USE OF A CONTINUOUS ION EXCHANGE PROCESS (MIEX®) TO REMOVE TOC AND SULFIDES FROM FLORIDA WATER SUPPLIES

Michael Bourke, US Market Manager, Orica Watercare Inc.

Introduction

Many Florida water utilities face a number of challenges in treating their water supplies to meet the current EPA water quality standards. These challenges will only increase as the EPA tightens these standards and for many utilities, conventional treatment processes will no longer be suitable.

Ion exchange has long been recognised as a technology capable of removing many dissolved compounds from water that cause water quality problems but short-comings such as high capital costs and resin fouling have limited its use in large scale water treatment plants. A new magnetic ion exchange resin (MIEX®) has been developed in Australia for use in a continuous ion exchange process that overcomes many of the problems associated with conventional ion exchange systems and makes this technology economically feasible for large water treatment plants.

A number of laboratory evaluations have been performed on Florida water sources including raw water from Pasco County, Aloha Utilities, Tampa Bay Water and Miami-Dade's Preston and Hialeah water treatment plants. These tests demonstrated very efficient removal of TOC and a significant reduction in the disinfection by-product formation potential of these waters. A trial was conducted at Pasco County over several months during 2000 with the primary objective of reducing sulfide levels. Results indicate very good sulfide removal and the additional benefit of TOC removal which will allow the County to meet future EPA disinfection by-product standards.

This paper discusses in detail the MIEX® technology, results of laboratory and pilot plant tests performed on Florida waters and where MIEX® can be best applied in solving water quality problems encountered in Florida.

The MIEX® Technology

The MIEX® resin has been specifically designed for the removal of dissolved organic carbon (DOC) from drinking water supplies. DOC typically makes up 80 to 90% of the total organic carbon (TOC) measured in water supplies. The negatively charged DOC is removed from water by exchanging with a chloride ion on active sites on the resin surface. The MIEX® resin is a micro size, macroporous, strong base, magnetic ion exchange resin, developed for the reversible removal of negatively charged organic ions.

The resin also has a very small particle size with a mean particle diameter of only 180μm. While the specific surface area is comparable to other conventional macroporous resins, the MIEX® resin has a lot more external bead surface area. This benefits the DOC exchange kinetics (less controlled by particle diffusion) and the resistance to fouling (less DOC exchanged into the particles due to shorter diffusion paths within the smaller beads)[1].

MIEX® resin is not limited to only DOC removal and will remove other negatively charged ions (anions) from water such as sulfates, sulfides and arsenate. The extent of removal of these anions depends on the competition between other anions in the water source. Very good removal of both sulfides and TOC has been achieved in a trial at Pasco County and these results will be discussed later in this paper.

Unlike conventional ion exchange processes, the MIEX® resin has been developed to enable removal of DOC to occur in a stirred contactor, much like a flash mixer in a conventional water treatment plant. Under mixing conditions, the resin beads are uniformly dispersed in water to maximise the kinetics of DOC exchange. This reduces the resin inventory in contact with water to only 2-12% of that normally associated with conventional ion exchange processes.

A magnetic component is built into the resin particle structure so that when mixing is removed, the fine resin beads rapidly agglomerate into larger, fast settling particles. This enables conventional up-flow settlers to be used for resin-water separation. While the treated water overflows from the settler, the resin is recovered as a concentrated underflow stream. The efficiency of resin recovery exceeds 99.9% at very high settler rise rates (4 gpm/ft^2). A small amount of recycled resin is continuously removed for regeneration and replaced with regenerated resin. A schematic of the process is shown below in Figure 1.

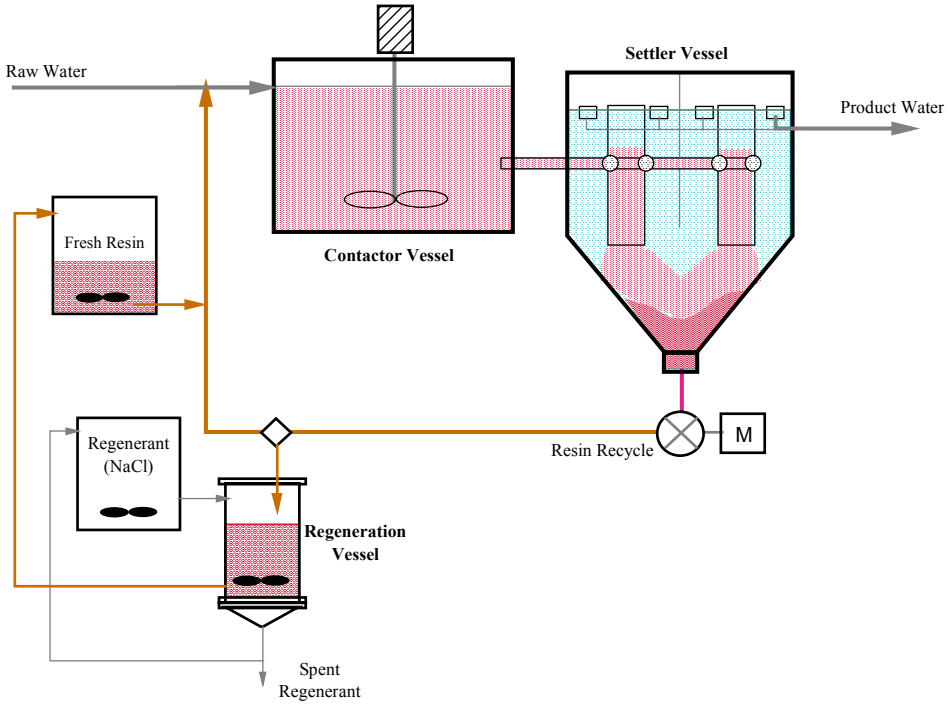

Figure 1: Flow diagram of the MIEX® continuous ion exchange process

TOC Removal and DBP Reduction

Trials in Australia have shown that MIEX® resin, used in a continuous ion exchange process, is highly effective at removing low and medium molecular weight TOC and can achieve greater removals of TOC than enhanced coagulation[1].

There are many water sources, particularly in the South East and Mid Atlantic regions of the US, where coagulants cannot achieve the required TOC removal due to the characteristics of the TOC. Coagulants are effective at removing the high molecular weight fraction of TOC but remove very little of the lower molecular weight fraction. Research shows that MIEX® resin preferentially removes the low to medium molecular weight fraction that is not removed by inorganic coagulants even at very high coagulant doses. This has been demonstrated on a groundwater source in a trial at Wanneroo, Perth, Western Australia (Figure 2)[2].

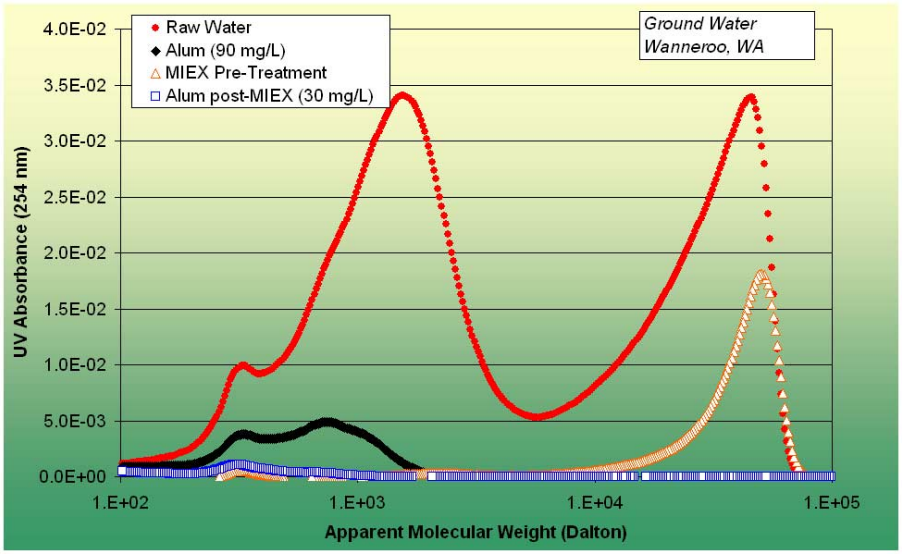

Figure 2: Characteristics of TOC removed with MIEX® resin and Alum on Wanneroo ground water, Western Australia.

A laboratory study performed by the University of South Florida (USF) in 2000 on Pasco County ground water sources also demonstrated that MIEX® resin can remove a greater fraction of TOC than enhanced coagulation (Figure 3). USF's laboratory study also showed a significant reduction in the THM formation potential of the raw water sources after MIEX® treatment, as would be expected with lower TOC levels (Figure 4).

In a subsequent pilot plant trial conducted at Pasco County's Little Rd Water Treatment Plant, an analysis of the molecular weight profile of the TOC before and after treatment with MIEX® resin showed this TOC to be predominantly of low molecular weight (Figure 5) which is consistent with the greater amount of TOC removed compared to enhanced coagulation.

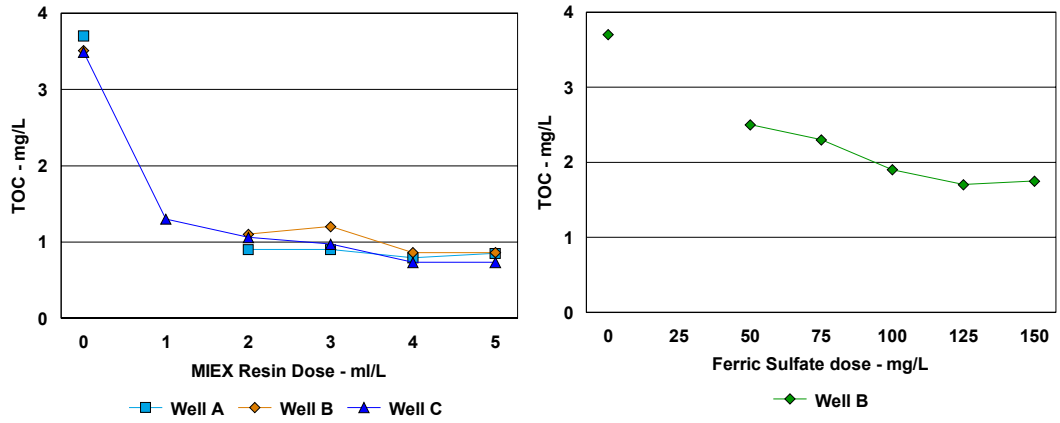

Figure 3: TOC removal with MIEX® Resin versus enhanced coagulation on Pasco County groundwater.

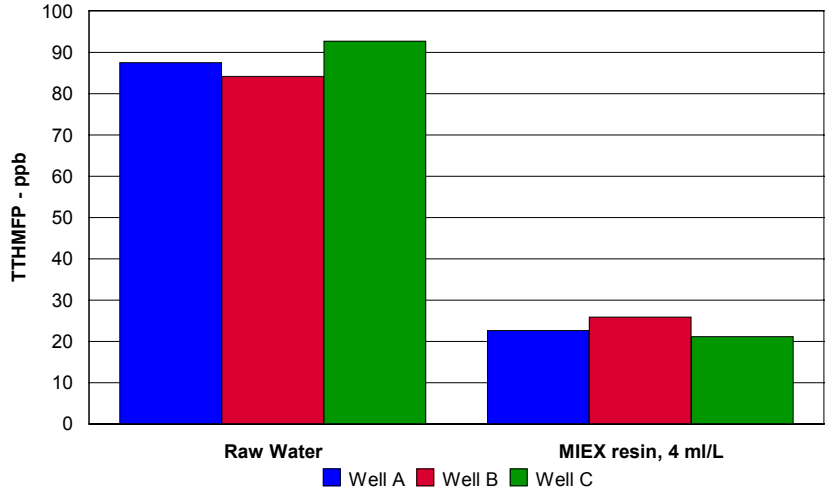

Figure 4: Reduction of THM Formation Potential of Pasco County groundwater after MIEX® resin treatment

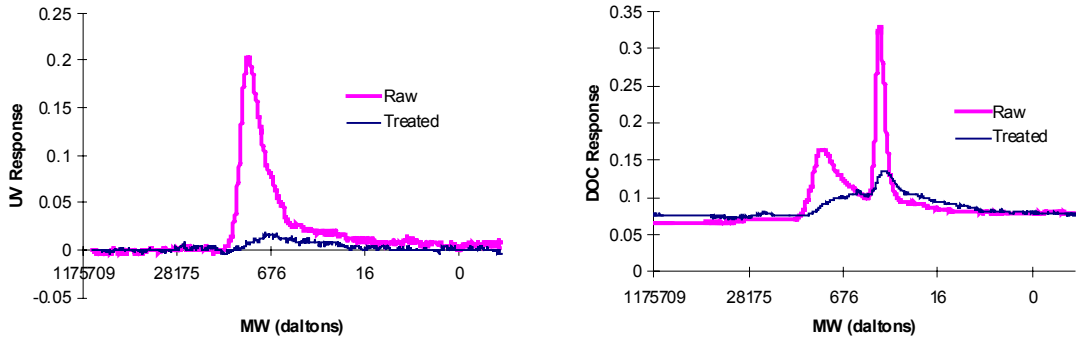

Figure 5: Characteristics DOC Removed during MIEX® Resin trial at Pasco County, FL

Bench scale tests were performed on raw water samples from the John Preston and Hialeah water treatment plants in Miami to determine how effective MIEX® resin was at removing TOC and therefore at reducing the disinfection by-product formation potential of this water.

The results showed that MIEX® resin was very effective at removing TOC from these water sources (Figure 6).

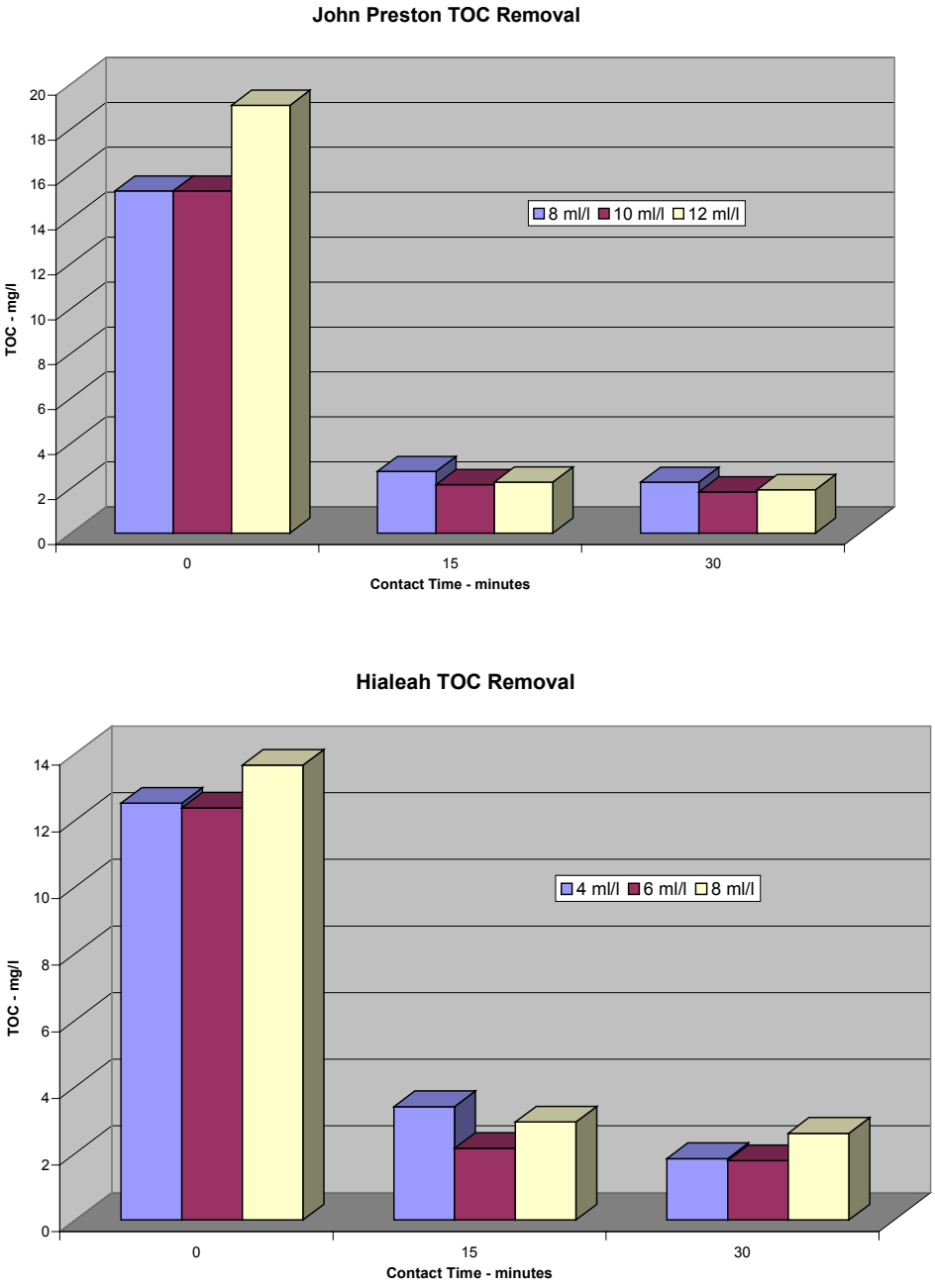

Figure 6: Bench scale TOC removal Tests on raw water from John Preston and Hialeah WTPs.

Research was recently conducted at the University of North Carolina to investigate the benefits of pretreating raw water with MIEX® resin prior to conventional coagulation processes. Tests were conducted on nine water sources that were selected to fit the EPA 3 x 3 matrix for enhanced coagulation as specified in the Disinfectants/Disinfection By-Products Rule. The full results of this work are reported in a previous paper[3]. A summary of the

disinfection by-product formation potentials of these waters after coagulation only and after MIEX® pretreatment followed by coagulation is shown in Figure 7. These results indicate that for a wide variety of waters, pretreatment with MIEX® resin followed by coagulation can significantly lower the treated water TOC and THM formation potentials compared to enhanced coagulation alone.

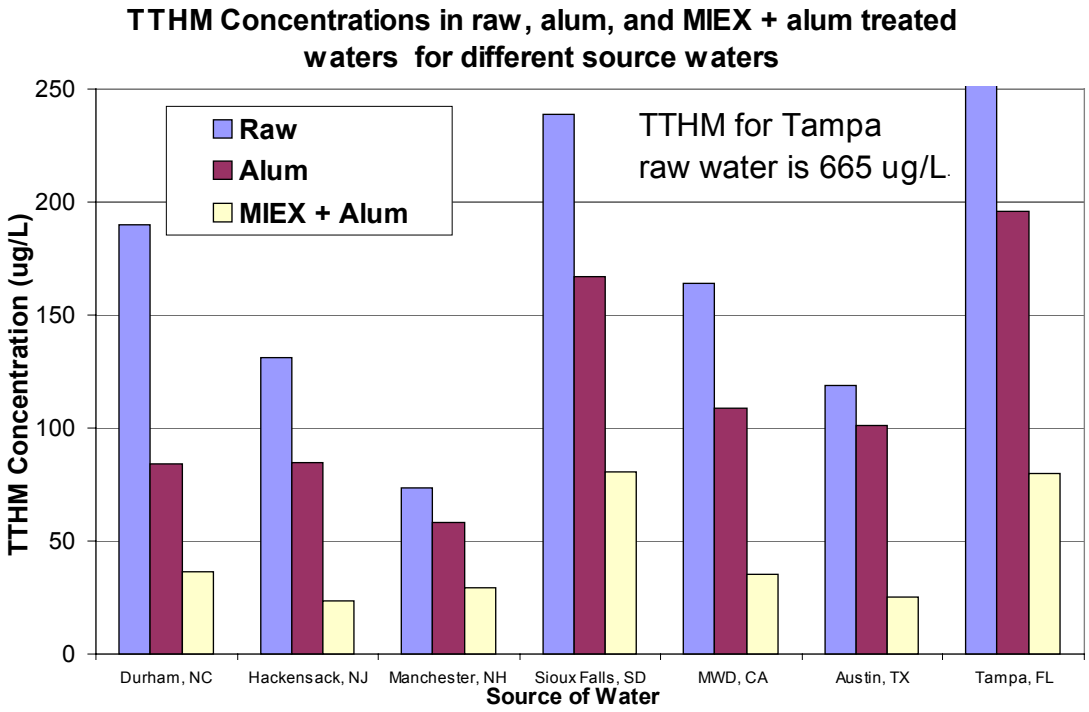

Figure 7: Comparison of THM Formation Potentials with and without MIEX® Pretreatment[3].

Sulfide Removal

While the MIEX® resin has been developed primarily for TOC removal, because it is an anion exchange resin it will also remove other anions from water such as sulfide, sulfate and arsenate. The degree of removal depends upon the competition of other anions present in the water. Pilot plant trials have been conducted at Pasco County to investigate the effectiveness of MIEX® resin in removing sulfides from the County's ground water supplies. A secondary objective of these trials was to investigate the additional benefit of TOC removal so that future EPA DBP standards could be met without the need to move away from free chlorine disinfection.

The trial showed that very effective sulfide removal could be achieved along with a 50-60% reduction in the TOC level. Sulfide removal results are shown in Figure 8.

Aloha Utilities, a private utility located close to Pasco County, also requires sulfide removal from its ground water supplies and is investigating the use of MIEX® treatment. Laboratory tests completed in February 2001 indicate very effective sulfide removal as well as UV_{254} Absorbance removal (an indicator of TOC removal) as shown in Figure 9. A pilot plant trial is proposed for April 2001.

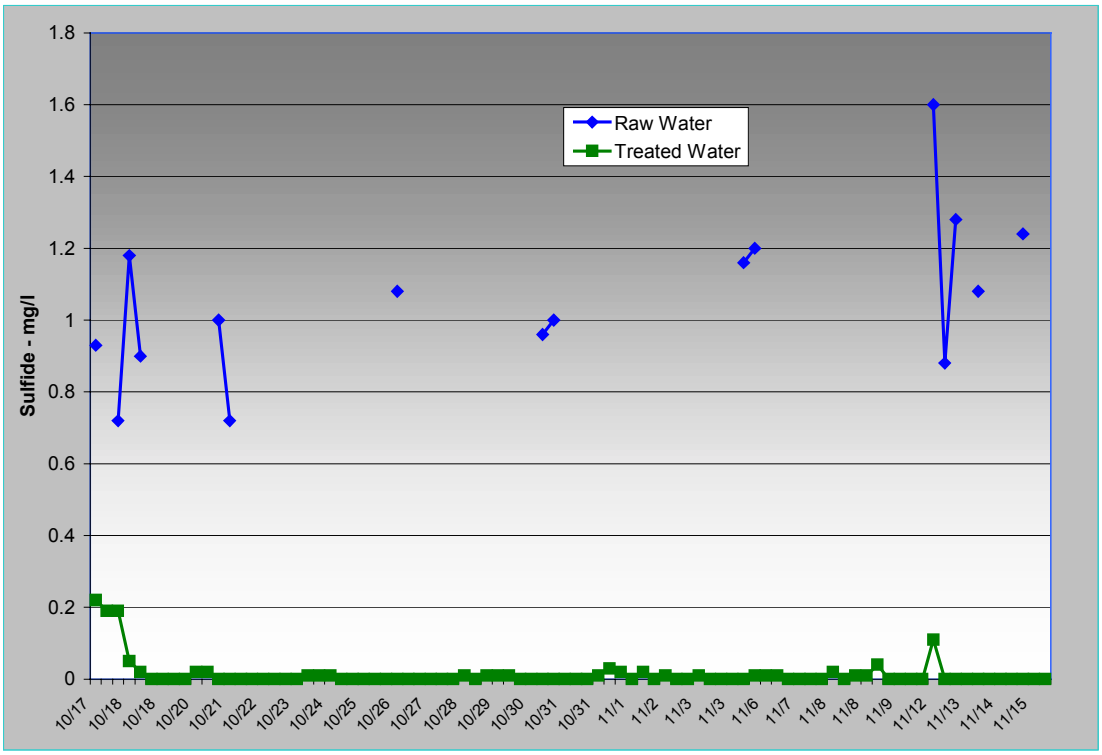

Figure 8: Sulfide removal achieved during MIEX® pilot plant trial at Pasco County.

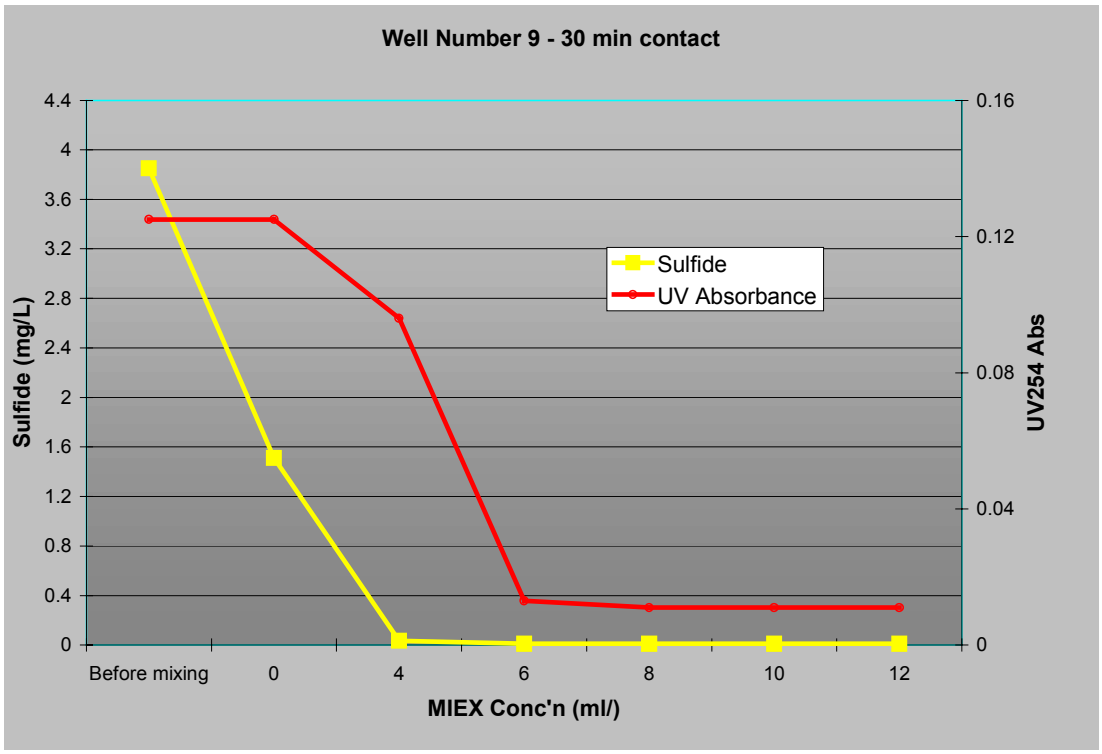

Figure 9: Sulfide removal achieved in bench scale tests on a water source at Aloha Utilities.

Conclusions

Tightening EPA water quality standards will require many water utilities in Florida to evaluate new water treatment technologies to enable compliance. In some cases, existing water treatment plants may not comply with more than one of the new water quality standards.

Ion exchange resins can be used to remove a number of soluble contaminants of concern and trials with the MIEX® resin technology have demonstrated simultaneous removal of TOC and sulfides, providing a simple and economical solution to problems encountered by many water utilities in Florida.

References

1. Slunjski, M; O'Leary, B; Tattersall, J; "MIEX Resin Water Treatment Process", Proceedings of Aquatech 2000, Amsterdam, Netherlands, Sep. 26-29, 2000

2. Slunjski, M; Bourke, M; O'Leary, B; "MIEX® DOC Process for Removal of Humics in Water Treatment", IHSS-Australian Branch Symposium: Humic Substances – Science and Commercial Applications, 18 Feb 2000, Monash Uni. Melbourne, Australia, pp22-27.

3. Singer, P; Bilyk, K; "Enhanced Coagulation Using a Magnetic Ion Exchange Resin", Proceedings of AWWA AWQTC, Salt Lake City, UT, Nov 5-9, 2000.

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