



Viledon® Water Solutions for energy-efficient water and wastewater treatment and reuse



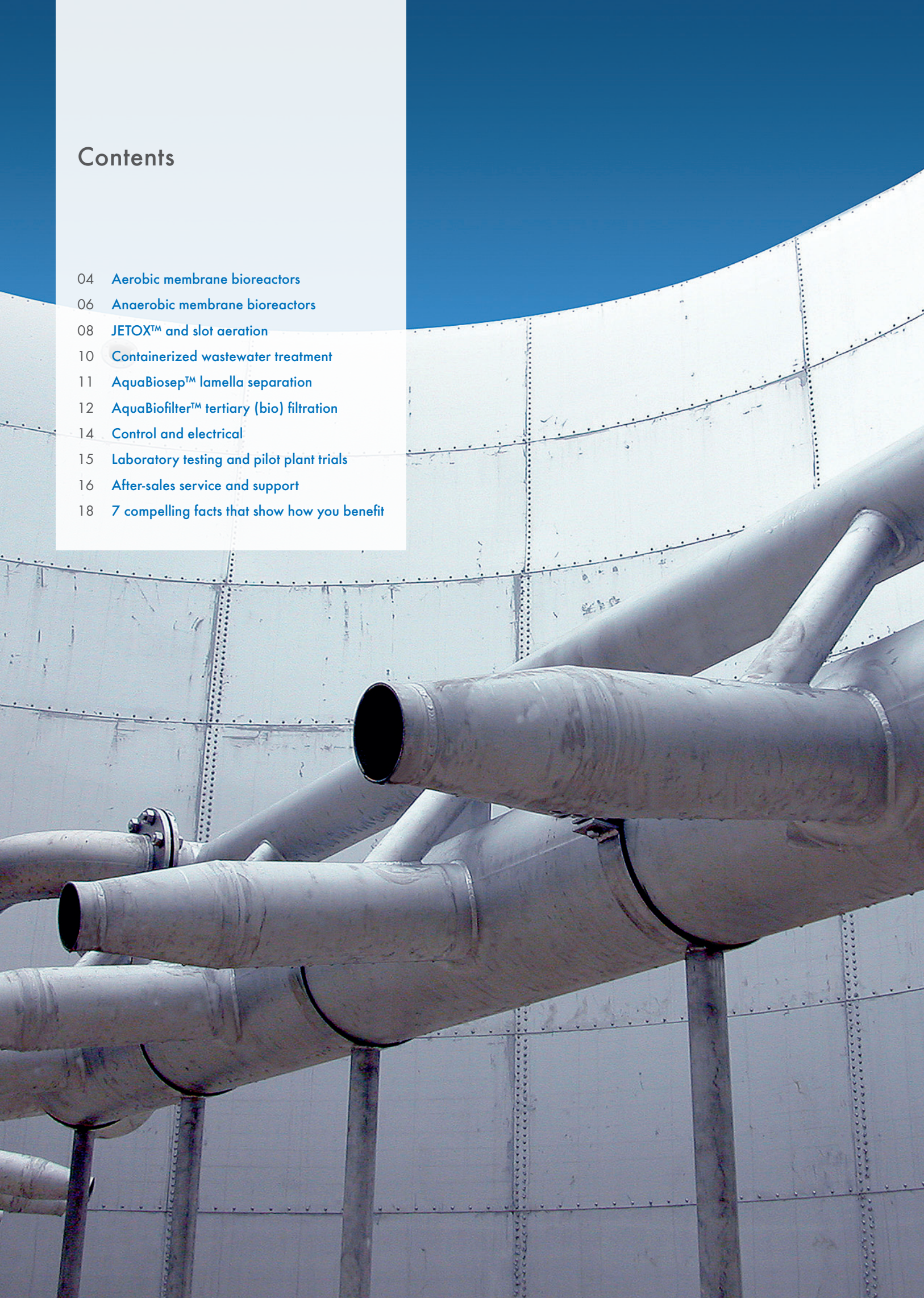
Industrial Filtration | Water Solutions

Freudenberg
Filtration Technologies



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Viledon® Water Solutions with Aquabio technology inside

Efficient water treatment to save resources and reduce costs

Freudenberg Filtration Technologies is a pioneer and driving force in the development of energy-efficient and cost saving systems, which open up significant competitive advantages. In this context, making proven Aquabio technology available to Freudenberg customers worldwide under the name of Viledon® Water Solutions is a logical development.

Freudenberg: a technology leader in industrial filtration

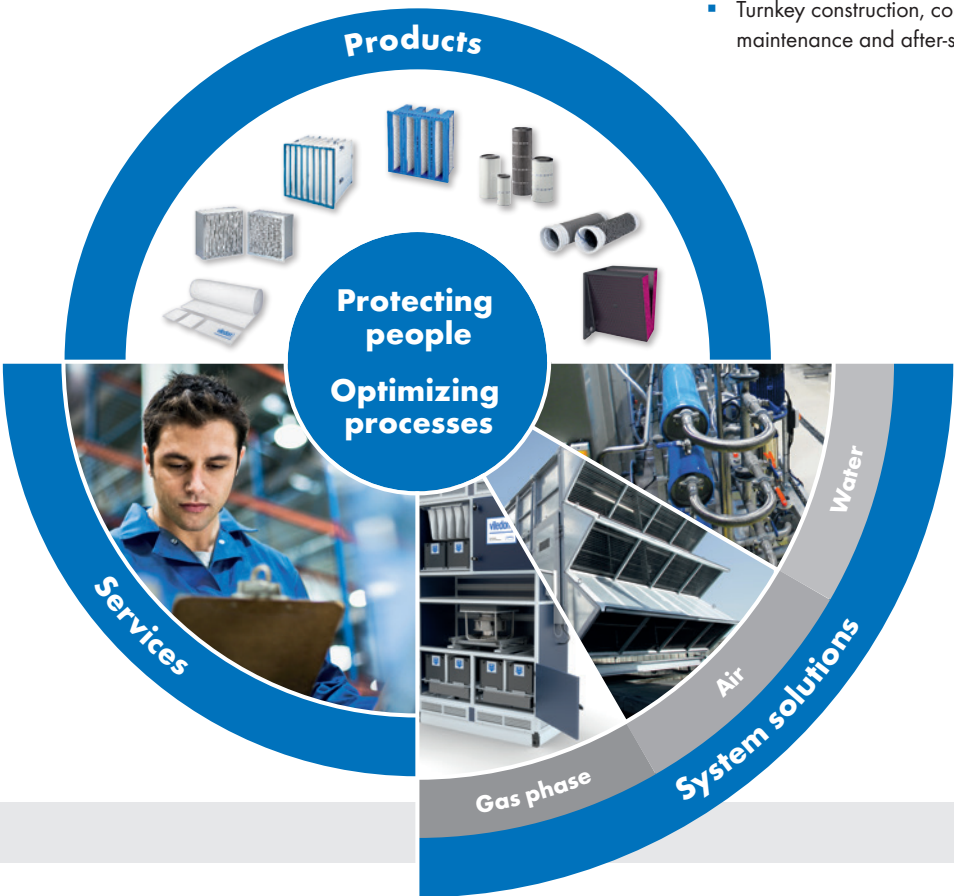
With around 1,700 employees at more than 30 locations worldwide, Freudenberg Filtration Technologies is a global technology leader in air and liquid filtration, offering a comprehensive range of filters and services. The company's Viledon® and micronAir® brands are synonymous with high-quality filtration systems for industrial and consumer applications. With their energy-efficient solutions, Freudenberg Filtration Technologies helps customers to conserve resources, reduce CO₂ emissions, drive down costs and gain competitive advantage.

Viledon® Water Solutions: the leading specialist in water and wastewater reuse

Viledon® Water Solutions is a well-known provider of water treatment and wastewater filtration systems for industrial applications. Whether you are considering a new build or upgrading an existing plant. Central to this success is the Viledon® 'process led' approach to all aspects of water and wastewater treatment. This ensures that the most appropriate technology is identified for each unique application.

Our full range of services includes:

- Pilot plant trials
- Process evaluation and analysis
- Initial project inception and design
- Turnkey construction, commissioning, maintenance and after-sales support



Aerobic membrane bioreactors (AMBR™ / AMBR LE™)

Advanced MBRs for exceptional treatment quality



Viledon® crossflow membrane bioreactors (MBRs), using tubular ultrafiltration membranes, are the most compact and cost-effective MBR systems available. By developing two types of crossflow-based technologies, Viledon® Water Solutions can offer you the most suitable alternative for

your particular circumstances. All our MBR plants have 'true' ultrafiltration membranes mounted outside of the bioreactor in dry, easily accessible conditions. No moving or critical parts immersed in the biomass means hygienic operation and ease of maintenance.

AMBR™

Uses high crossflow to achieve high flux rates. Plants are lower in capital cost and extremely compact with very low membrane area and reduced membrane replacement costs. The bioreactor can be operated at high biomass suspended solids concentrations (MLSS = mixed liquor suspended solids). The technology is aimed at lower flow and higher strength industrial wastewaters. The membrane banks are operated automatically, based on the level in the bioreactor, meaning that they are used on demand to match the inlet flow. When not required, individual membrane banks are automatically shutdown, auto-flushed to remove biomass and to await re-start, thus saving energy when the plant is not running at full design. AMBR™ plants are modular and can be containerized.

AMBR LE™

Employs intermittent backflushing and management of transmembrane pressure (TMP) to control fouling, enabling a reduction in crossflow velocity and a significant saving in energy. AMBR LE™ is aimed at medium to high flow and low to high strength industrial and municipal wastewaters. Variable speed recirculation pumps enable a variable flux rate that is used to optimize energy use relative to the plant load. Plants remain very compact, with low membrane area and optimal membrane replacement costs. Operation is directly linked to the liquid 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.

Simplicity of operation

Continuous in-house development of automation and control systems leads to simple operation for our clients using proprietary software. Real-time monitoring of our plants using internet links is a standard feature. All plants feature automatic operation, including flushing, backflushing, cleaning, start up and shutdown on demand.

Applications

- Secondary wastewater treatment to sewer or surface water
- Wastewater reuse
 - Non-potable for washing, irrigation etc.
 - Potable/ demineralized – with post treatment using nanofiltration or reverse osmosis and optional UV disinfection or chlorine dioxide dosing
- Nutrient removal, nitrification and denitrification
- Tertiary MBR polishing



Advantages

- High flux and MLSS = reduced footprint and lower capital cost
- CAPEX to OPEX balance is optimized
- Lower cost of membrane replacement due to fully automatic operation, including flushing, backflushing, cleaning, start up and shutdown on demand
- Reduced maintenance and higher aeration capacity due to external crossflow membrane system
- Can be easily retrofitted to existing systems
- Can be supplied as modular / containerized systems
- Can be used with supplementary pure oxygen

	MBR Type	Normal operating MLSS range (gTSS/l)	Sustainable normalized flux, litres/m ² /h (lmh)	Energy use on biomass separation, kWh/m ³ permeate produced	Energy management, membrane area & replacement
Viledon® Systems	AMBR™ 'Dry', out of tank	10 to 25 (air) > 25 if pure oxygen enhanced	80 to 250	1.8 to 3.5	Yes But limited to automatic flushing and shutdown on low / no flow. High flux means less capital cost, installed membrane area and replacement costs.
	AMBR LE™ 'Dry', out of tank	10 to 18 (air) > 25 if pure oxygen enhanced	40 to 120	0.25 to 0.7 Higher energy is temporary only for extreme peak hydraulic conditions (which cannot be dealt with using air flush/lift or submerged membrane systems)	Yes Permeate flow is automatically regulated and banks can still be automatically shut down on low / no flow. Peaking capability means significantly reduced installed membrane area and replacement costs compared to other 'low energy' technologies.
Other MBRs	Air flush/lift crossflow 'Dry', out of tank	8 to 15	25 to 60	0.25 to 0.7	Yes But limited to automatic flushing and shutdown on low / no flow. No significant peaking capability meaning more membrane area than AMBR™ and AMBR LE™ is required.
	Submerged HF / flat sheet	8 to 15	8 to 25	0.5 to 1.5 Field experience in various industrial applications	No Membranes submerged in biomass and must be regularly 'scoured'. Energy > 1.5 kWh/m ³ during flow / no flow. Low flux means very large membrane area is required.

Anaerobic membrane bioreactors (AnMBR LE™)

Innovative anaerobic treatment for energy recovery with high-quality output



Applications

- Food and beverage
- Palm oil industry
- Dairies
- Breweries
- Distilleries
- Pulp and paper
- Biofuels
- Chemical

Anaerobic digestion is a process which harnesses natural bacteria to treat biodegradable materials in the absence of oxygen, producing a methane rich biogas which can be captured and used to generate electricity and provide a source of heat. Viledon® Water Solutions combines an-

aerobic pretreatment with its AMBR LE™ and tertiary technologies to provide cost effective answers to treatment and reuse of highly loaded industrial wastewaters. In the food & beverage, paper, biofuels and chemical industries organic loads are often very high. In such cases it may

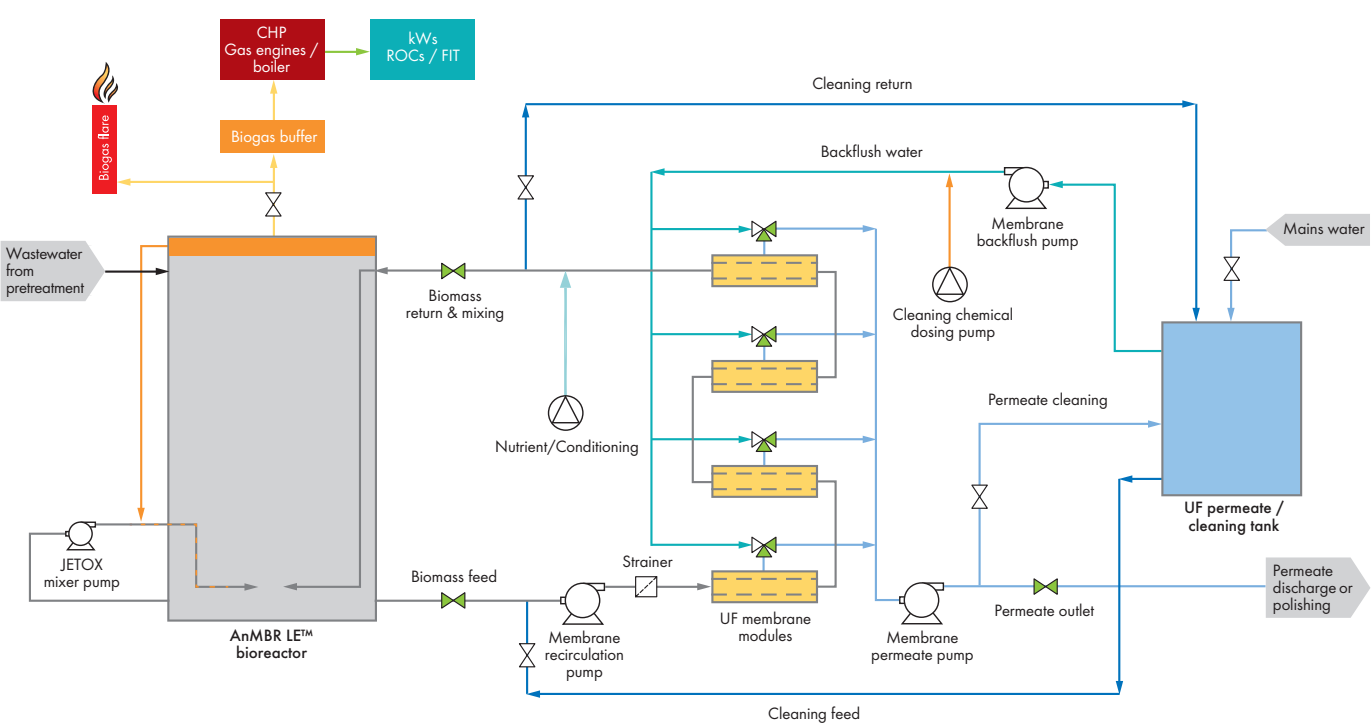
become cost effective to pretreat wastewater using a bespoke high rate anaerobic stage to reduce overall energy and waste biomass production. Capital costs are higher but operational costs can be reduced. If biogas is utilized, and water reused, then the return on capital can be very attractive.

Advantages

- High percentage of COD reduction and high biogas yield ($\text{Nm}^3/\text{kg COD}$)
- High quality final effluent and TSS free = simplified tertiary treatment
- Uncouples the hydraulic and biosolids retention time (SRT)
- Complete biosolids retention and control of a longer sludge age
- TSS free and effluent rich in nutrients available for irrigation reuse
- Much greater tolerance of TSS and fats, oil and grease in the influent
- Low-energy biomass separation, with no flocculants / coagulants required
- Completely enclosed pumped sidestream
- The external recirculation membrane loop is not exposed to the atmosphere / air
- No gas (e.g. methane) scouring is required on the membranes
- Infrequent cleaning and 'in loop' cleaning of membranes
- Reduced maintenance due to external crossflow membrane system



Figure: Example illustration of a complete anaerobic membrane bioreactor system



JETOX™ and slot aeration

Cost-effective and energy-efficient wastewater treatment



In industrial wastewater and biosolids aeration applications, jet and slot technology provides superior actual oxygen transfer efficiencies when compared to other aeration technologies. Continuous surface renewal at

the gas/liquid interface results in high alpha factors, giving enhanced process performance in the presence of surfactants, extra cellular enzymes and high mixed-liquor suspended solids (MLSS) concentrations.

Jet aerators

Jet aerators introduce high levels of kinetic energy of both liquid and air through a series of nozzles. Liquid is delivered at high velocity through an inner, primary jet and is then immediately and rapidly mixed with air in an outer jet chamber. Intense mixing and turbulence at this gas/liquid interface results in a plume that disperses rapidly across the tank floor.

Gradually, the gas bubble column rises towards the liquid surface and enhances mixing within the reactor.

Advantages

- Very low maintenance, with long-term reliable operation
- No biofouling or deterioration in performance over time
- Low installation costs
- High shear for improved efficiency in MBR biomass, i. e. when sludge viscosities are higher
- Alpha factor advantages are evident, particularly in industrial wastewater rich streams
- Dry pump installation
- Deep tank operation, saving space
- Oxygen retrofit possible
- Separate control of mixing and aeration
- SBR/ Batch, MBR and denitrification options
- Flexible and versatile, easily configured into any tank geometry

Slot injector

The slot injector is dimensionally similar to a modern jet aerator, but uses a slot-shaped configuration to achieve higher efficiencies. Like conventional jet aerator, slot injectors are two-phase gas/liquid contactors, but are differentiated by the shape and performance characteristics of the slot-shaped propulsion jet (inner nozzle) and mixing chamber (outer air/liquid nozzle).

Advantages

The slot injector is a lower liquid flow, high-pressure aerator. Although the solid passage is more limited, it has some notable advantages over conventional jet aeration technology:

- 50% – 60% reduction in liquid flow results in smaller and/or fewer pumps, as well as significant reductions in the size of liquid piping/valves and fittings inside and outside the tank. This provides capital savings.
- The higher system pressure means more efficient pump performance.
- Increased velocity of the jet plume means lower-pressure blowers.
- The higher-pressure pumping system lends itself to optimizing aeration system performance by varying both the pump and blower flow. Two-phase flow control allows for maintaining optimum gas/liquid ratios. This results in optimal energy efficiency over a wide band of operating conditions.

Differences between jet aerators and slot injectors

- The slot-shaped mixing chamber offers a greater contact or 'shear' surface area than a circular jet unit of identical area.
- The transition within the chamber from circle to slot, without any reduction in flow area, allows for the gas/liquid plume to retain more of its kinetic energy as it is discharged into the surrounding bulk liquid. This results in more effective gas dissolution.
- The operating characteristics of the slot injector are similar to those of an ejector or eductor. This means that within the propulsion jet chamber, there is a zone of extreme negative pressure-enhancing gas entrainment, as well as a defined mixing chamber with a characteristic pressure recovery zone. The result is a device that can dissolve large quantities of gas with significantly less liquid throughput.



Containerized wastewater treatment

Our compact, flexible and modular solution



Viledon® Water Solutions designs and builds turnkey containerized and modular membrane bioreactor plants. Containerizing key elements of the wastewater treatment system illustrates the modular design capability of Viledon® Water Solutions advanced membrane bioreactor technology.

Viledon® Water Solutions has designed and built complete plants to treat up to 600 m³/day of wastewater. We complete systems include pH control and ASTRASEPARATOR® lamella, proprietary JETOX™ aeration and mixing technology in the bioreactor, which can operate at mixed liquor levels in excess of 15,000 mg/l. The external AMBR™ crossflow ultrafiltration

biomass separation in such systems include containerized banks of membrane modules which are fully automated for start /stop, flushing and cleaning. A reverse osmosis treatment can be added upon request. The system design enables remote monitoring and operation in 'real time' from Viledon® offices if requested.

The high performance is achieved primarily by the biological treatment carried out in the AMBR™ plant. However, the pre-treatment provides pH correction, primary removal of solids and oily material to protect the downstream biological process.



AquaBiosep™ lamella separation

Cost-effective solid separation for wastewater, biomass, washwater, surface water and process water



AquaBiosep™ can be used for a variety of solid / liquid separation situations in process industries, water and wastewater treatment. The main benefit is a huge area saving of between 4 – 10 times the normal footprint when compared to conventional settlement methods. Correct selection of the type and size of a system requires accurate input data combined with know-how and experience of coagulation, flocculation and settling technology. Viledon® Water Solutions has the knowledge to design a system to suit your

needs, based upon a wide variety of full-scale references, pilot research and engineering capabilities. Viledon® designs standard units using approved materials that can be incorporated in standalone tanks (existing or new) as single or multiple units. For larger capacities, modules can be mounted into bespoke concrete basins provided by Viledon® Water Solutions, or constructed by a third party based on our technical guidelines.

Operation

The flow enters the module at the lower end of the plates. While the feed water is flowing upwards, in between the plates to the top of the unit, the sludge is settling on the plates, sliding downwards and is released at the bottom. To prevent any interference between the settling sludge and the feed water, a minimum free space of 0.7 m is required below the base of the unit. The treated water is released at the top of the unit via a discharge launder equipped with orifices to create homogeneous release over the full length. Optimum system configuration is determined on the basis of feed flow rate, solids concentration and density, settling rate, sludge volume and required treated water quality. In some cases, dedicated settling tests can be carried out to confirm the design.

Advantages

- Reduced space requirements
- Reduced installation costs
- Lower maintenance: virtually no wear and tear
- Improved efficiency, no short-circuiting and no wind influences

Applications

- Settlement of organic and inorganic solids
- Washwater treatment in drinking and process water treatment plants
- Settlement of surface and ground water for production and recycling plants
- Starch separation and recovery

AquaBiofilter™ tertiary (bio) filtration

For continuous removal of nitrogen (nitrification and denitrification), phosphate and tertiary solids

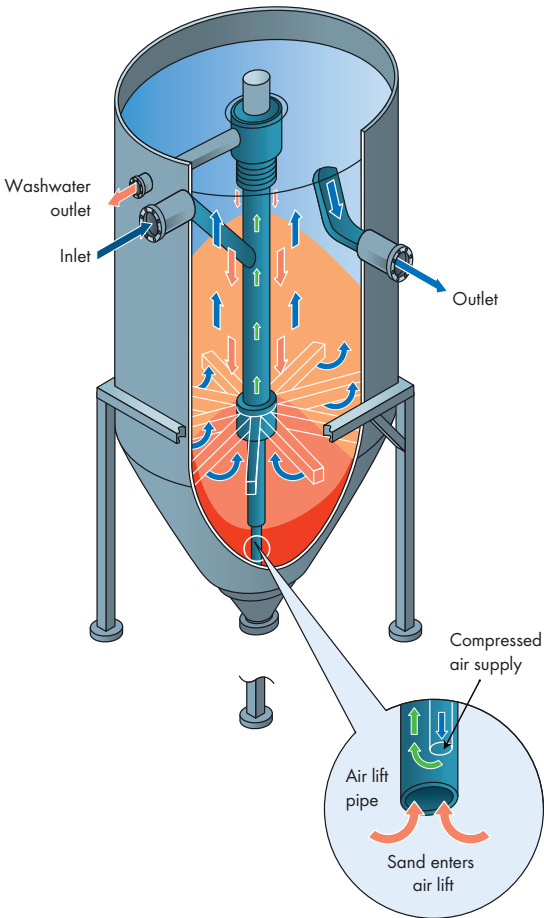
AquaBiofilter™ is a mode of continuously moving bed (bio) filtration with uninterrupted operation. The filter medium is continuously cleaned while the filter is in operation, guaranteeing constant process availability.

Operation

Feed water is introduced in the lower part of the filter and flows upwards through the sand bed. Filtrate is then discharged by gravity at the top. Solids are retained with the sand, which moves downwards towards the air lift. In biological applications, biomass forms on the sand surface which converts the organic components. Sand is continuously drawn into the airlift at the base of the filter cone and transported vertically upwards towards the sand washer at the top of the filter. Sand is washed continuously using a small volume of filtrate. If required, i.e. for nitrification, air is injected into the filter bed to create oxic conditions for biomass growth.

Advantages

- Continuous operation without any downtime
- Physical-chemical and biological treatment in one process unit
- No washwater storage or backwash pumps are required
- Continuous circulation means the entire sand bed is used for the process
- Steel and concrete tank construction is possible
- Compact installation with a low footprint
- Low operation and maintenance costs with minimal labour
- No pre-treatment is usually required
- High-efficiency laser cut aeration grid for nitrification applications
- Low- and high-pressure air options available for nitrification
- Biological treatment can be retrofitted to existing filters



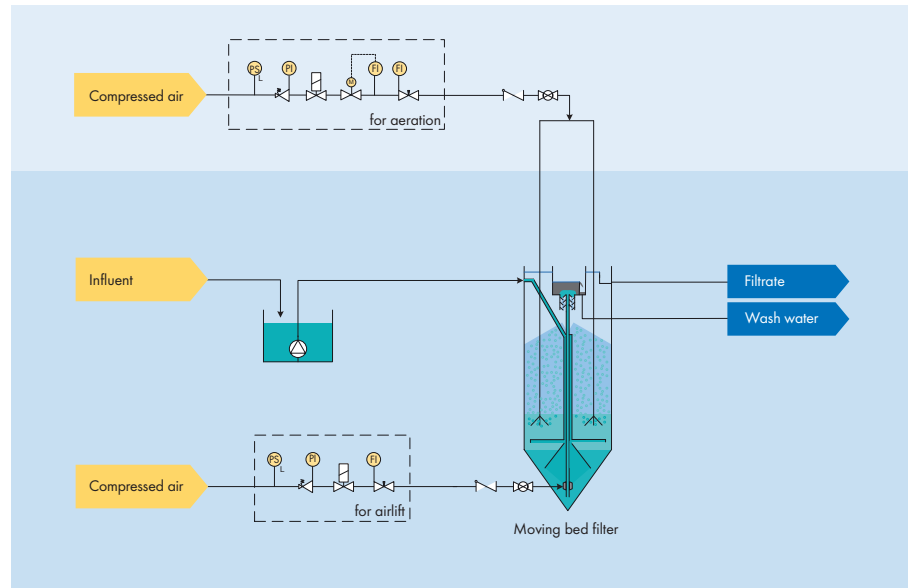
Applications
<ul style="list-style-type: none">Wastewater<ul style="list-style-type: none">Biological nitrificationBiological denitrificationSuspended solids (TSS) removalBOD removalPhosphorus removalSide stream filtration of cooling waterProcess water / drinking waterGroundwater (bio) filtrationSurface water (direct) filtration

Process	Component to be removed	Typical concentration (mg/l)	
		In	Out
Biological nitrification / BOD removal	NH ₄ ⁺ -N	5 – 20	1 – 5
	BOD	10 – 40	5 – 15
Biological denitrification	NOX-N	10 – 50	0 – 5
		5 – 10	0 – 1
Removal	PO ₄ -P	5 – 10	1 – 2
		1 – 2	0.1 – 0.2
Suspended solids removal	TSS	40 – 200	10 – 50
		10 – 40	1 – 10

Biological nitrification

For meeting stringent ammonia criteria using autotrophic bacteria.

- **Typical design loading rates**
0.5 kg to 0.7 kg N/(m³/d)
- **Oxygen demand**
4.6 mg O₂/mg N
- **Biomass production**
0.10 to 0.15 mgMLSS/mg N removed
- **Water temperature**
> 5 °C
- **Hydraulic loading rate**
5 to 15 m³/(m²/h) or m/h

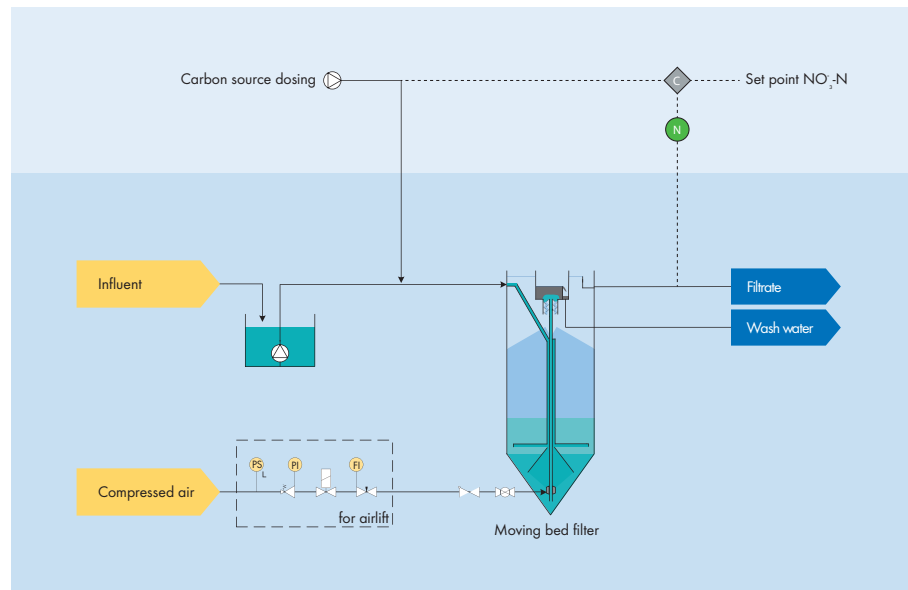


Under oxic (aerobic) conditions, bacteria attached to the sand grains are used to convert ammonia into nitrate.

Biological denitrification

For meeting stringent nitrate criteria using heterotrophic bacteria.

- **Typical design loading rates**
2 kg to 3 kg N/(m³/d)
- **Biomass production**
0.7 to 1.3 mgMLSS/mg N removed
- **Water temperature**
5 to 20 °C
- **Hydraulic loading rate**
8 to 20 m³/(m²/h) or m/h
- **Carbon source required**
methanol, ethanol, acetic acid
- **Consumption**
2.5 to 3.0 mg CH₃OH/mg N



Under anoxic conditions, bacteria attached to the sand grains use nitrate and nitrite to convert a substrate (a carbon source) into nitrogen gas as part of the dissimilation process.

Control and electrical

Always first choice



Capabilities

- Single door and modular MCCs
- Installation and site wiring
- Control system design and development
- Maintenance and servicing
- Automated solutions
- Ethernet, PROFIBUS, ASI and proprietary networks
- Internet remote access and control
- Electro-pneumatic automation
- After-sales support and service

Viledon® Water Solutions provides:

- Standard and custom-built control panels
- Electrical wiring and distribution systems
- Software development and testing

Viledon® supplies a wide range of electrical panels, from small distribution boards through to large Motor Control Centers (MCCs).

Whether OEM or end-user, we offer a solution that integrates the latest technology with superior engineering. Production is carefully monitored to ensure that customer specifications and time-scales are met. Our in-house testing facility also allows all our panels to be rigorously checked and dry-commissioned prior to leaving our works.

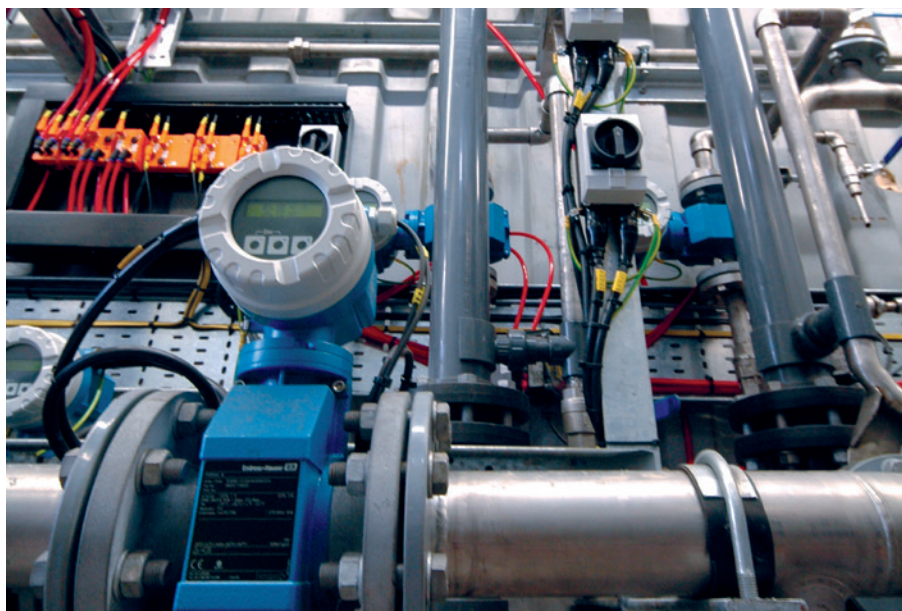
Our customer-centered approach ensures that quality workmanship is combined with competitive pricing and a professional and personal service.

Customer commitment

Commitment to customer service brings quality and excellence to our products. Our technicians, supervisors and managers are qualified and trained to provide off- and on-site testing, inspection and the highest health and safety standards. We offer a responsive and efficient service to ensure our scope of supply is delivered on time and to budgetary targets. Whether a new build or upgrading existing infrastructure, we work with our customers to meet the specific project needs and objectives.

Laboratory testing and pilot plant trials

Cost-effective and energy-efficient wastewater treatment



Viledon® Water Solutions provides laboratory and bench scale testing, including a full analysis service.

Transportable and containerized pilot plants are available for in situ trials of Viledon® processes, including:

- Membrane bioreactors
- Nanofiltration and reverse osmosis
- Jet aeration
- Filtration and separation

Trials enable optimization of treatment under variable flow and load conditions. Treatment efficiency and operational costs can be assessed along with upscaling to full-scale plant design and budgetary targets.

After-sales service and support

A comprehensive service you can rely on



Viledon® provides comprehensive after-sales service contracts, ensuring reliable and effective plant support and after-sales service.

All plant and equipment needs to be maintained and serviced to ensure the most efficient and effective operating performance. Regular servicing by an Viledon® engineer is a cost-effective means of achieving this, as well as increasing the lifetime of your valuable asset.

Service intervals can be weekly, monthly, quarterly or annually, as you prefer.

Typical service contracts may include:

- Review of current equipment
- Remote performance monitoring and review of data trends
- Identification and recommendation for rectification of any issues
- Membrane system cleaning (remotely, or on-site)
- Instrument checks and recalibration
- Taking samples and provision of cost-effective, in-house analysis
- Review of recommended spares and consumables
- Written report on inspection visits and recommended actions
- Supplementary training for new and operation staff after plant startup and optimization

In addition to our standard service contracts, we are also able to provide various other client-specific service agreements to meet individual requirements.



Remote plant monitoring

To ensure consistently high-quality treated water, it is essential to monitor plant performance and output on an ongoing basis. Viledon® treatment plants are designed with this in mind and all plants can now be monitored and even controlled remotely.

All our systems use software that is designed and written in-house with specific customer requirements in mind.

We can provide remote supervision to ensure that plant operation can be securely monitored and reviewed by Viledon® via the internet. This service allows us to observe the complete treatment process on a regular basis and enables us to provide ongoing upgrades and effectively maintain high-quality water output.



Benefits of remote online monitoring

Improved productivity and knowledge

Maintains high-quality water output, assisting your staff and saving time, improving productivity and efficiency.

Enhanced knowledge

Your business receives the benefit of our extensive and valuable operational knowledge.

Early warning

Remote monitoring can identify process and quality changes at an early stage so that remedial action can be taken to improve operating efficiency.

Changing requirements

Should your feed characteristics change, the plant can be adjusted remotely for optimal operation with immediate online data and feedback.

Cost savings

All of these benefits mean less down-time, increased plant and staff productivity, resulting in reduced operating costs and enhanced profitability.

Should you require further information in relation to our remote monitoring systems and service, please do not hesitate to contact us.

7 compelling facts that show how you benefit from Viledon® Water Solutions

1 No. 1 in water reuse

Market 'firsts' for recycling wastewater, notably in the food, beverage and chemical industries.

2 Extensive experience

Established client base and reputation with major blue-chip customers in a number of industries, as well as municipal water authorities.

3 In-house technologies

The breadth of our technologies enables us to address most wastewater and water reuse challenges.

4 Very strong knowledge base

Our in-house team includes skilled process, technical, design and project management staff.

5 High level of commitment

We have a comprehensive product offering, including commissioning and servicing of plants (often with remote/mobile access).

6 Remarkable record

Excellent health, safety and quality record as both main contractor and sub-contractor.

7 Global network

More than 30 locations worldwide.



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