Understanding and optimization of filtration systems in commercial swimming pools using particle counting

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The Company

Scientific underpinning of best practice

- optimising pool filtration and disinfection

- improving efficiency of chemical, water, energy use

- improving customer experience (water clarity, pool air quality).

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Introduction

Key points

- Filtration is important for removal of dirt from pool water

- Good filtration leads to good water quality (and more)

- *How do you know if your filtration is working properly?*

- We have some tools (models and measurement) which can help.

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Pool Water

Water is usually

drinking water quality

as it first

enters

the pool.

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The Problem is Bathers!

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Bathers Mess up the Water

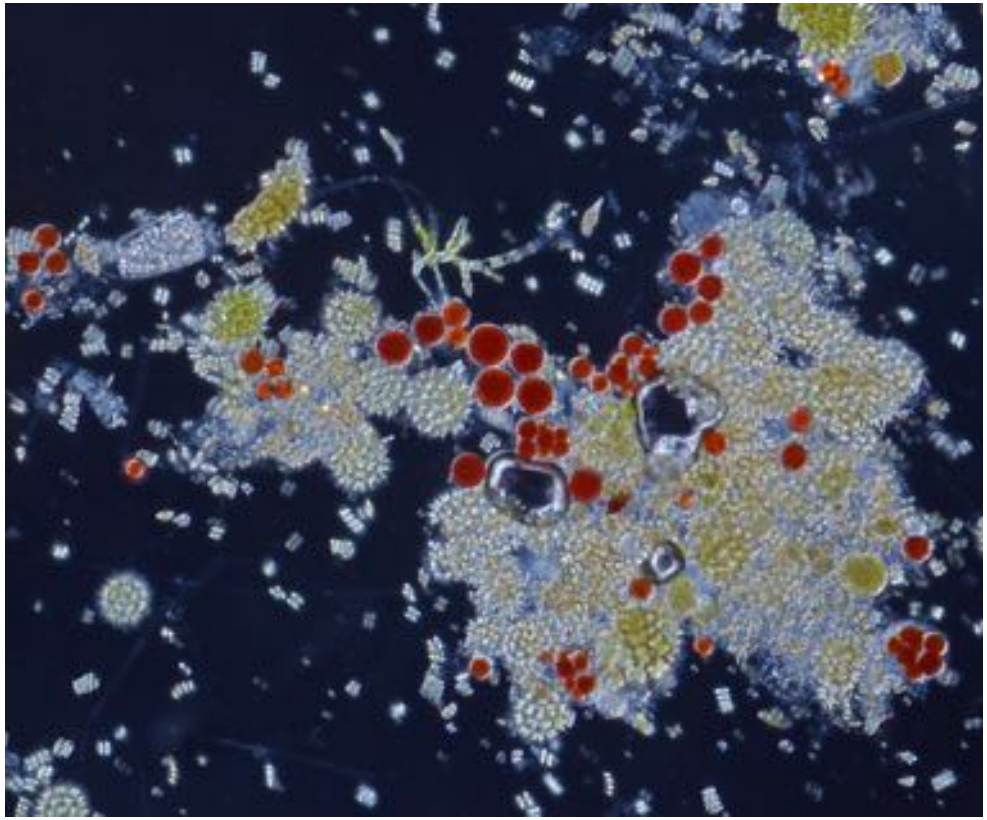
skin

oils

sweat

urine

faeces.



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Dirty Water Causes Problems

Hazy water

Visibility for lifeguards
Aesthetic appeal to bathers

Bioslime

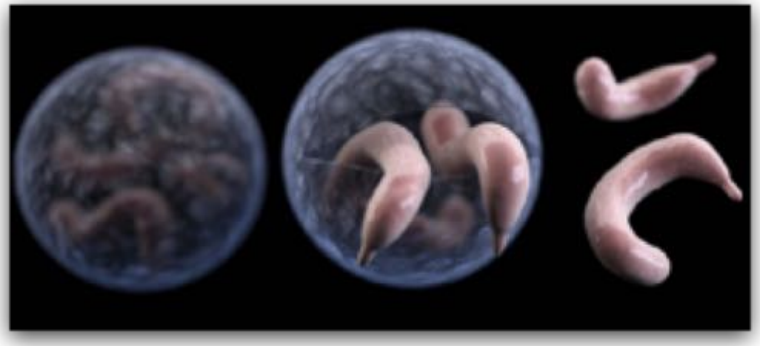
Microbiological risk
Chlorine consumed

Disinfection By-products

Poor air quality e.g. chloramines
Customer and staff complaints

Disease outbreaks

Cryptosporidiosis
Pool closure



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Methods for Measuring Dirtiness of Water

Method	Size range	Detection range	PWTAG Maximum for Pools
Clarity by eye	<1 µm	≥ 4 NTU	0.5 NTU
Turbidity meter	<1 µm	0.01-1100 NTU	0.5 NTU
Particle counter	2-750 µm	1 particle per mL - 8000 particles per mL	???

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So if water looks hazy, there is a major problem

Our Mobile Lab measures

Turbidity (single source)

Particle counts in user-defined size ranges e.g.

2-5 µm diameter
5-10 µm diameter
10-15 µm diameter
2-750 µm diameter

Monitors 6 sources of water (channels) in automated sequence with 5 min average value over several days.

Small footprint, easy to install, remote access to data.

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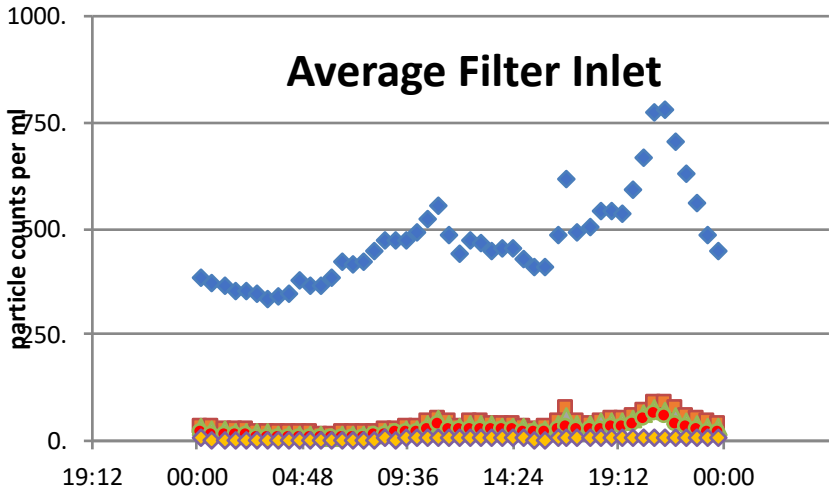
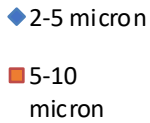
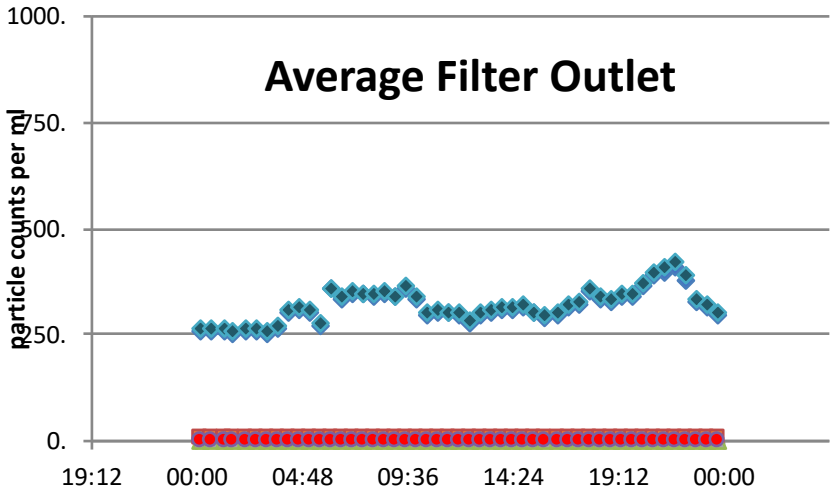
We Count Particles in Different Size Ranges

Particle Counting in 2-50 micron size band at filter inlet and outlet during a day







Key points:

- Counts higher during day and decrease during night until pool opens.
- Particle counts much greater for smaller size particles.
- Counts filter outlet lower than inlet, but similar pattern.
- Many small particles getting through the filter.

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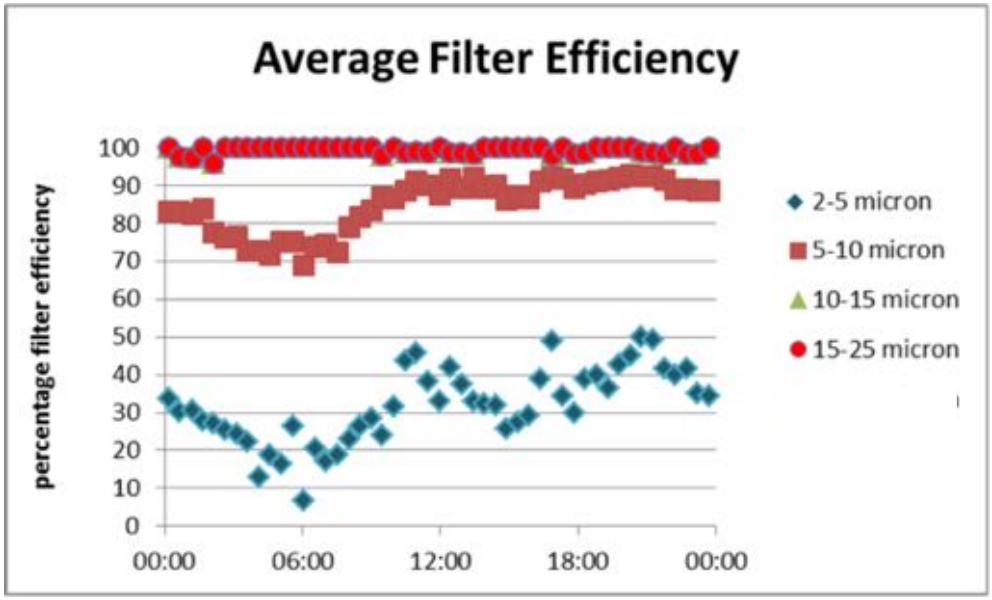
We Calculate How Efficient the Filter is in Removing Particles

Example based on particle counts at the filter inlet and outlet over 24 h

Filtration Efficiency = percentage (or fraction) of particles removed by filter



Key points

- **Filter efficiency higher for larger-size particles**
- **Only ~40% of 2-5 µm size particles removed by this filter during the day**

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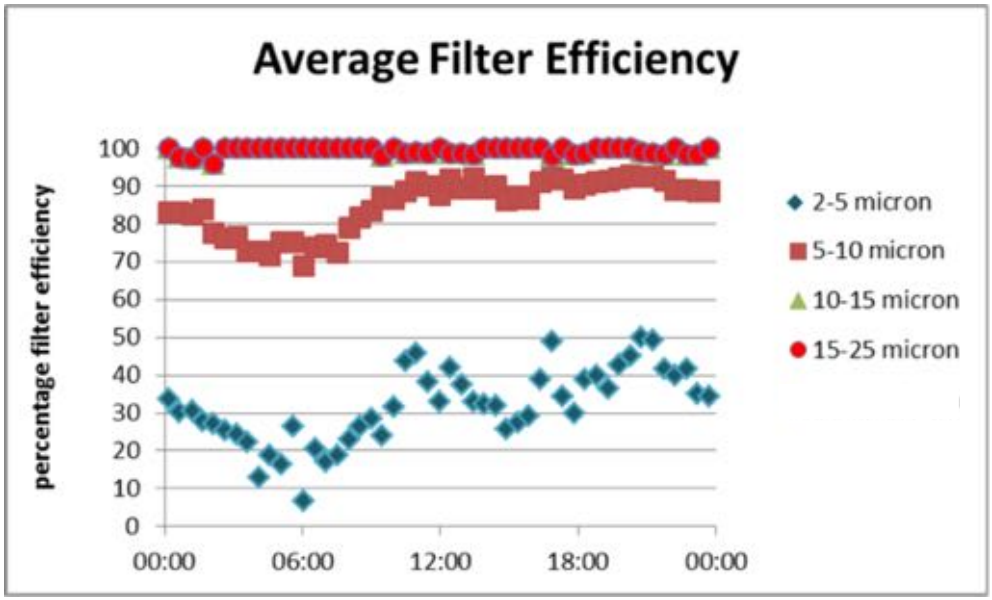
Filter Efficiency Appears to Decrease at Night

Example based on particle counts at the filter inlet and outlet over 24 h

Filtration Efficiency = percentage (or fraction) of particles removed by filter



Key points

- **Filter efficiency highest during times of high bathing load**
- **Filter efficiencies decrease during the night as water gets cleaner**

NB We also have data showing improvement in filter efficiency as filter ripens over several days following filter backwashing

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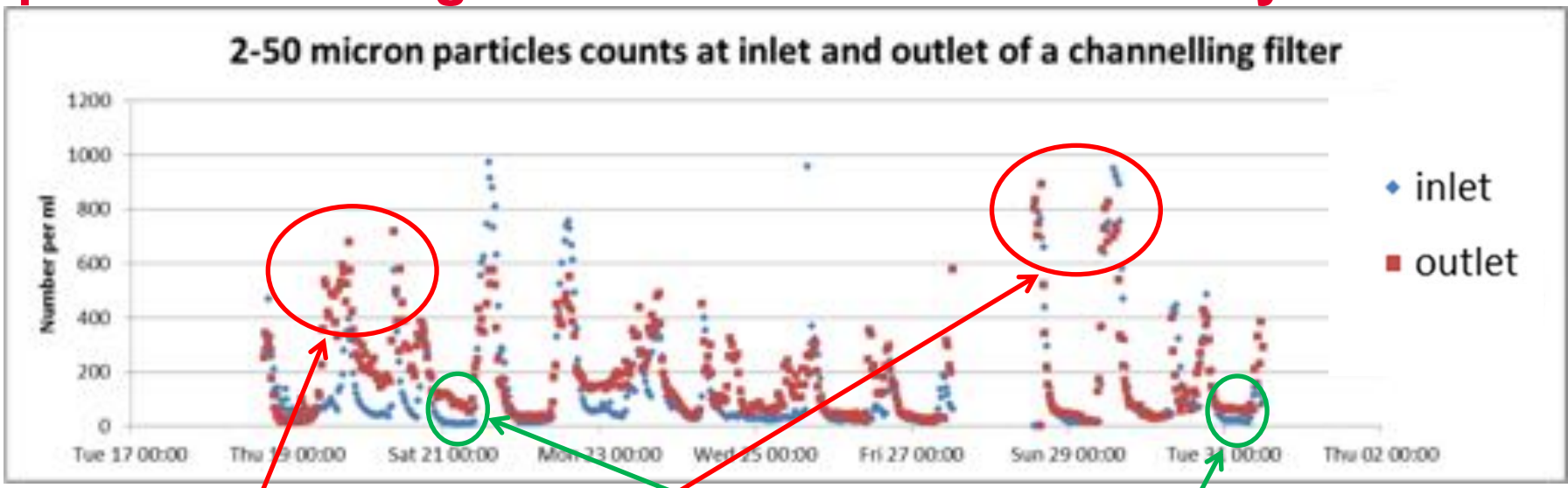
Filter Channelling- an example of issues revealed by particle counting over at least one backwash cycle



Daytime particle counts at filter outlet are similar to inlet counts.

Conclusion: filter hardly working because water bypassing media

Night-time particle counts at filter outlet sometimes exceed inlet counts.

Conclusion: previously trapped particles washing out at night.

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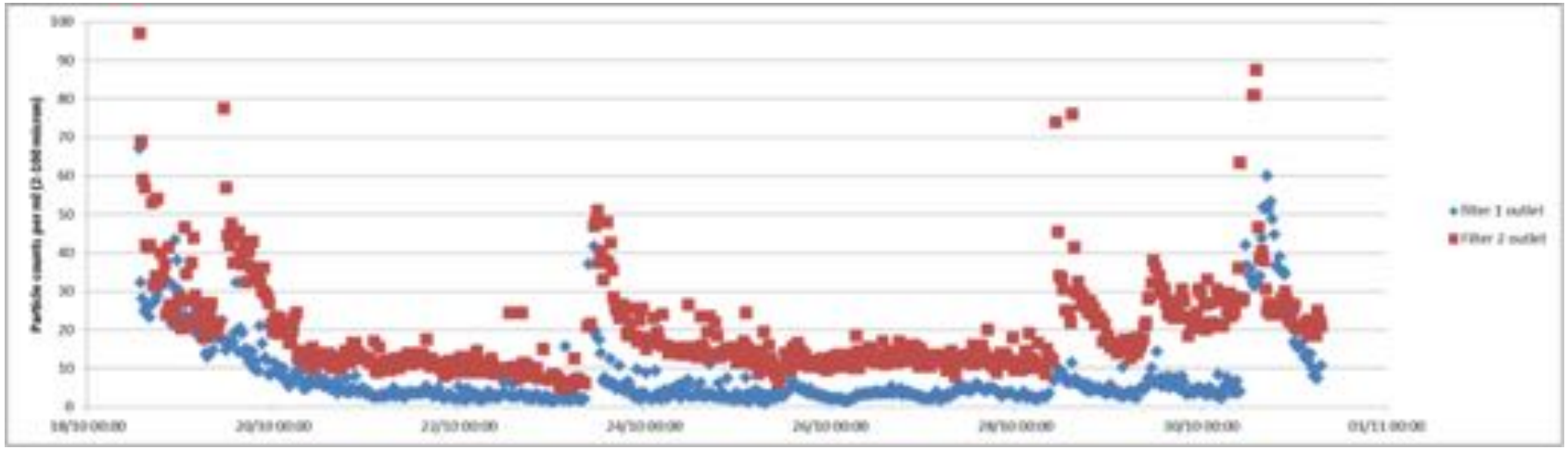
Differences Between Filters at Same Site



	FILTER 1	FILTER 2
Plateau filter efficiency	**90%**	**60%**
% of daily particles breaking through	5%	30%

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Predict Risk using Simple Model

We have calculated the removal of *Cryptosporidium* oocysts from pool water based on four combinations of mixing and filtration:

POOL MIXING

Well-mixed pool (63% water treated per turnover)

Pool with dead zones (53% water treated per turnover)

+

FILTRATION EFFICIENCY

Good filtration (90% removal of 4-6 µm size particles)

Poor filtration (50% removal of 4-6 µm size particles)

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Predict Risk using Simple Models

% water treated per turnover	% removal of particles by filter	% oocysts remaining after 6 turnovers	No of turnovers in same pool needed to achieve best practice
63	90	0.7	**6**
53	90	2.0	**8**
63	50	10.3	**13**
53	50	15.8	**16**

Key points

- Good filtration efficiency is key to managing risk from *Cryptosporidium*
- A combination of measurement and modelling can be used to manage risk

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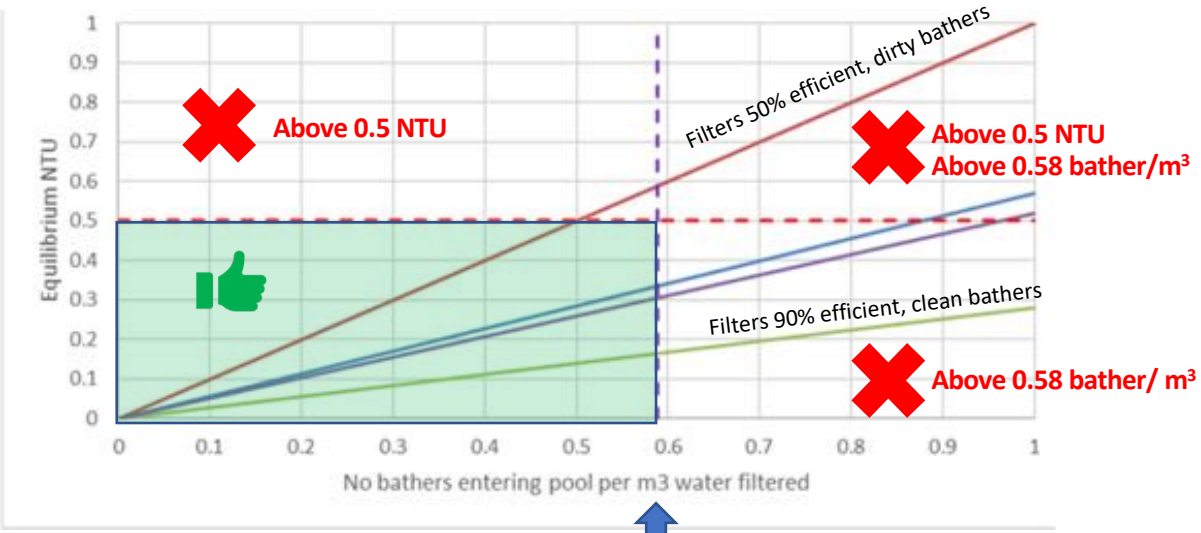
The Science and Good Practice Meet!

Science question:
What equilibrium turbidity is reached if constant bathing load is sustained indefinitely?
Predictable as we know range of turbidity input per bather (dirty bathers, clean bathers).

Science finding:
Treating 1.7 m^3 / bather will maintain water <0.5 NTU turbidity limit for most pools



0.58 bather/m^3 = 1.7 m^3/bather

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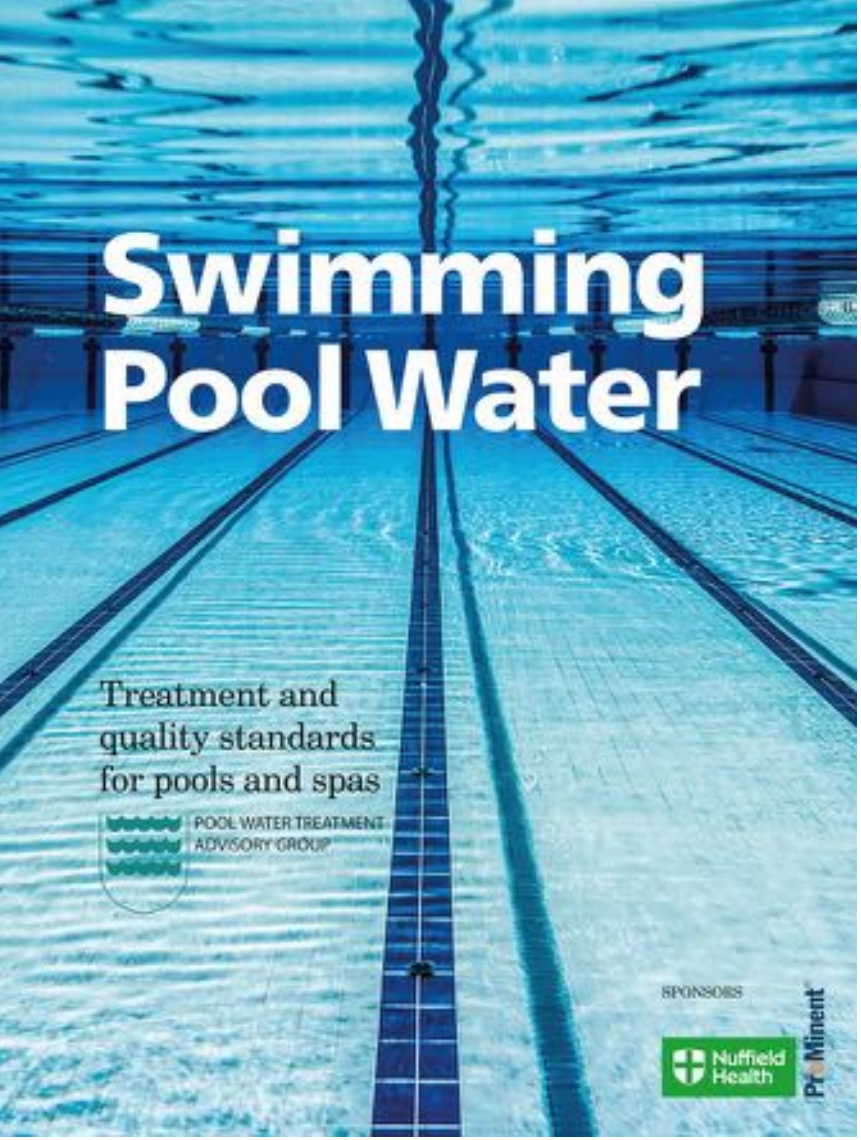

Circulation Rate (m^3/h) calculated from:

1.7 x Instantaneous Bathing Load

"it has been arrived at from good practice over the years."

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Take-Away

If water isn't clear you probably have a problem with your filtration which may not be obvious from visual filter inspections.

Particle counting and modelling are useful for checking filtration systems and for Crypto risk management.

Difficult to assess filtration from a single spot measurement - need data over whole backwash cycle.

Is there a role for turbidity measurements? Yes but needs further work.

Filter efficiency is as important as circulation rate.

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Thank you!

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