ELSEVIER

Desalination 204 (2007) 1–7

DESALINATION

www.elsevier.com/locate/desal

NORIT AirLift MBR: side-stream system for municipal waste water treatment

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Received 31 January 2006; accepted 14 February 2006

Abstract

The Ootmarsum wastewater treatment plant (WWTP) is owned by the water authority Regge & Dinkel (WRD) and is situated in the municipality of Dinkelland (eastern part of The Netherlands). The WWTP must be modernised, because it discharges the treated wastewater into a water system with considerable ecological vulnerability. In the restructuring plan the urban water chain/cycle was integrated into an ecological water management approach.

In cooperation with Grontmij engineering consultants a design study was carried out resulting in the choice for a so-called hybrid system. Such a system combines a conventional system followed by a sand filter with a membrane bioreactor (MBR). With a hybrid MBR, the costs can be reduced relatively to those of a complete MBR plant without making concessions in terms of effluent quality.

After an intensive selection procedure NORIT Membrane Technology (NMT) was selected with the novel NORIT AirLift MBR system. The construction work of the 650 m^3/h plant started in mid-2005 and will be completed by late 2006; start-up of the full scale will be early 2007.

As preparation for the full scale plant operation an intensive pilot study is currently being performed in order to develop a start-up protocol, to train operators, to check control philosophies, and to optimise the overall processing.

Keywords: Membrane bioreactor; Municipal waste water; Side-stream; Ultrafiltration; Hybrid system

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Presented at EuroMed 2006 conference on Desalination Strategies in South Mediterranean Countries: Cooperation between Mediterranean Countries of Europe and the Southern Rim of the Mediterranean. Sponsored by the European Desalination Society and the University of Montpellier II, Montpellier, France, 21-25 May 2006

1. Introduction

The Ootmarsum WWTP processes sewage from Lattrop, Tilligte and Ootmarsum and was constructed in 1974. The plant consists of an intake unit with bar screens and a grit collector, a carousel oxidation ditch and a secondary settling tank. The Ootmarsum WWTP is outdated and must be modernised. In view of the water flow requirement in the area, the WWTP will remain at the current location.

Besides renovation the biological treatment capacity must also be expanded from a population equivalent (PE) of 11,500 to 14,000. This must be combined with more effective treatment of the sewage. The Ootmarsum WWTP discharges the treated wastewater into a water system with considerable ecological potential. The restructuring plan of WRD and the municipality of Dinkelland includes measures concerning both the sewer network and the WWTP. The restructuring plan drawn up with the municipality of Dinkelland does not provide for an expansion of the hydraulic capacity of the Ootmarsum WWTP. Instead, additional measures will be taken in the sewer network.

Besides the standard effluent requirements additional targets for undissolved components will set, because the WWTP Ootmarsum will be a pilot plant for the application of a more comprehensive treatment techniques based on filtration. Effluent limits and target values are summarised in Table 1.

2. System choice

Grontmij engineering consultants carried out several studies and a number of possible waste-water treatment configurations were analysed. A feasibility study was also carried out to validate the choice of the filtration technique. The choice was between the downstream application of sand filtration, and a configuration in which the conventional active sludge system and final settling tank are provided with a sand filter and a membrane bioreactor (MBR) is installed alongside the existing treatment system. The choice fell on the second option, referred to as a hybrid system (Fig. 1). The feasibility study showed that the hybrid system entails higher start-up costs, but the predicted effluent quality is significantly better by coupling both systems (conventional and MBR) through an intermediate buffer. The additional costs of the hybrid system must be weighed against the experience that can be gained with the new MBR technology in the coming years, which may result in future cost savings and a lowering of the risk of failure.

The hybrid system consists of a MBR alongside a conventional system. The MBR has a limited hydraulic capacity. The idea is

Table 1
Effluent limits and target values

Component		Limit (2005)	Target value
BOD	mg/l	5	2
NH_4-N	mg/l	1/2 (summer/winter)	0.8 (90%.; temp $> 10°C$)
N-total	mg/l	10	4
P-total	mg/l	1	0.15
Undissolved components	mg/l	5	2

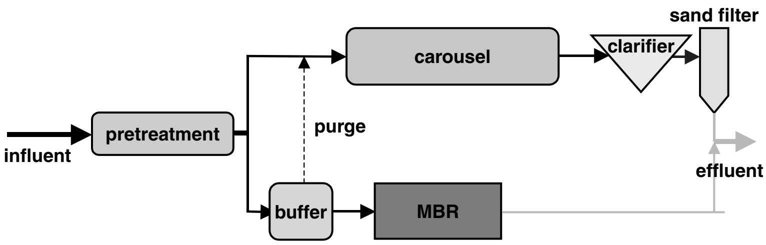

Fig. 1. Schematic presentation of the Ootmarsum hybrid configuration.

that a relatively large part of the dry weather flow (DWF) will be treated with the membranes. During periods of rain weather flow (RWF) the excess rainwater will be channelled via the intermediate buffer to the conventional active sludge system and the final settling tank. In this way, the surface area of the membranes can be considerably reduced in comparison with a complete MBR plant, and the membranes can be used at their optimum. With a hybrid MBR, the costs can be reduced relative to those of a complete MBR plant, without making many concessions in terms of effluent quality. There are a number of possible hybrid solutions. No experience has yet been gained with any of these options in the Dutch situation.

The MBR at the Ootmarsum WWTP will treat 50% of the total amount of sewage in periods of DWF, when the hydraulic capacity is only 23% of the RWF. The maximum hydraulic capacity of the MBR will be 150 m^3/h, while the total sewage inflow to the WWTP under RWF conditions is 650 m^3/h. The intermediate buffer will serve as a preliminary settling tank. During prolonged periods of RWF the buffer will have insufficient capacity and will therefore overflow. The overflow water (max. 175 m^3/h) will be treated in the conventional system. In this situation, the conventional system will have to treat a maximum of 500 m^3/h. A notable aspect of this configuration is the large variation in the hydraulic load of the conventional system. Table 2 shows the distribution of the waste water under DWF and RWF conditions.

After the described system a down-stream ecological filter will be installed consisting of a unit which is ecologically integrated into the landscape, and in which the "sterile" effluent is transformed to make it ecologically compatible with the surface water into which it is discharged.

3. Membrane system choice

On the basis of the operating costs and a number of quality criteria suppliers were invited to submit bids for designing,

Table 2
Flow through the two systems

	Unit	Conventional	Buffer	MBR	Total
Treated flow under DWF conditions	[m^3/h]	75	-	75	150
Treated flow under RWF conditions while buffer fills	[m^3/h]	325	175	150	650
Treated flow under long-term RWF conditions	[m^3/h]	500		150	650

supplying and constructing a membrane extraction unit. This resulted in two suppliers with a similar price/quality ratio. The two suppliers then participated in the following phase, in which the definitive design was drawn up, and ultimately NORIT Membrane Technology (NMT) was selected. The definitive design was then modified to accommodate the findings of a joint risk analysis carried out by NMT, WRD and Grontmij.

The NORIT AirLift MBR system consists of a loop with membranes positioned outside the bioreactor tank (Fig. 2), rather than having the membranes in the bioreactor or a separate part of the bioreactor, as in the submerged concepts. The membrane modules are arranged vertically and are aerated continuously at the bottom. This continuous aeration is the main driving force for the circulation of the activated sludge, while the feed pump is only used to overcome the hydraulic losses. Permeation is controlled by a suction pump, as in the submerged concept. A combination of forward flushing and periodic backflushing and/or relaxation intervals is used to control the cake layer formation inside the membrane tubes and to extend the intervals between maintenance cleanings. The continuous aeration also takes care of the fouling control inside the individual membrane tubes. The sidestream placement of the membranes means that almost all the options for individual optimisation of bioreactor and the membrane system are available. Moreover, a much lower volume of activated sludge is aerated additionally outside the bioreactor than in a submerged system, so that the biological processes are influenced as little as possible. The distinguished process parts make the membrane inspection and replacement very easily without removing complete cassettes with membranes out of the bioreactor (Fig. 3). In industrial applications this way of applying membranes in separation of water from sludge has lead to very compact units.

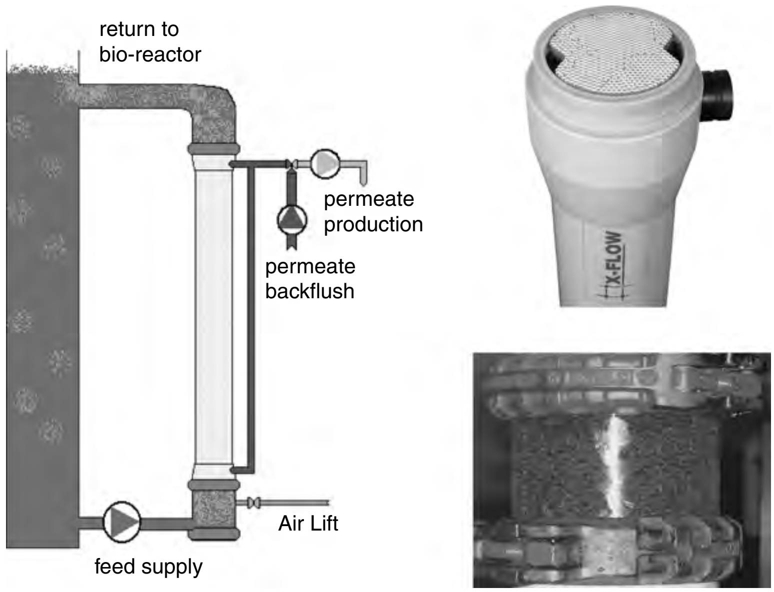

Fig. 2. Basic principle of the NORIT AirLift MBR with 8” X-Flow COMPACT membrane module and continuous aeration.

Fig. 3. Full scale NORIT AirLift MBR system.

4. Design

The Ootmarsum WWTP is configured for a biological capacity of 14,000 PE (@ 54 g BOD) under winter conditions (7.5 °C) and a capacity of 18,500 PE (@ 54 g BOD) under summer conditions (17.5 °C). The total hydraulic capacity is 650 m^3/h, and the DWF is calculated to be 150 m^3/h.

The waste water from Ootmarsum flows through gravity sewers and is collected at the inlet chamber of the WWTP. The waste water from Lattrop and Tilligte passes through pressure pipelines. It arrives downstream of the screw pumps and is subjected to preliminary treatment together with the waste water from Ootmarsum. The preliminary treatment is carried out with a bar screen (bar separation 6 mm) and a grit collector. The conventional active sludge system, consisting of the carousel, will be replaced and expanded by an upstream selector tank/anaerobic tank and a downstream discontinuous sand filter, which can handle a maximum of 250 m^3/h. If the flow exceeds this maximum, the excess is diverted through a bypass. The decision to replace the conventional active sludge system was taken in order to simplify connection to the MBR, and above all to ensure better continuity of treatment during the construction phase. All the waste water treated in the MBR will first be passed through a fine screen (separation width 0.75 mm).

The membranes will consist of 6 membrane stacks in parallel, each of them equipped with 14 modules, which can be extended to 18 modules (Fig. 4). No pilot studies have been carried out for the design of Ootmarsum WWTP, so the design of the membrane installation was based on experience with the side-stream concept at other locations, where the design base for Ootmarsum has proven itself over a period of several years [1]. Currently, as preparation for the full scale plant operation an intensive pilot study is being performed in order to develop a start-up protocol, to train operators, to check control philosophies, and to optimise the overall processing (Fig. 5).

The design of the ecological filter is not yet completed.

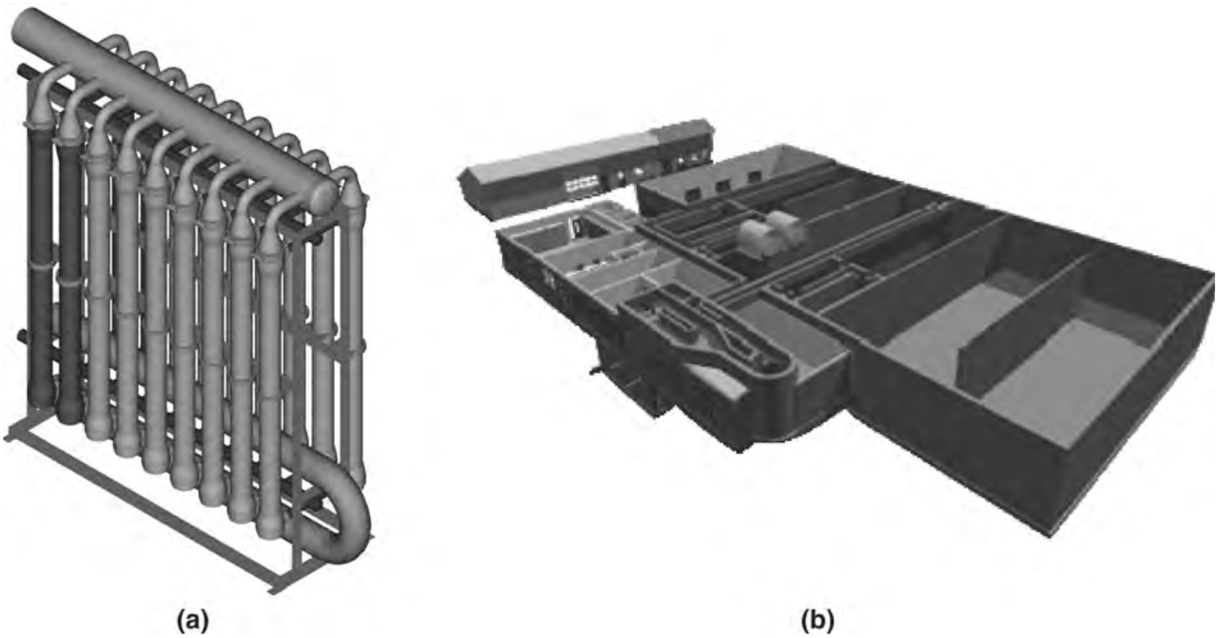

Fig. 4. Artist's impression of WWTP Ootmarsum: (a) AirLift MBR stack; (b) complete plant (membrane stacks will be placed in the green area in the centre top position).

Fig. 5. AirLift MBT pilot at WWTP Ootmarsum.

5. Costs

During feasibility study the hybrid system was compared with the conventional system including sand filtration. The complete MBR-plant option was taken as a reference. The study looked at the investment costs and the operating costs. The result is summarised in Table 3 as a factor of the conventional

Table 3
Relative investment and annual costs

	Investment costs	Annual costs
Conventional	1.0	1.0
MBR	2.0	2.5
Hybrid	1.4	1.6

configuration. The relative start-up costs and annual costs do not include the costs of the ecological filter.

Subsidies are provided from two sources, namely the STOWA innovation fund and the European Interreg IIIb programme, under the project name Urban Water Cycle (UWC). The activities carried out in the context of the Interreg IIIb programme make an important contribution to the goals of the Ootmarsum project, but, for reasons of transparency, are kept strictly separate from the described activities in the context of the innovation fund.

6. Final remarks

The construction work on the Ootmarsum WWTP has started in mid-2005 and will be completed by late 2006 or early 2007. Measurements of guaranteed values will then be carried out, and an extensive research programme will also be pursued, which will yield more knowledge of MBR plants in general and hybrid MBR systems in particular. Synergy effects will be a particular area of interest. The research programme will also have to provide insights into the achievement of certain ecological values, and must lead to a plant management concept in which continuity and the management of the consumption of energy and chemicals are central.

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