The MBR in broad Dutch perspective

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The path that leads from theoretical innovation to practical implementation is often a troubled one. This also applies to MBR technology. However, the Dutch wastewater sector has succeeded in further developing this (in the Dutch wastewater field) new technology into a system that can be applied to the Dutch context in a relatively short timeframe. The article below gives a brief overview of water board developments which have contributed to MBR technology. It also reviews MBR developments in the Netherlands, starting with the MBR aspirations of (the former) Water Board of Uitwaterende Sluizen in Hollands Noorderkwartier, and leading right up to the present. Furthermore, an overview is given of current and recently completed STOWA research projects, and the purpose and development of the water boards' innovation fund as an important success factor is also briefly explained. Finally, the article also discusses a second important success factor for the further development of new technology, i.e. broad co-operation. This means sharing expertise amongst the water boards, but also includes collaboration with commercial parties, consultancy companies and research institutions, both in the Netherlands and abroad.

Technological innovations often arise from a desire to optimise and/or increase efficiency. In the industrial sector in particular, innovations are often driven by technology push. Besides these incentives, innovations in domestic wastewater treatment, which in the Netherlands is the exclusive domain of the water boards, are also determined by policy development (national and international).

Policy developments

At the national level the recent Fourth Policy Document on Water Management includes an explanation of the Maximum Tolerable Risk (MTR) standards for surface water. Purification technology research aims primarily at removing phosphate and nitrogen. Until now relatively little attention has been given to the other substances mentioned in the MTR standards. We must realise though that surface water standards are not effluent standards. Nevertheless, surface water standards are used in practice as reference values against which the performance of (new) purification technologies is measured.

Phosphate and nitrogen were highlighted with the introduction of the discharge policy for urban wastewater and the European directive on urban wastewater. The limits of current purification systems are now being tested by shifting the focus to lower effluent concentrations (instead of 10 mg/l nitrogen the target is 2.2 mg/l and the phosphate target for research projects is 0.15 instead of the usual 1 or 2 mg/l). Besides nutrients, more and more attention is being given to priority substances (heavy metals, organic micro-pollution and hormone-disruptive substances, amongst others). These substances will also get the attention they deserve during implementation of the EU Water Framework Directive and they will throw new light on purification technology and techniques. The role of purification in this framework still has to be weighed against other measures (tackling the source of the problem, for example).

It may be concluded that the issue of the reuse of effluent is getting sufficient attention within the water boards recently. There are various initiatives/studies which are examining the (partial) closing of the aquatic cycle.

The comparison of purification management operations is an important source of inspiration for the water boards' innovation-consciousness. This has partly contributed to participation in research into innovative technologies gaining greater support.

External succes factors

Besides the general policy developments mentioned and the need for commercial optimalisation and a desire for purification techniques which lead to better effluent quality in general, there are also other important factors for successfully getting innovative technology operational. Firstly, it is vitally important that sufficient confidence is generated in the considered technology. Experience with pilot projects helps to engender this confidence. Design

Dutch delegation visits MBR plants in the United Kingdom (October 2003).

fundamentals can be substantiated through pilot studies and specific questions are more easily answered with test installations than in practice (for example, initiating an MBR can be effectively imitated with a test installation).

Positive business experience leads to the necessary confidence in the technology. Visits by water quality managers to MBR plants in the UK, for example, have definitely contributed to confidence in the technology[1]. This despite the fact that the application of the technology is different in the UK than is envisaged for the Netherlands.

A positive incentive for embracing the new technology also includes the compactness of an MBR. This plays an unmistakably important role in MBR development. MBR will score highly against conventional sewage treatment plants where purification space is at a premium. Possibilities for multifunctional ground use are also created.

Otherwise cost remains the most appealing factor, though this is usually less favourable during development when compared to conventional technology. To ensure broader application of this innovative technology in the future, these technologies will also have to compete economically with conventional technology. As the market expands, free-market processes will arise.

The above-mentioned developments and success factors can reinforce each other. Confidence in the technology can lead to more applications to which the market can react, both economically but certainly also technically. It may be concluded that this was indeed the case for MBR technology development. Running through the various development phases, much 'profit' has been achieved both economically and in terms of product improvement. Furthermore, a three-phase structured approach has played an important part. The knowledge acquired in various studies is further expanded upon with simultaneous scale enlargement to the eventual large-scale application. The great advantage of this structured and phased approach is that damage risk stays limited and increasing understanding can easily be integrated in subsequent development phases.

MBR development in the Netherlands in terms of scale

The development of MBR technology for the Dutch context has therefore been tested in various research set-ups. This raised important research questions such as those regarding effluent quality and operational management aspects (performance under different conditions, cleaning procedures in relation to the use of chemicals, energy consumption, etc.). The first Dutch MBR for domestic wastewater on a working model scale is now operational in Varsseveld. This installation fulfils a demonstrative function for Dutch water quality managers. It is the first project realised using the innovation fund set up for this very purpose by the water boards.

A couple of hybrid MBR plants in Heenvliet and Ootmarsum are also under construction now. These projects are also supported by the previously mentioned innovation fund. They are both relatively small plants. Both projects also have a demonstrative function for the hybrid application of MBR systems.

The first large scale working model MBR will probably be the Hilversum STP. Serious plans for the construction of an MBR plant are being prepared. The current STP is to be moved, and there is only a limited surface area available at the new location. Integration in the surroundings and effluent quality play a role in the decision to switch to MBR. Research has already been carried out for some time at this location using a pilot plant.

A review of MBR development in the Netherlands

A large study was carried out in 2000/2001 at the Beverwijk STP into the application of MBR for domestic wastewater in the Dutch context. For this purpose, MBR pilot plants from four different suppliers were tested under various conditions[2]. Within an extremely short timescale of seven months, it had to be shown whether MBR technology in the Dutch context was both applicable and expandable. These challenges were at first tackled by the then Water Board of Uitwaterende Sluizen in Hollands Noorderkwartier and DHV in collaboration with four membrane suppliers (Zenon, Kubota, Mitsubishi and Norit). In that same year, STOWA took over coordination of national MBR development the group of water managers was expanded with the inclusion of the then Water Treatment Board of Hollandse Eilanden en Waarden (now the Hollandse Delta Water Board), the Veluwe Water Board, the Rijn en IJssel Water Board, the Regge en Dinkel Water Board and the Water Board Amstel, Gooi en Vecht/DWR. This was extensively covered in the last two H_2O-MBR-specials[3][4].

The promising research results of these pilot studies at the Beverwijk STP led to the decision to build a working model of an MBR demonstration plant at Rijn en IJssel Water Board's Varsseveld STP. In order to make this demonstration plant a successful working model, and to keep damage risks to a minimum, research projects were initiated at Varsseveld and elsewhere at various pilot plants to further expand (still somewhat lacking) expertise.

Simultaneous research projects

In order to get a broader understanding of the possibilities and limits of MBRs, as well as to ensure the success of the Varsseveld demonstration plant, various parallel studies were conducted at different locations besides Beverwijk STP, as has already been mentioned. Therefore, research was started in 2002 by the STOWA in co-operation with the Rivierenland Water Board at the Maasbommel STP to study the applicability of a membrane bioreactor compared to a conventional active sludge system with linked sand filtration[5]. During the two-year-long study, both systems proved that it is possible to remove most phosphate and nitrogen. Besides removing nitrogen and phosphate, the study increased insight into the removal of various other components. The study has offered a great deal of useful information about the possibilities and limitations of both methods. A pilot study has also been started in Hilversum to prepare for the MBR plant to be constructed there.

In the province of Friesland, STOWA is carrying out research in co-operation with Fryslân Water Board into the working of a linked MBR. In this pilot study at the Leeuwarden STP, an MBR is linked to a conventional active sludge plant. Central to this is the removal of special substances (non-biodegradable organic micro-pollution). In this sense, it is an innovative application of MBR.

Finally, it should be mentioned that in 2002 STOWA carried out market research into MBR technology for use with domestic wastewater[6]. Through interviews and surveys 23 of the 26 regional water managers present in the Netherlands were approached. For the longer term (2020) 69 projects with an average/high probability were assessed by the water managers. This study revealed that the Netherlands is primarily a market for small-scale custom builds and does not support large-scale construction.

Hybrid applications

Besides the Varsseveld demonstration plant two demonstrations have now been started with MBR hybrid applications. This concerns a joint project of the Regge en Dinkel Water Board and the Hollandse Delta Water Board at Ootmarsum STP and Heenvliet STP respectively. Hybrid systems combine the advantages of MBR (high effluent quality, space savings) with the advantages of conventional active sludge plants which can process large volumes of wet weather discharges. During dry periods, all wastewater (or at least most of it) is processed by an MBR. During wet periods, rainwater is also discharged via the 'conventional path'. In this way, it is expected that, compared to an MBR plant through which wastewater is continuously flowing, energy would be used more efficiently with slightly lower total removal efficiencies. Especially at those locations in the Netherlands where wastewater and rainwater are often collected together, much will be expected of this hybrid application. The application will be installed in particular in plants needing attention due to capacity problems. However, it will also offer a solution which could be used to improve existing conventional purification where effluent is discharged into fragile surface waters. The Heenvliet STP and Ootmarsum STP joint project runs to the end of 2006. After Varsseveld STP, the MBR hybrid application demonstration project is the second one to be supported by the innovation fund set up by the water boards.

Innovation fund

Since they are still in the development stage, innovative techniques like MBR cannot yet compete with conventional technology and, by extension, do not have sufficient market profile. This means that scaling up of the technology to working models is not without risk and there is consequently a certain damage risk. Finally, the water boards' infrastructure must be used to scale up the technology. To spread the damage risk and extra costs, the water boards set up the so-called innovation fund in 2001. The fund works as follows: the plant to be developed is budgeted and this is then debited from the estimated costs of a comparable fictional conventional plant. After payment of a substantial extra contribution from the 'host water board', the difference is paid by the fund. In the unlikely event that the project is a total failure, recovery costs are also borne jointly by the fund. The fund has been assigned to the STOWA and is financed on the basis of the number of pollution units in a water board's managed area. The annual contribution has been based on the costs of the Varsseveld project. The commitment of the water boards applied for four years, and was at first exclusively designated to upscaling the MBR. It was agreed with the water boards that, after four years, the fund's function would be evaluated and, on the basis of this, decisions for the future would be made. When the innovation fund was set up, the Ministry of Transport and Public Works contributed about 1.4 million Euros. The water quality managers collected more than 4.4 million Euros in the period 2002-2005.

The Maasbommel research report is officially given out at the third Dutch MBR conference (Echteld, November 2004).

Within the Varsseveld project subsidies were received as part of LIFE (EU subsidy) and EINP (Ministry of Economic Affairs subsidy for energy investment deductions for non-profit organisations). After deducting the Varsseveld contribution, the balance has recently been assigned to the hybrid MBR projects: Heenvliet and Ootmarsum.

Future of innovation fund

As has previously already been mentioned, the water boards committed themselves to conducting both an evaluation of the fund's function and further decision-making regarding the fund's continuation. On 15 April 2004 there was a meeting of the participants of the STOWA, that is all water boards, where amongst other things the innovation fund's aim, scope and finance were considered. During this meeting it was also suggested to continue contributing to the innovation fund after 2005. A desire was also stated to widen the fund's objective: not only for MBR applications or projects related to wastewater systems. All the various tasks of the water board (water chain, water systems and water barriers) should be considered. Projects which are not specifically technical ('alpha' like applications), should also be considered for a donation from the fund. In the summer of 2004 STOWA's management decided in the light of this suggestion that from the 2005 fiscal year the innovation fund would be integrated with the STOWA's research program so that a mature R&D policy can be developed for the water boards. Innovation forms a separate theme throughout all the tasks in the multi-year planning.

Co-operation

The course followed by the research into development of the MBR in the Dutch context is an outstanding example of successful co-operation. This co-operation has taken various forms during the different phases of the study. Besides the STOWA this included involvement by various water boards, nearly all the large Dutch advisory agencies, all suppliers of MBR plants and many technical universities (national TU Delft, Wageningen UR and TU Twente and international TU Aachen) and technological top-institutes like TNO and Wetsus.

All those (who have been) involved with the study are convinced that this broad co-operation partly ensured the results achieved.

Co-operation and information exchange are central to STOWA projects. Around the MBR theme, various supervisory committees and a steering committee were created. Twice a year, a symposium is organised for all those involved in STOWA MBR-studies. Information exchange is central to this. When bringing a new development onto the market, it is important to learn from each other's *experiences in order to prevent unnecessarily* negative signals thwarting the developments.

Water boards work mutually with MBR projects; an example of this is the previously mentioned co-operation between the Hollandse Delta Water Board and the Regge en Dinkel Water Board in the field of hybrid MBR plants. Lastly, the co-operation with the Stichting Wateropleidingen is also an example of this. Stichting Wateropleidingen has already been holding an MBR course for a couple of years, ensuring the required education for future users.

International joint ventures

Co-operation also occurs at an international level, besides the above named specific co-operation in the study into MBR in the Dutch context. The STOWA participates, together with KIWA in the Global Water Research Coalition (GWRC), a collaboration between twelve global information institutions involved in research in the field of the water chain (UK, USA, South Africa, Australia, France, Germany, Switzerland and the Netherlands, amongst others).

MBR has been placed on the collective research agenda. Currently, a 'state of the science' report is being prepared, in which are assessed, besides current expertise, gaps and needs in expertise. This report is evaluated in an international workshop, after which the GWRC will review which of the joint projects should be tackled. The said workshop is linked to an international symposium about MBR that will be held on site on the occasion of the opening of the Varsseveld STP. In this way strengths are combined, preventing the wheel from being invented twice. More and more co-operation is occurring in Europe. Various research projects discover how to collaborate in an European context. The Varsseveld MBR demonstration project (Life subsidy) is an example of this.

Conclusions

Stagnation means decline. In order to progress, it is important to reposition one's horizons by focusing on the long(er) term. Current MBR applications are maybe (still) expensive. But in the long term, MBR can be economical. Flexibility, effluent quality, space saving and potential for multiple ground use and development of membrane prices all play a part in this. It is expected that a temporary high investment in MBR is justified.

New technology must be handled with care. Research is necessary to ascertain what the possibilities are, and especially what is not possible with the technology. It is important that the appropriate expectations are assumed *for a new technology. Disappointing* experiences do not help technological development. Research and practical experience contribute to realistic expectations.

Study results must be seen in their correct perspective as local conditions can have a strong influence on whether a technology is attainable.

A precondition for new technology is that the water sector should generate greater collaboration and expertise. Confidence in a new technology arises as joint experience is acquired. The impulse to win over confidence in the MBR comes from pilot studies and demonstration plants.

Furthermore, co-operation in innovation can form an important stimulus to strive jointly for greater progress. The sum 1 + 1 = 3 (more than the sum of its parts) applies here.

The merits of innovative applications must be assessed in a wise manner. Here lies the challenge for the water world: give MBR the chance to prove itself for applications in the Netherlands. ¶

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Samenvatting

De weg die bewandeld moet worden om innovaties in de praktijk tot uitvoering te laten komen is doorgaans een moeilijke. Zo ook voor de MBR-technologie. De Nederlandse afvalwatersector is er echter in geslaagd om in een relatief kort tijdsbestek deze, voor de Nederlandse afvalwaterwereld, nieuwe technologie verder te ontwikkelen tot een systeem dat onder Nederlandse omstandigheden kan worden toegepast. In onderstaand artikel wordt hiervan een beeld geschetst door in vogelvlucht aan te geven welke ontwikkelingen in de omgeving van waterschappen hebben geleid tot een bijdrage aan de ontwikkeling van de MBR-technologie. Er wordt een terugblik gegeven op de MBR-ontwikkeling in Nederland, beginnend bij de MBR-aspiraties van (destijds) het Hoogheemraadschap van Uitwaterende Sluizen in Hollands Noorderkwartier tot de dag van vandaag. Daarbij wordt een overzicht gegeven van de lopende en de recent afgeronde STOWA-onderzoeksprojecten en wordt kort de opzet en ontwikkeling van het innovatiefonds van de waterschappen als belangrijke succesfactor toelicht. Tenslotte wordt stilgestaan bij een tweede belangrijke succesfactor voor de verdere ontwikkeling van een nieuwe technologie, zijnde de brede samenwerking, binnen de waterschappen onderling om kennis te bundelen, maar ook samenwerking met marktpartijen, adviesbureaus en onderzoeksinstellingen, zowel in Nederland als daarbuiten.