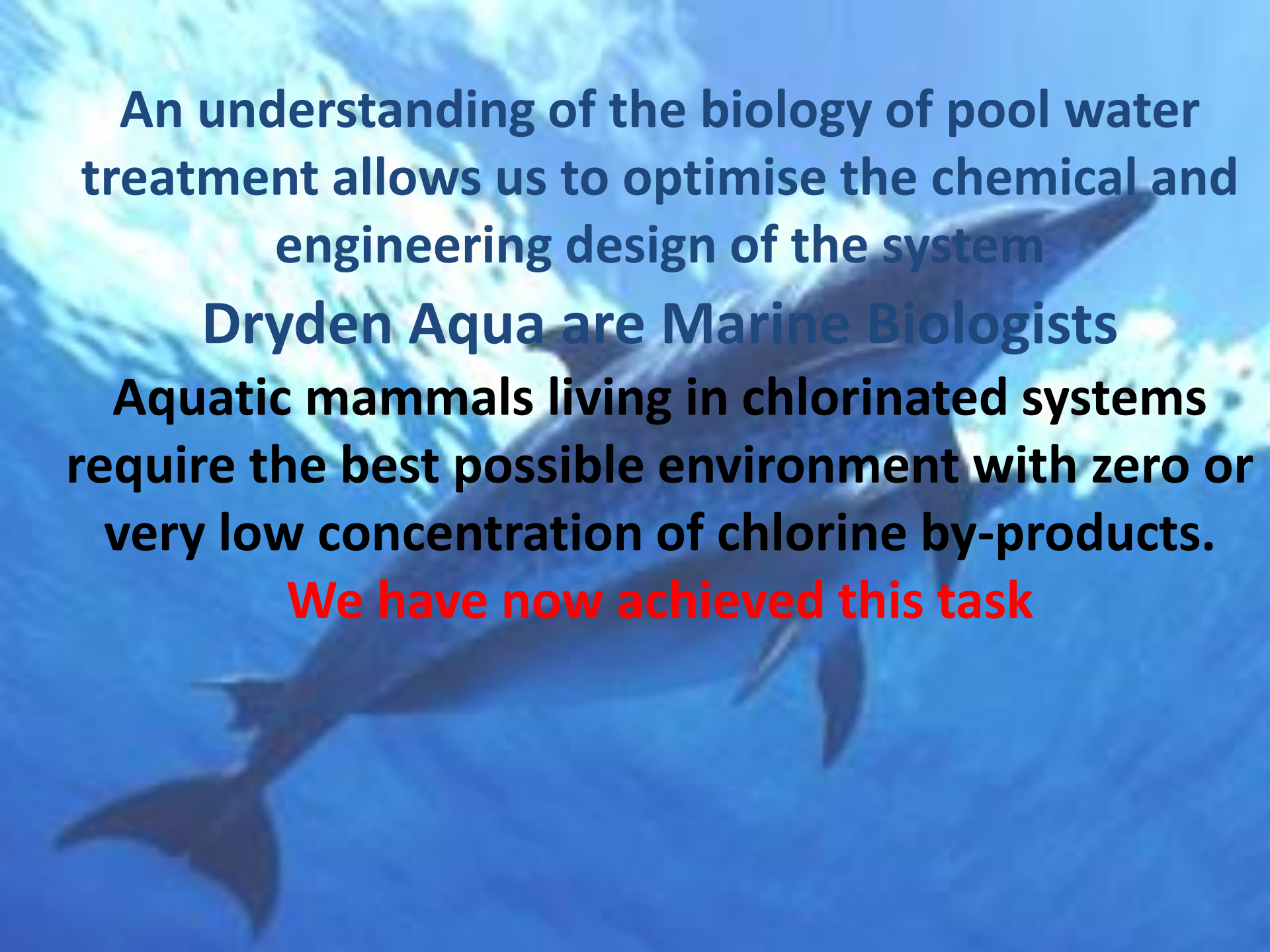


Integrated Pool Water Treatment



DRYDEN
AQUA

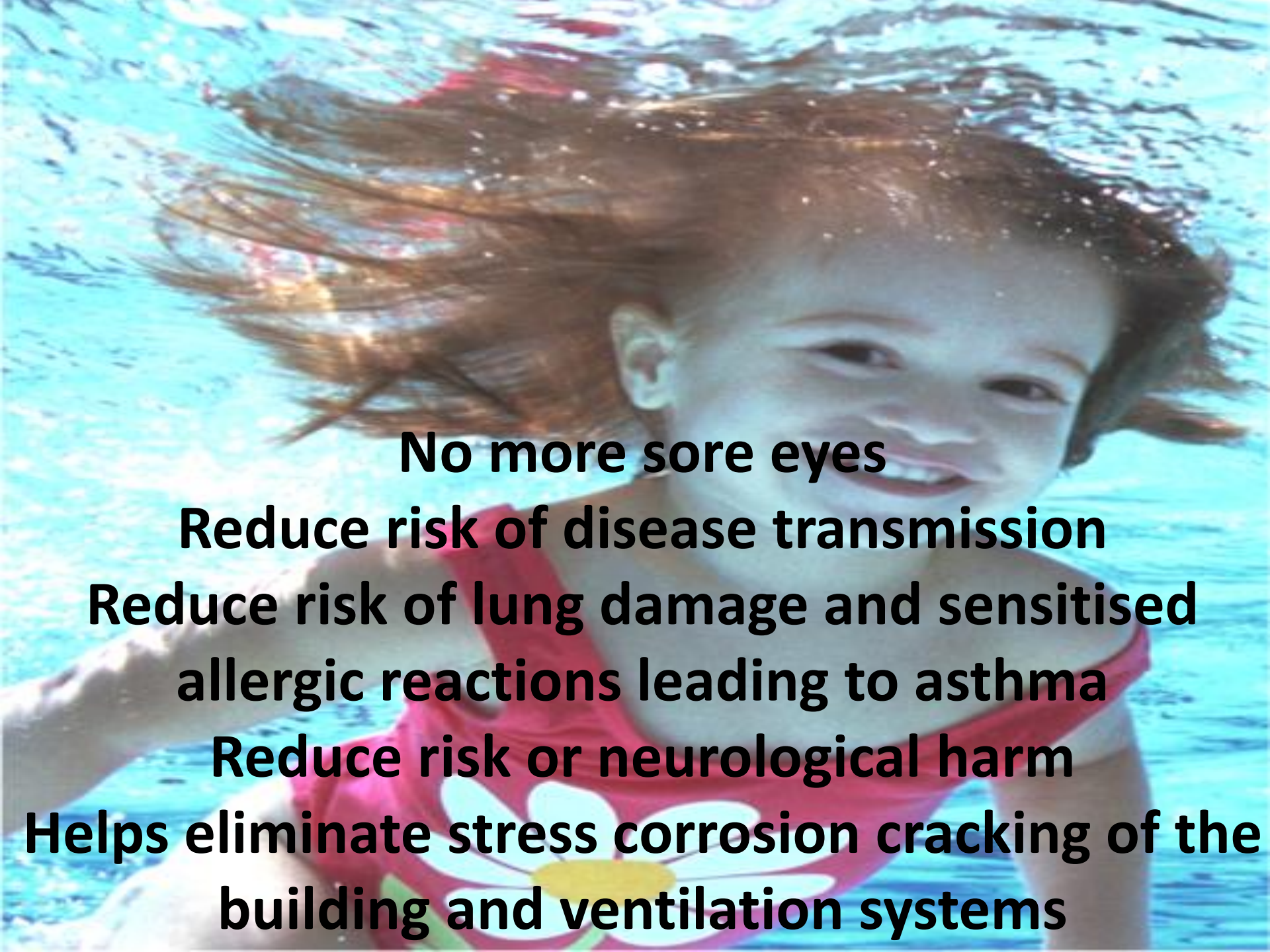
A large shark is swimming in clear, bright blue water. The shark is positioned diagonally across the frame, moving from the bottom left towards the top right. Sunlight filters through the water, creating a shimmering, dappled light effect on the shark's body and the surrounding water. The background is a deep, clear blue.

An understanding of the biology of pool water treatment allows us to optimise the chemical and engineering design of the system

Dryden Aqua are Marine Biologists

Aquatic mammals living in chlorinated systems require the best possible environment with zero or very low concentration of chlorine by-products.

We have now achieved this task



No more sore eyes

Reduce risk of disease transmission

Reduce risk of lung damage and sensitised allergic reactions leading to asthma

Reduce risk or neurological harm

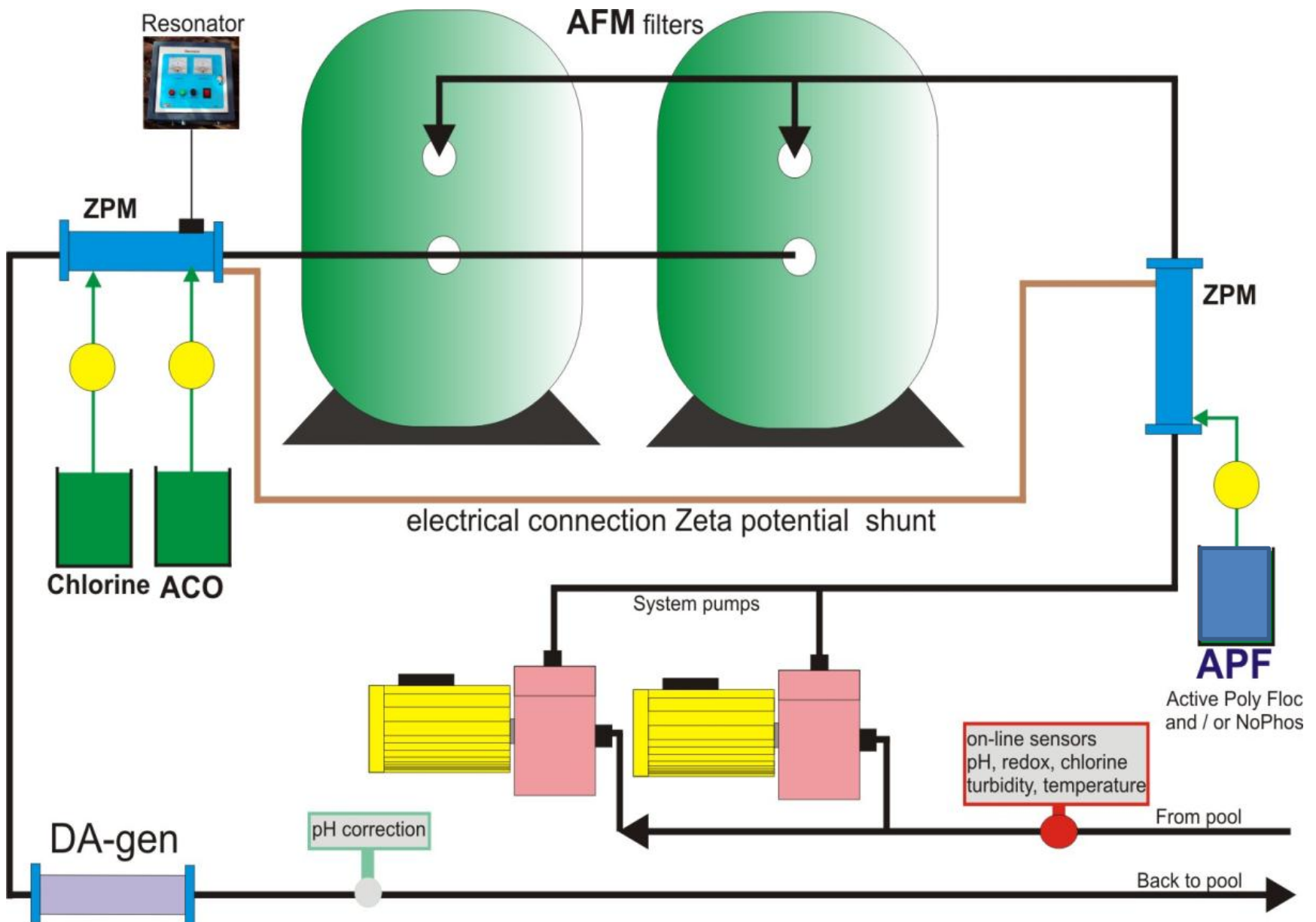
Helps eliminate stress corrosion cracking of the building and ventilation systems

Results

- Reduce chlorine demand by 50% to 95%
- Run a public pool at under 0.2mg/l inorganic combined chlorine, or a private pool with virtually no chlorine or oxidising chemicals
- Almost eliminate disinfection by-products
- Comply with upper health and safety limits for chloroform, nitrogen trichloride and Cyanogen chloride
- Swimming in a poor pool over DAP >4 is equivalent to smoking a cigarette every 3 minutes, we solve this problem.

How do we achieve these results ? ----->

Dryden Aqua Integrated pool treatment system

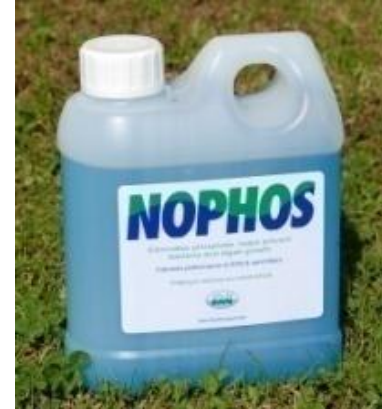


NOPHOS

APF

Active Poly Flocc

- NoPhos for use with private pools, APF may be used instead of NoPhos in private pools.
- APF is essential for public pools with AFM, also works well with sand systems
- APF & Nophos both have a +ve charge and drop the Zeta potential of the water.
- Most of the particles and dissolved components, have a – ve charge. APF and NoPhos neutralise and give them a +ve charge, this allows the –ve Zeta Potential charge on AFM to remove the particles from the water.

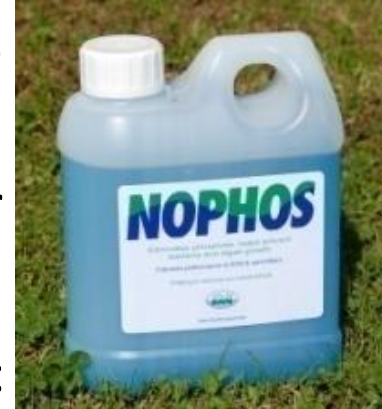


NOPHOS

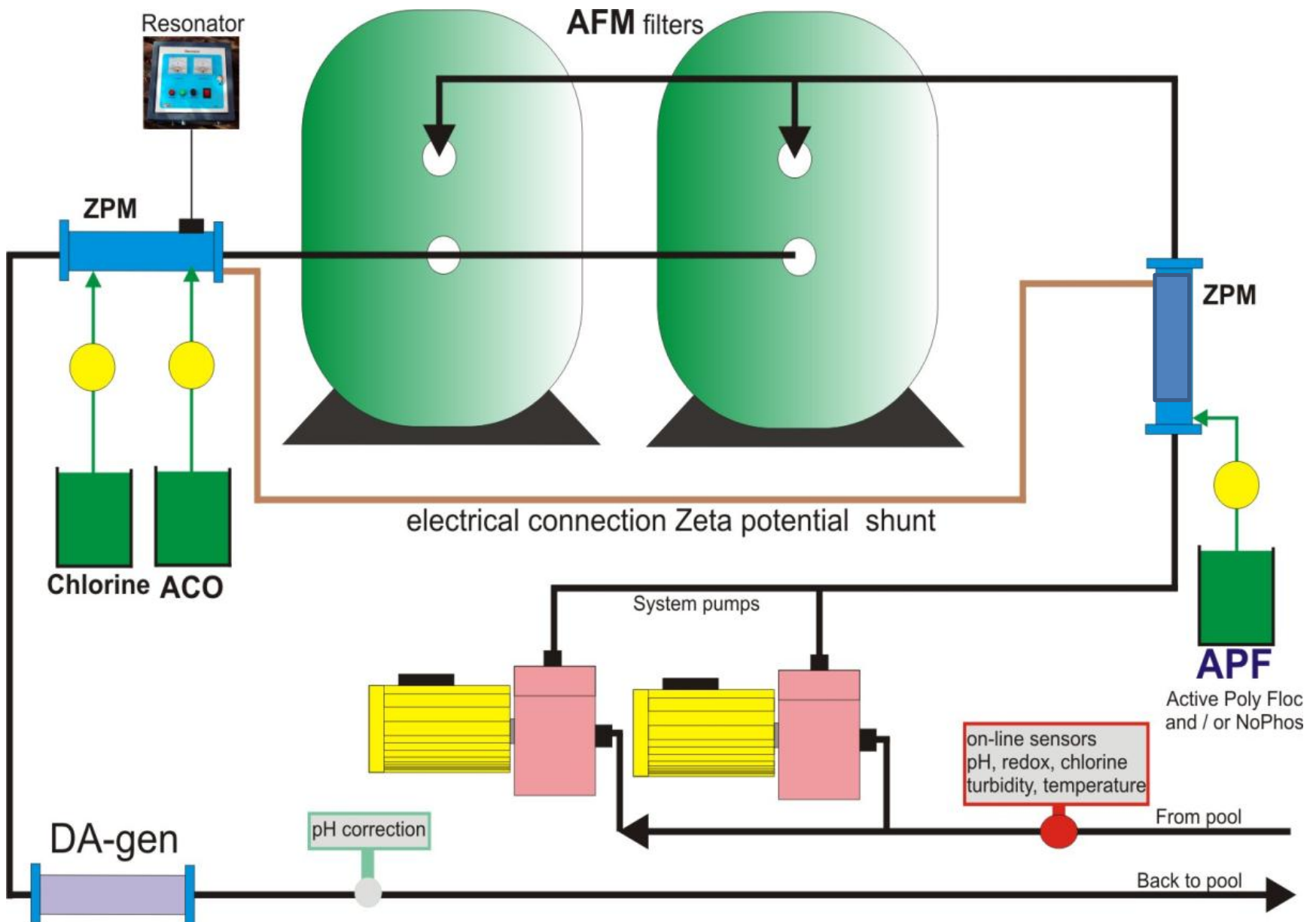
APF

Active Poly Flocc

- NoPhos is a coagulant & flocculent, but main function is to remove phosphate and stop algae and bacteria growth. Dilute 1 to 20, and injection into system at 1 ml per cubm of water filtered per hour, via a ZPM module.
- NoPhos may be hand dosed at 1 to 2 ml per cubic meter of water in the pool once per week.
- APF is a multi-spectrum product optimised for coagulation and flocculation, also contains NoPhos. Should be injected into a ZPM for best performance
- APF should be used in all public pools, essential for crypto oocyst control and to minimise disinfection by-products. Application rate 0.1 to 1.0 ml/cubic metre of water filtered per hour.



Dryden Aqua Integrated pool treatment system

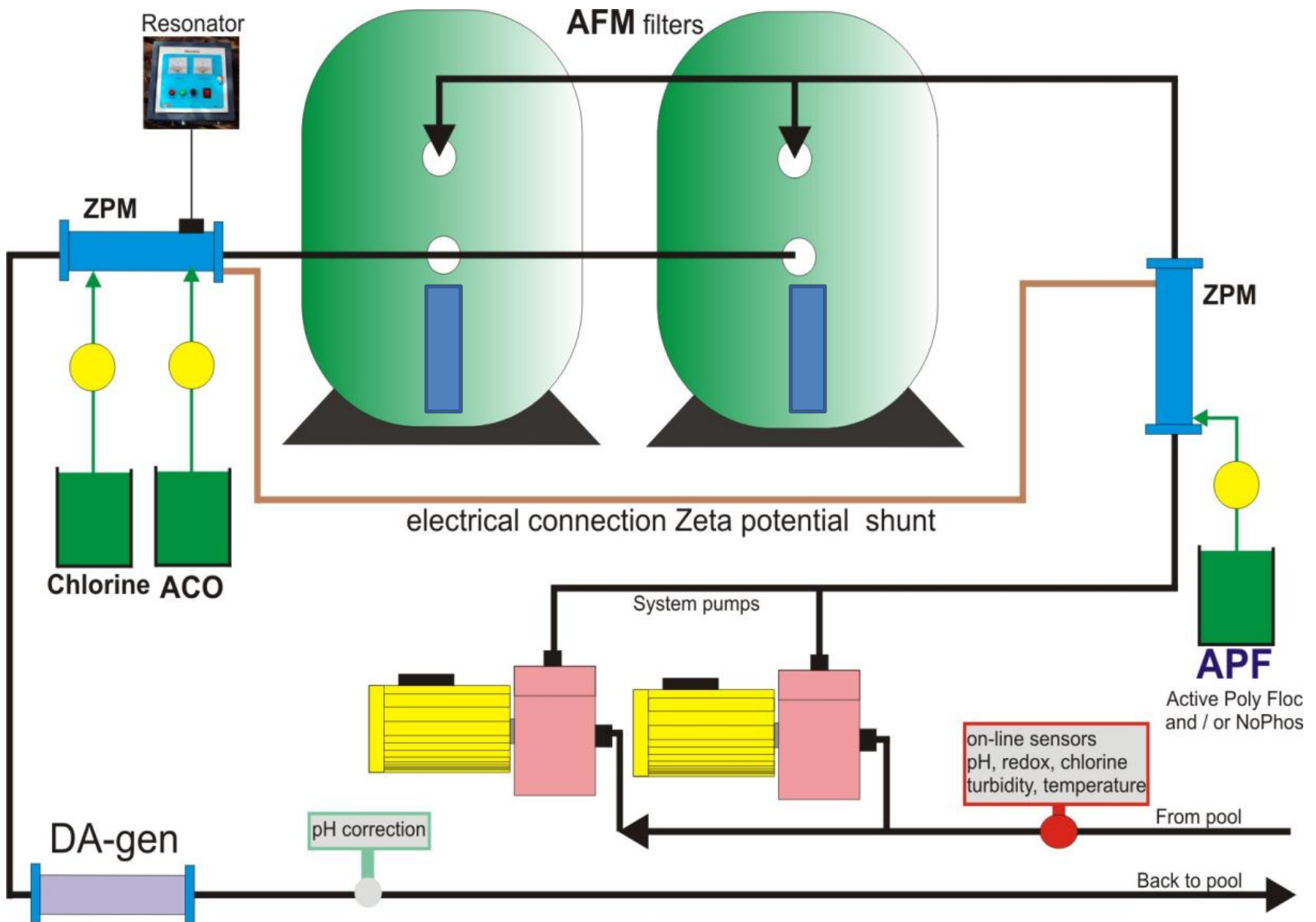


- Coagulation with APF & NoPhos involves dragging chemicals in solution, out of solution to form a small particle.
- Coagulation reactions occur in under 1 second, the reactions will not progress, unless the water is treated by a zpm.
- Most of the chlorine oxidation demand is from chemicals in solution, efficient coagulation with NoPhos or APF via a ZPM is absolutely essential for best results.
- The ZPM forms nano-bubbles that explode on the surface of oocysts, bacteria, fungi, yeast and viri. The high shear forces will kill crypto, or damage the oocysts and predispose them to oxidation by chlorine.
- The act of moving water, changes the way the water behaves. The ZPM generates hydroxyl radicals that aid disinfection.



product code	flange size	Water flow 0.3bar differential filter run phase cubm/hr	Water flow 0.5bar differential filter run phase cubm/hr	Water flow 1 bar differential filter back- wash cubm/hr	drawings
9.14.218	2" male bsp threaded	15	20	30	pdf
9.14.219	DN65	20	30	45	pdf
9.14.220	DN80	36	50	75	pdf
9.14.221	DN100	60	80	120	pdf
9.14.222	DN150	90	120	180	pdf
9.14.223	DN200	120	160	240	pdf
9.14.224	DN250	150	200	300	pdf
9.12.225	DN300	180	240	360	pdf

Dryden Aqua Integrated pool treatment system



- Surface -ve Zeta potential adsorbs +ve charged particles formed by APF and NoPhos.
- Surface catalytic properties oxidise bacteria and prevent biofouling.
- High uniformity coefficient and sphericity value insure good fluid hydraulics and filtration performance
- Run phase water flow, performance is inversely proportional to water flow. 15-30 m/hr
- Air purge prior to back-wash, 55 to 95 m/hr
- Back-wash at > 45 m/hr

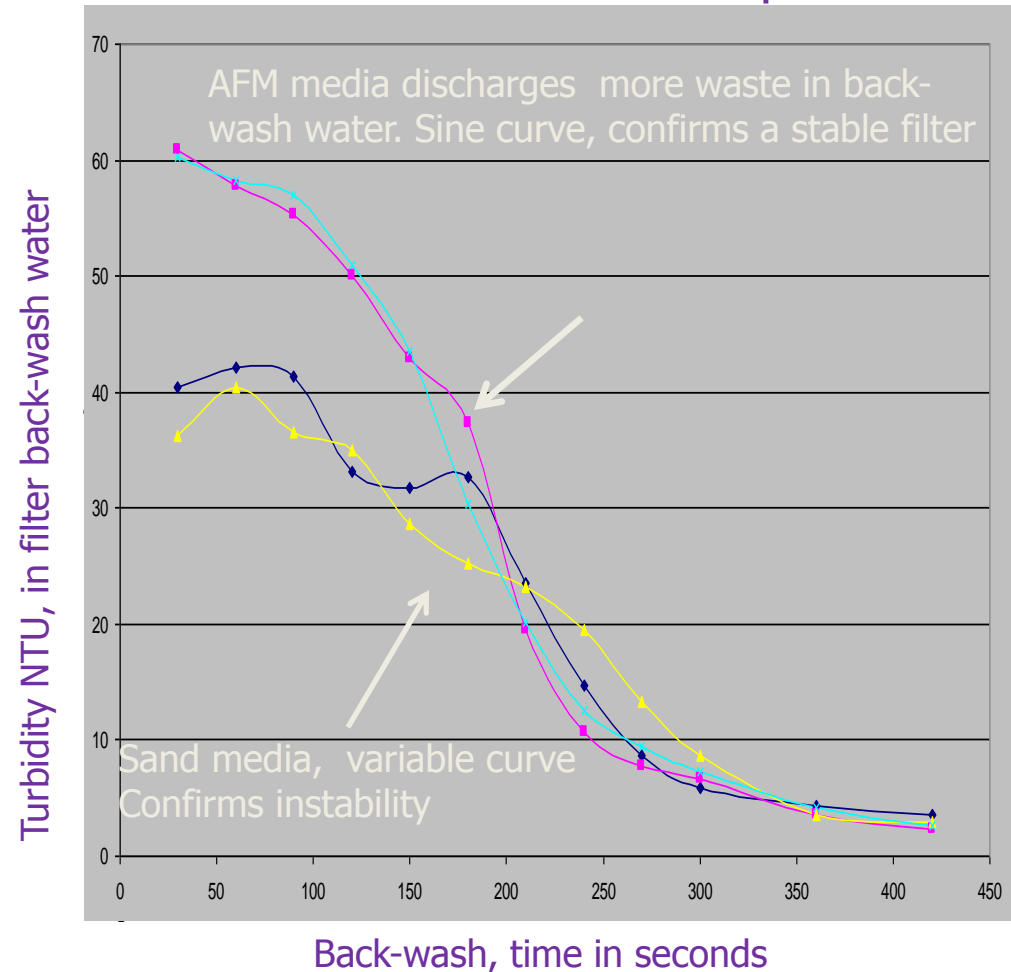


Back-wash

what goes in must come out

- **What goes into a filter must come back out** in the back-wash. If this does not happen, AFM filter performance will be compromised and sand filters will fail because the waste matter will feed a rapid growth of heterotrophic bacteria, that will coagulate and block the bed
 - **Run phase** 15 m/hr to 30 m/hr
 - **Air scour** at 95m/hr is recommended
 - **Back-wash** velocity must fluidize the bed by 15%.
 - AFM 45-55 m/hr
 - sand 55 to 65 m/hr
- Back-wash movie [click here](#)

AFM & Sand back-wash profile

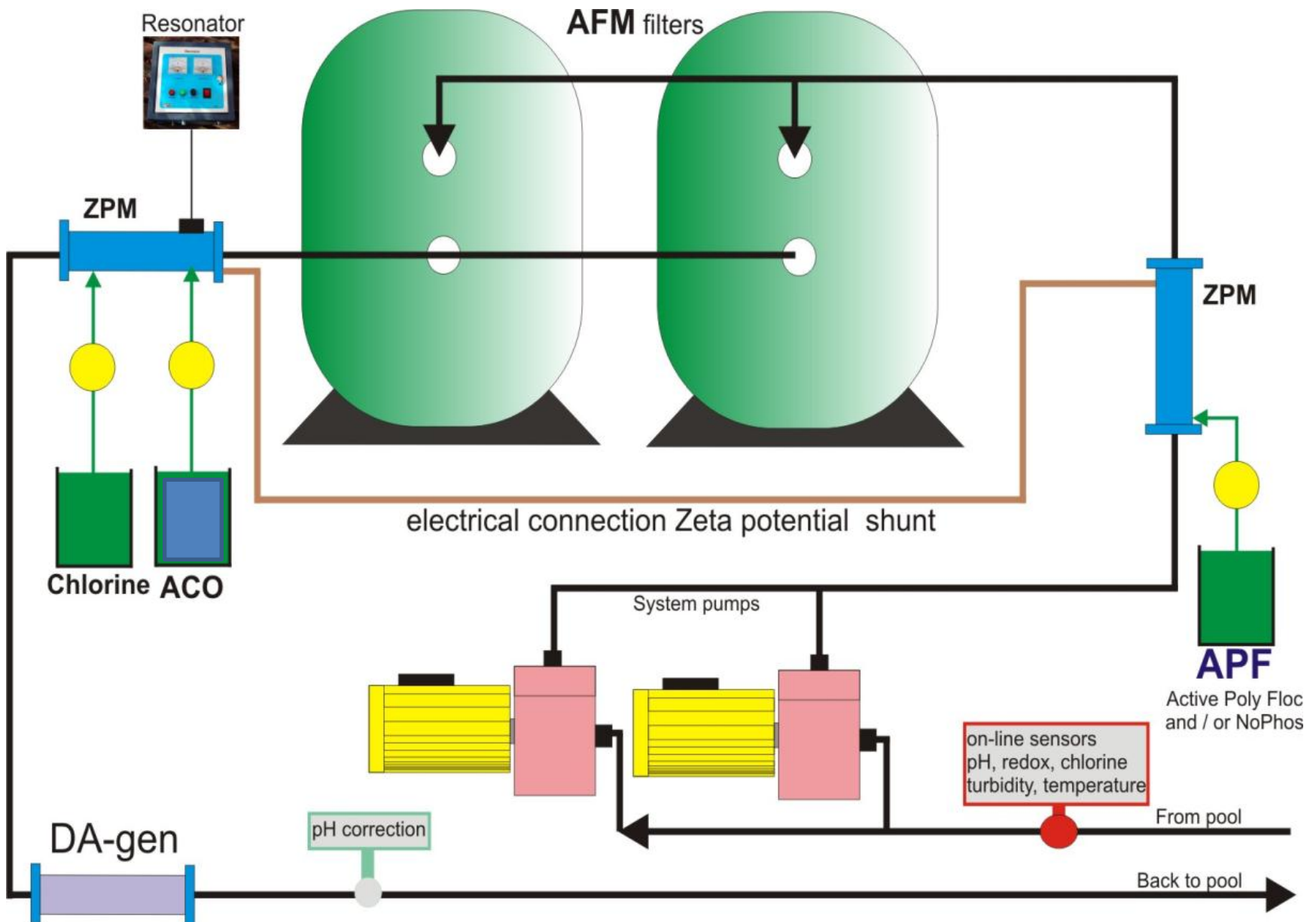


Back-wash profile confirms that with a 10 week old sand and AFM filters, 30% more waste is back-washed out of AFM. After 1 year the difference is as much as 50%.

The back-wash

- What goes in to a filter during the run phase must come out with the back-wash, or the filter will fail.
- An expansion of the bed 20% is necessary to get rid of the particles in the bed.
- A water flow of 45 m/hr is required for AFM, and 65 m/hr is required for sand (DIN standard).

Dryden Aqua Integrated pool treatment system

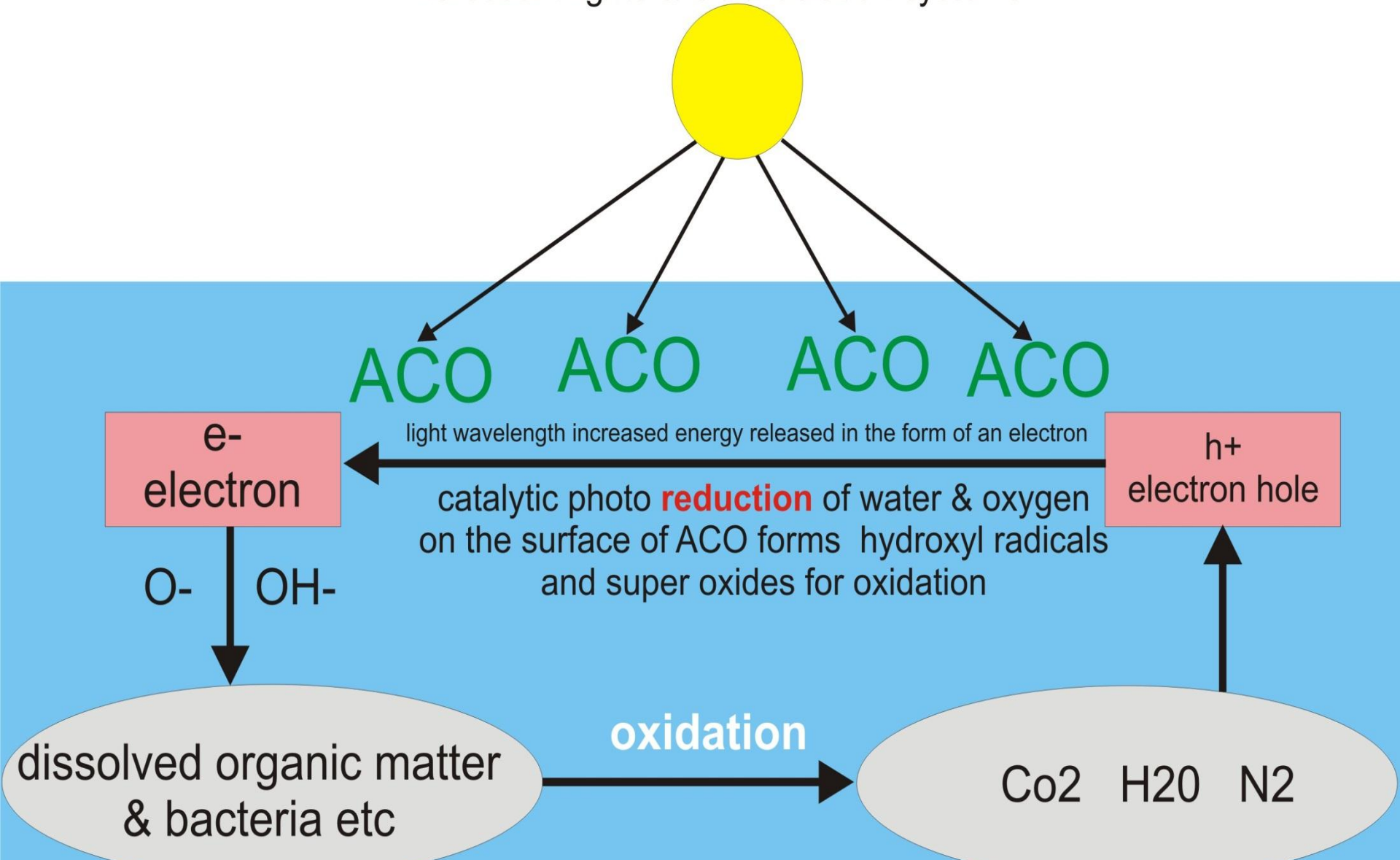




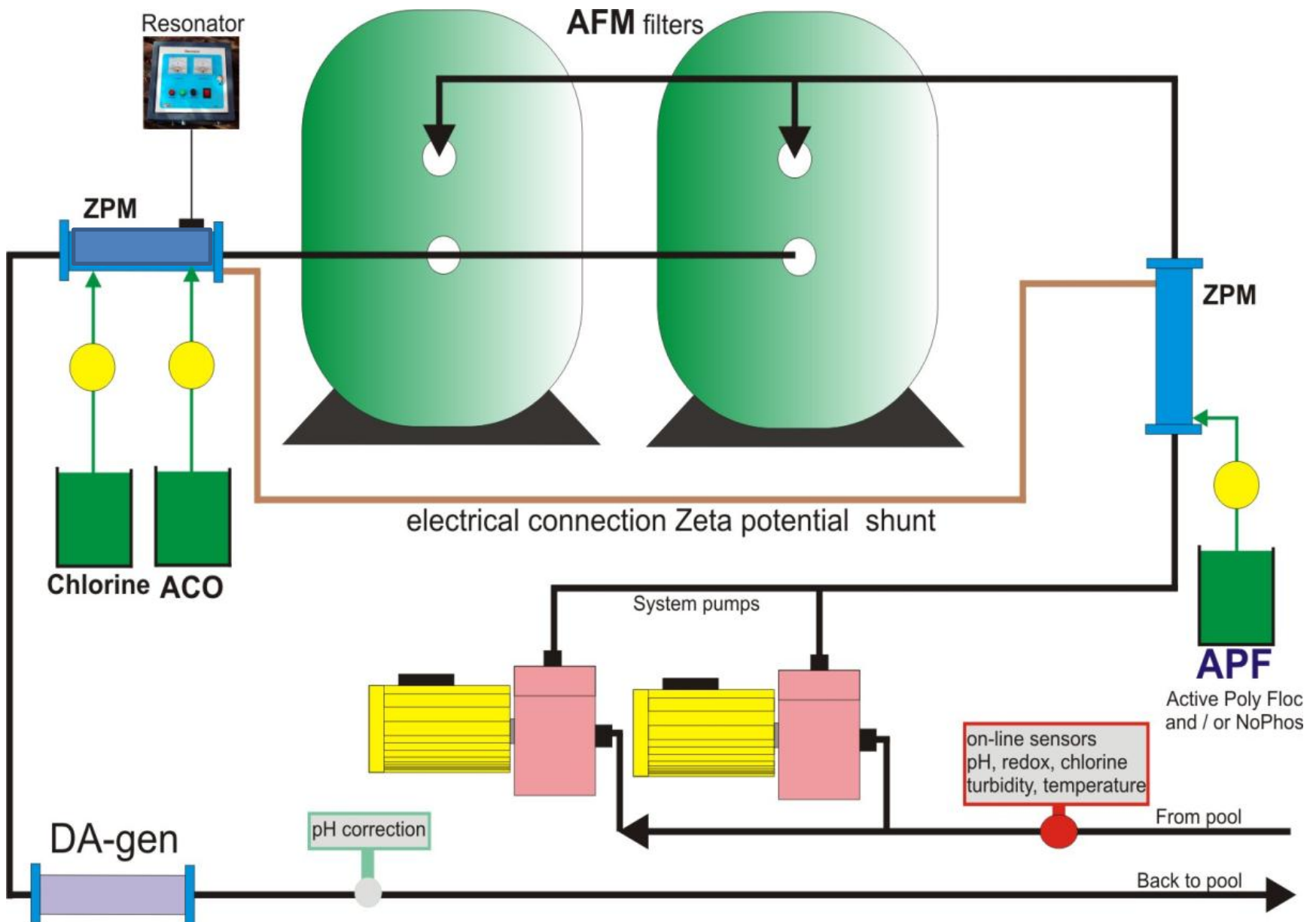
- Sun block for the water, prevent photolysis of chlorine from sunlight and UVc light.
- Helps prevent THM production
- Increase the surface -ve zeta potential of every surface in contact with the water. Makes surface self cleaning and self sterilising
- Hydroxyl radicals produced when the water is exposed to sunlight or UV light. Makes the water self sterilising
- Reacts with APF to form aluminosilicate feldspar, large heavy floc absorbs ammonium by ion exchange and is removed by AFM filters, even at high water flow.
- Application rate, same flow as APF, 0.1 to 1.0ml/M3 of water filtered per hour.

Light & ZPMr

sunlight, out-doors
through windows or even
florescent lights & UV irradiation systems



Dryden Aqua Integrated pool treatment system



- The zeta potential mixer with ACO shifts the zeta potentials of the water to a -ve charge
- Resonator shakes the water molecules and activates the ACO
- The resonator cavitates the water and produces nano bubbles that help disinfect the water and kill crypto oocysts without the use of chemicals.





With resonator

A resonator developed by Dryden Aqua is fitted into the socket on our ZPM units.

The resonator and ZPM activates the ACO catalytic reactions.

The resonator shakes the water at a molecular level and gives the water a memory with the ability to self sterilize

Cavitation of the water by the ZPM helps to sterilize the water and destroy cryptosporidium.



Dryden Aqua

Integrated water treatment for pools



Active Filter Media replaces sand



NoPhos eliminates phosphates and prevents bacteria and algae growth.



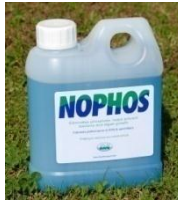
Active Polyfloc, multi-spectrum high purity flocculent engineered for swimming pools. Absolutely essential for oocyst control



Zeta potential, for mechanical coagulation and oocyst destruction. Amplifies the performance of NoPhos, APF and ACO



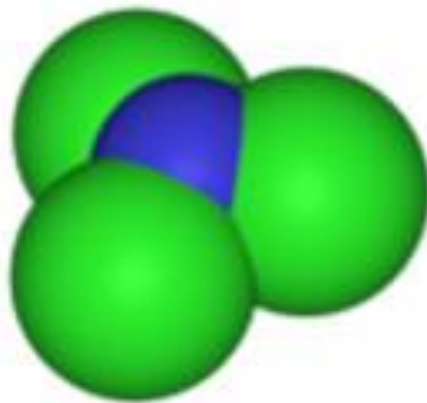
ACO is an Active Catalytic Photooxidation protects of chlorine from UV and sunlight photo reduction. Replaces cyanuric acid, and makes water self sterilising. May eventually replace chlorine



Technical information

In public or private pools where you can still smell chlorine after 1 minute, or if the water stings your eyes, it will be likely that the air just above the water surface exceeds the [15 minute HSE](#) exposure limit for the nerve toxin cyanogen chloride, unless the filtration system [DAP pool performance factor](#) is under 4. Public pools that employ the [Dryden Aqua Integrated system](#), will operate under DAP 4, chlorine consumption will drop from 5kg or 10kg to less than 2 kg per day for a 25m public pool with 500 bathers/day, combined inorganic chlorine will be below 0.2 mg/l and probably below 0.1mg/l. Chlorine disinfection by-products...gone as well as most respiratory problems and asthma precursors. Children exposed to lipid soluble disinfection by products are at greater risk from [spinal deformities](#), [neurobiological & genetic damage](#). We can help solve these problems and save the pool up to 50% of their running costs at the same time.

Chlorine Oxidation Demand Disinfection By-Products



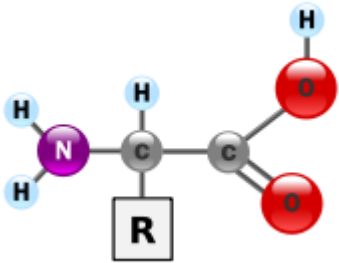
Nitrogen sources One hour in a swimming pool



50ml urine

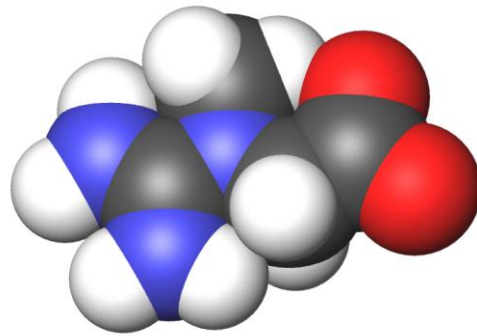


200ml sweat



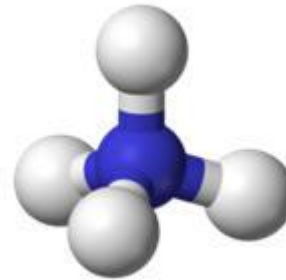
Amino acid

33mg



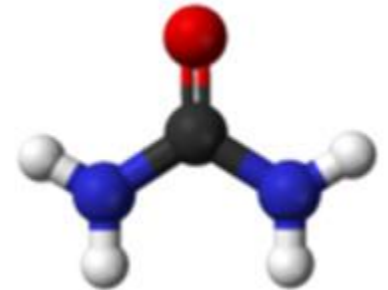
Creatine

41 mg



Ammonium

63 mg



Urea

648 mg

Chlorine must be used for all public pools

- Chlorine is required to provide residual disinfection in all public pools.
- Chlorine will be consumed and chlorine reaction products will form.
- A measure of the Chlorine Oxidation Demand (COD) is also a measure of water quality
- The lower the COD the better the
water quality
air quality
- Private Pools with a low COD, may use peroxide or other oxidising agents much more efficiently.

How do you know a good pool ?

- Dryden Aqua have developed the DAP performance standard.
- The DAP standard allows to you monitor the performance of any public swimming pool.
- The target should be to have a DAP performance under 4, this will be a safe well operated pool.
- The lower the DAP factor the better the pool. A full Dryden System operates under 2

Pool Performance Standard

based on chlorine consumption & pool attendance

Scale from 1 to 10

Kg of chlorine used
per 1000 bathers/day

2
good

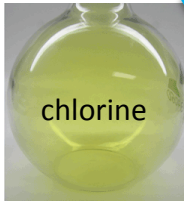
4

6

bad

8

10
ugly

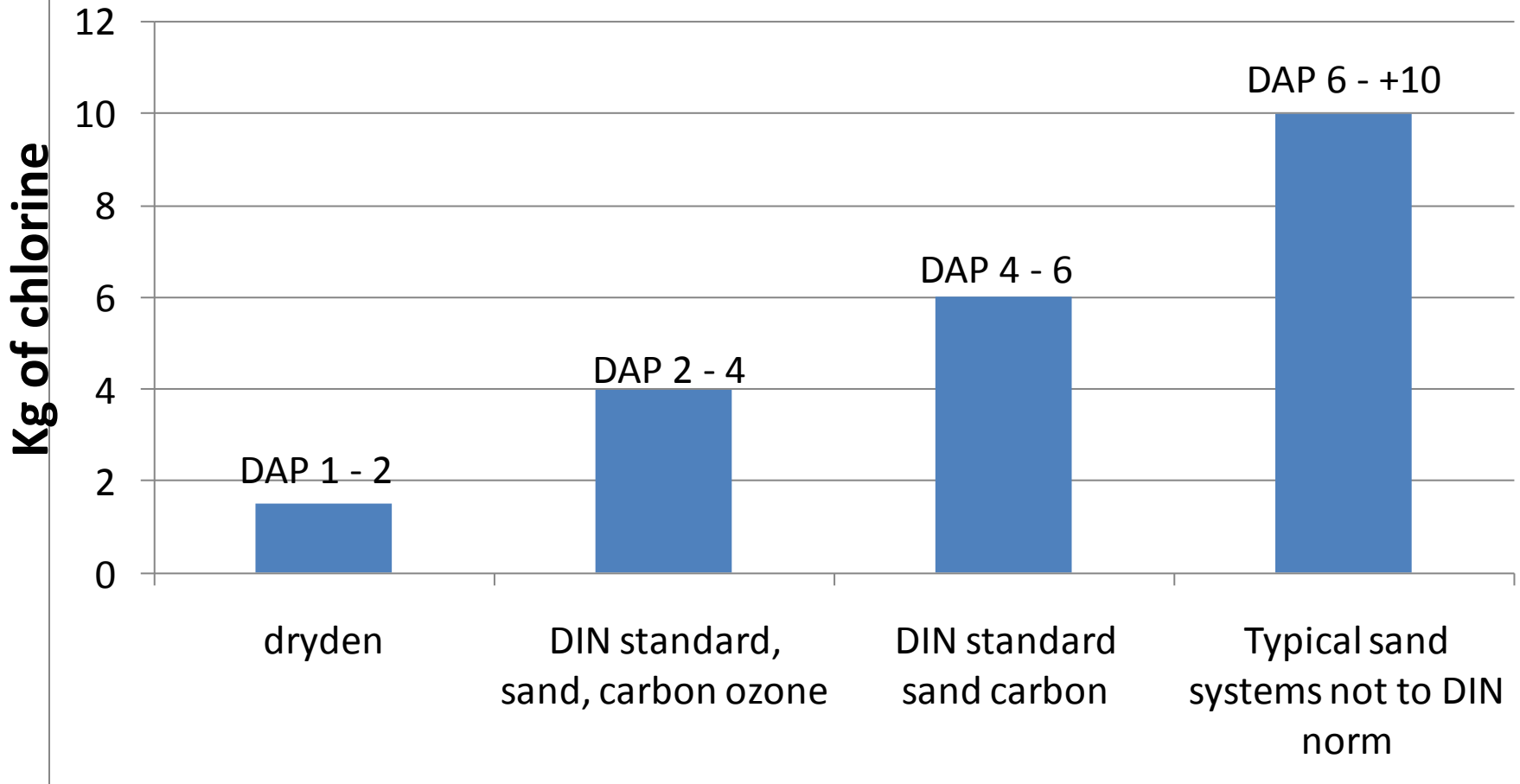


The less chlorine used the better the System Performance. Performance factor calculator [click here](#) Or send us your pool attendance data and amount of chlorine used per month We will calculate your performance factor and advise you of the potential savings that could be achieved.

1 kg of Calhypo = 0.68kg of chlorine
100 litres of sodium hypochlorite = 12 kg of chlorine

Chlorine oxidation demand

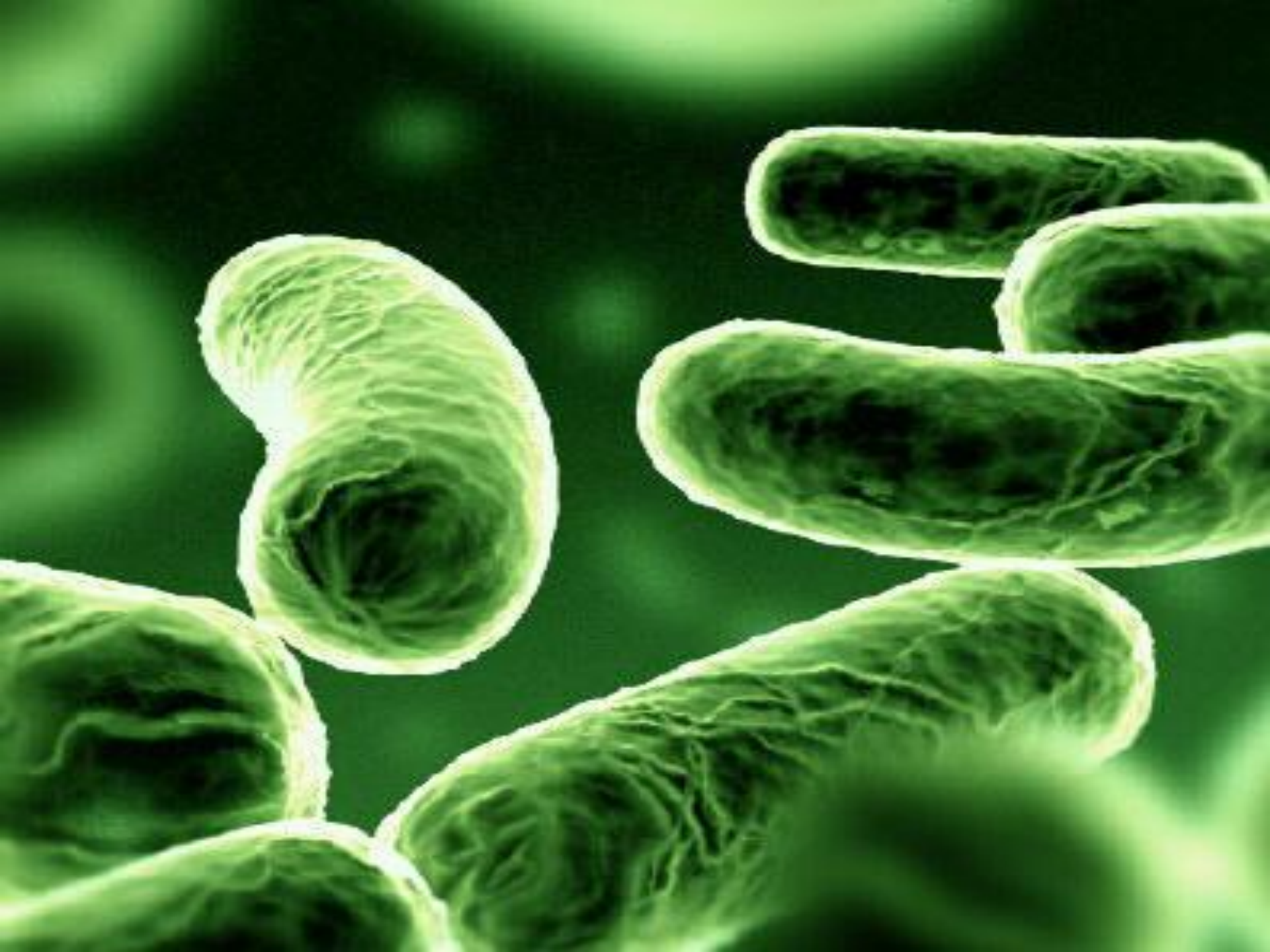
**Kg of chlorine / 1000 bathers / day
=> Grams of chlorine per bather**



Dryden Integrated system will use up to 90% less chlorine and chemicals.
Disinfection by-products are reduced by a similar percentage.

Chlorine demand

- Why is the chlorine demand of Dryden system up to 10 times lower than a typical sand filtration system ?
- A sand filter will become a biofilter, chlorine even at high concentrations can not oxidise bacteria growing on the surface of sand, or on any surface in contact with the water.



Biological metabolism of a sand filter

- Urea = 648 mg N Ammonium = 63 mg N, bacteria produce urease enzymes that convert urea to ammonium.

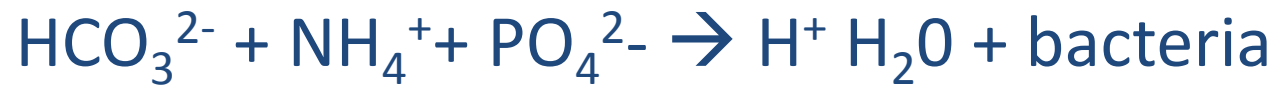


- Ammonium nitrogen levels may be increased by up to 10 times with a sand filter. This why combined chlorine will increase across a sand filter.
- The proof... Combined chlorine does not increase across an AFM filter



Organic matter and ammonium production in sand filters

- Autotrophic Bacteria, use inorganic carbon as CO_3 (carbon source) to manufacture organic matter in the form of bacteria



- Azotobacter, will fix dissolved nitrogen and turn it into ammonium



How can we reduce COD and production of Disinfection by-products



All bathers must shower, this removes 75% of all the nitrogen. Do not allow the use of shampoo before entering pool.



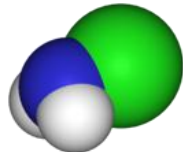
The pool is not a toilet



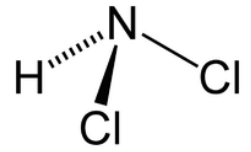
>95% of the surface area in contact with the water is the filter media, and this is where the bacteria are located unless AFM is used in the filters.

Disinfection by-products & Henry's constants, the more volatile the DBP, the greater the potential toxicity

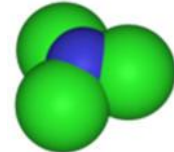
Inorganic chloramines



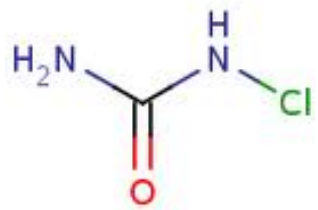
Monochloramine
0.45 atm reacts with DPD



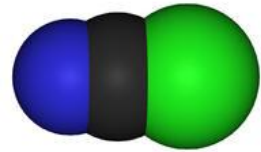
Dichloramine
1.5 atm reacts with DPD



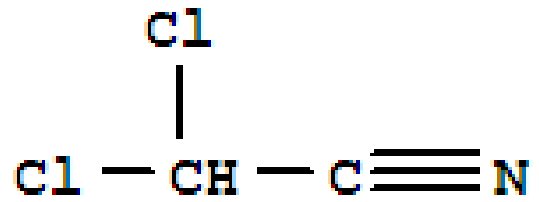
Nitrogen Trichloride
435 atm reacts with DPD



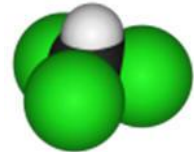
Chloroform Very soluble in water, reacts with DPD



Cyanogen Chloride 108 atm UV reaction product very toxic, does not react with DPD



Dichloroacetonitrile
UV reaction product
Very toxic



Chloroform 185 atm
UV reaction product does not react with DPD

Methylamine Dichloramine
CH3NCl2 154 atm

Inorganic chloramine formation & destruction

$\text{HOCl} + \text{NH}_3 \rightarrow \text{NH}_2\text{Cl} + \text{H}_2\text{O}$	4.16E+06
$\text{NH}_2\text{Cl} + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{NH}_3$	2.83E-05
$\text{HOCl} + \text{NH}_2\text{Cl} \rightarrow \text{NHCl}_2 + \text{H}_2\text{O}$	3.54E+02
$\text{NHCl}_2 + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{NH}_2\text{Cl}$	6.39E-07
$\text{NH}_2\text{Cl} + \text{NH}_2\text{Cl} \rightarrow \text{NHCl}_2 + \text{NH}_3$ (H^+ and buffer)	2.10E-03
$\text{NHCl}_2 + \text{NH}_3 \rightarrow \text{NH}_2\text{Cl} + \text{NH}_2\text{Cl}$ (H^+ catalyzed)	1.90E-03
$\text{NHCl}_2 + \text{H}_2\text{O} \rightarrow \text{NOH} + 2\text{H}^+ + 2\text{Cl}^-$ (OH^- catalyzed)	3.51E-05
$\text{NOH} + \text{NHCl}_2 \rightarrow \text{N}_2 + \text{HOCl} + \text{H}^+ + \text{Cl}^-$	2.78E+04
$\text{NOH} + \text{NH}_2\text{Cl} \rightarrow \text{N}_2 + \text{H}_2\text{O} + \text{H}^+ + \text{Cl}^-$	8.33E+03
$\text{NH}_2\text{Cl} + \text{NHCl}_2 \rightarrow \text{N}_2 + 3\text{H}^+ + 3\text{Cl}^-$	1.53E-02
$\text{HOCl} + \text{NHCl}_2 \rightarrow \text{NCl}_3 + \text{H}_2\text{O}$ (OH^- , OCl^- , buffer)	1.05E+03
$\text{NHCl}_2 + \text{NCl}_3 + 2\text{H}_2\text{O} \rightarrow 2\text{HOCl} + \text{N}_2 + 3\text{H}^+ + 3\text{Cl}^-$	1.76E+04
$\text{NH}_2\text{Cl} + \text{NCl}_3 + \text{H}_2\text{O} \rightarrow \text{HOCl} + \text{N}_2 + 3\text{H}^+ + 3\text{Cl}^-$	4.39E+02
$\text{NHCl}_2 + 2\text{HOCl} + \text{H}_2\text{O} \rightarrow \text{NO}_3^- + 5\text{H}^+ + 4\text{Cl}^-$	2.31E+02
$\text{NOH} + 2\text{HOCl} \rightarrow \text{NO}_3^- + 3\text{H}^+ + 2\text{Cl}^-$	0.00E+00
$\text{NCl}_3 + \text{H}_2\text{O} \rightarrow \text{NHCl}_2 + \text{HOCl}$	8.33E-06
$\text{NH}_2\text{CONH}_2 + \text{Cl}_2(\text{aq}) \rightarrow \text{NH}_2\text{CONHCl} + \text{H}_2\text{O}$	2.35E+04
$\text{NH}_2\text{CONHCl} + \text{Cl}_2(\text{aq}) \rightarrow \text{NHCICONHCl} + \text{H}_2\text{O}$	0.00E+00
$\text{NHCICONHCl} + \text{HOCl} \rightarrow \text{NH}_2\text{Cl} + \text{CO}_2 + \text{NHCl}_2$	0.00E+00
$\text{NH}_2\text{CONHCl} + \text{HOCl} \rightarrow \text{NHCICONHCl} + \text{H}_2\text{O}$	1.00E+02
$\text{NHCICONHCl} + \text{HOCl} \rightarrow \text{NHCICONCl}_2 + \text{H}_2\text{O}$	0.00E+00
$\text{NHCICONCl}_2 + \text{HOCl} \rightarrow \text{NCl}_2\text{CONCl}_2 + \text{H}_2\text{O}$	0.00E+00
$\text{NCl}_2\text{CONCl}_2 + \text{HOCl} \rightarrow \text{NHCl}_2 + \text{CO}_2 + \text{NCl}_3$	0.00E+00
$\text{NCl}_2\text{CONCl}_2 + \text{HOCl} \rightarrow \text{H}^+ + \text{Cl}^- + \text{CO}_2 + \text{NCl}_3 + \text{NOH}$	0.00E+00

Steady state inorganic chloramines

300 bathers / day 500 cubm water

pH	6.0	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6
free chlorine	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
hypochlorous	0.29	0.25	0.24	0.23	0.21	0.20	0.18	0.17	0.15	0.13
monochloramine	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.09	0.09
dichloramine	0.233	0.043	0.035	0.030	0.025	0.021	0.18	0.016	0.014	0.012
trichloramine	0.11	0.016	0.015	0.013	0.012	0.011	0.009	0.008	0.007	0.006
free chlorine	1	1	1	1	1	1	1	1	1	1
hypochlorous	0.97	0.83	0.80	0.76	0.71	0.66	0.61	0.55	0.49	0.44
monochloramine	0.01	0.02	0.02	0.020	0.020	0.02	0.02	0.02	0.03	0.03
dichloramine	0.071	0.013	0.011	0.089	0.076	0.065	0.056	0.049	0.043	0.039
trichloramine	0.34	0.048	0.046	0.043	0.040	0.037	0.033	0.030	0.025	0.022

If HCl is used for pH correction, injection point must be after the filters

Set chlorine and acid pumps to the lowest possible setting, avoid any excessive drop in pH or high free chlorine concentrations. Simply turning down the pumps will reduce the inorganic combined chlorine levels.

Urea & dissolved organic control

- Most of the chlorine demand is caused by chemicals in solution as opposed to solids in suspension.
- Sand based system control urea and dissolved organics by fixation as bacterial cell biomass and conversion to ammonium by urease enzyme. Ammonium is then converted by chlorine to inorganic chloramines.
- AFM systems are electro-mechanical (log 6 less bacteria), it depends upon adsorption reactions on AFM surface, and coagulation/flocculation with APF and ACO using ZPM modules.

Busy pools may need some help

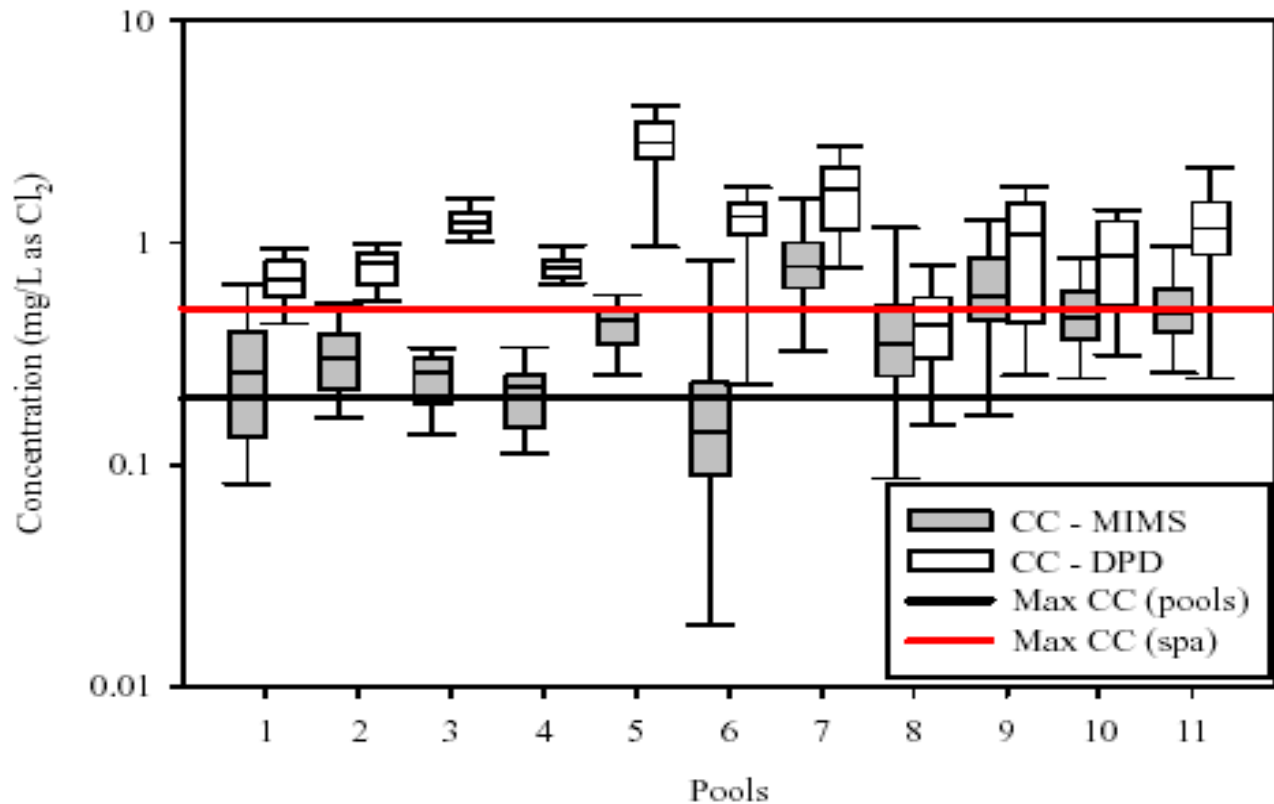


Organo-chloramine control with AFM

- UVC irradiation, process works but it forms THM`s and high levels of cyanogen chloride. Not deemed suitable or safe.
- Ozone and activated carbon, process is effective and they work well with AFM, APF, ACO and ZPM modules but ozone expensive to operate.
- Ion generator and buffers in development by Dryden Aqua provide a solution without generating chlorine reaction products.

DPD Interference

- DPD 3 analysis, over estimates by at least 300% against MIMS, membrane introduced mass spectrometry, from Bletchley 2009.
- Metals also interfere such as Titanium dioxide in ACO and to a lesser extent Aluminium in APF.
- Under standard procedures, use EDTA to chelate metal ions before you proceed with DPD analysis.



Summary dryden aqua integrated pool water treatment

- 75% to 90% reduction in chlorine consumption
- 75% to 90% Reduction of chlorine disinfection by-products, nitrogen trichloride
- Perfectly clear water, no turbidity <0.01 ntu
- A log 6 reduction in bacterial levels, elimination of endotoxins and exotoxins
- Very high protection against legionella, because there is no biofilm
- Very high protection against crypto oocysts, because there is no bacteria induced bed coagulation and worm-hole channels
- Pools are simple and easy to operate
- DPD analysis only gives an indication of combined chlorine
- Pools are a much lower cost to operate, savings in chemicals, water & energy. Return in capital usually under 18 months

Dryden Aqua

Integrated water treatment for pools



Active Filter Media replaces sand



NoPhos eliminates phosphates and prevents bacteria and algae growth.



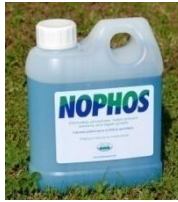
Active Polyfloc, multi-spectrum high purity flocculent engineered for swimming pools. Absolutely essential for oocyst control



Zeta potential, for mechanical coagulation and oocyst destruction. Amplifies the performance of NoPhos, APF and ACO



ACO is an Active Catalytic Photo protection of chlorine from UV and sunlight photo reduction. Replaces cyanuric acid, and makes water self sterilising. May eventually replace chlorine



Research activities

- DPD3 analysis for combined chlorine
 - Initial results indicate that DPD3 analytical techniques used by pools is subjected to interference from metals and organo-chloramines
- Toxic gas emissions from water surface
 - Cyanogen chloride and THM levels above the surface of the water can exceed European statutory exposure limits in pools using sand and crushed glass, especially if the system design is deficient.
- Performance Factor
 - Dryden Aqua can now confirm an 80% to 90% reduction in chlorine oxidation demand with a Pool Performance Factor <2

Introduction to Pool Water Treatment

