

Perceptions and Investigation of Poor Water Quality Supplied to The Resident of The City of Bloemfontein

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Abstract. Water shortages remain a significant challenge in Mangaung Metropolitan Municipality (MMM), affecting socio-economic development, agriculture, and residents' well-being. Frequent water interruptions have also contributed to negative perceptions about the quality of water supplied in Bloemfontein. This study aimed to evaluate existing water infrastructure and assess water quality provided by Vaal Central Water and MMM, while also examining community perceptions. A mixed-methods approach was applied in two phases. The first phase used a questionnaire (n=115) to gather quantitative data on public perceptions, while the second involved laboratory analysis of water samples from both supply sources. Advanced techniques, including spectrophotometry, ICP-MS, ICP-OES, and microbial tests, were employed. Findings revealed a link between perceived and measured water quality, particularly in terms of colour and turbidity. Elevated zinc and microbial levels exceeded SANS 241 standards in some cases. Overall, infrastructure performance is adequate, but maintenance gaps and poor communication contribute to public dissatisfaction.

1. Introduction

Access to safe and reliable drinking water is essential for health and socio-economic development, yet gaps in provision remain a global concern [1]. In Bloemfontein, persistent water shortages and intermittent supply have heightened concerns regarding the quality, safety, and reliability of municipal water services. These challenges affect households, agriculture, and economic activities, while also shaping public perceptions of service delivery. Residents' perceptions are particularly important, as they influence trust in municipal systems, water consumption behaviour, and reliance on alternative sources such as bottled water and boreholes. The relationship between Mangaung Metropolitan Municipality and Vaal Central

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Water is central to water provision, yet financial constraints, limited technical capacity, and weak communication continue to hinder effective service delivery [2].

Water quality is typically evaluated using physicochemical, microbiological, and trace metal parameters. Indicators such as pH, turbidity, temperature, and dissolved oxygen reflect overall water conditions, while microbial contamination signals immediate health risks. [3]. Trace metals, often originating from mining, agriculture, and waste disposal, pose long-term health concerns. Previous studies in South Africa have shown that aging infrastructure, intermittent supply, and inadequate treatment processes can compromise water quality and increase contamination risks [4]. In South Africa, aging infrastructure, intermittent supply, and inadequate treatment processes can compromise water quality. In Bloemfontein, water sourced from the Modder River and Welbedacht Dam is affected by infrastructure deterioration and maintenance challenges. Public perceptions, influenced by sensory attributes such as taste, colour, and odour, may not always align with technical assessments, highlighting the need to integrate both scientific evaluation and community perspectives [5]. Therefore, this study seeks to examine both the actual quality of water supplied and the perceptions of residents, in order to provide a more comprehensive understanding of water service challenges and to inform strategies for improving water management and public confidence.

2. Methodology

2.1 Location of the study area

Bloemfontein lies on a plateau at an elevation of about 1,392 m (29.1208°S, 26.2376°E) and is a semi-arid area dominated by grassland vegetation and scarce water resources. It forms part of the Highveld summer rainfall region, with an average annual temperature of about 14.5°C, receiving most rainfall in January and minimal precipitation. The bulk water supply, overseen by the Department of Water and Sanitation, includes treatment plants, dams, and transfer schemes. However, Mangaung Metropolitan Municipality faces growing challenges such as drought, climate change, pollution, poor raw water quality, and insufficient monitoring of emerging contaminants [6].

2.2 Research Design

The research approach used was a mixed method combining qualitative perception analysis and quantitative water quality testing. Quantitative data analysis results compared against community perceptions showed the significance of blending both methods to obtain a broader understanding. Therefore, perception data guides awareness strategies, technical fixes, communication, and accounts for lived practices, while objective measurements offer scientific evidence [2].

2.3 Target population and sampling

2.3.1 Resident participants and Sampling Method

The study targeted residents of Bloemfontein, focusing on urban households to assess perceptions of water quality. A non-probability convenience sampling approach was used to recruit participants. Questionnaires were distributed via email, WhatsApp, and Google, with additional support from a gatekeeper letter at the Central University of Technology, Free State. The study targeted households, and based on an estimated population of 567,000, a 95% confidence level, and a 3% margin of error, a sample size of 1,066 was deemed appropriate using Equation (1):

$$\text{Sample size} = \frac{\frac{z^2 p(1-p)}{e^2}}{1 + \left(\frac{z^2(1-p)}{e^2 N}\right)} \quad (1)$$

N = population size

e = Margin of error (percentage in decimal form)

z = z - score

2.3.2 Sample Collection and Laboratory analysis

Municipal drinking water samples were collected from two representative sites in Bloemfontein, located at the northern and southern ends of the city (P01: 29°09'15.1"S 26°10'24.5"E and P02: 29°06'46.6"S 26°13'25.8"E), following SANS 5667-5 guidelines (Figure 1). Sterile 750 ml bottles were used to collect samples from outside taps, which were inspected, cleaned, and flushed for five minutes to ensure representative sampling. Care was taken to avoid contamination, and samples were clearly labelled with site codes, date, and time before being stored in a cooler box and transported to the laboratory within 30 minutes. The two sites were selected due to different supply systems: P01 (Pellissier residential area) supplied via the Welbedacht–Bloemfontein pipeline, and P02 (CBD, Zastron Street) supplied via the Bloemfontein–Maselspoort pipeline. At the laboratory, the samples were analysed for physical, chemical, and microbiological parameters, including turbidity using a spectrophotometer, pH and electrical conductivity using an Eco pH meter, macro and micro cations using ICP-MS and ICP-OES, anions using a discrete analyser, and microbial indicators such as heterotrophic plate count, total coliforms, and *E. coli* using standard incubation methods.

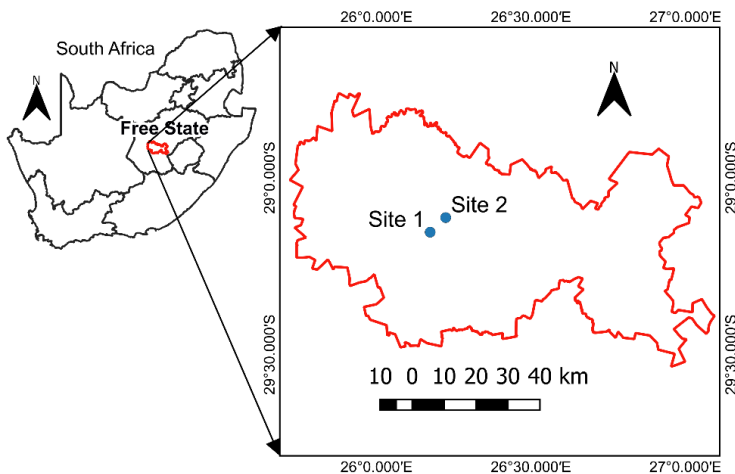


Fig.1. Location of sampling sites P₀₁ (residential area) and P₀₂ (CBD) within Bloemfontein, showing pipeline routes from Maselspoort Water Treatment Works (source: by author).

2.3.3 Validity, reliability and data analysis

Reliability, which refers to the consistency of results when a study is repeated, and validity, which indicates whether the measurement tool accurately measures what it intends to measure, were considered in the study. [7]. The collected data were organised and tabulated

in an Excel spreadsheet, where results were summarised using descriptive statistics, including minimum, maximum, mean, and standard deviation.

2.3.4 Ethical consideration

Ethical considerations were ensured through informed consent, voluntary participation, the right to withdraw, confidentiality, and anonymity, with no associated risks and possible publication of findings. Ethical clearance was obtained via the CUT Clarivate Converis platform and approved by the Research Ethics Committee, alongside gatekeeper approval from the Central University of Technology. Data were securely managed according to institutional policies.

3. Results

3.1 Quality and composition of tap drinking water

3.1.1 Physicochemical and microbial parameters

The physicochemical parameters analysed included turbidity, colour, pH, EC, Ca, Mg, Na, K, alkalinity, Cl, N, SO₄, CaCO₃, and TDS, with values reported as ranges and means (Table 1). Comparison with SANS standards indicated that most parameters were within acceptable limits. However, colour at sampling point P02 recorded the highest value, exceeding the recommended limit. This suggests potential deficiencies in water treatment processes or infrastructure. The elevated colour levels may indicate contamination risks and highlight concerns regarding overall water quality in the system. Moreover, the results also showed faecal coliforms and *E. coli* were detected in the samples (Table 2), albeit at levels below 1 MPN/100 ml, which still signifies contamination. According to SANS standards, these microorganisms should not be present in drinking water. Therefore, the findings support the study's hypothesis that faecal contamination exists within the water infrastructure.

The physicochemical analysis showed that one of the sample in the area recorded a colour level of 21 Pt-Co, exceeding the SANS limit of ≤ 15 Pt-Co. Microbiological results indicated the presence of *E. coli* and faecal coliforms in both sampled locations, although at levels of <1 MPN/100 ml, which still contravenes the SANS requirement of no detectable organisms. These findings suggest contamination within the water distribution system. Elevated turbidity and colour are likely linked to sediment runoff from the Caledon and Modder Rivers, as well as ageing and poorly maintained infrastructure, posing significant public health risks, including gastrointestinal illness and related complications [8].

Table 1. Concentration of physicochemical parameters in tap drinking water.

Concentration						
Contaminants	Unit	Min	Max	Mean	STD	SANS
Physicochemical parameters						
Turbidity	NTU	0.42	1.43	0.93	0.71	≤ 5
Colour	mg/L as Pt-Co	7.00	21.00	14.00	9.90	≤ 15
pH	pH units	7.67	8.44	8.06	0.54	≥ 5 to ≤ 9.7
EC	mS/m	18.48	19.73	19.11	0.88	≤ 170
Ca	mg/L	26.10	27.00	26.55	0.64	≤ 150

Mg	mg/L	5.86	8.00	6.93	1.51	≤ 70
Na	mg/L	9.21	9.70	9.46	0.35	≤ 200
K	mg/L	3.71	5.62	4.67	1.35	≤ 50
Alkalinity	mg/L	84.21	89.58	86.90	3.80	≤
F	mg/L	0.24	0.29	0.27	0.04	1.5
Cl	mg/L	9.50	14.46	11.98	3.51	≤ 300
N	mg/L	0.31	0.33	0.32	0.01	≤ 1.5
SO₄	mg/L	6.52	11.79	9.16	3.73	≤ 250
CaCO₂	mg/L	91.55	98.11	94.83	4.64	≤
TDS	mg/L	160.36	168.18	164.27	5.53	≤ 1200

Table 2. Occurrence of microbial contaminants in tap drinking water.

Concentration				
Contaminants	Unit	min	max	SANS
Microbial parameters				
Total coliforms	MPN/100ml	<1	<1	≤ 10
Faecal coliform	MPN/100ml	<1	<1	No detection
E. coli	MPN/100ml	<1	<1	No detection

3.2 Perceptions of residents on drinking water quality

3.2.1 Water usage

The questionnaire responses from 115 residents indicated that most households (92.2%) rely on municipal water for drinking and food preparation, with a small proportion (0.9%) using bottled water. The majority (52.2%) pay for water via a prepaid system, while 27.8% receive municipal billing. Over half of the respondents (54.8%) live in homes aged between 21 and 50 years, which may contribute to potential contamination risks due to ageing infrastructure. Notably, 92.2% of respondents have never tested their household water, raising concerns about undetected contamination. While 34.8% primarily consume tap water, others use bottled or treated water. Most respondents (65.2%) do not use filtration systems. Additionally, 79.1% reported inadequate communication from authorities, and 95.7% experienced water interruptions, often lasting several days. Furthermore, 60% were unaware of their water source, highlighting gaps in awareness and water management within the community.

The findings indicate that reliance on municipal water, combined with ageing infrastructure, limited household testing (92.2%), and low use of filtration systems (65.2%), may increase contamination risks. Frequent interruptions and poor communication further exacerbate system vulnerabilities. These results highlight deficiencies in infrastructure,

monitoring, and public engagement, necessitating improved management to ensure safe drinking water [9].

3.2.2 Perception of water quality

The respondent perception on water quality was rated using a 10-point Likert scale (1 = very poor, 5=neutral and 10 = very good) in terms of water-related issues. The findings indicate that before interruptions, only 2.6% of participants indicated very good water quality with 5.2% of participants indicating veery poor water quality water. After water interruptions, perceptions declined with 1.8% indicating very good water quality while 18.4% indicated very poor water quality. Most respondents (72.2%) reported distrust in tap water, while 21.7% were unsure and only a small proportion disagreed. In terms of consumption, 47.8% consumed tap water multiple times daily, 39.1% rarely did so, 8.7% consumed it a few times a week, and 4.4% consumed it once daily. Regarding organoleptic qualities, 50.4% reported strange odours, 32.2% reported none, and 17.4% were unsure; 56.5% reported strange taste, 24.3% reported none, and 19.1% were unsure; while 71.3% reported discolouration, 18.3% did not, and 10.4% were unsure. Furthermore, 40.7% reported noticeable particles, while 34.8% did not and 17.4% were unsure. In terms of water pressure, 45.2% reported a decrease, 40.9% reported no change, and 12.2% reported stable conditions. Finally, 63.2% of respondents believed the Municipality is not doing enough to improve water quality, 7.9% believed it is, and 28.9% were unsure, indicating overall dissatisfaction with service delivery and communication. Many households rarely test or treat water and rely on multiple sources, increasing contamination risks. A comprehensive approach with monitoring, reliable supply, safe storage, testing, and education is essential for safety and public trust.

From these findings it is clear that, public perception of water quality is largely shaped by service reliability and sensory characteristics. Interruptions in water supply tend to worsen perceptions, leading to increased reports of poor quality and reduced trust. Moreover, common issues such as unpleasant odour, taste, and discolouration suggest possible contamination. Low water pressure and general dissatisfaction point to weaknesses in the system, highlighting the need for improved infrastructure, monitoring, and communication. [10]

4.Conclusion

From the findings of the study, it can be concluded that the water supply system is compromised due to ageing infrastructure, maintenance backlogs, and financial constraints. Water quality analyses reveal physicochemical and microbiological contamination, with possible exceedances of SANS 241 standards. Public perceptions reflect low confidence, highlighting failures in treatment, distribution, monitoring, and communication. To ensure safe and reliable drinking water, infrastructure rehabilitation, improved operational management, and strengthened regulatory compliance are recommended.

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