POLLUTION OF THE VAAL RIVER SYSTEM IN SOUTH AFRICA: A CASE STUDY

ELKINGTON SIBUSISO MNGUNI
Trans-Caledon Tunnel Authority, South Africa

ABSTRACT
The Vaal River is one of South Africa's strongest flowing rivers. It is home to the Vaal Dam, which supplies water to the Gauteng Province, South Africa's economic hub. Over the years, the failing wastewater treatment system in the catchment area has led to continued pollution of the river, compromising this critical resource and the economy of the region. In 2018, following a public outcry, the South African Human Rights Commission instituted an inquiry into the state of affairs of the region's water and sanitation management issues as well as the level and extent of the pollution problem. The Commission discovered raw sewerage in a stream flowing through the Emfuleni Golf Course, burst sewer pipes on the banks of the Rietspruit, dysfunctional components in the Rietspruit Wastewater Treatment Works, blocked manholes, and children from a nearby school swimming in and consuming polluted water. Raw sewage was found to be discharging from dysfunctional wastewater treatment plants into the receiving Vaal River. In the findings of the report released in February 2021, the Commission found that the Vaal River was polluted beyond acceptable levels. This case study reviews the state of the Vaal River pollution, including the measures that have been designed to address the problem in the short, medium, and long term. It also looks into the successes and challenges being encountered in addressing the Vaal River water pollution problem.
Keywords: Vaal River, pollution, wastewater treatment, interventions.

1 INTRODUCTION

This case study provides the historical background and development of the water pollution crisis in the Vaal River System in the Gauteng Province, South Africa. It starts from the assessment of wastewater treatment capacities conducted in 2008 to a full-blown water pollution crisis due to raw sewage spillages in 2018. It then reviews the intervention efforts that followed a public outcry and an inquiry instituted by the South African Human Rights Commission (the Commission) in 2018, and further action that was taken after the release of its final report in February 2021. The study also provides a brief outline of the progress that has been made until the end of 2021 with concomitant challenges in the implementation of the interventions, as well as making some recommendations that could improve the situation.

2 LOCATION OF THE STUDY AREA

The pollution problem discussed in this study emanates mainly from the Sedibeng District Municipality (DM), which comprises the Lesedi, Midvaal and Emfuleni Local Municipalities, forming the southmost region of the Gauteng Province. The Vaal River forms the southern border of the district municipality. The Sedibeng DM borders with the North-West Province (to the west), Mpumalanga Province (to the east) and the Free State Province (to the south). Fig. 1 shows the location of the study area.

3 PROBLEM DESCRIPTION AND BACKGROUND

The Vaal River is one of South Africa's strongest flowing rivers. The Vaal Dam which supplies water to the Gauteng Province, South Africa's economic hub, is located on the Vaal River which forms the southern border of the province. In their submission to the

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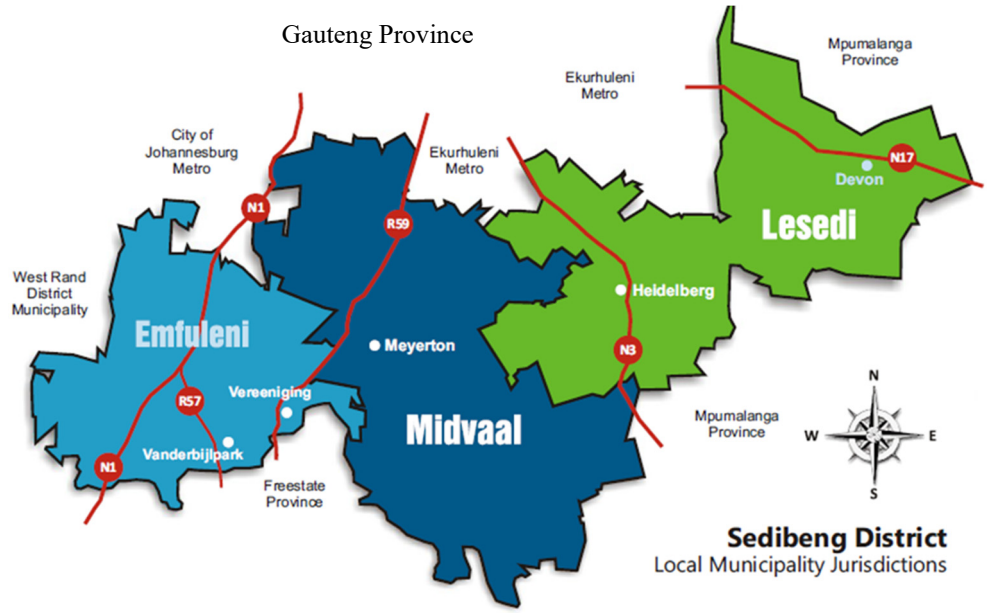

Figure 1: Locality of the study area [1].

Commission, the Water Research Commission, a government entity of South Africa, asserted that the Vaal River was the country's "most economically valuable aquatic ecosystem, and Africa's hardest working river for over a 100 years, and was able, in parts, to recover from mining and industrial pollution" [2].

Over the years, the failing wastewater treatment works in the drainage basins of the river have led to continued pollution of the river, thus compromising this critical resource for social, agricultural, commercial and industrial use, as well as for power generation.

One of the worst affected areas of the province is the Emfuleni Local Municipality (Municipality), a water services authority in terms of South Africa's Water Services Act of 1997 [4]. This is where the majority of the failed wastewater collection networks and wastewater treatment plants are located.

The locations of the three wastewater treatment plants under consideration, namely, the Sebokeng Wastewater Treatment Works (WWTW), the Rietspruit WWTW, and the Leeukuil WWTW, are shown in Fig. 2 which shows the study area. The Municipality is thus the focus of this case study in terms of the river pollution experienced in the region.

3.1 The capacity of wastewater treatment works in 2008

In a study commissioned to investigate wastewater treatment capacity in the Municipality, which was released in October 2008, it was found that the capacity of the wastewater treatment plants in the region would need to be extended by some 275 million litres per day (ML/day) by 2025 [5]. The proposed additional capacity would be composed of 100 ML/day at the extended Sebokeng WWTW, and 175 ML/day at a new WWTW to be constructed within the region. The additional capacity would be required to address the sanitation backlogs at the time and to cater for future growth in the region.

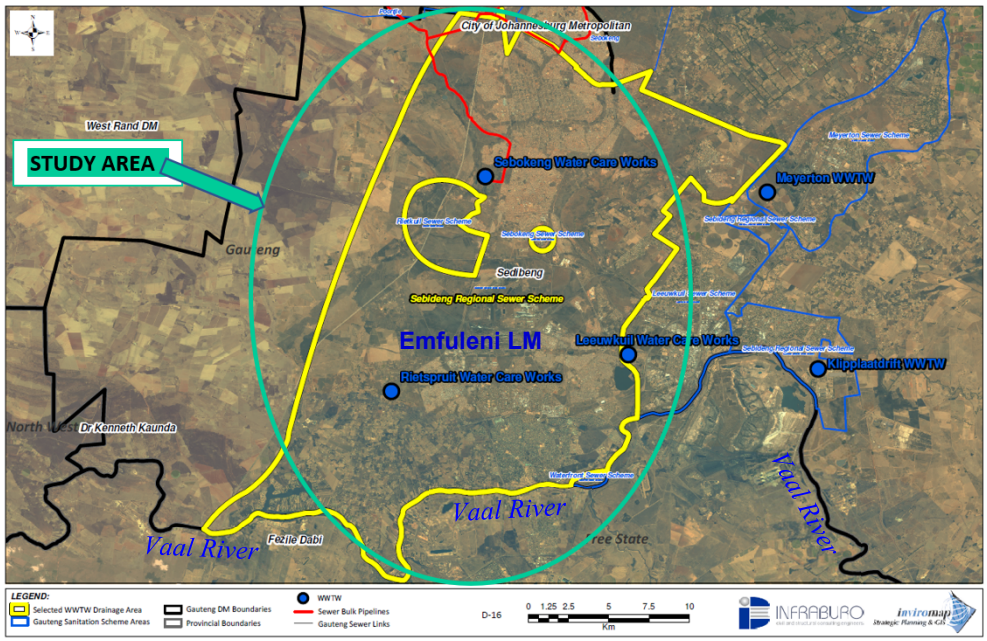

Figure 2: The three WWTWs within the study area [3].

It was also found that some 20 ML/day of surface and ground water infiltrated into the wastewater collector network flowing into the 100 ML/day Sebokeng WWTW. This infiltration problem needed to be addressed in the short term in order to free up much needed hydraulic treatment capacity in that plant.

The new WWTW would need to be built by 2015 in order to meet the treatment capacity requirements for the region by 2025 [5]. The 2008 report led to a proposal, in 2010, to develop and implement a multifaceted project to address the regional wastewater treatment capacity current and future requirements. The projects was referred to as the Sedibeng Regional Sanitation Scheme (SRSS) [3].

3.2 The Gauteng Province's WWTWs Master Plan of 2014

The Department of Water and Sanitation (DWS) further commissioned a study to develop a Master Plan for the Gauteng Province's WWTWs. The master plan was completed and released in April 2014 [3]. The plan provided updated technical, financial and operational data for all WWTWs in the Gauteng Province, including the three plants within Municipality, namely, the Sebokeng, Rietspruit and Leeukuil WWTWs. At the time, the Municipality indicated that all WWTWs had proper maintenance programmes in place and rated their plants as "regular". However, they did indicate that the main challenge with the treatment plants was that they could not replace the components which were due for such, thus causing operational difficulties. Further, the Municipality had not provided feedback for the number of breakdowns they were experiencing at the time.

The report further confirmed the findings of 2008 that the WWTWs in the municipality had a total design capacity of approximately 172 ML/day and the incoming flow of some 208 ML/day. This demonstrated that the treatment capacity of the plants within the Municipality

was inadequate, with two of the plants operating beyond their capacity, specifically, the Sebokeng WWTW was operating at 135 ML/day instead of 100 ML/day, and the Leeukuil WWTW at 45 ML/day instead of 36 ML/day. The Municipality indicated that the construction of the works to increase the capacity of the plants by upgrades or extensions had been delayed by some 4 to 6 years and that by the time those upgrades were completed new upgrades would be due [3].

3.3 The public outcry and the Human Rights Commission in 2018 to 2021

In 2018, following a public outcry, the Commission established an inquiry into the state of affairs with regard to water and sanitation management issues as well as the level and extent of pollution in the Vaal River System. The Commission, among other activities, undertook a visual inspection of the areas within the Municipality where complaints had emanated and publicised in different media outlets and platforms.

During the inspections the Commission discovered raw sewerage in a stream flowing through the Emfuleni Golf Course, burst sewer pipes on the banks of the Rietspruit River, dysfunctional components in the Rietspruit WWTW, blocked manholes, and children from a nearby school swimming in and consuming polluted water. Raw sewage was found to be discharging from dysfunctional wastewater treatment plants into the receiving tributaries of, and into the Vaal River [2].

The final report of the Commission was released in February 2021. In the findings the Commission found that the Vaal River was polluted beyond acceptable levels, which had serious implications for the Municipality as a water services authority [2]. Water services authorities have an obligation to protect water resources and to ensure that that residents have access to clean drinking water.

4 THEORETICAL CONSIDERATIONS

4.1 Basic design aspects of a wastewater collection and conveyance network

The basic design criteria for a wastewater collection network entails vertical and horizontal alignment design. The vertical alignment design requires that minimum grade requirements be met for self-cleansing capacity of the sewage being conveyed through the pipeline network. The flow through the network is ideally driven by gravity towards the wastewater treatment facility. However, should there be low points along the gravity main, it becomes necessary to install pump stations where sewage is pumped up a rising main to a high point where it can flow by gravity again until it reaches the treatment facility. Horizontal alignment design entails ensuring that change of direction at points of intersection are appropriate to ensure the natural flow of sewage. At points of change in grade and/or direction manholes need to be installed. It is critical that the pipe lengths in between the manholes be dead straight to avoid any potential blockages. The manholes are important to ensure that any blockages in the sewer network can be cleared when they occur.

The collapse of the wastewater collection network in the case of the Municipality points to lack of proper operation and maintenance by way of clearing the blockages when they occur in the collection network and failure to keep the pump stations in an operable condition by way of routine maintenance and replacement of mechanical and electrical components when required. This situation is further demonstrated in Section 5 below which deals with the status of the pollution problem from 2018 to date.

4.2 Asset management principles

The problem of water pollution in rivers, such as is the case in this study, emanates from the lack of the application of basic principles of integrated asset management, which is defined as, "an integrated process of decision-making, planning and control over the acquisition, use, safeguarding and disposal of assets to maximize their service delivery potential and benefits, and to minimise their related risks and costs over their entire life" [6]. This entails the appropriate development and implementation of such strategies and plans to operate, maintain, repair, refurbish or renew infrastructure assets, as well as making provision for the replacement of such assets or parts thereof when they have reached the end of their useful life.

Failure of the WWTWs to treat the wastewater to meet the legislated standards for discharge into the receiving environment is brought about by failure to apply the appropriate operation and maintenance standards and asset management principles.

In the case under study, indications are that appropriate investigations and condition assessments of the sanitation infrastructure assets were conducted and master planning was also carried out by the relevant authorities [3], [5]. What seems to have happened is a typical South African problem of developing impressive strategies and plans, but lack the appropriate implementation thereof.

5 FINDINGS: STATUS OF THE VAAL RIVER POLLUTION

According to a submission by the Department of Environmental Affairs to the Commission, water pollution in the country is prevalent with such problems having been identified in nine other water facilities outside the Vaal River system [2].

Although this case study focuses on the problems in the Emfuleni LM, pollution problems in the Vaal River System extend beyond the study area. For example, it was reported that a tributary to the Vaal River in Standerton, about 150 km upstream of the study area, also received untreated sewage from a dysfunctional wastewater management system [7]. It was also reported that a sewage spillage in Deneysville, about 40 km upstream from the study area, adjacent to the Vaal Dam wall [8].

The subsections below provide a snapshot of what was found in 2018 when the Commission initiated an Inquiry to the pollution problem in the Vaal River System, as well as some reported incidents in subsequent years.

5.1 Wastewater collection networks

Failure to maintain the sewage collection network by conducting scheduled or periodic maintenance and predictive or condition-based maintenance is evidently what led to the spillage of sewerage into the streets in residential areas as shown in Fig. 3. These spillages are not at low points in the sewer collection network, but at manholes. These blockages typically occur at points where the sewer main changes direction or grade or where there is an intersection of another sewer line. Such blockages would generally be reported to the municipality's water and sanitation operation and maintenance department to be cleared out. If there are no appropriate measures in place and the situation is not rectified timeously, one ends up with the situation that unfolded in the Municipality.

Figure 3: Sewage spillages in Sharpeville [9].

5.2 Pump stations

Failure to operate and maintain the pump stations according to sound asset management principles and best practice will invariably lead to sewage spillages at the pump stations. With the pump stations located at low points in the sewer networks, the sewage accumulates and ponds up without being pumped up and away from the pump stations. Fig. 4 shows typical cases where pump stations have failed as a result of which sewage created a pond inside and in the vicinity of the pump station. There are 44 pump stations in the Emfuleni sewer drainage basins or catchments, most of which have become dysfunctional.

Figure 4: A vandalised and abandoned pump station in Sharpeville and a flooded one in Vereeniging [9].

5.3 Wastewater treatment works

When the investigations into the nature and extent of the pollution problem in the Vaal were conducted, three wastewater treatment works were identified for prioritisation as part of the short-term intervention. In terms of the report released in 2014 [3], the three treatment plants had the status indicated as follows: The Sebokeng WWTW with a design capacity of 100 ML/day had inflows of 135 ML/day), Rietspruit WWTW with a design capacity of 36 ML/day had inflows of 28 ML/day) and the Leeukuil WWTW with a design capacity of 36 ML/day had inflows of 45 ML/day). All three treatment plants were operated on a 24 hour per day basis [3]. With the exception of the Rietspruit WWTW, the three plants were operated

beyond their design capacity. However, the report indicated that all the plants met the downstream receiving body objectives at 100%. In terms of the downstream receiving body ecological status, only the Leeukuil WWTW was rated as good, and the Sebokeng and Rietspruit WWTWs were rated as fair [3].

The performance of the three wastewater treatment plants seems to have deteriorated to the extent that by 2018 there was a pollution crisis in terms of the water discharges coming out of the treatment plants. The pollution problem seems to be continuing even as the short-term intervention is being implemented because reports from as recently as October 2021 show that there is little improvement in the situation as shown in Fig. 5 [10]. The treatment works would be overloaded as the wastewater collection network blockages get cleared.

Figure 5: Images taken on 25 October 2021 showing effluent discharged into a canal from the Rietspruit WWTW and the pollution of the Rietspruit River 2 km downstream from the WWTW [10].

6 FINDINGS: INTERVENTIONS AND PROGRESS AS OF JANUARY 2022

There are two notable interventions that followed the process of the inquiry initiated by the Commission in 2018, namely, the deployment of the South African Defence Force and the implementation of the Sedibeng Regional Sanitation Scheme: Short Term Intervention, as further detailed below.

6.1 The South African Defence Force Intervention

Following the public outcry and the intervention by the Commission and other state oversight bodies, the South African Defence Force (SANDF) was duly deployed to the Municipality for the period from October 2018 to October 2019, which was further extended to January 2020 [11].

According to the presentation made to the Commission, the SANDF was deployed to provide assistance with engineering and other expertise to resolve the pollution crisis on the Vaal. However, because the SANDF engineers were not specialists in the repair and maintenance of wastewater treatment infrastructure, they had to contract external specialists to assist, for a period of seven days. The scope of work for the SANDF included prioritising the Sebokeng WWTW: three modules and four pump stations and sewer lines; the Rietspruit WWTW: two modules, two pump stations and sewage lines; and the Leeuwkuil WWTW: two modules, 36 pump stations and sewer lines [2]. The SANDF managed to clean most of the modules in the WWTWs and kept the pump stations regularly cleaned. This was,

however, an immediate short-term intervention and a more permanent solution had to be developed and implemented. The SANDF highlighted challenges experienced during their intervention as the additional costs incurred during the operation and the lack of human resources within the Municipality which limited skills transfer [2].

6.2 The Sedibeng Regional Sanitation Scheme: Short-Term Intervention

Following the 2008 study into the capacity of the WWTWs in the Sedibeng DM, a regional scheme called the Sedibeng Regional Sanitation Scheme (SRSS) had been developed and proposed in a feasibility study released in 2010. According to a report released by the Department of Water Affairs in 2014, the SRSS was a Presidential Project as it was deemed to be critical for imminent growth in the region and to prevent the pollution of the Vaal River System through sewage spillages, a necessary intervention to protect the quality of drinking water sourced from the river system.

The report highly recommended that the matter highlighting the urgent need to implement the SRSS needed to be addressed at a top level between the Department of Water Affairs, Sedibeng DM, Midvaal LM and Emfuleni LM [3]. However, the report indicated that the Municipality and the neighbouring Midvaal LM had indicated that the projects were not being implemented at the time [3]. Without this recommendation being seriously considered and no action being taken, it was a matter of time before an ecological or environmental disaster happened.

When the situation finally got out of hand in 2018 and the sewage was seen flowing in the streets the authorities were forced to take drastic action. Among actions that were taken, as previously stated, was the deployment of the SANDF as a temporary solution. A more comprehensive intervention, albeit still short-term, was required for sustainable impact. This required the appointment of specialist engineers in wastewater treatment designs and implementation, particularly on the side of operation and maintenance of the wastewater management systems. Specialist and experienced civil, mechanical and electrical contractors were also required.

With the release of the final report of the Commission in February 2021, engineers were appointed for consultancy services for the short-term intervention, referred to as the Vaal River System Intervention programme (VRSI), as well as for the development and implementation of a medium to long term solution. This would include new infrastructure development and the optimisation and refurbishment of existing infrastructure.

The primary focus of the VRSI which was initiated in 2021 is to revitalise the existing wastewater collection, conveyance and treatment infrastructure. This is aimed at restoring the infrastructure to operational efficiency in the region. This intervention is part of the original SRSS envisaged in 2010 in terms of the scope of work for the medium to long term, but the current focus is on the short-term intervention which entails clearing up the wastewater collection network, clearing out the pump stations and treatment plants by carrying out remedial civil works and refurbishing and/or replacing the mechanical and electrical components [12].

The appointed civil engineers indicated that besides the refurbishment of the three WWTWs of Sebokeng, Rietspruit and Leeuwkuil, 44 individual pump stations are being upgraded, and the associated conveyance and sewer network pipelines are being unblocked. The DWS procured the services of Plant Hire and Bio-solids to unblock the sewer network and conveyance system and to handle bio-solids, respectively. The DWS also procured Civil Framework Contractors and aim to further procure the services of the Mechanical and Electrical (M&E) Contractors [12].

Progress on the implementation of the VRSI, as reported by the consulting engineers and the DWS, as of the end of January 2022 is outlined below.

6.2.1 Target for the quarter

The target for the last quarter of 2021 was to repair, refurbish and replace the various failed infrastructures, including bulk sewer lines, pumps, motors, electrical panels, screens, and manholes.

6.2.2 Actual progress for the quarter

In the last quarter of 2021, the actual progress included the completion of 195 high-pressure unblockings. Cleaning operations were logged daily in the Sebokeng Catchment, 101 in the Leeuwkuil Catchment and 100 in the Rietspruit Catchment. Cleaning operations in the three catchments are ongoing, which involves, among others, the cleaning of bulk lines over longer pipeline sections.

6.2.3 Reasons for non-achievement of targets

Some targets were not achieved because of the delays in concluding Service Level Agreements with the appointed seven (7) Civil Engineering Framework Contractors. The non-responsiveness of Mechanical Engineering framework contractors and the unavailability of Electrical Engineering Framework of Contractors also impacted performance [12].

Persistent community unrests or protests during implementation result in delays and increased costs of implementation. For example, the current intervention programme was disrupted when the bio-solids handling activities were halted from 13 October to 9 December 2021 in the Sebokeng WWTW and from 13 October to 13 December 2021 in the Rietspruit WWTW [12].

The community protest are due to the communities demanding job opportunities and the engagement of local enterprises beyond what is practicably possible on the project. At the end of March 2022, it was not possible to conduct a site visit to review progress because situation was said to be volatile.

7 CONCLUSION AND RECOMMENDATIONS

Some of the critical challenges that have led to environmental pollution of land and water resources in the Sedibeng DM region include the ageing sanitation infrastructure resulting in performance failures and a rise in maintenance costs.

Non-implementation of operation and maintenance strategies and plans led to a total collapse of the sanitation management system, resulting in the pollution levels being above acceptable standards, as the Commission found in their final report. Had the SRSS as first proposed in 2010 been implemented timeously, the crisis situation would not have arisen. As the crisis is continuing, it is important that all necessary resources, especially human capital and project funding, be made available. It would probably be helpful to reinstate the Presidential status of SRSS as was the case when it was first proposed in 2010.

The procurement processes for service providers and contractors needs to be prioritised and any bottlenecks cleared up in order to ensure timeous appointments and implementation to ensure successful completion of the intervention programme.

The problem of persistent community protests and unrests is a serious one and is responsible for many delays in the implementation of projects in general, and in particular, the implementation of the SRSS and the VRSI. A robust community engagement strategy and plan needs to be developed and implemented with the support of all levels of government

and politicians to manage community expectations. Political promises which create unrealistic expectation from the community need to be avoided.

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