Wehrle Environmental UK

Dairy Effluent Treatment Case Study: Dairygold, Mitchelstown, Ireland

MBR Treatment - Five Year Review

In this case study, Tony Robinson reports on the membrane bioreactor (MBR) wastewater treatment system that has been successfully operating at Dairygold's site in Mitchelstown, Ireland, for over five years. He describes Dairygold's approach to the MBR project, and the decision to upgrade the effluent treatment plant by treating the dairy and whey processing effluent component (accounting for 25% of organic loading) by using advanced cross-flow MBR technology provided by Wehrle Environmental. He shows how the MBR was fitted into a small available space and describes the ultrafiltration (UF) membrane technology used, how it is operated and controlled automatically, and he draws on Dairygold's operational experiences since commissioning of the MBR system in 1999.

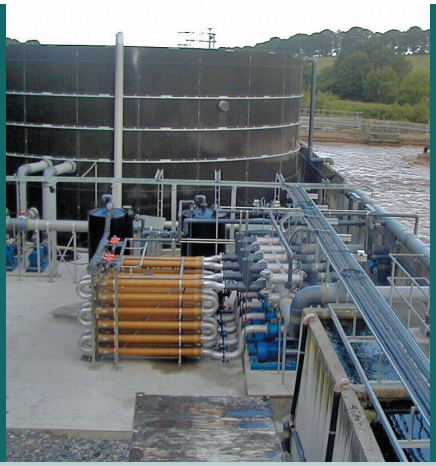


Figure 1
MBR Plant (before building erected) alongside second stage aeration basin

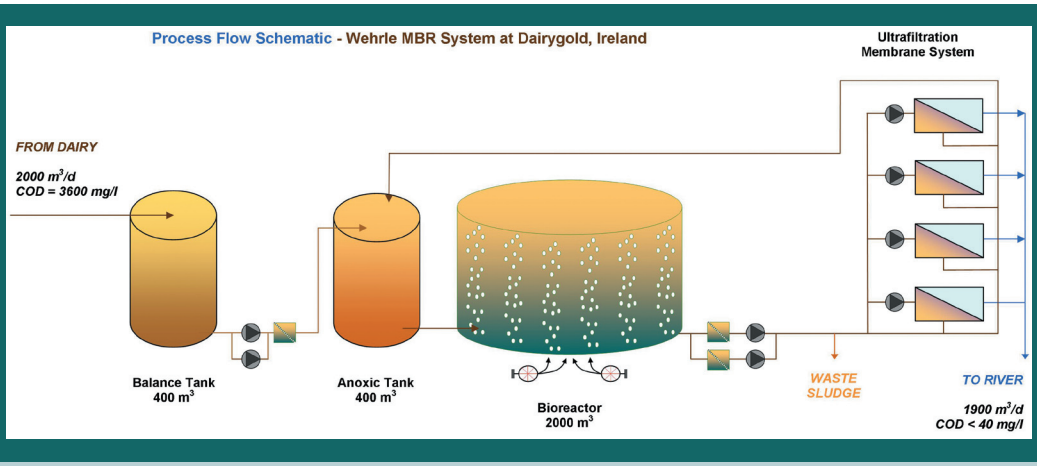


Figure 2
Main process components of Wehrle's advanced MBR system

Dairygold Project Requirements

Dairygold's effluent treatment plant (ETP) for the Mitchelstown site is able to treat four distinct local food waste streams. These originate from a cheese plant, a meat processing factory, a food ingredients plant, and a dairy spreads plant. These streams are piped separately to the ETP but the facility exists to combine flows as necessary before subsequent effluent treatment. Prior to 1999, waste from the four sources was treated by various processes including dissolved air flotation, a biotower system and two stages of conventional activated sludge (CAS) with traditional clarification.

In 1999, Dairygold were faced with the challenges of stringent Irish Environmental Protection Agency (EPA) requirements for effluent discharge to the local river, and a predicted increase in waste loading and volume due to an expansion in whey processing capacity. Due to limited available space, it was not possible to upgrade the existing ETP with conventional technologies to meet these challenges so Dairygold decided to utilise Wehrle Environmental's consulting and process contracting expertise to look at various ways of treating the four process waste streams.

Wehrle investigated the composition and flow variations of the waste streams and, after undertaking pilot trials with various membrane types and configurations, they concluded that the most cost-effective solution was to treat the segregated whey processing waste stream separately using MBR technology incorporating a specific type of ultrafiltration (UF) membrane.

As the whey processing waste accounts for significant organic loading to the ETP, treatment by MBR reduces the loading on the two stage CAS system and enables the overall combined effluent from the site to meet EPA requirements. The MBR solution implemented by Wehrle was the first of its kind to be installed in Europe. Figure 1 shows the MBR plant installed alongside the second stage aeration basin prior to erection of the building around Wehrle's technology.

MBR Process

Wehrle's MBR system is designed to treat 2,000 m^3/day of the segregated organic whey processing waste stream with a total suspended solids of 2,000 mg/l and chemical oxygen demand of up to 3,600 mg/l (see Table 1). Figure 2 includes a process flow schematic of the MBR system.

Table 1
Feed to Wehrle MBR system and permeate quality for discharge to river

Parameter	Units	Feed to MBR	MBR Permeate to River	EPA Consent Requirements
Biochemical oxygen demand (BOD)	mg/l	2,250	< 3	12
Chemical oxygen demand (COD)	mg/l	3,600	< 40	not specified
Suspended solids	mg/l	2,000	not detectable	30
Total nitrogen (TKN)	mg/l	75	< 15	15
Total phosphorous (Ptotal)	mg/l	10	< 0.1	not specified

Whey processing waste is piped from the production plant directly to the 400 m^3 Balance Tank, pumps then transfer the waste through 800 µm strainers to the MBR. The waste enters the Denitrification Tank (400 m^3) before overflowing into the Bioreactor (2,000 m^3). Mixed liquor from the Bioreactor is then pumped through the UF membrane system and returned back to the Denitrification Tank to be blended with more whey processing waste. Permeate is produced from the UF for discharge to river and a small proportion of mixed liquor is wasted from the system.

The combination of denitrification followed by nitrification is included in Wehrle's design to enable Dairygold to reduce the total nitrogen in the discharge to the river to less than 15 mg/l TKN. The Denitrification Tank provides an anoxic zone where blended whey processing waste and recycled mixed liquor are held for a specific period to biologically break

Figure 3
Aerated mixed liquor in Bioreactor

Figure 4
UF membrane system

down nitrate and nitrite compounds into inert nitrogen gas, which is vented to atmosphere.

The denitrified and blended mixed liquor then overflows to the Bioreactor where it is biodegraded and nitrification is facilitated. This is the breakdown of ammonia into nitrate and nitrite in the presence of oxygen. Oxygen required for the biological processes is supplied by injection of air through aerators installed inside the nitrification tank. Jet pumps are used to circulate the mixed liquor through the aerators, and blowers supply air into each aerator. The use of the aerator ejection system ensures complete mixing of the bioreactor contents.

Less than 4 m^3/h of mixed liquor is wasted from the MBR system. The waste flow is mixed with sludge from the conventional processes and dewatered using centrifuges before being applied to local farmland as part of Dairygold's Nutrient Management Plan.

A biomass concentration in excess of four times the value of typical CAS plants is reached in the Bioreactor (see Figure 3), with mixed liquor suspended solids concentrations typically in the range 16 to 20 g/l. This enables smaller space requirements leading to higher performances of the biological treatment process.

Separation of mixed liquor is accomplished by filtration within a highly efficient UF system (see Figure 4) that guarantees complete retention of mixed liquor and extensive removal of non-dissolved solids larger than 0.02 µm. Recirculated mixed liquor enters a header system feeding four identical membrane loops each comprising a dedicated recirculation pump and six modules, arranged in parallel, each module containing over 300 UF membrane tubes.

To allow for future expansion, the system was commissioned with only 22 out of 24 modules fitted with membrane tubes. It has not been necessary to utilise the spare capacity because the system has consistently achieved the design flowrate. This is due to higher flux rates being attained than those anticipated at the design stage.

Cross-flow tubular membranes are used, the mixed liquor being pumped along the membrane surface at high velocity. This high flow velocity ensures adequate turbulence which minimises membrane fouling.
The mixed liquor is filtered through the membrane wall, which provides an absolute barrier to form MBR permeate, free from bacteria, solids and biologically active substances. The amount of permeate produced is a function of the system pressure and mixed liquor flow velocity. An additional loop could be added in the future to increase MBR capacity by a further 25% over and above that gained by utilising the in-built spare capacity.

Membrane modules are flushed automatically on a weekly basis using permeate collected in the Washing Tank. Chemical cleaning using acid and caustic based solutions is undertaken on a quarterly basis.

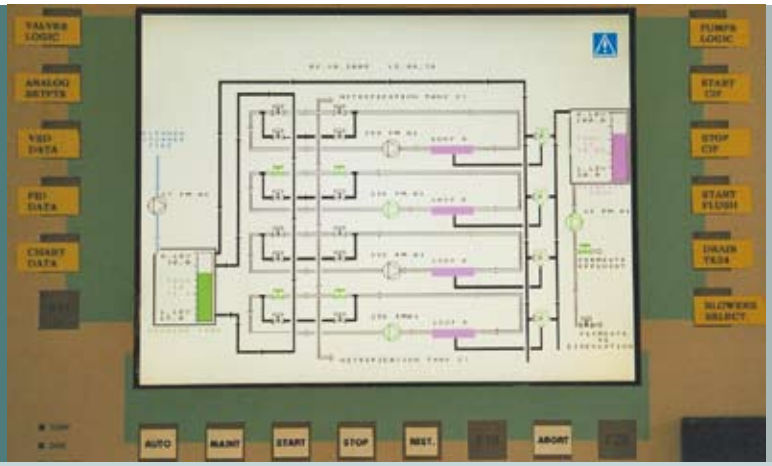
The MBR system is automated using programmable logic control (PLC). All aspects of plant monitoring and control are accessed via the PLC operator panel (see Figure 5). Pressures, flows and process parameters are measured at strategic points within the process and transmitted back to the PLC which automatically controls all aspects of normal process operation, and provides warning alarms to plant operators as required.

System Operation

On a recent visit to the ETP site, the operation of the plant since installation was discussed with Mr. Derry Cadogan, Dairygold's Environmental Manager at Mitchelstown.

Mr. Cadogan explained that Wehrle's solution was chosen by Dairygold because the MBR system could effectively treat high strength organic waste in a compact footprint, whilst eliminating odour. Looking back over the five years since the plant was installed Mr Cadogan said that Dairygold would probably go down the same route of choosing Wehrle MBR technology again as the membrane plant is very adaptable to load requirements.

Because of the seasonal nature of milk production in Ireland, Mr. Cadogan explained that the MBR system is shut down in the winter months, at which time the lower loading is processed by the conventional processes



"The size of the plant suits what we are doing; it is a very good solution, robust, easy to control and to stop and start."

Derry Cadogan, Dairygold

Figure 5
PLC operator panel screen shot - UF monitoring and control page

at the ETP. During shut-down the membrane tubes are soaked in-situ in a preservative solution. "The size of the plant suits what we are doing," said Mr. Cadogan, "it is a very good solution, robust, easy to control and to stop and start."

The UF membranes were still operating effectively having been guaranteed by Wehrle for the first five years of use. Currently two UF loops operate to produce approximately 50 m^3/h of permeate. This compares favourably with the design basis of 83 m^3/h from four loops. As a result of the higher than anticipated flux rates one loop is left redundant to cover cleaning and maintenance requirements.

Dairygold had employed Wehrle for the first two years of operation on a service contract basis but since then routine maintenance and membrane cleaning had been carried out by in-house engineers. "The system is low maintenance and cleaning is straightforward," Mr. Cadogan said.

The system was designed by Wehrle to be able cope with an expansion of throughput by installing membrane tubes in the two empty modules, and also by adding a whole additional stream if necessary. Mr. Cadogan told us that this feature of the process design was especially important to Dairygold as it could allow possible expansion of their facilities with minimal additional capital expenditure whist maintaining environmental standards and limits.

Conclusions

Dairygold's ETP at Mitchelstown in Ireland has been able to treat four separate process waste streams effectively over the last five years because of the installation of Wehrle's MBR solution, which reduces the organic loading to existing effluent treatment processes by 25%. The MBR system produces a high quality effluent that enables the overall effluent flow to consistently meet and exceed Irish EPA consent requirements. The inclusion of advanced MBR technology has provided increased treatment capacity with improved ETP performance and operational flexibility. Wehrle's ability to engineer a process solution that meets present and future requirements has been implemented within the tight space constraints available on site.

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