ACTIVATED CARBON VS ANTHRACITE AS PRIMARY DUAL MEDIA FILTERS – A PILOT PLANT STUDY.

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ACTIVATED CARBON VS ANTHRACITE AS PRIMARY DUAL MEDIA FILTERS – A PILOT PLANT STUDY.

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ABSTRACT

An 18 month pilot plant study was conducted in Western Australia involving 2 columns of anthracite of different bed depths and 2 columns of granular activated carbon (GAC) of different particle size were run in parallel as primary filters. The performance of each of the columns were evaluated including organics reduction (dissolved organic carbon (DOC), UV absorbance at 254nm, biological dissolved organic carbon (BDOC), and assimible organic carbon (AOC)), chlorine demand and total trihalomethane formation potential (TTHMFP). Each of the filtered waters were compared with the feed water and analysed regularly under varying operational conditions including MIEX® and enhanced coagulation feed water, empty bed contact times (EBCT) of 8 and 16 minutes, chlorinated feed water, and chlorinated backwash water. During the pilot plant study the GAC filters outperformed the anthracite filters with superior reduction of organics, lower chlorine demand and lower TTHMFP, with similar run times and filtered water turbidities to the anthracite filters. Chlorinated feed water significantly impacted on the filters performance and chlorinated backwash water slightly decreased filter performance. The optimum operating conditions were using the slightly coarser GAC filter (no head loss issues) at a 16 minute EBCT, however doubling the contact time did not double the performance. Filtering through GAC reduced the BDOC and AOC levels to produce biologically stable water. Biomass studies of the media and the backwash water from each of the filters indicated a higher biological density on the GAC filters compared to the anthracite filters. The adsorptive capacity of the activated carbon combined with the ability of the carbon to biologically regenerate ensured superior performance (compared to the anthracite filters) and prolonged bed life for organics reduction. Further work will extend the project to examine full scale dual media primary filters using GAC in place of anthracite.

1.0 INTRODUCTION

WA Water Corp can supply up to 240 MLD of water to the Perth distribution network from the Wanneroo WTP. This plant is fed from two ground water sources which are treated using conventional treatment techniques such as aeration, flocculation, upflow clarification, sand filtration and chlorination. In addition to this conventional treatment, WA Water Corp is in the unique situation of owning and operating the largest MIEX® plant in the world. This 110 MLD plant is used to reduce the smaller molecular weight molecules of DOC, prior to the conventional treatment.

Water from Wanneroo WTP has been associated with intermittent events of a musty odour that develops in the distribution network and has been identified as dimethyl trisulphide (DMTS). Extensive work conducted by WA Water Corp, in conjunction with Curtin University and CSIRO, have established that the odour events are related to both chemical and biological activity taking place in biofilms present in the distribution

system.
The generation of DMTS within the distribution was determined to be due to a number of processes including chemical and biological pathways; oxygen depletion and stagnation within the pipes; and the level of biodegradable dissolved organic carbon (BDOC) present in the water.

To combat this issue it was recommended that the plant should attempt to minimise the build up of biofilms within the distribution system by limiting the amount of biodegradable organic matter (BOM) present in the treated water. By doing this the bacteria present within the distribution system will have a smaller amount of food source available, and the chlorine residual should persist for substantially longer.

To reduce BOM a biological filtration pilot plant was commissioned to determine the effectiveness of activated carbon as a biological media to reduce the concentration of organics. The plant was operated for 18 months using two types of media – anthracite/sand and activated carbon/sand – to compare performance of the existing filters with potential BAC filters for further treating the MIEX® treated, clarified water from Wanneroo Ground Water Treatment Plant.

The project has now been finalised and this presentation summarises the performance of the biofilters over the 5 stages:

- Steady state;
- Extended empty bed contact time of 16 minutes;
- Enhanced coagulation feed water;
- Chlorinated backwash water; and
- Chlorinated feed water.

2.0 BIOFILTER OPERATION

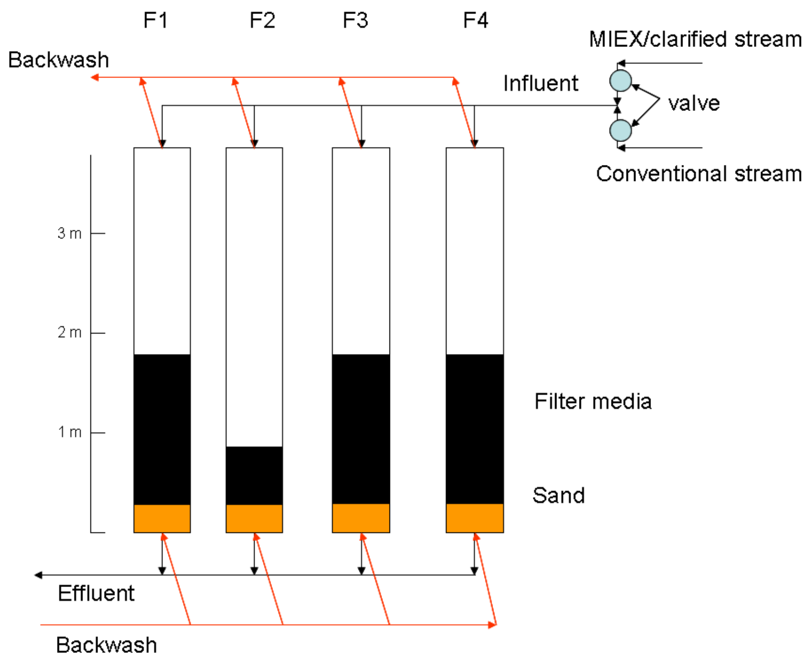
The four pilot scale biofilters consisted of 140 mm id. Perspex columns, each fed with either MIEX® treated and clarified water or water from an enhanced coagulation clarifier. The types and depths of media used in each biofilter are given in Table 1 and a schematic diagram is presented in Figure 1.

Table 1: ***The types and depths of media used in each biofilter*.**

Biofilter	Medium depth and type
1	0.3 m sand (0.65 mm) below 1.75 m anthracite (1.1 mm)
2	0.3 m sand (0.65 mm) below 0.65 m anthracite from the existing filters
3	0.3 m sand (0.65 mm) below 1.75 m GAC – Acticarb GA1000N (1.3 mm)
4	0.3 m sand (0.65 mm) below 1.75 m GAC – Acticarb GA1000N (0.7 mm)

The four biofilters were run in parallel so the effects of different filter media could be compared. At the commencement of the test program, the biofilters were fed with MIEX®-treated clarified water with an empty bed contact time (EBCT) of 8 min. The biofilters were backwashed with non-chlorinated water three times a week with air scouring and a backwash velocity that ensured a 30 % bed expansion for 10 min. The biofilters were run under these conditions for 6 months (Stage 1). It was considered that the biofilters were in a "steady state" of operation. To test the effect of EBCT on biofilter performance, the EBCT was increased to 16 min (Stage 2). After this sampling occasion, MIEX®-treated clarified water was replaced with water from the Wanneroo enhanced coagulation clarifier as the influent water to the biofilters, and the EBTC was returned to

8 min.
The biofilters were sampled again (Stage 3) after which MIEX®-treated clarified water was used again as influent water to the biofilters. To test the effect of the use of chlorinated backwash water on biofilter performance, water from the clear water tank, which typically contained 1.3 mg L^{-1} free chlorine, was used to backwash the biofilters (Stage 4). After the stage 4 sampling, to test the efficacy of the biofilters in treating chlorinated influent water, water from the clear water tank at the treatment plant was used as influent to the biofilters. This water contained 1.3±0.5 mg L^{-1} free chlorine.



<u>Figure 1:</u> ***Schematic diagram of the pilot scale biological filters at the Wanneroo Ground Water Treatment Plant.***

3.0 MONITORING

Routine, approximately weekly, monitoring of biofilter influents and effluents for pH, temperature, turbidity, UV_{254}, and dissolved oxygen concentration was undertaken using probes and on-line monitors.

Several major sampling events were undertaken at the end of each stage. At these times the following parameters were measured in the influent water, and the effluent water from each of the biofilters; AOC, BDOC, DOC, UV_{254}, chlorine demand and THMFP.

4.0 CONCLUSIONS

The attached figures show that activated carbon filters reduced organics more effectively than anthracite in all stages of the trial. The DO figures indicate a decrease in oxygen across the activated carbon beds indicating a presence of biological activity. This biological activity combined with the adsorptive capacity of the carbon provided a consistent reduction of organics within the carbon filters.

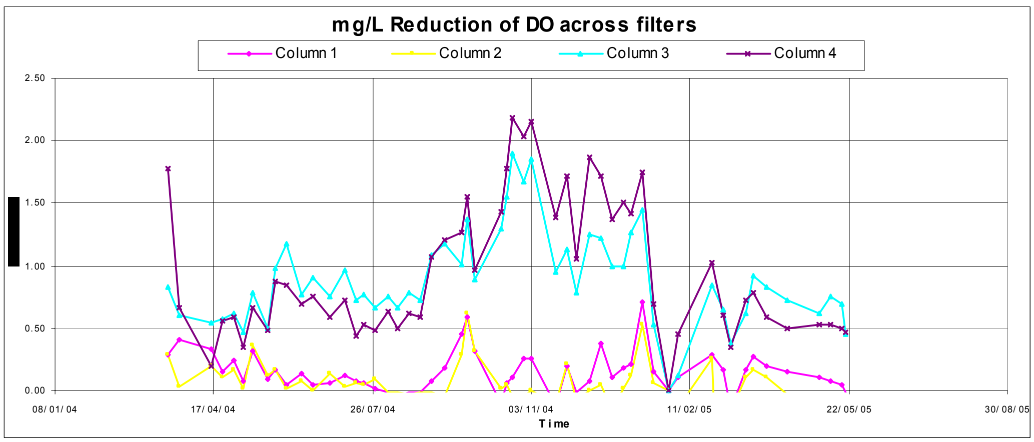
The addition of chlorinated backwash water and chlorinated inlet water reduced the carbon's ability to adsorb organics, however there was still some reduction occurring.

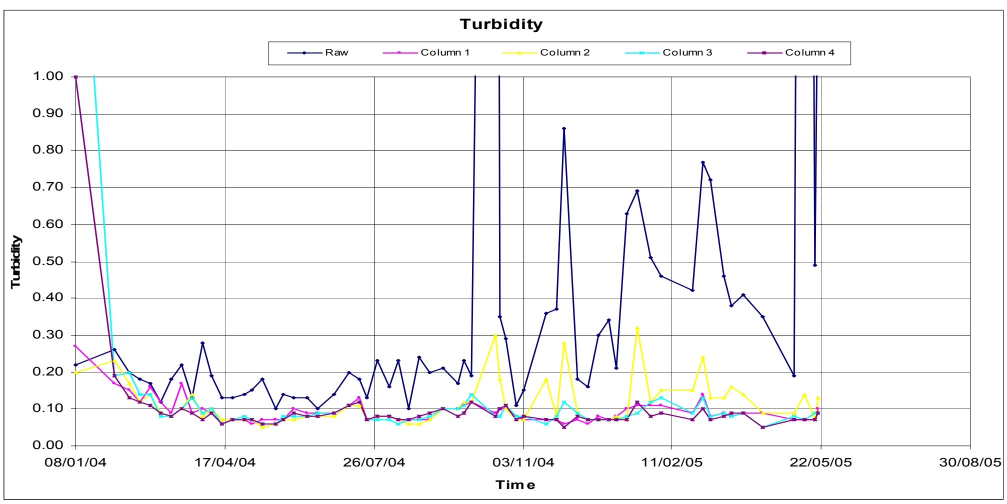
The increased empty bed contact time of 16 minutes provided very good organics reduction in the activated carbon filters, however this increase was not double that of the 8 minute EBCT.

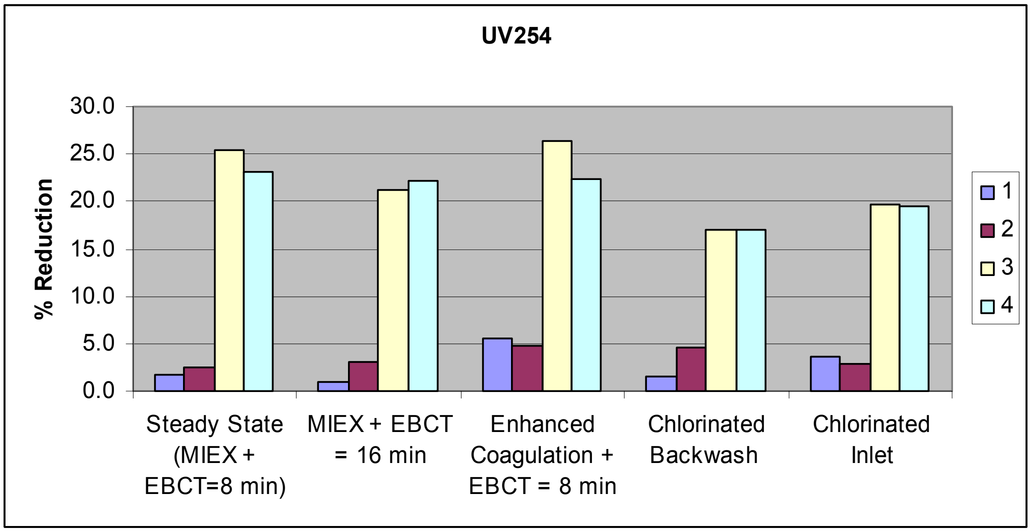
The carbon filters also acted effectively as primary filters with filter run times and filtered water turbidity very similar to the anthracite filters.

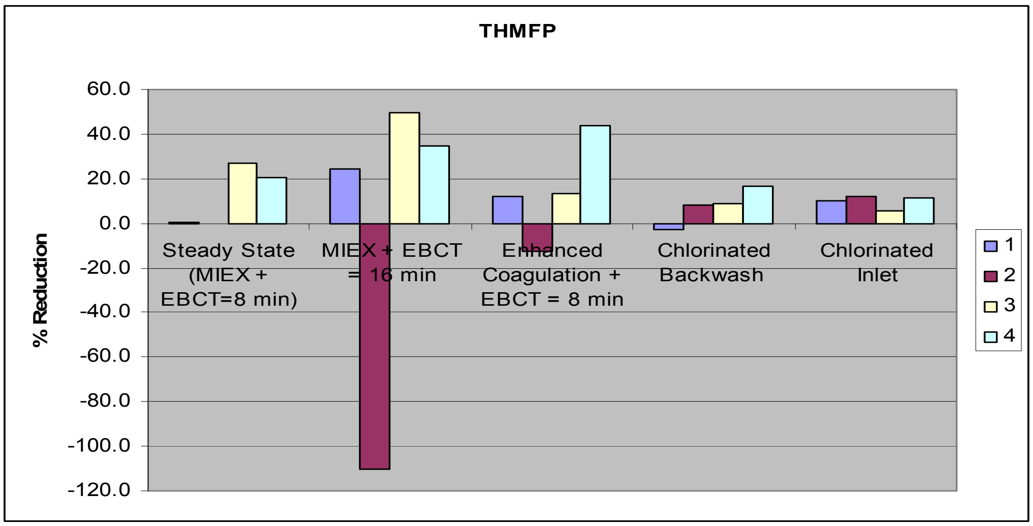
Overall this study showed that activated carbon filters are extremely effective as primary filters and have the added benefit of organics reduction resulting in cost savings with reduced chlorine demand and safer water with reduced THM formation and cleaner distribution systems.

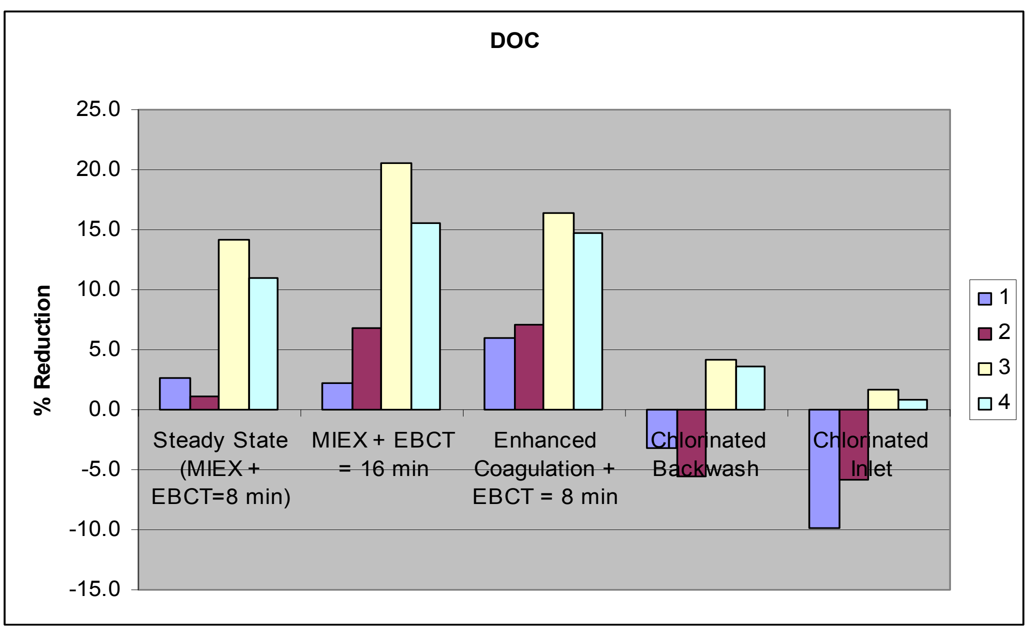
5.0 RESULTS

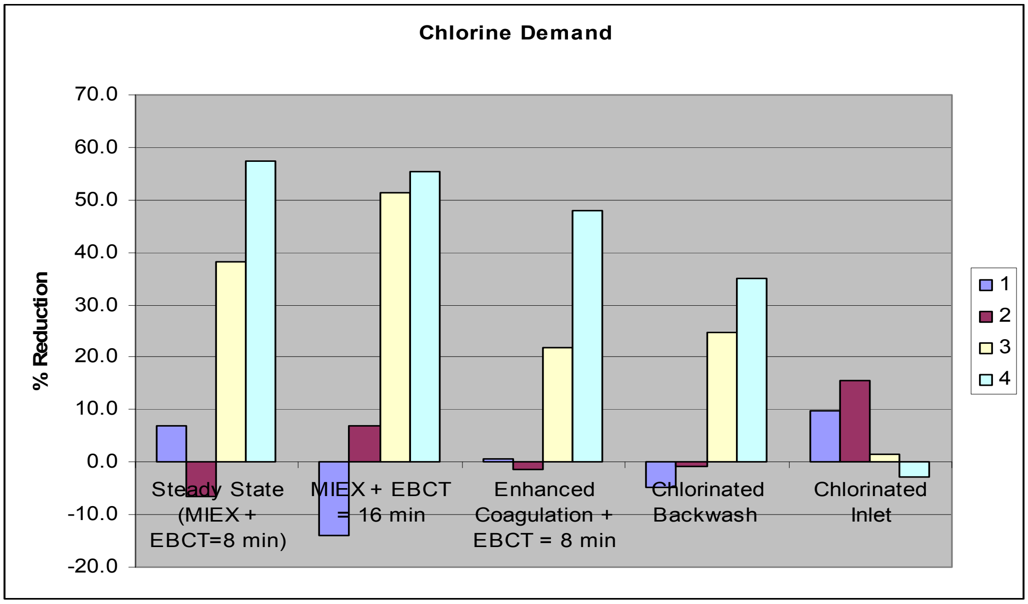


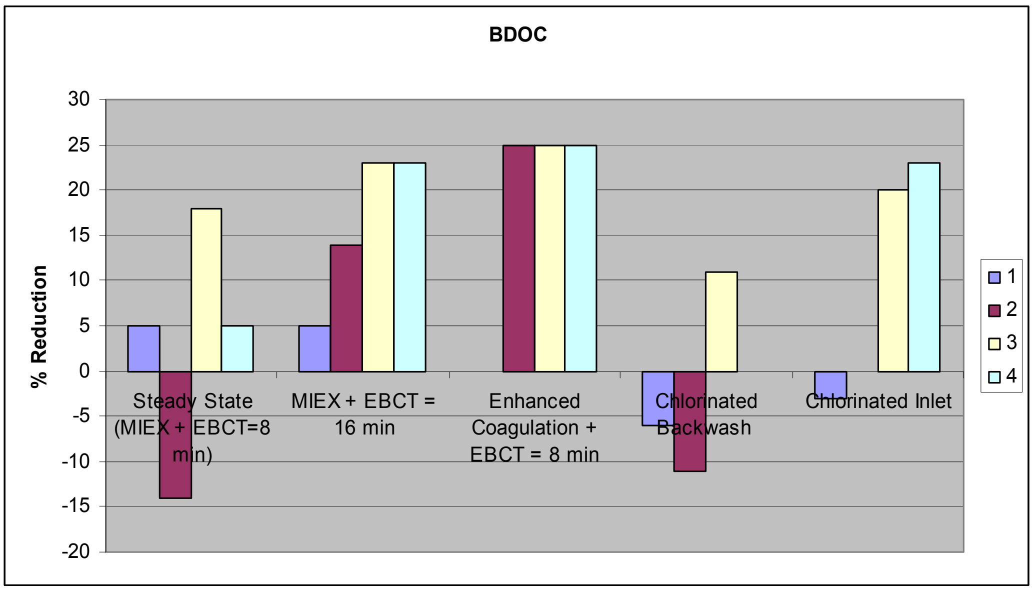



UV254
% Reduction
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Steady State (MIEX + EBCT=8 min)
MIEX + EBCT = 16 min
Enhanced Coagulation + EBCT = 8 min
Chlorinated Backwash
Chlorinated Inlet
1
2
3
4


THMFP
% Reduction
60.0
40.0
20.0
0.0
-20.0
-40.0
-60.0
-80.0
-100.0
-120.0
Steady State (MIEX + EBCT=8 min)
MIEX + EBCT = 16 min
Enhanced Coagulation + EBCT = 8 min
Chlorinated Backwash
Chlorinated Inlet
1
2
3
4


DOC
% Reduction
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
Steady State (MIEX + EBCT=8 min)
MIEX + EBCT = 16 min
Enhanced Coagulation + EBCT = 8 min
Chlorinated Backwash
Chlorinated Inlet
1
2
3
4


Chlorine Demand
% Reduction
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
Steady State (MIEX + EBCT=8 min)
MIEX + EBCT = 16 min
Enhanced Coagulation + EBCT = 8 min
Chlorinated Backwash
Chlorinated Inlet
1
2
3
4


BDOC
% Reduction
30
25
20
15
10
5
0
-5
-10
-15
-20
Steady State (MIEX + EBCT=8 min)
MIEX + EBCT = 16 min
Enhanced Coagulation + EBCT = 8 min
Chlorinated Backwash
Chlorinated Inlet
1
2
3
4