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Healthy Settlements with Septic Tanks and High Groundwater Table for Waste Management

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Abstract. *The KKN-Thematic Community Service Program in Leppe Village, Soropia District, Konawe Regency, focuses on enhancing environmental health by implementing adaptive septic tanks in areas with high groundwater tables. The village, located in a coastal region with high groundwater levels, faces significant challenges in waste management, contributing to groundwater contamination and health issues. This program aims to educate the community on the importance of proper sanitation systems, specifically septic tanks, to prevent waterborne diseases and improve overall public health. Through participatory methods, the program involves residents in the planning, construction, and maintenance of septic tanks designed to withstand high water tables. The community is also trained in regular maintenance, ensuring long-term sustainability of the systems. The project is part of a broader effort to improve the quality of life in rural coastal areas by promoting hygienic practices and environmentally friendly waste management solutions. The outcomes of this initiative include increased awareness, improved sanitation infrastructure in the village, and the establishment of a replicable model for other coastal areas. The project has fostered collaboration between local authorities, academic institutions, and the community, laying the groundwork for ongoing environmental health improvements in the region.*

Keywords: *Adaptive Septic Tank, Environmental Sanitation, Groundwater Contamination, Community Participation*

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INTRODUCTION

Improper disposal of human waste, common in rural and coastal areas, remains a significant problem in many regions worldwide (Ferronato & Torretta, 2019). In these communities, the common method of waste disposal is digging small pits approximately 1 to 2 meters deep, which are used as makeshift toilets (Prasad & Ray, 2019). This practice persists, particularly in rural and coastal areas, due to limited knowledge about sanitation and environmental health (Khan & Paul, 2023). These practices, including open defecation and inadequate septic systems, not only fail to meet health standards but also degrade ecological quality (Oluseyi & Nweke, 2020). Contributing factors include poor sanitation practices such as open defecation, frequent tidal flooding, and the inability of communities to design and construct appropriate septic systems for areas with high groundwater levels (Lebu, 2025).

More broadly, the failure to implement adequate sanitation systems has led to widespread contamination of water sources, exacerbating public health problems in rural areas globally (Herrera, 2019). These unhealthy practices have led to an increased risk of waterborne diseases, such as polio, diarrhea, and skin infections, especially in areas with contaminated groundwater (Pal et al., 2018). However, in Leppe Village, Soropia District, Konawe Regency, these challenges are further exacerbated by the region's specific environmental conditions, including high groundwater levels and frequent tidal waves. These factors create additional difficulties in implementing traditional waste management solutions, necessitating a tailored approach (Yukalang et al., 2018).

In Indonesia, the problem of groundwater pollution in residential areas is increasingly alarming. Poor wastewater management, coupled with inadequate government oversight and limited public awareness, has led to widespread water pollution (Zaidi & Handayani, 2025). Studies indicate that approximately 70% of groundwater in some residential areas is contaminated with faecal bacteria, significantly increasing the risk of diseases such as polio, diarrhoea, and skin infections (Andrade et al., 2018). Despite this, many residents still rely on contaminated groundwater for daily consumption, further exacerbating the public health crisis (Shaikh & Birajdar, 2024).

One potential solution to this pressing problem is a septic tank system, designed to treat household waste through a slow filtration process (de et al., 2018). Septic tanks allow solid waste to settle and organic matter to decompose, converting it into dissolved substances and gases (Halicki & Halicki, 2022). However, a significant and often overlooked challenge is the contamination of wells, groundwater, and surrounding water bodies with faecal bacteria from improperly designed septic systems, which can lead to various diseases (Mensah, 2022). To address this issue, it is crucial to construct septic tanks specifically designed to handle high groundwater levels, ensuring they remain effective even in areas with fluctuating groundwater levels (Daka, 2019).

The unique geographic and environmental conditions of Leppe Village where some homes are located in areas with high groundwater levels and others in flood-prone zones require specialised sanitation solutions. In this context, the importance of a wastewater management system that adapts to these conditions cannot be overstated (Mullin & Kirchhoff, 2019). Therefore, this study focuses on addressing these challenges by proposing the implementation of adaptive septic tanks designed to function effectively in areas with high groundwater levels. This approach aims not only to improve environmental quality but also to enhance public health by providing an efficient solution for waste management. Furthermore, the project aims to empower communities with the knowledge and skills necessary for the construction, use, and maintenance of these systems, ensuring their long-term sustainability.

This research examines the implementation of adaptive septic tanks in Leppe Village, focusing on how they can be used to improve sanitation in areas with high groundwater levels. The project, titled "Healthy Settlements with Septic Tank Implementation with High Groundwater Levels," aims to provide a sustainable solution for waste management, improving environmental quality and public health in the village. Through this initiative, communities will gain the knowledge and skills necessary to effectively maintain these systems, contributing to a healthier and more sustainable living environment in the long term.

METHODS

Research Design

This study employed a qualitative descriptive design grounded in the Participatory Action Research (PAR) framework, which integrates community participation into all stages of inquiry. PAR was chosen because sanitation problems in coastal settlements require not only technical solutions but also behavioral change, local collaboration, and culturally sensitive adaptation. The design consists of three interrelated phases diagnosis, action, and reflection which collectively

structure the process of identifying problems, implementing interventions, and evaluating outcomes. In the diagnostic phase, researchers worked with the community to identify sanitation challenges associated with high groundwater levels, existing waste disposal practices, and risks of groundwater contamination. The action phase involved co-designing and constructing adaptive septic tank prototypes with local residents, ensuring that the intervention aligned with local environmental conditions and community priorities. The reflection phase provided space for evaluating the effectiveness of the intervention, assessing changes in sanitation behavior, and formulating sustainability strategies collaboratively. This design establishes methodological rigor by ensuring systematic data collection, community participation, and iterative learning throughout the research cycle.

Research Setting and Participants

The study was conducted in Leppe Village, Soropia District, Konawe Regency, a coastal settlement characterized by high groundwater levels, tidal fluctuations, stilt housing, and limited sanitation infrastructure. These environmental conditions necessitate a septic tank design that accommodates high water tables and prevents effluent leakage. Participants in this research consisted of households residing in high-risk zones, village authorities, community leaders, technical experts, and university students involved in the KKN thematic program. A total of 30 households were purposively selected based on criteria such as settlement location, vulnerability to groundwater contamination, and willingness to participate. Additionally, key informants included the Village Head, community leaders, sanitation committee members, and technical supervisors. The purposive sampling technique ensured that participants represented the most relevant stakeholders and possessed firsthand experience with sanitation challenges in the study area.

Data Collection Techniques

Field Observation

Field observations were conducted to obtain a direct understanding of the environmental, geological, and infrastructural conditions of Leppe Village. Researchers documented the location of wells, housing structures, soil characteristics, and water table height through visual inspection and simple hydrological measurement. Observations also focused on identifying sanitation risks such as proximity between waste disposal sites and water sources, potential flooding zones, and community practices related to sewage management. Data were recorded using observation sheets, GPS coordinates, and photographic documentation.

Depth Interviews

In-depth semi-structured interviews were used to explore residents' knowledge, perceptions, and sanitation practices. Interview topics included awareness of groundwater contamination, previous experiences with septic tanks, cultural or economic barriers to sanitation improvements, and expectations for the new adaptive system. A total of 20 participants comprising household members, village officials, and community leaders were interviewed. Interviews were conducted face-to-face, recorded with consent, and later transcribed verbatim for thematic analysis.

Focus Group Discussions (FGD)

Two focus group discussions were conducted to generate collective insights and facilitate participatory decision-making. The first FGD focused on identifying sanitation problems, design preferences, and community priorities. The second FGD evaluated the prototype septic tank, discussed user experiences, and developed community-based sustainability strategies. Each session was attended by 12 participants, including representatives from different hamlets, local masons, and youth groups. FGDs allowed triangulation of data and helped validate findings emerging from interviews and observations.

Technical Documentation of Construction

Researchers systematically documented each step of the septic tank construction process, including material selection, excavation, waterproofing, pipe installation, and reinforcement work. This documentation ensured that the prototype adhered to engineering standards and that variations in construction methods were recorded for analysis. Notes were taken using construction checklists and material logs, complemented by photographs and field sketches.

Pre–Post Behavioral Survey

A brief survey using a 5-point Likert scale was administered before and after the intervention to measure changes in sanitation knowledge, awareness of contamination risks, and readiness to adopt adaptive septic tanks. Thirty households participated in this survey. The pre–post comparison enabled the study to quantify shifts in community understanding and behavioral intentions, complementing qualitative insights obtained through interviews and FGDs.

Data Analysis Techniques

Qualitative data were analyzed using thematic analysis, which involved systematic coding of interview transcripts, observation notes, and FGD results. The process began with data familiarization through repeated reading of transcripts, followed by open coding to identify recurring concepts. Codes were then grouped into broader themes such as environmental risk perception, sanitation constraints, community participation, and system feasibility. These themes were interpreted within the conceptual framework of PAR, linking community-identified problems with observed behavioral changes and technical outcomes. Quantitative data from the pre–post survey were analyzed descriptively to examine changes in knowledge, awareness, and behavior. Percentages and mean scores were compared to determine the extent of improvement, providing measurable indicators that supported qualitative findings. This combination of qualitative depth and quantitative support enhanced the robustness and credibility of the study.

RESULTS AND DISCUSSION

General Description of Leppe Village

Leppe Village is located in the Soropia District, Konawe Regency, Southeast Sulawesi Province. Geographically, it is situated along the coastal area of Kendari Bay, directly facing the Banda Sea. The geographic coordinates of Leppe Village are between 3°58'–4°03' South Latitude and 122°35'–122°40' East Longitude. Leppe Village is a coastal village that serves as a link between the land and sea areas and is included in the development zone for coastal and marine tourism in Soropia. Administratively, the boundaries of Leppe Village are as follows: (1) To the North, it borders Bajo Indah Village; (2) To the South, it borders Mekar Village; (3) To the West, it borders Abeli Subdistrict (Kendari City); (4) To the East, it borders directly on the Banda Sea.

Leppe Village is approximately 65 km from the capital of Konawe Regency, with a travel time of about 1.5 hours by land from Kendari. The majority of the settlement is located on water or along the shoreline, featuring stilt houses typical of the Bajo ethnic group, which reflects a strong adaptation to the marine environment. The climate of Leppe Village is classified as tropical wet, with two main seasons: the dry season and the rainy season. The dry season occurs between June and September, when the eastern winds from Australia bring dry air. The rainy season occurs between December and March, when the western winds from Asia and the Pacific Ocean bring large amounts of water vapour. The transitional months are between April–May and October–November, marking the changeover between the seasons.

According to local government data, the population of Leppe Village is approximately 210 families (KK), or around 850 individuals, spread across three hamlets. The population composition consists of around 430 males and 420 females. The majority of the population relies on fishing as their primary livelihood, followed by seaweed farming, small-scale trading, and informal sector work. In terms of education, the people of Leppe Village have varied educational backgrounds. About 35% of the population has completed elementary school, 30% are junior high

school graduates, 20% are high school graduates, and around 10% have attended higher education (Diploma or Bachelor's degree). However, approximately 5% of elementary school-aged children have not completed formal education due to economic factors and limited access to transportation.

The social and cultural conditions of the village are strongly influenced by the Bajo ethnic culture, which has a close relationship with the sea. Daily activities heavily rely on marine resources, and the values of cooperation, deliberation, and social solidarity remain very strong within the community. From an environmental perspective, Leppe Village is characterised by sandy and muddy soil with high groundwater levels, which significantly affects the sanitation system. Therefore, implementing adaptive septic tank technology in high groundwater areas is a strategic effort to create a healthy and sustainable environment in this coastal area. Administratively, Leppe Village is divided into three hamlets and six neighborhood units (RT). The village government is active in community empowerment activities, environmental cleanliness, and marine tourism development.

Thematic Community Service Program (KKN) Activities in Mata Wawatu Village

The implementation of the Thematic Community Service Program (KKN) in Leppe Village took place from September 12, 2025, to October 12, 2025. The handover of KKN students by the Field Supervising Lecturers was conducted on September 12, 2025, to the Leppe Village authorities. The details of the KKN activities in Leppe Village are as follows:

The Orientation for Thematic KKN Students

The orientation for students participating in Thematic KKN was held offline at the residential and settlement studio on September 10, 2025. The orientation session started with a briefing by the team leader, Dr. Ir. Ishak Kadir, ST., MT., followed by presentations and discussions with team members, including Dr. M. Husni Kotta, ST., M.Si, M.T, Annas Ma'ruf, S.T., M.T, Dr. Lawelendo, ST., MT., Dr. Ranno Marlany Rachman, ST., M.Kes, and Wisdha Ahdiyani, ST., M.Sc. Through this orientation, the KKN students received explanations about programs that align with the KKN theme, Healthy Residential Environment, focusing on implementing septic tanks in high groundwater areas to manage solid human waste. The participants of the Thematic KKN in Leppe Village are students from the Faculty of Engineering, including those from the Civil Engineering RIL Department, Marine Science Department, and Architecture Department. Leppe Village, a development partner of the Faculty of Engineering at Halu Oleo University, is the focus of this thematic KKN program. This initiative aims to address residential issues that require planning and guidance in the development of sustainable settlements.

Figure 1. Provisioning for Thematic KKN Students

Explain the results of the research in the form of problem-solving analyzed using relevant theories. The results of the study also revealed the findings of the research. Discussion is accompanied by logical arguments by linking the results of research with theory, the results of other studies (Seuring et al., 2020).

Site Observation

At this stage, a participatory approach is essential for determining the appropriate location for the construction of adaptive septic tanks that align with the coastal environmental conditions and the needs of the local community. The village government, together with the local residents, conducts deliberations to select the most suitable location for the installation of high groundwater septic tanks as part of efforts to create a healthy environment free from solid waste contamination. The process of determining the location and system design is carried out with guidance from the Service Team (Thematic KKN UHO 2025), which provides technical directions based on field observations, geotechnical soil conditions, and local community practices in domestic waste management. The system design and construction process are adapted to the local potential of Leppe Village, Soropia District, Konawe Regency, which has coastal characteristics, high groundwater levels, muddy soil, and proximity to the sea. The method used to determine the availability of land for septic tank locations considers several aspects:

Hydrological Conditions and Groundwater Levels

The location is chosen in an area with higher land elevation above the tidal water level to ensure that the septic tank does not become submerged and continues to function optimally even during sea level rise (Cox et al., 2019).

Safe Distance from Clean Water Sources and Dense Settlements

The placement of the septic tank ensures a minimum distance of 10 meters from clean water sources, such as dug wells or water storage tanks, to prevent bacteriological contamination of groundwater and drinking water supplies (Farouq et al., 2018).

Land Ownership and Status

The construction is carried out on land owned by the village or jointly managed land that has been agreed upon to avoid potential disputes and ensure the sustainability of the facility's maintenance.

Access and Maintenance Ease

The location of the septic tank is selected for easy access for periodic cleaning or pumping, while also ensuring that it does not interfere with the daily activities of the community (Oduah & Ogunye, 2023).

Environmental Safety and Flooding Risk

The location should be far from direct drainage areas (main drains, ditches, or open ponds) to prevent the infiltration of dirty water during the rainy season or high tides (Daka, 2019).

Community Participation and Consensus

The location determination is made through community deliberations to foster a sense of ownership and shared responsibility for the environmental cleanliness and future maintenance of the septic tank system (Goldstein, 2023).

Figure 2. Site Observation and Site Selection

Program Socialisation and Strengthening

The socialisation of this program is the initial phase aimed at providing basic knowledge and information to the village government, community leaders, and residents living near the site of the adaptive septic tank construction (Alam et al., 2020). This activity is carried out before the technical planning and construction stages begin to ensure that all parties understand the benefits, functionality, and their respective roles in achieving a healthy environment through the safe and sustainable management of solid human waste. At this stage, the Service Team (Thematic KKN UHO 2025) provides explanations about the concept of high groundwater septic tank technology, the rationale for its application in coastal areas such as Leppe Village, and its positive impacts on public health and water quality. Additionally, technical assistance is provided for planning the location, designing the construction, and creating a pilot septic tank unit that the community can independently replicate.

This socialisation method is crucial for: (1) Providing Understanding of Healthy and Environmentally Friendly Sanitation (Budge et al., 2022). Residents are introduced to the principles of managing solid human waste in a closed system that does not pollute seawater or groundwater, especially in areas with high groundwater levels like Leppe Village; (2) Explaining the Objectives and Benefits of the Program (Krimsky et al., 2024). Through socialisation, the community understands that implementing adaptive septic tanks is not just a physical project but an effort to maintain environmental health, prevent waterborne diseases, and improve the comfort of the settlement; (3) Introducing Activity Plans and Design (Auld & Mohammadian, 2012). The team explains the implementation stages, from site selection and septic tank structure design to the maintenance and periodic pumping process; (4) Providing Practical Guidance on Implementation and Maintenance (Jayathilake et al., 2019). The community is equipped with simple technical guidelines on how to operate the septic tank system, separate solid and liquid waste, and take steps to prevent leakage and contamination; (5) Building Participation and Collective Responsibility (Goldstein, 2023). The socialisation is conducted interactively through group discussions, simulations, and Q&A sessions, allowing the community to actively participate in the construction and maintenance of the sanitation facilities they will use.

Figure 3. Socialization and Community Strengthening

Training on Planning, Construction, and Assistance

Following the socialization activities, the Service Team provided direct assistance to the community in constructing a pilot septic tank unit in Leppe Village. This assistance included: (1) Determining the dimensions and construction materials suitable for high groundwater conditions; (2) Supervising the construction process to ensure it meets sanitation standards; (3) Training the residents on routine maintenance and safe disposal of sludge. With the program "Healthy Environment through the Application of High Groundwater Septic Tanks in Solid Human Waste Management," both students and community groups received direct explanations and guidance on the adaptive septic tank system design process from the Field Supervisor (DPL).

The design was technically developed by architecture students, taking into account soil conditions, groundwater elevation, and safety against flooding and seawater intrusion. It was then built collaboratively between the students and the local community. Through this activity, the community members were not only beneficiaries but also active participants in the development process. This involvement fostered a sense of ownership over the project outcomes and enhanced their understanding of the importance of closed and environmentally friendly solid waste management (Alimoradiyan et al., 2024). The assistance provided in this activity consists of several key stages, as follows:

Planning Assistance

At this stage, the Field Supervisor (DPL) and students provide technical guidance on determining a safe location, septic tank structure design, and the selection of building materials suitable for coastal conditions with high groundwater levels. This activity also includes participatory discussions with the community to ensure that the design aligns with local needs and can be implemented sustainably.

Figure 3. Septic Tank Planning

Implementation Assistance

During the construction process, the service team provides on-site assistance regarding construction procedures, such as the creation of waterproof walls and floors, installation of inlet-outlet pipes, and the arrangement of air vents and tank covers. This assistance ensures that all stages of the work meet safe sanitation standards and that the structural integrity is capable of withstanding high groundwater pressure.

Figure 4. Assistance in Assembling Iron Reinforcement and Cast Boards

The next stage, the community actively participated in the construction of the structure, which included tasks such as pouring concrete for the tank walls, laying pipes, and installing air vents. This collaborative effort ensured that the structure met safe sanitation standards and was built to withstand the pressures associated with high groundwater levels. The involvement of the

service team and the local community demonstrated a participatory approach, where knowledge and skills were shared to promote sustainable solutions in wastewater management.

Figure 5. Construction Implementation, Such as Making Waterproof Walls and Floors, Installing Inlet-Outlet Pipes

Maintenance Assistance

After the septic tank system has been completed, training is provided to the community on how to carry out regular maintenance, safely desludge the septic tank, and monitor the system's functionality to ensure it remains optimal. This stage emphasizes the importance of ongoing care to maintain the efficiency and sustainability of the septic tank system over time. The community is equipped with the necessary knowledge and skills to perform routine checks and interventions, ensuring the system continues to operate effectively, providing long-term environmental and public health benefits.

CONCLUSION

The implementation of the Integrated Community Service Program (KKN Tematik) in Leppe Village has yielded several important conclusions. The majority of the community lacks septic tanks, highlighting the need for efforts to support the transition to high groundwater septic tanks. The socialization activities have strengthened the understanding of the importance of healthy residential environments, particularly in managing solid human waste through the adoption of high groundwater septic tanks. The program has fostered collaboration between the government, local leaders, and the community, emphasising the importance of clean living practices and environmental health. Furthermore, the project has enhanced the relationship between academic institutions and the local government, creating a platform for collective action on sanitation. The program proceeded according to plan, achieving its objectives of improving sanitation and promoting a sustainable environment in Leppe Village. However, there remains a need for continued support, especially in reaching households without proper septic tank systems.

SUGGESTION

The integrated community service program (KKN Tematik) implemented in Leppe Village regarding healthy residential environments and the application of high groundwater septic tanks for managing solid human waste has been successful. However, there are still homes without adequate septic tank systems. Therefore, it is recommended to conduct further community service activities focused on flood disaster mitigation, specifically through door-to-door campaigns, to raise awareness about the use of healthier high groundwater septic tanks.

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REFERENCES

Alam, M. U., Sharior, F., Ferdous, S., Ahsan, A., Ahmed, T., Afrin, A., ... & Tidwell, J. B. (2020). Strategies to connect low-income communities with the proposed sewerage network of the Dhaka sanitation improvement project, Bangladesh: a qualitative assessment of the perspectives of stakeholders. *International Journal of Environmental Research and Public Health*, *17*(19), 7201. https://doi.org/10.3390/ijerph17197201

Alimoradiyan, H., Hajinezhad, A., Yousefi, H., & Giampietro, M. (2024). Fostering community participation in sustainable municipal solid waste management at multiple scales in Tehran, Iran. *Results in Engineering*, *22*, 102174. https://doi.org/10.1016/j.rineng.2024.102174

Andrade, L., O'dwyer, J., O'neill, E., & Hynds, P. (2018). Surface water flooding, groundwater contamination, and enteric disease in developed countries: A scoping review of connections and consequences. *Environmental pollution*, *236*, 540-549. https://doi.org/10.1016/j.envpol.2018.01.104

Auld, J., & Mohammadian, A. K. (2012). Activity planning processes in the Agent-based Dynamic Activity Planning and Travel Scheduling (ADAPTS) model. *Transportation Research Part A: Policy and Practice*, *46*(8), 1386-1403. https://doi.org/10.1016/j.tra.2012.05.017

Budge, S., Ambelu, A., Bartram, J., Brown, J., & Hutchings, P. (2022). Environmental sanitation and the evolution of water, sanitation and hygiene. *Bulletin of the World Health Organization*, *100*(4), 286. https://doi.org/10.2471/BLT.21.287137

Cox, A. H., Loomis, G. W., & Amador, J. A. (2019). Preliminary evidence that rising groundwater tables threaten coastal septic systems. *Journal of Sustainable Water in the Built Environment*, *5*(4), 04019007. https://doi.org/10.1061/JSWBAY.0000887

Daka, F. D. (2019). *Mitigating the effects of septic tank effluents from households on groundwater quality: a case of Meanwood-Kwamwena, Lusaka* (Doctoral dissertation, University of Zambia).

de Oliveira Cruz, L. M., Tonetti, A. L., & Gomes, B. G. L. A. (2018). Association of septic tank and sand filter for wastewater treatment: full-scale feasibility for decentralized sanitation. *Journal of Water, Sanitation and Hygiene for Development*, *8*(2), 268-277. https://doi.org/10.2166/washdev.2018.094

Farouq, A. U., Suru, H. U., Uwerevu, E. O., & Ikpesu, J. E. (2018). Effects of Septic Tank on the Quality of Groundwater from Hand-Dug Wells in Effurun, Delta State, Nigeria. *International Research Journal of Advanced Engineering and Science*, *3*(1), 137-141.

Ferronato, N., & Torretta, V. (2019). Waste mismanagement in developing countries: A review of global issues. *International journal of environmental research and public health*, *16*(6), 1060. https://doi.org/10.3390/ijerph16061060

Goldstein, L. (2023). To Build a Septic System an Analysis of EPA's New Environmental Justice Policies for Rural Communities Lacking Adequate Wastewater Sanitation. *Geo. Env't L. Rev.*, *36*, 131.

Halicki, W., & Halicki, M. (2022). From domestic sewage to potable water quality: New approach in organic matter removal using natural treatment systems for wastewater. *Water*, *14*(12), 1909. https://doi.org/10.3390/w14121909

Herrera, V. (2019). Reconciling global aspirations and local realities: Challenges facing the Sustainable Development Goals for water and sanitation. *World Development*, *118*, 106-117. https://doi.org/10.1016/j.worlddev.2019.02.009

Jayathilake, N., Drechsel, P., Keraita, B., Fernando, S., & Hanjra, M. A. (2019). *Guidelines and regulations for fecal sludge management from on-site sanitation facilities* (Vol. 14). Sri Lanka: IWMI.

Khan, M. S., & Paul, S. K. (2023). Sanitation-hygiene knowledge, practices and human health impacts: Insights from coastal Bangladesh. *Geosfera Indonesia*, *8*(2), 133-151. https://doi.org/10.19184/geosi.v8i2.39584

Krimsky, L. S., Warner, L. A., & Rampold, S. D. (2024). Flushing Out Homeowner Perceptions to Improve Voluntary Septic to Sewer Conversion With Social Marketing. *Social Marketing Quarterly*, *30*(2-3), 109-128. https://doi.org/10.1177/15245004241262030

Lebu, S. (2025). *Assessing the Resilience of Sanitation Systems to Extreme Rainfall and Flooding* (Doctoral dissertation, The University of North Carolina at Chapel Hill).

Mensah, J. A. (2022). *Groundwater Quality and Septic Tank Interaction: an Assessment of Health Implication in Amamoma, Cape Coas* (Doctoral dissertation, University of Cape Coast).

Mullin, C. A., & Kirchhoff, C. J. (2019). Marshaling adaptive capacities within an adaptive management framework to enhance the resiliency of wastewater systems. *JAWRA Journal of the American Water Resources Association*, *55*(4), 906-919. https://doi.org/10.1111/1752-1688.12709

Oduah, U. I., & Ogunye, E. B. (2023). A smart solution for preventing environmental pollution caused by overflowing onsite sewage septic tank. *Heliyon*, *9*(4).

Oluseyi, T. O., & Nweke, J. C. (2020). Implications of Improper Sewage Management on Public Health: A Case Study of Kosofe Local Government Area, Lagos State. *African Journal of Housing and Sustainable Development*, *1*(1).

Pal, M., Ayele, Y., Hadush, M., Panigrahi, S., & Jadhav, V. J. (2018). Public health hazards due to unsafe drinking water. *Air Water Borne Dis*, *7*(1000138), 2. https://doi.org/10.4172/2167-7719.1000138

Prasad, C. S., & Ray, I. (2019). When the pits fill up:(in) visible flows of waste in urban India. *Journal of Water, Sanitation and Hygiene for Development*, *9*(2), 338-347. https://doi.org/10.2166/washdev.2019.153

Seuring, S., Yawar, S. A., Land, A., Khalid, R. U., & Sauer, P. C. (2020). The application of theory in literature reviews–illustrated with examples from supply chain management. *International Journal of Operations & Production Management*, *41*(1), 1-20. https://doi.org/10.1108/IJOPM-04-2020-0247

Shaikh, M., & Birajdar, F. (2024). Groundwater and public health: exploring the connections and challenges. *International Journal for Innovative Science Research Trends and Innovation*, *9*(2), 1351-1361.

Yukalang, N., Clarke, B., & Ross, K. (2018). Solid waste management solutions for a rapidly urbanizing area in Thailand: Recommendations based on stakeholder input. *International journal of environmental research and public health*, *15*(7), 1302. https://doi.org/10.3390/ijerph15071302

Zaidi, I. A., & Handayani, I. G. A. K. R. (2025). Indonesia's Unclear Groundwater Management in Achieving Sustainable Development Goals: Regulations, Environmental Impacts, and Strategic Solutions. *International Journal of Sustainable Development & Planning*, *20*(1). https://doi.org/10.18280/ijsdp.200124