Decentralized waste water treatment by means of biology and membrane support

Short description

Introductory remarks

In this script we present a decentralized Membrane Bio-Reactor for the treatment of domestic wastewater streams.
The script is only intended to describe the essential process engineering and does not serve for detailed interpretation.

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1. Summary

The model of the central treatment of waste water and drinking water is exhausted in its possibilities. Wherever it makes sense to carry it out due to the high density of the population, it has happened. But still about 8% of private households in Germany are not connected to the sewage network.

The situation is even more serious in other countries. It is well known that things look different in many countries. While Central Europe is still privileged by its abundance of water, this is quite different in other countries. If the significance of the non-substitutable element water is only slowly becoming apparent in Germany, water has long been a scarce commodity in other countries.

This is where the sensible recycling of water comes in. So it is not only necessary to make it available that it can be tasted or has sufficient qualities that it can be used in secondary cycles, it must also be prepared after use so that it can be reused. The high hygienic level of the life-supporting medium is particularly important here.

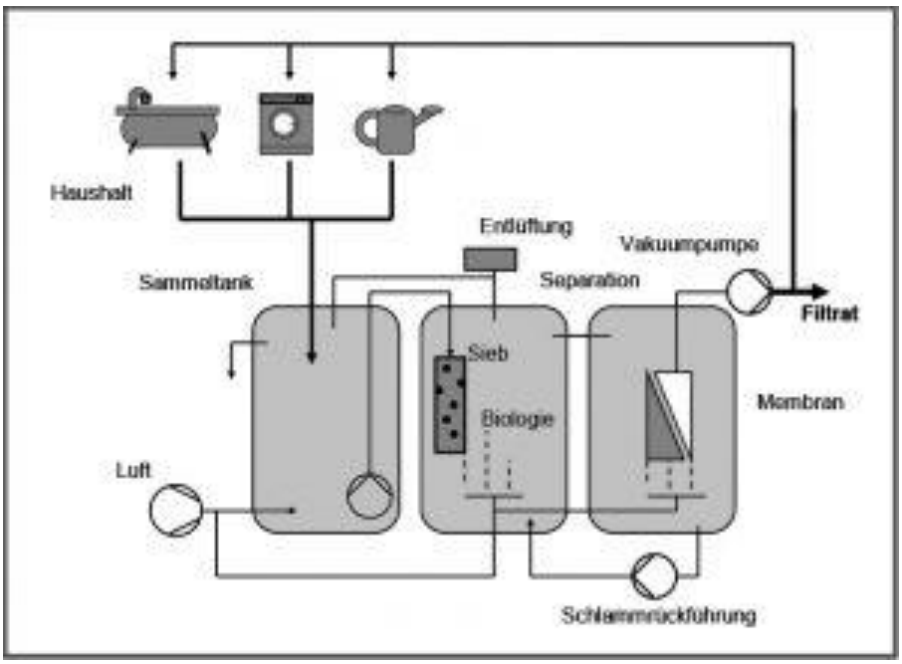
2. Proceedings

It essentially consists of three basic elements:

- Intermediate storage
- The biological treatment
- After-treatment by membrane technology

The wastewater is treated by this process to such an extent that it can be reintroduced into the domestic or commercial secondary water cycle.

Schematic diagram of the secondary circuit:



2.1 Intermediate storage:

The used water accumulates discontinuously. It must therefore be stored temporarily. This takes place in a darkened tank lined with plastics. In order to avoid odour nuisance, the air is vented via an activated carbon cartridge, which absorbs any odour emissions that may occur.

2.2 Biological treatment

Biological waste water treatment plants are of great importance for waste water treatment. Today, in addition to municipal applications, they are also used for the treatment of industrial waste water and landfill leachate, often using additional methods to optimise biology. An important such process is the ultrafiltration for biomass concentration and/or separation described below.

2.2.1 The Metabolic Processes in Biology

Most biologies contain organisms belonging to the group of destructors (bacteria) and lower forms of producing organisms (algae and autotrophic bacteria). There are also bacteria-eating and predatory protozoa. These feed on particulate substances that cause turbidity in the wastewater and thus contribute to the clarification of the wastewater.

Microorganisms feed to maintain their physical condition and reproduce. Nutrients are sourced from outside and transformed into the body’s own substances via biochemical processes. Part of the body’s own material is then released as a reproductive product. The building metabolism (anabolism) is linked to the

energy metabolism (catalism), i.e. energy and building blocks (nutrients) are obtained from outside. The following organisms are roughly distinguished:

Chemoorganotrophic organisms:

Nutrient: organic substances (C-source, H-source)
Energy: from chemical reactions (performance of protein synthesis)
Who: Animals, fungi, yeasts, most bacteria

Photolithotrophic organisms:

Nutrient: inorganic substances (C source: CO_2, H source, H_2O, (H_2S))
Energy: Light
Who: green plants, blue-green algae, bacteria

Chemolithotrophic organisms:

Nutrient: CO_2, H_2O (reducing chemical compounds)
Energy: Light
Who: Some bacteria, (oxidizing ammonia to nitrite, nitrite to nitrate, hydrogen sulfide to sulfur)

Photoorganotrophic organisms:

Nutrient: mainly organic matter
Energy: Light
Who: Some bacteria

A further distinction is made between the type of oxygen supply:

Aerobic reaction: oxygen acts as electron acceptor
Reaction product: H_2O

Electrons are only transferred to organic substances, only organic substances are produced (fatty acids, alcohols, small energy gain).

Anaerobic reaction: Bacteria work under exclusion of oxygen and use other energy sources.

Influences on biology also play a major role:

- substrate concentration
- pH
- temperature
- additional external parameters

As a rule, biologies are carried out as follows:

– Reaction tanks with organisms
– Ventilation:

(a) organisms shall be kept in suspension
(b) oxygen supply
c) Circulation

– Final clarifier: Calming, sedimentation of organisms
– Return of the organisms to the reactor

(nitrification, denitrification, COD degradation, enzymatic reactions)

2.2.2 Functionality of biology

In the activated sludge process, a reactor forms a biologically closed system and is fed continuously. The system is determined by the average residence time of the activated sludge. Its residence time is at least 10 times longer than the residence time of the wastewater. The organisms are constantly supplied with nutrient solution, i.e. the residence time of the nutrient solution is shorter than that of the organisms. As the organisms utilize the nutrient, the number of organisms in the system increases and is removed from the system. In municipal biologies a TS of 4 – 6 g/l biomass is targeted. If a maximum degradation rate is to be achieved in these plants and the plant is nevertheless to be compact and economical, it is necessary to increase the biomass concentration in bioreactors in order to make better use of space and time and to reduce the residence time of the polluted wastewater. Since known technologies for increasing the biomass concentration are no longer sufficient, ultrafiltration is used. Filtrate is removed from the inflow, which passes through the membrane and is discharged via a permeate collector. By using the technology described above, the biomass in the reactor can be increased up to 15 g/l DM (3-fold increase compared to

municipal biologies). This also changes the processes in biology with regard to degradation rates, excess sludge, aging, etc.

Furthermore, all organisms, such as bacteria and viruses, are safely separated by the use of the membrane specially developed for this application by us. This means that hygienically high-quality water is available for further applications.

2.3 General description of membrane technology

Ultrafiltration is a filtration process on a physical basis in which membranes are used to separate dissolved, dispersed or colloidal substances from predominantly aqueous solutions in the molecular range. The solution to be separated flows across the membranes at a certain speed and pressure. The larger molecules are retained depending on the pore size of the membrane, while small molecules, e.g. salts and water, can pass through the membrane. Furthermore, all viruses and microorganisms, including pathogenic germs, are safely separated. Viruses and bacteria are completely retained.

2.3.1 The need to use membrane technology

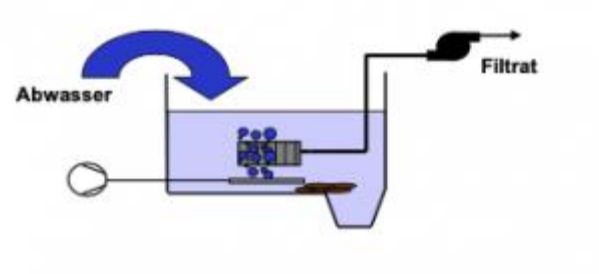
Ultrafiltration has decisive advantages when used after biology. It not only reduces the volume of biology by increasing the biomass in the reactor, but also the overall capacity of the plant. Furthermore, the membrane forms a safe barrier against viruses and bacteria. These are completely retained and do not enter the permeate. Depending on the exclusion limit of the membrane, an additional COD reduction takes place, since high-molecular components (e.g. organic compounds) cannot pass through the membrane. The substances remain in the cycle and can thus be used and degraded with delay by the microorganisms in biology as nutrients. These properties enable the filtrate/permeate to be reused as service water for new purposes. The membrane thus increases the effluent quality of the waste water.

2.3.2 *The module*

This is a submerged modular system which has been specially developed for the treatment of biologically treated wastewater. The filtrate is removed by vacuum on the permeate side. This module enables reliable and cost-effective filtration of water, waste water and process water.

Function:

In the submerged module, the filtrate is removed from the permeate side by vacuum. This ensures low energy consumption. At the same time, the module can be flushed back from the permeate side. A new welding process enables a high pressure difference between the feed side and the permeate side.



The module designed as an open channel system is also suitable for extreme filtration conditions. Due to its compact design, it can withstand the strongest impurities and can be easily regenerated if necessary.

This system is a modular structure with which any amount of space can be made available at low cost. Various modules with adapted membranes can be supplied. Thus it is possible to offer the optimal solution for individual problems.

3. Outlook for membrane technology in water applications

In recent years, additional problems have arisen that require the targeted use of membrane technology. Especially in summer we hear again and again in the media that certain waters are not suitable for bathing. Furthermore, several proceedings are currently pending at EU level in which the Federal Republic of Germany is being sued for compliance with the Bathing Water Ordinance for surface waters. These are essentially the increased values with regard to microorganisms. If we now know that a large part of the drinking water is obtained from surface water, we can quickly see the far-reaching consequences of this contamination. At present, membrane technology is successfully used in some drinking water plants because of the problems mentioned above. In the literature one finds again and again wet oxidation as comparable procedures. In this case, however, the organisms are killed if the system is sufficiently dimensioned, but the pyrogens and pathogenic germs remain in the water. The membrane (“the cuticle – from the Greek”) holds them back safely and permanently.

Some of the microorganisms originate from wastewater treatment plants in which these organisms are used, as described above, to breathe the substances found in wastewater. At present, the technology used (final clarification) cannot ensure that some of these organisms leave the sewage treatment plant continuously with the KA effluent. These values increase in particular when the hydraulic load (rainwater) increases. Often the receiving waters located at the sewage treatment plants are not able to ensure the necessary “residual degradation” and are therefore additionally loaded.