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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Industrial water treatment

Sustainable beneficiation of brewery effluent

A completed Water Research Commission (WRC) project has successfully tested algal ponding, constructed wetlands, hydroponic vegetables and aquaculture to beneficiate brewery effluent.

Background

The treatment of industrial effluent remains an economically and environmentally costly liability to the majority of industries today. Conventional methods of water treatment usually require high-tech equipment that is expensive to run and needs to be operated by a highly skilled workforce.

This project aimed to develop a sequence of effluent treatment methods using existing technologies, such as algal ponding and constructed wetlands, to develop a unique, low cost, low-tech, environmentally sustainable industrial water treatment process. It also aimed to combine these technologies with the production of algae, vegetables and fish in such a way that the end result was not only treated industrial effluent, but also the production of recovered water available for reuse and/or used for producing valuable downstream products.

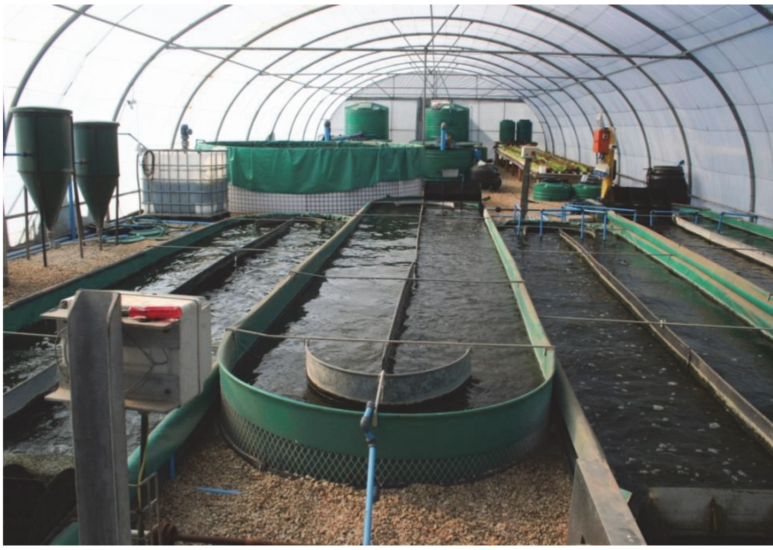
The treatment system

The pilot effluent treatment and beneficiation plant utilised effluent originating from the Ibhayi Brewery (SAB Ltd) in Port Elizabeth. It was first subject to anaerobic digestion in a commercial-scale anaerobic digester that is currently used to treat part of the brewery's effluent stream.

Post-anaerobic digester effluent was drawn into the experimental system's holding tank, after which it was subjected to treatment in the primary facultative pond. Post-primary facultative pond effluent was split into parallel streams (train-A and train-B), each leading to two paddlewheel-driven, D-ended raceways, i.e. two high rate algal ponding systems.

Each high rate algal pond train consisted of two raceways with water gravity-fed from the first to the second using an up-stand overflow pipe. Algae were removed from the post-high rate algal pond effluent using conical, algal settling tanks. Effluent could be drawn from any stage in the algal treatment process for further treatment in the constructed wetland.

Similarly, treated effluent could be drawn from any point in the high rate algal pond or constructed wetland systems and used for experiments in either the hydroponic vegetable production system or in the fish culture system. Different combinations of treatment and post-treatment effluent use were tested.



The pilot effluent treatment system.

Optimising the performance of the algal ponds

To optimise the rate of brewery effluent treatment in the high rate algal ponds, the flow rate was progressively increased in one of the high rate algal pond trains, and this train's nutrient removal efficiency was compared to the second train in which flow rate was maintained at a rate known to efficiently remove nutrients. This experiment was repeated at different times of the year and in a heated and unheated high rate algal pond system.

In autumn it was possible to reduce the hydraulic attention time to 3.8 d, and in summer to 2.5 d, i.e. a flow of 1 400 ℓ/d/high rate algal pond-train, without negatively affecting the rate of nutrient removal in the high rate algal pond system. The system's chemical oxygen demand increased from 140 mg/ℓ post-anaerobic digester to 80 mg/ℓ post high rate algal pond (43% decrease).

Beneficiating brewery effluent

The project investigated the use of treated brewery effluent as a water source in aquaculture and hydroponic vegetable production. It also investigated the use of algae brown in the high rate algal ponds as a fish feed supplement, and the potential of harvesting energy in the form of methane from the anaerobic digester.

Brewery effluent can be used as a nutrient source for hydroponic lettuce and tomato production. Plant growth in treated brewery effluent was not equivalent to the inorganic fertiliser control treatment, but production was increased significantly overall when the pH of the treated brewery effluent was maintained between 6.0 and 6.5.

The effluent-based solutions were able to provide all of the essential nutrients required for vegetative growth, flowering and fruiting suggesting that other vegetative, flower or fruit producing crops might be able to grow successfully in brewery effluent. The difference in growth was probably due to lower nitrogen levels, but this needs to be determined in future work.

The similarity of fish size, condition factor and reproductive output of adult and the growth of juvenile fish between treatments suggest that treated brewery effluent is a suitable water source for the culture of swordtail (*Xiphophorus helleri*).

Conclusion

The high rate algal pond/wetland system is an environmentally sustainable method of treating brewery effluent that allows for the recovery of water and nutrients from the wastewater. It is a low-energy, low-maintenance system (both biologically and physically), driven mainly by gravity and the sun's energy.

The only external energy inputs for the high rate algal pond system were two small motors that drove the paddlewheels. As such, the cost to build and operate the system could be recovered quickly and the potential exists to recover these costs even faster if the water and nutrients that are recovered are reused or sold.

The high rate algal pond and wetland system consistently brought most of the water quality parameters tested to within or close to the Department of Water and Sanitation general limits for the discharge of industrial effluent into a natural water resource. We also modelled these data to predict the success of this system under various conditions that might be applied to other industries.

Furthermore, the treatment/recovery process involved the production of downstream products such as algae, fish feed, fresh vegetables and fish. This project also saw the first attempt at optimising the use of industrial effluent as an inorganic source of fertiliser for hydroponic vegetable production.

Fish and vegetable production can take place using post-high rate algal pond water, or water that has been subjected to both high rate algal pond and constructed wetland treatment. Vegetable production can take place in post-anaerobic digester (i.e. without pre-treatment in the high rate algal pond or constructed wetland) provided it is subject to treatment in the primary facultative pond and provided that the pH of the medium is maintained between 6.0 and 6.5.

This constructed wetland did not require pre-treatment in the high rate algal pond and operated more efficiently when the pond was not included in the treatment train; however, it was not possible to exclude the primary facultative pond prior to treatment in the constructed wetland. The advantage of the wetland is that it is entirely self-sustaining, but the disadvantages include difficult to clean/recharge, may clog up over time, and take more time to commission, whereas the high rate algal pond can be inoculated and fully functional within days.

The downside of the high rate algal pond/constructed wetland system is that it takes up considerably more space than conventional methods of water treatment, for example activated sludge systems. The estimated area required to treat 1 000 m^3 of post-anaerobic digester brewery effluent per day is probably around 1.4 to 2 ha. However, with improved efficiency and optimisation this footprint might be reduced further.

The programme has successfully demonstrated that industrial effluent, which is currently considered a costly liability by most industries, can be turned into a job-creating, income generating stream, using simple technologies that have been available for years. It is just a matter of applying these technologies in a slightly different way.

Further reading:
To order the report, ***Environmentally sustainable beneficiation of brewery effluent; Algal ponding, constructed wetland, hydroponic vegetables and aquaculture*** (**Report No. TT 601/14**), contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.