the blue circle

The Blue Circle project is the answer to the industry's quest to close industrial loops of raw materials. The trajectory focusses on sustainable reuse of water and salt streams.

THE PROJECT IN BRIEF

BUDGET

€ 1.700.000

VLAIO'S CONTRIBUTION

€ 1.360.000

STAFF

+/- 200

man months

PROJECT COORDINATION

Flanders Water Technology Network
(TNAV)

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48
corporate project members

8
project partners

7
demonstrations

12
material streams investigated

DURATION

July 1st 2012 - June 30th 2016

RESULTS

Within the Flemish industry the project identified 12 frequently encountered problematic streams containing salts. Aiming at water reuse and possibilities for reuse of the salts, we investigated each stream and we have conducted pilot-scale demonstrations for the most promising technologies. Overall, some important goals were reached.

INCREASING WATER RECOVERY WHEN CLOSING THE WATER CYCLE

- Water recovery of reverse osmosis (RO) for the production of process water can increase by 10 to 20% by combining it with a cationic exchange pre-treatment.
- For complex waste streams, originating from the wastewater treatment sector and tank cleaning sector, the water recovery can increase up to 90% with ultrafiltration (UF) and RO.

DEVELOPING AN ECONOMICALLY FEASIBLE SOLUTION FOR THE REUSE OF SALT STREAMS

- Through the combination of nanofiltration (NF) and membrane distillation (MD), we managed to recover the regenerant of an ion exchange system for reuse as fresh regenerant.
- From the regenerant of ion exchangers for the production of demineralized water, we can recover acids and bases through electrodialysis with bipolar membranes or we can recover sodium chloride through nanofiltration-membrane distillation.
- By applying electrodialysis, we can recover sodium sulphate, which can be reused in the food sector. Using activated carbon we achieve the same for textile dyeing processes.
- By combining nanofiltration and electrodialysis, we can separate organics and sulphates from sodium chloride, after which we can reuse the sodium chloride for the regeneration of the ion-exchange resin serving the production of process water.

INNOVATIVE TECHNOLOGIES FOR THE SEPARATION AND CONCENTRATION OF SALT STREAMS WERE VALIDATED

- We separate monovalent from multivalent ions with nanofiltration.
- Nanofiltration and electrodialysis enable metal contamination to be separated from salts.
- Nanofiltration and electrodialysis are suitable techniques for separating salts and organic material coming from an olive pickling process.

VALORISATION OF SALT STREAMS

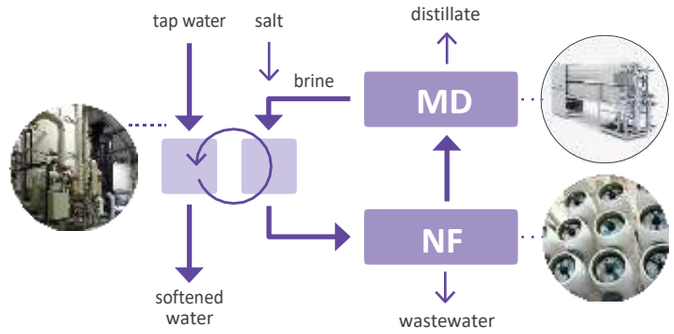
- Nanofiltration and electrodialysis achieve a recovery of 65-100% of ammonium nitrate from the chemical industry's nitrogen-rich wastewater streams. After removal of metals this can be used as a fertiliser.
- Organic matter from ion-exchange regenerant streams can be applied in agriculture after treatment by nanofiltration-electrodialysis.
- Salty waste streams can be applied in aquaculture in innovative ways. If compliant with high quality demands, fish can be raised in salty wastewater.

SUCCESS STORIES

More local reuse of water and salts

REUSE OF THE REGENERATION OF ION-EXCHANGERS

Ion-exchange is a preferred technology in industry to soften process water. With the regeneration of the resins, a salt stream is produced which contains high concentrations of NaCl with lower amounts of $CaCl_2$, $MgCl_2$ and other salts. Treatment of this waste stream through nanofiltration (NF) combined with membrane distillation (MD) allows the reuse of both salt and water for the regeneration of the resins.



RESULTS

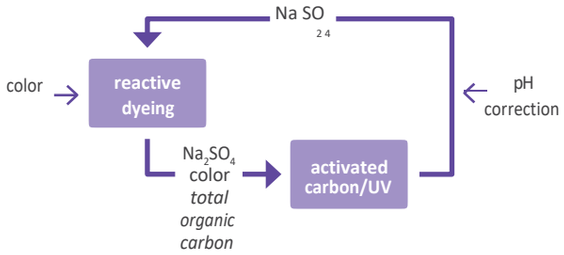
The NF-MD technique was demonstrated successfully at pilot scale at Ecover in Malle, in collaboration with Aquaver.

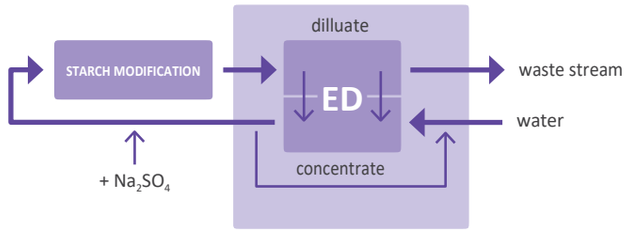
- The complete mixed regeneration stream was treated. Up to 84% of the water could be reused. This means that only 16% of the mixed regenerant was discharged as NF concentrate.
- The MD subsequently concentrates the NF concentrate. The MD concentrate can be reused for the regeneration of the ion exchanger (IEX). This results in savings of up to 70% of the salt, with only a limited decrease (4%) in the capacity of the resin.
- The produced MD distillate is a high-quality water stream that can be used in the regeneration process.

The operating costs are estimated at less than € 25/m³ of regenerant for average-sized and large installations. If the discharge costs surpass € 200/m³, local reuse becomes interesting for flows of 2.5m³ up to as much as 50m³ per day.

RECOVERY AND RECIRCULATION OF NA_2SO_4 AS A CATALYST IN A CHEMICAL PROCESS

Sodium sulphate is used in the food and textile industries, amongst others. The compound usually ends up in the wastewater of the manufacturer after use. Depending on the application, both activated carbon and electrodialysis can serve as techniques for the separation of the organic matter and sodium sulphate, enabling the local reuse of the latter.





RESULTS

Activated carbon was successfully used for the treatment of wastewater coming from a dyeing process at Monks International in Wielsbeke. The pilot project was executed in collaboration with Desotec. During another test, in collaboration with DVD Technology a.c.k. aqua concept Benelux, the wastewater was subjected to a UV treatment. Both tests produced comparable results.

- Up to 90% of the organic load was removed.
- Through the selective removal of organic compounds, up to 100% of the water and sodium sulphate present in this stream can be reused in new dyeing processes.

Electrodialysis was demonstrated successfully at pilot scale for the treatment of a sodium sulphate stream coming from a starch modification process at Cargill in Sas van Gent, in collaboration with IEC.

- Up to 85% of the sodium sulphate could be recovered. As part of the stream is used as the initial concentrate, 33% of the water is reused.

In all three cases, the technique is economically viable only if the waste stream has to be discharged at high cost. In the food sector the limit lies at € 50/tonne when applying electrodialysis. In the textile industry, treatment with activated carbon becomes interesting when the discharge cost surpasses € 200/tonne.

RECOVERY OF WATER FROM COMPLEX WASTE STREAMS

The wastewater treatment and tank-cleaning sector are faced with very complex waste streams. Recovering water from these streams is a big challenge. A combination of different membrane technologies is the solution. By only treating part of the wastewater, the discharge limits are not compromised.

RESULTS

Ultrafiltration (UF) followed by reverse osmosis (RO) and UF followed by forward osmosis (FO) and membrane distillation (MD) were tested on two different waste streams coming from the tank-cleaning sector.

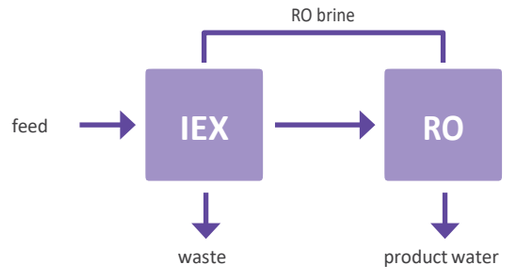
- Depending on the composition of the streams, a physico-chemical pretreatment may be necessary.
- UF-RO results in 75-90% recovery of the treated water; the combination UF-FO-MD achieves a recovery of 75-98%.

The high energy demand of MD makes the combination UF-FO-MD economically and ecologically uninteresting. The combination UF-RO is economically interesting, provided that only part of the wastewater is treated.

More efficient water recovery

INCREASING THE WATER RECOVERY OF A REVERSE OSMOSIS INSTALLATION WITHOUT THE USE OF ANTI-SCALANTS

Scaling is a problem often encountered when using reverse osmosis (RO) for the production of process water. To increase water recovery when scaling occurs, without the addition of anti-scalants, we can include an ion-exchange process (IEX) in the treatment scheme. IEX removes the multivalent cations (calcium, magnesium etc.) which are responsible for scaling. This results in the production of an RO concentrate rich in monovalent ions, which can be used for the regeneration of the IEX.



RESULTS

The IEX-RO process was demonstrated successfully at pilot scale at Induss in the port of Ghent in collaboration with Eurowater.

- We can increase the water recovery from 75% (with anti-scalants) to 85% (without anti-scalants). The increased RO recovery results in 12% water savings for the company. If we also reuse the RO concentrate for the IEX regeneration process, the water savings increase to 20%.
- To ensure an efficient regeneration of the IEX resins with the RO concentrate, a limited amount of NaCl needs to be added to the RO concentrate. Compared to classic IEX regeneration, 67% less salt is needed. The addition of NaCl is not necessary if the concentration of sodium and potassium in the feed is higher than the concentration of calcium and magnesium.

This technique is economically viable if the RO concentrate is recirculated for the regeneration process. Promising results were also obtained for other water types (e.g. treated wastewater). This indicates that the technique is widely applicable.

CONTINUING CHALLENGES AND FUTURE OUTLOOK

Water reuse is being applied more and more. Thanks to the technological evolutions obtained during the Blue Circle project, the efficiency of water reuse in industrial processes can be significantly increased – and without the need for additional chemicals. However, the sector still faces some challenges.

REGULATORY DISCHARGE POSSIBLE?

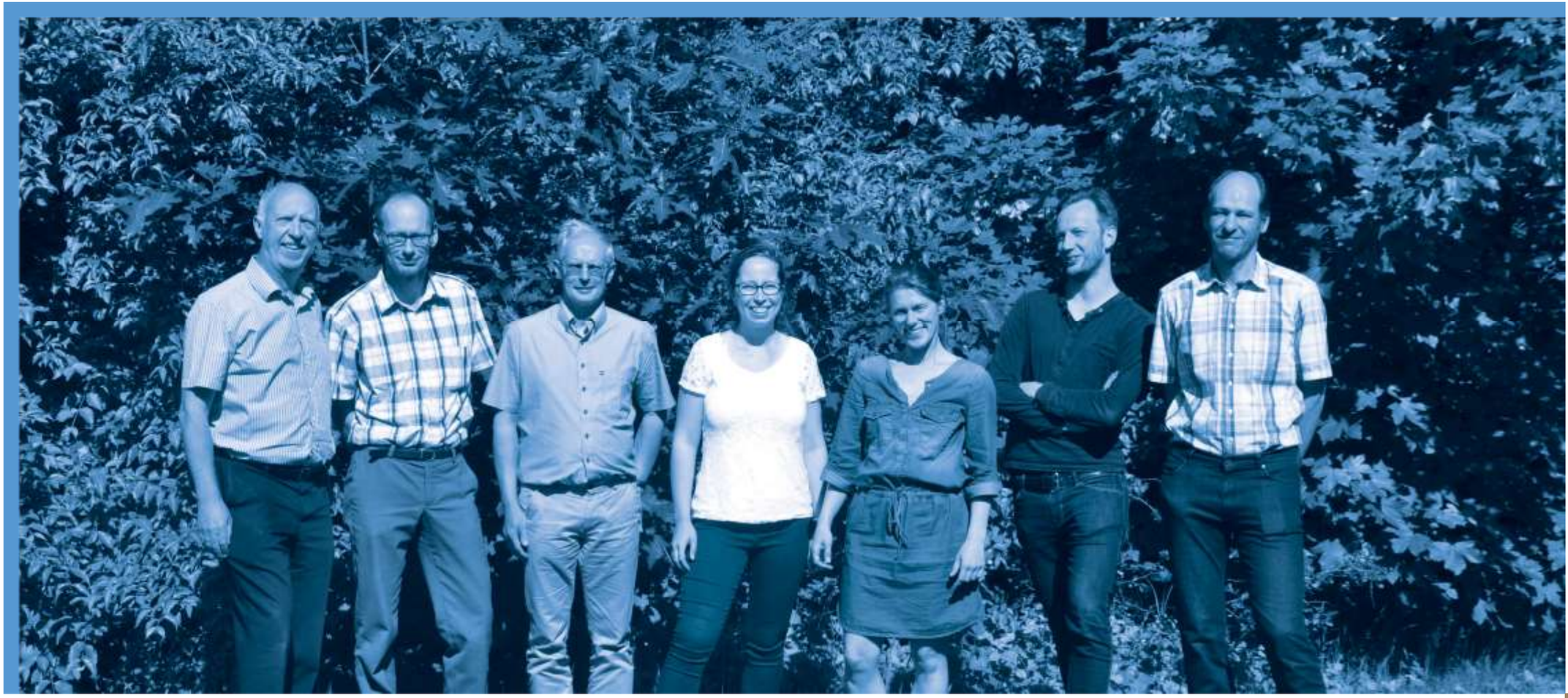
By applying the techniques from our research, a more concentrated waste stream can be produced: the removed solutes (salts, N, P, COD etc.) are contained in a smaller volume of wastewater, whilst the contaminant load remains the same. It is unclear if discharging these concentrated waste streams falls within the environmental permit of the company. In other words, there is a need for a clear, systematic approach, in which it is possible to determine beforehand whether a permit can be obtained for the discharge of a more concentrated waste stream at a lower volume. The industry demands clarity, to avoid confusion impairing the implementation of water reuse.

THE NEED FOR A LEGAL FRAMEWORK

Adding value to salt waste streams by reusing the salt appears to be possible only if the salt is pure enough or if internal valorisation is possible. In many cases, this is only economically viable if the salt rich waste stream can only be processed externally at a high cost and cannot be discharged. The market value is currently too low to externally market the recovered salts. Furthermore, administrative and legal hurdles (REACH legislation, e.g. registration and distribution as fertiliser in agriculture etc.) too often prevent valorisation of the limited volumes. Here as well there is a need for a good, unambiguous legal frame, which clearly shows the steps needed to market a recovered salt.

INCREASING KNOWLEDGE

Another important bottleneck for the valorisation of salts is their purity. Research within the Blue Circle project has shown that binary mixtures (two different salts or a mixture of salts and organics) can be usefully recovered in some cases. For more complex mixtures, there is a need for more research into new technologies for the selective crystallisation or recovery of pure salts as a (semi-solid) product. At present, there is limited knowledge of these technologies in Flanders, because of the limited economic value of the salts and the vague legal framework around their marketing.



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