science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

WATER RESEARCH COMMISSION

ALGAE-BASED WASTEWATER TREATMENT

An alternative, cost-effective technology for rural environments

Pond systems[1] are ideally suited for sewage treatment in rural communities and towns as they are simple and economical to operate and maintain. An algae-based wastewater treatment process, refined in a recent Water Research Commission project with the Council for Scientific and Industrial Research (CSIR) and the Department of Science and Technology, uses a specific consortium of algal species to remove nutrients[2] and create conditions for effective solar disinfection to reduce pathogens. A project was carried out with the aim of piloting a self-sustaining system that was independent of electricity or expensive chemicals and that could be effectively operated in spite of financial and capacity constraints.

BACKGROUND

The South African Constitution guarantees people the right to have their dignity respected and protected, to an environment that is not harmful to their health or well-being, and to have the environment protected for the benefit of present and future generations.

The Department of Science and Technology initiated the Innovation for Rural Development Partnership Programme in 2013. Previous research into algae-based

[1] A pond system is a wastewater treatment that uses a combination of aquatic plants, substrates and microorganisms.
[2] If too much of the nutrients nitrogen and phosphorus is released into the environment and there is a build-up, this can encourage rapid and unsustainable growth in algae numbers so that eventually most algae die. Decomposition uses up so much of the oxygen in the water that the animals living in the water die. Some algal species also produce toxins that contaminate drinking water supplies.

wastewater treatment and technologies by the CSIR was deployed in support of this project.

The principal objective of this project, which was guided by the Water Research Commission, was to facilitate the effective and efficient removal of nutrients and pathogens in wastewater treatment works. These contaminants pose a risk to the health of downstream communities and water users, to development opportunities, and to the biological integrity of water resources.

THE CHALLENGE

Green Drop[3] assessments cover the entire value chain (from reticulation to pumping, treatment and discharge) of wastewater treatment in municipalities. The 2014 assessment confirms that wastewater treatment works in South Africa, especially in rural areas, are facing significant challenges. According to the 2014 Green Drop Report, although the state of these facilities is improving, nearly a quarter of all wastewater treatment systems are in a "critical state". With the percentage of households that have access to Research and Development Programme-standard sanitation steadily increasing, the pressure on treatment works will continue to increase.

THE SOLUTION

Conventional pond systems used for wastewater treatment depend on sludge separation and natural degradation in a series of ponds. The piloted algae-based treatment process used this existing infrastructure at treatment works, where the consortium of algal species (isolated and cultured in the laboratory) was introduced to the treatment ponds. The algae species work through complementary mechanisms to assimilate nutrients and create conditions for effective solar disinfection to reduce pathogens.

[3] The Department of Water and Sanitation's Green Drop certification programme for wastewater treatment works is aimed at improving compliance with relevant legislation and best practice.

The key objective of the technology is to ensure that any effluent that is discharged from the wastewater treatment works is free of pathogens and contains acceptable levels of nutrients, thereby improve human health, creating economic opportunities and protecting downstream ecosystems.

THE PILOT PROJECT: SEKHUKHUNE DISTRICT MUNICIPALITY, LIMPOPO

Working closely with Sekhukhune District Municipality, the project team identified the Motetema wastewater treatment works as an optimal site for piloting the technology. The Motetema works are situated close to Groblersdal, in the Sekhukhune District of Limpopo.

The Motetema system treats domestic waste for a population of about 11 400 people. It was designed to treat an average effluent of 2,5 megalitres a day, but actually receives effluent of about 4,5 megalitres a day.

The system operates without mechanical aeration, which means that it is suitable for use when there is a lack of advanced wastewater treatment infrastructure and electricity.

A series of ponds are employed at the Motetema works. There are 12 ponds, organised in two groups of six. Only one group works at a time. While one group works, the other six ponds are cleaned. The pond system works using gravity, with overflow from one pond to another.

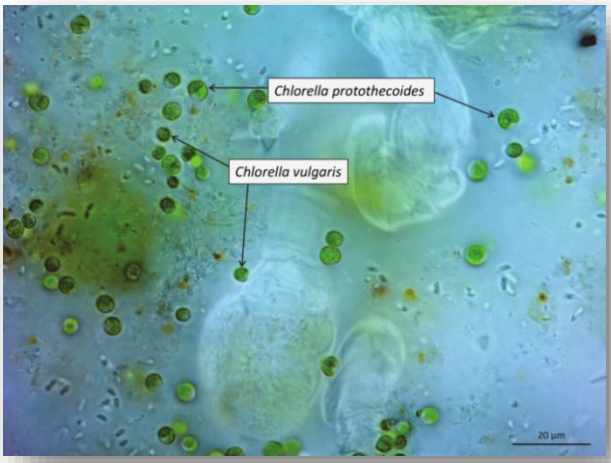
Engagements with the municipality confirmed that, apart from an increase in the effluent that enters the system at the Motetema works owing to the continually increasing population, general governance issues contribute to the increasing burden on the municipality. Other key challenges include ageing infrastructure, insufficient technical skills and limited financial resources.

The project therefore also worked to develop human capacity at the municipality. Engagements focused specifically on the science behind the intervention as well as related management issues.

Motetema wastewater treatment works

HOW THE TECHNOLOGY WORKS

Two species of microalgae from the phylum Chlorophyta, namely *Chlorella vulgaris* and *Chlorella protothecoides*, were isolated, cultured on a large scale in the laboratory and in raceways, and transported to the Motetema wastewater treatment works. An operating manual has been developed to assist the operator at the works to monitor the algal cultures in the onsite algal reactors, and treat the selected ponds on an ongoing basis.



A microscopic view of the inoculated[4] algae, *Chlorella vulgaris* and *Chlorella protothecoides*

[4] Inoculation is the introduction of algae into a culture medium.

Five reactor tanks (with a capacity of 5 000 litres each) have been installed at the Motetema wastewater treatment works with a network of pipes and valves that feed the cultures to the relevant ponds. The algae successfully compete with naturally occurring algae, and ongoing dosing ensures the effectiveness of the treatment process.

The algae bioreactors at Motetema wastewater treatment works

CONCLUSIONS AND RECOMMENDATIONS

The successful implementation of the algae-based system in Sekhukhune District Municipality has demonstrated the value of partnering with a municipality that has the interests of its constituents at heart. This example is also highly relevant to smaller municipalities throughout the country, where such systems could reduce the contamination of water resources and the risk to downstream communities.

The effective treatment of wastewater will improve the quality of downstream socio-economic activities, ultimately leading to improved quality of life.

The approach brings significant opportunities for municipalities to address the backlogs in wastewater treatment, since it uses existing infrastructure with a more effective treatment process to address the risks of untreated and partially treated wastewater.

While capital investments should be focused on sustainable solutions in the long term, the algae-based treatment options will provide relief in the short and medium term, and continue to provide better wastewater treatment to small and medium-sized communities.

ENQUIRIES

For more information, contact Ms Karen Nortje (Governance) or Dr Paul Oberholster (Technical) at 012 841 2911 or email callcentre@csir.co.za.