Stakeholder contestations of water quality use and management in the Vaal Barrage catchment

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DATES:
Received: 08 Feb. 2024
Revised: 30 Aug. 2024
Accepted: 30 Aug. 2024
Published: 26 Sep. 2024

HOW TO CITE:
Odume ON, Chili A, Nnadozie CF, Slaughter A. Stakeholder contestations of water quality use and management in the Vaal Barrage catchment. S Afr J Sci. 2024;120(9/10), Art. #17887. https://doi.org/10.17159/sajs.2024/17887

ARTICLE INCLUDES:
☒ Peer review
☐ Supplementary material

DATA AVAILABILITY:
☐ Open data set
☐ All data included
☒ On request from author(s)
☐ Not available
☐ Not applicable

EDITORS:
Jennifer Fitchett
Pfananani Ramulifho

KEYWORDS:
contestations, resource quality objectives, Vaal River, water quality, water-use licences

FUNDING:
South African National Research Foundation, Water Research Commission (K5/2910)

The water resources within the lower section of the Upper Vaal catchment, where the Vaal Barrage is situated, are highly utilised and developed, and water quality regulation has become a contested space between resource users and the regulators. The credibility and scientific defensibility of discharge standards in water-use licences (WULs), the relationship between upstream and downstream waste loads, the relationship between flows and water quality standards in WUL, and the water quality components of the resource quality objectives (RQOs) are being contested. This study explores the perceptions and motivations underlying these contestations as a contribution to scientific understanding of water quality management in a highly developed system. Perceived unrealistic RQOs, perceived lack of scientific credibility of the methods for deriving water quality standards in WUL, data inadequacy, as well as poor institutional capacity were identified as the top motivations for contesting applicable regulatory instruments in the catchment. Punitive measures, incentives, and education and awareness-raising were identified as key to accelerating compliance. Overall, this paper contributes to our general understanding of the intricacies of water quality management within a contested space.

Significance:

Water quality management in South Africa is increasingly becoming a contested space, particularly in catchments that are highly developed and utilised. The findings in this study imply that (1) there is a need for a multi-pronged approach to increase water quality compliance, (2) there is a need for trust within the regulatory system to foster confidence among actors and stakeholders, and (3) transparent, open processes and scientifically credible and defensible methods, and data are needed for deriving standards in water-use licences (WULs).

Introduction

The lower section of the Upper Vaal catchment is among the most utilised catchments in South Africa because of its location in an economic heartland of the country.[1] Factors such as an expanding industrial footprint, a growing human population, and increasing agriculture, mining and informal settlements impact the Upper Vaal River and the Barrage.[1] These activities have led to reports of high levels of chemical and microbial pollutants in the lower section of the Upper Vaal River system.[2] Pollution poses a threat to both human health and further economic growth, as well as threatening ecological integrity, and the sustainability of the ecosystems upon which humans rely.[3,4]

Water quality remains a challenge in the Upper Vaal River catchment.[5,6] For example, salinity has remained an important water quality issue in the Vaal River and has received the most management attention.[7] Elevated nutrient levels, metals and high bacterial counts have also been reported in the Upper Vaal, indicating water quality related risks to both human and ecological health.[8,9] Water quality is impacted by diverse sources in the lower section of the Upper Vaal River, but the key contributors to deteriorating water quality include failing municipal treatment works (WWTWs), mine water discharges, irrigation return flows, urban run-off, industrial discharges, and atmospheric depositions.[7,10] As noted by McCarthy et al.[11], the collapse of the Klip River wetlands has further compounded the water quality situation downstream as these wetlands are no longer able to effectively remove nutrients. Water quality thus remains a complex challenge in the lower section of the Upper Vaal River system.

In South Africa, water pollution is controlled through environmental policies and regulatory instruments such as the South African national water quality policy and strategy[12], as well as water quality licensing, which is an important water quality regulatory instrument[13]. Examples of other instruments that are used to manage water quality and pollution in South Africa include general authorisation, water quality guidelines, the waste discharge charge system, the Green Drop programme, and environmental impact assessments.[14] These instruments are collectively referred to as source-directed control (SDC) measures. Equally important are the resource quality objectives (RQOs), reserve determination, the national classification system, and water resources classification of significant water resources, all of which are deployed towards protecting water resources. They are collectively referred to as resource-directed measures (RDMs).[15]

Odume et al.[14,16] have shown that water users in the catchment of the lower section of the Upper Vaal contested applicable water quality regulatory instruments such as discharge standards in water-use licences (WULs). A study carried out by Odume et al.[16] noted that water resource users and the regulators were contesting the scientific defensibility of the standards in WULs; the relationship between RQOs and standards in WUL; the implications of upstream waste loads on the standards in the WUL of downstream users; the relationship between flows and water quality; and the relationship between diffuse and point source pollution. These contestations led to tension between water resource users and the regulators in the catchment and have presented themselves as critical barriers to achieving sustainable water resource utilisation.

Contestation may be driven by water resource users' diverse values, perceptions, and motivations for water use. Jones et al.[17] define values as more strongly held than attitudes underpinning decisions and behaviour. For example, in the lower section of the Upper Vaal system, where the Vaal Barrage is situated, stakeholders have various reasons for water resource use, such as industrial use, mining, and agriculture, all of which are driven by economic benefits. The motivations for water use may contribute to the contestations of the applicable regulatory instruments, particularly if water resource users perceive that such instruments may impact the sustainability of their businesses and overall interests.[18] Understanding the social dimension of environmental problems is fundamental to understanding how stakeholders perceive and interpret regulatory instruments.[19] Overall, motivations in this study describe the 'why' stakeholders choose to contest the water quality instruments, particularly the discharge standards in WUL, the way such discharge standards were derived, and the relationship between discharge standards in WUL and the water quality component of the RQOs.

Given the highly industrialised, and diverse users of water resources within the catchment, downstream water users within the catchment have requested the regulatory authority to clarify how waste loads generated by upstream users were considered when deriving standards for downstream users.[14,16] Furthermore, downstream users in the catchment emphasised the need for stringent standards and targets for upstream users to control water quality impact and to meet the RQOs.

What is clear from these contestations about water quality in the lower section of the Upper Vaal system is the necessity to draw on a diversity of approaches, including a command-and-control to one that considers the interests and values of diverse stakeholders within the catchment.[20] Stakeholder engagement can assist in addressing the water quality challenges and gain community support, trust, and buy-in. Despite the identified contestations over water quality use and regulatory instruments in the lower section of the Upper Vaal[14,16], no study has explored the perceptions and motivations underlying these contestations. This study fills this gap as a contribution to the scientific understanding of water quality management in a highly industrialised and complex catchment.

Methods and materials

Study area description

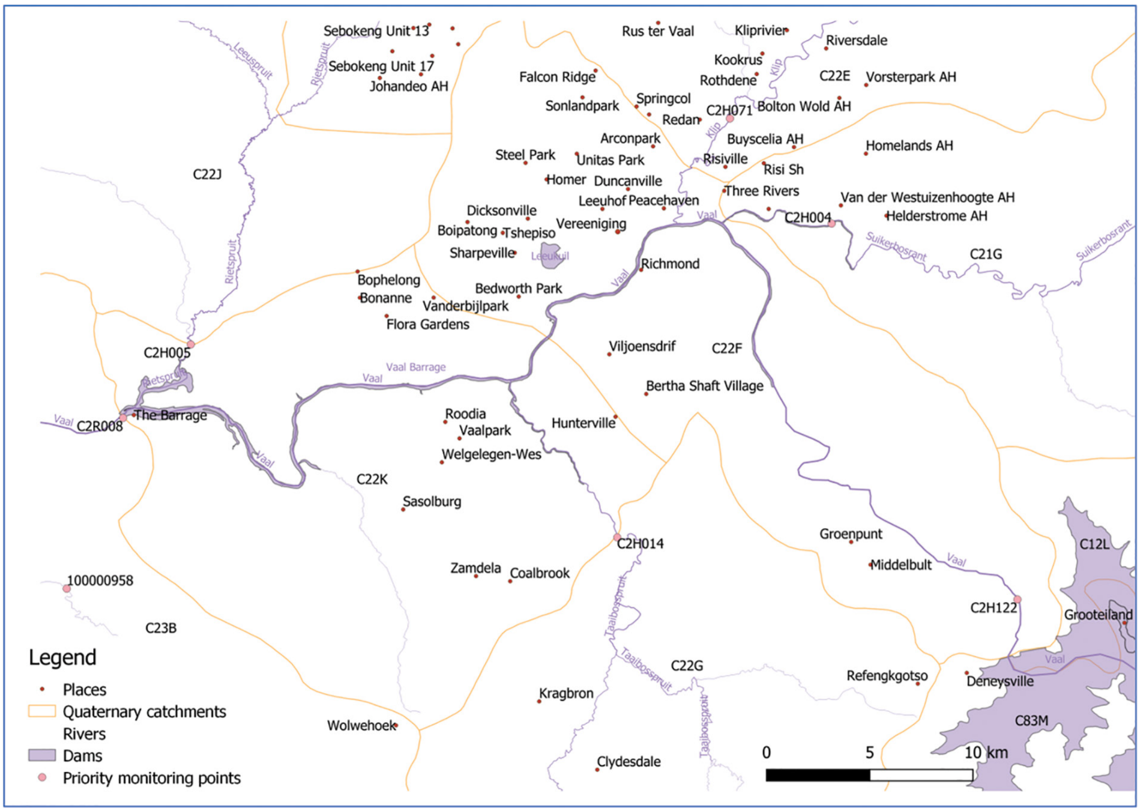
The Vaal River flows from the Drakensberg Mountains in the eastern interior; it then reaches the confluence with the Orange River before discharging into the Atlantic Ocean.[21] The Klip River, Little Vaal, Wilge, and Waterval are the main tributaries of the Vaal River. The Vaal River is regarded as the hardest-working river in South Africa as it is highly utilised within the economic hub of the country. The Vaal Barrage catchment lies within the quaternary C22K catchment, as shown in Figure 1. The Vaal Barrage was completed in 1923, and it was intended to supply potable water to the surrounding areas, but its purpose has since evolved, supporting many wet industries, and its water quality has been severely impacted.[22]

The demography in the Upper Vaal catchment has been extensively influenced by economic activities over the years, especially the downstream catchment, where the Vaal Barrage is situated. The completion of the Vaal Barrage stimulated employment and economic opportunities that led to the beginning of urban development and, ultimately, to an increased population that is now estimated at 10 million people.[1] The Barrage also led to an increase in economic activities such as mining, commerce, manufacturing, and farming.[23]

Water quality in the lower section of the Upper Vaal River and the Barrage is heavily impacted. Unacceptable levels of total dissolved solids (TDS), total suspended solids (TSS), toxic metals, and faecal coliforms have been reported.[24]

Theoretical framework, sampling strategy and data collection

The study draws on social constructivism as a theoretical lens because it argues that knowledge and understanding are constructed jointly by individuals through their experiences.[25] In a sense, social constructivism



Source: Odume et al.[16] (reproduced with permission)

Figure 1: The Vaal Barrage catchment showing quaternary catchments, rivers and dams.

sees human beings as capable of rationalising their experiences, constructing mental models of these experiences, and communicating these through languages.[25] These experiences, the constructed mental models, and the way these are communicated play a role in people's perceptions and views about the world around them. This theoretical framework was considered appropriate for exploring why and how people may perceive water quality in certain ways and, thus, the contestations that may arise from these.

The study utilised a purposive sampling technique, deliberately targeting research participants with interest, experience, and in-depth knowledge of water quality in the study area. Participants were also selected on the basis of a previous study by Odume et al.[14] Nineteen participants were engaged through a semi-structured questionnaire. They represented industries, governments, communities, non-governmental organisations (NGOs), and state-owned enterprises (SOEs). The sample size was considered adequate because the intention was to select participants with expert knowledge of the subject matter and who also had experience of the local water quality issues and the ongoing contestations.

To gain insight into the motivations, perceptions, and values underpinning water quality contestations in the study area among the expert stakeholders, a mixed-methods approach was utilised involving participant observation, semi-structured interviews, and document analysis.[18] Data from all three methods were then triangulated to obtain in-depth insights into the contestations of water quality instruments in the study area. The adoption of the mixed-methods approach ensures validity and credibility of the study.

The semi-structured questionnaire had four sections. The first centred on perceptions of the importance of water resources in the lower section of the upper Vaal catchment, the second on the water quality challenges faced in the system, the third on perceptions of RQOs, and the fourth elicits stakeholders' perceptions and motivations underpinning the contestation of WUL standards, as well as basic demographic information. The questionnaire was administered both electronically and in person during a workshop held on 14 February 2020. Participant observations were undertaken by attending the Leeu-Taaiboschspruit forums on 12 February 2020 and 14 November 2020 in Sasol Kliplapa, Gauteng. Notes were taken with particular attention to water quality management.

Data analysis

The data were analysed using descriptive statistics and thematic analysis.[26,27] The thematic analysis was conducted using the framework developed by Creswell[27]. As the sample size is quantitatively small, the qualitative, thematic analysis provides in-depth insights into the contestations.

Results

Participant demographics

A total of 19 respondents were interviewed for this study. Approximately 74% of the participants work in the public sector, 15% of the participants were in non-profit organisation (NPOs), and 11% in the private sector. Participants' interest in the water sector include water resource management (37%), integrated water quality management (11%), environmental policy implementation (5%), environmental toxicology (11%), environmental protection (16%), and activism/social justice/advocacy/civil society (5%). The participants' level of education and qualifications were Bachelor of Science (15%), Honours degree (5%), Master of Science (57%), and Doctor of Philosophy (21%). The participants' specialisations included ecology, hydrogeology, hydrology, chemistry, and toxicology, as shown in Figures 2 and 3.

Perceptions regarding the RQOs

From the data, three main themes emerged on perceptions regarding the RQOs: (i) unrealistic RQOs and the implications thereof, (ii) poor institutional capacity, and (iii) solutions to RQOs disputes/contestations. When participants were asked whether the gazetted RQOs for water resources for the catchment were realistic, more than a third of them (37%) found the RQOs to be realistic. About 26% of the participants found the RQOs to be unrealistic and 5% regarded them as "very unrealistic". Participants who found the RQOs unrealistic provided reasons such as:

> *I am not convinced that the resource quality objectives have a proper scientific basis. If the objectives are too lenient, we may not see any benefit of setting parameters as per WUL. Some levels are too lenient, but others are too strict.*
>
> *RQOs are formulated based on the available data, reflecting current conditions of a catchment. Therefore, whether formulated RQOs are realistic or not, depends on whether data used to formulate RQOs were realistic (depending on whether data that was used appropriately reflected current conditions, with sufficient temporal and spatial coverage). In the case of the Upper Vaal Catchment, only data that was available at the time of RQOs formulation was used.*

Approximately 5% of the participants were unaware of the gazetted RQOs. About 26% of the participants were not sure whether the RQOs were realistic or not, as shown in Figure 4. The participants who indicated that the RQOs were realistic gave different reasons; one of the

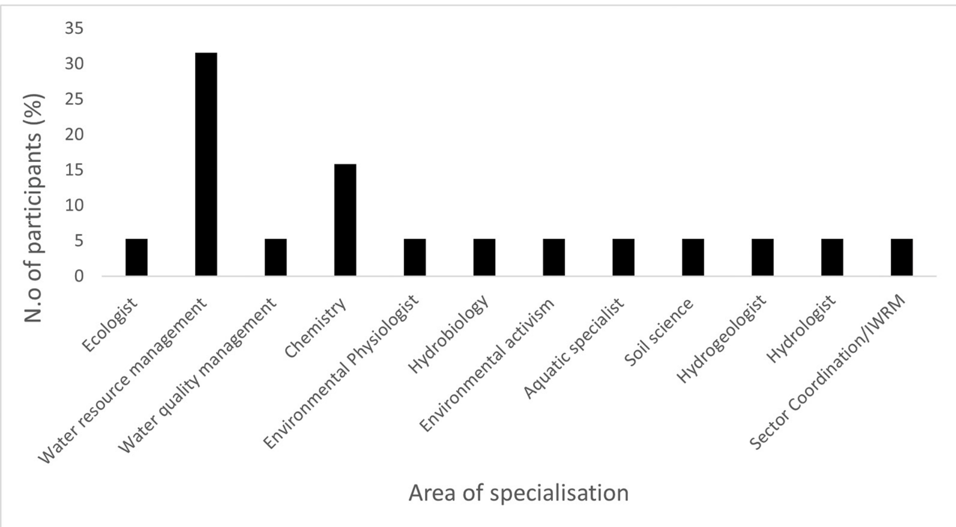


Figure 2: The specialisations of the research participants who were interviewed in this study.

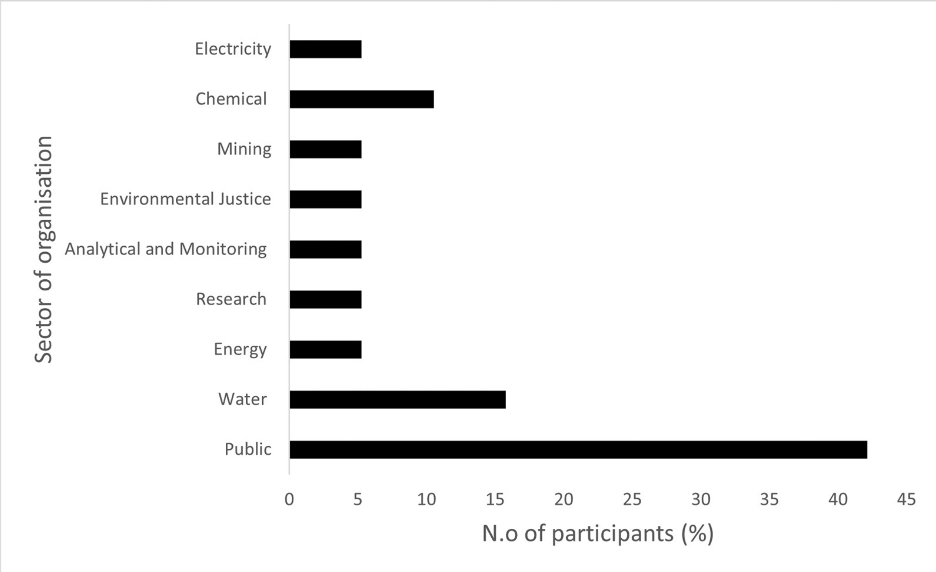


Figure 3: The sectors from which the participants interviewed in this study were drawn.

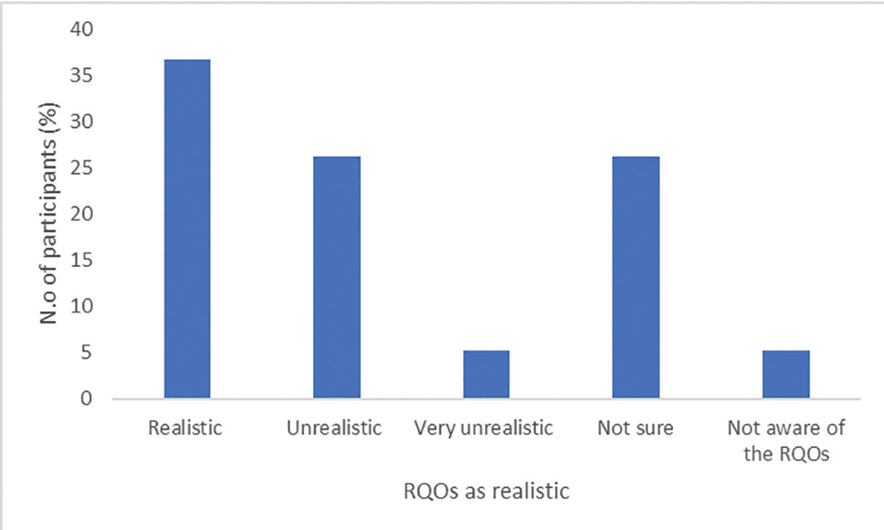


Figure 4: Participants' responses on whether the water quality component of the RQOs was realistic or not.

participants indicated the availability of historical data as the basis as to why the RQOs should be considered realistic:

> *There is enough historical data available to base RQO on, so they should be achievable. The RQOs in most catchments have been determined scientifically so they should be realistic, but mines/industries have to be more willing to try to comply.*

Participants were asked about the most likely consequences of not meeting the gazetted water quality component of the RQOs. About 63% of the participants agreed that degraded ecosystems and impaired ecosystem functionality would be a serious consequence (Table 1). Twenty-six percent of the participants perceived the risk of human infections and diseases due to impaired water quality as a serious consequence of not meeting the RQOs. About 11% of the participants considered job losses due to increased operational costs related to treating raw water for industrial uses.

Participants were asked to rank the necessary actions required to control water-use activities within the catchment on a scale of 1–5, with 1 being the least important and 5 the most important action(s) required to meet

Table 1: Perceived consequences of not meeting the water quality component of the resource quality objectives (RQOs)

Consequences of not meeting the RQOs	N= % frequency
Degraded ecosystems and impaired ecosystem functionality	63
Job losses due to increased operational costs related to treating raw water	11
Risk of human infections and diseases due to impaired water quality	26
Business profitability due to increased operational costs	0
Impact on water quality-sensitive crops and general agricultural productivity	0
Aesthetic value of the water resources within the catchment	0

the water quality component of the RQOs. About 74% of the participants indicated statutory enforcement and compliance monitoring; 53% felt raising awareness, education, and continuous stakeholder engagement were important; and 58% indicated that the 'polluter pay' principle would be the most important way to control and regulate activities within the catchment. Interestingly, participants ranked voluntary self-regulation, for example, through ISO and incentives/rewards to water users for perceived good behaviour, to be the least important action. Only 11% of the participants ranked self-regulation higher, and only 16% of the respondents ranked incentives for good behaviour high. However, one of the participants reflected deeply on the criticality of drawing on a diversity of approaches:

> *There is not a 'silver bullet'. The available management instruments, i.e. ranging from employing command-and-control approaches (e.g. licencing), to the utilisation of economic instruments (e.g. the Waste Discharge Charge System), to the support of self-regulatory programmes (e.g. ISO 14001), to civil pressure (e.g. management by shame approaches and participatory management through catchment forums) should all be used to achieve improvement and maintenance of resource water quality.*

Institutional capacity to deliver on mandate has been identified as critical in the South African water sector (e.g. Odume et al.[28]). The participants in the present study identified institutional capacity as the primary reason why the RQOs would not be achieved. When the participants were asked whether the RQOs in the catchment were achievable, approximately 68% of them indicated that it was either unlikely or highly unlikely that RQOs were achievable. These participants stressed that institutional capacity was necessary to meet the gazetted RQOs. One of the participants indicated:

> *There is a lack of commitment from the Department* [Department of Water and Sanitation] *in bringing all the role players in to achieve RQOs purposes.*
>
> *The DWS is finding it more and more difficult to effectively plan, manage and regulate water resources. There are multiple reasons for this. E.g. huge gaps in water quality monitoring. Etc.*

Participants emphasised the role of resource managers and catchment management agencies to meet the RQOs:

> *Once the RQOs are set, they are binding to all who use the resource. RQOs are set for the resource and not for the users* [licence conditions]. *It becomes the responsibility of* [the] *CMA* [Catchment Management Agency] *and regional people* [DWS staff in the regional office] *to implement the monitoring of the set RQO.*

Although most participants were of the view that the RQOs cannot be met, 16% were of the view that the RQOs were likely to be met provided as implementation and assessment plans reflect the current local conditions of the catchment:

> *It is highly likely that the gazetted RQOs would be met, provided that appropriate implementation and assessment plans which reflects current local conditions of the catchment are made available or put in place.*

Interestingly, one participant challenged the notion of the RQO and focused on whether the objectives would result in promoting sustainable resource management within the catchment:

> *Honestly it would vary per catchment; many objectives are not stringent at all, and in fact, if they were met, would result in an unsustainable catchment management situation. An example is the manganese limit set for the Mooirivier, which results in acute toxicity to the receiving environment. While on the other side, there are other objectives that have been set that can never be met, or have no reasonable scientific basis for why they were included, such as the uranium limit in some catchments (with known uranium sources) of 15 ug/L as opposed to drinking water quality requirements as per SANS and WHO of 30 ug/L, not to mention the higher qualities that can be tolerated by the receiving environment, as supported by literature. Therefore, the question is less about the likelihood of achieving these objectives and more about whether these objectives would result in the improvement in the catchment management we really need to see occurring in order to ensure sustainable catchment management for present and future water users (includes the environment). It is highly likely that the gazetted RQOs would be met, provided that appropriate implementation and assessment plans which reflect current local conditions of the catchment are made available or put in place.*

Water quality standards in WULs

Water quality licensing is an important statutory instrument for reducing pollution.[13] Compliance with standards in water quality licences can be enhanced if water resource users view such standards as credible, scientifically defensible, and the process of their derivation as fair and transparent.[16] In the current study, when participants were asked about the key challenges of water quality licensing, participants ranked scientific credibility and defensibility of the methods for deriving water quality standards in WUL as top (Table 2). Other key challenges identified as priorities for WUL were clarity regarding the relationship between RQOs and water quality licensing, as well as institutional capacity, including expert knowledge. Some of the participants, particularly industry representatives, were of the view that the lack of scientific expertise, in particular on the part of the regulators, added to the uncertainty regarding scientific defensibility and credibility of the standards. These participants argued that such uncertainties could lead to the licence conditions being unrealistic. The relationship between RQOs and WUL also featured prominently; the participants were of the view that transparency was

Table 2: Perceived top water quality licensing challenges in the Vaal Barrage catchment and associated rivers. Note that one participant could indicate more than one challenge as a priority

Perceived top water quality licensing challenges	N=% Frequency
Scientific credibility and defensibility of methods for deriving water quality standards in licence conditions	63
Institutional capacity, including expert knowledge, to deal with water quality licensing	58
Clarity regarding the relationship between water quality components of the RQOs and water quality licensing	58
Institutional efficiency and effectiveness in issuing water quality licences	53
Perceived fairness in enforcement, compliance monitoring and sanctions	37
Backlog of licence applications	37
Lack of transparency in the way licence conditions are derived	32
Over-stretched regulators who are unable to cope with new applicants	26

critical as users do not understand the link between the water quality components of the RQOs and discharge standards in WUL. For example, a participant from the public sector opined that:

> *That is why the concept of RDM* [Resource Directed Measures]*, including clarity regarding the relationship between the water quality component of the RQOs and water quality licencing, seems not easy to understand by many of us.*

Participants also referred to institutional capacity in government structures and inadequate financial resources as factors that impede finalising the water quality licensing process. These issues were captured in the participants' responses as follows:

> *The Regulator is highly ineffective due to the lack of funding, multiple layers of poor senior managers, enormous bureaucratic and administrative burden, distrust, centralised decision making, disempowered middle managers and junior staff, rigid work environment that is not conducive to innovation, etc.*

> *Increasing vandalism of water infrastructure and reticulation, the non-payment for water services and the filling of technical positions with unsuitably qualified/ experienced staff are contributing factors, pointing to serious socio-economic challenges; an unsustainable culture of non-payment for services, and the creation of serious essential technical skills shortages. E.g. the performance of WWTWs is getting poorer. WWTWs that previously complied, are finding it more and more difficult to complying, etc.*

The participants were asked whether the process of deriving water quality standards in WUL conditions was consultative enough. Approximately 32% of the participants disagreed, with 11% strongly disagreeing that the process for deriving WUL standards was consultative. About 26% chose to be neutral and 26% of the participants agreed that the process was consultative.

The participants were asked about the actions necessary to stimulate the spirit of self-regulation and compliance with water quality licence conditions. Interestingly, severe punishment for sustained bad behaviour by water users, as well as scientific credibility and defensibility of methods of deriving water quality licence standards, were top for the participants (Figure 5). Most of the participants indicated that these two measures were the most important, each scoring 32%. Participants also viewed institutional efficiency dealing with water quality licensing issues as important (16%). Although incentives as a means of promoting compliance have been promoted in the sector, this did not receive much attention as only 11% of the participants thought that incentives for sustained good behaviour could lead to self-regulation and compliance.

The participants were asked to rank the actions that can be taken to address disputes regarding licence conditions, on a scale of 1 to 5, where 1 represents the lowest priority and 5 the highest priority; 53% ranked negotiation between parties as the highest priority, followed by a reconsideration and reformulation of licence conditions (32%). About 26% of the participants ranked legal challenge in the court of law as the lowest priority, and 11% of the participants ranked an appeal for the licence condition as the lowest priority.

Discussion

The aim of the study was to unpack the motivations and perceptions underpinning the stakeholder contestations of the water quality regulatory instruments such as the water quality components of the RQOs and WUL standards. The water quality components of the RQO are measurable qualitative and quantitative goals that must be met to protect the ecosystems at a desired level of protection.[29] The present study explores reasons why stakeholders within the catchment may contest the RQOs. Most participants in the present study regarded the RQOs as realistic; however, some of the participants were of the view that the RQOs were either unrealistic or very unrealistic. These views may have arisen because (1) the catchment is complex and the RQOs may not reflect this complexity in terms of the multiple point and diffuse sources of pollution[14]; (2) the historical pollution in the catchment could mean that the RQOs do not reflect an appropriate baseline; (3) the RQOs may be relaxed for some water quality variables, yet too stringent for others; (4) credibility and adequacy of the data upon which the RQOs are based, and which in turn informs WUL. Whatever the case may be, the perception that the RQOs are unrealistic implies that stakeholders are less likely to embark on activities that ensure that the RQOs are met, which may be detrimental to long-term economic and social well-being as well as the ecological integrity of the catchment. A study by Sindane and Modley[30] found that households in parts of the study area perceived poor water quality as having detrimental socio-economic effects on members of their households, indicating the need for urgent collective action to improve water quality within the system.

The water quality components of the RQOs are usually formulated through a consultative process in which stakeholders are encouraged to participate and make input.[21] What the results of the present study suggest is the need to broaden and strengthen the participation process to take forward more local and catchment-embedded knowledge in the formulation of the RQOs. If the RQOs reflect more of the local knowledge

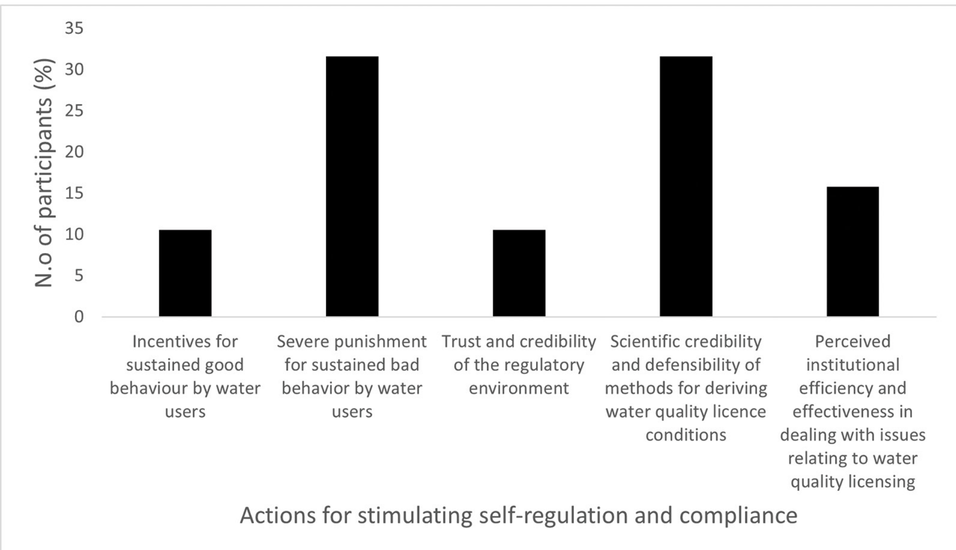


Figure 5: Participants' responses regarding actions necessary to stimulate self-regulation and compliance with water quality standards in water-use licences.

of the catchment, feelings about whether the RQOs are unrealistic may be diminished. The *National Water Act* does not make provision for revising the RQOs after they have been gazetted[29], so contesting gazetted RQOs becomes difficult. The fact that the NWA does not make provision for revising the gazetted RQOs is a weakness that has been identified in the Act.

Scientific credibility improves the legitimacy and reliability of the regulatory environment.[31] Credible scientific measurement is essential to environmental decisions and policies.[32] A study by Odume et al.[14] showed that one of the contested issues associated with water quality regulatory instruments is the perceived lack of scientific credibility and defensibility of the standards in the WULs. In the present study, the credibility and adequacy of scientific data has been raised as a concern regarding both the RQOs and standards in WUL. Berg et al. noted that credible data collection and sharing can foster coordination and build trust.[33] In addition to data adequacy, the participants advanced several reasons why they disputed the scientific credibility of the process of deriving water quality standards in WUL. For example, the participants argued that the links between WUL and RQOs were not clear and that the implications of upstream waste loads on the standards for downstream resources users were also unclear. Given these reasons, it is important that the regulator and resource users embark on an open, transparent process that reassures all stakeholders of the scientific credibility of the methods and processes for arriving at standards in WUL. Such a process can have a positive, reinforcing effect on the regulatory environment.[33]

Compliance with regulatory instruments is necessary to achieve a balance between resource protection and use. Effective compliance could lead to equitable water allocation, improved relationship between users, and a reduction in illegal water use that threatens ecosystems.[34] Within the water sector in South Africa, compliance monitoring is done by institutions such as the Department of Water and Sanitation (DWS), catchment management agencies (CMAs), and regional offices of the DWS. To ensure compliance, a study conducted by Hugo[35] reported the need for a structured criminal penalty system for environmental violations in terms of the *National Water Act, Act No. 36 of 1998*[36]. An effective administrative penalty system could be a solution for ensuring that water users comply with the provision of their WUL. As argued by Hugo[35], such an administrative penalty system for environmental violations would implement punitive measures in the case of non-compliance and provide incentives to encourage compliance.

Punitive measures as a way of stimulating compliance are recognised as calculated motivation.[37] Calculated motivations refer to resource user compliance motivated by the likelihood of fines that are imposed upon violation of the water quality standards in the WUL.[37] A study by Winter and May[37] revealed that the likelihood of detection, the likelihood of a fine, and the cost of compliance are important factors that influence a resource user's decision to comply with the provision of WUL. The likelihood of detection refers to the frequency of inspection, which may lead to the detection of violation, whereas the likelihood of a fine may influence the resource users to comply, particularly if the costs of the fine far exceed that for compliance.[37] The NGO Save our Vaal environment (SAVE) have in the past taken Sasol's coal mining division to court to halt the latter's then plan to commence mining operation on sensitive ecosystems within the Barrage catchment. SAVE won the case, implying that civil society organisation has a critical role to play regarding water quality management.[38] Apart from punitive measures, other mechanisms exist for facilitating and encouraging compliance, such as incentives, education and awareness-raising, self-regulation through ISO, as well as trust and credibility within the regulatory system.

The research participants indicated that education and raising awareness can encourage compliance with the water quality standards in the WUL. Studies such as that undertaken by Okumah et al.[39] have indicated that scientific evidence and raising awareness can influence resource users' actions towards meeting regulatory standards. The study suggests that active awareness-raising and education can result in stakeholders making better, informed decisions.[28]

Conclusion

In this paper, the perception and motivation underpinning water use, and the contestation of relevant regulatory instruments were explored. Perceived unrealistic RQOs, perceived lack of scientific credibility of the methods for deriving water quality standards in WUL, as well as poor institutional capacity were identified as the top motivations for contesting applicable regulatory instruments in the catchment. However, the research participants recognised the importance of water resources within the catchment and the need to heighten compliance levels to protect them. Punitive measures, education, and awareness-raising were identified as key to accelerating compliance. The general implications of the findings in this paper are that (1) there is a need for a multi-pronged approach to increase water quality compliance, (2) there is a need for trust within the regulatory system to increase confidence in the system, (3) there is a need to strengthen institutional capacity both in terms of implementation and costs recovery for services delivered, and (4) transparent, open processes and methods are needed for deriving standards in WUL to assure their credibility and defensibility. Overall, this paper contributes to our general understanding of the intricacies of water quality management within a contested space.

Funding

The authors received funding support from the South African National Research Foundation through the COP funding on Social Learning and Sustainable Development. Additional funding was received from the Water Research Commission, Project No. Project K5/2910.

Data availability

The data supporting the results of this study are available upon request to the corresponding author.

Declarations

We have no competing interests to declare. We have no AI or LLM use to declare. Ethical clearance was obtained from the Rhodes University Ethics Committee with approval number 2019-0288-693.

Authors' contributions

O.N.O.: Conceptualisation, methodology, data collection, sample analysis, data analysis, validation, writing – the initial draft, writing – revisions, student supervision, project leadership, funding acquisition. A.C.: Data curation, data collection, sample analysis, data analysis, initial draft. C.F.N.: Data analysis, validation, writing – the initial draft, writing – revisions. A.S.: Student supervision, project management, writing – revisions. All authors read and approved the final manuscript.

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