PAPER 5

EFFECTIVE ENERGY AND CAPITAL SAVING APPLICATION AT KRUISFONTEIN WASTE WATER TREATMENT PLANT BY INCORPORATING EXISTING INFRASTRUCTURE AS WELL AS PATENTED AND PROPRIETY TECHNOLOGY

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ABSTRACT

Prior to the project the existing wastewater treatment works at Kruisfontein consisted of a trickling filter with anaerobic and oxidation ponds. A design and supply public tender was advertised by the Kouga Local Municipality for the upgrading of the works to a 2 Mℓ/day activated sludge wastewater treatment plant. The tender document specified a 2 Mℓ/d treatment capacity utilising activated sludge, however stated that alternative design proposals would be considered. Tecroveer submitted a proposed solution that combined the activated sludge process with the Pond Enhanced Treatment and Operation (PETRO) to increase treatment capacity from 2 Mℓ/d to 4 Mℓ/d with minor modifications to the existing ponds. By utilising the ponds, a conservative 2 Mℓ/d treatment was added to allow for a higher carbon-to-nitrogen (C:N) ratio to ensure proper de-nitrification.

The Tecroveer patented internal recycle technology combined with an optimal geometrical circular design enabled Tecroveer to offer a best value for money solution to the client.

The PETRO process distinguishes itself from any other pond combination as pre-treatment in that the polysaccharides enable the algae to settle in the main process secondary settling tank. Other pond pre-treatment systems produce high levels of suspended solids as algae is unable settle out, and therefore do not comply with the general authorisation effluent parameters.

For this application, Tecroveer offered the patented Transfer Mixer to:

- Mix the anaerobic zone and the anoxic zone
- S-recycle - pump RAS from the clarifier to the anaerobic zone
- A-recycle - pump MLSS from the aerobic zone to the anoxic zone.

The combined function of mixing and pumping is performed by this single piece of mechanical equipment, thereby achieving capital, operational and life cycle cost savings to the client.

The wastewater treatment plant, which has been designed and successfully completed at Kruisfontein, is a noteworthy example of how the effective combination of the existing infrastructure, with innovative transfer technology in between process stages, can reduce energy consumption and maintenance programs, while still meeting and even improving upon the required General Limit for effluent discharge. The design features and challenges of this project are presented in this paper.

Figure 1.1: **Kruisfontein WWTW Site Layout, May 2017**

Picture 1.1: **Kruisfontein Reactor, June 2018**

Picture 1.2: **Kruisfontein SST, June 2018**

INTRODUCTION

Following a successful tender process, Kouga Local Municipality appointed Tecroveer as the principal contractor for the upgrade of the Kruisfontein Waste Water Treatment Plant in 2014. This turnkey project involved the construction of a 2 Mℓ/day plant with provision for a future phased upgrade of capacity to 4 Mℓ/day. The scope of work was further increased in 2017 to include the upgrade of the bulk sewer system.

Infrastructure constructed comprises two division boxes, an 11 800 m^3 facultative pond, a 3 950 m^3 reactor, two 20 m in diameter secondary settling tanks, a chlorine disinfection contact channel, a control building, a chlorine dosing building, a sludge de-watering structure, plant access roads and 1.8 km of bulk sewer lines.

A variety of electrical and mechanical equipment was installed to meet the solution requirement, including flow measurement instrumentation, a dredger, tilting weirs, overflow weirs, two 11 kW Tecroveer Transfer Mixers (TFM) for S-recycle, two 3 kW TFM for A-recycle, two 3 kW radial mixers, two 2.2 kW WAS pumps, two 30 kW aerators, two 37 kW aerators, two 45 kW aerators, two half-bridge scrapper clarifiers, a volute dehydrator, a pace to flow chlorine gas disinfection system, two 4 kW wash water pumps, and two 10 kW pond recycle pumps. The project also included approximately 8 500 m^3 of excavation works, 1 100 m^3 of cast concrete and 200 t of fixed reinforcement. The plant began operating in December 2017 and was completed in February 2018 with a final project cost of R57.5 million, excluding VAT. Through the application of innovative technology to utilise the existing pond system, the solution was able to increase the capacity of the plant, reduce the size of the reactor, optimise the cost of the project and reduce on-going operating costs.

THE SOLUTION

The solution incorporated existing infrastructure with patented systems and proprietary technology to deliver a cost effective, reliable and efficient treatment system. As per tender requirements a three-stage Phoredox activated sludge treatment process was implemented to comply with General Limit Values for treated wastewater. To ensure optimised economies of design, a

Picture 1.3: **Kruisfontein WWTW Final Effluent, June 2018**

circular reactor was implemented around the anaerobic zone with settling tanks situated adjacent to the reactor. Each zone is completely mixed, with the flow entering into the anaerobic zone, flowing over to the anoxic zone, flowing in both directions around the anaerobic reactor to the aerobic zone, and from the anoxic zone to the aerobic zone flowing again in both directions around the anoxic reactor.

This permits complete mixing of the aerobic zone to take place through the use of stepped aeration with two 30kW aerators, two 37kW aerators, and two 45kW aerators. In order to accommodate the requirement for future expansion, the works were designed to be easily mirrored for duplication and capacity expansion.

The patented PETRO pre-treatment process, which works in tandem with the activated sludge process, extends the capacity of the system without incurring further costs. In addition, the solution at Kruisfontein makes use of application of proprietary TFM, negating the requirement for return activated sludge pumps and enabling sludge to be mixed and returned simultaneously. The solution also utilises a technical innovation called stepped aeration to optimise the biological breakdown of bacteria in aerobic, anoxic and anaerobic environments, thus enhancing the entire wastewater treatment process.

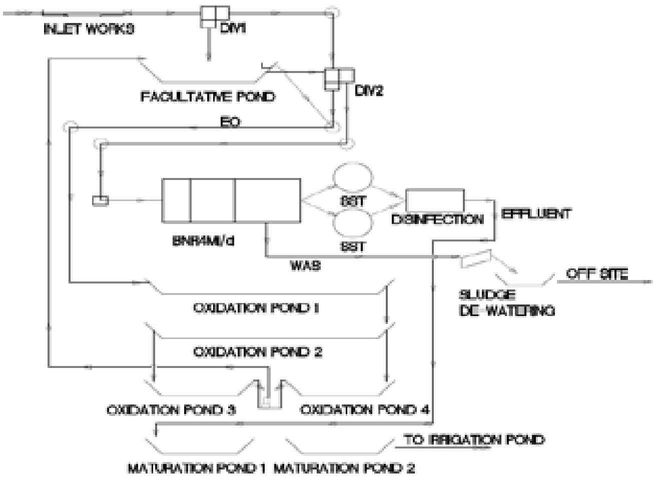

Figure 1.2: **Kruisfontein WWTW - Process Flow Diagram (PFD)**

THE PETRO PROCESS

Pond Enhanced Treatment and Operation (PETRO) is a patented pre-treatment process developed by the South African Water Research Commission (WRC) and Piet Meiring. The process distinguishes itself from any other pond combination as pre-treatment in that the polysaccharides enable the algae to settle in the main process secondary settling tank. Other pond pre-treatment systems produce a high level of suspended solids as the algae is unable to settle out, and therefore do not comply with the general authorisation effluent parameters.

Legacy oxidation pond systems at older wastewater treatment plants have therefore typically had to be decommissioned and replaced, at significant cost, when the plants are upgraded.

PETRO is unique as a pond pre-treatment process in that it minimises the amount of suspended solids in the water prior to secondary treatment, thereby effectively utilising existing pond infrastructure and enhancing treatment capacity. It leverages anaerobic biodegradation, followed by aerobic degradation in an oxidation pond, before the wastewater is further refined using the activated sludge process. PETRO enhances the activated sludge process by effectively removing the majority of organic material from the wastewater prior to secondary treatment.

Harnessing the power of the sun for the pre-treatment process also enables further cost savings by reducing the energy requirement in the activated sludge process.

The Melbourne wastewater treatment plant in Australia is currently the largest facility in the world utilising the PETRO process. The 250 Ml/day treatment facility has saved huge amounts of money over the years, primarily through the use of solar energy in the PETRO pond system. This cuts electricity consumption at the plant almost in half, resulting in significant savings.

The Bloemwater Sterkwater wastewater treatment plant is the largest PETRO process installation in South Africa, with a capacity of 10Ml/day. This plant has a dramatically reduced carbon footprint compared to other local plants, as the PETRO process enables the organic load to be halved. Both Melbourne and Sterkwater utilise the PETRO with activated sludge (suspended growth), and highlight the benefits of incorporating the process into wastewater treatment solutions.

Picture 1.4: **Kruisfontein WWTW PETRO Recycle**

TRANSFER MIXERS (TFM)

The Kruisfontein treatment plant deploys a full-scale application of the transfer mixer, negating the requirement for return activated sludge pumps. Utilising this innovative technology enables sludge to be mixed and returned simultaneously with the one vertical mixer, as opposed to the typical system that requires a return pump with a head that is easily blocked and requires frequent maintenance. This not only reduces capital costs, it also reduces the number of points of failure in the system, saves electricity, and improves efficiency and reliability.

TFM essentially offers breakthrough transfer technology that combines mixing and activated sludge process circulation requirements into one installed unit. It can be utilised to transfer raw sewage into the process, as well as for internal activated sludge re-circulation (a-recycle, r-recycle and return), RAS return from the secondary settling tank, and Waste Activated Sludge (WAS) streams.

Notable design features of the TFM are the dual curved-blade radial flow impeller, which prevents clogging and thus reduces maintenance, and the fact that all serviceable parts are situated above the water line for ease of access. This further increases cost efficiency. Low fluid shears with high volume transfer results in high transfer efficiency and thus a smaller carbon footprint, while variable speed drives enable a high degree of process flexibility. The low shear value in the transfer mechanism also facilitates improved flocculation retention in the biomass, enabling the biomass to settle faster and thus improving secondary settling tank performance. A higher dispersion rate of the recycle stream into the biomass improves conditioning and reaction time. TFMs can also be tested and calibrated in a full-scale testing scenario prior to being shipped to site, decreasing installation time.

The TFM is used at Kruisfontein to mix the anaerobic zone and the anoxic zone, as well as to pump the S-recycle Returned Activated Sludge (RAS) from the clarifier to the anaerobic zone and to pump the A-recycle Mixed Liquor Suspended Solids (MLSS) from the aerobic zone to the anoxic zone. By combining these functions into a single piece of mechanical equipment, significant capital, operational and lifecycle cost savings can be achieved.

Picture 1.5: Kruisfontein Patented Transfer Mixer

AERATION

A further technical innovation implemented at Kruisfontein is the stepped aeration process, which mimics the aeration process of water in nature. During the wastewater treatment process, solids and liquids are separated and a biological process is encouraged, where bacteria feeds upon the substrate and breaks down oxidisable compounds. Part of this process incorporates a biological reactor, which introduces oxygen into the water to aid bacteria in aerobic digestion. In other zones there is no dissolved oxygen, which forces bacteria to break down target contaminants that do not require oxygen.

This is known as anaerobic digestion. In order to maintain the proper oxygen levels in each zone, aeration needs to be carefully controlled.

Stepped aeration optimises this within process configuration, utilising sensors to determine oxygen levels in the wastewater and automatically adjusts the aerators to rotate with the minimum amount of energy required to ensure the water is treated and cleaned to the required standard. By maintaining the correct balance of oxygen in the water of the reactors, wastewater can be circulated between the aerobic, anaerobic and anoxic phases efficiently before being discharged into the settling tank. Settled sludge can then be returned to the reactor to ensure the bacterial balance is maintained.

Ensuring that the balance of oxygen is maintained correctly also assists with denitrification and the biological removal of phosphates, which are key to removing residual nutrients within wastewater. Stepped aeration not only facilitates this, it also minimises the electrical energy consumption required to produce clean water.

OPTIMAL DESIGN

The solution implemented at Kruisfontein has been optimised to ensure water can be treated to the required levels in a cost effective and efficient way. The combination of the PETRO process, TFM and stepped aeration create an engineered solution that results in dramatically lowered costs for the treatment of wastewater.

The design of the system ensures that the original oxidation pond systems could be reused to clean water to the requisite standard, which enables the plant to treat a greater volume of wastewater for the same cost and turns what was previously a liability into a distinct asset.

Picture 1.6: Kruisfontein LDO controlled Aerator

In addition, the treated water is not simply sent back into river systems or harnessed for irrigation purposes; it is also recycled several times, resulting in a number of different applications. The water treatment process by its nature results in two end products, specifically clean water and residual organic sludge. The Kruisfontein solution features a mechanical dewatering process, which can then either be utilised in a compost processor alternatively supplied to brick makers in the area.

CONCLUSION

Every aspect of the solution implemented at Kruisfontein was developed with the aim of improving efficiency and reducing costs. This creates an innovative turnkey project that promotes sustainability and energy efficiency while reducing expenditure at the outset as well as on-going operating costs. In South Africa there are many historic wastewater treatment plants that have oxidation ponds that are typically decommissioned when plants are upgraded. The Kruisfontein system enables these ponds not only to be harnessed but to be utilised in such a way as to create a low technology yet highly effective and cost efficient treatment application. Utilising such a system can enable municipalities to increase wastewater treatment capacity without significant additional spend. It also creates a sustainable solution, leveraging solar power to reduce dependence on fossil fuels and offering a low risk, eco-friendly solution the produces high quality treated wastewater.

By ensuring the highest levels of effectiveness and efficiency, municipalities can be empowered to vastly improve service delivery in the area of wastewater treatment. With ever-growing populations and dwindling water supplies, this is more important than ever before. Clean, potable water is key not only to servicing existing populations but also to the growth and development of any municipality. This type of solution is applicable not only in South Africa and the African context as a whole but around the globe.

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