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Microbiological analysis of well water quality in Gempol Village-Klaten Regency, Indonesia

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Abstract

Background: Water quality refers to the condition of water assessed based on certain parameters as defined by drinking water and sanitation regulations. Poor water quality can impact human health, leading to issues such as recurring diarrhea and a loss of essential nutrients like zinc. In Gempol Village, where most residents rely on wells for their daily water needs, good environmental sanitation is essential for public health, as it can reduce health risks such as worm infections and malnutrition, especially in children.
Purpose: To assess well water quality in Gempol Village, Karanganom District, Klaten Regency by testing for microbial contamination.
Method: Employing a descriptive design with a qualitative approach, the study was conducted in February 2024 in Gempol Village, located in Karanganom Subdistrict, Klaten Regency. It focused on 12 wells within the village as its population. A 100 ml water sample was obtained from each well using sterile bottles through purposive sampling. Data collection involved using an observation sheet to measure the distance between wells and septic tanks, document the family members' health history, and determine the wells' role as a drinking water source. Microbiological analysis was performed to assess *E. coli* contamination and total Coliform levels. According to bacteriological standards, acceptable *E. coli* levels in water are 0/100 ml, while total Coliform levels should remain below 50/100 ml.
Results: Only four sources of clean water were not contaminated with *E. coli* and another five water source exceeded the permissible level. The construction of the well and its distance from the source of pollution have a significant effect on the number of Coliform bacteria in the tested water samples.
Conclusion: The microbiological quality of well water in Gempol Village shows that only three water points meet the safety threshold as outlined in the Indonesian Ministry of Health Regulation 32/2017. The design of septic tank construction and the distance between wells and pollution sources affect the total bacterial contamination in well water.

Keywords: Coliform; E. Coli; Well Water.

INTRODUCTION

Water is a limited natural resource essential for the survival of all life. Although scarce, water sources can be identified through hydrological cycle indicators using physical and chemical parameters (Gultom, Rahman, & Heriansyah, 2021). In Indonesia, 72.04% of households have access to safe drinking water sources, (Central Bureau of Statistics Indonesia), 2017). This means that 27.96% of the population still lacks access to clean drinking water. Poor environmental sanitation, including inadequate wastewater treatment and disposal systems, contributes to high infant mortality rates from diarrheal diseases and the spread of disease-carrying vectors. Addressing environmental

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health issues requires a multi-faceted approach, impacting various aspects of life. Integrated water, sanitation, and waste management efforts are crucial for controlling diseases like dengue fever and diarrhea. Specific water management interventions should focus on enhancing water quality and infrastructure (Overgaard, Dada, Lenhart, Stenström, & Alexander, 2021).

By 2017, 67.89% of Indonesian households had access to adequate sanitation. In 2008, the Ministry of Health and other ministries launched the community-based total sanitation initiative, which includes five pillars: stopping open defecation, hand-washing with soap, managing drinking water and food, waste management, and liquid waste management. (Ministry of Health of the Republic of Indonesia, 2020). Indonesia has increased access to adequate drinking water from 82.14% in 2011 to 87.75% in 2018 (Ministry of National Development Planning, 2019).

Water quality is determined by testing specific parameters, ensuring it is suitable for use as drinking and sanitation water (Rosyidah & Mayasari, 2018). Drinking water must meet microbiological, physical, chemical, and radioactive standards to be safe for consumption as stipulated by Indonesian Health Regulation No. 492/MENKES/PER/IV/2010, which requires that drinking water be free of pathogens and harmful chemicals (Tanjung, Rinaldi, & Siregar, 2022).

Clean water and sanitation are basic needs and key of Sustainable Development Goals (SDGs), aiming by 2030 for universal and equitable access to safe, affordable drinking water, ending open defecation, and improving water quality by reducing pollution and managing resources effectively (Indarti, 2021). These targets align with SDG Goal 6, covering access to safe water (6.1), adequate sanitation (6.2), and water quality improvement (6.3) (Suryani, Maretalinia, Suyitno, Juliansyah, Damayanti, Yulianto, & Oktina, 2020). As of 2017, 72.04% of Indonesian households have access to clean drinking water (Central Bureau of Statistics (Indonesia), 2017).

Community support is vital for enhancing clean water and sanitation management. Consuming contaminated water is linked to stunting, due to microorganisms like pathogens and *E. coli* bacteria. Ingesting dirty water disrupts bodily functions, leading to repeated diarrhea, loss of fluids, and critical micronutrients in children. A lack of zinc in the intestines can further impair body function, leading to recurring diarrhea and vulnerability to infections like worms, resulting in malnutrition and growth delays in children (Hartati & Zulminiati, 2020).

The community-based total sanitation program addresses nutritional diseases and environmental sanitation issues by implementing five pillars: addressing open defecation, promoting handwashing with soap and running water, managing drinking water and household food, household waste management, and household liquid waste management (Lopa, Darmawansyih, & Helvian, 2022). Proper environmental sanitation is essential for supporting public health, as it significantly impacts community health levels. Poor environmental sanitation can reduce the quality of life and lead to various health issues (Ernawati, 2020).

Good environmental sanitation acts as a protective factor against stunting, meaning it can help prevent it. Key sanitation facilities include clean water sources, latrines, and wastewater disposal systems (Aisah, Ngaisyah, & Rahmuniyati, 2019). Studies show a link between environmental risk factors, such as access to sanitary latrines and handwashing with soap and running water, and health outcomes (Novianti & Padmawati, 2020). Additionally, the physical conditions of homes, such as flooring and walls, also impact stunting prevalence. Environmental sanitation, along with a history of infectious diseases, has been associated with stunting (Wulandari & Rahayu, 2019).

RESEARCH METHOD

A descriptive research project employing a qualitative approach. It involved assessing environmental sanitation conditions and water quality among residents of Gempol Village, along with conducting interviews with some community members. The analysis focused on detecting *E. coli* and total coliform bacteria in water samples from wells and springs. The research took place in February 2024 in Gempol Village, Karanganom District, Klaten Regency, with the population comprising all well water sources in the village. Samples were collected in 100 ml volumes using sterile bottles, selected purposively from 12 water sources. Additionally, researchers used an

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observation sheet to document the distance between wells and septic tanks, family health histories, and sources of drinking water.

Microbiological testing was conducted at the Faculty of Health Sciences laboratory, Muhammadiyah University of Surakarta, to detect microbial contamination of *E. coli* and coliform bacteria. Descriptive analysis techniques were used to assess *E. coli* and total coliform levels in the well water samples. According to bacteriological standards, acceptable water quality requires *E. coli* at 0/100 ml and total coliform levels below 50/100 ml (Ministry of Health of the Republic of Indonesia, 2017).

RESEARCH RESULTS

Table 1. Total Bacterial Counts of *Escherichia Coli* and *Coliform* in the Well Water Sample

Sample	*Escherichia Coli* (CFU/100ml)		*Coliform* (MPN/100ml)		Distance to Septic Tank
1	19	Above guideline value	11	Within guideline value	11 meter
2	0	Within guideline value	1	Within guideline value	7 meter
3	0	Within guideline value	31	Within guideline value	10 meter
4	1	Above guideline value	35	Within guideline value	15 meter
5	90	Above guideline value	234	Above guideline value	15 meter
6	0	Within guideline value	3	Within guideline value	7 meter
7	1	Above guideline value	6	Within guideline value	10 meter
8	3	Above guideline value	29	Within guideline value	4 meter
9	7	Above guideline value	52	Above guideline value	5 meter
10	31	Above guideline value	336	Above guideline value	20 meter
11	0	Within guideline value	371	Above guideline value	20 meter
12	5	Above guideline value	272	Above guideline value	7 meter

Based on Table 1, the water quality test results show that well water samples numbered 2, 3, 6, and 11 are free from *E. coli* bacteria. In contrast, well water samples numbered 1, 4, 5, 7, 8, 9, 10, and 12 exceed the established *E. coli* standard.

The well water sample numbered 2 has the lowest coliform count at 1 MPN/100 ml. Meanwhile, the sample from well number 11 shows the highest total coliform level, measuring 371 MPN/100 ml.

DISCUSSION

Several factors impact environmental sanitation, including the availability of family latrines and wastewater management facilities (Nanda, Anasti, Andini, Ramadhani, Ayuanda, & Tanjung, 2023). This study examines the microbiological quality of well water, identifying key elements influencing sanitation and water quality comprehensively. Primary considerations include well conditions, variations in physical water quality, the proximity of septic tanks, and their relationship with nearby buildings, providing detailed insights into water-related challenges in the region.

Table 1 illustrates differences in *E. coli* and Coliform bacteria levels across various samples. Samples 1, 5, 8, 9, and 10 exhibited significant contamination, pointing to potential microbial pollution in the well water. In contrast, Wells 2, 3, 6, and 11 showed no *E. coli* presence and low Coliform levels, indicating better water quality. However, Samples 3, 4, 7, 9, and 12 displayed variations in results that warrant further investigation. These fluctuations could be influenced by seasonal changes, weather patterns, or human activities near the wells. Further analysis is required to identify contributing factors and explore potential correlations between environmental conditions and test outcomes.

The findings highlight the complex interplay of environmental factors affecting sanitation and water quality in Gempol Village. These include well construction, water quality variations, septic tank distances, and surrounding building conditions, all of which are examined in detail. Proper environmental sanitation practices, such as healthy latrines, waste

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disposal systems, and wastewater management, play a crucial role in maintaining well water quality. Poor sanitation can serve as a potential source of water pollution (Bangun & Nababan, 2020).

All tested wells were constructed as permanent structures, ensuring consistent usage and reliable data collection. The distance between wells and septic tanks varied between 4 and 20 meters, and these variations likely influenced the quality of the water. Differences in septic tank placement and surrounding conditions further underscore the importance of optimizing sanitation infrastructure to protect water sources.

The physical state of buildings surrounding wells can significantly affect water quality. For instance, wells located closer to septic tanks are more prone to bacterial contamination (Keman, 2022). This connection could be explored further through qualitative research, such as in-depth interviews. The impact of well conditions is evident in the high levels of *E. coli* and Coliform bacteria detected in Wells 1, 5, 8, and 10 before testing. The presence of permanent buildings near these wells appears to be a major factor contributing to decreased water quality.

Septic tank distance is another crucial factor. For example, Well 4, with a 15-meter distance, showed higher bacterial levels before testing, while Well 8, with a 4-meter distance, demonstrated improved results after testing, emphasizing the importance of maintaining proper spacing to ensure good water quality.

Physical water parameters, such as taste, smell, temperature, and color, also varied significantly among wells (Djana, 2023). These variations may result from environmental influences like nearby trash, proximity to septic systems, or human activities around the wells.

Microbiological testing for *E. coli* provides a clear indication of water contamination by pathogenic bacteria. High *E. coli* levels before testing suggest the presence of contaminant sources related to poor environmental sanitation (Rendrahadi, 2021). Test results exceeding water health standards for *E. coli* and Coliform bacteria pose potential health risks to consumers, making it essential to understand the implications and implement corrective or preventive measures promptly. Differences in water quality among wells directly impact the health of communities dependent on these sources. Poor sanitation practices and contaminated water can increase the prevalence of waterborne diseases (Azizah, 2022).

The physical condition of wells strongly influences the microbiological quality of water in Gempol Village. Better-maintained wells, including their floors, walls, and covers, generally exhibit lower bacteriological contamination. Conversely, poorly maintained wells are more likely to show higher contamination levels (Maulana & Porusia, 2021). Attention to well infrastructure is critical to improving water quality and ensuring public health.

Wells located near septic tanks exhibit the highest levels of Coliform bacteria contamination, particularly in areas with livestock pens nearby. In such cases, the pollutant source is approximately 7 meters from the water source. The surrounding environment often includes dense populations, obstructed drainage channels due to waste, and poorly functioning or outdated toilet facilities, all of which exacerbate contamination risks. The presence of *E. coli* in Gempol Village likely stems from the proximity of septic tanks to well structures.

In Mulyoharjo, homes lacking septic tanks and disposing of waste directly into the river show lower levels of *E. coli* contamination in their well water compared to homes equipped with septic tanks (Porusia, Asyfiradayati, Putri, & Dwinanda, 2022). However, river water in Mulyoharjo exhibits high levels of *E. coli* contamination. The close proximity of septic tanks to wells further increases the likelihood of water pollution. Proper placement of septic tanks, ensuring adequate distance from wells and rivers, is essential to prevent contamination of these water sources (Daramusseng & Syamsir, 2021). Tube wells with intact concrete covers, no cracks, and located more than 11 meters from septic tanks, combined with the absence of domestic waste nearby, have a significantly lower risk of Coliform bacteria contamination (Sudiartawan, Bawa, & Juliasih, 2020).

Geological and geographical factors, as well as construction limitations of landfills and wells, can also influence water quality. If a water source is close to a major pollution source and lacks effective water pollution control measures, bacteria can infiltrate the water horizontally and vertically via groundwater, urine, or rainwater. The extent of bacterial movement

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depends on factors such as soil porosity (Bambang, 2014).

These findings highlight the importance of regular monitoring and maintenance of wells. Early detection of potential water quality issues through routine checks allows timely implementation of corrective or preventive actions. The microbiological quality assessment of Wells 3, 4, 7, 9, and 12 reveals variations that require further attention. Analyzing environmental factors, such as septic tank distance and nearby permanent structures, provides deeper insight into the sanitation conditions in Gempol Village.

For wells exceeding acceptable contamination levels, corrective actions are necessary. These measures may include well cleaning, contamination protection, or upgrading monitoring systems to ensure the water meets health standards for safe consumption (Marzuki & Tahrim, 2024).

Implementing source-based water safety measures and preventing cross-contamination at the point of use are crucial strategies for improving water quality in supply systems and minimizing health risks. Source-based interventions involve designing and building water sources that safeguard against contamination and ensure the production of clean water. These measures also include community-driven sanitation efforts to protect water catchment areas from pollution caused by human, animal, and agricultural waste, as well as source-based water treatment. At the point of use, safety measures include proper water storage and household water treatment (Pooi & Ng, 2018). However, these practices may be difficult to implement in rural areas due to a lack of knowledge, misinformation, negative attitudes, and limited experience with effective water treatment methods and safe storage practices (Bitew, Gete, Biks, & Adafrie, 2017).

Factors such as the number of plants, contact time, and waste concentration play a role in the reduction of chromium levels in tannery wastewater. Journal analysis indicates that phytoremediation, particularly using water hyacinth plants, can effectively reduce chromium levels by accumulating the metal. Studies show that chromium content in water samples can meet WHO standards after 10, 20, or 28 days of treatment (Astuti, Sukmawati, Asyfiradayati, & Darnoto, 2022).

Interviews with local communities offer insights that laboratory tests may not reveal. This comprehensive understanding forms a strong foundation for developing corrective or preventive actions to improve well water quality, especially in cases where it falls short of health standards. Regular monitoring and maintenance have been identified as essential to ensuring that drinking water in Gempol Village meets health requirements.

The Water, Sanitation, and Hygiene (WASH) program has been shown to reduce diarrhea cases in schools in Ethiopia (Gebrehiwot, Geberemariyam, Gebretsadik, & Gebresilassie, 2020). This underscores the importance of addressing water sanitation issues to reduce disease rates.Local health authorities, in partnership with communities and other stakeholders, must design and construct communal water sources that provide safe, sufficient water year-round. Additionally, maintaining existing water infrastructure is critical, given the widespread damage to water systems. Promoting water safety measures at the point of use, such as safe water storage and household water treatment, should be encouraged through health education, surveillance, and community discussions at the village level (Gizaw, Gebrehiwot, Destaw, & Nigusie, 2022).

CONCLUSION

The microbiological quality of water from 12 wells shows that only 4 wells meet the threshold set by the Indonesian Ministry of Health Regulation No. 32/2017. The design of septic tank construction and the distance between wells and pollution sources significantly affect the total bacterial contamination.

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