Available online at https://asric.africa/engineering-sciences
ASRIC Journal on Engineering Sciences Vol.6(1)(2025) 52-59

Assessment of Groundwater Quality and Faecal Contamination Risks Underneath the Qoboza Klaaste Building, University of Johannesburg

Moosa Phulwana[1], Patience Davhana[1], Mondli Mthombeni[1]

[1]Faculty of Engineering and The Built Environment, University of Johannesburg, Doornfontein Campus
222070721@student.uj.ac.za, patienced@uj.ac.za, mondlim@uj.ac.za

Corresponding Author: patienced@uj.ac.za

Received 18 July 2025; revised 18 August 2025; accepted 23 October 2025

Abstract
The study assesses the safety and feasibility of the groundwater under the Q/K building (Qoboza Klaaste) of the University of Johannesburg under the terms of physicochemical and microbiological quality. Groundwater ingress is a persistent structural and resource concern, exacerbated by legacy mining impacts and urban sewer infrastructure. Groundwater samples were benchmarked against the South African drinking water quality standard (SANS 241:2015). Physical parameters (pH and electrical conductivity) were found to be compliant, whereas turbidity exceeded acceptable limits in 8 out of 15 samples. Microbiological tests revealed consistent detection of Total Coliforms and E. coli, indicating faecal contamination. Acid Mine Drainage (AMD) was not a significant factor; sewer line leakage was identified as the primary source of contamination. Untreated groundwater is unsuitable for human consumption but may be safely repurposed for non-potable applications. Recommendations include sump infrastructure upgrades, routine water quality monitoring, and disinfection strategies to mitigate health risks and enable potential reuse. Q/K Groundwater, if not treated it can be used for flushing toilets and watering gardens

Keywords: Groundwater quality, Urban hydrogeology, Parameters, Contamination, Infrastructure risk.

1. Introduction
Groundwater is an essential water security, particularly as surface water resources face increasing stress due to climate variability, urbanisation, and population growth. It supplies over 60% of rural and small-town communities, supporting domestic, agricultural, and industrial needs (Nkosi, Mathivha and Odiyo, 2021). In urban contexts, groundwater can alleviate pressure on municipal systems, especially during supply disruptions or emergencies. However, its sustainability is threatened by over-abstraction, pollution, and inadequate governance. In Johannesburg, historical mining activities have left a legacy of environmental degradation, with Acid Mine Drainage (AMD) emerging as a major concern (Laker, 2023). AMD occurs when water infiltrates abandoned mine voids, mobilising heavy metals and acidic compounds that seep into surrounding aquifers, rendering groundwater is not safe for consumption.

Groundwater originates from the infiltration of precipitation into subsurface geological formations known as aquifers, storing approximately 95% of Earth's freshwater (Vandenbohede et al., 2008). It constitutes one of the most vital freshwater resources globally, supporting billions of people through drinking water supply, agricultural irrigation, and industrial processes (Ji, Dahlgren & Zhang, 2015). Current estimates suggest that groundwater accounts for approximately 21–30% of global annual freshwater use, with demand projected to increase by 61% by 2050 due to population growth, climate change, and urban expansion (Jodhani et al., 2025). In South Africa, groundwater serves as a critical alternative for water-scarce communities, particularly in rural areas (Selelo, Matimolane & Mathivha, 2025).

However, contamination from anthropogenic activities, including inadequate sanitation, industrial discharge, and mining, poses significant health risks (Ochieng et al., 2010; Musingafi, 2014). In Johannesburg, the legacy of gold mining has led to widespread AMD, while urban migration exacerbates demand, further straining infrastructure and increasing the likelihood of contamination (Molle & Berkoff, 2009). Poor groundwater quality is strongly linked to the prevalence of diseases spread through contaminated water, like cholera., typhoid, and amoebiasis, particularly in areas with limited treatment infrastructure (Anas et al., 2021). These risks underscore the importance of systematic monitoring and targeted interventions to safeguard public health and ensure sustainability.

The Witwatersrand Basin in which the Doornfontein Campus of the University of Johannesburg (UJ DFC) is located is typified by complicated hydrogeological circumstances, as well as a mining history that affects the surrounding environment (Patience et al., 2023). The Qoboza Klaaste (Q/K) Building, located atop a spring network, experiences frequent groundwater ingress, particularly during the rainy season, necessitating active pumping to prevent basement flooding. This persistent groundwater flow poses structural risks and presents an opportunity to explore alternative water uses, provided the water meets safety standards. Within this context, groundwater monitoring at UJ DFC is essential for ensuring public health, infrastructure integrity, and sustainable resource management (WHO, 2022). The quality of groundwater under the Q/K Building was compared with regulatory limits of SANS 241:2015 in this research. The objectives were to: (1) examine important physical and microbiological indicators, (2) establish the main sources of contamination, and (3) present mitigation measures that can be used to enhance water safety and resiliency in campuses.

This study is important as it contributes to understanding groundwater quality in a high-risk urban academic setting. By identifying contamination pathways and assessing compliance with national standards, the study provides evidence-based insights for infrastructure management and water safety planning. The findings are particularly relevant for the University of Johannesburg, which faces intermittent water shortages and structural challenges due to persistent groundwater ingress. In addition, the study offers a framework for repurposing excess groundwater, currently discharged from the Q/K Building, into a usable resource, contingent on quality assurance and treatment feasibility.

Nonetheless, the study faced certain limitations. Due to budgetary constraints, the analysis focused primarily on physical and microbiological parameters, while chemical parameters such as nitrates, sulphates, and heavy metals were excluded. These are essential for a complete assessment of groundwater safety and will be pursued in future phases. Additionally, data on the daily volume of groundwater pumped from the Q/K basement were unavailable due to time limitations. Future research should therefore incorporate comprehensive chemical profiling and quantify groundwater discharge rates to better inform reuse strategies for the University and surrounding buildings.

2. Methodology

2.1 Study Site Description

The study took place in Qoboza Klaaste (Q/K) Building within the Doornfontein Campus of the University of Johannesburg (UJ DFC). It is in Witwatersrand Basin in Gauteng Province, South Africa as seen in figure 1 (Patience et al., 2023). Figure 2 indicates that the building is situated on a watershed with a west east direction, creating a drainage divide between north bound streams to Limpopo River and south bound streams to Orange River. The area is covered by two subgroups of broken aquifer rocks. These are the conglomerate, breccia and shale of the Platberg Subgroup, and the Basaltic Lava, agglomerate, and tuff of the Kliprivierberg Subgroup in the north (Patience et al., 2023). The building is positioned at a top of a spring network that contributes to persistent groundwater ingress, particularly during the rainy season. This groundwater accumulation poses structural risks and necessitates continuous pumping to prevent basement flooding. The site was selected due to its hydrogeological sensitivity and the potential for groundwater reuse, contingent on quality assessment.

Fig. 11: University of Johannesburg Doornfontein Campus Source (Wikipedia)

Fig. 2 : Qoboza Klaaste Building Source (Google Earth Pro)

2.2 Sampling Methods and Techniques

In this study, water samples were collected in the basement in different sump pits (figure 3) daily using clean and disinfected beakers and taken to the laboratory (figure 4) for test, assessment the suitability of groundwater for human consumption. The turbidity was measured using the TN 100 turbidity meter using 30 ml primary standards of 0.02, 20.0, 100, and 800 NTU to measure the turbidity. pH, electrical conductivity (EC) and temperature was measured using a Hanna HI 98129 waterproof meter. The HI 98129 meter was first calibrated with pH buffer solution (4, 7, 9) and EC with a standard conductivity solution to make sure it was accurate. The temperature was measured by turning on the meter and dipping the probe in a 30 ml beaker of sample water. The other samples were taken to the University of Johannesburg water lab for testing of microbiology and physical parameters for this research. All analytical results were evaluated and compared with the national standards for drinking water

(SANS241:2015). In this way, the standards lay down threshold limits for physical, microbiological and chemical parameters to assess water for human use.

2.3 Laboratory Analysis

This research has two stages of analysis, namely:

Stage 1: Field and Sampling phase

In this phase, the physical factors such as Electrical Conductivity, Temperature, Turbidity and PH of groundwater samples are obtained daily to look at other parameters such as chemical and microbiological as well.

Stage 2: The Laboratory Analysis

It is a phase where collected groundwater samples are taken to the lab to analyse Total Coliforms (TC) and E.coli bacteria using IDEXX Colilert-18 and MPN tables.

Fig. 3: Groundwater sump pit source

2.3.1 Physical Parameters

The following physical parameters were measured: i) Temperature (°C) recorded in situ, ii) pH, iii) Electrical Conductivity (EC) measured in mS/m and iv) Turbidity (NTU), following standard operating procedures.

2.3.2 Microbiological Parameters

Microbiological analysis focused on: i) Total Coliforms Quantified using the Most Probable Number (MPN) method in accordance with Standards procedure for the Examination of Water and Wastewater. ii) Escherichia coli (E. coli) detected and enumerated using the Colilert® system, with results expressed in MPN/100 mL. All microbiological tests were conducted within 24 hours of sample collection to ensure accuracy and reliability.

Fig. 4: *18 Test kit – Colilert method (Source: University of Johannesburg, Water and Health Research Centre (2019))*

Total Coliform and E. coli samples were investigated in the Water and Health Research Centre (WHRC) in the University of Johannesburg at Doornfontein Campus (UJ DFC). Analysis was done using IDEXX Colilert-18 method as shown (Figure 4) which is a selective and specific substrate technology that is aimed at the simultaneous detection of the bacteria.

3. Results and Discussion

3.1 Physical Parameters

The samples of groundwater were taken in a period of 15 days and compared to the South African National Standards (SANS 241:2015) drinking water quality to determine compliance. As shown in Table , the physical parameters assessed included temperature, pH, electrical conductivity (EC), and turbidity. Temperature varied across sampling days due to temporal differences, ranging from 23.1°C to 25.6°C, which may influence microbial activity but is not directly regulated under SANS 241.

Table 1: *Groundwater Physical parameters source*

	GROUNDWATER			
Duration (days)	Temperature	PH	Electrical Conductivity (mS/m)	Turbidity (NTU)
1	17.9	6.88	33.8	0.15
2	19.3	7.04	35.8	0.62
3	18.6	7.25	26.5	2.25
4	19.7	7.15	31.1	1.86
5	25.4	4.13	34.7	0.42
6	23.5	7.11	29.8	0.83
7	21.9	7.58	31.6	0.66
8	20.6	6.55	42.1	6.26
9	20	7.01	46.3	3.46
10	20.2	7.59	51	2.61
11	19.8	7.4	48.9	2.37
12	20.1	7.43	39.2	5.55
13	20.4	6.892	45	0.47
14	20.5	7.051	45.5	1.69
15	20.2	6.879	45	0.9
	South African National Standards (SANS) 241: 2015 LIMITS OF DRINKING WATER QUALITY			
ACCEPTANCE CRITERIA		≥ 5 to ≤ 9.7	≤ 170	≤ 1
		OK	OK	NOT OK

3.1.1 PH Analysis

The pH values of the groundwater samples ranged between 6.5 and 7.6, falling well within the SANS 241:2015 acceptable range of ≥5 to ≤9.7. This indicates that the groundwater is neither excessively acidic nor alkaline, minimising risks of corrosivity and taste alteration. Water outside this pH range may lead to infrastructure degradation and consumer dissatisfaction due to metallic or bitter taste profiles

3.1.2 EC Analysis

Measured EC values ranged from 26.5 to 48.9 mS/m, significantly below the SANS 241:2015 operational limit of ≤170 mS/m. These low conductivity readings suggest minimal dissolved ionic content, reflecting low mineralisation and a reduced likelihood of salinity-related taste issues. Furthermore, the absence of elevated EC values and the neutral pH profile collectively suggest that the groundwater is not significantly impacted by Acid Mine Drainage (AMD), which typically manifests through elevated EC and depressed pH levels (DWA, 2013). This is particularly relevant given the proximity to the Witwatersrand mining basin, where AMD is a known environmental concern.

3.1.3 Turbidity Analysis

Turbidity values ranged from 0.5 to 6.26 NTU, with only 7 out of 15 samples (fig.5) meeting the SANS 241:2015 limit of ≤1 NTU. Elevated turbidity compromises aesthetic quality and may shield pathogenic microorganisms from disinfection processes. The observed exceedances are likely attributable to episodic contamination events, notably mechanical failures in the sump pit system. On days when sump pumps malfunctioned, overflow and backflow of water into the pit were reported, facilitating the reintroduction of contaminated water into the groundwater system. This mechanical failure likely mobilised fine sediments and suspended particulates, contributing to the elevated turbidity levels observed.

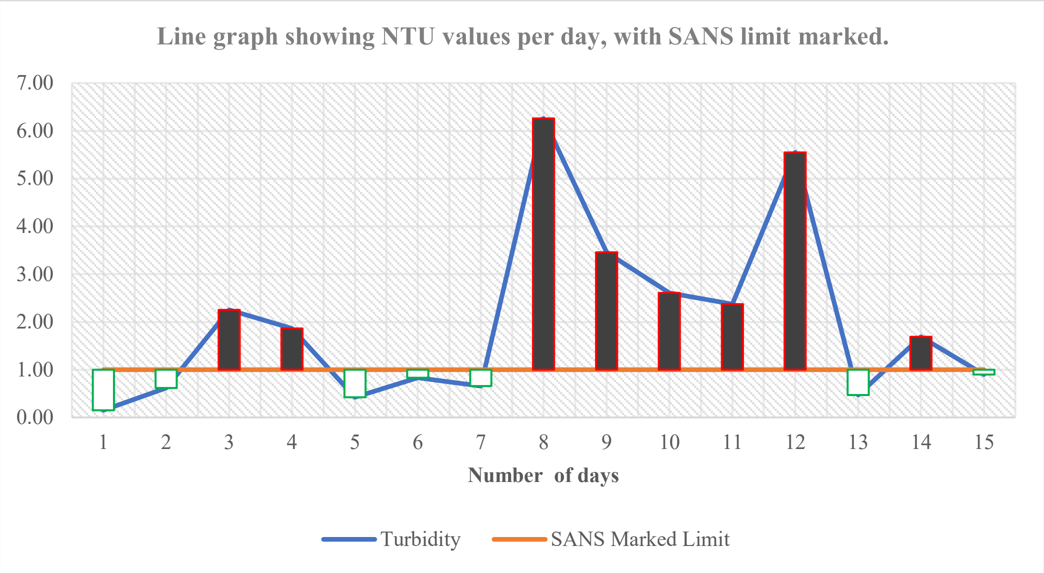

Fig. 5: Turbidity Trends Over Sampling Period

3.2 Microbiological Parameters

The microbiological analysis in of groundwater samples revealed significant deviations from the South African National Standard (SANS 241:2015) for drinking water quality as shown in Table 2, specifically concerning Total Coliforms and E. coli counts. All samples exhibited TC concentrations exceeding the permissible limit of ≤10 MPN/100 mL, indicating potential environmental contamination and compromised aquifer integrity. More critically, the detection of E. coli in all samples, where the standard mandates complete absence (0 MPN/100 mL), confirms recent faecal pollution and poses a direct threat to public health.

***Table 2:** Microbiological Parameters source*

	GROUNDWATER		
Duration (days)	Temperature	Total Coliforms (MPN per 100 mL)	E-Coli (MPN per 100 Ml)
1	17.9	231	< 1
2	19.3	613	1
3	18.6	817	< 1
4	19.7	260	2
5	25.4	58	< 1
6	23.5	1120	3
7	21.9	99	< 1
8	20.6	>24196	162
9	20	345	9
10	20.2	1553	4
11	19.8	326	< 1
12	20.1	86	4
13	20.4	9804	< 1
14	20.5	1733	< 1
15	20.2	1733	< 1

South African National Standards (SANS) 241: 2015		
LIMITS OF DRINKING WATER QUALITY		
ACCEPTANCE CRITERIA	≤ 10	No-detect (0)
	NOT OK	NOT OK

These findings suggest that groundwater is microbiologically unsafe for human consumption without adequate treatment. The presence of E. coli is particularly alarming, as it is a reliable indicator of pathogenic organisms capable of causing waterborne diseases such as gastroenteritis, cholera, and hepatitis A. Supporting physicochemical parameters, including elevated turbidity and moderate temperatures, may further facilitate microbial persistence and reduce the efficacy of conventional disinfection methods. Immediate remedial actions, including source protection, well infrastructure assessment, and implementation of disinfection protocols, are warranted to mitigate health risks and restore compliance with drinking water standards.

4. Conclusion

This study investigated the quality of groundwater in the Q/K Building at the University of Johannesburg's Doornfontein Campus by analysing its physical and microbiological parameters in accordance with SANS 241:2015 standards. The findings revealed that while the groundwater exhibited acceptable pH (6.5–7.6) and electrical conductivity (26.5–48.9 mS/m) values indicating low mineralisation and minimal influence from Acid Mine Drainage (AMD), turbidity levels exceeded permissible limits in more than half of the samples. These elevated turbidity readings were linked to mechanical failures in the sump pit system, which allowed contaminated water to re-enter the groundwater reservoir, suggesting a direct pathway for physical contamination.

Microbiological analysis further underscored the compromised quality of the groundwater. All samples tested positive for Escherichia coli (E. coli), and Total Coliform counts consistently exceeded the SANS 241:2015 threshold of ≤10 MPN/100 mL. The presence of E. coli is a definitive indicator of faecal contamination and poses a serious public health risk, rendering the groundwater not safe for human consumption without appropriate treatment. These results point to a combination of infrastructural vulnerabilities and environmental exposure as the principal sources of contamination.

In light of these findings, the study recommends a multi-pronged intervention strategy: (i) immediate repair and maintenance of the sump pit pumping system to prevent overflow and backflow events; (ii) implementation of routine water quality monitoring, particularly for microbial indicators; and (iii) consideration of point-of-use treatment technologies such as UV disinfection or chlorination to ensure potable water standards are met. These actions will not only mitigate current contamination risks but also support the University's broader sustainability and health objectives by enabling safe use of groundwater resources on campus.

Acknowledgement

We thank the Water and Health Research Centre (WHRC), University of Johannesburg, for laboratory support and technical guidance. We would like to express our deep and sincere gratitude to Dr German Nkhonjera, Head of the Department of Civil Engineering Technology at the University of Johannesburg, for the financial support and the kind words of wisdom about research output. Finally, a big vote of gratitude to the authors for supervising the writing process, reviewing the paper, the teamwork and support towards the paper. Not to forget all industry colleagues, friends, and family for all the support rendered during this endeavour and the Almighty.

References

Anas, M., Sami, M.A., Siddiqui, Z., Khatoon, K., Zeyad, M.T. and Malik, A., 2021. Impact of Climate Change on the Incidence and Transfer of Food-and Water-Borne Diseases. In Microbiomes and the Global Climate Change (pp. 123-144). Springer, Singapore.

Department of Water Affairs and Sanitation (DWA) (2013). Witwatersrand, Gauteng: Acid Mine Drainage: Long Term Solution. South Africa. Online available at: http://www.dwa.gov.za/projects/amdfslts/default.aspx. [Accessed 10 September 2019].

Ji, X., Dahlgren, R.A. and Zhang, M. (2015). Comparison of seven water quality assessment methods for the characterization and management of highly impaired river systems. *Environmental Monitoring and Assessment*, [online] 188(1). doi:https://doi.org/10.1007/s10661-015-5016-2.

Jodhani, Keval H, et al. "Sustainable Groundwater Management through Water Quality Index and Geochemical Insights in Valsad India." Scientific Reports, vol. 15, no. 1, 13 Mar. 2025, www.nature.com/articles/s41598-025-92053-1, https://doi.org/10.1038/s41598-025-92053-1.

Laker, M.C. (2023). Environmental Impacts of Gold Mining—With Special Reference to South Africa. *Mining*, 3(2), pp.205–220. doi:https://doi.org/10.3390/mining3020012.

Molle, F. and Berkoff, J., 2009, February. Cities vs. agriculture: A review of intersectoral water re-allocation. In Natural Resources Forum (Vol. 33, No. 1, pp. 618). Oxford, UK: Blackwell Publishing Ltd.

Musingafi, M.C.C., 2014. Fresh water sources pollution: a human related threat to freshwater security in South Africa.

Nkosi, M., Mathivha, F.I. and Odiyo, J.O. (2021). Impact of Land Management on Water Resources, a South African Context. *Sustainability*, 13(2), p.701. doi:https://doi.org/10.3390/su13020701.

Ochieng, G.M., Seanego, E.S. and Nkwonta, O.I., 2010. Impacts of mining on water resources in South Africa: A review. Scientific Research and Essays, 5(22), pp.3351-3357.

Patience, D., German, N., Jeffrey, M. and Alowo, R. (2023). Pollution in the Urban Environment: A Research on Contaminated Groundwater in the Aquifers Beneath the Qoboza Klaaste (QK) Building at University of Johannesburg in South Africa. *Springer eBooks*, [online] pp.773–782. doi:https://doi.org/10.1007/978-3-031-22434-8_74.

Selelo Matimolane and Mathivha, F.I. (2025). Tackling rural water scarcity in South Africa: climate change, governance, and sustainability pathways. *Frontiers in Environmental Science*, 13. doi:https://doi.org/10.3389/fenvs.2025.1550738.

Vandenbohede, A., Van Houtte, E. and Lebbe, L. (2008). Groundwater flow in the vicinity of two artificial recharge ponds in the Belgian coastal dunes. *Hydrogeology Journal*, 16(8), pp.1669–1681. doi:https://doi.org/10.1007/s10040-008-0326-x.

World Health Organization (2022). Drinking-water. [online] World Health Organization. Available at: https://www.who.int/news-room/fact-sheets/detail/drinking-water.