How PWNT's SIX® treatment can effectively remove DOC

Some waters have elevated concentrations of DOC (dissolved organic carbon), especially in sources such as surface waters that are under the influence of secondary effluent, recreation, heavy population, farming and industry. Climate change also results in higher DOC concentrations in surface water globally.

For water with elevated concentrations of DOC, the usage of IX (Ion eXchange) as a pre-treatment will help in the removal of colour and increase efficiency in all downstream processes, including coagulation, membrane filtration, AOP and GAC. As with these affected water, it also contains suspended and colloidal matter, hence, making it nearly impossible to use the standard state-of-the-art fixed bed IX columns. This is due to the beds fouling quickly (i.e., head loss build-up) with the suspended matter and functioning as a filtration bed than as an adsorption media.

To treat these heavy polluted waters, the technologies are based on fluidized bed reactors or totally-mixed reactors with very high concentrations of resin. In these processes, the bed volumes are treated until regeneration are designed to be as high as possible — the goal is to remove as much of the pollutants as possible to lower the salt consumption needed for regeneration [Slunsjki, 1999]. This approach has a few disadvantages as it makes the treated water less attractive to use (i.e., more expensive). But more importantly, for some waters, the anion ion exchange process may not be feasible. This is so as the polluted waters often contain AOC (assymmable organic carbon) and phosphates, which will be adsorbed. Together with the large detention times (used to minimise the number of regenerations) and porous resin beads, the perfect environment for bacteria to grow is created. In addition, biofilm forms on the resin to blind the active groups of the resin, which is known as "resin blinding". Resin blinding occurs slowly but can lead to serious problems. Besides losing adsorption capacity [Wachinski, 2006], it leads to the need to operate with a higher resin concentration or longer contact time [Verdickt, 2011; Cornelissen 2009], thus, increasing operational costs and/or lowering plant capacity. In fact, with time, the biofilm starts to release organic matter or adenosine triphosphate (ATP) that can be detrimental to downstream processes [Cornelissen, 2010], especially membranes.

To overcome resin blinding, fixed bed or fluidised reactor systems are flushed with a high pH solution on a periodic basis to kill and dissolve the biofilm as much as possible. But these fixed beds cannot treat waters with suspended matter. For some commercial resins like the MIEX® hydrophobic resin, it is not possible to use high pH (hydroxide ions) to control biofilm development as the resin is not resistant to hydroxide, and with exposure, would begin to fall apart over time; shortening the lifetime of this relatively expensive resin.

These issues have led to the development of a new ion exchange process [Galjaard, 2009] by PWNT. Compared to the other ion exchange processes which treat waters containing suspended matter, the 'single pass' or 'suspended' ion exchange process (SIX®) achieves full control of the adsorption process without (serious) 'blinding' the resin or producing biomass, hence, producing optimum sorption kinetics and reduced contact times. This can be done with any resin that is commercially available, and the resins used to date can be treated with hydroxide for biofilm control, if necessary.

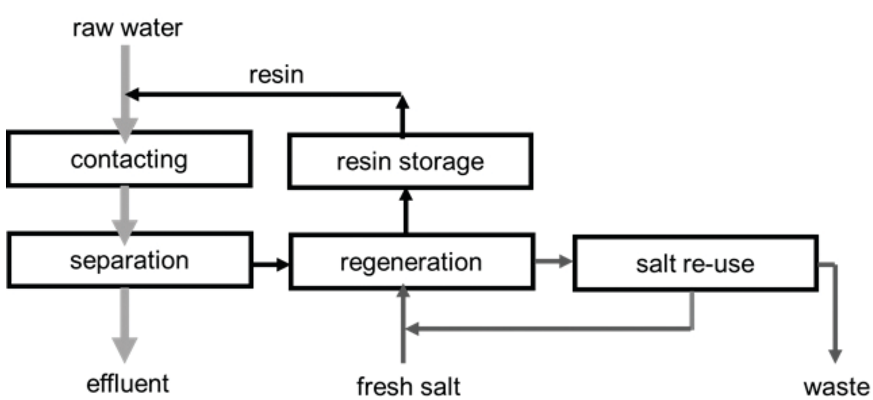


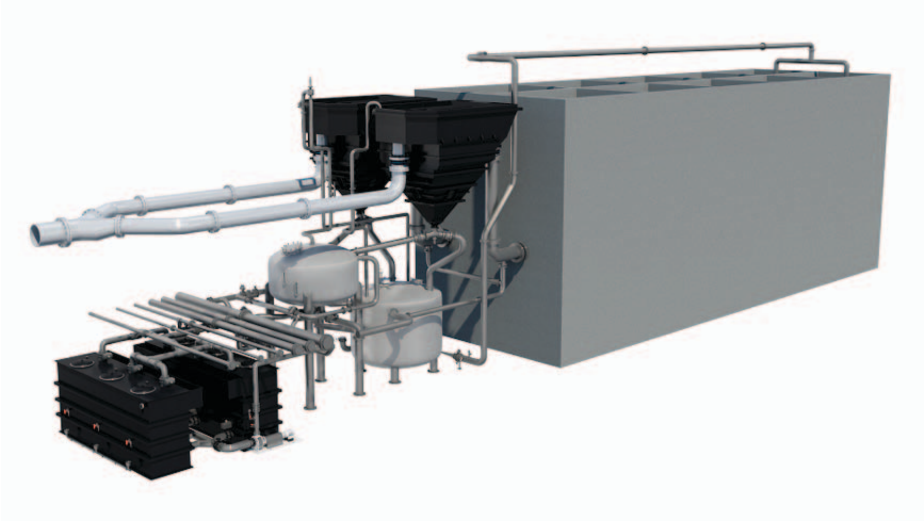
Figure 2: Schematic of the SIX® process

The SIX®-process: Basic principle

In the SIX® process, resin is dosed from a dosing tank into the raw water at a low concentration of four to 20ml resin/L, depending on the raw water quality, desired treated water quality, and resin type. This mixture then flows through the plug flow contactors where the resin has the same residence time as the treated water; because the resin travels together with the water through these contactors. Unlike packed bed systems in which the resin is retained in the contactors, all resin particles are exposed to equal conditions, leading to homogeneous distribution of the adsorbed matter over these particles. This gives rise to a more stable and superior process performance as well as more efficient use of the counter anion (Cl-) during regeneration.

The number, shape, and design of the contactors play an important role in the adsorption kinetics of this process. The aim of design is to approach the ideal contactor system of a plug-flow reactor [Ramaswamy, 1995], leading to shorter residence time of the resin, and therefore, shorter contact times. After the contact time in the contactors, the resin is separated from the treated water using a customised lamella settler. The resin collects in the hopper and is immediately regenerated and returned to the dosing tank (Figure 2).

Knowing the exact residence time of the resin makes it possible to regenerate all of the resin equally — leading to an equally low number of regenerations. The relatively short contact time (e.g., 10 minutes < t < 30 minutes) of the treated water with the resin before the regeneration procedure makes it difficult and almost impossible for bacteria to grow on the resin particles surface. This overcomes the problem of resin blinding and ensures that the resin continues to operate at stable adsorption kinetics. This is shown with the help of a pseudo first-order reaction according to Lagergren, for which reaction constants can be determined using jar tests (Koreman 2013).



Since 2014, several studies have been conducted with this new process on several sites or utilities in Europe. For instance, the studies were conducted with South West Water (UK), Scottish Water (UK), Stockholm Water and Waste VA (S), Norrvatten (S), Welsh Water (WW, UK), Anglian Water (AW, UK) and PWN (the Netherlands) to investigate the initial feasibility of the SIX® process. It was concluded that suspended ion exchange SIX® resulted in substantial removal of NOM (55 – 85 per cent) and colour (60 – 80 per cent) for moderate resin concentrations (10 – 20 mL/L) and contact times (20 – 40 minutes). The scenario of SIX®, in combination with coagulation can be considered a serious DOC reduction option for utilities facing challenges. The process already led to full-scale design at PWN and South West Water and to serious full-scale consideration for Stockholm Vatten, Norrvatten and Scottish Water. **WWA**

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The Interreg 2 Seas DOC2C's Programme

The Interreg 2 Seas DOC2C's project is an extensive research programme to investigate the possibility of improved dissolved organic carbon (DOC) removal from source waters in the European 2 Seas Area. Therefore, the DOC2C's Consortium, consisting of PWNT (NL), South West Water (UK), De Watergroep (BE), Lille University (FR) and Delft University of Technology (NL) received a grant from the Interreg 2 Seas Programme to significantly improve and accelerate innovation in drinking water treatment by collaboration within the 2 Seas area. This project is co-financed by the Dutch Government, the Province of North Holland (NL) and the Province of West Flanders (BE). The DOC2C's project will cover a period of four years. SIX® is one of the water treatment technologies that can be considered to reduce DOC effectively.

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