UNITED KINGDOM

The development in MBR technology

In the UK, as in other countries, large-scale municipal wastewater treatment is largely based a two-stage process comprising primary sedimentation followed by biological treatment either by the activated sludge process (ASP) or trickling filtration (TF). Whilst well established and reasonably robust, the use of both ASPs and TFs is constrained by the requirement for relatively large land areas, secondary sedimentation for biomass (sludge) separation from the clean effluent, further increasing the footprint and introducing the settlement problem of 'bulking', surface or fine bubble aeration (for ASPs), which is low in energy efficiency, further treatment of the generated waste sludge prior to its disposal and equilisation of hydraulic and organic loadings to maintain a constant treated effluent quality.

The use of microfiltration or ultrafiltration membranes in biological wastewater treatment has been well documented and recently extensively reviewed and can overcome many of the above problems. Such membranes produce a very high quality permeate product, almost free from particulates, and also permit absolute control of solids retention time (SRT) and so the mixed liquor suspended solids (MLSS) concentration. This both reduces the required reactor size and *promotes the development of specific* nitrifying bacteria, so enhancing ammonia removal, as well as producing less sludge.

The emergence of MBRs in the UK municipal sector has been brought about by increasingly stringent regulations pertaining to discharges to bathing waters. The water companies most affected, Welsh Water, South West Water and Wessex Water, entered into a joint programme in the early-mid 1990's which originally took the form of a small Kubota system pilot plant at Kingston Seymour sewage treatment works, just south west of Bristol. The plant comprised a nitrification/denitrification two-compartment tank containing 240 m^2 of membrane area and having a flow capacity of 125 m^3 day^{-1} flow capacity. Successful trials paved the way for the 1900 m^3 day^{-1} plant at Porlock, which went on line in February 1998 and subsequently the Swanage plant which was officially launched in November 2000. The success of the Kubota system, whose hydraulic performance and water purification performance has barely wavered in increasing from pilot plant to full scale (table 1), led to the formation of the spin off company MBR Technology in 1999 as a subsidiary of Wessex Water.

The high profile attained by the MBR technology in the UK as a result of the success of the plants at Porlock and Swanage has led to a burgeoning of pilot plant trials both by the water utilities and by various industrial sectors. The most recent MBR-based sewage treatment works is at Lowestoft, which is based on the Zenon membrane and is has just come on stream. This is a hollow fibre membrane, as opposed to the flat plate geometry of the Kubota membrane.

Both the Zenon and Kubota systems are examples of submerged MBR systems, as opposed to sidestream systems, wherein the membrane is immersed in the bioreactor rather than fitted external to it (figure 1). Submerged systems tend to allow greater hydraulic efficiencies, reflected in greater permeabilities, due to their operation at substantially lower fluxes than sidestream systems (table 2). Low flux operation is essential in submerged systems, since this greatly reduces fouling of the membrane: the removal of deep or 'irreversible' membrane fouling can only be achieved by ex-situ chemical treatment, adding both to process complexity and to operating costs. 'Reversible' fouling, on the other hand, can be largely removed by physical means such as backflushing which can, for HF membranes, be incorporated into the process cycle.

Whilst demanding far lower hydraulic pumping, submerged systems rely on more vigorous aeration than sidestream systems, since this represents the main means of controlling fouling and clogging, and this impacts directly on the operating costs.

Table 1: *Summary of performance of Kubota MBR process plant.*

parameter	Kingston Seymour	Porlock	Swanage
capacity (m^3/day)	125	1.900	13.000
flux (LMH)	27-32	27	34
permeability (LMH/bar)	300-500	220-2500	280-3400
log removal of faecal coliforms	>5	>5	>5

Fig. 1: *MBR process configurations: (a) sidestream, and (b) submerged.*