DESIGN AND CONSTRUCTION OF THE WORLD'S FIRST LARGE SCALE MIEXÒ WATER TREATMENT PLANT

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EXECUTIVE SUMMARY

The Water Corporation of Western Australia has over a number of years been investigating various water treatment technologies aimed at dissolved organic carbon (DOC) removal. Research was prompted by intermittent outbreaks of DMTS (Dimethyl Trisulphide) in the clearwater distribution system. The presence of DMTS in tap water is noted as a "swampy" odour, and is suspected to be the product of biological action in the distribution system. DOC in the treated water promotes biofilm growth in the distribution system, and this coupled with NSRS (non-sulphide-reduced-sulphur) in the water leads to DMTS formation (Franzmann et al 1999). With elevated levels of DOC linked to the formation of DMTS, the MIEX® Process was trailed at Wanneroo Groundwater Treatment Plant (GWTP), a currently used source of DMTS affected water.

After two years of pilot plant and laboratory work, the Water Corporation of Western Australia has initiated the design and construction of the world's first large scale MIEX® plant. Black and Veatch Australia has been appointed as the Engineer, Procure and Construct (EPC) contractor for delivery of the MIEX® plant at Wanneroo groundwater treatment plant. The total cost of the EPC contract is on the order of $15M AUD. The full scale MIEX® train will have a capacity of 112.5 MLD, and include the provision for a second train to be added if required. The existing Wanneroo plant has a peak capacity of 225 MLD with a variety of bores (50 in total) supplying the raw water.

The MIEX® Process differs from conventional ion exchange technology in that the ion exchange part of the process is continuous. The resin is regenerated in a separate area of the plant. The particle size of the resin is considerably smaller than conventional ion exchange resins (150 to 180 microns). High recovery rates of 99.9% are possible due to the magnetic properties of the resin. Once mixing energy is removed, the resin beads attract to one another to form large agglomerates with a high settling velocity (25 m/hr). This affords the use of settling tanks with up flow rates in the region of 10 to 15 m/hr.

The general layout of the MIEX® plant consists of two mixed Contactor tanks feeding 6 hopper bottomed Settlers. The regeneration facility uses two regeneration vessels with one Regenerant Tank. Two salt saturating systems are used to prepare and deliver the brine solution for the Regenerant Tank. Hydrochloric acid and sodium hydroxide dosing facilities are provided for regenerant preparation. The hydraulics of the existing Wanneroo plant dictated that a low lift Pump Station be used, to lift the treated water for gravity flow into the existing Clarifiers.

The MIEX® plant is being constructed on the existing Wanneroo GWTP site as a retrofit. Located at the head of the works after the aerator, the plant will treat the raw water prior to alum coagulation, clarification and filtration in the existing plant.

The main driver for DOC removal is the control of DMTS outbreaks. Another benefit is the reduction in chlorine demand during water treatment, and resulting in chlorine residuals extending further into the water distribution network, without supplementary chlorine dosing. A lower overall chlorine dose is therefore required to achieve the desired chlorine residual. The reduced DOC and chlorine levels also contribute to lower levels of dis-infection by-products.

KEY WORDS
Ion Exchange, MIEX®, Di-methyl-tri-sulphide, Dissolved Organic Carbon, Water Treatment

INTRODUCTION

The Wanneroo Ground Water Treatment Plant (GWTP) is a conventional water treatment plant, using aeration, coagulation, clarification and filtration steps. The plant is capable of a maximum flow of 225 MLD, and draws water from a borefield consisting of both shallow and deep artesian bores. The raw water quality can vary greatly, depending on the number and type of bores feeding the plant at any particular time. During periods of high flow, the raw water contains high levels of naturally occurring dissolved organic carbon (DOC) of up to18mg/L. Not all the DOC is removed in the conventional treatment process, with the clearwater for distribution still containing up to 5mg/L of DOC.

DOC and NSRS have been recognised as precursors for DMTS formation in the water distribution system. DMTS outbreaks are intermittent, and do not follow a pattern with respect to the geographical spread from the plant reservoir. Research into the formation of DMTS has revealed that biological action in the distribution system produces DMTS, with DOC playing a major part by acting as the organic source. For the Wanneroo GWTP, a number of technologies aimed at reducing the level of DOC further were investigated. The MIEX® Process, which uses an ion exchange resin that reduces the DOC in the raw water after aeration and prior to coagulation, was identified as the most practical and lowest cost treatment option.

The MIEX® Process differs from conventional ion exchange technology in that the ion exchange step is carried out on a continuous basis, while the regeneration step is performed in a batch operation. This allowssteady state conditions to be maintained in the ion exchange area of the process. The resin particles are also smaller (150um) than conventional ion exchange resins. Following contact with the raw water, a magnetic component within the resin matrix allows the particles to form larger agglomerates that settle out at a high rate (25m/hr).

A 1MLD pilot plant was operated at the existing Wanneroo GWTP, in conjunction with laboratory tests, over a period of two years. Winter and summer bore combinations were tested with the aim of generating process performance data for all likely operating scenarios. Removal figures showed that approximately 60% reduction in raw water DOC could be achieved prior to alum coagulation, which further reduced the DOC concentration to around 1.5 to 2.0 mg/L.

Based on the pilot plant performance, the Water Corporation of Western Australia has chosen the MIEX® Process over ozonation- BAC and BGAC as a new treatment step for the Wanneroo GWTP. The Water Corporation has selected Black and Veatch Australia as Main Contractor for the Engineering, Procurement, and Construction (EPC) of the MIEX® plant. This paper discusses the design of the new MIEX process planned for Wanneroo.

Plant Process Design

The large-scale Wanneroo MIEX® plant consists of two 400m^3 concrete Contactors, in which the MIEX® resin and raw water are intimately mixed. The minimal contact time of 10 minutes is applicable at full flow conditions. The resin concentration in the Contactors may be varied, to suit raw water quality and plant flow at any time.

The resin / raw water mix flows from the Contactors to six concrete hopper-bottomed Settlers. The Fitch-type feedwells inside the Settlers encourage inter-particle contact, while decreasing the velocity head of the inlet stream. The gentle flow conditions inside the feedwells allow the magnetic forces of attraction between the resin particles to take effect, resulting in larger agglomerates of resin to form and settle out into the hopper bottoms. The feedwell depth extends to the point in the Settlers where the hopper-bottom section begins, maximising the opportunity for resin coagulation and settlement. The maximum rise rate in the Settlers of 15 m/h allows 99.9% recovery of the resin in the Settlers. The Settler overflow of MIEX treated water then rejoins the existing conventional process stream upstream of the Plant Clarifiers. The resin slurry is collected at the base of the Settlers, and pumped back to the head of the process to either return to the first Contactor, or be taken off for regeneration.

A percentage (5% to 10%) of the resin slurry is removed from the recycle stream, and diverted to the regeneration facility. Resin regeneration is accomplished using a 12% brine solution (the regenerant). Although the regenerant increases in DOC and sulphate concentration with each regeneration step, the regenerant can be used for multiple regenerations. The regenerant has been reused up to 9 times on pilot plant trials while laboratory data supports the possibility of up to 12 reuses. Each reuse cycle requires an adjustment of the regenerant, returning the chloride concentration to the original starting point prior to the next regeneration cycle.

Once regenerated, the resin is dumped from the Regeneration Vessel into the Fresh Resin Tank, from where it rejoins the MIEX® Process in the first Contactor. The rate at which the fresh resin is delivered to the process matches that of the resin that is removed from the stream for regeneration. This maintains a constant resin concentration in the two Contactors.

The brine solution is prepared in storage-type Salt Saturators, as used in the chlor-alkali industry. Two such Saturators are used in the process. A “Clean” Saturator provides the regeneration facility with a fresh charge of brine for the first regeneration. The second, “Dirty” Saturator is used to saturate a portion of the used regenerant with brine for the 9 reuse cycles.

The MIEX® Process is illustrated in figure 1.

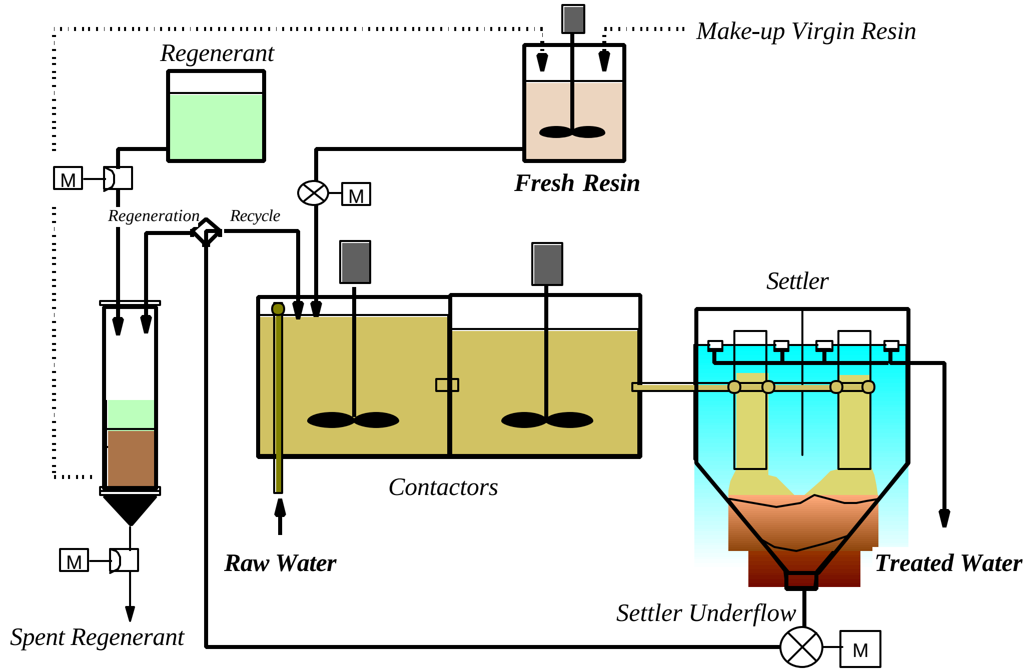

Figure 1 MIEX Ò Process flow diagram

MIEX Process Performance

Pilot trials and laboratory work have provided conclusive results indicating that the MIEX® Process, and alum coagulation, or other chemical coagulation, complement each other, regardless of process order. For the raw water at Wanneroo GWTP, it was found that the MIEX® Process favoured the lower molecular weight fraction of DOC, while alum coagulation removes the larger molecular weight DOC components. This results in impressive reductions of DOC through the plant. Figure 2 below illustrates the DOC removal performance on raw water with MIEX® treatment only. A final DOC of less than 2 mg/L is achieved through the combination of MIEX® treatment and enhanced coagulation (M Slunjski 1999), assuming an incoming raw water DOC of 9.5 mg/L

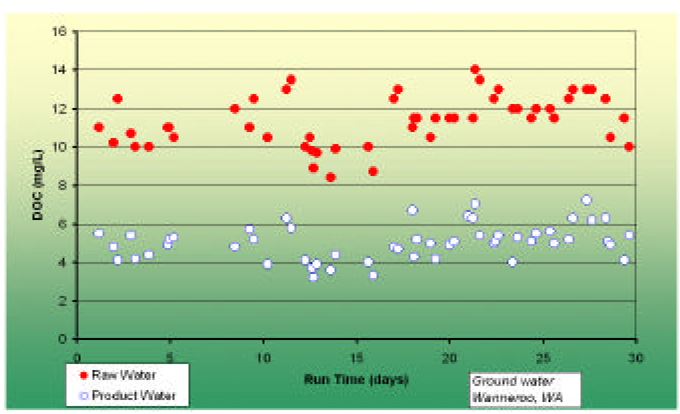

Figure 2. DOC Removal from raw water using MIEX Ò resin

In the Wanneroo trials, enhanced coagulation alone could not match the reductions in DOC, NSRS and THMFP (Trihalomethane formation potential) that MIEX® treatment, together with enhanced coagulation, achieved. The results from pilot trial 2 showed that 75% and 90% reductions in DOC and NSRS respectively could be achieved through MIEX® and coagulation treatment. An 85% reduction in THMFP also resulted from jar tests during trial 2. This was achieved using an alum dose of 20 to 25 mg/L for the MIEX® treated water, while enhanced coagulation alone required the larger dose of 80 mg/L. Figure 3 below illustrates the reductions in THMFP and NSRS achieved with MIEX® treatment alone, enhanced coagulation and MIEX® treatment with alum coagulation.

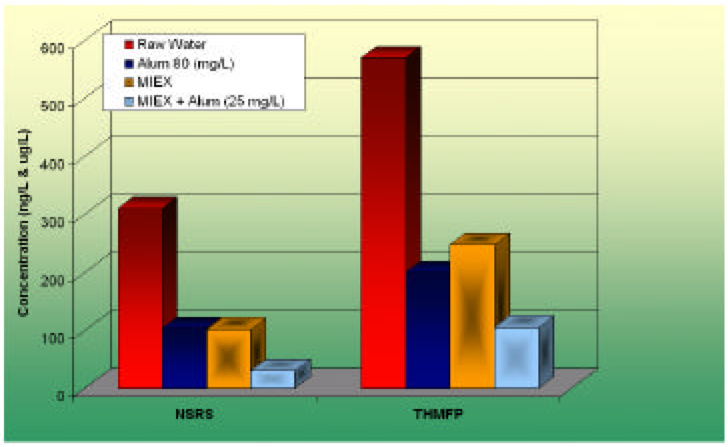

Figure 3. NSRS and THMFP results using Alum alone, MIEX Ò and MIEX Ò + Alum

Removing the smaller DOC fractions prior to coagulation enables more efficient use of the coagulant. Jar tests have shown that MIEX® treated water, with a coagulant dose of 1/3 the conventional dose, can produce a higher water quality, in terms of DOC, than conventionally treated water. The lower coagulant dose also creates less of a pH depression, placing less demand on pH correction after coagulation. The treatment process downstream of MIEX® treatment will therefore operate using reduced chemical dose rates, and therefore produce less sludge.

The process advantages described above can be achieved for the existing Wanneroo GWTP by constructing a MIEX® plant, located at the head of the treatment stream.

Resin loss

The 99.9% recovery figure is based on the resin mass leaving the MIEX® Process in the treated water stream. The indicated 0.1% loss rate is in the form of attrited resin, which can no longer attach itself to the bulk of the resin particles in the Settler feed. These smaller resin particles escape the process with the treated water discharged from the Settler overflow. A certain degree of resin attrition is unavoidable, due to resin transport/pumping and mixing in the process units. The use of low shear mixers and low shear pumps will minimise resin loss.

Plant Hydraulic Profile

The hydraulic profile as shown in Figure 4 illustrates the main process stream, consisting of the Contactors, Settlers and Pump Station. The existing levels between the Clarifiers and the Aerators required the Settler hopper-bottoms to be constructed to a depth of approximately 5m below ground level. The design of the single MIEX® train includes the provision for a second train, if required in the future.

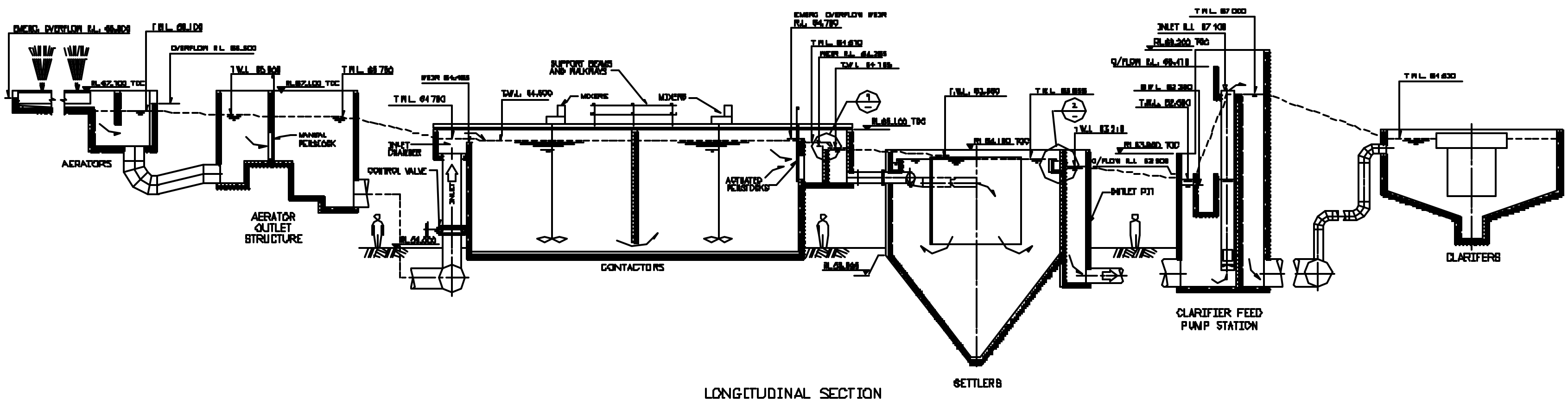

Figure 4. Hydraulic profile

CONCLUSIONS

With more stringent water quality requirements being implemented worldwide, water utilities now have the option of utilising a range of new technologies for meeting these requirements. When coupled with an existing conventional treatment plant, MIEX® water treatment can result in substantial DOC reduction, while using a lower coagulant dose. A more stable water, in terms of chlorine demand, is produced, reducing operating costs by using a lower overall chlorine dose. The capacity of the water to form disagreeable disinfection by-products (THM s) is also reduced.

Utilisation of the MIEX® Water Treatment Process represents an effective means for achieving enhanced water quality, at a reasonable cost.

ACKNOWLEDGEMENTS

The MIEX® resin was developed jointly by Orica Australia and CSIRO Molecular Science. SA Water Corporation and Orica developed the MIEX® process technology. The Water Corporation of Western Australia developed the process further for large-scale application. GHD assisted with the full-scale concept and detailed design.

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