Technical Article

MBR + NF technology significantly improve landfill leachate quality at SITA's Beacon Hill Landfill site

First published in Filtration+Separation magazine, October 2007

Already widely used for landfill leachate treatment elsewhere in the UK and around the world, Wehrle's membrane system incorporates nanofiltration (NF) for effluent polishing following MBR, to significantly reduce chemical oxygen demand (COD), ammonia and solids. The system was designed to be relocated in the future. The combination of MBR and NF technology reliably and cost-effectively produces a high quality effluent.

Wehrle technology for landfill leachate treatment

Wehrle MBR systems are considered 'best available technology' under IPPC regulations across a range of industrial sectors. For the first time in the UK, landfill leachate at SITA's Beacon Hill site (see Figure 1) near Poole in Dorset is being treated to remove contaminants by utilising MBR and NF technology.

Figure 1
Wehrle containerised MBR/NF installation at SITA's Beacon Hill landfill site

Landfill leachate poses specific challenges for MBR technology. High concentrations of COD, ammonia and chloride require a biological treatment system that extensively nitrifies (i.e. oxidises ammonia to nitrite and nitrate), whilst the membrane system must withstand the corrosive chloride-rich influent. At Beacon Hill, the local trade effluent consent contains a strict limit of 625 mg/l COD. On-site treatment using MBR and NF technology was necessary, since the leachate has a high COD loading, up to 5000 mg/l (see Table 1).

Table 1
Typical process data for raw leachate, MBR effluent and NF permeate

Parameter / Unit	Raw Leachate	MBR Effluent	NF Permeate
COD Concentration (mg/I)	5000	1200	<100
BOD Concentration (mg/I)	250	<10	<10
Ammonia Concentration (mg/I N)	2000	<2	<1
Temperature (°C)	20		
pH	8.0	7.1	7.7
Total Phosphate (mg/I)	I 5	<5	<1.5
Total suspended solids — TSS(mg/l)	250	<50	<25
Chloride (mg/l)	1400	1200	1200
Sulphate (mg/l)	200	200	<10
Conductivity (µS/cm)	16000	11000	10000
Alkalinity (mg/l)	14000	200	<50

Wehrle designed and constructed a compact, mobile process solution for SITA UK to ensure sustainable effluent production. Faced with a restricted plant footprint area, located within future landfill void space, the system had to be compact and designed to be relocated in the medium term future. To substantially reduce COD levels, three biological nitrification reactors (seen from the top of the influent balance tank in Figure 2) reduce COD and ammonia levels in three series stages. Following cross flow UF for biomass solids separation, cross flow NF is utilised for COD effluent polishing.

Adam Bentham, effluent manager at SITA UK commented, "Wehrle offered a bespoke solution for our requirements at a competitive cost whilst delivering a high quality end product."

SITA manage a large portfolio of landfill sites in the UK, leading the recycling and waste management industry with leading technologies such as Wehrle's, and others including energy recovery from waste landfill gas. Electricity is produced at Beacon Hill – 2.3 MW is exported to the UK grid.

Committed to best environmental practice, SITA operate a comprehensive environmental management system to ISO 14001 and have their own internal quality environmental monitoring system (QEMS). As principal contractor on this project, Wehrle had to meet stringent QEMS targets set by SITA to ensure the project met and exceeded regulatory requirements.

Beacon Hill membrane processes

The MBR approach to effluent treatment is becoming the method of choice across a wide range of applications, and the only realistic membrane process option for leachate treatment with high COD, ammonia and chloride loadings. The MBR aeration stage is followed by a UF system using a physical membrane barrier to remove suspended solids. MBR systems are robust and reliable, and produce a much lower solids loading in the final effluent compared to conventional clarifiers. They are space efficient, being well suited for treatment plant upgrade where space is limited.

The Wehrle system installed at Beacon Hill receives a pneumatically generated leachate supply of 60 m^3/day (average) to a balance tank, providing up to 3 day's storage to equalise loadings to the process. The leachate is pumped to three 40 m^3 biological tanks in series, first passing through 800 µm stainless steel basket strainers. The nitrification efficiency is optimised in the biological system by continuous pH control (by caustic dosing) and phosphoric acid addition to maintain a C:N:P ratio of 100:5:1. In addition to ease of future plant relocation, three stages of nitrification in the compact biological tanks reduce ammonia to within consent levels and COD to below 1200 mg/l for subsequent treatment by NF.

Effective aeration occurs in each bioreactor, operating at a biomass concentration of 16-20 g/l, more than four times the norm for conventional activated sludge or SBR. Continuous dissolved oxygen monitoring enables automated adjustment of the oxygen feed to optimise conditions and minimise power consumption.

Aerated effluent enters the ultrafiltration system, housed in a space-efficient 40' ISO container as a fully assembled and pre-tested system. Transfer is via a dedicated stainless steel pump through three cross-flow tubular membrane modules arranged in series. Cross-flow MBR systems pump the mixture of leachate to be treated and activated sludge across the surface of the membranes. At Beacon Hill, each tubular module contains in excess of 350 UF membrane tubes, which provide an absolute barrier to solids and pathogens greater than 0.02 µm in diameter.

Figure 2
Biological tanks (in background) at Beacon Hill, providing three stages of nitrification, viewed from the leachate balance tank

UF permeate is further treated using NF membrane technology. The feed is pressurised and enters two housings arranged in parallel, each containing spirally wound NF membranes. NF typically removes divalent ions such as calcium, magnesium and sulphate, along with chemical compounds and residual biological components comprising COD. Treated permeate is discharged to trade effluent sewer, with a concentrated stream recycled back to site. Monovalent ions, such as sodium and

chloride, have low NF removal efficiency. Hence, these components are removed from the system in the effluent eliminating the possibility of salt concentrations building up on site.

The high final effluent quality produced by MBR/NF systems can allow re-use of treated water within installations in some industrial applications, improving water use efficiency and reducing trade-effluent costs for discharge to sewer. Lower sludge production rates, with associated sludge storage, treatment and disposal cost savings, also offset the capital cost of installations, typically resulting in short pay-back times.

The system at Beacon Hill is controlled using a PLC with HMI display. Remote telemetry allows for interrogation of the PLC and operation of the automated control system. Pressure, flow and process parameters are continuously monitored to inform the PLC, which then automatically controls the entire process. Membrane maintenance consists of weekly flushing with permeate, and quarterly chemical cleaning using acid and caustic solutions. In view of the small quantities of cleaning chemicals used as a proportion of the leachate treated, used chemicals are returned to the leachate balance tank.

The biological process was 'seeded' using activated sludge from a MBR system treating landfill leachate in Germany, and since commissioning the process has comfortably exceeded the permeate water quality requirement.

Adam Bentham said that Wehrle had reassured SITA with their process design, not needing to change any design parameters from tender through to commissioning. SITA were also impressed with the build quality of the containerised system, and also the versatile and adaptable process allowing for relocation in the future. He said, "Wehrle successfully completed a six week performance test of the system. No significant hindrances to plant performance were encountered. The attention to detail, especially in relation to health and safety documentation, was impressive. We are pleased to have contracted Wehrle for a further 6 months to operate and optimise the plant – the quality of final effluent produced is well above the level required."

Conclusions

Already in use across a range of industrial and municipal wastewater treatment applications, the first MBR treatment system for landfill leachate incorporating NF technology in the UK has been commissioned at SITA's Beacon Hill site. This has allowed the operators on site to reliably discharge effluent to sewer as effluent quality has improved. Their system readily achieves the necessary COD and ammonia treatment requirements and is resistant to the corrosive chloride-rich leachate. Membrane treatment offers a viable, low maintenance, cost-effective solution to landfill leachate treatment and other industrial wastewater treatment problems.

MBR technology, coupled with NF membrane systems, provide a superior effluent quality with low COD levels suitable for trade effluent disposal, and open up the potential for water reuse on site. The lack of monovalent ions in the NF concentrate means that NF 'waste' can be recycled back to the landfill site without the accumulation of salinity in the leachate.

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