



Dryden Pool Academy SESSION 4

BIOLOGY IN FILTERS AND DISINFECTION BY-PRODUCTS




10
HIGH-LEVEL
TRAINING
SESSIONS





1

AGENDA 9:30 – 10:30






9:30


The biology of a sand filter and the main problems of biofilm

Disinfection by-products: How are they formed and how to reduce them

- Trichloramines
- THM's (chloroform)
- Chlorates



10:25 Q&A : Questions / Answers





2

Questions & Answers

Prepare and send us your questions during the meeting using the chat!

Chat
Raise Hand

Q&A

3

Dryden Pool Academy presentations and replays






Replay available for 7 days after each session (EN, DE, FR, US)

PDF Presentation available for download 24 hr before each session (every Thursday)

www.drydenaqua.com



4



3 simple steps!

SESSION 3



1



Length – Speed – Turbulence

If you slow the speed by a factor of 2, the pressure loss goes down by a factor of 4

2



Use the magic ruler
Suction side : 1,0 – 1,5 m/s
Pressure side : 1,5 – 2,0 m/s


3




Make smart energy savings with an eco mode!

5

5

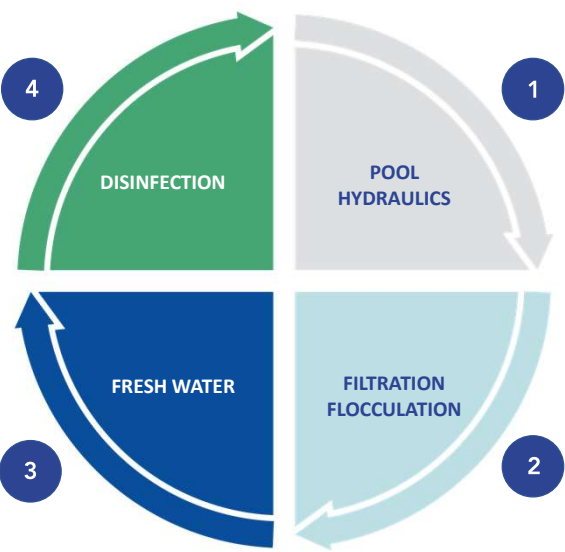


We must reduce our chemical & energy footprint



Chemical consumption will be reduced

- Reduced operating costs & environmental impact
- **Optimal bather comfort & safety (less DBP's)**



Pool hydraulics must be perfect

- to reduce energy losses
- to ensure correct filtration & backwash flows

Water consumption will be reduced


- Reduced running costs & energy losses (water, chemicals, heating)
- Reduced environmental impact

Filtration must be optimized

- to remove more organics
- to reduce oxidation demand and DBP's
- To reduce water consumption

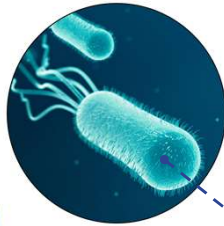
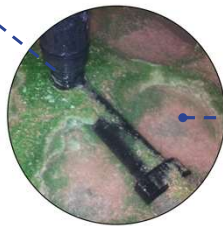


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6




DRYDEN POOL ACADEMY


The biology in a sand filter and the main problems of biofilm

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Biology in sand filters

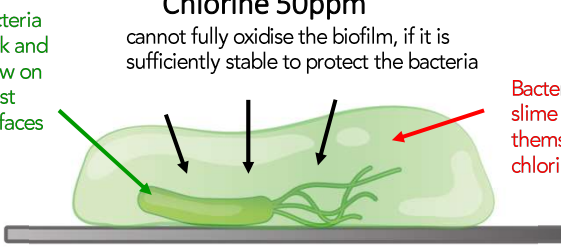


► How do bacteria survive in a swimming pool?

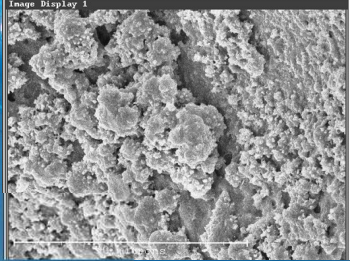

Chlorine 50ppm
cannot fully oxidise the biofilm, if it is sufficiently stable to protect the bacteria

Bacteria stick and grow on most surfaces

Bacteria secrete a slime to protect themselves against chlorine oxidation




Biofilm can develop on walls, floor, pipework and especially in the filter media





The filter media represents approx. 90% of the total pool surface
1m³ of sand has a surface of 3.000 m²

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Biofilm => Example of a 25 x 12,50 m pool
Pool volume 480m³ => flowrate 120m³/h



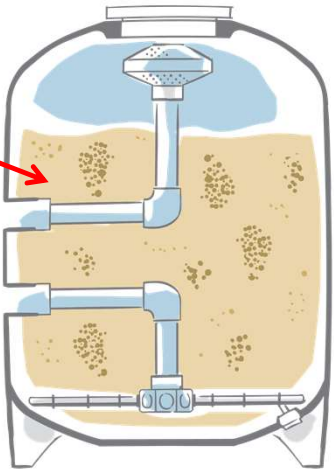
The filter media is the largest surface


1 m³ of sand = 3.000 m²

Ex: 2 Filters Ø 1640mm => 4m² x 1.25


- 5m³ x 3.000 m² = **15.000 m²**
- Pool 25 x 12,5 x 1,5 = **425 m²**

▶ **Filter media => 97% of total surface**






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The main problems of biofilm:
1. Channeling and coagulation of sand



- ▶ Biofilm leads to coagulation of sand and the formation of channels
- ▶ Inconsistent and unreliable filtration

Clumps

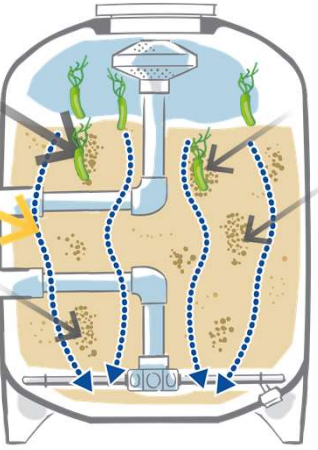
Channels


Bacterial flocs discharged into pool


Turbidity increases

Chlorine consumption increases

Filtration is no longer reliable





NO biofilm 

- No clumping
- No channeling
- Reliable filtration

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2 ► Biofilm is a «home» for growing pathogens



In the biofilm live entire communities of bacteria and other pathogens – including Legionella, amoebae, crypto, pseudomonas...

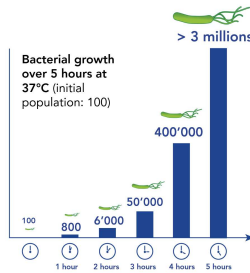
At 30°C water temperature, they can double in mass every 30 min.

Even the highest chlorine concentrations and the most aggressive backwashing can't stop this development!



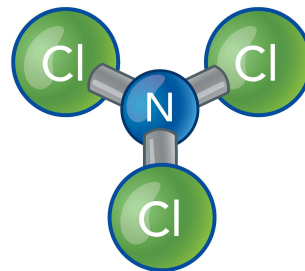
No bacteria, viruses and other pathogens

Food and temperature make a huge difference!





PROBLEM N°3 OF BIOFILM

The formation of trichloramines




3 ▶ Biofilm is responsible for the formation of trichloramines






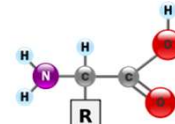
50 ml urine



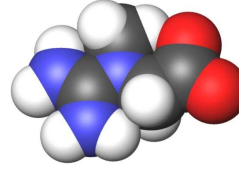
200 ml sweat



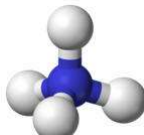
In two hours in the water, an athlete can secrete up to 1 l of sweat and 80 ml of urine.



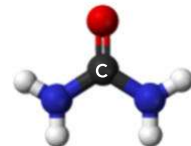
Amino acid



Creatine



ammonium about 10%




urea about 80%

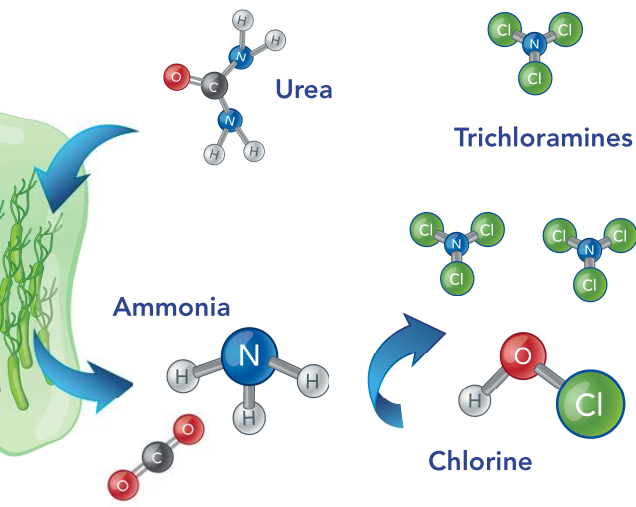
Dryden Aqua

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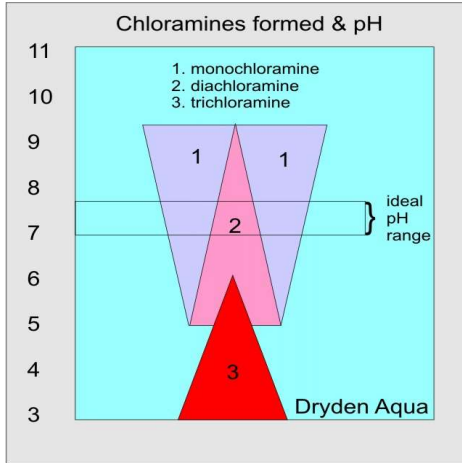
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3 ▶ Biofilm is responsible for the formation of Trichloramines






Chloramines formed & pH



NO biofilm



→ No or significantly less trichloramines

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Trichloramines provoke corrosion



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Trichloramines are inhaled by bathers at the water surface

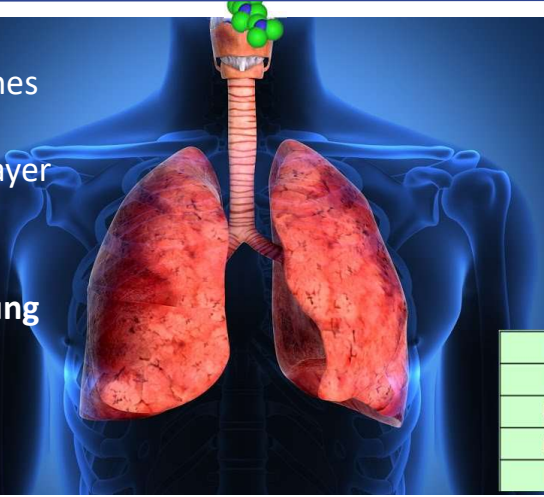


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Trichloramines : Lifeguard lung disease

Trichloramines
damage the
protective layer
of the lungs
=> Asthma
(lifeguard lung
disease)



Stoff	H ¹⁾
HClO	0,069
NH ₂ Cl	0,45
NHCl ₂	1,52
NCl₃	435



Disinfection by-products => If they are volatile – They are toxic

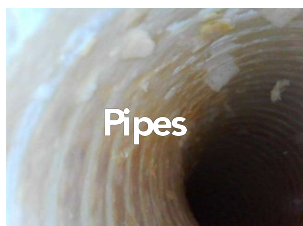
Trichloramine
435 Henry's c.

17

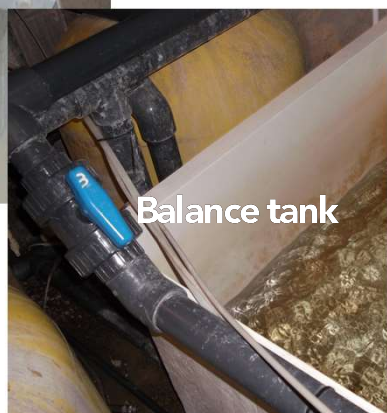
How to reduce the formation of trichloramines => Eliminate or prevent the formation of biofilm



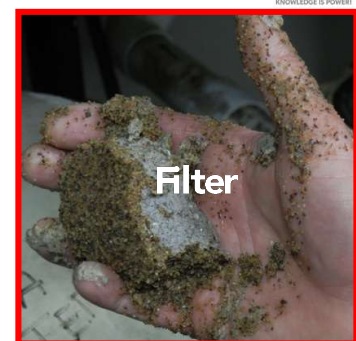
Walls and
channels



Pipes



Balance tank



Filter

Most biofilm in the
filter bed => largest
surface in contact
with water

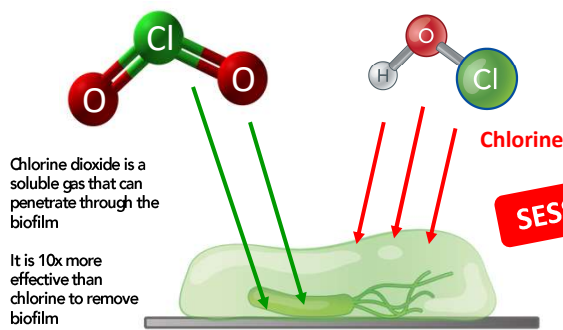
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How to reduce the formation of trichloramines
=> Eliminate or prevent the formation of biofilm



ELIMINATE EXISTING BIOFILM USING CHLORINE DIOXIDE

Chlorine dioxide ClO₂ passes through the biofilm – not chlorine!



SESSION 9

EVEN BETTER: PREVENT THE FORMATION OF BIOFILM IN THE FILTER AT THE SOURCE WITH...

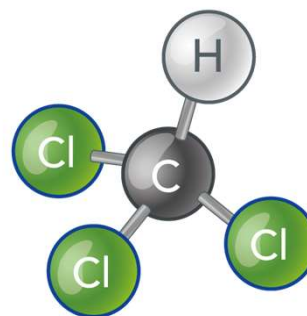
AFM : 100% BIO-RESISTANT FILTER MEDIA



SESSION 5



Chloroform



Chloroform (THMs) is formed in water when chlorine reacts with organics

UV systems splits big molecules in smaller ones

Organic compound

Methane (CH₄)
Smallest organic molecule (1 carbon atom)

Chloromethane (CH₃Cl)

Dichloromethane (CH₂Cl₂)

Hypochlorous acid (chlorine)

Chloroform (CHCl₃)
or trichloromethane
Less organics = Less potential to form THMs (chloroform). This can be confirmed by measuring the TOC (total organic carbon) Methane with 4 hydrogen atoms

Organic compounds are composed of mainly carbon and hydrogen.

Chlorine oxidizes organic molecules such as oil, lipids or protein

Organic compounds keep breaking down into smaller parts.

Chloroform (CHCl₃) is a very volatile toxic by-products.

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Chloroform : More toxic than trichloramines?

Chloroform passes the lungs to reach the bloodstream and nerve system.

Disinfection by-products => If they are volatile – They are toxic

Chloroform, 185 bar
Henry Konstante

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Disinfection by-products => If they are volatile – They are toxic



Volatile chlorine by-products are especially dangerous for small children less than 2 years old, because their blood-brain barrier is not yet fully developed.



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Oxidability => organic pollution measurement



Oxidation of organics with potassium permanganate (KMnO_4)
Analysis made to measure the total organic pollution of water

The higher the concentration of organic matter => The higher the permanganate (KMnO_4) consumption.



Permanganate oxidability (KMnO_4)
total organic carbon (TOC): $\text{TOC} \times 1.5 = \text{KMnO}_4$

The lower the better



KMnO_4

- => Development of micro-organisms
- => Increased chlorine consumption
- => Increased chloroform formation (THM)

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DRYDEN AQUA
SUSTAINABLE WATER QUALITY

How to reduce chloroform ? => Reduce the organic load



DRYDEN POOL ACADEMY
KNOWLEDGE IS POWER!

▶ FILTER OUT MORE ORGANICS WITH AFM[®]ng



AFM[®]
ACTIVATED FILTER MEDIA



↓ TOC



↓ THMs

**LESS ORGANICS
LESS POTENTIAL TO
FORM CHLOROFORM**

SESSION 5

▶ REDUCE OXIDATION DEMAND IN COMBINATION WITH COAGULATION & FLOCCULATION



→




**LESS CHLORINE
=> LESS POTENTIAL TO
FORM CHLOROFORM**


SESSION 6



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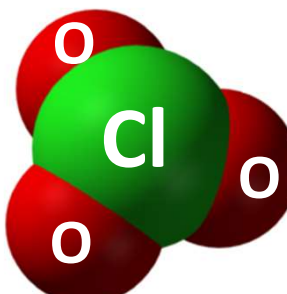


DRYDEN AQUA
SUSTAINABLE WATER QUALITY



DRYDEN POOL ACADEMY
KNOWLEDGE IS POWER!

Chlorates



ClO₃⁻

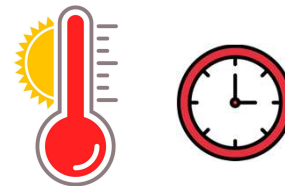
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How are Chlorates (ClO₃⁻) formed?

Chlorates are formed by decomposition of hypochlorite (ClO⁻).
Chlorate concentrations vary greatly depending on the type of chlorine used.
The main problem is sodium-hypochlorite (NaOCl or liquid chlorine)

oxidation state	-1	+1	+3	+5	+7
anion named	chloride	hypochlorite	chlorite	chlorate	perchlorate
formula	Cl ⁻	ClO ⁻	ClO ₂ ⁻	ClO ₃ ⁻	ClO ₄ ⁻
structure					

Chlorine can have the oxidation states -1, +1, 3, 5 or 7 with the corresponding anions Cl⁻, ClO⁻, ClO₂⁻, ClO₃⁻ or ClO₄⁻: chloride, hypochlorite, chlorite, chlorate and perchlorate



Hypochlorite decomposes with time, heat, and exposure to sunlight

Why are Chlorates (ClO₃⁻) harmful?

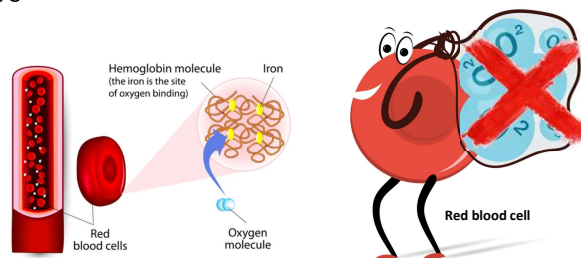
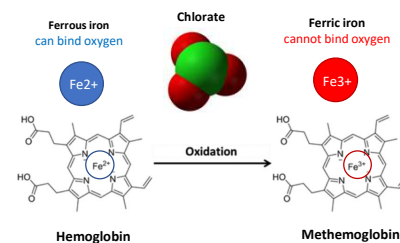
Problem:


Chlorate oxidizes iron (Fe²⁺) in hemoglobin forming methemoglobin

Methemoglobin is a hemoglobin containing oxidized iron (Fe³⁺) which no longer binds and carry oxygen.


From 20% methemoglobin, the first signs of a lack of oxygen (headache, dizziness) appear.

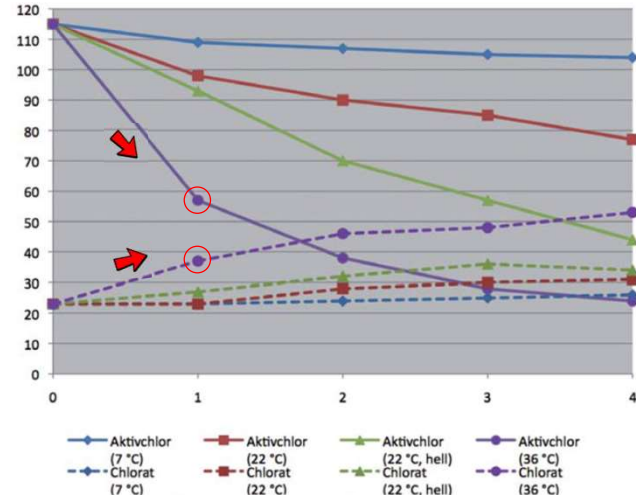
- **Limit value in public pools:**
- **DIN 19643: 30 mg / l**
- **SIA (Swiss norm) 389/9: 10 mg / l**






**Sodium hypochlorite and room temperature:
Active chlorine decreases - chlorates rise**



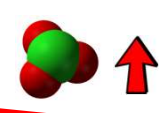


Month	Aktivchlor (7°C)	Chlorat (7°C)	Aktivchlor (22°C)	Chlorat (22°C)	Aktivchlor (22°C, hell)	Chlorat (22°C, hell)	Aktivchlor (36°C)	Chlorat (36°C)
0	115	25	115	25	115	25	115	25
1	110	35	100	28	95	30	60	38
2	108	38	90	30	70	35	40	45
3	105	40	85	32	55	38	30	50
4	103	42	78	35	45	40	25	55



In 1 month, with a room temperature of 36°C, you can lose ≈50% of active chlorine and generate ≈100% more chlorates! (= see purple curve)

- ⇒ NaOCl demand increases by a factor of 2
- ⇒ Concentration of chlorates will double in NaOCl




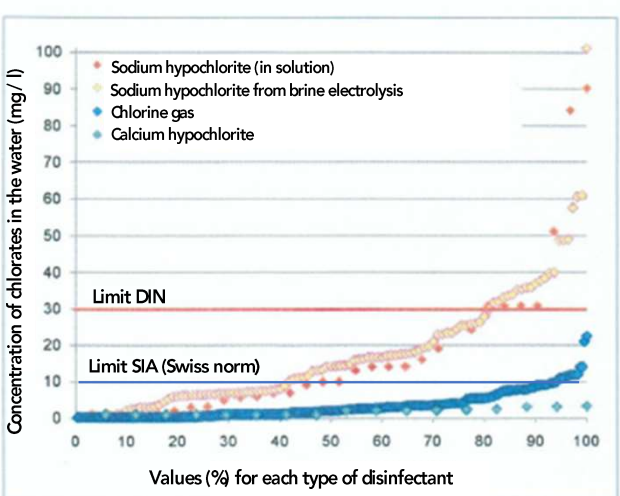
CHLORATES CONCENTRATION WILL BE INCREASED BY A FACTOR OF 4

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Chlorates


Chlorate concentrations vary greatly depending on the type of chlorine!





Disinfectant Type	Chlorate Concentration (mg/l)
Sodium hypochlorite (in solution)	~90
Sodium hypochlorite from brine electrolysis	~85
Chlorine gas	~20
Calcium hypochlorite	~10


Limit DIN: ~30 mg/l
Limit SIA (Swiss norm): ~10 mg/l



Problem with sodium hypochlorite NaOCl especially if:


- ⇒ Degradation of hypochlorite responsible for high chlorate concentrations
- ⇒ Heat, humidity, storage exposed to light !!!

Important ⇒ cool technical room (ideally 15 °C, dark and well ventilated)



Less problems with:

- Calcium hypochlorite Ca(ClO₂)
- Chlorine gas (Cl₂)



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DRYDEN AQUA SUSTAINABLE WATER QUALITY

Chlorate concentration below 1 mg/l with DA-GEN!

DRYDEN POOL ACADEMY KNOWLEDGE IS POWER!

DA-GEN

OH⁻ O^{•-}

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DRYDEN AQUA SUSTAINABLE WATER QUALITY

Solutions to reduce chlorate concentrations

DRYDEN POOL ACADEMY KNOWLEDGE IS POWER!

- 1**

More fresh water
- 2**

Store sodium hypochlorite in a dark, cool place (recommended => 15 ° C)
- 3**

DAISY => Reduce oxidation demand
- 4**

Use calcium hypochlorite or a DAGEN (=> DAISY +)

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Old therapy pool with 2 skimmers in Switzerland
Size: 4 x 10m – volume 50m³



Heavy load
50-80 bathers per day
Temperature 33°C

Combined chlorine > 1mg/l

THMs > 300 ug/l

Chlorates





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Turnover only 15m³/h instead of 40m³/h !
According to Swiss norm



Old installation
Filter d640mm (0,30m²)
Liquid chlorine






According to Swiss norm
you would need

3x filters ø840mm
Or 2x filters ø960mm
Or 1x filter ø1440mm

Compromised installation
Filter d840mm (0,52m²)
DA-GEN




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DRYDEN AQUA
SUSTAINABLE WATER QUALITY

Results : Amazing – but not good enough




DRYDEN POOL ACADEMY
KNOWLEDGE IS POWER!

Combined chlorine

THMs

Chlorates




Auftrag vom	: 19.07.18	Prüfungsbeginn	: 19.07.18
Probeneingang	: 19.07.18	Prüfungsende	: 24.07.18

Ergebnis:

Parameter	Methode (MB-Nr.)	Einheit	Resultat / Einheit	Höchstwerte
Chlor frei	Im Unterauftrag	mg/l	0.17	0.8
Chlor gebunden	Im Unterauftrag	mg/l	0.21	0.2
Chlor gesamt	Im Unterauftrag	mg/l	0.38	
Harnstoff	Im Unterauftrag	mg/l	0.11	1
Bromat	Im Unterauftrag	mg/l	< 0.005	0.2
Chlorat	Im Unterauftrag	mg/l	0.54	10
Trihalogenmethane (THM, ber. als CHCl ₃)	Im Unterauftrag	mg/l	0.072	0.02


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DRYDEN AQUA
SUSTAINABLE WATER QUALITY


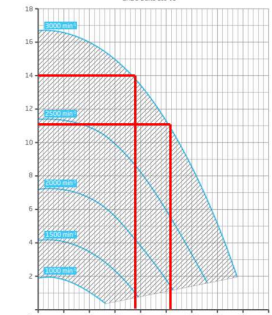
Problem: Backwash velocity too low (appr. 35m/h) because of ZPM DN50 pressure loss 0.4 bar



DRYDEN POOL ACADEMY
KNOWLEDGE IS POWER!

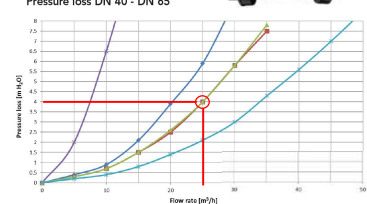


Infos Filterpumpe

Badu Delta Eco VS


Gez:	N.S.	Geändert:	Datum:	Auftrag Nr.	
Datum:	10.08.18	N.S.	07.11.18	Schema Nr.	V1
				Blatt:	135

Pressure loss DN 40 - DN 65






After removing ZPM and adding FlowVis
 => ZPM out (- 0.4 bar) + FlowVis in (+ 0.1 bar) => flowrate 26 m³/h
 => 0.3 bar less pressure drop => Backwash speed = 50 m / h

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Perfect Results



Zeitpunkt der Probenahme : 13:30

Auftrag vom : 31.10.18 Prüfungsbeginn : 31.10.18

Probeneingang : 31.10.18 Prüfungsende : 07.11.18


Ergebnis:

Parameter	Methode (MB-Nr.)	Einheit	Resultat / Einheit	Höchstwerte
Chlor frei	Im Unterauftrag	mg/l	0.32	0.8
Chlor gebunden	Im Unterauftrag	mg/l	0.06	0.2
Chlor gesamt	Im Unterauftrag	mg/l	0.38	
Harnstoff	Im Unterauftrag	mg/l	0.23	1
Bromat	Im Unterauftrag	mg/l	< 0.05	0.2
Chlorat	Im Unterauftrag	mg/l	< 0.1	10
Trihalogenmethane (THM, ber. als CHCl ₃)	Im Unterauftrag	mg/l	0.018	0.02

Combined chlorine


THMs

Chlorates




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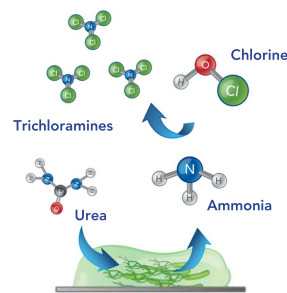


3 simple steps!

SESSION 4

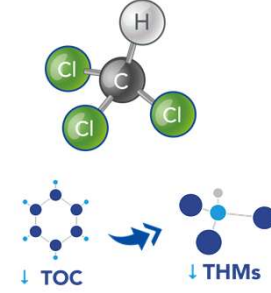


1




No biofilm in the filter bed
=> Significantly less formation of toxic trichloramines

2



Less organics in the water
=> Less formation of chloroform and other THMs

3



For the lowest chlorate concentration => Use calcium hypochlorite or a DAGEN

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JOIN SESSION 5 ON FEBRUARY 19TH

SESSION 5

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AFM[®] was developed to lower DBP's

Marine biologist
Dr. Howard DRYDEN

PHD in sand and zeolite filtration - specialized in water treatment for over 35 years.

Lung infections due to toxic volatile trichloramines and THMs in the air just above the water surface

His 1st mission: Develop a technology to eliminate toxic chlorine by-products

AFM[®]
Activated Filter Media

Replaces sand in all types of sand filters

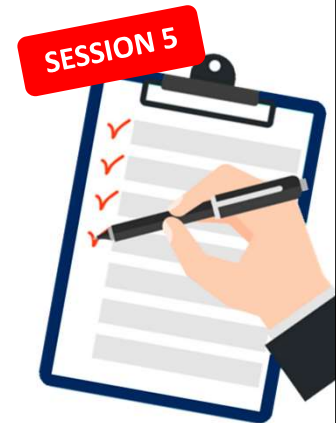
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FEBRUARY 19TH 2021

zoom

**SESSION 5****AFM: ACTIVATED FILTER MEDIA**

- What is AFM® and what does activation mean?
- AFM®ng: The Game Changer
- AFM® filtration and backwash performance
- The new 50/50 layering



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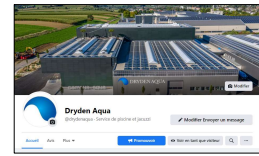


DRYDEN
POOL ACADEMY

Questions / Answers



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