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A regulatory framework for bottled water quality monitoring: A case of Emfuleni local municipality

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Abstract

Background

The quality of drinking water has recently become of utmost concern to consumers worldwide, especially in areas where Water Service Authorities (WSAs) failed to provide safe water. To combat this challenge, government entities regulate water to ensure that safe water is provided. The Emfuleni Local Municipality (ELM) has experienced cases of water contamination by human excretion, whereby communities were affected. As a result, there was a sharp increase in bottled water (BW) use, which however gave rise to unregulated and counterfeit versions of popular brands. This situation poses threats to public health.

Aim

This study sought to determine the regulation of drinking water and to assess whether environmental health practitioners (EHPs) monitor the quality of water sources (BW and tap water) in ELM as outlined by the National Environmental Health Norms and Standards (NEHNS).

Settings

The study was conducted in the Emfuleni Local Municipality in South Africa.

Methods

A quantitative cross-sectional study design was employed in this research. Fifteen online questionnaires using a Google Forms survey were distributed amongst all EHPs servicing ELM. Secondary data that included the Integrated Development Plan (IDP) and Service Delivery Budget Implentation Plan (SDBIP) for the 2017–2020 financial years were also evaluated, specifically for water quality monitoring (tap and bottled water). The dataset was analysed using the Statistical Package for the Social Sciences (SPSS) version 29.

Results

Due to complexity in the legislation and NEHNS in relation to Municipal Health Services (MHS), bottled water was not sampled at all. A number of EHPs were also not conversant with the regulations governing BW. Moreover, NEHNS consider bottled water as food, which does not fall under the MHS.

Conclusion

There should be clarity in the legislation to ensure that bottled water monitoring is intensified to protect public health within the WSAs.

Contribution

The findings of this study could assist policy-makers to make informed decisions on water quality monitoring, as well as clarify legislative issues on bottled water.

Previous

Next

Keywords

Environmental health practitioner; Bottled water regulation; Emfuleni local municipality; Water quality monitoring

1. Introduction

Water is a scarce and important resource for humans and animals, and its safety is of great concern [1]. The United Nations (UN) declared that safe and clean drinking water is a basic human right [2]. This right is also enshrined in the South African Constitution [3], which prompted water regulators to develop water legislation and regulations governing water quality and supply. In addition, a report by the World Health Organization (WHO) [4], in 2017 suggested that access to clean and safe drinking water is important for good health and development in any country, and it should be made available to everyone. However, most developing countries lack access to clean and safe potable water due to water contamination at the sources [2,[5], [6], [7], [8], [9]]. Consequently, these might lead to diseases that are attributed to poor quality water consumption and may also lead to death if not treated [4].

The demand for access to clean and safe drinking water has also contributed to the high usage of bottled water (BW) in most developing countries, which is not properly regulated, and in most instances when it is regulated, consumers are not well conversant with the law [2,5,10,11]. In addition, BW is classified as food in many countries, including South Africa (SA) [[12], [13], [14]], which brings about complexity on who should monitor and apply that regulation within the local authority where BW is packed and distributed. Bottled water, on the other hand, is regulated by the National Department of Health (NDoH) [13,14], and must conform to the SANS 241 standards for drinking water. The Environmental Health Practitioners (EHP's) mandate as part of Municipal Health Services (MHS) within the District and Metropolitan Municipalities is to monitor public drinking water quality, which is also the responsibility of the Department of Water and Sanitation (DWS). Therefore, monitoring of BW is currently not part of MHS or the responsibility of the DWS [14]. Hence, the accountability for monitoring BW has become more complex as it is still under the control of the Food Control sub-Directorate within the NDoH [14], although the monitoring is not frequent. Consequently, when BW is monitored, the focus is more on chemical and physical parameters of BW than microbiological monitoring.

The Chartered Institution of Water and Environmental Management (CIWEM) [15] and Food Safety Authority of Ireland (FSAI) [16] stated that replacing tap water with BW has no general health advantage, and that people should be aware of these false claims. Tap water is subject to stringent quality and regulatory controls over BW [15,16]. The general public has access to information on the microbiological, physical and chemical contents of tap water [15], in contrast to BW [12]. Consequently, poor quality drinking water has been implicated in the spread of waterborne diseases such as Cholera, Typhoid fever and dysentery [17]. Hence, diarrhoea is regarded as one of the most common symptoms of water infection related to contaminated drinking water, with a mortality rate of more than 800000 each year, whereby children under the age of 5 constitute 5.3% of the deaths [18].

According to the National Health Act, 2003 (no. 61 of 2003) [19], EHPs are required to monitor water quality and food compliance in SA. In addition, Hodgson & Manus [20], stated that the NDoH, mandate supports drinking water quality management, including the collection of information on waterborne disease incidences. Therefore, EHPs are required to take the lead in health and hygiene education linked to water and sanitation in order to enhance drinking water quality management. In general, the EHP's role and function is to support communities in having access to clean water, including water sampling and analysis. It is a major concern that these functions are not usually monitored, which is exacerbated by the lack of legislative clarity as it is seen as the mandate of the Food Control sub-Directorate within the NDoH.

Despite concerns about the quality of BW in SA [21], and due to the limited data available on the microbiological content of BW distribution, BW has become one of the most popular businesses without the stringent measures required. Currently, there are limitation on BW enforcement, especially in the informal sector. Even though the relevant legislation was promulgated in 2007 [13], with a majority of consumers not being aware, the focus has shifted to big industries that produce volumes of BW. Most of these big industries are members of the South African National Bottled Water Association (SANBWA) and are audited in accordance with the SANBWA standards and BW regulation [13]. The audit is only open to members with a compliance rate of between 85% and 100% [13].

The gap in the lack of BW quality monitoring and clarity on the legislation between the NDoH, Food Control sub-Directorate and MHS has caused the EHPs within the District and Metropolitan Municipalities to not focus on BW quality monitoring. This could have led to the finding of more than 45000 bottles of counterfeit BW that were circulated in the ELM [22]. Studies have demonstrated the shortage of EHPs as well as working tools for the EHPs in SA [[23], [24], [25]] as amongst the serious concern for water monitoring. Hence, the lack of clarity on the role of EHPs within the District and Metropolitan Municipality as well as NDoH Food Control sub- Directorate is one of the gaps. In addition, the WHO has recommended that at least 10000 people be served by a single EHP. Nonetheless, the SA government has chosen a policy whereby each EHP is accountable for 15000 people in each area across SA [23,26]. This objective, although ambitious, showcases government's commitment towards effective service delivery. However, in SA, there is a backlog of more than 4000 EHPs, according to the South African Local Government Association (SALGA) [27]. For instance, the Emfuleni Local Municipality (ELM), which has a population of over 700,000 is serviced by 15 EHPs, leaving the municipality with a backlog of 31 EHPs. This also affects the responsibility of EHPs in water quality monitoring. On the other hand, SA is one of the leading consumers of BW on the continent [28], which requires constant water quality monitoring for public health safety. However, the lack of clarity on legislation influences most of the municipalities not to allocate a sufficient budget for monitoring BW and to only focus on public water provided by WSAs, although it has been proven by several studies that BW is not always safe [[29], [30], [31]].

Other studies also indicate that companies that are not inspected on a regular basis tend to be non-compliant with BW standards for chemical and microbiological content [29,32]. Similarly, a recent study conducted in SA by Olowoyo et al. [33], which tested 12 BW brands purchased from formal and informal shops in Pretoria, indicated that 3 out of 12 BW samples were not fit for human consumption. However, tap water is always under scrutiny as opposed to BW due to its priority in water quality monitoring in rendering MHS. Hence there is a need of stringent measures to monitor BW to protect public health in SA.

2. Methods

2.1. Evaluation of water quality monitoring by EHPs

The assessment of regulatory compliance for water quality by EHPs was performed online using Google Forms survey software. The study was conducted between April and June 2021. The Fifteen (15) questionnaires link, which represents the total number of EHPs in the ELM, were distributed using WhatsApp's and emails. The Google Form survey was designed on the basis that if the participant did not agree to consent, the participant would automatically not proceed to the next question. Participants were assessed based on their knowledge of regulations governing BW and food; water sampling practices (frequency, type of water sampled); challenges encountered when conducting water quality monitoring; and occurrences of water-related disease outbreaks. The results were received immediately after the participants completed the survey questionnaires. Of the 15 questionnaires distributed, only 11 responses were received.

2.2. Review and evaluation of ELM water quality monitoring reports within ELM

An analysis of ELM documents was conducted using secondary data, which included the Integrated Development Plans (IDPs) and Service Delivery and Budget Implementation Plans (SDBIPs) for the financial years 2017–2020, with a focus on the sampling and monitoring of bottled and tap water. The Integrated Development Plan (IDP) is a five-year strategic plan that directs the plans of each municipality in SA [34]. It is a comprehensive plan that describes the vision, mission and objectives of the municipality, and initiatives used for the betterment of the municipality's service delivery [34]. The IDP is used to guide the municipality in its decision-making processes and to ensure that resources are allocated in a way that is consistent with the municipality's objectives [34]. In the context of water quality monitoring, the IDP can be used to guide the municipality's efforts to ensure that the water sources (BW and tap water) are monitored and maintained at a high standard.

In addition, the IDP can also be used to identify areas where improvements are needed, as well as to develop plans to address these areas. On the other hand, the SDBIP is a management and implementation tool that establishes in-year data, including monthly budget targets and quarterly service delivery goals such as the provision of water of good quality, which includes sampling and monitoring; and connects each department's performance to the overall budget. Therefore, the budget, which is informed by the IDP, informs the SDBIP [34],and includes the monitoring of drinking water.

2.3. Sampling and power analysis

The priori power analysis was done to determine if the sample size would be sufficient for the problem statement. According to Lan & Lian [35] priori power analysis is a valuable method that is usually used to determine necessary sample size of a study and used as a sufficient method to ensure statistical power before a study is conducted. The power analysis was performed using SPSS v29, power analysis focusing on correlation. The results are shown in the table below centred on the spearman correlation which was appropriate given the nature of the data and question:

Power analysis - Spearman correlation.

Test	N	Actual Power	Test Assumptions
Spearman Correlation	11	0.919	Null:0.89, Alternative: 0.85 Sig.: 0.05

The actual power was 0.919 for the one-sided test indicating it can detect correlations in the dataset. From the table above the null hypothesis correlation is rejected at 0.05 level of significance.

2.4. Data analysis

All responses were recorded, and the dataset was entered onto an Excel spreadsheet and exported to SPSS version 29 for analysis. Descriptive and inferential statistics were used for data analysis. Both sets of data were compared using statistical analysis at a 90% and 95% confidence level and trends were marked. The inferential test was performed using a chi-square test and Spearman correlation analysis.

Five composite variables were created to answer the research objective to ascertain whether EHPs monitor the quality of bottled and tap water as stipulated in the National Health Act 61 of 2003. The variables were Regulations, Sampling Practices, Water Analysis, IDP Familiarity and Participation and, Water Monitoring plan.

The Chi-square test was also employed to determine whether there is an association between categorical variables. This test does not assume normality in the data and is suitable for the categorical nature of the variables studied. Chi-square was appropriate for this study to analyse the relationship between categorical variables. By using the chi-square the study was able to uncover associations between various aspects of water quality monitoring practices among EHPs. Additionally, the Spearman rank correlation coefficient, a non-parametric test, was utilized to assess the monotonic relationship between variables [36].

The Spearman rank correlation coefficient does not require the data to follow a normal distribution, making it robust in analysing relationships even when normality assumptions are violated. These statistical methods were chosen based on the characteristics of the data and the nature of the research questions, ensuring robust and reliable analyses without stringent assumptions about the distribution of the data. Given the sample size, it was found appropriate for inferential statistical methods to be used to analyse the data.

3. Results

Eleven EHPs participated in the study, with 54.5% being females and 45.5% males. Amongst the participants, 63.6% were aged 22–35 years, while 36.4% were aged 36–60 years. In terms of qualifications, 45.5% had bachelor's degrees; 36.4% had diplomas; and 18.1% had post-graduate qualifications. The positions held were approximately 72.7% EHPs, 18.1% Chief

EHPs, and one manager. The majority of the EHPs (90.9%) were conversant with regulations governing food safety and 72.7% were conversant with regulations governing bottled water.

The variable called *"Regulations"* had a mean of 1.81 and a standard deviation of 0.33. This indicates that on average respondents EHP's have a relatively high level of familiarity with the regulations. The mean score for "sampling practices" was 2 with a standard deviation of 0.447 this suggests that on average respondents EHP's engaged in water sampling practices and there is moderate variability within the sample. The mean for Water Analysis was 2.636 with a standard deviation of 1.063 this indicated that on average the respondents performed various types of water analysis. The mean for IDP Familiarity and Participation was 1.864 and standard deviation of 0.3233. This suggested that the EHP's have a high level of familiarity and participation with IDP, variability in response by the EHP's was low. Lastly, the water monitoring plan had a mean score of 1.7273 and standard deviation of 0.786; this indicated that EHP's had some level of involvement in water monitoring plans. From this analysis participants had a high level of familiarity with regulations, IDP, engage in water sampling practices, perform various types of water analysis plans, and have some involvement in water monitoring plans.

The participants were then requested to specify the types of water sources from which they conducted water quality monitoring. Fig. 1 shows that 36.4% of the EHPs reported water quality monitoring and analysis for only tap water, while (27.3%) indicated water quality monitoring and analysis for both tap water and surface water. Few EHPs (18, 2%) reported water quality monitoring in various sources which include tap water, borehole water and surface water, whilst another 18.2% revealed that they do not take part in water monitoring and analysis. Interestingly, the bar chart in Fig. 1 indicates that none of the EHPs conduct water quality analysis for BW, given that a total of 81.8% of the participants do take water samples for laboratory analysis, except for BW.

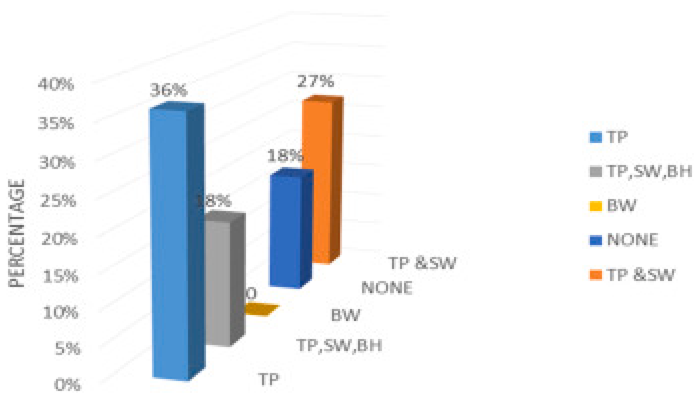

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Fig. 1. Type of water sources monitored by EHPs.

TP=tap water, SW=surface water, BH=borehole water, BW=bottled water.

The participants were then evaluated on the parameters that are used to test water quality. Participants further reported on water monitoring and analysis based on the parameters tested for different water sources. For tap water, 45.5% of the participants indicated that they test for microbiological concentration; 27.3% for microbiological concentration and chemical residual; 9.1% for chemical residual; and 18.2% of the participants indicated that they do not test tap water.

For borehole water, 36.4% of the participants indicated that they test for microbiological concentration, 27.3% for chemical, 9.1% for microbiological concentration and chemical residual, and 27.3% of the participants indicated they do not test borehole water. For BW, 27.3% of the participants indicated that they test for microbiological concentration, 18.2% for chemical residual, 18.2% for microbiological concentration and chemical residual, 9.1% chemical residual, and 27.3% of the participants indicated they do not test the surface water.

For surface water, 36.4% of the participants indicated that they test for microbiological concentration, 27.3% for chemical residual, 9.1% for microbiological concentration and chemical residual, and 27.3% of the participants do not test surface water. About 45.5% of participants are familiar with the IDP for water quality monitoring. The majority (72.7%) do not participate in its development. A total of 54.5% reported that they do not conduct water quality monitoring training, while 36.4% have conducted water monitoring plans. The results are shown in Table 1.

Table 1. Level of water quality monitoring.

Statement	**Level of Acknowledgement**		
	Yes	**Maybe**	**No**
Familiar with Integrated Development Plan for water quality monitoring in the municipality	45.5%	36.4%	18.2%
Take part in the development of an Integrated Development Plan for water quality monitoring in the municipality.	18.2%	9.1%	72.7%
Conduct water quality Monitoring Training	36.4%	9.1%	54.5%
Had a water monitoring plan	54.5%	9.1%	36.4%

Statement	Level of Acknowledgement		
	Yes	Maybe	No
Follow water monitoring plans	45.5%	27.3%	27.3%

The participants were assessed on how often they conduct water monitoring training. Only five indicated that they conduct water sampling. In this regard, 20% indicated on monthly basis, while 80%- indicated on a yearly basis.

In terms of challenges preventing the participants from following water monitoring plans, 62.5% reported that it is because of budget constraints; 18.2% stated a lack of financial approval to sample water; and 12.5% indicated limited transport resources. Regarding water-related disease outbreaks in the previous year, 45.5% reported no outbreaks; 36.4% confirmed having experienced outbreaks; and 18.2% were not sure. Therefore, amongst those who experienced outbreaks, multiple diseases were mentioned, namely 83.3% of the outbreaks were diarrhoea, 33.3% were stomach pains, and 16.7% were vomiting.

The results revealed that there is a strong relationship between regulations and sampling practices where $\rho =.710, p = 0.007$ this shows an increase if there is an increase in usage and implementation of regulations, will result in the improvement in sampling practices. There is a significant negative correlation between Water Monitoring Plan and Training and Regulations ($\rho=-0.540$, $p<0.05$). This suggests that regulations and Water monitoring plan has a negative relationship with all the other variables meaning there is potential inverse relationships among water monitoring plan and training, regulations, sampling practices and IDP familiarity and participation as indicated in Table 2.

Table 2. Relationships between water quality monitoring practices and IDP familiarity and participation among EHPs using the chi-square.

Variables	Chi-square( )	p-value	Interpretation
Take part in the development of an integrated Development Plan for water in the municipality and * follow your water monitoring plans	11.000	0.027	This is statistically significant association; EHP that participate in Integrated Development plan are more likely to follow water monitoring plans

Variables	Chi-square(χ^2)	p-value	Interpretation
take part in the development of an integrated Development Plan for water in the municipality and * Have water monitoring	11.115	0.025	There is a statistically significant association; EHPs involved in integrated development plan are more likely to have established water monitoring plans
Familiar with integrated Development Plan for water quality monitoring in the Municipality and * Have water monitoring	7.288	0.121	There is no statistically significant association at a level of 5%; that EHPs that are familiar with integrated development plan adhere to water monitoring.
Familiar with integrated Development Plan for water quality monitoring in the Municipality and * follow water monitoring plans	8.021	0.091	There is no statistically significant association at a level of 5%; that EHPs that are familiar with integrated development plan adhere to water monitoring plans. If it was at a 10% level of significance they would have been an association

The findings from the Evaluation of IDPs and SDBIPs for the 2017–2020 financial years for ELM provide insight into this question [37,38]. The data revealed a significant decline in the number of water samples collected by EHPs for microbiological analysis over this period, dropping from 435 samples in 2017 to only 62 samples in the 2020 financial year.

4. Discussions

The current study revealed that BW is not monitored by the EHP's. The absence of BW sampling throughout the entire 2017–2020 period raises concerns regarding compliance with regulatory standards. This study reaffirms this absence, emphasizing the lack of sampled BW, with EHPs focusing solely on tap water, borehole water, and surface water.

Although the EHPs indicates an understanding of the required water analysis for BW, the absence of actual sampling for BW within the ELM suggests potential gaps in monitoring practices.

The significant decrease in water sampling activities over the three-year period underscores the importance of assessing compliance with regulatory standards and monitoring efforts in ensuring water quality. The findings highlight the need for further investigation and potential interventions to improve monitoring practices and ensure compliance with regulatory requirements.

This practice might put the public at risk of consuming contaminated water. It is also worth noting that there are no proper mechanisms in place to enforce BW regulation, especially in South Africa's informal sector. However, legislation was promulgated in 2007 [13]. The focus has shifted to large industries that produce volumes of BW. A number of EHPs are not familiar with such regulation due to a lack of clarity, and BW categorised as food. Most of these large industries are members of the SANBWA and are audited using SANBWA standards and BW regulation [13]. The audit is open only to members, with a compliance rate between 85% and 100%. In addition, all members' BW are branded with the SANBWA logo, certifying that are of good quality and safe to drink.

Unfortunately, authorities are neglecting or shifting the responsibilities of regulating BW. This has contributed to a high rise in the informal BW market in SA because of a lack of strict control and lack of water quality monitoring. For instance, people are packaging and re-branding BW without following regulatory compliance guidelines, and with no consequences. The regulations relating to BW make provisions for the fact that packaged/BW labelling must conform to the provisions of the regulations governing the labelling and advertising of foodstuffs [14]. However, in most cases, BW is often re-branded in contrast with the regulations. Most of these BWs contain misleading information such as images of people, companies and sponsors of events, and are used in parties, weddings, funerals and other social gatherings such as government and sporting events. Subsequently, drinking poor quality or contaminated BW can put the life of unsuspected consumers at a health risk. It is also of concern to note that there is no data available for all BW companies that operate in SA. This might be due to the fact that BW is perceived as being of better quality [5,6,9] and safer to drink than tap water.

Consequently, there is also a challenge of poor BW monitoring, as found in this study which could be due to BW not regarded as the MHS function but that of the Food Control sub-Directorate within the National Department of Health.

The responsibility for water quality and food control is with two different sub-directorates, which makes it difficult for EHPs to follow directives from both directorates. For instance, tap drinking water monitoring is placed in the Environmental Health sub-Directorate under Primary Health, whereas BW monitoring is placed in the Food Control sub-Directorate under Health Regulations and compliance management in the NDoH [14] respectively. However, according to the NHA (Act 61 of 2003), water quality monitoring and food safety control are the responsibilities of MHS, and are implemented at the Metropolitan and District Municipalities, spearheaded by the Environmental Health sub-Directorate in the NDoH in line with the legislation. Another contributing factor might be due to the fact that BW is not listed as a key indicator for service delivery in the District Health Information System (DHIS) for rendering comprehensive MHS in contrast with tap water. These findings concur with Brei [39], that BW is not properly regulated in terms of public health and is not usually tested for quality compared to tap water.

To this end, most studies have highlighted that BW is not always safe, as perceived by the public [[29], [30], [31]]. Furthermore, in Zimbabwe, 40 BW brands were banned because of non-compliance [5]. The challenge might be that some BW companies do not adhere to drinking water standards [5,6], are informal [10], and are unmonitored and unregulated. In addition, poor water monitoring systems and regulations may influence the rapid increase in BW companies and place the entire country at risk [10]. Therefore, it is imperative that government authorities put more effort into regulating and monitoring BW producers. It is also appropriate to develop a framework for BW monitoring, especially for small-scale enterprises in SA to protect public health. The framework should include sampling, testing, analysis, reporting, corrective actions, monitoring and public health education.

According to Brooks et al. [40], EHPs are strategically positioned to diagnose, intervene and prevent public health threats. Conversely, the role of EHPs in water quality monitoring is of paramount importance for safeguarding the public. If these responsibilities are avoided, they can lead to catastrophic effects on public health. Hence, EHPs are mandated to take water samples to the laboratory for microbiological and chemical analyses [20,41]. This function is in the District and Metropolitan Municipalities in SA [23,41], including food control. BW is regarded as food in SA. However, in the NDoH, Food Control sub-Directorate is placed within another Directorate, separate from the Environmental Health sub-Directorate [14]. On the other hand, EHPs are not adequately monitoring BW as there is confusion on who should monitor it. This might also contribute negatively to delivering comprehensive MHS especially on BW monitoring. In addition, water quality is regarded as a social determinant of human health. However, the issue of water quality has not been adequately addressed in the 2020–2021 Annual Report for the NDoH, even though there are concerns regarding drinking water quality in certain areas of the country, especially in rural areas [7,42].

5. Conclusion

The study highlights the need for improved water quality monitoring in the ELM, particularly for BW. The findings indicate that BW monitoring needs to be intensified to protect public health, as none of the EHP's collected samples of BW for analysis. The study also found that a number of EHPs are not conversant with regulations governing BW, which could lead to inadequate monitoring of water quality. The majority of the EHPs take water samples for laboratory analysis, except for BW, indicating a need for increased awareness and education among EHPs regarding the regulations governing BW and the importance of monitoring its quality. The study also highlights the challenges faced by EHPs in conducting water quality monitoring, including budget constraints, lack of approval for water quality monitoring and limited transport resources. The study emphasizes the importance of the IDP and SDBIP as tools for carrying out water quality monitoring and ensuring that resources are allocated in a way that is consistent with the municipality's goals and objectives. The study provides valuable insights that could assist policy-makers in making informed decisions on water quality monitoring, especially for BW. It is therefore appropriate for the NDOH to clarify the role of BW monitoring as an MHS function, rather than to leave it as a Food Control sub- Directorate function, which is only due to the poor attention it is given at the District and Metropolitan levels.

Ethical approval

The study acquired ethical approval from the Faculty Committee for Research Ethics [FCRE] of the Tshwane University of Technology FCRE 2021/02/005 (FCPS 02) (SCI).

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Data availability statement

Data associated with this work is not published in any repository. Data will be shared on request.

CRediT authorship contribution statement

J.L. Maselela: Writing – original draft, Methodology, Investigation, Conceptualization. **M.I. Mokgobu:** Writing – review & editing, Supervision. **L.S. Mudau:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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