

Tubular sidestream (Cross Flow) MBR applications for industrial effluents.

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INTRODUCTION

The use of MBR technology for wastewater treatment is now well established, however there is a range of process variations available, and it is important to select the system most suitable for the task.

For low strength-high volume wastewater, for example - sewage, low ultrafiltration energy costs per cubic metre are important. This requirement is usually best met by a submerged membrane process. However, for high strength-low volume wastewater the capital and operating costs for ultrafiltration are low relative to the total COD load, and cross flow MBR is often the best choice.

Most industrial wastewater falls into the second category. For the treatment of this wastewater, cross flow MBR has been found to have many advantages. In this system, the tubular membranes are housed in modules through which a side stream from the aeration tank is continuously pumped.

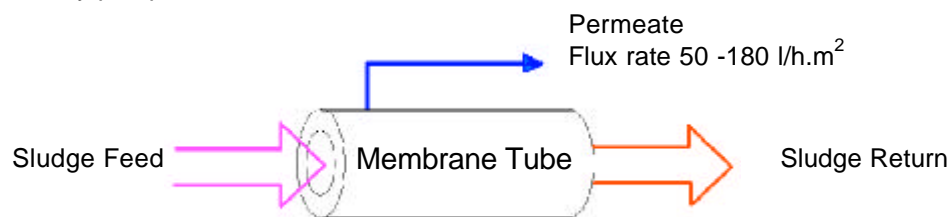


Fig.1

Permeate is discharged while the concentrate is recycled to the aeration tank. This configuration provides a number of practical advantages:

- The membranes are separate from the aeration tank and cannot affect the efficiency of the aeration
- The 'self scouring' action created by the velocity of the sludge along the surface of a tubular membrane, in fact, considerably reduces the fouling factor.
- The membranes can also be easily back washed, chemically cleaned 'in situ' (CIP) or removed for servicing after switching to a parallel module.
- Some wastewaters containing high inorganic dissolved solids precipitate salts during biotreatment these can cause problems with cleaning for submerged membranes.
- It is possible to operate the plant at a higher MLSS than is possible with most alternative systems
- It is not necessary to use additional aeration for cleaning the membranes in situ



Dairygold Ireland
Ultrafiltration modules

The Wehrle BIOMEMBRAT[®] process utilises the aforementioned features to provide an optimal solution for the treatment of many industrial wastewaters and landfill leachates.

The bioreactor can be operated at up to 35 kg/m³ MLSS, which minimises reactor volume for a given F/M loading. The smaller aeration tanks can be pressurised at up to 3 bar (BIOMEMBRAT Patent) to facilitate the provision of optimum dissolved oxygen concentration even at a high organic loading.

The pressurised tanks also minimise the airflow, reducing the risk of stripping out volatile compounds, and reducing the size of air scrubbers where these are required.

A further effect of using a smaller aeration tank is that the energy from the exothermic bioprocess and from the aeration and pumping is used to heat a relatively small volume of liquid. This enables the Biomembrat process to operate at an elevated temperature, usually 30 to 35°C, providing the following advantages :

- **Biology**

- Increased rate of bio-oxidation of pollutants.
- Improved performance of 'hard' COD removal.
- Higher rate of nitrification.
- Lower sludge production.

- **Ultrafiltration**

- Increased flux rates with increased temperature.

For industrial effluents where recalcitrant organic substances often occur it can be necessary to operate in a low F/M – long sludge age mode. The high MLSS in the BIOMEMBRAT facilitates this mode of operation, which together with the retention of bacteria by the membranes maximises the biodegradation. This is reflected in the observed improvement in COD reduction when the treatment of a dairy effluent by BIOMEMBRAT was compared with a conventional activated sludge process.

A low F/M loading is also necessary for nitrification, and minimises the production of surplus sludge.



BIOMEMBRAT treating landfill leachate at Lorrach

The plants can be designed to incorporate a denitrification stage if required. Denitrification takes place in an anoxic tank which precedes the aeration tank, and receives both the flow of incoming wastewater and the recycled thickened sludge from the ultrafiltration unit. Methanol is dosed to this tank as necessary to ensure an adequate carbon source. A typical basic flow sheet is shown in Fig.2

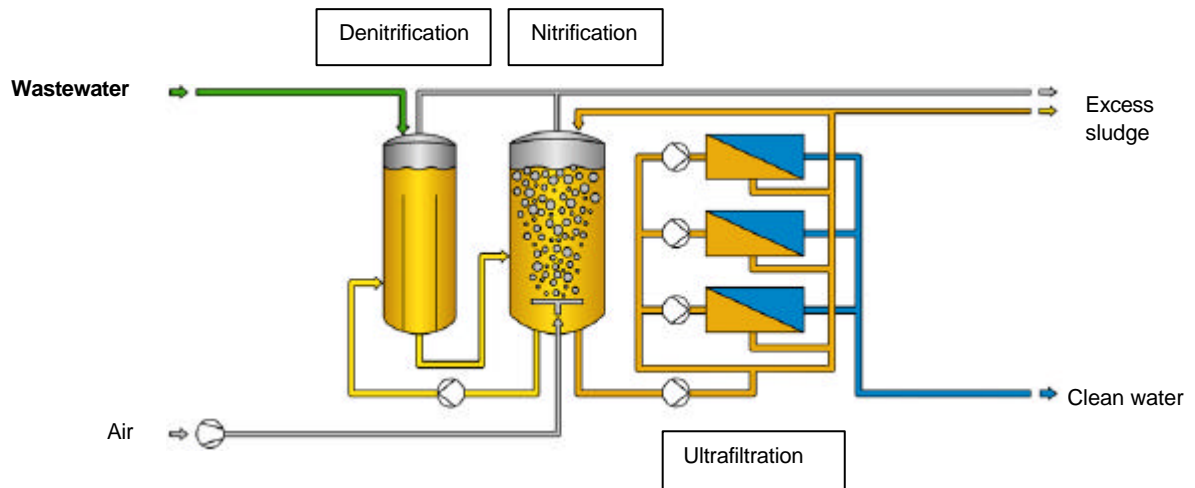


Fig. 2 BIOMEMBRAT Flow Diagram.

The UF permeate (clean water) is free from SS, bacteria and large organic molecules, but can contain smaller difficult to biodegrade organic molecules which are recorded as 'hard' COD. This can often be removed by Activated carbon; some of the BIOMEMBRAT plants are followed by Activated Carbon Columns, as shown in Fig 3

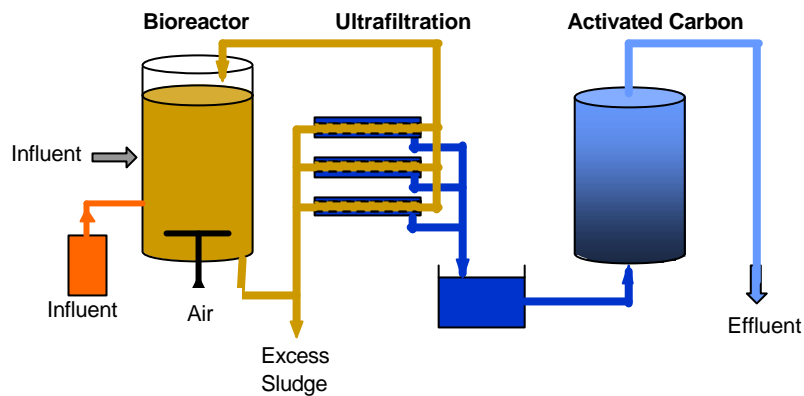


Fig 3 BIOMEMBRAT Flow Diagram with Activated carbon

Using a side stream cross flow ultrafiltration system gives high flux rates. These vary with the type of wastewater being treated, but are usually in the range 60 – 180 l/m².h. With the new design of cross-flow membranes now coming onto the market, energy costs as low as 1.75 kWh/m³ of wastewater are now achievable. This is comparable to the compressor/blower energy necessary for the air bubbles required by some submerged systems to prevent the build up of fouling material along the membrane walls

OPERATIONAL EXPERIENCE

The BIOMEMBRAT process has been installed in more than 50 full-scale operating plants across Europe. The plants have been chosen to treat a wide variety of industrial wastewater including land fill leachate and contaminated ground water, plus effluents from rendering, tanning, chemical production and the food industry.

The BIOMEMBRAT plant treating whey effluent at Dairygold, in Ireland is the largest cross flow unit in Europe and is designed to treat 2000 m³/day. Not only is this plant capable of extremely high flux rates, it easily is able to cope with fouling material, e.g. precipitated calcium deposits.

Wehrle Werk AG have gained considerable experience from their full scale plants some of which have been operating since 1992.



Dairygold BIOMEMBRAT adjacent
To a conventional activated sludge plant

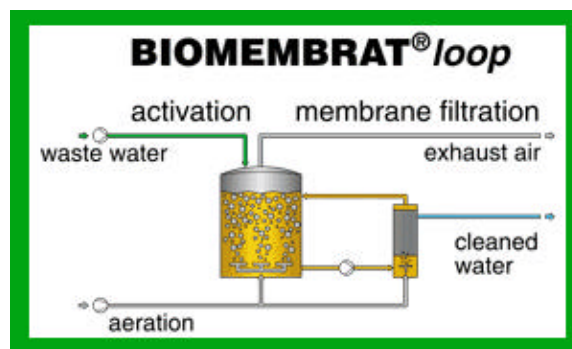
Several of the plants in Germany are operated by Wehrle Werk AG themselves, which provides particularly valuable operational information. In addition to the full scale plants it is usual to conduct pilot trials prior to design upon wastewater where operational experience is limited; this has provided a wide knowledge of the treatment of many industrial effluents by the MBR process.

Design details of some full scale plants are outlined on the attached sheet

FURTHER DEVELOPMENTS

The choice of the best MBR process for a particular wastewater depends upon many factors as outlined above. A major factor is power consumption, which becomes especially important for high volume, low strength wastewater.

Wehrle have therefore developed a modification of the BIOMEMBRAT process, the BIO-LOOP, designed to reduce power consumption. The power requirements for a cross flow membrane are a factor of the rate of flow through the tubular membranes, which in turn is dictated by the need for a self cleaning velocity.





BIO LOOP at Freiburg

By mounting the ultrafiltration modules in a vertical position and injecting air at the base of each membrane tube, it is possible by the introduction of air scouring to substantially reduce the velocity of flow through the tube thereby reducing the back pressure and power consumption.

As any engineer dealing with pipeline hydraulic flows knows, a reduction in flow velocity by a factor of 2 will result in a power reduction by a factor of about 4.

Typical power consumption for standard cross flow modules used in MBR is in the region of 1.75 – 3.5 kWh/m³, at a flow velocity of 3 – 4 m/second.

In comparison, it is possible to operate the BIO - LOOP system at 2 – 3 m/sec, resulting in a theoretical power consumption of less than 1.0 kWh/m³ and flux rates of 60 – 110 l/m².hour.

The above combination of high flux rate and low energy is achievable because of the scouring action being created by the injection of air. The 'airlift' of bubbles, working up the tubes helps to reduce the membrane fouling factor.

For example:

Flux rate l/h.m²	Velocity m/sec	Power for pumping kWh/m³
60	2.1	0.8
110	2.4	1.0

A full-scale plant has now been operating at Freiburg Germany for almost two years, treating landfill leachate with excellent results.

The application of the BIO-LOOP cannot be used for any type of wastewater. It is a half way house between full cross-flow MBR and the submerged MBR, in the opinion of the authors, more experience is required before this type of MBR can be universally applied.

CONCLUSION

The term '*horses for courses*' can aptly be applied to MBR systems. Low-load, high-flow wastewater can be catered for by submerged MBRs. Conversely, High-load, low flow wastewater is better being treated by a full cross-flow MBR

Overall, using the Biomembrat system it is possible to design a plant, which has the following major advantages for the treatment of industrial wastewater:

- Small footprint.
- Ability to remove nitrogen by nitrification/denitrification.
- Optimum temperature for biological activity.
- High MLSS providing pre thickened surplus sludge.
- Low F/M loading for difficult to degrade organic compounds.
- Long sludge age for enhanced nitrification and minimum sludge production
- Pressurised system to optimise DO and reduce the air stripping of volatile substances
- Closed system using a low air volume to facilitate odour control where necessary.
- Reduced membrane fouling
- The high operating temperature maximises the ultrafiltration flux rate.
- Easy to clean ultrafiltration membrane system. Typical CIP cycle – 2-3 hours.