EVALUATION OF A MAGNETIC ION EXCHANGE RESIN AND OZONE TO ACHIEVE EPA DBP STANDARDS AT THE VILLAGE OF PALM SPRINGS.

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INTRODUCTION

The Village of Palm Springs is a utility in South East Florida, which supplies drinking water to a community of around 50,000 customers. The water supply is drawn from the surficial aquifer in Eastern Palm Beach County and treated in two lime softening plants. The water source has high levels of color and total organic carbon (TOC), which are not removed in the existing lime softening processes. Essentially all of the TOC is present as dissolved organic carbon (DOC) in this water source. Some color is removed from the treated water by bleaching with chlorine during a 30-minute contact time before ammonia is added to provide a chloramine residual for disinfection in the distribution system. Treated water then passes through stripping towers which remove 75 to 85% of the trihalomethanes (THMs) formed during disinfection. This disinfection practice will no longer produce acceptable results under the Stage 1 EPA DBP Standards without removal of disinfection byproduct (DBP) precursors due to the formation of DBPs during the 30 minute chlorine contact period, particularly haloacetic acids (HAAs) which are not removed via stripping. This is a common problem with ground water treatment plants on the East Coast of Florida that until recently had to comply with the 1979 Total Trihalomethane Rule which set the MCL for TTHM's at 100µg/l but no MCL for HAAs. For this water supply to comply with the new Stage 1 and Stage 2 EPA Disinfection/Disinfection By-Product rules, it will be necessary to remove additional DBP precursors (DOC) prior to disinfection or change disinfection practices to meet the lower more stringent MCL's for TTHM's and HAA's.

TREATMENT OPTIONS

The Village of Palm Springs' consultant, Eckler Engineering, Inc., conducted a study of technologies available to reduce color and DOC prior to disinfection so that the Main (6 MGD) and Pratt (4 MGD) water treatment plants could be brought into compliance with the Stage 1 and 2 EPA DBP Standards. The two options selected for bench and trial evaluations were pretreating the raw water with either ozonation or a continuous magnetic ion exchange system (MIEX®).

Nanofiltration has often been selected in similar applications in SE Florida when it has been necessary to increase the existing plant capacity as well as improve the treated water quality. In these cases nanofiltration can provide additional capacity and the resulting treated water, with very low hardness, DOC and color levels, can be blended with the output from the existing lime softening plant to lower the overall TOC and color levels prior to disinfection. The two softening plants at the Village of Palm Springs are only 5 and 15 years old respectively, still have some time before reaching their payback period and have adequate spare capacity to meet the Village of Palm Spring's water demand for many years to come. In this case a plant expansion could not be justified and nanofiltration was therefore not considered due to the high capital and O&M costs of this option as well as concentrate disposal concerns. Technologies were therefore investigated to reduce DBP precursors prior to disinfection while utilizing the existing treatment facilities to bring the plants into DBP compliance.

Ozone was bench and pilot tested, first at the Main WTP. It was found that while ozone was very effective at reducing the color levels, very little DOC was removed and therefore high levels of DBPs would still be formed after final disinfection with chlorine (see Table 1). Ozone was therefore eliminated as an option for DBP precursor removal.

Following bench scale tests with the MIEX® resin that showed very good removal of color and DOC and reductions in DBP Formation Potentials, a MIEX® pilot plant trial was conducted at the Main WTP during January/February, 2003 with the objective of demonstrating on a continuously operating plant that color and DOC could be reduced reliably to allow the EPA THM and HAA limits to be achieved and to develop design parameters for a full scale plant.

Table 1: Water Quality Summary for Various Treatment Options at the Main WTP

Parameter (average values)	Raw Water	Raw water treated with ozone	Raw water treated with MIEX® resin
DOC (mg/L)	11.8	7.5	3.4
UV254 Absorbance (cm^{-1})	0.353	NM	0.054
True Color (Pt Co Units)	26	11	1.3
Hardness (mg/L as $CaCO_3$)	287	NM	286
Alkalinity (mg/L as $CaCO_3$)	269	180	260
pH	7.1	7.5	7.3

NM = Not Measured

THE MIEXâ TECHNOLOGY

The MIEX® resin was specifically developed in Australia for the removal of dissolved organic carbon (DOC) to minimize the formation of DBPs in 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 sulfate, sulfide, chromate, nitrate and arsenate. The extent of removal of these anions depends on the competition between other anions in the water source.

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 maximize 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 99.95% at very high settler rise rates (6 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.

Research conducted in Australia has 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].

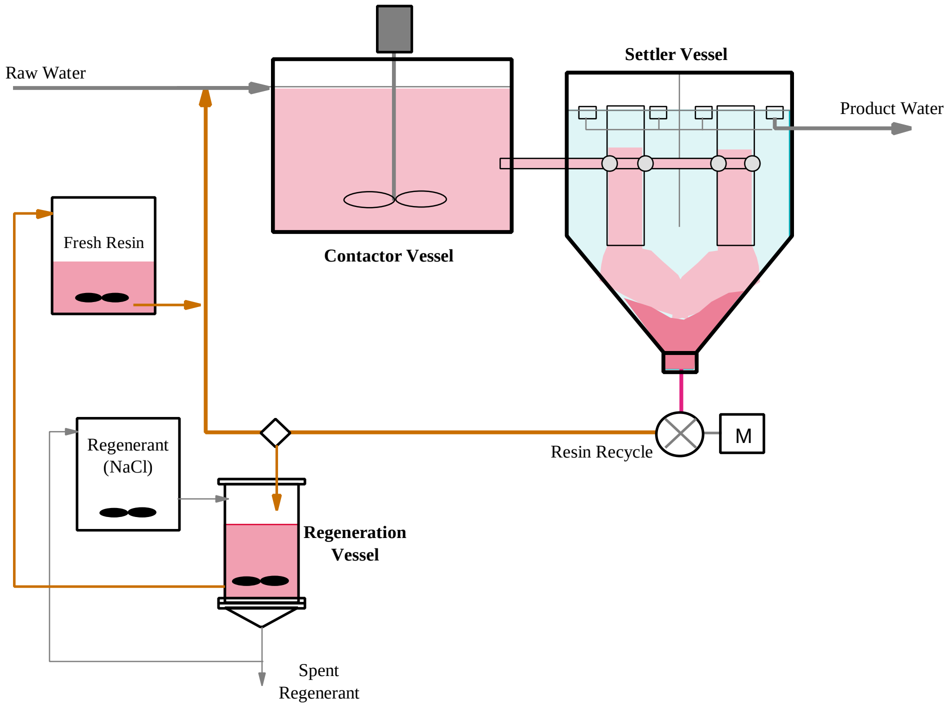


Figure 1: Flow diagram of the MIEX® continuous ion exchange process

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 30 MGD MIEX® groundwater treatment plant at Wanneroo in Perth, Western Australia (Figure 2)[2]. On some water sources such as that used by the Village of Palm Springs, MIEX® resin can achieve very good TOC and color removal without the need for subsequent coagulation due to most of the TOC in the water having a high affinity for ion exchange.

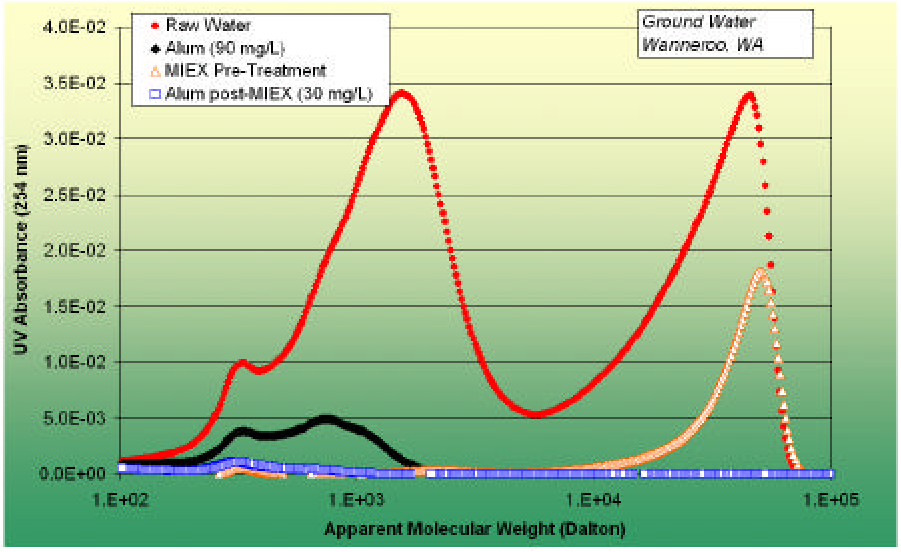


Figure 2: Characteristics of TOC removed with MIEX® resin and Alum on Wanneroo ground water, Western Australia.

MIEX® TRIAL AT THE VILLAGE OF PALM SPRINGS

The MIEX® trial was conducted using a continuously operating 2gpm pilot plant which treated raw water received by the Main WTP (Figure 3). Based on the jar test results, two sets of operating conditions were tested as shown in Table 2.

Table 2: Pilot Plant Operating Conditions

Parameter	**Units**	**Condition 1**	**Condition 2**
Resin contact time	min	20	20
Regeneration Rate	%	5	10
Contactor Resin Concentration	mL/L	10	20
Regeneration Frequency	#/day	1	1

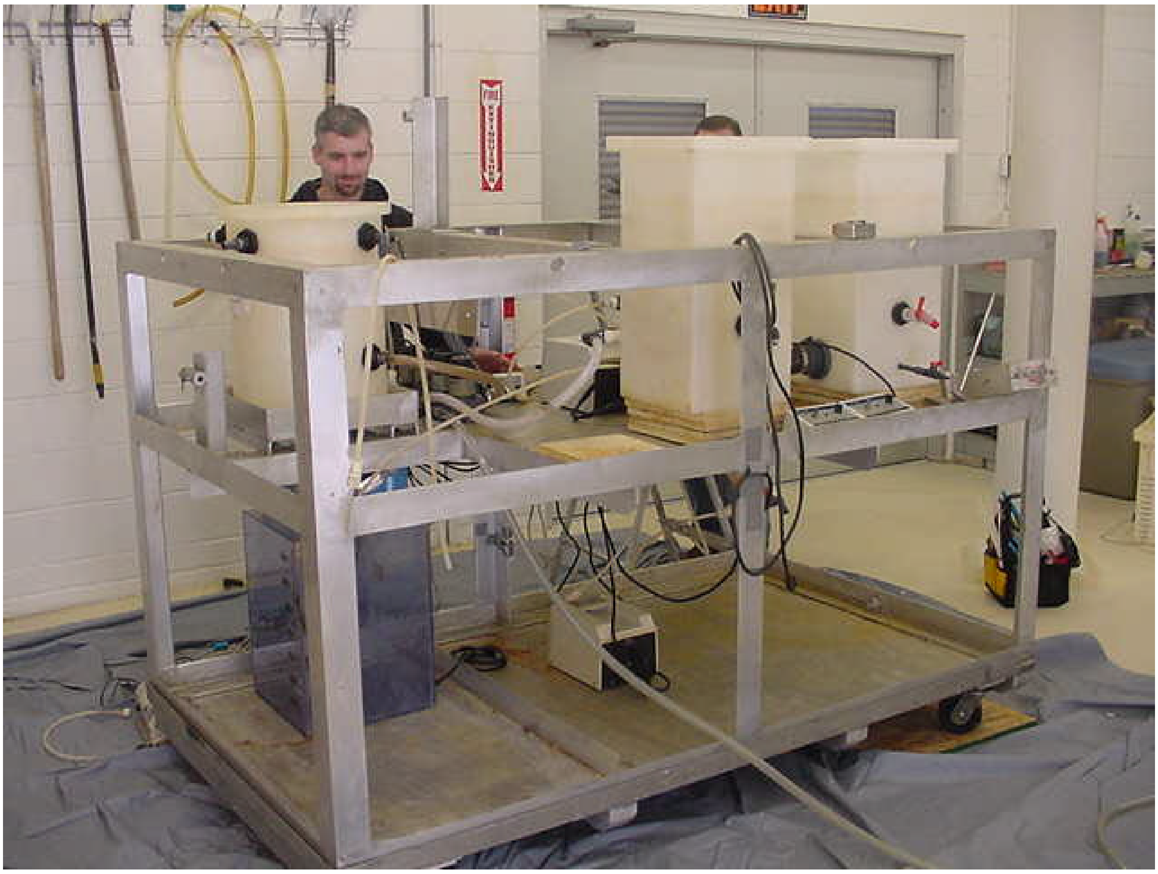


Figure 3: 2GPM MIEX® pilot plant at the Village of Palm Springs, Florida

The color and TOC removal results indicated similar performance for both sets of operating conditions (Figures 4 & 5).

A summary of the results achieved in the trial is as follows:

- MIEX® resin reduced the raw water THMFP by 69.5% (from 167 to 51 µg/l) and reduced the HAAFP by 61% (from 94 to 37 µg/l). MIEX® pretreatment in addition to the existing treatment provided at each plant will therefore provide the Village of Palm Springs with a comfortable buffer below the EPA Stage 1 and 2 DBP standards of 80 and 60µg/l respectively (Table 3).
- MIEX® treatment reduced raw water DOC by an average of 71% (from 11.8 to 3.4 mg/L), which allowed compliance with the EPA DBP standards. It was demonstrated in jar tests that even greater TOC removal could be achieved (>80%) but this was not necessary to meet the EPA standards (Figure 4).
- MIEX® reduced the true color of the ground water by an average of 95% from 27 to 1.3 Pt-Co units (Figure 5)

Table 3: Disinfection Byproducts

		THMFP (ug/L)		HAAFP (ug/L)	
Date	**Sample ID**	**Raw**	**Treated**	**Raw**	**Treated**
1/29/03	129A	-	46	-	16
1/31/03	131A	100	44	54	35
2/03/03	203A	92	36	90	16
2/05/03	205B	310	78	140	80
Average		**167**	**51**	**94**	**37**

Figure 4: DOC Removal During MIEX® Trial

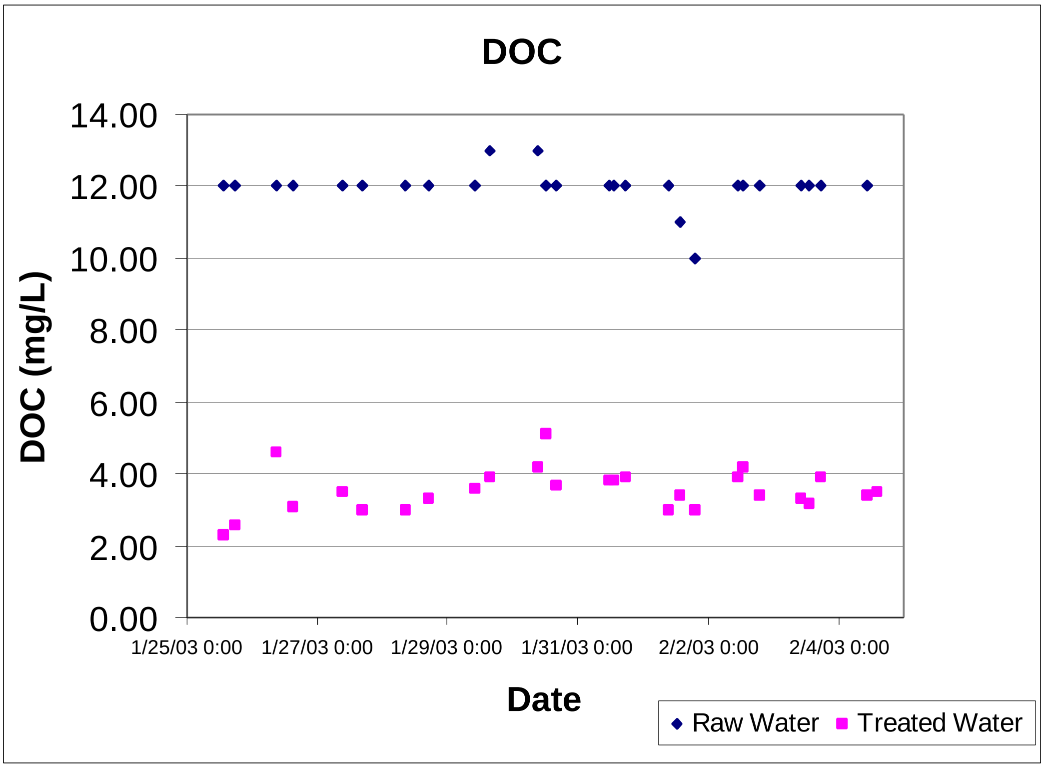
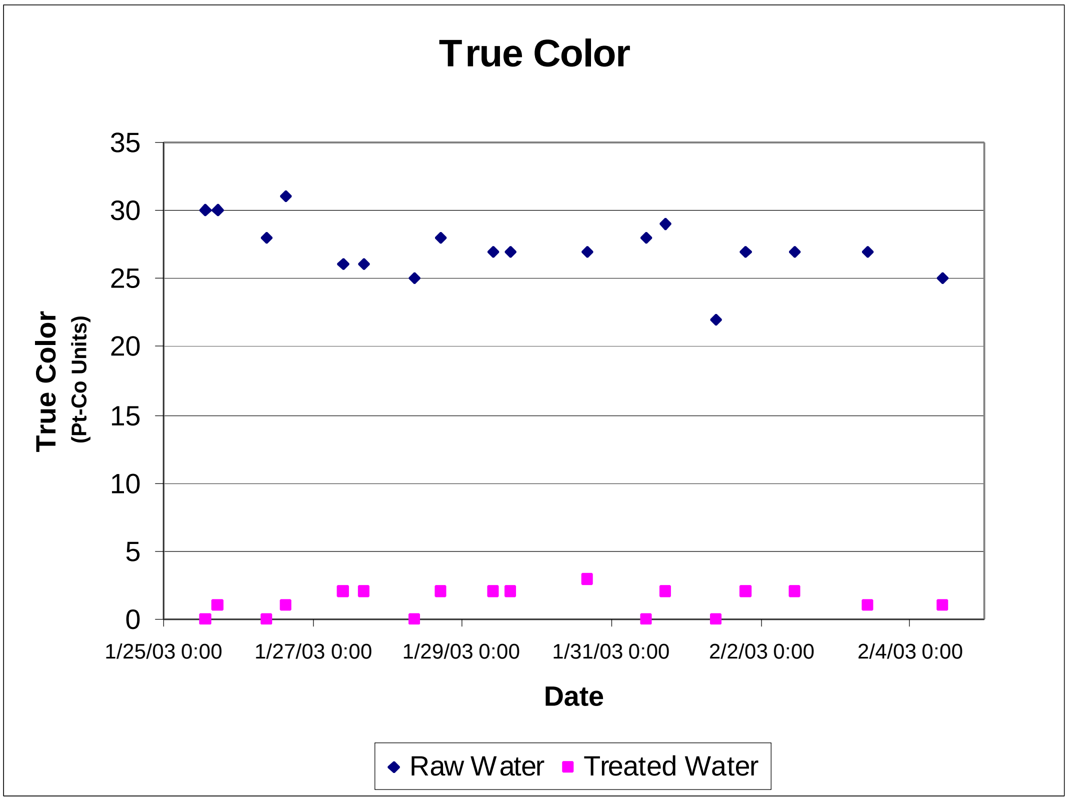


Figure 5: Color Removal During MIEX® Trial



CONCLUSIONS

The trial results showed that a MIEX® pretreatment system followed by the existing treatment process at the Main and Pratt WTPs will provide very good removal of DOC and color and allow both plants to achieve the EPA Stage 1 and 2 DBP Standards with a comfortable safety margin.

Following the trial at the Main WTP, Eckler Engineering recommended to the Village of Palm Springs that MIEX® pretreatment be installed at both the Main and R.L. Pratt water treatment plants. Designs for the MIEX® systems at these plants are complete and this project was bid in July 2003. The MIEX® plants are currently under construction and due to be operating by June 2004 and will be the first operating MIEX® installations in the United States.

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 University. Melbourne, Australia, pp22-27.