An Impact-Driven Response to South Africa's Water Challenges: CSIR's Water Sustainability Flagship

H.H. Pienaar, M. Claassen, M.P. Matji, and K. van Breukelen

***Abstract*—**Critical water challenges in South Africa are well recognized and documented. Various key initiatives to address these challenges have been considered by a number of key sector role-players across the water sector. Both the Water for Growth and Development (WfGD) framework [1] and [5] as well as the National Water Resources Strategy (2nd draft edition) represents the Department of Water Affairs (DWA) strategic response in managing the country's water more effectively and efficiently to enhance the country's socio-economic aspirations [5]. The section on water resources and water services in the National Development Plan, led by the National Planning Commission (NPC) also follows a clear and productive logic, starting with a vision, reflecting honestly on the current situation and providing a clear road map for the future [9]. However, there still appears to be a fragmented and isolated approach within the water sector in responding to these water challenges which often result in ineffective solutions at the national level, despite genuine efforts by the Department of Water Affairs (as water sector leader) to realise a more holistic response to these challenges. The CSIR introduced its water sustainability flagship (WSF) programme, which is aimed at advancing a set of large-scale practical and effective science-based integrated solutions. The objective of the WSF is to contribute to the equitable, efficient and sustainable use of water to ensure that South Africa attains its national [10], social and economic growth and development aspirations [2]. Through this WSF programme, four strategic clusters of outcomes have been identified (in consultation with key stakeholders) to be addressed namely: infrastructure, governance and land-use, water quality and water quantity, water and energy use efficiency. The WSF programme will address the above fragmentation and initially focus on wastewater treatment with a strong emphasis on all the aforementioned four strategic clusters of outcomes being identified. It will link human settlement planning, technology and management options, and downstream user requirements to effectively manage wastewater and deliver water of good quality to support downstream social and economic development. This presentation reports on the WSF which serves as a key mechanism to focus the CSIR's research and development (R&D) capabilities in contributing to solving the country's water challenges.

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I. Introduction

ACCESS to good quality water is one of the most basic requirements for economic, social and environmental development [4]. Yet, inadequate planning for water provision, failing sewage treatment works and a lack of reliable monitoring systems for waste water treatment plant failure threaten the wellbeing of communities in many parts of the country [7]. The urgent need for intervention has prompted the CSIR to tackle water sustainability as a flagship project in which the focus is, above all, on implementation. The optimal management of waste water resources reduces the stress of pollution on our scarce water sources and could mitigate the current water scenario and researchers set about planning interventions focused specifically on this leverage point [10]. Initial outputs include an innovative automated water quality monitoring system, an anaerobic biodigester, which produces biogas for energy, and a water demand forecast model.

South Africa's water resources are limited, but have to support a growing economy [5]. It is believed that water scarcity in itself does not determine the success or failure of economic development, but rather a country's ability to manage its water resources successfully within its means. Locally, poor governance, failing infrastructure and inadequate investment has pushed many municipal water services to the brink of collapse and led to protests in both affluent and poor sectors of society about pollution and poor service provision [3]. Government's 2011 green drop report [6], which assessed 821 municipal waste water systems, found only 40 were in excellent condition. A total of 78 were in good condition, 243 were average, 143 performed poorly and 317 were in a critical condition. The health outcomes of poor access to clean water are well documented, for example deadly forms of diarrheal disease.

II. Research Method

Improvements in water sustainability will rely on an integrated approach where infrastructure, planning, governance and monitoring are addressed simultaneously. This is why several CSIR research competencies are being drawn upon for this project. The aim is to achieve better

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water quality, less pollution and a decreased health risk in the regions where the implementation takes place [7]. Initial research has focused on waste water treatment plants in the City of Ekurhuleni and West Rand district municipality in Gauteng province and the Sekhukhune District Municipality in the Limpopo province.

III. Analysis And Discussions

A. Planning and Governance

During the first year of the flagship project, CSIR researchers have completed an upgrade of the CSIR urban dynamics platform, software which can model future human settlement patterns in Gauteng over a 30-year period and extend our capability to make long-term water demand forecasts. Currently many water treatment plants do not have the capacity to serve existing populations and further development will exacerbate the situation. The ability to forecast water demand, can assist a municipality to strategically direct infrastructure expansion to be more efficient in the long-term. Environmental researchers have also completed preliminary assessments of the vulnerability of communities and ecosystems downstream of water treatment plants in the Sekhukhune district. Water samples taken from rivers downstream from the treatment plants have shown high levels of bacteria rendering the water unsuitable for consumption. Tests were also done upstream and at the outflow at the plants, confirming that the plants contribute to the eutrophication of the river.

According to anecdotal evidence from the communities who live downstream, they use the river water when piped water supply is disrupted and suffer health consequences. Further quantitative studies will follow and researchers will also assess the efficacy of policy and regulatory instruments to establish whether it is sufficient to control the impact of the failing water treatment facilities. The researchers are now looking at water purification technology such as filters and solar disinfection methods, which can be used in these communities.

B. Using waste for energy

CSIR researchers have developed biodigesters that work more efficiently than those currently commercially available thanks to automated processes that optimize temperature, pH levels and loading rates. These are parameters that assist in the biological breakdown of organic waste. If they are maintained at the right levels, the retention time of the solid waste is reduced and the quality of biogas harvested is optimized. CSIR biodigesters are now able to produce biogas that contain up to 72% methane gas which can be used for heating or electricity to reduce costs at the waste water plant. Harvested biogas was previously vented into the atmosphere. Another advantage of optimal processing is that the deactivated sludge, which can be used for compost in agricultural ventures, is better stabilized. This is being piloted as part of a community gardening programme. Figure 1 presents the challenges in graphical form.

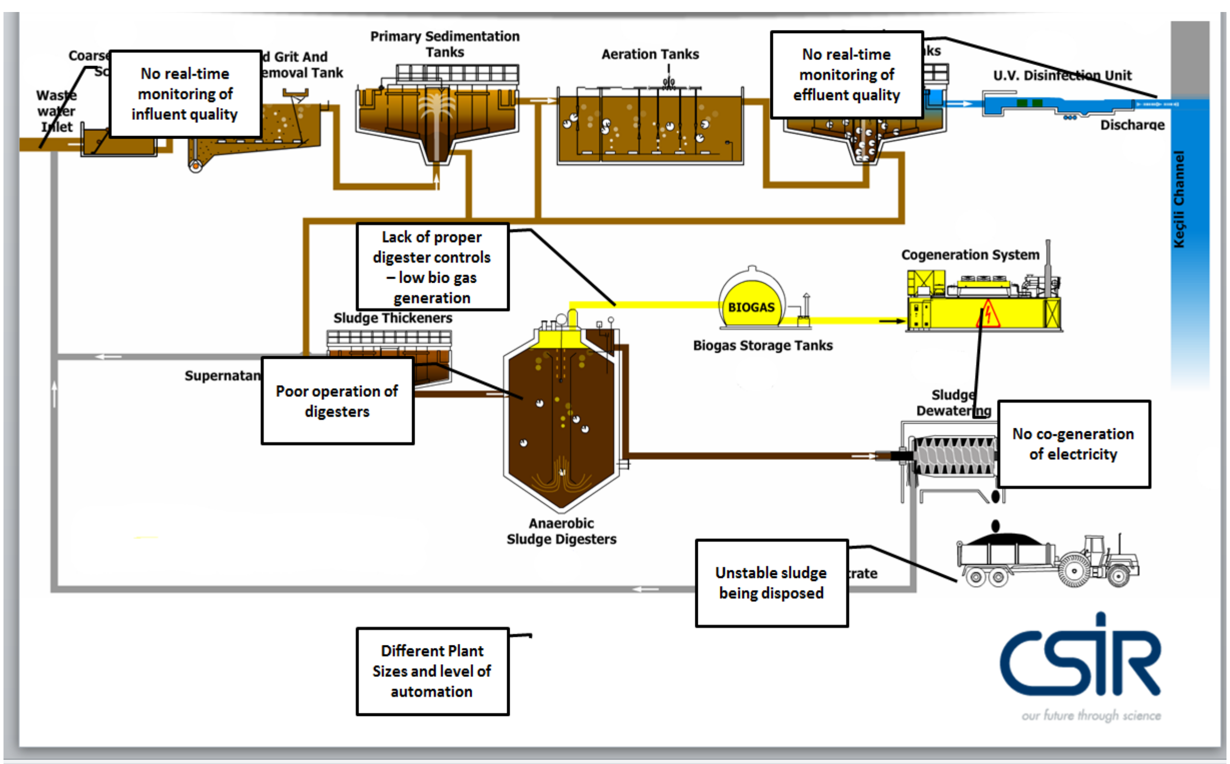

Fig. 1 Typical Wastewater Treatement Works and Challenges in South Africa

Figure 2 is a graphical layout on how the CSIR technological interventions are implemented to respond to the challenges.

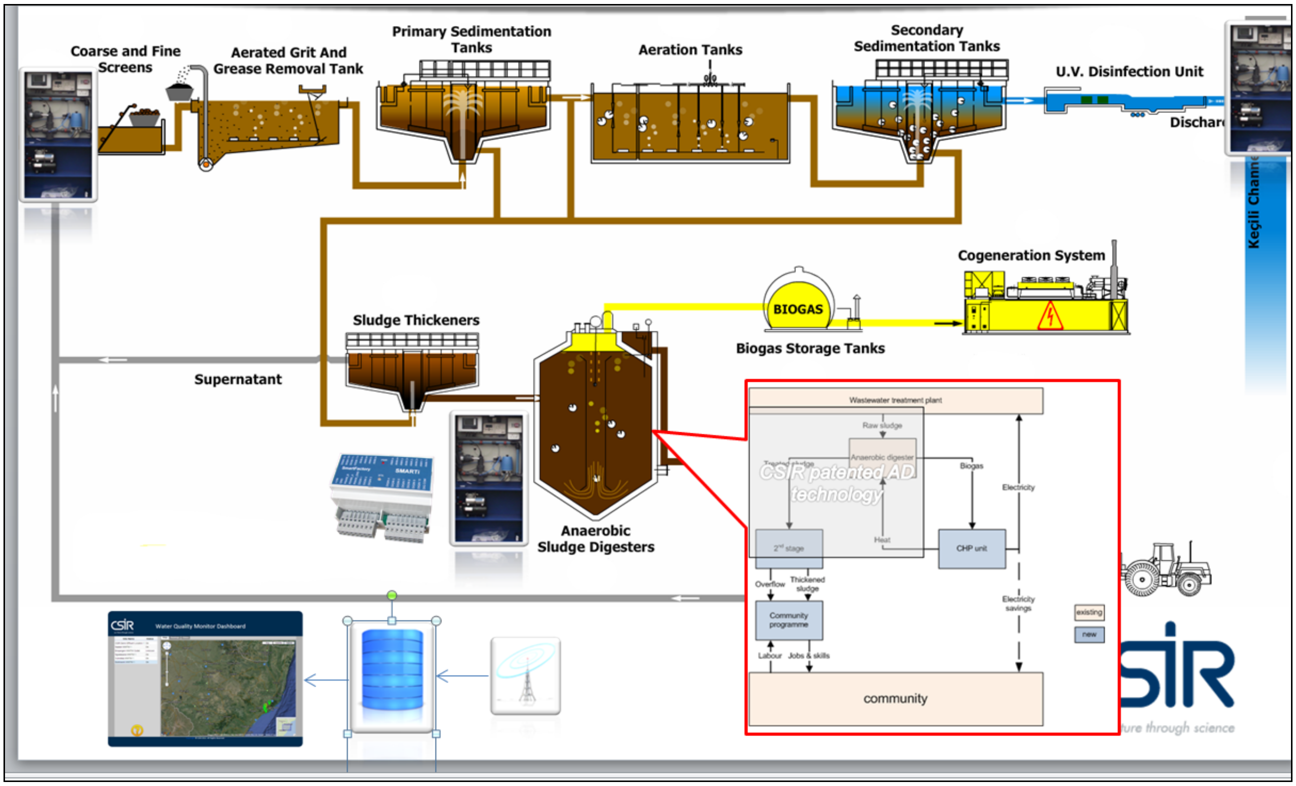

Fig. 2 CSIR Technological Interventions to respond to the Challenges

The researchers have also completed assessments to develop ways to clear contaminants from the gas. Levels of contaminants differ depending on whether a municipality's source of waste is mostly industrial or residential and the assessments were based on the assessments from the West Rand District Municipality, Gauteng Province.

Assessments were conducted in four wastewater treatment plants within the West Rand District. The CSIR technology will be upscaled in one of the three assessed plants. Hydrogen sulphide is a typical contaminant, which produces sulphuric acid when condensation takes place. This can damage the generators if the biogas is used for energy. The researchers are now ready to pilot a digester at selected waste water treatment plant. This CSIR technology is designed in such a way that it can be retrofitted to older digesters at the country's 350 wastewater treatment plants, which could save further costs and reduce the pressure on waste water treatment plants.

C. Real-time monitoring system for waste water treatment works

While more affluent municipalities are able to establish costly monitoring systems for waste water quality, the lack of real-time information in poorly resourced areas could hamper effective and efficient responses to problems at the plants. Pollution, due to failures at a plant which are not brought under control, can reach communities downstream with dire health, environmental and agricultural consequences.

Researchers have designed a more affordable near real-time monitoring system which consists of sensing stations and software which is being tested at Sekhukhune district municipality's waste water plants. Water is pumped to a unit where probes test the pH, dissolved oxygen, conductivity and other parameters which could indicate deteriorating waste water quality. These readings are sent in real time via SMS to a CSIR surveillance point.

Units have been installed at six waste water treatment plants on the municipal power grid and a seventh has been adapted for a solar power source. A handheld version is being piloted for more remote treatment plants where security concerns come into play, and municipal water quality staff will be trained to operate it.

The units are designed to take measurements every half an hour, which could provide a substantial improvement to current protocols at some plants in poorer resourced areas where water is monitored on a monthly basis or in critical cases, not at all. The CSIR researchers are also giving input to improve process management, capabilities and infrastructure, hoping to guide the Sekhukhune District Municipality to an acceptable green drop status.

D. Other project partners

Key project partners to the CSIR are West Rand municipalities, Gauteng Department of Economic Development, and Rand Water Board. Municipalities provide infrastructure for upscaling the technology. Rand Water is the largest water utility in South Africa. Their strategic role is to provide assistance with implementation, monitoring and maintenance during the pilot stage and also the national roll-out. Gauteng Department of Economic Development's interest is on promoting green infrastructure and also funding green infrastructure skills development

IV. Conclusions And Recommendations

Successful implementation of the abovementioned interventions will make the following contributions to the South African infrastructure delivery programmes:-

a. Improve functionality of the wastewater treatment works in South Africa.
b. Reduce greenhouse gas emissions from wastewater treatment works, hence contributing to measures for addressing climate change.
c. Reduce the extent of pollution in the river systems. Sludge exposed in the fields is washed off into the nearby river systems.
d. Produce electricity to supply the operations at the wastewater treatment works. The electricity supplied on site will reduce reliance on the national grid.
e. The technology is also contributing to renewable energy options in the municipal environment
f. Roll-out of early warning system for improving performance of wastewater treatment plants.
g. Early warning system for unpredictable discharges.
h. Increased plant automation and monitoring.
i. Savings on chemical consumption.
j. Increase in plant efficiency and agility.
k. Stabilised sludge could be disposed of safely in accordance with sludge guideline.
l. Sludge disposal may include beneficial use of sludge depending on the quality.
m. Increased sludge treatment capacity at that specific wastewater treatment plant.

In addition to the abovementioned contributions, High level selection criteria was developed based on the wastewater treatment process, infrastructure condition and capacity requirements (e.g. Existing digesters and related pump stations with no structural damage and plant capacities exceeding 25 Mℓ/d = when biogas to electricity projects become feasible)

Acknowledgment

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References

[1] 2030 Water Resources Group, 2009. Charting Our Water Future: Economic frameworks to inform decision-making.
[2] Council for Scientific and Industrial Research (CSIR) (2011). A CSIR Perspective on Water in South Africa 2010. Council for Scientific and Industrial Research, Pretoria, South Africa. 74 pages.
[3] Council for Scientific and Industrial Research (2007). The State of Municipal Infrastructure in South Africa and its Operation and Maintenance: An overview. A CSIR / cidb report. Council for Scientific and Industrial Research, Pretoria, South Africa. 17 pages.
[4] Department of Environmental Affairs (DEAT), 2006. State of Environment Outlook Report for 2006.
[5] Department of Water Affairs (DWA), 2011. Water for Growth and Development in South Africa.
[6] Department of Water Affairs (2010a). Green Drop Report 2009. Version 1. South African Wastewater Quality Performance. Department of Water Affairs. Pretoria, South Africa.
[7] Department of Water Affairs (2010b). Blue Drop Report 2010. South African Drinking Water Quality Performance. Department of Water Affairs. Pretoria, South Africa.
[8] Department of Water Affairs (2010c). Strategic Overview of the Water Sector in South Africa 2010. Department of Water Affairs. Pretoria, South Africa.
[9] National Planning Commission. 2011. National Development Plan. Vision for 2030.
[10] King, J. and H. Pienaar (eds) 2011. Sustainable use of South Africa's inland waters: A situation assessment of Resource Directed Measures 12 years after the 1998 National Water Act. Water Research Commission Report No. TT 491/11. Water Research Commission, Pretoria. 259 pp.

Dr. Harrison Pienaar holds a PhD in geohydrology, obtained from the University of the Western Cape. He is a well-known water resource management expert and his 19-year career include working in industry and government where he previously steered a number of key water sector related programs, i.e. *Water for Growth and Development in SA, Systematic Conservation of SA's Freshwater Biodiversity* and *Water Sector's Response to Climate Change* among other. He currently works for the CSIR as a Competence Area Manager, being responsible for managing R&D work in water resources as well as leading the organization's water flagship programme. One of his contributions in addressing strategic water resource issues is captured in a book entitled: "*Sustainable use of South Africa's inland waters: A Situation Assessment of Resource Directed Measures 12 years after the 1998 National Water Act*". He also serves as an advisory council member of the Water Institute of Southern Africa (WISA) and the South African Institute for Aquatic Biodiversity (SAIAB).