How Thames Water reinvented its fast sand filters

CELEBRATING: "-Thames Water has strong traditions for being in the forefront of water treatment. Our long term research into different filtering materials has been highly fruitful." Dr. Michael Chipps, head of reserach at Kempton Water Laboratories.

ADVANCED: The research facilities at Kempton Park.

THAMES WATER

A pioneer in filtration reserach

When algal blooms put the sand filters under pressure, Thames Water started its own in-house research into new filter materials. Not only did the effort cure the constraint, the use of new filter materials has saved millions in investments.

THE USE OF SAND for water filtration has for more than a century been the backbone of water treatment in the Thames region. This simple method still brings safe water to the millions of inhabitants in the region, including the city of London. However, some years ago the primary sand filters of some water works of Thames Water had difficulties dealing with the increasing amount of organic load in the raw water, which was caused by algal blooms in the reservoirs. Thames Water had to search for other filter materials.

Renovating

After years of research with trials and full scale testing, Thames Water have today a deeper understanding of rapid filtering and precise data on the performance of current filter materials.

"The research has given us unique basis for building better filters. So far we have renovated many of our filters with success, and the work continues", tells Dr. Michael Chipps, lead scientist of the water research centre of Thames Water at Kempton Park Water Work in Middlesex.

Way back

The first water works of the Thames region were established in 1845. According to regulations, water should only be produced above the maximum tidal level, to avoid risk of re-contamination from sewage. All drinking water was produced by "slow filtering" in large outdoor filters, with the size of half a football pitch. The water passes through a deep layer of sand that filters the natural way.

The slow sand filters are maintained by occasionally scraping off 2-3 centimeters of the top layer.

The slow sand filters of today have been modernized with a layer of activated carbon, to eliminate odor and taste.

A change of the climate

However as the slow sand filters some decades ago started struggling to keep up with the demand, new rapid sand filters were installed to pre-treat the water. The slow sand filters are still often used in some water works of Thames Water, as a finishing step with a barrier against parasites etc.

Changes in the climate and more nutrients in the water source (The Thames River) most likely caused constraints on the fast sand filters. The primary reason is algal blooms in the water reservoirs. This led to an increasing need of back washing of the primary sand filters, and the production capacity has decreased due to this.

The slow sand filters have a limited scope for improvement, since they cannot be back flushed and work only by natural processes.

"Our focus was therefore to improve the rapid sand filters and our ambition was to find new filter-


TESTING: Research staff with great interest in improving filtering.

CANDIDATES: Both anthracite, sand and expanded clay has been thoroghly tested and compared for hydraulic properties and filtering performance.

ing materials for these, furthermore to rebuild and re-furnish them with a new filtering material, and the right support systems", explains Dr. Chipps.

Water, energy and time

The problem of the rapid sand filters was actually not the ability to filter itself, although the capacity of a single filter was reduced. The key problem was a large need for back flushing.

"Back flushing is our biggest expense. It requires energy, clean water and reduces production time. Water, energy and time are money. Ultimately, the need for back flushing is a limit for the total capacity of a plant", explains Dr. Chipps.

The research has produced valuable results. Dr. Chipps and his team has managed to improve on the output of the fast sand filters greatly. First by introducing dual-media, and secondly by using expanded clay (Filtralite).

The need for backwashing of the filters has been reduced, and the production is today far less vulnerable to algal blooms than it used to be.

"With new filter materials, and especially Filtralite Mono Multi, we have increased the capacity of water works without having to increase the actual footprint. Our research has been profitable", says Dr. Chipps.

Today Filtralite Mono-Multi® (Filtralite HC 0.8-1.6 in bottom and Filtralite NC 1.5-2.5 on top) is the preferred choice of filter material, and 37 filters have so far been renovated with this.

Thames Water is on a long term program to replace all filters with Filtralite. It has given the filters better performance and lower operating costs.

Broad approach

Testing new filtering materials first started on a broad basis. All commercial available filter materials World Wide were tested. A wide range of materials were first tested for hydraulic performance and crude filtering performance. To support the observations also scanning electron microscopy (SEM) was taken of the filtering particles. The SEM revealed physical characteristics, as well as a revealing the amount of biological growth on the material.

"We have studied all aspects, like the filtering ability itself of different sizes and types of particles, the hydraulic resistance, the amount of particles a filtering material is able to hold, and how often they need backwashing. As algae are a part of the problem, we have of course studied how the filtering material behaves during high loads of algae, as in algal blooms", explains Dr. Chipps.

More than a dozen filter materials were studied, further research was done with the top four filtering materials. These were sand, crushed glass, sand/anthracite and Filtralite Mono-Multi®.

Further studies

These four top candidates were then compared and characterized in all respects; Minute studies of the development of the pressure during filtering cycles were done. Filtering performance and dynamics were characterized. The continuous monitoring included collecting data on head loss, flow rate, turbidity & particle counts of the filtrate. The research went on for several months.

This work was carried out in cooperation with the Department of Civil & Environmental Engineering at the University College of London.

"We also looked at the degree of biological growth on the different materials, and discovered that this may affect the filtering performance. Material that gradually become "fouled" with microbial growth is becomes increasingly difficult to backwash", says Dr. Chipps. The durability and the commercial availability of the material were also looked upon.

The duo filter

The best results were achieved with so-called dual-filters. The two combinations sand/anthracite and Filtralite Mono-Multi® (two sizes) performed far better than any other material. The ability to catch particles of different sizes in the filter bed seem to be of high relevance, and this ability seem to give less head loss and longer filtering cycles, i.e. a reduced need of backflushing.

"If we take all considerations into the picture, 2 layers of Filtralite filters are highly effective, so we have also studied different fractions of these. It seems clear that the Filtralite Mono-Multi® possess an extra filtering dimension, which may be explained by its open structure. This is the reason why we have already renovated 37 rapid sand filters with Filtralite Mono Multi", states Dr. Chipps.

The discovery of Filtralite Mono-Multi® has already saved Thames Water great investments, as older fast filters can be renovated and given increased capacity without increasing the footprint.

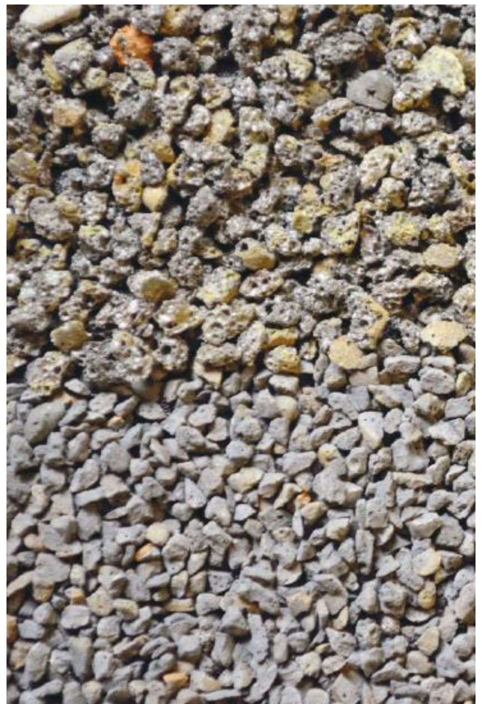
"Our new precise knowledge of filtering material has saved the company millions of GBP in investments into new systems", states Dr. Chipps.

The Filtralite function

Filtralite is made from expanded clay and developed especially for water filtering purposes. Filtralite works by a different principle than sand. The two kinds of the Filtralite used at Thames Water typically have the fractures of Filtralite HC 0,8-1,6 mm and Filtralite NC 1,5-2,5 mm respectively. Filtralite can be characterized as small hard pieces of open sponge, with internal pores of various sizes. As the water passes through the filtering bed, the particles are trapped in the pores of the Filtralite bodies. The water is hence free to pass right through the Filtralite itself, making clogging difficult. Thanks to its porous structure Filtralite is a more open filtering medium than sand, with extra large room for storing particles. As the pores of Filtralite are smaller than the spaces between sand grains Filtralite also catch cyanobacteria, and reduce the total amount of small particles escaping the filters as well.

The wash water flow needed for each backwashing is also reduced, due to the lower specific weight of Filtralite than sand.

MONO-MULTI: Filtalite at work, note its porous nature and distinct layers



LAB: A separate monitoring room provides control and data recording.

ADVANCED: Parallell trials with different filtering materials give relevant data.

EXACT: Studying the pressure dynamics of filtering cycles provides valuable data

Fact summary

1. Glass media provided some advantage over sand media, but not significant to operations:
– Biological fouling of glass media was evident despite collapse-pulse backwashing.
– Just as vulnerable to being clogged by algae as sand.
– Run lengths 20-40% longer than sand-only media.

2. Dual media - Filtralite - pilot filters demonstrated consistently longer run times (100-800% longer) than conventional dual media pilot filters (sand/-anthracite), whilst producing acceptable filtrate quality.

3. SEM analysis indicated scope of expanded clay for biological colonisation,however this was thought to benefit treatment rather than hinder it.

4. Full scale results are promising: replacement of sand by a bed of Filtralite (in a operational RGF) has lead to longer run times, whilst still meeting quality requirements.

5. Filtralite appears less vulnerable to blinding by algae (pilot scale & full scale results)

THAMES WATER

The giant steam engines at Kempton Park are a proof of advanced engineering, they were built to pump fresh water all the way to the city of London and are today a listed historic place.

“ Local knowledge and engineering skills has been a trademark of Thames Water”, tells Michael Chipps, lead scientist at the research centre at Kempton Park.

Today Thames Water has started a technological revolution in filtering. “ We have actually re-invented our sand filters, today we save millions of GBP thanks to new filtering materials, and amongst these, Filtralite is the most outstanding.”

Engine house at Kempton water park. Photo: Ron Early

The Thames Region including the capital of London has a steadily increasing need for water. The raw water available is however not increasing in the same degree.

“ Our major concern are periodical algal blooms, that clog the filters or reduce their filtering capacity by half and demand more frequent back flushing. In some cases we have been on the verge of water shortage”, explains Dr. Michael Chipps, chief scientist at The Thames Region’s research laboratories at Kempton Park Water works.

FILTRALITE FACTS: Filtralite is a lightweight ceramic particle aggregate made from expanded clay. Filtralite is designed, and proven to be an excellent material, for water and wastewater purification. The low density granules have large pore volumes with large surface areas, which are ideal characteristics for conventional filtration. Filtralite is also an ideal medium for biofilm growth. See more at www.filtralite.com