Pile cloth media filtration to remove algae from reservoir water to enhance water treatment works resilience

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INTRODUCTION

In London, Thames Water's largest surface water treatment works (WTW) are supplied by storage reservoirs. Reservoirs increase the operational resilience and generally improve water quality but can experience significant algal blooms, creating challenges for the WTW. Some algal taxa are hard to capture with coagulation or filtration whilst others rapidly clog the surface of filters. At several sites the water can be sourced from more than one reservoir, which allows some management of the quality of the water to be treated. However, climate change could significantly affect patterns of rainfall and consequently the ability to manage reservoir water quality. Seasonal algal blooms could be more severe, last longer and affect a greater number of reservoirs simultaneously. Increased amounts of algae, turbidity and other micro-particulates could have an adverse effect on the capacity of current treatment processes. Research to improve the resilience of WTW to climate change needs to find a way to remove peak loads from the stored water, ensuring the sustainability of the existing assets.

Mecana pile cloth media filtration (PCMF) is a well-established tertiary treatment for wastewater, which provides a continuous suspended solids removal filtration method. The aim of the study was to determine how well PCMF would remove different algae from reservoir water. Wastewater studies have shown that the Microfibre cloth filter performed similarly to conventional granular media, but with the advantages of a smaller footprint, lower backwash losses (<1%), low head loss generation and continuous operation.

METHOD

A TF2 drum filter (Figure 1) was installed at a west London treatment works in February 2016, fitted with a standard Microfibre cloth with a 2m^2 filtration surface. The pilot plant was supplied with a stored water flow rate of 16 m^3/h. A second pilot plant – a TF4 drum filter – was trialled at an east London treatment works with a novel development cloth. The TF4 operated from March 2016 with a cloth surface area of 4m^2 and an inlet stored water supply flow rate of 32 m^3/h. The duration of the trial was intended to ensure the filters were challenged with high algal loadings from spring, summer and autumn algal blooms.

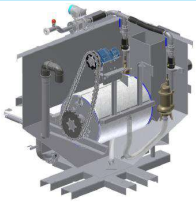

Figure 1 – Drum filter design

The plants were operated with minimal changes on site, but changes to backwashing were occasionally attempted for the development cloth.

Backwashing occurred on demand when a level trigger in the tank of 300mm was reached, which initiated a standard single drum rotation. Grab samples were taken weekly from the inlet and filtrate for chlorophyll-*a* and turbidity analysis.

RESULTS – TREATMENT PERFORMANCE

The water treatment performance of both pilot plants is presented in Figure 4 and 5 for west and east London, respectively. It can be seen that when loading was high the filters removed a high percentage of the applied microscopic solids. Algae removal was assessed through a filtrate chlorophyll-*a* target, independent of inlet concentration, of ideally <10 µg/l 95%-ile and no greater than 25 µg/l chlorophyll-*a*. This was achieved at both sites. Many of the results for filtrate chlorophyll-*a* performance were comparable with roughing rapid gravity filter (RGF) performance. This was assessed using a target derived from analysis of west London RGF data, which showed that when the influent chlorophyll-*a* was >2 µg/l and <120 µg/l, the RGFs would typically remove 85% of additional chlorophyll-*a*. Filtered water turbidity achieved its target of <2.0 NTU 95%ile.

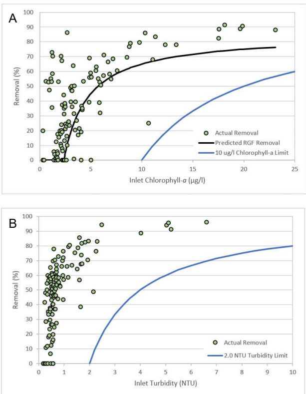

Figure 4 – West London water treatment performance for (A) Chlorophyll-*a*; and (B) Turbidity

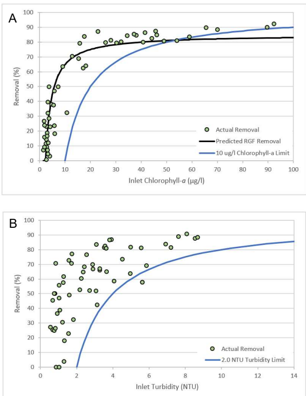

Figure 5 – East London water treatment performance for (A) Chlorophyll-*a*; and (B) Turbidity

Following a *Melosira* algal bloom in August 2017 at the west London site, grab sampling showed the effectiveness of the PCMF in removing the algae within the filtered water (Figure 6).

Figure 6 – Grab samples. L → R: Backwash, Inlet and Filtrate

Figure 7 – Underwater photos of the TF2 unit during the trial. (A) and (B) Prior to backwashing; and (C) Following a backwash

The accumulation of solids on the cloth surface is normal and desirable during operation (Figure 7A & 7B). Following a backwash cycle, the cloth's surface is removed of all particulate solids (Figure 7C) through the suction header.

TECHNOLOGY

Pile Cloth Media Filtration

Comparable in structure to animal fur (Figure 2), the pile fibres remain flat during filtration creating a dense barrier to suspended solids.

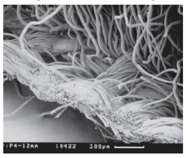

Figure 2 – Cloth structure

Solids that are deposited on the cloth are removed by a backwashing process (Figure 3). During backwashing the fibres are 'hoovered' by a suction header as the drum undergoes a complete rotation, allowing the fibres to briefly stand vertically. This enables the filtering operation to continue with no interruption from the cleaning cycle.

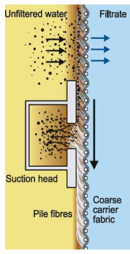

Figure 3 – Backwashing process

Further benefits of this filtration technology include low operational / maintenance costs and low energy requirements.

RESULTS – ALGAL TAXA

Table 1: Most common algal taxon in West London

1st Most Common Algal Taxon (No. of Occurrences)	
Anabaena	4
Aphanizomenon	7
Asterionella	13
Centric Diatom	4
Ceratium	1
Chlamydomonas	1
Eudorina	1
Euglena	1
Fragilaria	8
Melosira	41
Microcystis	8
Oocystis	2
Pandorina	1
Pennate Diatom	7
Scenedesmus	1
Sphaerocystis	13
Tribonema	3
Unicellular Chlorophycae	2

West London

Melosira was the most prevalent taxon throughout the year, with 41 occurrences during the trial period of the Mecana Microfibre cloth (Table 1).

Pennate diatoms (7 occurrences) were also seen, mainly during the autumn period. These tend to be the more troublesome algae to remove (Figure 8).

Overall, algae removal during the highest challenge periods equated to efficiencies of 82 – 91%, with an overall *Melosira* removal during the entire trial period of 75%.

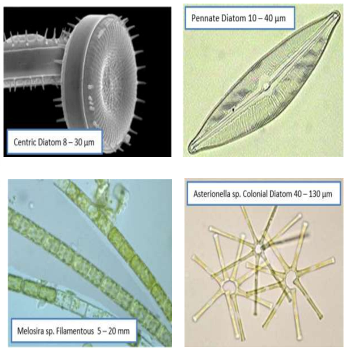

Figure 8 – Common algal species of principle concern

East London

Melosira (Figure 8) was the 1st most common algal taxon seen in the East London development cloth trial, with 23 occurrences, during both spring and autumn algal bloom periods (Table 2).

Centric diatoms and pennate diatoms were also present during the trial as the 1st most common algal taxon in 17 and 9 samples, respectively.

Occurrences of *Asterionella*, *Tribonema*, *Ankyra* and *Aphanizomenon* were also seen. (Table 2)

Overall, chlorophyll-*a* removal efficiencies during this development cloth trial were seen up to 92%.

Table 2: Most common algal taxon in East London

1st Most Common Algal Taxon (No. of Occurrences)	
Aphanizomenon	1
Ankyra	2
Asterionella	3
Centric Diatom	17
Melosira	23
Pennate Diatom	9
Tribonema	3

CONCLUSIONS

Both PCMF Microfibre and development cloth performances showed removal rates comparable to typical conventional RGF treatment. The graphs show load-dependent removal, but this is acceptable, and it is probably beneficial to subsequent treatment stages that not all the particles have been removed. For chlorophyll-*a* the variation in removals is likely to be due to the different shapes and sizes of the algae. The PCMF technology used backwash volumes typically below 1% of the forward flow, this compares well with standard RGF backwash volumes of 3 – 5%. The trials have suggested that the novel application of this technology could provide extra protection to the treatment processes employed on water treatment works in future periods of high algal loading.