

Qualitative Analysis of Onsite Sanitation Challenges in an Urban Setting: The Case of Jimma Town, Ethiopia

Authors: Donacho, Dereje Olijira, Tucho, Gudina Terefe, Soboksa, Negasa Eshete, Faro, Mekonnen Haile, and Hailu, Abebe Beyene

Source: Environmental Health Insights, 17(1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/11786302231154421>



BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non-commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Qualitative Analysis of Onsite Sanitation Challenges in an Urban Setting: The Case of Jimma Town, Ethiopia

Dereje Oljira Donacho^{1,2} , Gudina Terefe Tucho¹,
Negasa Eshete Soboksa³ , Mekonnen Haile Faro⁴
and Abebe Beyene Hailu¹

¹Departments of Environmental Health Science and Technology, Jimma University, Jimma, Ethiopia. ²Departments of Health Informatics, College of Health Science, Mattu University, Mattu, Oromia, Ethiopia. ³Department of Environmental Health, Dilla University, Dilla, Ethiopia. ⁴Department of Educational Technology and Information Management, Mattu University, Mattu, Oromia, Ethiopia.

Environmental Health Insights
Volume 17: 1–6
© The Author(s) 2023
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/11786302231154421



ABSTRACT: On-site sanitation is the most popular sanitation option for households in many African countries, including Ethiopia. Despite the option being common, there are challenges attributed to the sustainability of those facilities. This community-based exploratory study aimed to explore the challenges in the provision of safe urban on-site sanitation in Jimma town, Ethiopia. Data were collected through key informant semi-structured interviews, transit walks through the village, and focus group discussion (FGD). The FGD was audio recorded and notes were taken by experts. Records and notes were transcribed separately and thematically analyzed. Three major themes or challenges were discovered. Accordingly, the first theme was the community's perception and taboos surrounding human waste. The second theme was urban land use and informal settlements. Ensuring standards separately for sanitation facilities is difficult because of the expansion of illegal settlements. The third theme was poor sanitation planning, operation and maintenance, and institutional setting. Urbanization without infrastructure generally has a complex nature that leads to a fragile sanitation situation in the future. The results suggest the need for multi-dimensional system development and a collaborative sanitation master plan. Furthermore, interventions aimed at breaking the taboo on human waste as a sanitation platform may turn challenges into opportunities.

KEYWORDS: Challenges, Ethiopia, on-site sanitation, urban

RECEIVED: November 30, 2022. **ACCEPTED:** January 16, 2023.

TYPE: Original Research

FUNDING: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was supported by Jimma University, Department of Environmental health science and technology as part of the Ph.D. dissertation. The finding reported in the article is fully the views of the authors and does not necessarily express the views of the sponsoring organization. The sponsoring institution (JU) only supported daily payment for the data collector and did not involve in data analysis, and interpretation.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

CORRESPONDING AUTHOR: Dereje Oljira Donacho, Departments of Health Informatics, College of Health Science, Mattu University, Oromia, Mattu, 318, Ethiopia. Email: dodbau3687@gmail.com

Introduction

Sanitation is a personal and private matter that is recognized as one of the most fundamental human rights.^{1,2} In many countries, the challenges of establishing universal access to and use of safe sanitation are rapidly becoming a major issue.³ The issue is global in scope, with disparities between countries and households, with more variation in Sub-Saharan Africa than in other regions.⁴ Lack of sanitation is more problematic in most of the cities of less developed countries.⁵

In many African countries, urban dwellers suffer from a lack of urban structures and, more commonly, water, sanitation, and hygiene facilities. The magnitude of the problem is greater in urban slums and densely populated urban centers.⁶ Most of the sanitation options in urban Africa are on-site sanitation (OSS).⁷ OSS options include pit latrines, septic tanks, compost toilets, and other drop-and-store sanitation options are used as major choices.⁸ The sanitation facility preferences of most households in many countries are networked water flush toilets. However, resource availabilities are the usual constraints for installation and maintenance. On the other hand, sewer systems (SS) are expensive and they are not affordable for the urban poor.⁹ Moreover, SS needs more water to flush, which

makes the case more complicated in areas where water supply coverage is low.¹⁰ OSS is also a relatively low-cost sanitation option and can be installed, and maintained with locally available resources.¹¹ Despite recent sanitation innovations, OSS technologies make it easier to treat and reuse fecal sludge, which has received a lot of attention as a sanitation option in this resource recovery era, but the problem in many African countries appears to be complicated. The challenge in safe onsite sanitation attributes to regulatory gaps in their installation, treatment, emptying, transportation, and disposal.¹² The containment methods are also filling up much faster than expected, increasing the need for emptying and exposing the users to additional expenses.¹³ The issue of socio-cultural appropriateness of sanitation systems, as well as community acceptance, are driving factors in developing an effective sanitation system in the global south.¹⁴

Evidence suggests that factors such as political commitment, technical capacity, financial constraints, rapid population growth, settlement topography, institutional capacity, and a lack of a policy framework all contribute to low safe access to urban sanitation in many countries.^{3,15,16} The challenges in one community are not necessarily from the same perspective; there



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

is no one-size-fits-all in dynamic, rapidly urbanizing, resource-constrained settings. Additionally, sanitation issues are more closely related to culture, household reactions to the problem, and community perception of waste handling, transportation, treatment, and resource recovery values in the community.¹⁷ Moreover, studies on this concept in Ethiopia are limited, particularly among community members, health workers, mothers, professionals, and key informants from their experience with the challenges.

Jimma town is one of the fastest-growing business centers in Ethiopia and is considered a market center for the South West areas of Ethiopia. In Jimma town, findings show only 13% of households have access to safely managed sanitation at the household level. The characteristics of the household determine the access level. The majority of the households used the onsite sanitation options.¹⁸ However, the information on the challenges of providing safe onsite sanitation stems from community perception, sanitation infrastructure, and the urban development system is limited. The existing evidence and rationale for the efforts to achieve sanitation targets are limited to establishing holistic, sustainable interventions. Therefore, this qualitative explanatory study was aimed at exploring the challenges associated with the low levels of safe urban sanitation access in the study area. Ultimately, the results of the study help to design policy frameworks for the development of integrated resource-oriented sanitation platforms.

Methods and Materials

Study setting

This study was conducted in Jimma Town, Southwest Ethiopia. It is located 352 km from the capital city (Addis Ababa). Jimma town is one of the fastest-growing towns in the country. Jimma town has a total population of 195 228 people living in 17 kebeles with an estimated 40 450 households.¹⁹ The town is located at 7°40'24.47" north latitude and 36°5'4.95" east longitude.

Study design and participants

This qualitative exploratory study was carried out from October 2020 to January 2021. An exploratory study design is a strategy used for collecting data to explain a phenomenon. It is a process that seeks to identify potential solutions or causes for a problem. The approach is used to investigate a phenomenon (a situation worth studying) that has not been studied before in the proper way.²⁰ This methodology was chosen in our case because there was little information available about the current urban on-site sanitation challenges, particularly in Jimma town. When there is limited information on the nature of the problem under consideration and insider perspectives on the research problem is required, exploratory research methods are preferred. In Ethiopia, dealing with home-based sanitation management is considered impolite in public. Residents'

challenges, practices, and experiences must be addressed to solve the problem. Understanding the nature of the issue aids in the safe disposal of human waste.

Data was collected through informant interviews, transit walks through the village, and focus group discussions (FGD). The number of interviews and the FGDs were fixed based on idea saturation. In this study, a total of 42 individuals participated, of which 12 participated in the interview and 30 participated in the focus group discussion. Community leaders, professionals working in the sanitation sector, urban Extension workers (UHEW), environmental health experts, and household mothers participated (Supplemental Material S1 Table). A total of 3 FGDs were conducted in different areas. Grouping was organized at Hermata Mentina (2 FGDs) and Mendera Kochi (1 FGD). The age of the participants ranged from 26 to 76, while the mean age was 43 years.

The criteria for the FGD participants were: having onsite sanitation facilities, speaking the local language (Afan Oromo or Amharic), and giving consent to participate. The homogeneity was maintained based on gender, language, and kebeles. Key informants were selected purposively based on their participation in the urban sanitation intervention, urban health extension workers' experience in the town, religious leaders, and elders.

Data collection methods and tools

Face-to-face communication was used to collect data using guide questions (Supplemental Material S2). The questions were pretested in Mattu town. The semi-structured interviews and focus groups were both conducted based on the study participants' voluntary participation; there was no refusal. The focus groups were held with members of the community (household heads, mothers, religious leaders, urban health workers (UHEW), and kebele leaders). This allows them to understand different points of view on the issue and express their opinions without fear. The participants formulated ground rules before the discussion to break the fear and respect for the idea of the other. Sanitation experts, religious leaders, elders, community representatives, waste handlers, and mothers participated in the interviews.

The interviews were conducted at households in the community and health facilities, but the FGDs were conducted at the kebele level. This was preferred to increase the active participation of the participants, and the interviews were conducted while on a transit walk in the town. The questions were also designed to facilitate open communication in coherent and easy ways for the respondents. The participants were respected for their responses, and additional questions were raised based on their answers until idea saturation was reached. The finding was also taken written and noted by the research assistant (ie, MSc Environmental Health) and the principal investigator (ie, PhD student).

In this data collection and analysis, the researcher as well as the research assistant were neutral in their view and had no relationship with the participants; they had built an easy way of communication through self-introduction to the participants. The research team explained the importance of the research, its benefits for the study area, and its risks to the participants before data collection started.

This study was conducted in 5 selected kebeles (small administrative units) in the town. Accordingly, Mandera Kochi, Hermata Mentina, Bacho Bore, Kofe, and Hermata Markato were included in the study. These kebeles were purposeful, based on the previous surveys in town and the sanitation status.^{18,21} All of the requested participants were interested in the research idea and participated voluntarily. All the participants gave their written informed consent before participating in the study. The research principal and the research assistant facilitated the FGDs at both sites (Medera Kochi and Hermata Mentina). In addition, in-depth interviews were conducted with carefully chosen participants. The notes, observations made during the field visits, and interview responses were written and noted. Both the interviews and the FGDs were audio-recorded, and the results were compared for missing information during note-taking. The FGD lasted an average of 2 hours. Finally, the notes from both note-takers were also compared for the quality of information gathered.

Trustworthiness

The quality of qualitative research is assured by the following standards: the satisfaction of credibility, participant selection, and transparency of the data collected.²² In this study, the information was gathered in a way that ensures its credibility and transferability. The participants were selected from different settings and different community structures using eligibility criteria and transit walk to access the doorsteps of the respondents, as confirmed by the research team. Additionally, the findings from the FGDs, in-depth interviews, and transit walk observation were triangulated in the analysis to strengthen the credibility of the findings. The validity and reliability were ensured by triangulating the data from the interviews with the information obtained from the FGD and then sharing the results with the attendees.

Data analyses

The steps taken in the analysis were illustrated in the figure below (Supplemental Material S3-Figure), which was developed from the literature.²³ The audio-recorded data in the FGDs were transcribed by the 2 researchers and compared with the notes taken during the discussion section by 2 note-takers. The transcription of the 4 notes (ie, 2 of which were taken during FGD's sections by 2 note-takers

and 2 transcriptions from audio recorders by 2 experts) was reviewed and compiled into 1 document for further analysis. The transcriptions were color-coded, checked for repetition of ideas and meanings in context, and finally thematically analyzed. The results were categorized into different themes for ease of display and contextualization for the readers. The results were presented based on the main themes discovered in the analysis. The findings were organized using the standard method for qualitative research and consolidated criteria for reporting qualitative research (Supplemental Material S4).

Ethical consideration and consent to participate

The Institutional Review Board (IRB) of Jimma University granted ethical approval. After being informed about the nature and purpose of the study, each study participant signed a written informed consent form before data collection began. Participants were informed that they could refuse to participate in the study at any time and withdraw at any time. The study's confidence was ensured at all stages.

Results and Discussion

The finding highlighted the main challenges to safe on-site sanitation in Jimma town (Figure 1). The main challenges were categorized into 3 major themes and 8 sub-themes originated from thematic analysis (Supplemental Material S5-Table). The major themes are listed below:

- Community perception of waste management
- Urban land use and informal settlements
- Sanitation planning, "operation and maintenance," and institutional setting

Major theme 1: Community perception of waste management

Under this theme, 3 sub-themes were discovered from the analysis.

Sub-theme 1.1: Belief. Anyone who deals with fecal matter is (feces) not mentally healthy. The question, discussed in detail with the participants, was: Does the community give a positive response to using feces-originated products for agriculture?

'.gonkuma, ta'uu bin danda'u. Udaa nyaachis jechuun, adabbii cimaa irratti raarwate' It is categorically unacceptable. It is the highest punishment to allow someone to use feces-derived products. [46-year-old father, in an interview]

The reasons were that all human feces products are risky for health, the community discriminates against a person dealing with human feces, and the farm products may absorb the wastes

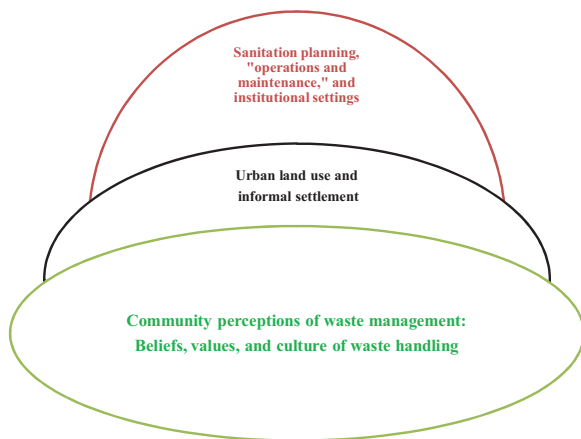


Figure 1. Schematic diagram of onsite sanitation challenges: The case of Jimma Town, Ethiopia, 2021.

inside. Collecting, transporting, and using human feces are also taboo in the community. In the town, many youths participated in the sanitation campaign, were employed in cleaning services, and mothers participated in road cleaning. They worked during the night hours just to decrease community discrimination. However, in recent years, this has somewhat improved.

In the FGD, contradicting concepts were noted by different individuals. The professionals affirm that if the waste is treated well, it is possible to use it as a resource. Environmental health experts and the UHEW argued for the use of resource recovery options as the most sustainable alternative to sanitation. Other studies support this viewpoint, concluding that resource-oriented sanitation options are sustainable sanitation options.^{24–26} The other groups—the elderly, mothers, and religious leaders—have different views on the reuse of feces-originating products.

In many countries worldwide, sanitation technology options are shifting to resource recovery-oriented technologies.^{26,27} This concept depends on the community's perception of waste management and the value that the community gives to resources recovered in the system.¹⁷

Sub-theme 1.2: Values. In the community, human feces are not a resource and should not be reused in any form. The majority of the participants confirm that the use of human feces for any public use is unacceptable in their community. The cultural attachments to using human feces as a resource like biogas, bio-char, or compost as fertilizer are likely negative perceptions. Many of the respondents suggest that using human feces for human usage is unethical within the community.

Sub-theme 1.3: Culture of waste handling. In this study, we explored the taboo related to the management (collecting, treating, transporting, and using) of human feces in the community. Handling feces in any form is not acceptable. Handling feces is not acceptable in the community, so emptying toilet fecal matter may cost more, and finding workers is a challenge.

Major theme 2: Urban land use and informal settlement

This major theme has 2 sub-themes: urban land use and illegal settlement.

Sub-theme 2.1: Urban land use. In households where land ownership is not legally approved, improving toilet facilities is likely to be impossible. The informal settlements that are growing without the approval of the city authorities lack most of the basic infrastructures including sanitation access. Most of the households, especially in the urban slums of the town, do not have access to sanitation facilities. Road infrastructure and vacuum trucks for emptying fecal sludge are the main challenges in densely populated households. The land space preserved for the replacement of full toilets is not available in most households. This is because of land use problems by the dwellers. The land provided by the government is not adequate in space. The land space allocated to households in current urban planning does not correspond to the available sanitation technology. The land provision for housing improvement in the current housing program in urban cannot support the use of pit latrines as sustainable sanitation.

“..... in the current land supplementation, it is 165–180 m². The pit latrine is the toilet facility that I am using. To control flies, I know that it needs to be at least 6 meters away from the main house. How I can build on such a small plot of land?” [According to one of the 45-year-old FGD participants]

This finding shows that, because of insufficient land space, the current land supplementation forces the community to build pit toilets up to the common wall with the main house. Most households in the town rely on onsite sanitation, such as traditional pit latrines, ventilated improved pit latrines, and, to a lesser extent, septic tank flushing.¹⁸ This technology, by its nature, needs large land space, periodic emptying, and low water usage as its benefits over other options.⁹

Sub-theme 2.2: Illegal settlements. The household's local, known as “chereka bet,” lacks improved toilets, and they anticipate displacements. The buildings are built with temporary materials during the night (locally known as “Chereka bet,” which means “the house built during the night hour”). They don't even have permanent roofing for the main house, which houses a large number of people. There is no improved sanitation facility in place, nor is one planned for the future. This is why they neglect it, anticipating displacement due to informal land ownership without government recognition. This finding is consistent with findings from Jimma Town focused on informal settlements.²⁸

Major theme 3: Sanitation planning, operation and maintenance, and institutional setting

The main issues addressed under this theme were the challenges related to urban sanitation planning, operation and

maintenance, and institutional settings. Under this major theme, 3 sub-themes were discovered.

Sub-theme 3.1: Operation and Maintenance of sanitation technologies. The sanitation system in many buildings is not functional, not in place, or restricted for public service. Toilet upgrades are given low priority during construction and maintenance. The availability of construction materials is limited in the market. On the other hand, the cost of sanitation facility construction materials is expensive for the majority of residents. Some of the initiatives are more resource-oriented toward facilities like compost toilets, but they are not acceptable to the communities. Toilet facilities in the town are not area-specific and standardized in their design, material specification, and site selection.

Sub-theme 3.2: Sanitation planning. Different opinions and views were raised, but the main message of the participants was that most of the urban infrastructure does not include a sanitation scheme. Nearly all participants (40 out of 42) suggest the urban infrastructure has a gap in its consideration of sanitation issues. The priority of building construction (residential houses) is not the toilet facilities in its planning phase. In residential houses, toilet construction is optional and built when the building is completed. In some cases, a temporary plan is included in the planning and construction phase. This fact is not limited to individual households but also institutional settings. Some public gatherings lack toilet facilities entirely. Even if one wanted to build a public toilet, the amount of open space preserved for such a purpose is limited. According to the WHO, Sanitation Safety Planning (SSP) is a step-by-step risk-based approach to assisting in the implementation of local-level risk assessment and management for the sanitation service chain²⁹. It includes involvement in every stage of the sanitation value chain, from containment to conveyance, treatment, and disposal³⁰. Planning is the basis for future development as well as a solution to the current sanitation crisis. Following this fact, the challenges in this study area were a significant lack of inclusive sanitation planning.

Sub-theme 3.3: Institutional setting. The sanitation sector is dispersed; different segments of the government sectors work on sanitation separately with dispersed efforts. In municipal offices, urban planners and land management units, urban health extension units in the health sector, and environmental protection as other sectors. Each has its own goal, target, job description, annual plan, and budget for making the environment a more sustainable and comfortable town. Despite these efforts, untreated waste is dumped into a river that runs through town (the Hawetu River). The finding is consistent with the quantitative household surveys in the town that only 13% of households have access to safely managed sanitation services.^{18,31} On the same topic of poor development activities, the majority of participants mentioned a lack of inter-sector

collaboration. When one sector is due for intervention in sanitation, the others may not collaborate which leads to unsuccessful interventions in sanitation sectors. Regulatory enforcement interventions are based on each institution cooperating with the other and looking to the other for legal enforcement in cases of environmental pollution misconduct, including open defecation.

Conclusions

This study revealed that waste management and reuse of feces products are influenced by the community perception that is attached to cultural beliefs and the value given to the resources recovered from the waste in the community. The challenge is that in promoting resource-oriented sanitation options, the community relies on the community's perception of human feces reuse, which is completely unacceptable in this current study area. The achievement of safe sanitation for urban needs high inter-collaboration among different sectors that are currently working differently for the same goal. Because of land scarcity and a lack of a legal framework to standardize sanitation technologies in the current urban expansion, urban planning, land use, and urban infrastructure expansion are more complicated for those illegal settlements. Moreover, the challenge of improving sanitation access in the town needs an integrated multi-sectoral collaboration and policy framework that incorporates sufficient land space for households that incorporate the current sanitation technology in use. Additionally, efforts in innovation and incubation of sanitation technologies that can alleviate this complicated problem are very important.

Acknowledgements

I would like to express our sincere appreciation to Jimma University, Jimma town health department, respective health centers, health extension workers, urban planners, health experts, and Mr. Gutema Haile and Thanyang Koang for their contribution to the data collection. I would also like to thank the data collectors, supervisors, study participants, and all others involved in any process of the study.

Author Contributions

DO draft the research idea and developed the study protocol, collect the data, draft the report, and interpreted the finding. MH, NE, AB, and GT were involved in the analysis and interpretation of the findings. DO produce the initial draft of the paper; MH, NE, AB, and GT provided feedback and contributions to various sections. All authors reviewed and approved the final content.

Availability of Data and Materials

The datasets generated and analyzed during the current study are not publicly available because they are confidential to protect the participants' anonymity but are available from the corresponding author at reasonable request.

Consent for Publication

Not applicable.

Ethics Approval and Consent to Participate

Ethical approval was obtained from the Institutional Review Board (IRB) of Jimma University. Before the start of data collection, written informed consent was obtained from each of the study participants after information was provided about the nature and objective of the study. Participants were informed that they have the right not to participate in the study or can withdraw at any time point. Confidentiality was assured at all levels of the study.

ORCID iDs

Dereje Oljira Donacho  <https://orcid.org/0000-0001-6145-2914>

Negasa Eshete Soboksa  <https://orcid.org/0000-0003-3451-175X>

Supplemental Material

Supplemental material for this article is available online.

REFERENCES

- Meier BM, Kayser GL, Amjad UQ, Bartram J. Implementing an evolving human right through water and sanitation policy. *Water Policy*. 2013;15:116-133.
- Winkler IT. The Human Right to sanitation. *Univ Pa J Int Law*. 2015;37:1331.
- Bishoge OK. Challenges facing sustainable water supply, sanitation and hygiene achievement in urban areas in sub-Saharan Africa. *Local Environ*. 2021;26:893-907.
- UN-Water. Snapshot of global and regional urban water, sanitation and hygiene inequalities. UN-Water. 2021. Accessed March 28, 2022. <https://www.unwater.org/snapshot-of-global-and-regional-urban-water-sanitation-and-hygiene-inequalities/>
- Lüthi C, Willetts J, Hoffmann S. Editorial: city-wide sanitation: the urban sustainability challenge. *Front Environ Sci*. 2020;8:585418.
- Schrecongost A, Pedi D, Rosenboom JW, Shrestha R, Ban R. Citywide inclusive sanitation: a public service approach for reaching the urban sanitation SDGs. *Front Environ Sci*. 2020;8:19.
- Daudey L. The cost of urban sanitation solutions: a literature review. *J Water Sanit Hyg Dev*. 2018;8:176-195.
- Andersson K, Otoo M, Nolasco M. Innovative sanitation approaches could address multiple development challenges. *Water Sci Technol*. 2018;77:855-858.
- Tsinda A, Abbott P, Pedley S, et al. Challenges to achieving sustainable sanitation in informal settlements of Kigali, Rwanda. *Int J Environ Res Public Health*. 2013;10:6939-6954.
- Sharma N, Gupta S, Vyas AD. Estimation of fuel potential of faecal sludge in a water scarce city, a case study of Jaipur Urban, India. *Water Pract Technol*. 2020;15:506-514.
- Hashimoto K. Institutional frameworks for onsite sanitation management systems. Asian Development Bank Institute. 2021. Accessed August 2, 2022. <https://think-asia.org/handle/11540/13831>
- Weststrate J, Gianoli A, Eshuis J, Dijkstra G, Cossa IJ, Rusca M. The regulation of onsite sanitation in Maputo, Mozambique. *Utilities Policy*. 2019;61:100968.
- Bhagwan JN, Still D, Buckley C, Foxon K. Challenges with up-scaling dry sanitation technologies. *Water Sci Technol*. 2008;58:21-27.
- Prescott MF, Dobbie MF, Ramirez-Lovering D. Green infrastructure for sanitation in settlements in the Global South: a narrative review of socio-technical systems. *Sustainability*. 2021;13:2071.
- Andersson K, Dickin S, Rosemarin A. Towards "sustainable" sanitation: challenges and opportunities in urban areas. *Sustainability*. 2016;8:1289.
- Peal A, Evans B, Ahilan S, et al. Estimating safely managed sanitation in urban areas; lessons learned from a global implementation of excreta-flow diagrams. *Front Environ Sci*. 2020;8:1.
- Khalid A. Human excreta: a resource or a taboo? Assessing the socio-cultural barriers, acceptability, and reuse of human excreta as a resource in Kakul Village District Abbottabad, Northwestern Pakistan. *J Water Sanit Hyg Dev*. 2018;8:71-80.
- Donacho DO, Tucho GT, Hailu AB. Households' access to safely managed sanitation facility and its determinant factors in Jimma town, Ethiopia. *J Water Sanit Hyg Dev*. 2022;12:217-226.
- CSA-Ethiopia. *Population-Projection-At-Wereda-Level-From-2014-2017*. Central Statistical Agency; 2013. Accessed April 8, 2021. <http://www.statsethiopia.gov.et/population-projection/>
- Moen K, Middelthun A-L. Qualitative research methods. In: Laake P, Benestad H, Olsen B, eds. *Research in Medical and Biological Sciences*. Elsevier; 2015:321-378.
- Donacho DO, Tucho GT, Zeine Ousman W, Both TK, Hailu AB. Evidence-based user interface sanitation technology selection for Urban Slums: a multi-criteria analysis; the case of Jimma Town, Ethiopia. *Environ Health Insights*. 2022;16:11786302221127270.
- Mays N, Pope C. Quality in qualitative research. In: Pope C and Mays N eds. *Qualitative Research in Health Care*. John Wiley & Sons, Ltd; 2020:211-233.
- Bazeley P. *Qualitative Data Analysis: Practical Strategies*. SAGE; 2013.
- Lima PDM, Lopes TADS, Queiroz LM, McConville JR. Resource-oriented sanitation: identifying appropriate technologies and environmental gains by coupling Santiago software and life cycle assessment in a Brazilian case study. *Sci Total Environ*. 2022;837:155777.
- Hashemi S, Boudaghpour S. Economic analysis and probability of benefit of implementing onsite septic tank and resource-oriented sanitation systems in Seoul, South Korea. *Environ Technol Innov*. 2020;18:100762.
- Salana S, Banerji T, Kumar A, et al. *Resource Recovery-Oriented Sanitation and Sustainable Human Excreta Management. Sustainable Resource Management: Technologies for Recovery and Reuse of Energy and Waste Materials*. John Wiley & Sons; 2021.
- Katukiza AY, Ronteltap M, Niwagaba CB, Foppen JW, Kansime F, Lens PN. Sustainable sanitation technology options for urban slums. *Biotechnol Adv*. 2012;30:964-978.
- Abebe MS, Derebew KT, Gemedo DO. Exploiting temporal-spatial patterns of informal settlements using GIS and remote sensing technique: a case study of Jimma city, southwestern Ethiopia. *Environ Syst Res*. 2019;8:6.
- WHO. *Sanitation Safety Planning*. WHO; 2015. <https://www.who.int/publications-detail-redirect/9789241549240>
- Abey Suriya K, Willetts J, Carrard N, et al. City sanitation planning through a political economy lens. *Water Alternatives*. 2019;12:907-929.
- Weldezzgina D, Muleta D. Bacteriological contaminants of some fresh vegetables irrigated with Awetu River in Jimma Town, southwestern Ethiopia. *Adv Biol*. 2016;2016:1-11.