; meanwhile, the groundwater quality was significantly correlated with external factors with a correlation coefficient of 0.656.* ***Conclusion:*** *Groundwater quality was not aligned with standards for drinking water as evaluated from the biological parameters. Both internal and external factors influence the Total coliform content.*

INTRODUCTION

As the world's population grows, the need for clean water will also continue to increase. To meet daily needs, humans greatly rely on groundwater, an essential resource to life which is expected to increase by around 1% annually over the next 30 years (1–3). In several Asian countries, including India and Thailand, the vast majority of people are dependent on groundwater for subsistence (4–5). However, continuous pumping of groundwater may reduce its quality as the aquifer layer becomes vulnerable to contaminants (6–7).

Groundwater contamination is closely related to humans' activities. High population density followed by human use of land leads to lowering the groundwater quality. Almost every human activity leads to the deliberate or accidental discharge of waste, whether chemical or organic waste which has the potential to contaminate the groundwater (8). As a result, increased human and industrial activities contribute to a decline in groundwater quality (9–12).

Water that is completely saturated and kept in aquifers beneath the surface of the earth, between the rock and the soil, is known as groundwater (13). Groundwater differs from surface water in that it is found underground and has different dynamics, thereby making it difficult to control and monitor the quality of groundwater (4). A decrease in the quality of groundwater may be caused by heavy metal contamination such as iron (Fe) and manganese (Pb), as well as pathogens such as bacteria, viruses, fungi, and protozoa (2,9). Pathogenic microorganisms are often discovered in groundwater

Cite this as :
Haniifah D, Soesilo TEB, Martono DN. Evaluation of Factors and Biological Parameters of the Groundwater in Makasar Subdistrict, East Jakarta. *Jurnal Kesehatan Lingkungan*. 2023;15(1):46–55. https://doi.org/10.20473/jkl.v15i1.2023.46-55

because they bind tightly to surface water; pathogens such as bacteria, viruses, fungi, and protozoa that originate in human or animal excrement eventually can pollute groundwater (14–15). According to a literature study conducted in India in 2018, septic tank leaks in metropolitan areas contaminated the soil; improperly designed landfills produced solid waste that decomposed leachate. Manufacturing activities could contribute to heavy metal pollution in the areas (16).

People that employ a septic tank system to handle their domestic wastewater typically live in urban regions. Septic tank systems are common wastewater treatment and often have a volume large enough to hold wastewater for several days (17). The existence of septic tanks can affect groundwater; unstandardized septic tank designs can lead to impermeability and inappropriate installation which should be considered from distance to wells and depth (18). Septic tank leaks may drain to domestic wastewater, seep into the soil, and contaminate groundwater. Additionally, improperly built and maintained drainage channels have an impact on the quality of groundwater (2).

Poor environmental sanitation leads to problems with biological parameters in water quality (6). Up to 25% of people worldwide lack access to clean water that is free of microbial contamination. In over an extended period, this condition can be harmful to children's health (1,19–21). Research in India around 2017 to 2018 revealed the use of poor-quality groundwater severely influenced human's health seen from changes in the color of people's skin and yellow cavity, specifically in children (22).

Coliform and *Escherichia coli (E. coli)* are the most basic bacteria that are used as biological indicators of water contamination (23–24). Coliform is classified into two groups, namely fecal coliform, which comes from human feces, and non-fecal coliform, which comes from the decay of plants and/or animals (25–26). Coliform contamination of groundwater wells is typically caused by the inappropriate septic tank installation and/or domestic waste source contamination. The decomposition of animal waste nearby to the wells could also have an impact on the groundwater quality.

Research conducted in developing countries such as Bangladesh and Southeast Kenya in 2012 and 2016 discovered a connection between sanitary conditions and drainage systems with microbiological contamination, particularly fecal bacteria contaminating groundwater (2,25). In addition, other studies performed in Matraman District-East Jakarta, Palmerah District-West Jakarta, and Cilegon in 2017 and 2019 to 2020 show that the amount of *E. coli* is influenced by variations in depth of excavation in the groundwater wells, distance from septic tanks to wells which does not comply with the standards, and seepage of wastewater by canals which cracks drainage (18,27–28). Residents' septic tanks must be placed at least 10 meters away from groundwater wells according to Indonesia National Standard (SNI) 03-2398-2002 (29). The minimum distance reduces waste liquid leaking from the septic tank to avoid contamination of nearby wells. Cracked and/or leaking drainage canals may cause wastewater to enter the ground, decreasing groundwater quality (28). Furthermore, the increased presence and number of animals affect the groundwater quality biologically because animals' feces and decomposition of carcass can be a source of aquifer contamination in the soil (22,27).

Green open space is a simple effort to maintain aquifers in the ground; the availability of a water catchment area is important to source water from rain, rivers, and runoff (30). One of the factors causing poor groundwater quality is change in land function into buildings and asphalt roads which distract the natural purification of aquifers in the ground. The high number of the constructions can limit rainfall penetration into the soil, preventing contaminants from being diluted (31). The Indonesian Ministry of Public Works and Public Housing regulates the requirements for public and private green open spaces in urban areas; in the Regulation No. 05/PRT/M/2008, it is stated that the proportion of green open space is at least 30% (32).

DKI Jakarta is the capital city of Indonesia with a population of more than 10 million people who use groundwater for daily needs (33). In Jakarta, piped water providers distribute water to up to 64% of its customers, leaving the remaining 36% to rely on groundwater (34). The Makasar subdistrict is one of the eastern parts of the capital city ranked fifth for having groundwater consumers in Jakarta in 2019, and its residents use 345,118 m^3 of groundwater (35). Makasar subdistrict has an area of 21.85 km^2 or around 11.62% of the East Jakarta City. For its administrative areas, Makasar subdistrict consists of five urban villages, i.e., Halim Perdana Kusuma, Pinang Ranti, Cipinang Melayu, Kebon Pala, and Makasar. Three urban villages which still use groundwater are Halim Perdana Kusuma, Pinang Ranti, and Cipinang Melayu. Most citizens in these urban villages still rely on groundwater for their daily needs. Meanwhile, the massive use of groundwater constantly increases the risk of lowering the groundwater quality.

According to data from the Jakarta Regional Sewerage Corporation, access to household wastewater management services only reached 22.43% of 22.93% in 2021 (36). In other words, 77.57% of Jakarta residents have not received proper handling of domestic wastewater. This certainly has increased the possibility of *E. coli* contamination in groundwater which comes from unmanaged fecal wast (2,23). Poor drainage and sanitation practices may be linked to biological parameters of groundwater quality, in which fecal and non-fecal bacteria influence groundwater in Makasar subdistrict.

Therefore, this study aimed to assess the biological parameters of groundwater quality and determine the correlation between the parameters of internal and external factors with the groundwater quality in Makasar subdistrict.

METHODS

This quantitative study used secondary and primary data collected using literature review and survey methods; direct groundwater samples were gathered, and questionnaires were distributed to respondents. The research was conducted from February to October 2022. The data obtained from the sampling were about groundwater quality and the biological parameters of coliform content. Meanwhile, the primary data obtained from the questionnaire were related to groundwater quality data, coliform content indicators, and influencing factors.

The population in this study was residents who lived in the urban villages of Halim Perdana Kusuma, Pinang Ranti, and Cipinang Melayu, Makasar subdistricts, East Jakarta and used groundwater for their daily needs. The research location was chosen purposively because the majority of citizens still depend on groundwater to fulfill their daily needs of clean water. Furthermore, these areas were not provided with piped water and piped sanitation systems for domestic waste needs.

Water samples that inform groundwater quality were obtained from two sources: secondary and primary data. Secondary data were informed by the Jakarta Environment Department, which annually tests groundwater quality in all areas of Jakarta. The investigated areas were chosen as recommended by the Jakarta Environment Department. Water sampling was then carried out in each urban village's office to represent groundwater quality in three different urban villages. Meanwhile, primary data on the latest groundwater quality were gathered from in the laboratory water test results. The three locations/subdistricts where water sampling was done met the inclusion criteria: (1) households that still use groundwater for their daily needs, (2) dense and not densely populated settlements, (3) groundwater that flows from upstream to downstream, (4) houses that have not used a piped water system, and (5) houses that are close to and far from green open spaces. The pump outlet was used to collect groundwater samples that flow with the support of a manual or mechanical pump. Groundwater samples were collected from the faucet used daily by the residents and placed in an impermeable sample bottle; it was put into a cooler box and delivered immediately to the laboratory for testing. In this study, groundwater quality was tested using biological parameters indicating coliform content. Coliform content is groundwater quality measured from fecal (human or animal) contamination and verified using MPN/100 mL units. All groundwater wells selected for water sampling, in particular, were between 10-50 m in depth.

Factors that can affect groundwater quality have something to do with the biological condition of groundwater; these factors include internal and external factors. The distribution of questionnaires was carried out to obtain information about the influencing factors, especially the content of Total Coliform in groundwater of each location. At the individual level, respondents for the survey were productive residents of Makassar subdistrict, family members (aged 20–60 years; preferably heads of the family), and/or wives (housewives) who live at home and use groundwater as daily clean water. Respondents were chosen using a stratified random sampling technique, and members from the population were taken randomly to each urban village. The basis for determining the number of respondents was done using the Isaac and Michael formula. A total of 277 samples participated for the survey. Survey related to internal factors consists of questions about sanitary maintenance, the distance of the septic tank from groundwater wells, and the septic tank condition itself. Based on the Indonesian National Standard 03-2398-2002 from National Standardization Agency and previous research, primary data gathered from the questionnaire became the materials to analyze pollution factors and biological parameters in groundwater resources (2,29). In addition, survey on external factors included the distance between the drainage system and the dwelling, the state of the drainage system, the distance between the residence and animal access, and the availability of green open space. The questionnaire consists of 10 questions, with a yes or no response option.

The data were analyzed statistically to determine any relationship between groundwater quality and the factors. The correlation test was used to seek the association of fluctuations of two variables to identify the strengths and directions of the correlations between these variables. The correlation analysis was processed using the Spearman's Rho Correlation Analysis. SPSS software was chosen as a statistical calculation tool to facilitate data processing in this study. Groundwater quality data from Jakarta Environment Department and laboratory test results were compared to groundwater quality standards. The quality standard is the quantity range of a substance either gas, liquid, or solid which must not exceed the specified scores, and if exceeded, it will cause some risk (37). The data of coliform content consisted of the highest and lowest coliform content across the three locations. Furthermore, water sampling was done to determine the risk value of groundwater. Groundwater quality was classified into four risk categories based on the quantity of coliform content: safe (<1 MPN/100 mL), low (1-10 MPN/100 mL), intermediate (11-100 MPN/100 mL), and high (>100 MPN/100 mL) (2).

RESULTS

Groundwater Quality Analysis

Table 1 shows the results of the groundwater quality test and biological parameters based on data from the Jakarta Environment Department over the last three years. The Jakarta Environment Department conducted groundwater quality sampling in each urban village office (see Figure 1). Table 1 shows that Total coliform-contaminated groundwater is most commonly found in Cipinang Melayu, followed by Pinang Ranti. Meanwhile, the groundwater in Halim Perdana Kusuma village has good quality.

Table 1. Quality Measurement Results for the Total Coliform Parameter for the 2019-2021 Period

	Coordinate		Total Coliform (MPN/100 mL)		
Location	**Latitude**	**Longitude**	**2019**	**2020**	**2021**
Halim Perdana Kusuma	06°16'03.5"	106°52'40.3"	0	0	0
Pinang Ranti	06°17'15.1"	106°52'52.3"	0	0	100
Cipinang Melayu	06°14'41.5"	106°53'54.7"	200	200	100

Source: (38–40)

Table 2 describes the results of groundwater quality test and biological parameters of seven examined wells in three urban villages. Figure 2 presents groundwater sampling locations. According to the laboratory test, coliform contamination was discovered in the Halim Perdana Kusuma area, followed by Cipinang Melayu. Regarding the Total Coliform content, Pinang Ranti has the lowest coliform content, and thus it is considered having good groundwater quality. Table 2. Laboratory Test Results of Groundwater Quality Measurement of Total Coliform Indicator

The Total Coliform content in safe groundwater was at 66.67% from 2019 to 2020, and 33.33% in 2021 (see Table 1). The high-risk Total Coliform content at an intermediate level in groundwater was at 33.33% in 2019 and 2020, and 66.67% in 2021. Furthermore, Table 2 shows that 57.14% of wells have safe groundwater and 42.86% of wells have intermediate-risk coliform content.

Table 2. Laboratory Test Results of Groundwater Quality Measurement of Total Coliform Indicator

Wells	Total Coliform Content (MPN/100 mL)	Regulation of Ministry Health No. 492/2010	Regulation of Ministry Health No. 32/2017
Halim Perdana Kusuma			
Wells Number 1	0		
Wells Number 2	48		
Wells Number 3	50		
Pinang Ranti			
Wells Number 4	0	0	50
Wells Number 5	0		
Cipinang Melayu			
Wells Number 6	27		
Wells Number 7	0		

Analysis of Factors Influencing Total Coliform Content

From the questionnaires answered by 277 respondents, most of them used groundwater for domestic purposes such as bathing, washing, consuming, and watering plants. Table 3 shows respondents' responses towards internal and external factors of groundwater quality.

Table 3. Questions about Total Coliform Contamination Factors

	Internal Factors	Yes (%)	No (%)
Question 1	Do you share toilet facilities with anyone other than your family members?	18.1	81.9
Question 2	The location of septic tank is in the yard	55	45
Question 3	Have you ever emptied the toilet facilities?	24	76
Question 4	Is your sanitation facility leaking or overflowing all year?	12	88
Question 5	The sanitation facility at my house is > 10 m from my household's groundwater well.	80.5	19.5
Question 6	My neighbor's sanitation facility is > 10 m from my household's groundwater well.	78	22
	External Factors	**Yes (%)**	**No (%)**
Question 1	There is animal access (animal cage) within 10 meters of my home's groundwater wells.	22.4	77.6
Question 2	There are open water sources (e.g., rivers, reservoirs, lakes, etc.) within 20 m of your home's groundwater well.	20.9	79.1
Question 3	The drainage system around the residence is in good condition (not damaged).	91.3	8.7
Question 4	The house that I live in has 30% green open space.	32.1	67.9

Source: Modified by (2)

Correlation Analysis of Factors Influencing Total Coliform Content and Concentration

According to the results of SPSS tools and Spearman's Rho correlation analysis, internal and external factors were assessed using the Gutmann scale by giving a value of 1 for a positive statement and a value of 0 for a negative statement. Each individual sub-factor was assessed and combined into a composite variable by giving a value of 1 for good results and 2 for poor results. The results of the composite variable assessment are correlated with groundwater quality measured by the Jakarta Environment Department and according to laboratory test results. In this study, internal factors were investigated through questions number 1–6, and so were external factors investigated through number 7–10 (see Table 3). Table 4 presents the relationship analysis between Total Coliform concentrations obtained from the Jakarta Environment Department and laboratory tests of groundwater quality along with respondents' responses to the questionnaires. Results show that Total Coliform concentration and influencing factors were correlated with a significance value of < 0.05.

Table 4. Correlations between Total Coliform Parameter and Causative Factors

	Internal Factors	External Factors
Total Coliform (2021)*		
Correlation Coefficient	0.201	-0.144
Determination Coefficient (r^2)	0.04	0.021
Sig (2-tailed)	0.001	0.016
Total Coliform**		
Correlation Coefficient	0.634	0.656
Determination Coefficient (r^2)	0.402	0.43
Sig (2-tailed)	0.002	0.001

* *Total Coliform concentration from Jakarta Environment Department*
** *Total Coliform concentration from laboratory test results*

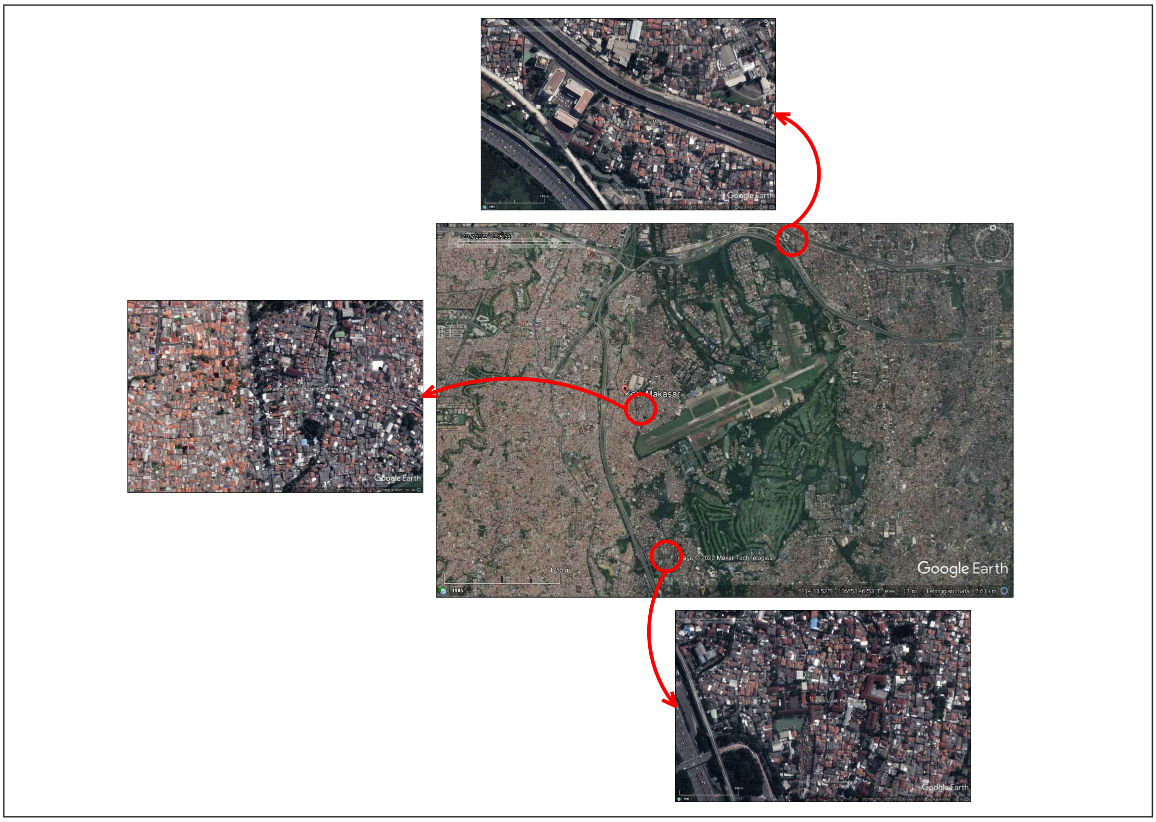

Figure 1. Groundwater Sampling Locations in Urban Villages Office

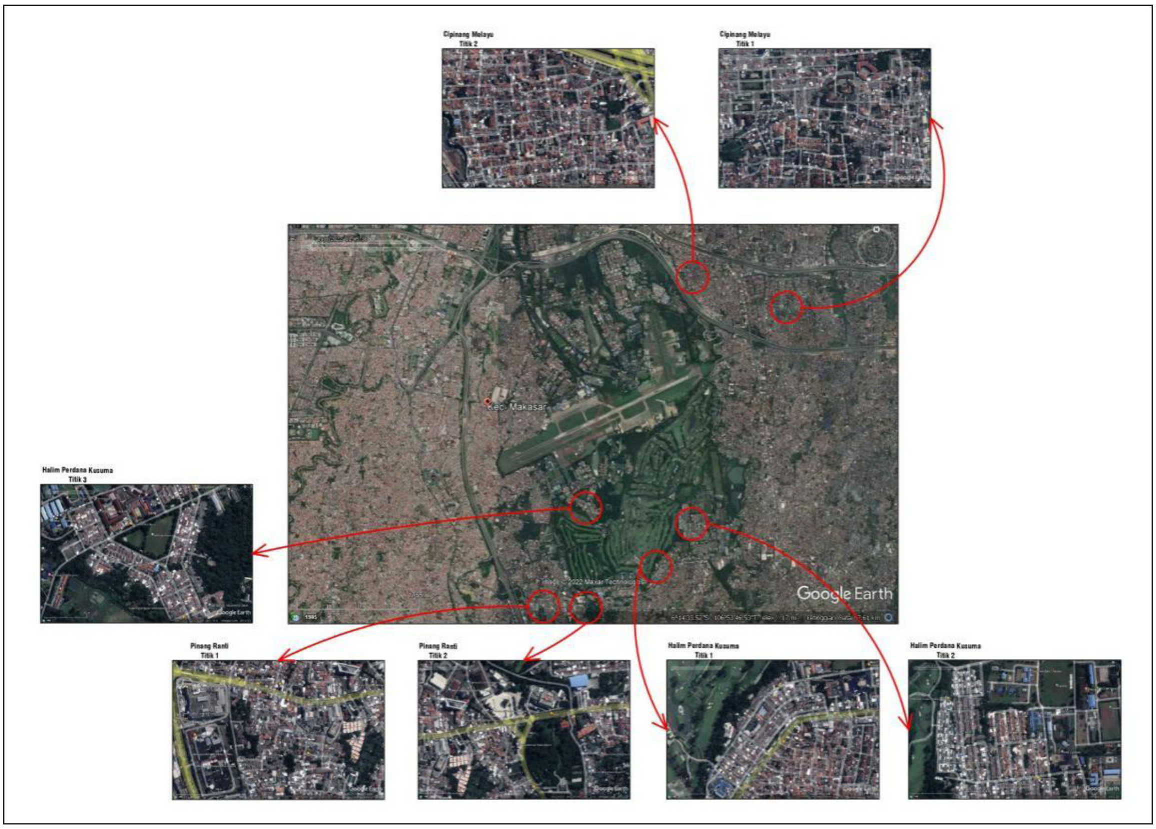

Figure 2. Groundwater Sampling in Seven Wells

DISCUSSION

Groundwater Quality According to Total Coliform Parameters

Data analysis shows the Cipinang Melayu area had the highest coliform concentration from 2019 to 2021. As compared to the drinking water quality standards stated by the Indonesian Minister of Health No. 492 of 2010, Pinang Ranti and Cipinang Melayu areas did not meet the standards in 2021. Meanwhile, Halim Perdana Kusuma fulfilled the drinking water quality standards according to the biological parameter, which was set at 0 MPN/100 mL from 2019 to 2021; a similar result was found by Pinang Ranti that met the quality standard in 2019 and 2020 (41).

The laboratory test results of groundwater quality mention that the overall groundwater quality in the Makasar subdistrict area has been maintained to follow safe water standards for hygiene purposes. The subdistrict has strived to meet the biological parameter, which is less than 50 MPN/100 mL, as determined by the Regulation of the Indonesian Ministry of Health No. 32/2017 (37). For drinking water purposes, however, the groundwater at several locations, including wells number 2 and 3 in Halim Perdana Kusuma village and well number 1 in Cipinang Melayu, was unacceptable since these wells had a poor biological parameter.

The largest coliform contamination in groundwater was found around rivers and lakes according to the water sample analysis (see Figure 1). Additionally, the three urban villages chosen were the heart of residentials with a high density of people, causing the contaminants to grow more. Meanwhile, groundwater sample testing carried out directly in the laboratory (see Figure 2) results in similar information that residential areas which are far from green open spaces tend to have higher coliform content. Green open space helps reduce coliform content even though the groundwater sources are close to a densely populated settlement.

Furthermore, the Jakarta Environment Department explains that groundwater was in the safe category (0 MPN/100 mL) from 2019 to 2021 in Halim Perdana Kusuma village and Pinang Ranti village. However, an intermediate risk was found in 2021 (100 MPN/100 mL) in Pinang Ranti village and Cipinang Melayu village. High-risk groundwater quality was found in Cipinang Melayu in 2019 and 2020 (200 MPN/100 mL), and then it decreased to intermediate-risk quality in 2021 (100 MPN/100 mL).

Indicated safe-risk groundwater quality (0 MPN/100 mL) was found in well 1 in Halim Perdana Kusuma village, wells 1 and 2 in Pinang Ranti, and well 2 in Cipinang Melayu. Meanwhile, wells number 2 and 3 in Halim Perdana Kusuma (48 MPN/100 mL and 50 MPN/100 mL, respectively), together with well number 1 in Cipinang Melayu (27 MPN/100 mL) had intermediate-risk groundwater quality according to the total amount of coliform detected.

Factors Influencing Total Coliform Content in Groundwater

Internal factors are internal conditions that can influence the Total Coliform content in groundwater. The p-value of internal factors that describes sanitary conditions was less than 0.05, with a correlation coefficient of 0.201 according to Jakarta Environment Department and 0.634 according to laboratory test results. Internal factors such as distance to septic tank, as well as septic tank maintenance, location, and condition have significant impacts on the number of Total Coliform content in groundwater by 4% to 40.2%. Total Coliform content will have a concentration that meets quality standards if the internal conditions are properly managed. However, if the internal conditions are poor, Total Coliform concentrations will increase.

According to the Indonesian National Standards 03-2398-2002, septic tanks in residential areas must be located at least 10 meters away from groundwater wells. Ensuring the installation of septic tank, residents can avoid septic tank leaks. According to research from 2012 to 2020 in Kenya, Bangladesh, Matraman District-East Jakarta, Palmerah District-West Jakarta, and Cilegon, contamination by feces could play a role in decreasing the quality of groundwater (2,18,25,27–28). Based on the findings of this study, as many as 80.5% of residents thought that their septic tank was more than 10 meters away from their groundwater wells, and 78% of residents had groundwater wells that were more than 10 meters away from nearby septic tanks.

In addition to the distance between the well and the septic tank, maintaining residential sanitation system must be of concerns. For example, clearing the sanitation system should be carried out every year to prevent overflow and leakage of waste in the septic tank and water pollution to the surrounding environment. The questionnaire results show that only 24% of respondents had ever drained a septic tank. As many as 76% of residents never emptied their septic tank to maintain sanitation system and prevent contaminant pollution.

Besides internal factors, external factors that can influence the Total Coliform content in groundwater come from outside the residents' homes. The results of external factor test show that groundwater quality was correlated with external factors with a correlation coefficient of -0.144 according to Jakarta Environment Department and 0.656 according to laboratory test results. It means that external factors variable, such as drainage maintenance, distance to animal access and drainage, and the presence of green open spaces, had a significant influence on groundwater quality, with 2.1% and 43%, respectively. External factors had an inverse relationship with groundwater quality indicated by a negative correlation value. Various sampling locations contribute to different correlation coefficient directions.

Other external factors must be carefully considered to prevent a decrease in groundwater quality. Drainage systems around residentials can affect groundwater quality as they might carry pollutants such as bacteria (28). Inappropriate drainage canals, which may be fractured and/or leaky, provide a significant risk of lowering groundwater quality. Furthermore, distance to groundwater wells might contribute to water pollution from drainage channels. As many as 20.9% of the residents reported that they built a well that was 20 meters away from the drainage, while 91.3% said that the drainage system in their houses was in a good shape (no leaks). Decreasing groundwater quality was biologically able to be detected by identifying the Total Coliform content in groundwater.

In general, aquifers may recharge water that has been extracted and utilized for human needs from rain, rivers, lakes, and streams that seep down through the soil and rock. This process is called natural recharge (13). The natural recharge process will get distracted if the land is mostly surrounded by buildings, houses and paved roads, causing water not to penetrate in the ground. As a result, adequate access to green open space in the residential areas is required to restore groundwater. This current study shows that only 32.1% of residents lived in areas with at least 30% of green open spaces. It implies that the difficulty restoring water free from pollutants is commonly found among the residentials. About 67.9% of respondents did not have a residence with a sufficient green open space.

The decomposition of animal waste around the wells might also lower groundwater quality as coliform may spread out. Within 10 meters of their groundwater wells, 22.4% of homeowners claimed to have access to animals or animal cages. Therefore, animals' feces or carcass may result in the degradation of groundwater quality. According to the statements, well 2 which distance is around 10 m from the animal cages around Halim Perdana Kusuma village has the potential to contaminate groundwater biologically. Animal decomposition and feces may decrease the groundwater quality (22). This current study assessed the influencing factors of the Total Coliform content in groundwater from two sides: within and outside the residential areas. However, this study did not conduct investigations on whether influencing factors of groundwater quality impact respondents' health. Location samples might also affect the results of groundwater correlation test according to Jakarta Environment Department and laboratory test results. Therefore, further studies need to research on this matter as well.

ACKNOWLEDGMENTS

The authors would like to thank the respondents who participated in this study voluntarily.

CONCLUSION

Groundwater quality in the three examined urban villages did not meet drinking water or clean water standards. Groundwater has various risk categories, from low risk to high risk. The difference in risk categories depends on locations of water sampling. Internal factors and external factors may decrease groundwater quality. The condition and distance of the septic tank from the resident's wells were internal factors that might increase Total Coliform content in groundwater. External factors include the surroundings of the house, such as the condition and distance of drainage channels, the distance from wells to animal access, and the availability of green open space are correlated with Total Coliform content. In addition to groundwater samples, future studies can consider to research Nitrate parameters in groundwater compared with Total Coliform from domestic waste or septic tanks.

REFERENCES

1. Bodrud-Doza M, Islam SMDU, Rume T, Quraishi SB, Rahman MS, Bhuiyan MAH. Groundwater Quality and Human Health Risk Assessment for Safe and Sustainable Water Supply of Dhaka City Dwellers in Bangladesh. *Groundw Sustain Dev*. 2020;10(100374):1-12. https://doi.org/10.1016/j.gsd.2020.100374
2. Ferrer N, Folch A, Masó G, Sanchez S, Sanchez-Vila X. What are the Main Factors Influencing the Presence of Faecal Bacteria Pollution in Groundwater Systems in Developing Countries?. *J Contam Hydrol*. 2020;228(103556):1-11. https://doi.org/10.1016/j.jconhyd.2019.103556
3. United Nations Water. The United Nations World Water Development Report 2022: GROUNDWATER Making the Invisible Visible. Paris: United Nations Educational, Scientific and Cultural Organization; 2022.
4. Meinzen-Dick R, Janssen MA, Kandikuppa S, Chaturvedi R, Rao K, Theis S. Playing Games to Save Water: Collective Action Games for Groundwater Management in Andhra Pradesh, India. *World Dev*. 2018;107(1):40–53. https://doi.org/10.1016/j.worlddev.2018.02.006
5. Piyapong J, Thidarat B, Jaruwan C, Siriphan N, Passanan A. Enhancing Citizens' Sense of Personal Responsibility and Risk Perception for Promoting Public Participation in Sustainable Groundwater Resource Management in Rayong Groundwater Basin, Thailand. *Groundw Sustain Dev*.2019;9(100252):1-12.https://doi.org/10.1016/j.gsd.2019.100252
6. Chatterjee R, Chowdhury M. Impact of Excessive Pumping on Groundwater Quality: the Arsenic Problem of the Ganges-Meghna-Brahmaputra Delta in Southeast Asia. *Journal of Environmental Science and Sustainable Development*. 2020;3(2):371–401. https://doi.org/10.7454/jessd.v3i2.1052
7. Ha K, Lee E, An H, Kim S, Park C, Kim GB, et al. Evaluation of Seasonal Groundwater Quality Changes Associated with Groundwater Pumping and Level Fluctuations in an Agricultural Area, Korea. *Water (Switzerland)*. 2021;13(1):51. https://doi.org/10.3390/w13010051
8. Talabi AO, Kayode TJ. Groundwater Pollution and Remediation. *J Water Resour Prot.* 2019;11(01):1–19. https://doi.org/10.4236/jwarp.2019.111001
9. Arslan B, Akün E. Management, Contamination and Quality Evaluation of Groundwater in North Cyprus. *Agric Water Manag*. 2019;222(1):1–11. https://doi.org/10.1016/j.agwat.2019.05.023
10. Khan R, Indhulekha K, Mawale YK, Dewangan R, Shekhar S, Dwivedi CS, et al. Impact of Anthropogenic Activities on Groundwater Quality and Quantity in Raipur City, Chhattisgarh, India. *In: IOP Conference Series: Earth and Environmental Science*. 2020;597(012006):1-10. https://doi.org/10.1088/1755-1315/597/1/012006
11. Luque-Espinar JA, Chica-Olmo M. Impacts of Anthropogenic Activities on Groundwater Quality in a Detritic Aquifer in SE Spain. *Expo Health*. 2020;12(4):681–698. https://doi.org/10.1007/s12403-019-00327-7
12. Akhtar N, Syakir I, Bhawani S, Umar K. Various Natural and Anthropogenic Factors Responsible for Water Quality Degradation: A Review. *Water (Switzerland*). MDPI; 2021;13(19):2660. https://www.mdpi.com/2073-4441/13/19/2660#
13. Miller GT, Spoolman SE. Environmental Science Fifteenth Edition. New York: Cengage Learning; 2016.
14. Wu G, Yang J, Jiang H, Deng Y, Lear G. Distribution of Potentially Pathogenic Bacteria in the Groundwater of the Jianghan Plain, Central China. *Int Biodeterior Biodegradation*. 2019;143(104711):1-8. https://doi.org/10.1016/j.ibiod.2019.05.028
15. Baia CC, Vargas TF, Ribeiro VA, Laureano J de J, Boyer R, Dórea CC, et al. Microbiological Contamination of Urban Groundwater in the Brazilian Western Amazon. *Water (Switzerland)*. 2022;14(24):4023. https://doi.org/10.3390/w14244023
16. Ravish S, Setia B, Deswal S. Groundwater Quality in Urban and Rural Areas of North-eastern Haryana (India): a Review. *ISH Journal of Hydraulic Engineering*. 2018;27(2):224–234. https://doi.org/10.1080/09715010.2018.1531070

17. Adegoke AA, Stenstrom TA. Septic Systems. In: Water and Sanitation for the 21st Century: Health and Microbiological Aspects of Excreta and Wastewater Management (Global Water Pathogen Project). Michigan: United Nations Educational, Scientific and Cultural Organization; 2019. 1-15.
18. Anisah U, Iswanto B, Rinanti A. Distribution Patterns Study of Escherichia coli as an Indicator for Ground water Quality at Matraman District, East Jakarta. *In: IOP Conference Series: Earth and Environmental Science.* 2018;106(012080):1-7. https://doi.org/10.1088/1755-1315/106/1/012080
19. Nowicki S, Lapworth DJ, Ward JST, Thomson P, Charles K. Tryptophan-like Fluorescence as a Measure of Microbial Contamination Risk in Groundwater. *Science of the Total Environment*. 2019;646(1):782–791. https://doi.org/10.1016/j.scitotenv.2018.07.274
20. Mahagamage MGYL, Manage PS, Manage PM. Water Quality and Microbial Contamination Status of Groundwater in Jaffna Peninsula, Sri Lanka. *Journal of Water and Land Development.* 2019;40(1):3–12. https://doi.org/10.2478/jwld-2019-0001
21. Shaharoona B, Al-Ismaily S, Al-Mayahi A, Al-Harrasi N, Al-Kindi R, Al-Sulaimi A, et al. The Role of Urbanization in Soil and Groundwater Contamination by Heavy Metals and Pathogenic Bacteria: A Case Study from Oman. *Heliyon*. 2019;5(5):e01771. https://doi.org/10.1016/j.heliyon.2019.e01771
22. Singh AK, Das S, Singh S, Pradhan N, Gajamer VR, Kumar S, et al. Physicochemical Parameters and Alarming Coliform Count of the Portable Water of Eastern Himalayan State Sikkim: An Indication of Severe Fecal Contamination and Immediate Health Risk. *Front Cell Dev Biol*. 2019;7(174):1-17. https://doi.org/10.3389/fpubh.2019.00174
23. Chuah CJ, Ziegler AD. Temporal Variability of Faecal Contamination from On-Site Sanitation Systems in the Groundwater of Northern Thailand. *Environ Manage*. 2018;61(6):939–953. https://doi.org/10.1007/s00267-018-1016-7
24. Odiyo JO, Makungo R. Chemical and Microbial Quality of Groundwater in Siloam Village, Implications to Human Health and Sources of Contamination. *Int J Environ Res Public Health*. 2018;15(2):317. https://doi.org/10.3390/ijerph15020317
25. Ercumen A, Naser AM, Arnold BF, Unicomb L, Colford JM, Luby SP. Can Sanitary Inspection Surveys Predict Risk of Microbiological Contamination of Groundwater Sources? Evidence from Shallow Tube Wells in Rural Bangladesh. *American Journal of Tropical Medicine and Hygiene*. 2017;96(3):561–568. http://ajtmh.org/cgi/doi/10.4269/ajtmh.16-0489
26. Rodrigues C, Cunha MÂ. Assessment of the microbiological quality of recreational waters: indicators and methods. *Euro-Mediterr J Environ Integr*. 2017;2(25):1-18. https://doi.org/10.1007/s41207-017-0035-8
27. Dayanti MP, Fachrul MF, Wijayanti A. *Escherichia coli* as Bioindicator of the Groundwater Quality in Palmerah District, West Jakarta, Indonesia. *IOP Conference Series: Earth and Environmental Science*. 2018;106(012081):1-7. https://doi.org/10.1088/1755-1315/106/1/012081
28. Agustina TF, Hendrawan DI, Purwaningrum P. Analysis of Groundwater Quality around Bagendung Landfill, Cilegon. *Jurnal Bhuwana*. 2021;1(1):29–43. http://dx.doi.org/10.25105/bhuwana.v1i1.9274
29. National Standardization Agency. SNI 03-2398-2002 about Procedures for Planning a Septic Tank with a Infiltration Wells. Jakarta: National Standardization Agency; 2002.
30. Verma N, Anda M, Wijayanti Y. Artificial Recharge for Sustainable Groundwater Management Plan in Yogyakarta. *Indonesia Journal of Urban and Environmental Technology*. 2019;2(2):120–133. http://dx.doi.org/10.25105/urbanenvirotech.v2i2.4364
31. Siswantining T, Sutjiningsih D, Fitria F. Escherichia coli Model as Ground Water Quality Indicator in Urban Area by Using Multivariate Regression (Case Study in East Jakarta Indonesia). *AIP Conference Proceedings*. 2014;1(020139):1-10. https://doi.org/10.1063/1.5054543
32. Ministry of Public Works of Republic Indonesia. Regulation of Ministry Public Works No. 05/PRT/M/2008 about Guidelines for Provision and Utilization of Green Open Space in Urban Areas. Jakarta: Ministry of Public Works of Republic Indonesia; 2008.
33. Luo P, Kang S, Apip, Zhou M, Lyu J, Aisyah S, et al. Water Quality Trend Assessment in Jakarta: A Rapidly Growing Asian Megacity. *PLoS One*. 2019;14(7):e0219009. https://doi.org/10.1371/journal.pone.0219009
34. Taftazani R, Kazama S, Takizawa S. Spatial Analysis of Groundwater Abstraction and Land Subsidence for Planning the Piped Water Supply in Jakarta, Indonesia. *Water (Switzerland)*. 2022;14(20):3197. https://doi.org/10.3390/w14203197
35. Central Beureu of Statistics Indonesia. Groundwater Utilization in DKI Jakarta Increases in 2019. Jakarta: Central Beureu of Statistics Indonesia; 2019. https://statistik.jakarta.go.id/penggunaan-air-tanah-di-dki-jakarta-meningkat-di-tahun-2019/
36. Jakarta Regional Sewerage Corporation. Perumda Pal Jaya, Expert in Managing Jakarta Residents' Waste. Jakarta: Jakarta Regional Sewerage Corporation; 2022. https://paljaya.com/perumda-paljaya-piawai-mengelola-limbah-warga-jakarta/
37. Ministry of Health of Republic Indonesia. Regulation of Ministry of Health of Republic Indonesia No. 32/MENKES/2017 about Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene, Swimming Pool, Solus per Aqua, and Public Bath. Jakarta: Ministry of Health of Republic Indonesia; 2017.

38. Jakarta Environment Department. Document of an Information on Environmental Management Performance for DKI Jakarta Province in 2020. Jakarta: Jakarta Environment Department; 2020.
39. Jakarta Environment Department. Document of an Information on Environmental Management Performance for DKI Jakarta Province in 2021. Jakarta: Jakarta Environment Department; 2021.
40. Jakarta Environment Department. Document of an Information on Environmental Management Performance for DKI Jakarta Province in 2022. Jakarta: Jakarta Environment Department; 2022.
41. Ministry of Health of Republic Indonesia. Regulation of Ministry of Health of Republic Indonesia No. 492/ MENKES/2010 about Quality of Drinking Water. Jakarta: Ministry of Health of Republic Indonesia; 2010.