

Learning from each other

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At universities since the late 80s learning communities were introduced and they showed to have a powerful effect on students learning and achievement. Although I do not want to compare the AquaFit4Use team with a learning community of students the 4 key factors McMillan and Chavis defined 1) membership (2) influence (3) fulfillment of individuals needs and (4) shared events and emotional connections are all applicable. Learning from each other is one of the pillars of the AquaFit4Use Project having a big impact at sustainable water use in the four industrial sectors with the highest water consumption. Chemistry is one of these sectors and the other sectors paper, food and textiles can learn a lot from this industry. The chemical sector differs strongly from the others as it is not a very homogeneous industry, both in types of processes and in the scale. What we can learn from this is that on one hand each factory has his own conditions and location specific circumstances, but on the other hand a lot of technologies are that robust that they are applicable under very different and varying conditions. Combining the right technologies is one of the solutions, but sometimes you have to take additional measures for unexpected changes. A good and fast reacting monitoring system could be very helpful under these conditions.

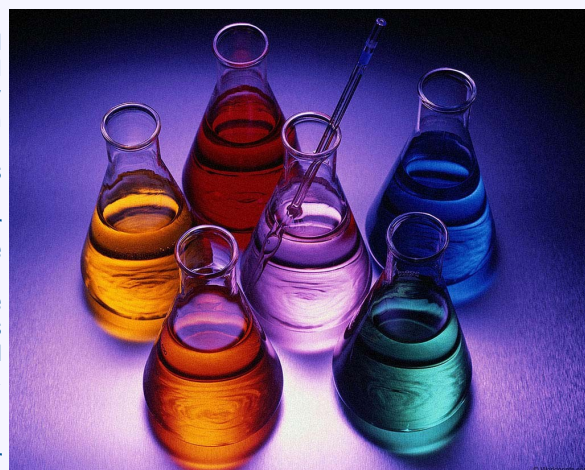
The key factors membership, influence and fulfillment of individual needs are hopefully sufficient explained, shared events are also very important in the project (see also the next newsletter and the website) and I can assure you that in a big EU project like AquaFit4Use the emotional connections play also a very important role



The chemical Industry in Aquafit4Use

The chemical sector plays a significant role in the European economy, contributing with a 30% of the world's total chemical production, employing 1.2 million people and generating around €550 billion in sales. By adopting measures to increase resources and energy efficiency and developing improved production processes, the European chemical industry is significantly reducing its overall environmental impact. In addition, innovation and new technologies are enabling chemical companies to develop sustainable solutions for society as a whole.

The chemical and pharmaceutical industries are very diverse businesses. Even though the total amount of different substances produced in the chemical and pharmaceutical industry might be big, the amount of unit processes and unit operations for the chemical reactions and processing and refining of products are typically limited. Water is essential in most chemical and pharmaceutical production units. It occurs as a medium, a product stream to refine or a waste water. For a specific production, the choice of unit processes and operations together with the choice of raw material and process equipment define the required water quality and quantity, which can vary in a wide range. A major part of the overall water consumption is used for steam generation and cooling.



In terms of water treatment, the chemical sector has historically focussed on:

- The treatment of strongly polluted effluents.
- Removal of trace elements.
- The treatment of water, especially for cooling, with a strong emphasis on corrosion problems and chemical conditioning.

Up to present, water loop closure has got only limited attention. However, the chemical and pharmaceutical industries in Europe are aware of the importance to reduce their water use and emissions. Most companies have a commitment to reduce the amount of water used per unit of product produced. However, in some branches of the sector, e.g. the pharmaceutical industry, this might not be possible due to present regulations by the authorities. Two chemical companies, Perstorp and BASF have joint forces in close collaboration with leading water treatment suppliers and RTO within AquaFit4Use with the aim to investigate several local and global water reuse scenarios.

participating partners





Complex chemical sites: From total effluent reuse to local loop closure

During the last decades new knowledge and technologies related to process water production, waste water treatment and water loop closure have been developed and implemented. Also the chemical and pharmaceutical industries in Europe are aware of the importance to reduce their water use and emissions.

The issue of water reuse in the chemical industry is being tackled from various perspectives in AquaFit4Use at 2 test sites. Research is focussed on the following three main approaches

Evaluation of membrane bioreactor (MBR) process stability for narrowing / closing industrial water circuits

Membrane bioreactors (MBRs) have been evaluated for many municipal and industrial cases as an advanced treatment technology. Although some references already exist for chemical wastewater treatment plants, the question remains how well MBR technology can cope with the high variability and specific product streams appearing in the final effluent of complex chemical sites. In AquaFit4Use, the application limits with regard to process reliability, stability and membrane lifetime were thus evaluated.

The integrated production site of BASF in Antwerp, Belgium, was selected within the BASF-group to perform the study. It combines 54 production units in 4 production sectors, i.e. agricultural chemicals, plastics and fibres, finishing products and other chemicals. Three different MBR technologies representing flat sheet and hollow fibre module configurations and different membrane materials were linked to the full-scale treatment plant and tested in parallel for 1 year (Figure 1). It could be concluded that membrane separation of mixed liquor from the BASF Antwerp treatment plant was technically feasible at flux ranges of 8 – 20 l/m².h. Membrane permeability was clearly influenced by wastewater composition, with several simultaneous upsets in all pilot units. More scaling and fouling was observed than originally expected and this caused the need of frequent cleanings. In addition to the rather high cleaning frequency, membrane recoveries were sometimes unpredictable. The test results thus under-achieved the expectations for a stable and reliable long-term full-scale application at the BASF Antwerp site. In view of water reuse, MBR is generally considered an excellent pre-treatment step for application of reverse osmosis (RO). In our test trials, the Silt Density Index already gave an indication that the permeates would lead to severe fouling of RO membranes, and were unacceptable as a feed without pre-treatment. Simulations at various recoveries and with or without the addition of antiscalants confirmed that many ions were present in too high concentrations to allow for RO treatment. Thus, (part of) the hazardous scalants must be removed before the MBR permeates can be fed to a RO installation.



During the one year trial period, various fouling indicators were determined weekly on mixed liquor from the three running MBR pilot units at BASF Antwerp. In particular, the MBR-VFM (VITO Fouling Measurement) approach originally developed for municipal wastewater, was adapted and validated for application on chemical wastewater. The MBR-VFM method allows the detection and differentiation between the physically reversible and irreversible component of fouling occurring on the sensor immersed in the bioreactor (see Figure 2). Measurements with various types of membranes and measurement protocols gave similar results. Significant fluctuations were observed over the test period for both reversible and irreversible fouling propensity. However, the relation between mixed liquor characteristics or fouling indicators and on-line permeability was limited, absent or differed between the pilot units for unclear reasons.

Complementary to the on-line fouling propensity evaluation, the MBR-VFM was a suitable tool to screen various fouling reducing additives for their potential to counter the negative impact of foulant substances in the wastewater.

Tested fouling reducers were natural and synthetic polymers, iron salts and activated carbon. The cationic polymers Nalco MPE50 and Adifloc KD452 and 2 novel cationic polymers were found to have a positive effect and high effectiveness on mixed liquor filterability. This positive impact was confirmed during parallel laboratory-scale MBR trials where one of the novel products was added. Both the on-line filtration performance and the different fouling indicators indicated that the novel product effectively reduced fouling. The MBR-VFM demonstrated that this was true for both the reversible and irreversible component. Using the MBR-VFM for dynamic MBR process control, i.e. the variable dosing of additive, could thus be beneficial to optimize filtration performance and reduce operational costs. effects over dosing MPE50 separately.





However, from the test results, it seems it might also be beneficial to solely dose the additive when upsets in fouling behaviour occur, instead of continuous dosing (albeit at variable dosage). Combining additives with different working mechanisms, such as activated carbon and MPE50, had no beneficial effects over dosing MPE50 separately.

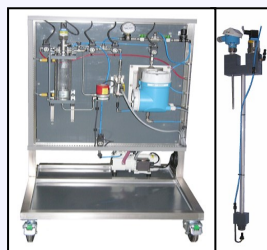


Figure 2 - MBR-VFM set-up and detail

Upcoming events

[6th IWA conference](#)

4–7 October 2011

Aachen—Germany

[International Water Week](#)

29 October—4 November 2011

Amsterdam—The Netherlands

[Water, energy and Food Security Nexus conference](#)

16-18 November 2011

Bonn—Germany

Optimisation of water quality for different reuse options for treated effluent

A second test site was located in Sweden (Perstorp Specialty Chemicals AB). Here, the existing centralised conventional activated sludge (CAS) system was compared with treatment of the same effluent in a pilot scale membrane bio-reactor (MBR) facility. Test of various treatment trains for further polishing of the effluent from CAS and MBR were also included in the experimental programme (see Figure 3). Effluent from the CAS and the MBR were in trial runs post-treated in Denutritor for removal of biological growth potential. In other trial runs, the effluents from the CAS and MBR, respectively, were post-treated with advanced oxidation technology based on ozone or ozone/hydrogen peroxide to test the feasibility for further improvement of the effluent quality. Finally, the effluents from CAS/Denutritor and MBR, respectively, were treated in a RO pilot unit. Emphasis was put on the possibility to find the minimum water quality or “water-fit-for-use” for cooling purposes and other reuse options for “low grade water quality”, while keeping good cooling or process water practise by reducing the biofouling and hygienic risks.

Results showed that while the effluent from the MBR pilot was not improved as compared to the CAS facility with respect to conventional dissolved wastewater parameters, the biogrowth potential of the MBR effluent was significantly lower and comparable to effluent from the CAS/Denutritor. The low biogrowth potential being a highly important quality improvement for most reuse options, it can be concluded that the effluent from MBR or CAS/Denutritor is significantly better suited than CAS effluent for reuse purposes at Perstorp. The most attractive reuse option for the upgraded centralized effluent was identified as intake water for the water treatment to the boiler feed supply. Upgrading of the MBR-treated centralized effluent (or CAS/Denutritor with ultrafiltration) with RO is needed and the reduced bio-growth potential is essential for the further RO upgrading. Based on economic feasibility the suggested reuse scheme looks reasonably attractive for

Perstorp as a step towards increasing production capacity without increasing the effluent discharge volume. This is important as the effluent discharge volume today is the bottle-neck once production capacity increase is needed.



Figure 3 – Technologies used in various treatment trains tested at Perstorp: Denutritor (top left), Advanced Oxidation Processes (top right), MBR (bottom left), RO (bottom right)





Evaluation of local loop closure options to minimize water consumption and waste streams by water and product recovery

“Polishing technologies” to reduce trace organics to very low levels are essential to a successful water recovery on a local level, i.e. within or between adjacent plants. Advanced Oxidation Processes (AOP) are known to treat persistent organic pollutants and toxic substances and to make these more biodegradable/less toxic. But AOP also has the potential to solve this “polishing need” to increase the quality of the water for reuse.

At Perstorp, a tailor-made technology concept for product recovery by RO has been identified, and by additional polishing treatment, significant water reuse potential of the RO-permeate as make-up water in cooling towers exists. However, the feasibility of the concept depends on the efficiency, reliability and economics of the polishing technology in removing low molecular weight, “trace organics” (methanol, formaldehyde and formic acid), which is a barrier for possible water reuse options at Perstorp specifically and in the chemical industry in general. As part of the technology testing for removal of trace organics in the RO permeate, DHI has conducted comprehensive laboratory testing with AOP, and more specifically with the combination of medium pressure UV-light and hydrogen peroxide. The presence of the trace organics in a water matrix with no inorganic radical scavengers and complete transmission of UV-light, makes the use of this AOP seem feasible for the application. The experiments show that it is possible to achieve complete mineralization of the trace organics at a stoichiometric consumption of hydrogen peroxide and that the degradation of methanol happens stepwise over formaldehyde to formic acid before mineralization. As for formaldehyde the degradation goes through formic acid before mineralization. No degradation at all was observed when the RO-permeate was merely irradiated with UV light or added hydrogen peroxide. The further analysis of the data will allow for assessment of the technical and economic feasibility of a full scale implementation.



Figure 4 – AOP tests for removal of trace organics from RO permeate

Participating chemical companies



Perstorp, a world leader of the specialty chemicals market, with emphasis on products that are used in the coatings, chemicals, plastics and in construction industries



BASF, a world leader in producing chemical consumable materials and semi-finished products, which are applied to hundred thousands of products for consumers and industry

RTD performers and technology providers working with the chemical sector



general AquaFit4Use information



Project title AquaFit4use—Water in industry, Fit-for-use Sustainable Water Use in Chemical, Paper, Textile and Food Industry
Acronym AquaFit4use
Participants 34
Start date 1 June 2008
Duration 48 months
Total budget 14.800.000 euro
Total EC funding 9.650.000 euro

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Colophon

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