Poster abstracts

OVERVIEW

E4Water Case Study 1-“Mild desalination pilot results”

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Global stress on available water sources makes innovation necessary for efficient water use in the European chemical industry. Recycling and using unconventional water sources as make-up for cooling towers can reduce the water footprint. The aim of the CS1-Case Study is to explore options for alternative feed water sources to produce mild desalinated water (<1 mS/cm) at affordable costs. A pilot, with a product capacity of 2-3 m^3/h to test the treatment of waste water effluent, rain water and cooling tower blow down water via nanofiltration/electrodialysis reversal, resulted in conclusions presented in this poster. The water was pre-treated with iron dosage, flocculation, lamella separator and ultrafiltration.

Stable operation was achieved with coagulation, sedimentation, and ultrafiltration on all three feed water sources. However sedimentation appeared not necessary with relatively low iron dosages (5-10 mg/l).

Mild desalination using nanofiltration yields a better product quality in terms of electrical conductivity and total organic carbon than is required, although stable operation is hard to maintain on cooling tower blow down water and waste water effluent.

Electrodialysis reversal, a potential driven process, has a product quality within specification except for total organic carbon when treating cooling tower blow down water. The operation is more stable and robust than nanofiltration. The higher total organic carbon level with treating cooling tower blow down water can be lowered via post treatment with ion exchange resins.

E4Water Project Case Study 1: Dow Benelux production site, Terneuzen, The Netherlands

“Mild desalination of water streams for optimum reuse in industry or agriculture at affordable costs – design, construction and start-up of demo facility”

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The objective is to reduce fresh water dependency by 20% and increase water loop closure by 90% in order to feed industrial, urban and agricultural sectors by testing several mild desalination technologies, develop new applications and process to reuse water and obtaining a product water with a conductivity of <1 mS/cm for less than 0.40 € /m³. The pilot plant consisted of a common pre-treatment of Cascade Mixer, Flocculator tank and Ultra filtration followed by two options of mild desalination technologies, Nano Filtration and Electrodialysis Reversal. Four streams are researched in this treatment train, a water reservoir (Spuikom), Dow’s waste water treatment effluent (Biox), cooling tower blow down from a nearby power plant (CTBD), and Westelijke Rijkswaterleiding (WRWL), the latter being simulated by using a mix of Spuikom and Biox.

Three different treatment trains were evaluated along with their specific cost analysis. Option 1A consisting of a mix of Spuikom, Biox and WRWL with pre-treatment, followed by Nano Filtration, option 1B, similar mix and pre-treatment but Electrodialysis will be used instead, and option 2 consisting of two separated treatment trains, one exactly as option 1B and a second train for CTBD stream only. This second stream comprises Ultra Filtration, EDR and Ion exchange.

Results

- Option 1A resulted in a total feed in of 553 m³, a recovery of 65% and a cost of 0.42 €/m³ of product water.
- Option 1B resulted in a total feed in of 488 m³ with total recovery of 74% at a cost of 0.47 €/m³ of product water.
- Option 2 resulted in a total feed in of 524 m³, a total recovery of 68% and a cost of 0.58 €/m³ of product water.

Conclusions

- EDR is a more robust technique than NF for these streams, whereas NF yields the better quality.
- Interest costs, O&M, and analysis are not included.
- Concepts (and costs) are not yet optimized for pretreatment and use of chemicals.

Symbiotic water reuse in the chemical industry

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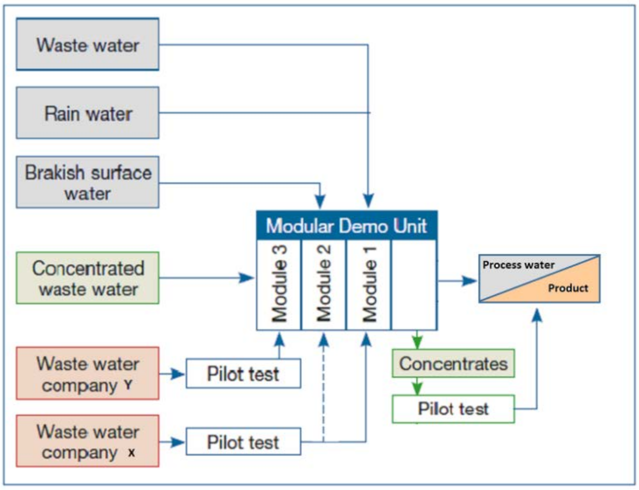
The aim of the E4Water INOVYN Case Study is to ultimately deploy, in a step-wise approach, a water management concept that will save large volumes of drinking water intake and come close to zero salt waste and zero liquid discharge. Enabling synergy in water savings with neighborhood industries in the Port of Antwerp Chemical Cluster is the key to significantly reduce consumption of potable water in this area. The three main objectives are:

- Scenario evaluation and step wise implementation of innovation plan to reach gradual reduction of drinking water intake from 20% to 60%
- Reduction of emission load in final effluent by replacing waste-generating steps or applying advanced treatment options for concentrate streams (application of waste design and zero waste concepts)
- Transition of demo unit into 'Industrial experimental garden' to serve as open infrastructure to enhance innovation with regard to water reuse in the chemical sector leading companies to a symbiotic cooperation in terms of reuse.

The INOVYN site is located in this coastal region and faces pressure on fresh water uptake (Flanders "Integral Water Policy" and "Rainwater Decree"). This Case study of the project was divided in three modules with each a DEMO-installation:

- Module/DEMO 1: Producing high quality water (<5 µS/cm, 6,5<pH<8,5) from phreatic water and waste water (>2000 µS/cm) from an external company
- Module/DEMO 2: Producing high quality water (<5 µS/cm, 6,5<pH<8,5) from brackish surface water (>15000 µS/cm)
- Module/DEMO 3: Reuse concentrated salty water (5-14% NaCl) from an external company for the membrane electrolysis process of INOVYN Manufacturing Belgium site



"Concept industrial experimental garden"

Results

DEMO 1 test the possibility of reusing waste water from an external company and phreatic water to produce high quality water for the INOVYN site. The DEMO unit consists of a disc filter as pre-treatment and an UF-RO module. In this case only the technological evaluation has been done. The economical evaluation has been taken into account with phase 2 of the DEMO unit; which is the integration of DEMO 1 unit into DEMO 2 unit. 100% treatment of the waste water wasn't possible with the current DEMO unit setup due to the waste water quality. The largest problem was the very small (<50 µm) black carbon particles (difficult to remove from UF), small plastic fibers (leading to plugging of the UF). Due to this the unit was only in operation for a limited period of time. The tests of reusing the waste water and phreatic water are continued with phase 2.

DEMO 2 test the possibility to produce high quality water from brackish surface water for the INOVYN site. The DEMO unit consists of an Amiad-strainer as pre-treatment and an UF- and RO-modules. A stable operation was achieved with 100% brackish surface water as feed during phase 1.

Phase 2 started when the tests were executed according to a research plan of DEMO 1 & 2, which is the integration of the waste water from the external company and phreatic water into DEMO unit 2.
The unit operates with a mixture of the 3 water types. The technological evaluation of the DEMO unit shows a stable process performance.
DEMO 3 test the possibility to reuse concentrated salty water from an external company for the membrane-electrolysis of INOVYN. Instead of directly injecting the concentrated salty water stream into the INOVYN process, a mini-electrolysis was built to test this water type and to shield the hazards of testing in a production environment. The DEMO unit was designed and built with a “plant on truck” concept. After commissioning the unit was first fed with a vacuum salt/demin water mixture. A first promising water type (10-14% NaCl) was tested during phase 1. A stable process operation was achieved after some modifications to adapt to the unforeseen complications of the external water. The technical evaluation looks promising after the test results with 8 consecutive loads. A final conclusion was made after a membrane-autopsy at the end of the tests that the first water type was suited for reuse in the INOVYN process.
After the membrane autopsy, maintenance of the DEMO unit and new membranes of the same type were placed in the cell of the unit to test a second promising water type with a lower salt concentration (5-8% NaCl). The preliminary results gave a stable operation and cell performance. A final conclusion will also be made after a membrane autopsy.

Future

The DEMO study’s describes the technical and economic feasibility of a full-scale installation to working up of wastewater, phreatic & dock water to high quality water and to reuse the concentrated salty water from an external company. The results of DEMO units 1 & 2 will also study the basis to generate the design parameters for a possible full-scale plant for the production of process water & demineralized water.

It was difficult to compete with the relatively “low cost price” of water in the region of INOVYN Manufacturing Belgium with the DEMO 1 & 2 units. But this can be lowered with a full scale installation when also an intermediate water quality can be delivered. Nevertheless the knowledge gained from the DEMO units is valuable for other partners/companies facing “high water costs” or water scarcity.
An economical study of reusing the concentrated salty water shows a relatively high CAPEX and OPEX costs to integrate the concentrated salty water from the external company into the INOVYN Manufacturing Belgium site. One of the main key factors for a rapid evaluation is the Pay Back Time. The PBT is high and between 5.8 years and 7.8 years. It is clear that a further reduction of the PBT has to be obtained before the realization of the project will be decided by the management of the both companies.

E4Water Case Study 2 – “Industrial Experimental Garden”

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No abstract available.

Combining nanofiltration and membrane distillation for the reuse of ion exchange softening regenerate

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Ion exchange is frequently used in industry for the softening of tap water. During the softening stage multivalent ions such as magnesium and calcium are exchanged for the sodium ions present on the resin. Following saturation of the resin with multivalent ions, regeneration with NaCl (100 g/l) is required. This regenerate contains high concentration of NaCl and lower concentrations of $CaCl_2$, $MgCl_2$ and other salts. In regions with moderate to hard tap water, the regenerate volume can amount to 10% of the treated water. Specifically the high content of chlorides is problematic in view of discharge. For inland factories with stringent discharge limits, regeneration brines need to be treated externally as a waste at high cost.

In this study we therefore evaluated the possibility for purifying and concentrating ion exchange regenerate to such extent that it can be reused. The process scheme consists of a filtration step where a purified NaCl rich permeate is generated, followed by a membrane distillation step to concentrate this permeate back to the required brine concentration. We demonstrated this scenario on pilot scale at a Belgian industrial detergent factory. Application of a TFC-SR100 (Koch, 2.5 m^2) module resulted a low retention for Na^+ (3%) and a high retention for bivalent ions (84% for Ca^{2+}). Membrane distillation was able to concentrate (CF ~4,5) the permeate back into a brine and at the same time produce a high quality distillate (< 5 µS/cm). Based on these results, the overall process will result in a 70% reduction in salt consumption for regeneration and a 84% reduction in water consumption.

The cost of external treatment of brines ranges from 50 euro/m^3 to 200 euro/m^3 depending on the salt load (Flanders region). Economic evaluation shows that NF-MD is an economically feasible alternative to external treatment of the regenerate when daily flows are sufficiently large i.e. > 50 m^3/day. Operational cost are estimated lower than 25 euro/m^3 IEX regenerate for these daily flows.

Recycling of wash water at P&G‘

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Wash water streams coming from rinsing of equipment in a detergent production site is in many cases considered as waste. On site treatment in waste water plants is possible but typically requires advanced oxidation process (AOP) technology which uses chemicals and creates a waste sludge. As an alternative, some sites will send these streams for external incinceration.

A new treatment approach, based on nanofiltration, has been demonstrated at industrial scale in a detergent production site in China. Wash water could be split into a concentrate stream and water fraction. The concentrate stream contains most of the valuable surfactants and has a value to recycle. The water fraction can easily be polished by MBR to feed cooling towers. As such, this production site does not discharge any process wash water and recovers all resources out of the rinsing water: both chemicals (as surfactants) as the water.

Towards integrated water management system in petrochemical site

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Objective

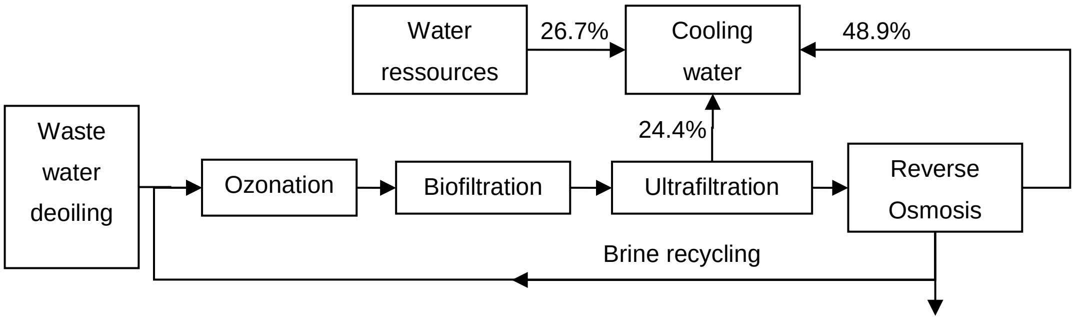
The study carried out on a petrochemical site industry aims the demonstration of reduction of withdrawal intake while improving the quality of the wastewater for compliance with future regulations particularly on micropollutants discharge. The objective is to develop combination of treatment technologies for complex industrial wastewater streams for recycling and reuse within cooling water make up and/or in other operation/production processes, by ensuring an innovative and cost effective water scheme.

Results

Due to the results obtained during pilot trials phase, the major part of the micropollutants collapsed to concentrations below their limit of quantification, and as expected, ozone oxidation combined with biological treatment proves very high performances towards refractory organic matters. On the other hand, results of recovery rate of 87% in stable operating conditions on the ultrafiltration membrane and around 75% on reverse osmosis were obtained.

Conclusion

The related integrated water management systems are designed with a high level of reliability. They achieve the reduction of the water withdrawal with rate ranging between 40.2 and 42.6%. The capital and operational cost evaluations further performed seem to favour the system involving extended wastewater treatment using after deoiling, ozonation, biofiltration, ultrafiltration and partial reverse osmosis and reuse of the mixture UF/RO permeates as cooling make-up water.



The extended treatment line proposed includes complementary and synergistic stages arranged in a treatment train able to combine pollution concentration and degradation into cycles. The whole results in an innovative Low Liquid Discharge system.

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Development of a software module for the integrated water management in the chemical industry.

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Economically and Ecologically Efficient Water Management in the European Chemical Industry (E4Water)

The Water Framework Directive (2000/60 / EC) and the more recent Marine Strategy Framework Directive (2008/56 / EC) are proposing a sustainable water management to achieve an improvement in the water quality and to reduce or stop the discharge of hazardous substances (Libralato et al . 2010). The European chemical industry has a high potential to increase eco-efficiency in industrial wastewater management. E4Water addresses crucial process industry needs to overcome bottlenecks for an integrated and efficient water management.

Aim

The aim of the work package of the Technical University of Berlin is the development of an integrated model for the management of industrial wastewater, mass and energy flows. The model shall calculate the economical and ecological effects of water recycling, optimize treatment technologies, processes, sites and demonstrate fresh water savings and the recovery potential of energy and valuables.

Methodology and Results

Using the simulation software Simba (http://simba.ifak.eu) an integrated model was created that calculates the water, energy and material flows in the production of an existing PVC production near Barcelona, Spain. The envisaged wastewater treatment technologies have been added to the existing processes. It was shown that, for example, at a recycling rate of 60% wastewater, the heat energy requirement is reduced by about 47%, compared to operation without recycling, can be saved in compliance with the limits.

Water Management and Technology

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VITO is a leading European independent research and technology organisation in the areas of cleantech and sustainable development, elaborating solutions for the large societal challenges of today. VITO’s headquarters are located in Mol, Belgium. The Water management and Technology Department (WMT) supports industry, authorities and cities to setup demonstration projects and living labs to evaluate sustainable water management concepts. Within WMT 44 specialists (hydrologists, hydrogeologists, economists, IT developers and environmental technologists are working together in order to bring integrated solutions for challenges related to water quality and water quantity. WMT offers a width spectrum of services, from measuring and modelling of soil, water, ground water and surface water streams to evaluation of water needs and water treatment options for industry. WMT host also VLAKWA (Flemish Knowledge centre water). The Flanders Knowledge Centre Water stimulate entrepreneurs, researchers , water sector and government to work together in the management of water resources by network events and setting up collaborative projects.

Increasing RO recovery without anti-scalants – a pilot study

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Within the Blue Circle project (IWT-VIS 110807) focus is on the recovery of salts and on the increase of water efficiency in industrial activities. After extensive lab-scale research, the most promising techniques were demonstrated on pilot-scale. One of these techniques was a hybrid ion-exchange (IEX) – reverse osmosis (RO) system for increased RO recovery.

In industrial applications of RO, multivalent ions in the feed often hamper the water recovery process, as they can cause scaling of the membrane. By incorporating cationic ion-exchange (IEX) as a pre-treatment step, multivalent cations can be removed from the feed and the RO recovery can be increased. However, this requires additional water and chemicals for the regeneration of the resins. This can be avoided by recycling the RO concentrate back to the IEX. Previous research has shown that the RO concentrate (high concentrations Na^+ and K^+) can be used as a regeneration solution [1]. A schematic overview of the process is shown in the figure 1.

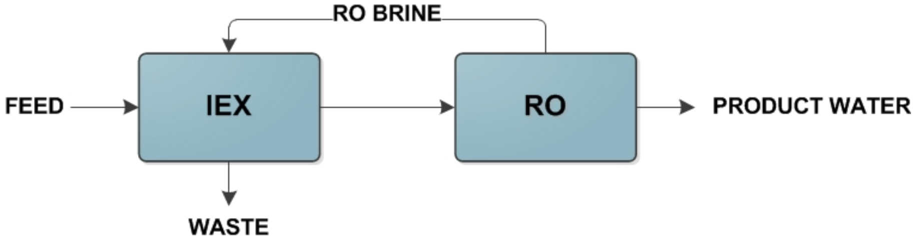

Figure. Schematic overview of the envisioned hybrid process

The technological and economic feasibility of the process was demonstrated during a pilot-scale test running several months in the harbour of Ghent. The RO recovery was increased from an average of 75% to at least 85%, limited only by the technical capabilities of the system. Furthermore, an increase in revenue for the product water of 25% is predicted based on an extensive economic analysis.

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Ceramic membranes for water treatment

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Nanofiltration (NF) membranes made of ceramics are of many advantages regarding stability (chemical, mechanical, thermal) and flux in comparison to polymeric ones. In the decade since their introduction, these membranes have been successfully used in the treatment of surface water, by direct filtration, and for treatment of waste water from the oil sand industry [1]. They have also been successfully applied in the textile industry to remove dyes and decrease DOC and salt load [2].

Ceramic membrane development has proceeded at a fast pace over the last few decades. After the development of the world's first and only ceramic (TiO_2) nanofiltration membrane with a cut-off of 450 g/mol by Fraunhofer IKTS [3], focus was put on the integration of the membranes in industrial water processes. Recently a ceramic membrane with a cut-off of 200 D in aqueous media and organophilic ceramic nanofiltration membranes were introduced [4]. Current developments aim on increasing active membrane area per membrane element in order to improve efficiency and decrease footprint. So the specific membrane area of state of the art ceramic NF-membranes with a cut-off of 450 Da was increased from 0.25 m² to 1.3 m² with a strategy for future specific membrane area increase [5] for very large scale applications as produced water treatment.

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Key topic: *Innovative materials, process technologies, tools and methodologies for an integrated water management.*

Water Stewardship as the Framework for Management Innovation

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The context

The chemical production sector is acutely exposed to a number of physical, regulatory and reputational water-related risks arising in the areas in which it operates despite the significant investments in technology to improve the overall water management of its operations in recent decades. This is mainly due to the scope of its operations and high visibility amongst the wider public. EWP has carried out a joint initiative with five chemical sites in Europe to implement an innovative management framework to evaluate their current water management performance and assess gaps that need to be addressed1.

The tool

The European Water Stewardship (EWS) stands as a voluntary process that provides guidance towards sustainable water management on-site. As a result of its implementation, the 5 sites received an analysis of the critical points from which comprehensive and targeted response strategies were elaborated to mitigate the impacts and risks at operational and River Basin level. Its 49 indicators are based on main concepts of the EU Water Framework Directive, so complying with the standard prepared the operations to be both in compliance with the legal requirements as well as advance on voluntary basis towards becoming a responsible water stewards.

Outcomes

EWS provided the implementation sites an interactive platform, where companies shared their experiences and best management practices. This fostered public-private partnership solutions, collaborative water management actions and projects that ensured robustness of production over the long term for the entire River Basin. EWS raised awareness that water has to be managed in a holistic manner, distinct from the “in-fence” concept. EWS also emphasized the need to think strategically with regard to water. Water issues have to be part of the entire business management – not only of CSR or technical departments. EWS helps drive this essential management innovation which complements technical innovation in water resource management.

1 http://www.ewp.eu/wp-content/uploads/2013/09/ECPA_EWS_Final-External-Report.pdf .

Nalco's 3DTRASAR technology allows to recycle 175000 m^3 water per year

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The case relates to a major chemical plant located in northern Europe manufactures plastics and intermediates. As part of its commitment to sustainability, the company drives a continuous focus on the identification of new ways to optimise water usage, minimise wastewater emissions, and to reduce costs across its operations. At this particular manufacturing plant, a specific goal has been established to reduce fresh (city) water consumption by 27% by the end of 2015.

A project was initiated with the objective to recycle wastewater currently being collected and discharged directly from the site.

By implementing 3D TRASAR technology, the plant has been able to recycle the wastewater stream to the cooling system, and replace 65% of the current potable water demand.

The demand for potable supply has been reduced by 175,200 m^3 per year, fresh potable water supplies have been conserved, the environment protected, and savings of around €85,000 per year have been realized. The overall reduction in the use of potable water on site has conserved precious water resources equivalent to the annual needs of 3,000 people.

About 3DTRASAR Technology

The 3D TRASAR cooling water management programme delivers on-demand control and optimisation of cooling water chemistry and microbiology, continuously protecting the system from corrosion, scale formation, and microbial infection.

3D TRASAR technology control systems take account of the inherent variability in system water conditions, maintaining protection from corrosion and scale by prediction of problems, and intervening before they occur. The programme controls system chemistry, dosing on-demand, and minimising the amount of materials added to the system, minimising costs without prejudicing system integrity.