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Integrating One-Health Approaches: Total & Fecal Coliform Contamination from Wastewater to River Systems and Its Implications for Clean Water and Agriculture (Case Study: Garut Regency, Indonesia)

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ABSTRACT: Water quality is crucial for public health, food security, and ecological balance. In heavily utilized water resources, the risk of microbial contamination, indicated by total and fecal coliforms, increases, posing significant public health and environmental challenges. These coliforms are key indicators used to assess water quality and treatment effectiveness. The objective of this study is to investigate the pathways and impact of total and fecal coliform contamination from wastewater to river systems in Garut Regency, Indonesia, and to assess its implications for clean water resources and agricultural practices. We assessed the levels of total and fecal coliforms in wastewater, well water used for drinking water source, as well as in river water used for agricultural irrigation across different areas of Garut Regency, Indonesia. The laboratory analysis showed that fecal and total coliform levels in the Cigulampeng River in Garut Kota Sub-District surpassed the standards outlined in Government Regulation No. 22 of 2021, Class II, which is intended for irrigation. Additionally, the total coliform levels in well water from Karangpawitan Sub-District exceeded the safe limits for drinking water. In Tarogong Kidul Sub-District, both residential river water and a company's well water were found to be unsuitable for irrigation and drinking, respectively, due to elevated coliform levels.

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INTRODUCTION

Water quality plays a pivotal role in safeguarding public health, ensuring food security, and preserving ecological balance. In regions where water resources are heavily used for agricultural, industrial, and domestic purposes, the risk of microbial contamination significantly increases, leading to serious public health and environmental challenges. This is because these activities can introduce a variety of contaminants, including fecal coliforms and other pathogens, into water systems. The runoff from agricultural fields, effluent from wastewater treatment plants, and industrial discharges are common sources of such contamination. Studies have shown that precipitation and resulting runoff can increase this issue by transporting fecal matter from upland areas to surface and well water sources, thereby deteriorating water quality and posing health risks to communities reliant on these water bodies. Previous study revealed that there was a potentially high risk of waterborne pathogens infection for wastewater treatment plant (WWTP) workers and communities that use river water upstream and downstream (Mbanga *et.al*, 2021). Recent study showed that there was the correlation between land use types and water quality, showing that areas with intensive agricultural and industrial activities tend to have higher levels of waterborne contaminants, including microbial pathogens, posing significant risks to both ecosystems and human health (Liu *et.al*, 2024). Among the key indicators of water contamination are total coliforms and fecal coliforms, groups of bacteria that signal the potential presence of harmful pathogens in water bodies. These bacteria are commonly used as indicators to assess water quality and the effectiveness of water treatment processes. These bacterial groups are widely recognized for their effectiveness in signaling fecal pollution and are commonly employed in water quality monitoring and treatment process evaluations. For instance, total coliforms generally indicate the presence of bacterial contamination in water, while fecal coliforms, which are a subset of total coliforms, are more specific to contamination from fecal material. These indicators are critical for managing water safety, as they help identify water bodies that may pose public health risks if used for drinking, recreation, or agriculture (Holcomb & Stewart, 2020; Seo *et.al*, 2019).

In the context of a One-Health approach, which emphasizes the interconnectedness of human, animal, and environmental health, the study of coliform contamination in water systems is crucial. This approach advocates for integrated efforts across multiple sectors to address the complex interactions between environmental contamination and public health risks. Recent research has highlighted the importance of considering all aspects of health—human, animal, and environmental—when managing water contaminants. By integrating various disciplines and sectors, the One-Health approach helps in promoting sustainable water stewardship and developing effective strategies to mitigate the risks posed by waterborne pathogens and pollutants. This multidisciplinary strategy is crucial for ensuring that interventions are holistic and effective across all areas of health (Goncalves *et.al*, 2023; Prata, 2022). Understanding how coliform bacteria from wastewater enter river systems and affect clean water resources is essential for developing effective strategies to protect both public health and agricultural productivity.

This study focuses on Garut Regency, Indonesia, a region where rivers are a vital source of water for both domestic use and agricultural irrigation. The discharge of untreated or inadequately treated wastewater into river systems raises concerns about the contamination of water sources by total and fecal coliforms. By examining the contamination levels of these coliforms in river systems and their implications for clean water and agriculture, this research aims to provide insights into the risks posed to public health and the environment.

MATERIALS AND METHODS

Study Area

We selected several representative sites near agricultural areas to test surface water (including river water and drainage) in Tarogong Kidul Subdistrict, as well as residents' well water in Garut Kota, Karangpawitan, and Tarogong Kidul Subdistricts, and wastewater from domestic activities in Tarogong Kidul Subdistrict. The study area is illustrated in Figure 1.

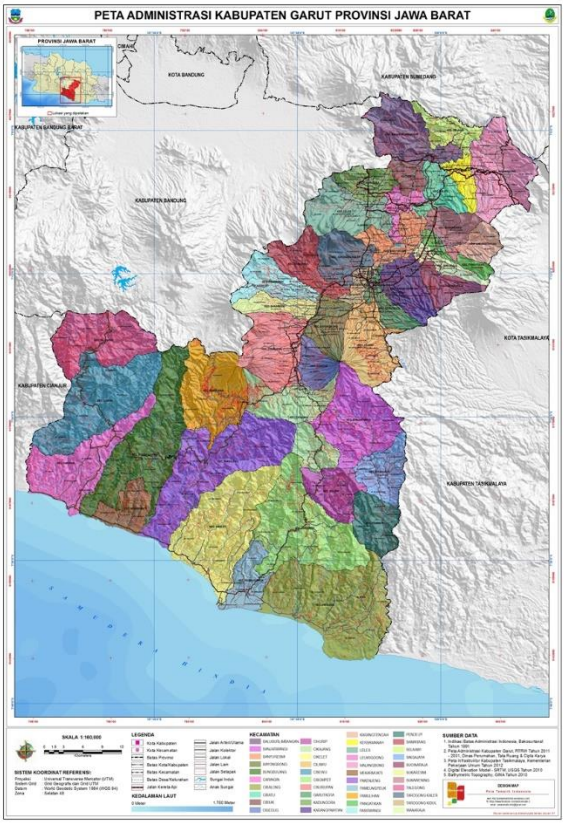

Figure 1. Study Area

Sampling and Laboratory Analysis

For sampling and laboratory analysis, we collaborated with various agencies. The analysis of river water quality in Tarogong Kidul Subdistrict and well water and river in Garut Kota Subdistrict was conducted in partnership with the Garut Regency Environmental Agency. Additionally, the analysis of well water in Karangpawitan Subdistrict, as well as well water, wastewater, and surface water in Tarogong Kidul Subdistrict, was carried out in collaboration with the Environmental Quality Control Laboratory of PDAM Tirtawening, Bandung City.

RESULTS

The laboratory analysis results are presented in Table 1. We compared the results against several regulatory standards. Surface water (river and drainage) was assessed using Government Regulation No. 22 of 2021. Well water was evaluated according to the Minister of Health Regulation No. 2 of 2023, which serves as the implementation guideline for Government Regulation No. 66 of 2014 on Environmental Health. Wastewater was analyzed in accordance with the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.68/Menlhk/Setjen/Kum.l/8/2016, Annex I, which outlines the quality standards for domestic wastewater.

Table 1. Coliform Levels in Various Water Sources in Garut Regency

No	Water Sources	Location	Results		Quality Standard	
			Fecal Coliform (MPN/100 ml)	Total Coliform (MPN/100 ml)	Fecal Coliform	Total Coliform
1	Resident's well water	Garut Kota Sub-District	0	0	0**	0**
2	Cigulampeng River	Garut Kota Sub-District	2000^	10000^	1000 (Class II)*	50000(Class II)*
3	Resident's well water	Karangpawitan Sub-District	-	1,1^	0**	0**
4	River water near residential	Tarogong Kidul Sub-District	2000^	10000^	1000 (Class II)*	50000(Class II)*
5	Company's well water	Tarogong Kidul Sub-District	-	6,9^	0**	0**
6	Domestic Wastewater	Tarogong Kidul Sub-District	-	920	1000***	3000***
7	Drainage	Tarogong Kidul Sub-District	2300^	3100	1000 (Class II)*	50000(Class II)*
8	2nd Company's well water	Tarogong Kidul Sub-District	-	2,2^	0**	0**
9	2nd Domestic Wastewater	Tarogong Kidul Sub-District	-	920	1000***	3000***
10	Ciojar river	Tarogong Kidul Sub-District	540	920	1000 (Class II)*	50000(Class II)*

^: exceeded the quality standard

*: Government Regulation No. 22 of 2021

**: Minister of Health Regulation No. 2 of 2023

***: Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.68/Menlhk/Setjen/Kum.l/8/2016

The laboratory analysis revealed that the fecal and total coliform levels in the Cigulampeng River in Garut Kota Sub-District have exceeded the quality standards set by Government Regulation No. 22 of 2021, Class II, which is designated for irrigation purposes. Additionally, the total coliform levels in the resident's well water in Karangpawitan Sub-District surpassed the acceptable standard for drinking water sources. River water near residential areas in Tarogong Kidul Sub-District also exceeded the irrigation standards. Furthermore, the company's well water in Tarogong Kidul Sub-District were found to be unsuitable as a drinking water source due to elevated coliform levels.

DISCUSSION

Agricultural practices are actively present in the areas around Garut Kota, Karangpawitan, and Tarogong Kidul sub-districts. These regions are part of Garut Regency, which has a significant focus on both traditional and urban farming. In Tarogong Kidul, for example, there is a growing interest in urban farming among the youth, which is seen as an important aspect of sustainable agricultural development in the region. This trend is supported by local initiatives aimed at promoting small-scale farming practices, including vegetable cultivation, which contributes to the local food supply and economy (Widyaningsih *et al*., 2022). Moreover, sustainable agricultural land management is a critical focus in Garut Regency, including these sub-districts. Efforts have been made to protect agricultural lands from being converted to other uses, with a significant portion of land, particularly for rice farming, being preserved for agricultural purposes. This commitment to maintaining agricultural land ensures that farming remains a vital

part of the local economy and food security (Warlina & Pradana, 2021).

The sustainable management of water resources is crucial for ensuring the long-term viability of agricultural practices, particularly in regions that rely heavily on irrigation. Rivers play a pivotal role in supplying the necessary water for crop production, making the efficient and responsible use of these water bodies essential. Recent studies highlight the importance of sustainable irrigation practices in agricultural areas globally. These studies explore how water resources, particularly river systems, are used for irrigation and the impact of these practices on both water availability and agricultural productivity. For example, the Segura River Basin in Spain has been a focal point for analyzing water footprints in irrigated agriculture, emphasizing the need for efficient water management to ensure sustainability amidst competing demands from urban, agricultural, and industrial sectors (Martínez-Paz *et.al*, 2018). Moreover, a global review on sustainable irrigation practices underscores the significant role irrigation plays in agriculture, accounting for a large proportion of water usage worldwide. This research stresses the need to balance agricultural productivity with environmental conservation, particularly in regions facing water scarcity due to climate change (Velasco-Muñoz *et.al*, 2019; Palma & Tomaz, 2024).

Both the Cigulampeng and Ciojar rivers in Garut are used for irrigation purposes. The Cigulampeng River, in particular, has been reported as a source of water for irrigating nearby paddy fields. Similarly, the Ciojar River is also utilized for agricultural irrigation, providing essential water for crops in the surrounding areas. The use of these rivers for irrigation highlights the importance of maintaining water quality to ensure the safety and productivity of agricultural activities. However, the Cigulampeng River has been found to have elevated levels of fecal and total coliform, which could potentially impact the safety and productivity of the crops irrigated by its waters. Previous study has shown that the quality of irrigation water, particularly its microbial content, significantly affects the safety of agricultural produce. For instance, water contaminated with fecal coliforms poses risks to both crop safety and consumer health. This is particularly concerning in regions where rivers or other open water sources are used for irrigation without adequate treatment, as pathogens from contaminated water can be transferred to crops, potentially leading to foodborne illnesses. These findings highlight the importance of ensuring the microbiological quality of irrigation water (Douti *et.al*, 2021).

The laboratory findings revealing elevated fecal and total coliform levels in both surface and well water sources in Garut Regency raise significant concerns from a One-Health perspective, which emphasizes the interconnectedness of human, animal, and environmental health. The presence of coliforms, especially in water sources designated for drinking, poses direct risks to human health, potentially leading to waterborne diseases. Contaminated irrigation water can also lead to the contamination of crops, further escalating the risk of foodborne illnesses. Livestock and other animals relying on contaminated water for drinking are at risk of illness, which can, in turn, affect food safety, particularly in communities dependent on animal products like milk and meat. The high levels of coliforms indicate possible fecal contamination from human or animal waste, which can disrupt local ecosystems. Contaminants in water bodies can affect aquatic life, reduce biodiversity, and compromise the overall health of the environment. Addressing these issues requires integrated strategies that consider the environmental sources of contamination, the health of local communities, and the impact on agriculture. The One-Health approach advocates for improved water management practices, including enhanced wastewater treatment and better protection of water sources from contamination, to ensure the sustainability of both human health and agricultural productivity. Recent studies and initiatives highlight the importance of the One-Health approach in managing water resources. For instance, the One Health Breakthrough Partnership underscores the critical role of water quality in safeguarding the health of ecosystems, humans, and animals, emphasizing the need for cross-sectoral collaboration to address these interconnected challenges. Research also demonstrates that water contaminants significantly impact agriculture and public health, reinforcing the necessity of a One-Health perspective to effectively mitigate risks and promote sustainable water stewardship (Hoffman *et.al*, 2022; Prata, 2022).

CONCLUSION/RECOMMENDATION

The findings from the study on total and fecal coliform contamination in Garut Regency, Indonesia, highlight significant public health and environmental risks. The elevated coliform levels in the Cigulampeng River, well water in Karangpawitan, and both residential and company wells in Tarogong Kidul indicate widespread contamination. These exceedances of established water quality standards for irrigation and drinking water emphasize the urgent need for integrated One-Health strategies. Such strategies must address the sources of contamination, protect water resources, and ensure the health and safety of both humans and ecosystems in the region. This study underscores the critical importance of cross-sectoral collaboration in managing water quality and promoting sustainable agricultural practices.

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