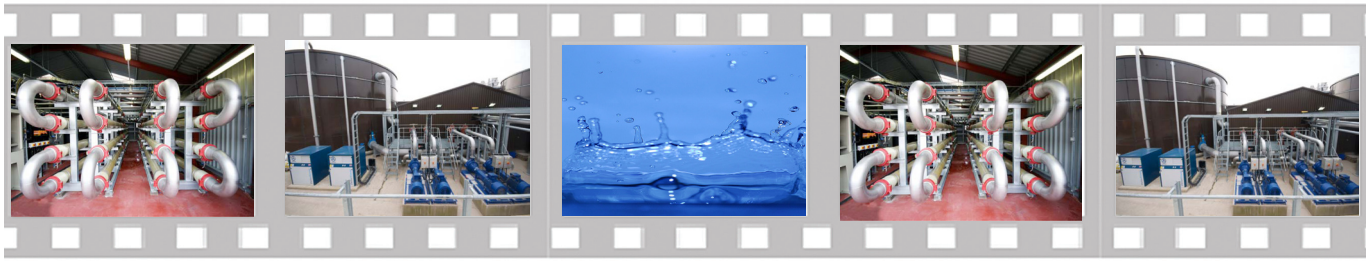
Recycling Food Processing Wastewater To Potable Water Standards



Over the past ten years installation of wastewater reuse plants in the sector has boosted confidence in safe reuse and reduced the 'stigma' of recycling water in food factories.

By Geraint Catley & Steve Goodwin

The issues surrounding wastewater recycling in the food and drinks sector are generally well known. Over the past ten years UK owned company, Aquabio Limited, based in Worcester has pioneered design and installation of wastewater reuse plants in the sector. In turn, this has boosted confidence in safe reuse and reduced the 'stigma' of recycling water in food factories.

The driving issues are now linked to the economics of recycling water in times of rising incoming water charges and outgoing effluent disposal costs, plus limitations on borehole/surface water extraction or final discharge constraints. Users with incoming mains water supplies are charged for both potable water into the factory and trade effluent out of it.
Recycling is therefore an increasingly attractive option. With recent developments in treatment technology the 'payback' on capital investment has reduced significantly, in many cases to below 2 years. These 'motivating' factors are intensified by business growth and/or factory expansion, corporate pressure from customers to reduce carbon footprint or improvement of environmental 'credentials'.

Abstraction is also affected by more global concerns such as decreasing ground water levels caused by a higher general demand for water and/or climate changes. Companies who already have an existing wastewater pretreatment infrastructure in place may well find the investment for potable recycling option more attractive. Even the UK Government is offering an Enhanced Capital Allowance (ECA) Tax Incentive Scheme for water reuse investments where 100% of the capital expenditure is fully allowable in the year following start-up of an 'eligible' efficient membrane based plant reusing >40% of the factory wastewater.

Crossflow Based MBR Technology

Aquabio uses its own crossflow membrane bioreactors (MBRs) as the 'core' process in its wastewater recycling plants. By developing three types of crossflow based MBR technology over the past 12 years Aquabio offers the most cost effective alternative for specific circumstances. All Aquabio MBR plants have 'true' ultrafiltration (UF) membranes mounted outside of the bioreactor in dry conditions, which means hygienic operation, ease of maintenance and no parts immersed in the biomass. The three types of system are:

AMBR™: this utilizes high crossflow to achieve high flux rates. The bioreactor can be operated at high biomass suspended solids concentrations (MLSS). The technology is aimed at lower flow and higher strength wastewaters. Plants are extremely compact, with very low membrane area and low membrane replacement costs. The membrane banks are operated automatically based on the level in the bioreactor and hence utilized, as required, to

match the inlet flow. When not required individual membrane banks are automatically shutdown, auto-flushed to remove biomass and await re-start; thus saving energy when the plant is not running at full design, or when membrane flux is higher than design. AMBR™ plants are modular, can be containerized and are relatively low in capital investment cost.

AMBR LE™: utilizes intermittent backflushing to control membrane fouling, and hence allows a reduction in crossflow velocity and significant energy savings. Medium to high MLSS concentrations are accommodated; AMBR LE™ is aimed at medium to high flow and low to high strength wastewater. With variable speed recirculation pumps the system allows for a 'managed' flux rate which is used to optimize energy consumption relative to the plant load.

Plants remain very compact, with low membrane area and moderate membrane replacement costs. Plants also operate on a direct link to level in the bioreactor, automatically adjusting membrane permeate production (and energy use) to suit the inlet flow conditions. AMBR LE™ is particularly suited to applications with inconsistent or variable wastewater flows, high peak or seasonal loads, or when electricity costs are moderate to high.

BIOVERT®: this incorporates vertically mounted modules and uses air injection to further reduce energy consumption. This process allows for medium MLSS concentrations and is aimed at higher flows and low to medium strength (i.e. mainly larger municipal applications). Plants are compact, with vertically mounted membrane modules and have more installed membrane area.

Plants operate on a more constant level in the bioreactor, with controlled air injection at either the top, or the bottom, of the membrane tubes. Air scour and turbulence reduces surface fouling and energy use is very low. BIOVERT® plants are particularly suited to applications with large consistent wastewater flows and when electricity costs are high.

Operations input is low for factory personnel thanks to Aquabio's proprietary control software and remote real time monitoring is a standard feature using internet links. All plants have automatic operation including, flushing, backflushing, cleaning, start up and shutdown on demand.

Case Study:

Kanes Foods, Nr. Evesham, UK

Background

In 2001 Kanes Foods in Evesham installed an Aquabio 'first generation' AMBR™ plant combined with reverse osmosis and UV disinfection for wastewater reuse at potable water standards. On the initiative of the company's owner Dr. John Randall, and

Figure 1: AMBR™ UF Membrane Bank

Figure 2: AMBR LE™ Close Up

MBR Type	Normal Operating MLSS Range (gTSS/l)	Sustainable Normalized Flux LMH	Energy Use On Biomass Separation kWh/m3 Permeate Produced	Configuration/ Maintenance	Energy Management
AMBR™	10 to 20 (Air) 15 to 35 (Pure oxygen 'enhanced)	80 to 250	1.8 to 3.5	'Dry', out of tank. Low level, horizontally mounted membranes	Yes. Banks are automatically flushed & shutdown on low/no flow
AMBR LE™	10 to 20	80 to 250	0.25 to 1.4	'Dry', out of tank. Low level, horizontally mounted membranes	Yes. Permeate flow automatically regulated & banks can still be automatically shutdown on v. low/no flow
BIOVERT®	8 to 15	30 to 60	0.2 to 0.5	'Dry', out of tank. Vertically mounted membranes	Yes. Banks are automatically flushed & shutdown on low/ no flow
Submerged HF/Flat Sheet	6 to 12	8 to 25	0.6 to 2	Submerged in biomass & vertically mounted with course air scouring from below	No. Membranes submerged in biomass and must be regularly 'scoured'. Energy can be >2kWh/m3 during v. low/no flow.

Table 1: Comparing The MBR Systems

Parameter	Original Plant	New Plant	Combined
Volume to screening/ balancing	1.200 MLD	2.250 MLD	2.250 MLD
COD concentration (average)	1,000 mg/L	1,000 mg/L	1,000 mg/L
Volume to DAF system	0.815 MLD	1.435 MLD	2.250 MLD
Volume to MBR process	0.815 MLD	1.435 MLD	2.250 MLD
Volume to RO system	0.815 MLD	0.858 MLD	1.673 MLD
Volume of potable quality water for re-use	0.650 MLD	0.600 MLD	1.250 MLD

Table 2: Design Basis For The Plants At Kanes Foods

Process Stage	Original Plant	Original Plant
Preliminary Screening	Old screen now redundant	Rotary Drum Screen, 220 m3/hr, 0.7mm
Balancing	Old 900 m3 Balance Tank now used for outlet balancing	1640 m3 Balance Tank c/w mixing/aeration
DAF Treatment Secondary Screening	DAF system, 50 m3/hr Backflushing Filter/Screen, 0.5 mm	DAF system, 60 m3/hr Rotary Drum Screen, 80 m3/hr, 0.25mm
Biological Treatment	2 No. 250 m3 Bioreactors c/w Jet mixing/aeration	1 No. 765 m3 Bioreactor c/w slot mixing/aeration
UF Membrane Separation	4 No. Membrane Banks, 34 m3/hr	4 No. Membrane Banks, 60 m3/hr
Reverse Osmosis	RO system, 27 m3/hr	RO system, 25 m3/hr
UV Disinfection	UV disinfection unit, 27 m3/hr	UV disinfection unit, 25 m3/hr
Sludge Handling	22 m3 Sludge Tank	50 m3 Sludge Tank

Table 3: Summary Of Process Treatment Schemes, Kanes Foods

extensive trial work over the preceding 18 months, this became the first food plant in Europe to recycle treated wastewater on a large scale producing high quality, potable water. Due to factory growth and continuing limitations on water supply and discharge options, Kanes has recently installed a second AMBR LE™ plant on the same site to increase the treatment capacity and recycle volume.

The 2001 'first generation' AMBR™ process treatment scheme comprises upstream screening, flow balancing, dissolved air flotation (DAF) treatment for fine vegetable solids removal, the AMBR™ itself and downstream treatment by reverse osmosis followed by UV disinfection. This process yields potable quality water suitable for blending with mains water for use within the factory. The process comprises two 250 m^3 bioreactors with four banks of crossflow membrane modules.

The maximum biomass solids (MLSS) concentration employed has been as high as 22 g/L, but the bioreactor is generally operated at around 10 g/liter. Sludge production is calculated as being 0.14 kg DS/kg COD removed at a sludge age of over 100 days.

Each membrane bank (Fig. 1) comprises four UF membranes. The membranes operate at an average flux of 153 liters permeate production/m^2 membrane area (LMH) normalized to 25°C. The permeate water has average TSS, BOD and COD concentrations of only 4, 7 and 16 mg/L respectively. The UF permeate then passes to a two-stage reverse osmosis plant which achieves an overall recovery of 75%. The reject stream is discharged to sewer and the permeate, which typically has a conductivity of 40–100 µS/cm, is passed to the UV disinfection unit and on to the client's water supply tank.

Old Plant Performance

The plant has now been in continuous operation for 9 years and has performed consistently in terms of biological treatment,

membrane performance and final reuse water quality. For the majority of the time membrane performance has been better than design, allowing one bank to be maintained as a standby and so offering more process flexibility and lower energy use. Occasional reductions in membrane flux have been linked to poor biomass health which has been rectified by closer management of the process.

Latest Developments

Due to continued production expansion and the consequent pressure on incoming water supply and discharge consent, a second wastewater treatment plant has been constructed by Aquabio and commissioned in February 2010. This new plant provides an additional 1.435 mega-liters (MLD) of biological/ MBR treatment capacity and an additional 0.6 MLD of re-use water (Table 2).

The plant replicates the successful process scheme of the existing plant (Table 3) but utilizes Aquabio's AMBR LE™ technology to provide significant energy savings compared to the original plant. New common inlet screening and flow balancing facilities are provided, allowing the original balance tank to be used to balance outgoing flows to sewer. Again, DAF treatment is employed to remove fine vegetable solids prior to the AMBR LE™ system. A single bioreactor of 765m^3, allowing for MLSS concentrations up to 12 g/L, is aerated by a blower assisted slot type aeration system, with high alpha factor characteristics.

The AMBR LE™ UF membrane system comprises 4 banks of 4m long membranes. Low energy performance is achieved by the use of backflushing to control membrane fouling thus allowing much reduced cross flow velocities and hence significantly lower energy use.

The combination of backflushing frequency and variable cross flow velocity is optimized to give the lowest energy use for the required throughput. Significant process flexibility is offered by the inclusion of variable speed recirculation pumps and optional permeate pumping to control the trans-membrane pressure (TMP) and hence the flux performance.

Stable performance is currently being achieved at an energy use of 0.3-0.5kWh per m^3 of treated permeate for the biomass separation, a significant improvement on the original plant. By the end of March 2010 both Aquabio plants had recycled the huge total of 1.68 billion liters (3.7 Billion Imperial Gallons) of potable quality water back into the factory since their start up. Additional quantities of AMBR™ permeate water have also been reused in non-potable duties.

Conclusion

With ever increasing water costs and pressures on, food and drinks production, tightening water extraction, discharge limitations and developments in treatment technology, water recycling has become a high priority subject for most medium to large scale food and drinks producers around the world. Aquabio is at the forefront of implementing proprietary plants which has enabled food and drinks companies to take greater control over their own 'water cycle'. These factors, along with significant savings in energy consumption with Aquabio's latest AMBR LE™ and BIOVERT® processes, means that companies can save considerable amounts of core operating expenditure, improve corporate image and promote their environmental 'credentials'.

About The Authors

Geraint Catley and Steve Goodwin work at Aquabio Limited. Over the past ten years UK owned company, Aquabio Limited, based in Worcester has pioneered design and installation of wastewater reuse plants in the sector. The authors can be reached at: g.catley@aquabio.co.uk and s.goodwin@aquabio.co.uk respectively. www.aquabio.co.uk