term operation and maintenance commitments following the facility start-up in December 2016. Following agreement of the budget capital and operating costs, the project entered a period of front-end engineering, in-situ pilot trials with a containerized pilot unit, collaboration with the regulatory and planning bodies, and optimization of process and commercial elements. For the project to proceed successfully, management and staff from the following stakeholders cooperated closely: Bakkovor Group, Cucina Sano facility, Aquabio, Environment Agency, Witham Drainage Board, and Local Planning Authority and Environmental Health Service.

Benefits

The water reuse scheme offers many benefits in terms of the environment, social ethics, finance, community, and job opportunity.

Environmental: Water consumption and discharge volumes have significantly decreased. From start-up of the plant in December 2016 through December 31, 2017, more than 75 percent of wastewater received from the factory has been reused, a total of 135 million litres. Consequently, there has been a major reduction in heavy traffic movements to and from the site and in the locality, eliminating approximately 6,750 road tankers, weighing approximately 30 tons each, per year.

There has been an improvement of running water through the dyke (i.e. local water drainage system), which enhances the surrounding aquatic environment.

Society and ethics: The Cucina Sano project sets a new benchmark for the potential to replicate and transfer the water reuse concept to other Bakkavor sites and into the European food and beverage sector. It provides an example of significant reduction of the Cucina Sano site's water footprint and its efficient water use. Additionally, the project helped the customer, Marks & Spencer, meet its continual improvement objectives and aided Bakkavor in reaching its corporate social responsibility (CSR) targets.

Finance: The company forecasts net savings of more than US$869,000 after deducting operating costs. Key performance indicators (KPI), such as recycle percentage rates and energy use,

Reverse osmosis filtration at the Cucino Sano water recovery facility Photo by Aquabio

with shared financial benefits that nurture a collaborative approach for efficient operation and maximizing water reuse.

Corporate Social Responsibility (CSR) benefits have a direct impact on customer relationships and strengthen Cucina Sano's position as a key supplier to Marks & Spencer.

Community and job opportunities: Bakkavor remained committed to proactive community engagement throughout the implementation process and during the operational stage. The water recycling facility opened up employment opportunities for two fulltime plant operators who are encouraged to minimize carbon dioxide emissions by choosing to commute by bicycle. The company offers skills enhancement and retraining from factory skills to facility management skills.

Future prospects

The Cucina Sano water recycling facility, a ground-breaking industrial water reuse project by Aquabio Ltd, is setting the standards for large-scale wastewater to potable water reuse within the food processing industry. The project has embraced innovative technology and know-how, met corporate sustainability objectives, saved costs, reduced resources, and enhanced the profile of safe water reuse, setting the example for others in the industrial processing sector to follow.

Author's Note

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Onsite MBR treatment keeps pace with increased production

Noosa Yoghurt's new onsite wastewater treatment system, designed by Evoqua's ADI Systems, replaced an unsustainable method for wastewater disposal and allowed the dairy processor to expand production. The state-of-the-art membrane bioreactor (MBR) biological wastewater treatment system generates a high-quality effluent for reuse in graywater applications using a single treatment stage, **Daniel Bertoldo** of ADI Systems reports.

Since Noosa Yoghurt's inception in 2008, the company has rapidly grown in the competitive yogurt market. In less than ten years, Noosa Yoghurt's manufacturing facility in Bellvue, Colorado, United States (US), has substantially expanded its product line in terms of flavors and tub sizes, and annual sales have steadily grown. Increased demand for Noosa Yoghurt products has also resulted in progressive increases in wastewater generation. The facility had previously mixed wastewater with cow manure and land-applied as fertilizer; however, this method of wastewater disposal became unsustainable, and Noosa Yoghurt needed a more feasible method for treating its high-strength wastewater.

Noosa Yoghurt wanted a robust, resilient treatment system that would consistently generate a final effluent to meet the direct discharge limits for biological oxygen demand (BOD); total suspended solids (TSS); fat, oil, and grease (FOG); total nitrogen (TN); and total phosphorus (TP). In anticipation of future increases in production, Noosa Yoghurt sought a system that would be easily expandable, which would allow the company to spread out capital expenditures for wastewater treatment over several years. Furthermore, the treatment system would need to be adaptable to handle potential changes in imposed direct discharge limits

ADI Systems' packaged membrane tank is shipped with all internals and membrane cassettes pre-installed, resulting in a short turnaround from delivery to generating solids-free effluent. Photos by Evoqua/ADI

The prefabricated membrane tank is compact and provides a plug-and-play approach to water recovery. Photo by Evoqua/ADI

resulting from an increase in permitted discharge flow.

Challenges of treating dairy processing wastewater

While Noosa Yoghurt is not unique in encountering the many challenges associated with treating dairy wastewater, the company sought out an innovative solution. Dairy manufacturers typically generate wastewater with high concentrations of BOD, TSS, and FOG, which can disrupt the stability of a treatment process.

Additional challenges come along with the cleaning of vessels and processing equipment, which is typically conducted several times per day and results in significant changes in hourly flow. Cleaning and disinfection chemicals used during cleaning operations are subsequently discharged to the pretreatment facility and can contain high concentrations of compounds, which can be toxic to the biomass used to treat the wastewater if present in sufficient quantities. Furthermore, high concentrations of calcium in the wastewater can cause scaling of the surfaces of treatment tanks, piping, and equipment.

Finding the right solution

After an extensive technology search, Noosa Yoghurt selected Evoqua's ADI Systems to provide process design services and to supply a prefabricated modular membrane tank with ancillary equipment. This modular membrane tank resulted in a plug-and-play approach, which significantly simplified onsite construction associated with the membrane tank.

The technology of choice, an ADI® aerobic membrane bioreactor (MBR) system, would be designed and installed in phases. Prior to the start-up of the components installed for Phase 1, Noosa Yoghurt signed a contract with a major American retailer, which would further increase production and wastewater generation. In effect, Noosa Yoghurt's facility would need to be expanded much sooner than originally projected. Fortunately, the modular design of the MBR system made this change easy to implement.

The solution to increase treatment capacity while meeting the revised discharge limits involved installing a second modular membrane tank to operate in parallel with the first modular membrane tank and to expand the MBR system in order to achieve biological nutrient removal (BNR). As part of the Phase 2 expansion, components were added to the MBR system to double the hydraulic and organic load capacity, promote denitrification, and reduce alum requirements for chemical phosphorus removal.

ADI MBR system

The ADI MBR system is a modification of the conventional activated sludge (CAS) system. Both technologies use a mixed population of microorganisms to aerobically digest organics and nitrify ammonia; however, MBR technology uses a physical membrane barrier to achieve solids-liquid separation and biomass retention as opposed to gravity clarification employed by CAS systems. This fundamental difference results in a number of advantages.

The physical membrane barrier results in a more reliable method for biomass retention compared to gravity settling. As a result, MBR technology is better equipped to handle fluctuations in influent wastewater characteristics, which would otherwise disrupt biomass settleability. The membranes have a high tolerance for FOG content, which is of particular importance for dairy manufacturers.

The MBR system can operate at much higher mixed liquor suspended solids (MLSS) concentrations – typically in the range of 8,000-15,000 milligrams per liter (mg/l) – than traditional CAS systems. The higher biomass concentration allows for a reduction in aeration basin size without sacrificing the target food-to-microorganism (F:M) ratio. The use of membranes also results in a more compact solution when compared to a CAS system.

> Noosa Yoghurt expands operations by using modular membrane bioreactor system.

The MBR system typically operates at a longer solids retention time (SRT) – greater than 20 days – when compared to CAS systems and eliminates the potential for biomass washout. These factors help to grow and retain the population of microorganisms responsible for nitrification. The MBR system is well equipped to consistently and completely nitrify organic nitrogen and ammonia in the raw wastewater (RWW). Only soluble nitrogen and phosphorus will contribute to the effluent TN and TP concentrations. With adequate chemical addition, effluent TP concentrations can be driven to extremely low concentrations such that even very strict discharge limits (< 0.1 mg/l) can be met using MBR technology.

Noosa Yoghurt reuse system

Phase 1 of the new wastewater treatment system at Noosa Yoghurt's manufacturing facility was commissioned in September 2016 and has since consistently met biological treatment objectives. The MBR system consistently achieves a high chemical oxygen demand (COD) removal efficiency (99.3 percent) and generates a final effluent with BOD concentrations less than 5 mg/l, corresponding to an average BOD removal efficiency of 99.9 percent.

The MBR system is capable of achieving this high degree of organics removals (including raw organics, TSS, and FOG) without primary pretreatment of the raw dairy wastewater. Raw solids and FOG are sent directly to the MBR system, which has sufficient hydraulic retention time (HRT), SRT, and membrane capacity to digest the complex organics without impacting biological stability or membrane performance. MBR permeate TSS concentrations have been consistently less than 2 mg/l.

The Phase 2 expansion components were commissioned in April 2017. The MBR system continued to maintain high COD and TSS removal efficiencies after the expansion components were commissioned. The prefabricated membrane tank simplified on-site construction and allowed the treatment facility to expand with increasing production.

The MBR system maintains biological stability, minimizes maintenance requirements, and consistently generates a high-quality final effluent with average effluent concentrations for COD, BOD, and TSS of 40 mg/l, < 5 mg/l, and < 2 mg/l, respectively. Incorporating BNR into the MBR process has resulted in MBR effluent TN concentrations of < 4 mg/l. The MBR system provides Noosa Yoghurt with the option of directly discharging treated water to the local river or reusing treated water for graywater applications at the dairy plant.

Author's Note

Daniel Bertoldo is a process engineer for ADI Systems, an Evoqua company, who is based in ADI Systems' head office in Fredericton, New Brunswick, Canada. Daniel has been involved in the process design, commissioning, start-up, and aftercare of more than 20 biological wastewater treatment systems across North America. This article is based on the author's presentation, "Case study of the Noosa Yoghurt membrane bioreactor wastewater treatment system," given at the Water Environment Federation Technical Exhibition and Conference 2017, held in Chicago, Illinois, United States.