THE FUTURE-ORIENTED SOLUTION DESIGNED FOR DECENTRALIZED WASTEWATER TREATMENT AND REUSE

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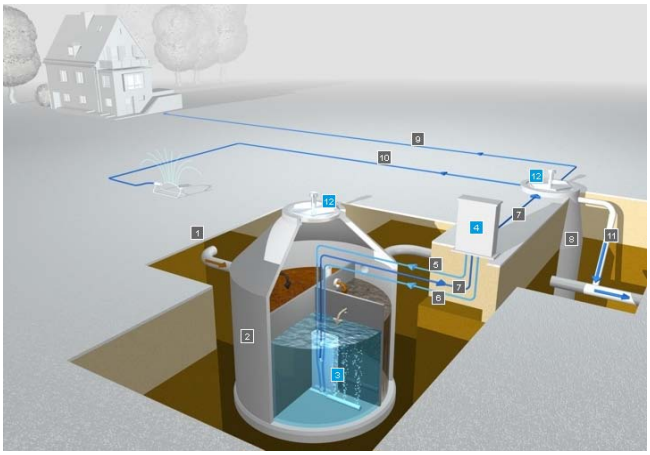
Abstract: *It is often the case that residential estates, municipalities or community centres (such as sports facilities) are not connected to central or semi-central wastewater treatment plants. Wastewater generated in these places is still discharged via individual multi-compartment septic tanks. This disposal route can be damaging to groundwater and so alternative solutions must be found. In addition hotels and holiday resorts in remote locations need their own facilities for wastewater treatment and ideally recycling.*
This paper is about a future-oriented solution for membrane wastewater treatment presenting a 500 inhabitants design concept and its investment costs. Hire is presented the MembraneClearBox® system developed from HUBER SE for small sewage treatment plants for up to 500 PE. The system combines the benefits of biological wastewater treatment and membrane filtration with submerged ultrafiltration membranes. The units consists of an aeration system and the MembraneClearBox® ultrafiltration rack with membrane modules. The number of modules is throughput-dependent. The effluent quality is so high that the treated wastewater can be used for flushing toilets. This can reduce the drinking water demand of a household by up to 40 % ! The effluent can also be used for irrigation.
KEYWORDS: *WASTEWATER, BIOREACTOR, MEMBRANECLEARBOX, HUBER BIOMEM® COMPLETE PLANT*

1. Introduction

1.1 System description

The wastewater of connected residential estates, or directly from a complete hotel for example, flows into a buffer tank. (Picture 1) Then the flow is passed through a preliminary screen (HUBER fine screens) to remove coarse material before it enters the bioreactor of the HUBER BioMem® Complete Plant where the pollutants contained are decomposed biologically. A submersible pump delivers the wastewater then into the filtration chamber where the activated sludge and clarified water are separated. Due to the low separation size of 38 nm not only all solids but also all bacteria and virtually all germs are retained and remain in the sludge that has to be removed regularly. The effluent can directly be reused for irrigation or infiltration (groundwater recharge) or as service water, or may be discharged into a receiving water course.



1	wastewater inflow	7	clean permeate effluent
2	septic tank / cesspool	8	permeate storage tank
3	Huber MembraneClearBox® - The biological sewage plant up to 50 PE	9	clean and disinfected service water (e.g. for toilet flushing or washing)
4	HUBER control cabinet for small sewage treatment plant MCB	10	clean and disinfected irrigation water
5	scouring air	11	clean and disinfected effluent
6	aeration air	12	stainless steel HUBER Manhole Cover

Picture 1. The Systems Concept

The principle of membrane filtration is based upon the separation of solids suspended in a watery solution by means of a pressure difference. While the water permeates through the membrane, the solids, bacteria and even most viruses are retained on the concentrate side on the membrane surface where they are removed by relative movement. The pressure differential necessary to pass the liquid through the membrane depends on the membrane pore size and membrane quality. The submerged MembraneClearBox® ultrafiltration membranes retain all solids, bacteria and germs bigger than approx. 38 nm separation size and guarantee thus a maximum effluent quality. Compliance with latest legal effluent standards and reuse of the water as service water is possible without the need for additional treatment stages. The modular design allows for realisation of various system sizes for municipal applications.[1]

2. Choosing the modular design of the Membrane

This MembraneClearBox® is to provide for 500 inhabitants. The current Macedonian maximum allowed BOD_5 is below 20 mg/l. The maximum amount of mixed liquor suspended solids should not exceed 30 mg/l.

Table 1: Input parameter

Number of the inhabitants (inh)	Waste water quantity for 120 l/inh	BOD_5
500	60 m^3/d	30 kg/d

Table 2: Average contamination of municipal wastewater [2]

Parameter	Specific polluting load (g/inh·d)	Average concentration for 120 l/inh per day (mg/l)
COD	120	500
BOD_5	60	250
N	11	45.8
P	1,8	7.5
Mixed liquor suspended solids	70	291.6

The membrane's capacity for wastewater treatment determines the module number in the Membrane units. Therefore the Membrane unit choice is case dependent.

Q_{input} = 500 inh * 120 l/inh·d = 60.000 l/d

60.000 l/d / 24 h = 2.500 l/h
2.500 l/h / 15 l·m²/h = 166.66 m² · 1,1 = 183.32 m²

The Membrane unit operates with pauses, and multiplication by 1,1 is introduced.[2]

It has been calculated that the appropriate membrane area is 183.32 m^2 and the most suitable unit is with 2.5 m^3/h sewage.

Picture 2: HUBER MembraneClearBox®

The volume of the aeration basin for daily BOD_5 -fraction expressed in Bd (kg/d):

$V_{AT} = Bd_{BOD5} / (B_{SL} * SS_{BA})$ m^3

V_{AT} - Useful capacity of the aeration tank [3]
Bd_{BOD5} - Daily BOD_5-fraction
B_{SL} - BOD_5- Sludge loading
SS_{ST} - Mixed liquor suspended solids in the ac. sludge tank

3. Determination of the volume for the waste water treatment with sludge stabilization

B_{SL} < 0,07 kg/(kg·d)
That corresponds to a sludge age from over 15 days. [4]

SS_{ST} = 10 kg/m³ (8-12kg/m³ from Huber SE)

Bd_{BOD5} = 500 inh * 60 g/inh·d = 30 kg/d

V_{AT} = 30 / (0,07 * 10) = 42.85 m³

The aeration tank capacity should be little greater than 42.85m3.
The needed amount of oxygen that is to be transferred in the wastewater to provide biological oxidation of the organic material is calculated by:

$\alpha OC = (O_O * Bd_{BOD5}) / 24$ kg/h

αOC - Oxygen transfer capacity in wastewater [5]
$O_O \geq 3,0$ kg/kg - Oxygen transfer capacity and BOD_5 -space loading
Bd_{BOD5} = 30 kg/d
αOC = (3 * 30) / 24 = 3.75 kg/h

This amount is enough for oxidation of C and N under normal conditions.
The amount of oxygen transferred is calculated by:

$Q_V = \alpha OC / (f_{O2} * h_V)$ m^3/h

f_{O2} = 8-10 g/m^3 - Specific utilization of oxygen [6]
h_V = 1.5 m - Injecting depth of air in the water
$Q_V = 3,75 / (10 * 10^{-3} * 1.5) = 250$ m^3/h

The amount of air current is 250 m^3/h. This can help us in calculating the investment costs.

4. Results and discussion

To establish the overall investment costs (Table 3) first the individual costs should be calculated. This analysis will not take into account the operating costs because it is a small wastewater treatment plant and they are small. If needed, they can be added later on.

Table 3: Investment cost

	Kind of the costs	Costs in €
1	Pipestrainer (mechanical treatment)	17000
2	Collecting main basin, aeration and filtration tank [7]	20000
3	Blowers, aerators, pump and pipework system for the aeration tank [8]	5.000
4	VRM- Vacuum Rotation Membrane	60.000
	Total	102.000

The clarification process on municipal and industrial plants has been characterized by large space requirements, big structures, odor development and poor degradation and retention efficiency in case of varying loads. This results in a heavy environmental burden in the form of emissions and impairment of nature, high building costs and plant maintenance costs.
The HUBER membrane systems allow for size reduction of the structures required by up to 70 % and even increase the performance of wastewater treatment plants. Problems with scum or sludge overflow that occur with sedimentation are no longer an issue with filtration. Even existing structures can be retrofitted and the capacity increased. Existing preliminary and secondary clarification tanks can be modified and further used as storage and stand-by tanks.

5. Conclusion

The effluent quality of such plants complies with all presently applicable standards and even allows direct reuse of the bacteria-free and germ-free effluent as service water (e.g. for irrigation). The benefits of HUBER *MembraneClearBox*® System are:

- ➢ Minimised sewer building costs
- ➢ Bacteria-free and germ-free effluent
- ➢ Possibility for use of existing tanks
- ➢ Reuse of treated wastewater saves drinking water
- ➢ COD < 30 mg/l, NH4-N < 1 mg/l, with denitrification NO3-N < 25 mg/l

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