- ORAL PRESENTATION -

MEMBRANE-BIO-REACTORS: A FUTURE TECHNOLOGY FOR WASTE WATER TREATMENT PLANTS

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ABSTRACT

In the quest for efficient and economical water use and the optimization of land footprint needed in water production, membrane bioreactors (MBR) are leading the way.
In this article, we look at how the membranes in a MBR work, and show some construction developments in this sector of water industry. Secondly the article discusses a completely new and extremely environmentally friendly module cleaning technology. This technology has meanwhile been successfully tested in different pilot units for example in cooperation with Darmstadt University of Technology.

KEYWORDS: Membrane bio reactor, MBR, module construction, membrane cleaning

COMPANY MICRODYN-NADIR

MICRODYN-NADIR GmbH with locations in Europe, Asia and USA is the leading independent manufacturer of micro, ultra and nanofiltration membranes and modules.

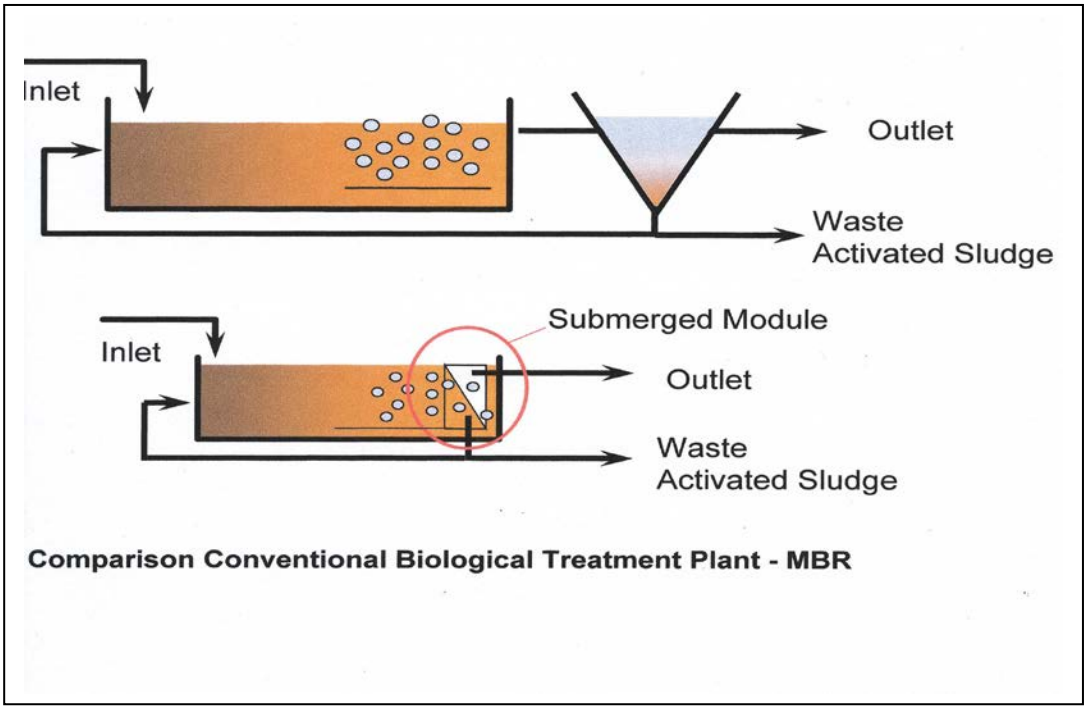
This is and will be our core competence now and in the future, therefore we pursue very intensive research and development activities at our Head Quarter in Wiesbaden Germany.
For over 45 years now, our products are utilized in many varied industrial and municipal applications, among others in the field of water and wastewater treatment, but also in many process-integrated applications.
Our products' outstanding sharp cut-offs and reproducibility allows a high application variety in the most difficult industrial uses. One of our most innovative products is the immersed BIO-CEL module for membrane bioreactors. Our precondition for this development was:

- MICRODYN-NADIR has long-term experience in development and production of membranes for waste water application

- Since years leading companies are successful using NADIR®-membranes in MBR applications
- The high performance of the NADIR®- membranes is repeated confirmed in numerous plants
- MICRODYN- NADIR as supplier for all kinds of membrane modules knows exactly about of advantages and disadvantages of hollow-fiber and flat sheet submerged systems.

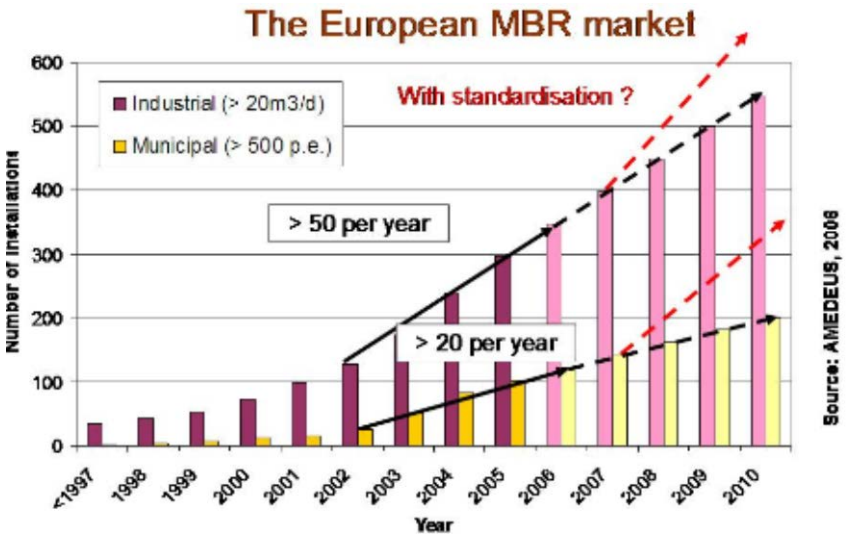
Reasons for MBR and Market development

Membrane bioreactors (MBR) combine classic biological wastewater treatment with membrane technology. The biomass is separated from the cleaned wastewater by means of membranes (usually ultra or micro-filtration). The great advantage of this method is that the membrane acts as a barrier to biomass, particles and bacteria, leading to a substantial improvement in effluent quality compared to conventional, purely biological techniques – in terms of solids and hygienic parameters. The unification of biological and membrane technology to treat wastewater additionally increases the concentration of biomass in the activated sludge tank. It is thus possible to augment the capacity of a traditional activated sludge plant by converting it accordingly. Or it is possible to reduce the footprint of a new plant, in which case a further space saving is realised, because the final sedimentation stage can be dispensed with.



Picture 1: Comparision Conventional Biological Treatment Plant - MBR

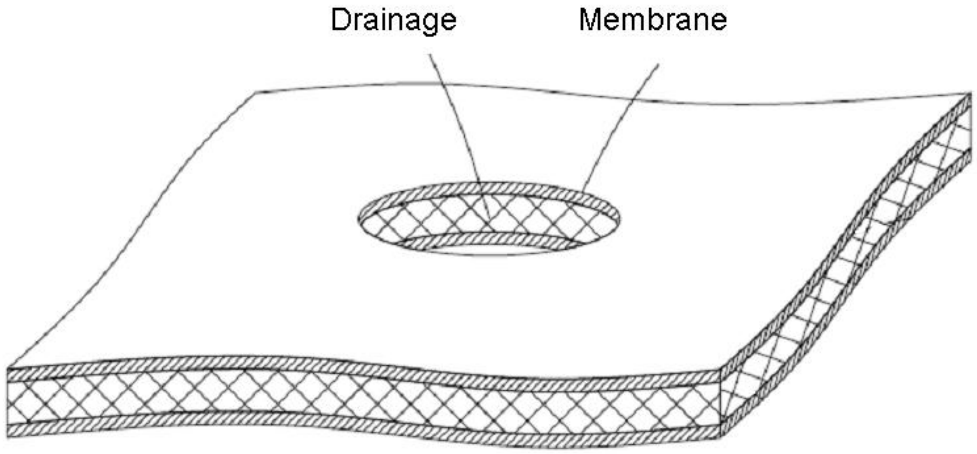
Since the discharge from an MBR plant is absolutely free of solids, this innovative solution is ideally suited for supplementary treatment steps with reverse osmosis or nano-filtration as well as UV or ozone.
Because of these fantastic application possibilities it is not a big surprise that MBR market is growing:



Graph 1: European MBR market, source: Amadeus report 2008

Advantages of BIO-CEL® module

Patented BIO-CEL® module combines the advantages of capillary and plate modules in one type of submerged membrane module. The key is to sandwich two membranes around a spacer material, creating a plate module without a plate. The edges are welded and the filtrate is extracted though a hole in the middle, which keeps pressure drops to a minimum. A series of these individual membrane bags are joined vertically to form a module.



Picture 2: Construction of a BIO-CEL® membrane

The BIO-CEL® module does not suffer from braiding, because it uses flat membranes, or silting, because the module is open at the buttom. Frameless fixing of the membranes means no edge blocking. Since the membrane bags are flexible, internal tension is not a problem, and the gaps between the membranes do not become blocked. The absence of plates allows a higher packing density. Bio-Cel modules can also be backwashed, and due to the better hydraulic conditions this works considerably better than it does with capillary membranes.

First membranes and modules were installed in 2005. Since the beginning of 2008, Bio-Cel modules are also available in cassettes, making the system even easier to install and service. Particularly in large plants, the ability to separate the aeration and membrane systems is a big step forward. The latest version, the BIO-CEL® BC 400 cassette system, was introduced to market in May 2008. This new module is designed especially for large plants and has a membrane area of 400 m². Its high packing density, comparable to that from capillary modules, makes the BC 400 ideal for plants handling large volumes in small areas.

Picture 3: BioCel® BC with membrane cassettes and base frame including Air-Scour system

Cleaning is still essential

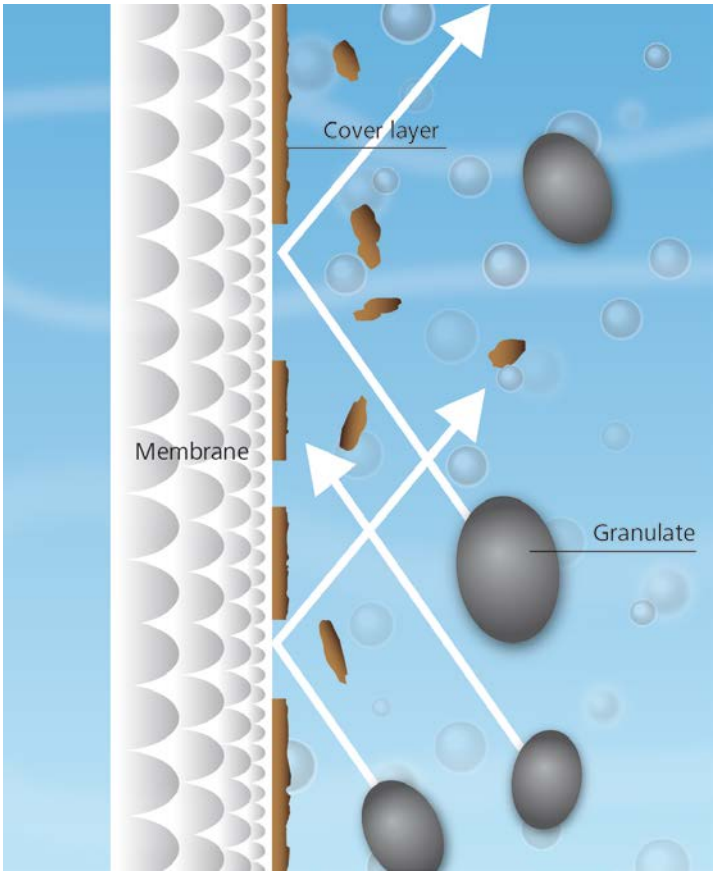
MICRODYN-NADIR's BIO-CEL® module only requires simple pre-treatment of the feed flow and allows extended operation times between cleaning cycles. However, even with this novel development, chemicals still cannot be completely dispensed with for intensive cleaning.

The reason for cleaning the membrane modules in an MBR plant is to remove the deposits from the membrane which reduce its permeability during operation. A distinction is made between scaling and fouling. Scaling refers to inorganic deposits, usually calcium carbonate or ferric salts, which have to be removed by cleaning with acids. The acids normally used for this purpose are mainly organic, for example citric, formic or acetic acid, and they are unobjectionable from an environmental viewpoint because the spent cleaning solutions can be disposed of without any problems directly with the help from the membrane biology. Fouling, on the other hand, is caused by organic deposits, why it is often also called biofouling. Fouling can be eliminated with oxidants like hydrogen peroxide or sodium hypochlorite (NaOCl). Chlorine has become established as the norm for removing fouling in MBR plants due to its excellent cleaning efficiency. Unfortunately, it has the drawback that the concentrations in which it is used – up to 2000 mg/l in some cases – result in the formation of large quantities of AOX compounds. AOX is a sum parameter for so-called „adsorbable organic halogen" compounds, which are classified as environmentally harmful substances on account of their eco toxicity. Although MBR technology is in principle a very eco-friendly process as far as membrane cleaning is concerned, it does have this important ecological disadvantage.

Chemical-free process

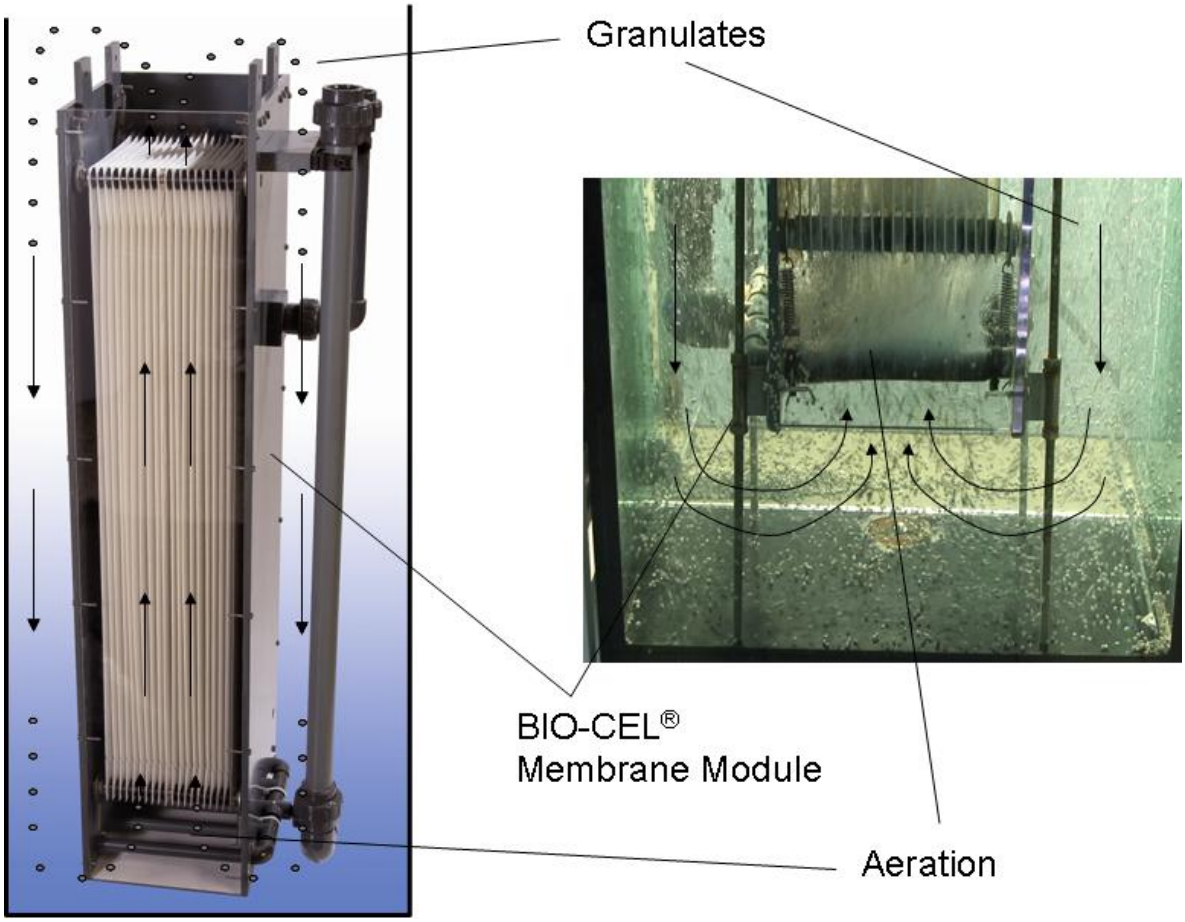
To overcome that weakness a development was started to determine the BIO-CEL® module's suitability for chemical free cleaning in activated sludge, bearing in mind that the permeability of the membrane must not be impaired. Previous trials had already confirmed that the module can remain in use for over a year without intensive cleaning (i. e. cleaning the BIO-CEL® in a chemical bath). Chemical back-flushing in an activated sludge tank suffices. However, the new study revealed that permeability is lost despite back-flushing with chemicals and that intensive cleaning is unavoidable sooner or later.

The starting premise for this investigation into chemical-free cleaning of BIO-CEL® modules was the idea that, using mechanical beans, incipient deposits on the membrane can be prevented from forming deposits or deposits that are already present are continuously removed. The plastic granulate used for this purpose needs to flow upward between the membrane pockets with the aeration that is essential to operate the modules, in order to produce the mechanical cleaning action.



Picture 5: principle of BIO-CEL® MCP

The granulate density has to be such, that it is slightly heavier than the activated sludge and therefore able to settle outside the module, but not so heavy that it cannot be whirled up again and conveyed up to the top by the aeration underneath the module.

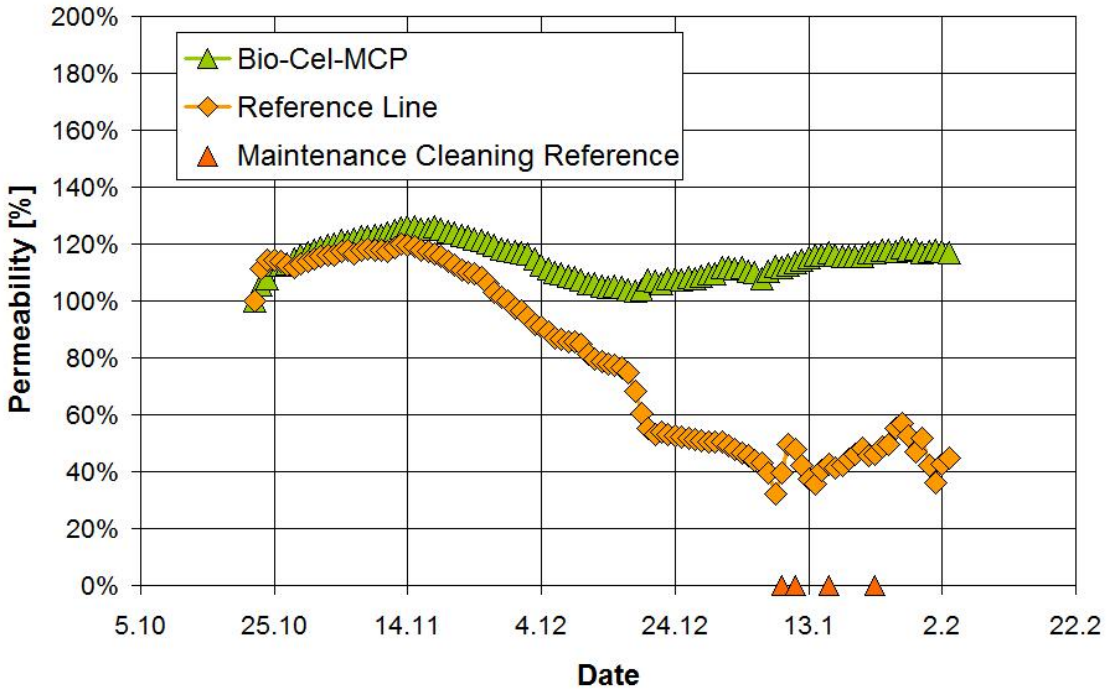


Picture 6: Path taken by granulate through the BIO-CEL® module: deposits on the membranes are continuously removed by mechanical beans

Action of the granulate

Two BIO-CEL® modules, each with a membrane area of 10 m², were installed in two parallel filtration chambers on a pilot plant scale (under identical conditions). One BIO-CEL® module based on a back-flushable flat sheet membrane module (reference) was operated conventionally in activated sludge without adding granulate, while the other (granulate) was required to clean a mixture of sludge and granulate (BIO-CEL®-MCP = mechanical cleaning process). Both modules were set to a flux of 15 l/m² h for the first three months. After around seventy days in service, the permeability of the reference module had fallen to approximately 40 % of the initial value whereas the MCP module had not yet lost any of its permeability. The module without granulate was then maintained at a constant permeability by introducing intermediate cleaning (back-flushing with NaOCl). In the next trial phase, the flux of the module with granulate (MCP) was increased to 40 l/m² h. This high flux was what eventually triggered a reduction in permeability. The rate was then kept constant at 30 l/m²

h for a period of several weeks. The BIO-CEL® - MCP module has been cleaning without chemicals throughout the trial (500 days so far and still continuing). The results for the two modules are directly compared in the table.
In a follow-up test, granulate was also added to the activated sludge in the reference module. After only seven days, this BIO-CEL® module had likewise regained its original permeability. This shows that even subsequent cleaning with granulate has the desired effect on the modules.



Graph 2: Comparison of two modules at a flux of 15 l/m² h: after around seventy days in service, the permeability of the reference module has fallen to approximately 40 % of the initial value.

Applications with BIO-CEL® Modules

Meanwhile you will find BIO-CEL® modules in waste water treatment plants of:

- Municipal
- Beverage bottler
- Military training area
- Hotel
- Brewery
- Fish faring
- Food production

- Chemical industry
- Fermentation plant
- Chicken slaughterhouse
- Pharmaceutical industry
- Milk factory
- on ships
- .....

CONCLUSIONS

Several years of experience in wastewater treatment plants around the world have proved the success of MBR technology based on submerged modules. However, this experience has also shown a need for improvement in module construction to overcome operational problems like silting, braiding, and edge and gap blocking. Additionally this experience has shown a need for improvement the chemical cleaning of membrane, especially the problems with AOX compounds in waste water. The article shows the advantages of BIO-CEL® module construction from Microdyn-Nadir. The module combines the advantages of existing capillary and plate systems, without their disadvantages, by using a patented flexible membrane bag. The study findings, concerning mechanical cleaning, demonstrate that the BIO-CEL® module can be cleaned mechanically by adding granulate to the activated sludge. In other words chemical-free cleaning is possible and problems with AOX compounds will become a thing of past.
At least the article explain advantages of BIO-CEL® module and shows that this module type is able to fulfill extreme requirements of waste water treatment plants.

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