Membrane bioreactor (MBR) for landfill leachate, industrial wastewater and municipal wastewater purification

TDL ENERGIE | WATER TREATMENT | LANDFILL GAS | REFERENCES | SERVICE

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Basic principle

The principle of the membrane bioreactor from TDL Energie GmbH is similar to that of a purification plant in that it entails a combination of biological wastewater purification with bacteria in a bioreactor, and subsequent filtration to separate the sludge from the treated water. However, this filtration process does not take place in a high-capacity settling basin, but rather is performed with state-of-the-art, compact membrane filtration units.

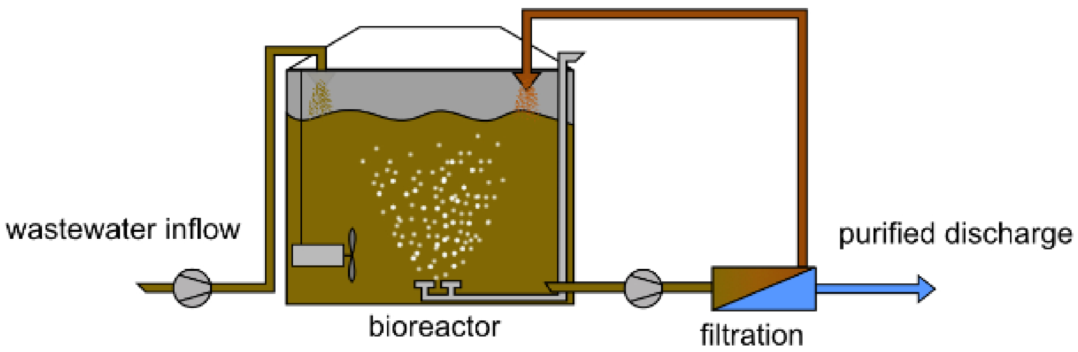


Fig. 1: Schematic depiction of an MBR system.

Advantages of MBR technology

Due to its structure, an MBR system had the following advantages over traditional plant technology:

1. **Higher throughput and breakdown capacity, as membrane filtration achieves an exponentially higher concentration of the bacteria mass (factor 3 to 4).**
2. **Reduced space requirements and smaller container volumes (up to 50%) due to higher bacteria concentration.**
3. **Reserve of microplastics and pathogens, e.g. multi-resistant germs and viruses.**
4. **Less sludge waste due to the reduced production of excess sludge achieved through mineralisation.**

Combined with downstream activated carbon adsorption, a membrane bioreactor is the only technology that generates residue-free wastewater that is free of bacteria, viruses, non-biodegradable organic contaminants, microplastics or trace substances (e.g. medication residue, pesticides or X-ray contrast media.

Thanks to its high breakdown output, an MBR system is suitable for a variety of complex wastewaters, from landfill leachate and wastewater from the food, textile and paper industries, to municipal purification plants.

Existing traditional, biological purification plants can quickly transition to an MBR system via the installation of a membrane plant.

Description of the process

1. Biological purification stage

The bacteria in the biological purification stage of a membrane bioreactor perform two important tasks in the treatment of complex and heavily contaminated wastewater, e.g. landfill leachate:

1. The breakdown of the nitrogen compounds in the wastewater, in particular ammonium compounds (NH_4^+) and
2. the removal of all biodegradable organic components.

The first step in the process can take place over two stages in an MBR system, namely denitrification and nitrification. The denitrification reactor converts nitrate (NO_3^-) into gaseous and non-toxic nitrogen, which can leak from the container. As this reaction can only take place when enough components containing carbon are present, an external source of carbon may have to be applied in individual instances.

The water, now heavily loaded with ammonium and residual carbon, is transferred to the next stage (nitrification), for which the bacteria require nitrogen. Along with the breakdown of the organic material into water (H_2O) and carbon dioxide (CO_2) this step primarily involves the oxidation of the ammoniacal nitrogen into nitrate. The nitrate is then pumped back into denitrification, with the activated sludge, where it is eliminated by the formation of nitrogen.

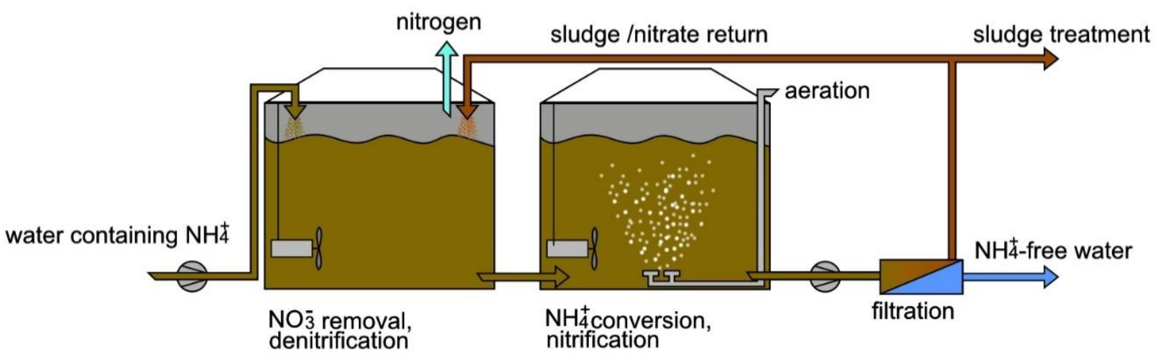


Fig. 2: Process chart of the biological denitrification and nitrification for breaking down nitrogen.

Here, too, there is a positive synergy effect in the upstream denitrification: due to the low carbon content, the nitrification bacteria require less oxygen, which reduces the energy costs of this step in the process.

As not all wastewater is the same, the concept of the membrane bioreactor can be exclusively adapted to suit the location because of its modular design.

2. Membrane filtration

Because the activated sludge begins to grow as a result of the high nitrogen supply, some of this excess sludge must regularly be removed from the system and fed into sludge treatment. For years, TDL Energie GmbH has used the proven ultrafiltration method to separate the sludge.

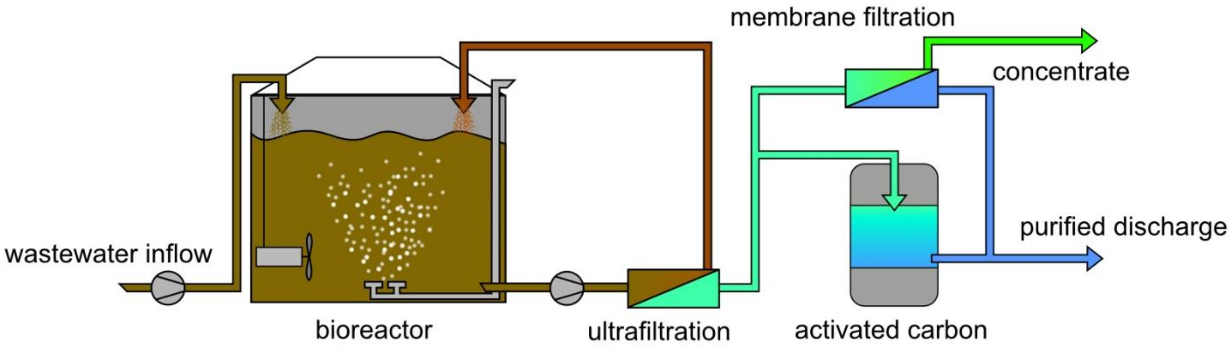


Fig. 3: Process combinations for further preparation of the MBR process, e.g. through nanofiltration or activated carbon adsorption.

Ultrafiltration is a physical separation process in which the wastewater flow, containing sludge, is fed through a porous membrane surface so that water components can be filtered out to a specific maximum size. Compared to conventional settling basins, this ensures complete reservation of the biomass, which increases bacteria concentration. At the same time, the reservation creates an optimal adjustment of the micro-organisms to the wastewater, including the slow-growing ones. Their increased breakdown efficiency reduces the time spent in the containers. The combination of the two effects makes it possible to construct a compact unit due to the decreased container dimension requirements.

All non-biodegradable components that pass through the membrane pores can be separated with other filtration techniques after membrane filtration (activated carbon adsorption, nanofiltration or reverse osmosis), so that that previously contaminated wastewater, e.g. landfill leachate, creates an outflow of the highest quality, namely the direct discharger quality pursuant to AbwV.

Case example - Landfill Burghof

Since 2000, the landfill leachate created at the Landfill Burghof has been treated with a process combination of MBR system, nanofiltration and activated carbon adsorption, and then directly fed in.

Fig. 4: Aerial image of the Landfill Burghof with leachate treatment circled.

As the quantity of leachate increased over the years, the plant was expanded from an initial treatment capacity of 180 m³/d to a maximum throughput of 270 m³/d in the year 2014.

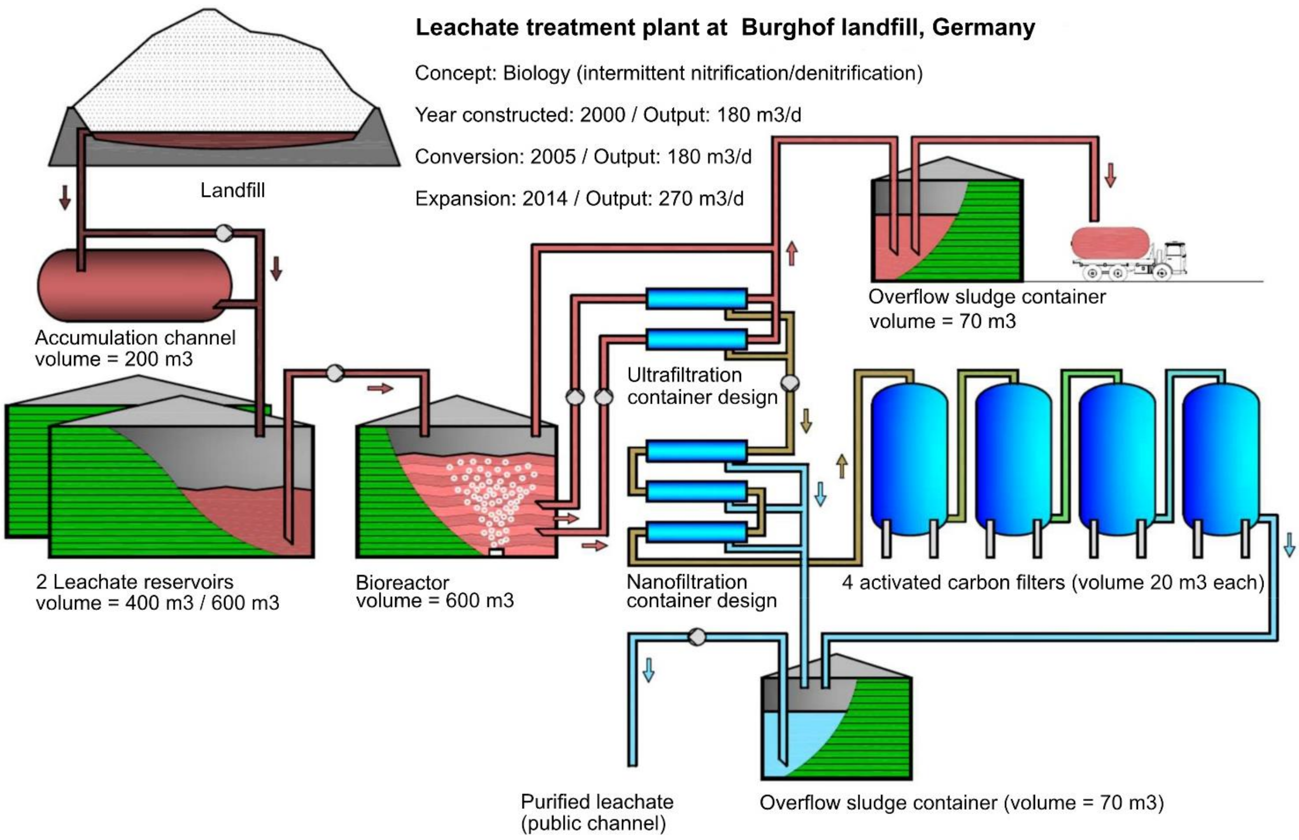
Process description

The landfill leachate is fed into the two leachate reservoirs (V_1 = 400 m³, V_2 = 600 m³) either directly or via an accumulation channel (V = 200 m³). The water then passed from there to the bioreactor, which consists of intermittent nitrification and denitrification. This means that both the oxidation of the ammoniacal nitrogen and the breakdown of the nitrate to nitrogen take place in the same containers. This can be achieved by activating or deactivating the fan depending on the treatment state.

The mixture of biomass and purified wastewater is then pumped into multi-channel ultrafiltration, whereby only the watery phase (permeate) passes through the membrane, and the solid (concentrate) is either fed back into the reactor or temporarily stored in the excess sludge reservoir (V = 70 m³) before disposal.

The permeate, which contains all non-biodegradable components (residual CSB, AOX, salts) is then purified through nanofiltration until feedable water is created. Nanofiltration is capable of holding back nearly all contents except for water and small ions. The accruing concentrate, approx. 10% of the accruing leachate, must either be disposed of externally or further purified with activated carbon (as is the case in Burghof). The concentrate of the NF is fed through a series of activated carbon adsorbers (V = every 20 m³), the valves of which can be adjusted such that the container with the smallest load is always first.

The activated carbon drainage is also so clean that it can be directly fed in, and is mixed with the NF permeate in the drainage reservoir (V = 70 m³). The purified leachate is then disposed of via a public channel.



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Reference facilities

Landfill Burghof, 270 m³/d

TDL Energie GmbH
Emil-Dittmer-Strasse 4
24539 Neumuenster, Germany
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Landfill Weiherberg, 72 m³/d, MBR + activated carbon

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Landfill Scheinberg, 240 m³/d, MBR + activated carbon

Landfill Am Lemberg, 40 m³/d, MBR + activated carbon

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