ISSN: 3049-7272

Research Article

Journal of Biomedical Sciences and Biotechnology Research

Groundwater Quality Assessment at Cemeterial Area and Non-Cemeterial Area: A Case of Mwanakwerekwe and Kiembesamaki in Urban District of Unguja, Zanzibar

Raya Rashid Amour*, Abdul AJ Mohamed and Said S Bakar

Department of Natural Sciences, the State University of Zanzibar-SUZA, Tanzania

***Corresponding author**
Raya Rashid Amour, Department of Natural Sciences, the State University of Zanzibar-SUZA, Tanzania.

Received: October 21, 2025; **Accepted:** November 14, 2025; **Published:** November 20, 2025

ABSTRACT
This study presents a comparative analysis of groundwater quality in Mwanakwerekwe Cemetery and the non-**cemeterial area** of Kiembesamaki, both located in the Urban/West District of Unguja Island, Zanzibar. Groundwater is the primary source of drinking water in Unguja, Zanzibar, yet its quality is threatened by anthropogenic activities such as burial practices near residential areas where water sources are found including wells. This study assesses the physicochemical parameters of groundwater in dug wells at the cemeterial area (Mwanakwerekwe) near the Mwanakwerekwe cemetery and the **non-cemeterial area** (Kiembesamaki). A total of 15 water samples were collected 9 from Mwanakwerekwe and 6 from Kiembe Samaki in Urban West region of Zanzibar Island. These samples were analysed for various parameters including, **salinity, hardness, pH, EC, TDS, NO_2^-, Cl^-, Ca^{2+}, Mg^{2+}, SO_4^{2-}, Na^+, K^+, PO_4^{3-} and Fe^{2+}** through both in-situ measurements following standardized water testing protocols and laboratory analysis carried out by the Zanzibar Water Authority (ZAWA), complemented by statistical evaluation techniques. The results revealed significant variations between the two areas. **Phosphate** levels were notably higher in **Mwanakwerekwe** with a mean concentration of 50.67 mg/L compared to 21.70 mg/L in **Kemba Samaki** ($p = 0.035$). Similarly, **salinity** was significantly higher in Mwanakwerekwe (Mean = 0.396 psu) than in Kiembe Samaki (Mean = 0.275 psu, $p = 0.024$). **Magnesium** concentrations were also elevated in Mwanakwerekwe, with a mean of 38.83 mg/L compared to 25.91 mg/L in Kiembe Samaki, though this difference was not statistically significant ($p = 0.096$). Chloride levels were higher in Mwanakwerekwe (Mean = 66.96 mg/L) compared to Kiembe Samaki (Mean = 47.27 mg/L), but the difference was not statistically significant ($p = 0.091$). Other parameters such as **pH, EC, TDS,** and **Hardness** did not show significant differences between the two areas. The pH ranged from 6.73 to 7.66 in Mwanakwerekwe and 7.13 to 7.77 in Kiembe Samaki, while EC values averaged 861.22 µS/cm in Mwanakwerekwe and 674.17 µS/cm in Kiembe Samaki. TDS concentrations averaged 560.67 mg/L in Mwanakwerekwe and 456.67 mg/L in Kiembe Samaki. **Hardness** values were generally higher in Kiembe Samaki (Mean = 635 mg/L) than in Mwanakwerekwe (Mean = 538.89 mg/L), but the difference was not statistically significant ($p = 0.189$). A strong positive correlation was observed between electrical conductivity (EC) and total dissolved solids (TDS) at M/Kwerekwe with a coefficient of determination (R^2) of 0.987, indicating a near-perfect linear relationship. At K/Samaki, the correlation between EC and TDS was moderate (Figure 4b), with an R^2 value of 0.716. These findings suggest that both parameters are predominantly influenced by the concentration of dissolved constituents present in the water. The findings suggest that groundwater wells in Mwanakwerekwe, particularly near the cemetery, is more prone to contamination, with **phosphate, salinity,** and **magnesium** levels exceeding the World Health Organization (WHO) permissible limits. In contrast, Kiembe Samaki groundwater wells generally met these standards, posing fewer risks to human health. Based on these results, it is recommended that regular wells monitoring and mitigation strategies be implemented, particularly in areas close to cemeteries.

Keywords: Groundwater Quality, Mwanakwerekwe Cemetery, Kiembesamaki Non-Cemeterial, Physicochemical Parameters, Zanzibar Island

Introduction
Groundwater is a major source of available drinking water worldwide which is estimated for about 95% by and about 91% by Groundwater is the main source of water supply in both rural and urban populations [1-3]. It is a primary water source for domestic, agricultural, and industrial uses in many countries [4]. Groundwater was considered to be very clean and safe in the past but nowadays it is getting polluted with the rapid growth of urban and industrial activities, particularly in developing countries, where proper waste disposal measures are not followed consistently [5].

Citation: Raya Rashid Amour, Abdul AJ Mohamed, Said S Bakar. Groundwater Quality Assessment at Cemeterial Area and Non-Cemeterial Area: A Case of Mwanakwerekwe and Kiembesamaki in Urban District of Unguja, Zanzibar. J Biomed Sci Biotech Res. 2025. 3(4): 1-6. DOI: doi.org/10.61440/JBSBR.2025.v3.32

In Tanzania's mainland, more than 25% of the domestic water consumption comes from groundwater sources [6]. The population growth and distribution have led the increasing of water demand [7]. In most cities and towns, sewer networks are either non-existent, inadequate or in an advanced state of disrepair. For example, only about 15% of Dar es Salaam residents are connected to the city sewer network that was built in the late 1950s [8]. Many residents now depend on groundwater sources, mostly from shallow onsite wells for drinking and other domestic use, the supply of safe drinking water has remained a challenge, with poor communities relying on shallow wells for their daily domestic water needs [9].

In Zanzibar, groundwater is a significant freshwater resource for both urban and rural areas. The dependency of groundwater sources is more than 95%, since it is the major available water source that meets the requirements of the growing population and economic sectors [10]. The Zanzibar sewerages system dates back to the 1920s serves only about 18% of the population [8]. Several pollution assessment studies have been carried out in Zanzibar [8]. Accelerated and uncontrolled human activities, such urbanization, and solid waste disposal near the water wells may have a strong impact on the quality of groundwater sources [11]. Unprotected dug wells, which are considered highly susceptible to contamination with pathogenic organisms. More importantly, the poorly built or poorly located septic systems for household wastewater also have made the water quality inferior and inadequate [12]. However, cemeteries have received little attention as potential sources of pollution [13]. In many countries, the mismanagement of human corpses has presented a serious problem [14]. World Health Organization (WHO) suggested that drinking water In Unguja Island, cemeteries are commonly established close to the household and groundwater sources in many areas. They are frequently built near communities due to religious and cultural reasons or a lack of land availability. Although there is an ongoing city water supply system, people living around the study site and its territories are still exploiting groundwater for daily use. This may be due to different reasons including water supply problems, improper management of the city, inefficient regulations, or unwillingness to pay for use. These circumstances could be witnessed in highly populated areas such as Mwanakwerekwe, whereby serious environmental consequences, particularly the deterioration of groundwater quality are likely to occur. cemeteries represent potential environmental threats etc [15-20]. Most existing cemeteries were established without regarding the possible threats to the local environment and the surrounding community [13].

Mwanakwerekwe cemeteries are the common Muslim Cemeteries located in the Zanzibar Urban/West Region. This Muslim cemetery is believed to have begun burials in the late 19th century estimated around 1892s [21]. In Unguja Island, cemeteries are commonly established close to the household and groundwater sources in many areas. They are frequently built near communities due to religious and cultural reasons or a lack of land availability. Although there is an ongoing city water supply system, people living around the study site and its territories are still exploiting groundwater for daily use. This may be due to different reasons including water supply problems, improper management of the city, inefficient regulations, or unwillingness to pay for use. These circumstances could be witnessed in highly populated areas such as Mwanakwerekwe, whereby serious environmental consequences, particularly the deterioration of groundwater quality are likely to occur. The biological process of contamination occurs whenever a cope is buried, there are several alterations. Soft tissue starts to decompose a few hours after death due to autolysis mechanisms, subsequently, these products can be percolated through the soil to the water taken after precipitation, and contaminate the groundwater [22]. Infiltration and percolation of rainwater through the soil graves allow the migration of several different pollutants, which can pollute the aquifers [23].

supplies such as wells and springs should be away from cemetery areas at least 30 m [15]. Cemeteries have some adverse effects on the environment by increasing the concentrations of some organic and inorganic substances corpses is not permissible in wells with 250 m depth from which potable water is provided [16]. Cemeteries have the possibility of contaminating soil and water [17]. Many researchers are convinced that all cemeteries represent potential environmental threats etc. Most existing cemeteries were established without regarding the possible threats to the local environment and the surrounding community [13]. Mwanakwerekwe cemeteries are the common Muslim Cemeteries located in the Zanzibar Urban/West Region. This Muslim cemetery is believed to have begun burials in the late 19th century estimated around 1892s [21].

Some studies use this framework to measure groundwater parameters and come up with positive results. Therefore, this study aims to assess the quality of groundwater wells located in areas surrounding cemeteries, that considered as potential sources of groundwater contamination compared to non-cemetery location, focusing on analysing the physicochemical parameters such as nitrites, sulfates, chlorides, pH, electrical conductivity, salinity, hardness, temperature, calcium, magnesium, sodium, potassium, phosphate, and iron. Given the possible environmental risks, it is essential to implement effective groundwater protection measures during both the active burial phase and after the cemetery has reached full capacity. From the above-elaborated facts, therefore, further research is necessary to comprehensively assess the long-term impacts of cemeteries on groundwater quality and the broader environment.

Materials and Methods

Study Area

The areas selected for the present study are Mwanakwerekwe cemetery and Kiembe Samaki located in Urban West Unguja shown in (Figure 1).

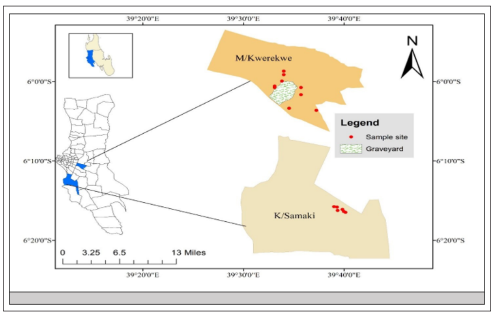

Figure 1: Map of Water Sample Sites in Mwanakwerekwe and Kiembe Samaki

Source: GPS field data collected, map generated using GIS software (2025)

Sampling and Analysis

- **Sample Size:** 15 total (9 Mwanakwerekwe, 6 Kiembesamaki)
- **Measured Parameters:** nitrites (NO_2^-), chloride (Cl^-), calcium (Ca^{2+}), magnesium (Mg^{2+}), sulfates (SO_4^{2-}), sodium (Na^+), potassium (K^+), phosphate (PO_4^{3-}), pH, salinity, hardness, electrical conductivity (EC), temperature, Total Dissolved Solid (TDS) and iron (Fe^{2+})
- **Methods:** In-situ readings and lab analysis by Zanzibar Water Authority (ZAWA).

Statistical Approach

Data Analysis

Statistical Package for Social Science (SPSS) version 25 was used for the statistical data analysis of measured parameters. Descriptive statistics including One Way ANOVA statistical methods of analysis were used in the study. The correlation matrix, which is based on Pearson's correlation coefficient, was utilized for displaying relationships between variables. During the data analysis the factors such as correlation analysis between and within the analysed parameters, and their levels of differences were determined. The significant differences for analysed parameters were also demonstrated through Analysis of Variance (ANOVA).

Results and Discussion

Table 1: The Mean Levels of the Physico-Chemical Parameters

Physico-Chemical Parameters	M/Kwerekwe Site	K/Samaki Site	p-value
pH	7.2011	7.4817	0.076
Electrical Conductivity	861.22	674.17	0.07
Total Dissolved Solids	560.67	456.67	0.122
Temperature	29.78	29.95	0.463
Salinity	0.3956	0.2750	0.024
Hardness (as $CaCO_3$)	538.89	635.00	0.189
Iron	0.0222	0.0133	0.489
Chloride	66.9611	47.27333	0.091
Calcium	165.33	213.33	0.067
Sulphate	75.1544	96.00	0.768
Phosphate	50.66589	21.7867	0.035
Magnesium	38.83067	25.91133	0.096
Potassium	40.811	21.917	0.528
Nitrite	0.0130	0.0090	0.568
Sodium	61.3922	54.3517	0.342

Note: All are mg/L except; pH no unit, temperature (°C), EC (µS/cm) and salinity (psu)

pH

The Mean pH of M/Kwerekwe is 7.20 mg/L and K/Samaki Mean is 7.48 mg/L. The pH values for both water sources are near neutral, with K/Samaki being slightly more alkaline than M/Kwerekwe. Both values fall within the acceptable range for drinking water [24]. The higher pH values observed suggest that carbon dioxide and carbonate-bicarbonate equilibrium is affected more due to changes in physical-chemical condition [25].

Iron

The mean iron concentration in water samples from M/Kwerekwe was found to be 0.0222 mg/L, while K/Samaki exhibited a lower mean value of 0.0133 mg/L. Both values fall well within the permissible limits set by the World Health Organization (0.3 mg/L), indicating that iron contamination is not a significant concern at either site. However, M/Kwerekwe demonstrates a marginally higher concentration, which may reflect localized environmental influences or infrastructure characteristics.

Sulfates

The mean sulfates of M/Kwerekwe are 75.1544 mg/L and K/Samaki mean is 96.00 mg/L. Sulfates concentration is higher in K/Samaki as shown in (Table 1), which might contribute to the differences in taste and water chemistry between the two sources.

Phosphate

Phosphate levels in M/Kwerekwe are significantly higher 50.67 mg/L than in K/Samaki 21.70 mg/L, with a p-value of 0.035 as represented in (Table 1). This indicates potential contamination from cemetery leachates, as phosphate levels are much higher than the WHO-recommended limit of 1 mg/L [24]. Sources of phosphorus in the cemetery include tissue, bone, and teeth from corpses and fertilizers, similarly, the situation revealed in the study research of [26].

Magnesium

Magnesium levels are higher in M/Kwerekwe, which could also contribute to water hardness. Magnesium levels in M/Kwerekwe (38.83 mg/L) are higher than in K/Samaki (25.91 mg/L), contributing to overall water hardness. This elevation may be associated with the presence of nearby cemeteries, where human decomposition can act as a diffuse source of magnesium to underlying groundwater systems. Given that the human body contains approximately 25 g of magnesium 60% stored in bones and 40% in muscles and soft tissues [27].

Potassium

The mean Potassium of M/Kwerekwe is 40.811 mg/L whereas K/Samaki Mean is 21.917 mg/L M/Kwerekwe has almost double the potassium concentration of K/Samaki, which might affect the overall mineral balance. Potassium is higher in M/Kwerekwe with value of 40.81 mg/L (Table 1), indicating higher mineral content.

Nitrite

The mean nitrite concentration in groundwater from M/Kwerekwe was 0.01300 mg/L, while that from K/Samaki was slightly lower at 0.00890 mg/L. Although M/Kwerekwe exhibited a marginally higher nitrite level, both values remain within the acceptable limits for potable water as specified by [24]. These low concentrations suggest minimal immediate health concerns; however, slight elevation in M/Kwerekwe may warrant further scrutiny due to potential localized sources such as cemeterial leachate or sewer line leakage.

Sodium

The mean Sodium of M/Kwerekwe Mean is 61.8222 mg/L while the mean of K/Samaki is 54.3517 mg/L. Sodium content is higher in M/Kwerekwe compared to K/Samaki, though both are moderate and may not pose health risks in drinking water. Sodium levels in both areas slightly exceed the WHO limit of 50 mg/L, with M/Kwerekwe having 61.39 mg/L and K/Samaki at 54.35 mg/L. From the comparison of the two water sources, it is clear that M/Kwerekwe has higher concentrations of dissolved solids, phosphate, and potassium, along with higher electrical conductivity and temperature. On the other hand, K/Samaki has higher water hardness, calcium, and sulfates content. Both water sources exhibit pH values that are close to neutral, and neither source shows alarming levels of any harmful contaminants based on the provided data.

Anova

Variation in the levels of parameters between the samples was tested statistically using One-way ANOVA to compare whether the difference between samples of water is significant or not. The ANOVA results indicate statistical significance for some parameters. Significant differences were found in parameters like salinity and phosphate where ($p < 0.05$). Hence, the pH, P-value is 0.024, meaning there is a significant difference between the two areas in pH levels, and Phosphate, P-value 0.034 shows significant differences between the areas. Electrical Conductivity and TDS, are not statistically significant as P-values exceed 0.05 (p –value > 0.05). This confirms that these parameters are higher near Mwanakwerekwe Cemetery, indicating groundwater contamination is due to the vicinity of cemeteries.

Analysed Water Quality Parameters

This is an analysis of the mean concentrations of parameters in water samples collected from two locations, M/Kwerekwe and K/Samaki. The graphical representation of the mean bar graph and scattered-plot line graph presents a comparison between the two locations in terms of these key water quality parameters.

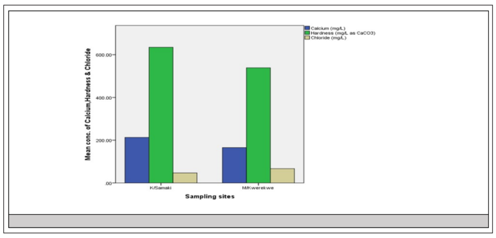

Figure 2: Concentration of Calcium, Hardness, and Chloride in Water Samples

The above graph above shows the mean concentration of three important water quality parameters. Calcium (Ca), hardness (mg/L as $CaCO_3$), and chloride (Cl) for two sampling sites, K/Samaki and M/Kwerekwe. The mean concentration of Ca (mg/L), hardness (mg/L as $CaCO_3$), and Cl (mg/L) in water samples collected from two locations. This figure analyzed that, the calcium and hardness levels are higher in Kiembe Samaki, which could affect the usability of water in domestic settings. According prescribe limit, chloride levels, which contribute to salinity, are higher in Mwanakwerekwe [28]. The mean Chloride of M/Kwerekwe is 66.9611 mg/L and the K/Samaki mean is 47.2733 mg/L. Hence, chloride levels are higher in M/Kwerekwe.

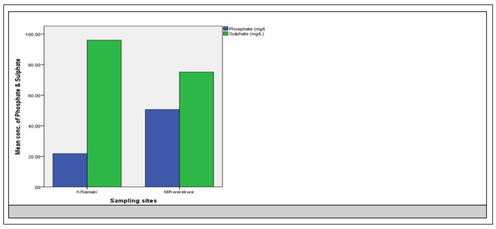

Figure 3: Concentration of Phosphate & Sulphate in Water Samples

The graph shows a clear disparity in the concentrations of nitrite and iron between the two sampling sites. The phosphate concentration is much higher in Mwanakwerekwe as shown in (figure 2) above, indicating potential contamination from cemetery leachates whereas Sulphate concentration is higher in Kiembe Samaki. Sulphate conc. is 75.15 mg/L of M/Kwerekwe and 96.00 mg/L of K/Samaki. Hence, Sulphate concentrations are higher in K/Samaki, which may impact the water's taste and quality. Phosphate in M/Kwerekwe is 50.67 mg/L and K/Samaki is 21.70 mg/L. Phosphate levels in M/Kwerekwe are more than double those in K/Samaki. High phosphate levels may indicate contamination from the cemetery. WHO recommends 1 mg/L for drinking water, so this is well above safe limits.

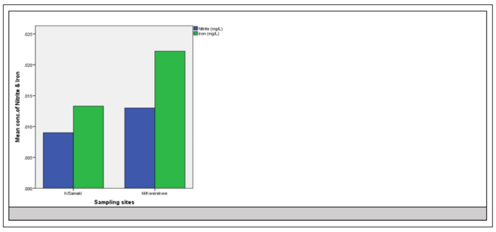

Figure 4: Concentration of Nitrite & Iron in Water Samples

The graph highlights a clear disparity in the concentrations of Nitrite and Iron between the two sampling sites as shown in Figure 3. Both Nitrite and Iron levels are low in both areas, but the concentration of iron in water samples is slightly higher in Mwanakwerekwe while Nitrite concentrations are low in both areas and within WHO limits (0.1 mg/L), with M/Kwerekwe showing slightly higher concentration. As Iron conc. of M/Kwerekwe is 0.0222 mg/L and K/Samaki is 0.0133 mg/L. Both areas have low iron concentrations, but M/Kwerekwe shows slightly more, though still within safe limits (WHO guideline: 0.3 mg/L).

A strong positive correlation was observed between electrical conductivity (EC) and total dissolved solids (TDS) at M/Kwerekwe (Figure 4a), with a coefficient of determination (R^2) of 0.987, indicating a near-perfect linear relationship. At K/Samaki, the correlation between EC and TDS was moderate (Figure 4b), with an R^2 value of 0.716. These findings suggest that both parameters are predominantly influenced by the concentration of dissolved constituents present in the water.

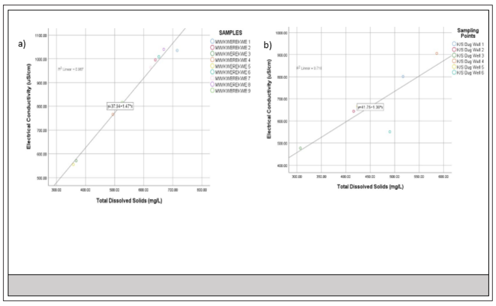

Figure 5: EC-TDS Correlation in Water Samples

Conclusion

This study demonstrates localized groundwater contamination in Mwanakwerekwe, Zanzibar, potentially linked to cemetery leachates. Comparative analysis revealed significantly elevated phosphate and salinity levels in Mwanakwerekwe wells compared to those in Kiembe Samaki, indicating anthropogenic impact from burial practices. Although variations in pH, total dissolved solids (TDS), electrical conductivity (EC), and hardness were observed, these were not statistically significant, suggesting limited spatial dispersion of contamination. Strong correlations between EC and TDS and between calcium and hardness highlight mineral dissolution dynamics in affected aquifers. Notably, phosphate and magnesium levels in Mwanakwerekwe exceeded World Health Organization (WHO) guidelines, raising potential risks to human health for populations reliant on untreated groundwater. In contrast, water samples from Kiembe Samaki largely complied with WHO standards.

These findings underscore the need for regular groundwater monitoring, adoption of safe burial practices, and establishment of buffer zones around cemeteries. Public health authorities should prioritize risk mitigation measures and community education to safeguard drinking water quality. Further research incorporating seasonal variation and hydrogeological mapping is recommended to fully assess long-term environmental impact and inform regional water resource policies.

Recommendations

To address the observed groundwater wells contamination near Mwanakwerekwe cemetery, the following measures are proposed:

- **Routine Monitoring:** Implement systematic surveillance of physicochemical water parameters in wells adjacent to cemeterial land use to detect early signs of contamination.
- **Protective Buffer Zones:** Establish regulated land-use buffers around cemeteries to minimize leachate migration into surrounding aquifers.
- **Leachate Containment Infrastructure:** Introduce engineered barriers or containment systems within burial grounds to prevent the infiltration of organic and inorganic pollutants.
- **Public Awareness Campaigns:** Promote education and outreach programs targeting local communities on the risks of consuming untreated groundwater and the importance of water source protection.
- **Policy and Regulatory Frameworks:** Strengthen environmental legislation pertaining to cemetery siting, groundwater protection, and water quality standards to ensure sustainable resource management.
- **Further Research:** Encourage multidisciplinary studies incorporating seasonal sampling and hydrogeological modelling to elucidate long-term contamination trends and inform public health interventions.

These targeted strategies are essential to preserve groundwater integrity and mitigate exposure risks in vulnerable urban settings.

Acknowledgement

Special appreciation is expressed to academic supervisors Dr. Said S. Bakari and Dr. Abdul A. J. Mohamed for their expert mentorship, patience, and valuable insights that greatly enhanced the quality of this study. Acknowledgment is also due to Madam Mulhat, Assistant Chemistry Lecturer at Sumait University, for her consistent support and technical advice.

Gratitude is further extended to the faculty members of the Department for their constructive feedback, and to the then Zanzibar Water Authority (ZAWA) and the Water Institute (WI) for granting access to laboratory facilities and data resources. The author also recognizes the encouragement received from family, friends, and classmates at the State University of Zanzibar (SUZA), whose support contributed meaningfully to the completion of this work.

References

1. Bowell RJ, McEldowney S, Warren A, Matthew B, Bwankuzo M. Biogeochemical factors affecting groundwater quality in central Tanzania. In: Appleton JD, Fuge R, McCall GJH, editors. Environmental Geochemistry and Health. Geological Society Special Publications London. 1996. 107-130.
2. World Health Organization. Trihalomethanes in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 2005.
3. Palamuleni LG. Effect of sanitation facilities, domestic solid waste disposal and hygiene practices on water quality in Malawi urban poor areas: a case study of South Lunzu township. Phys Chem Earth. 2002. 27: 845-850.
4. Andrew Ako Ako, Jun Shimada, Takahiro Hosono, Kimpei Ichiyanagi, George Elambo Nkeng, et al. Evaluation of groundwater quality and its suitability for drinking, domestic, and agricultural uses in the Banana Plain (Mbanga, Njombe, Penja) of the Cameroon Volcanic Line. Environ Geochem Health. 2011. 33: 559-575.
5. Nadu T. Ground Water Quality in Coimbatore, Tamil Nadu along Noyyal River. 2005. 50: 187-190.
6. Elisante E, Muzuka ANN. Occurrence of nitrate in Tanzanian groundwater aquifers: A review. Appl Water Sci. 2017. 7: 71-87.
7. Pantaleo PA, Komakech HC, Mtei KM, Njau KN. Contamination of groundwater sources in emerging African towns: The case of Babati town, Tanzania. Water Pract Technol. 2018. 13: 980-990.
8. Type I, Contribution J. A review of water quality and pollution studies in Tanzania. 2022. 31: 617-620.
9. Pauschert D, Gronemeier K, Bruebach K. Urban Water and Sanitation Poverty in Tanzania. Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany; 2012.
10. Hansson E. Groundwater on Zanzibar: use and contaminants. Thesis. University of Gothenburg, Sweden. 2010.

11. Mohamed AAJ, Rahman IA, Lim LH. Groundwater quality assessment in the urban-west region of Zanzibar Island. Environ Monit Assess. 2014. 186: 6287-6300.
12. Srinivas R, Prashant B, Ajit PS. Groundwater quality assessment in some selected areas of Rajasthan, India using fuzzy multi-criteria decision-making tool. Aquatic Procedia. 2015. 4: 1023-1030.
13. Rodrigues L, Pacheco A. Groundwater contamination from cemeteries: cases of study. 2003.
14. Afangideh CB, Udeme U. Assessment of groundwater. 2022. 19.
15. Crisanto-Perrazo T, Guayasamin-Vergara J, Mayorga-Llerena E, Sinde-Gonzaez I, Vizuete-Freire D, et al. Determination of empirical environmental indices for the location of cemeteries: an innovative proposal for worldwide use. Sustainability. 2022. 14.
16. Kandoli SJ, Alidadi H, Najafpoor I, Mehrabpour M, Hosseinzadeh M, et al. Assessment of cemetery effects on groundwater quality using GIS. Desalination Water Treat. 2019. 168: 235-242.
17. Üçisik AS, Rushbrook P. The impacts of cemeteries on the environment and public health. WHO Regional Office for Europe, Copenhagen, Denmark; 1998.
18. Dippenaar MA, Olivier J, Lorentz S. Deadly contamination. 2017 November.
19. Dent BB, Knight MJ. Cemeteries: a special kind of landfill. In: McCall J, editor. Proceedings of the International Association of Hydrogeologists Conference: Groundwater—Sustainable Solutions. Melbourne, Australia; 1998.
20. Dent BB, Forbes SL, Stuart BH. Review of human decomposition processes in soil. Environ Geol. 2004. 45: 576-585.
21. Khoja Shia Ithna-Asheri Jamaat of Zanzibar. History of Jamaat. 2025. Available from: https://ksikjznz.org/history.
22. Vass AA, Bass WM, Wolt JD, Foss J, Ammons JT. Time since death determinations of human cadavers using soil solution. J Forensic Sci. 1992. 37: 1236-1253.
23. Paíga P, Delerue-Matos C. Determination of pharmaceuticals in groundwater collected in five cemeteries' areas (Portugal). Sci Total Environ. 2016. 570: 16-22.
24. World Health Organization; WHO/UNICEF Joint Water Supply & Sanitation Monitoring Programme. Progress on sanitation and drinking water: 2015 update and MDG assessment. 2015.
25. Karanth KR. Groundwater Assessment, Development & Management. New Delhi: Tata-McGraw-Hill; 1987.
26. Formanek PA. Contamination. 1997.
27. Mbuga H. The effect of septic tanks sewage disposal system distances on borehole water quality in Ongata Rongai, Kajiado County, Kenya. 2016.
28. World Health Organization. Chemical fact sheet: nitrate & nitrite. In: Guidelines for Drinking-water Quality (4th ed., 1st & 2nd addenda). 2022. 3: 438-444.