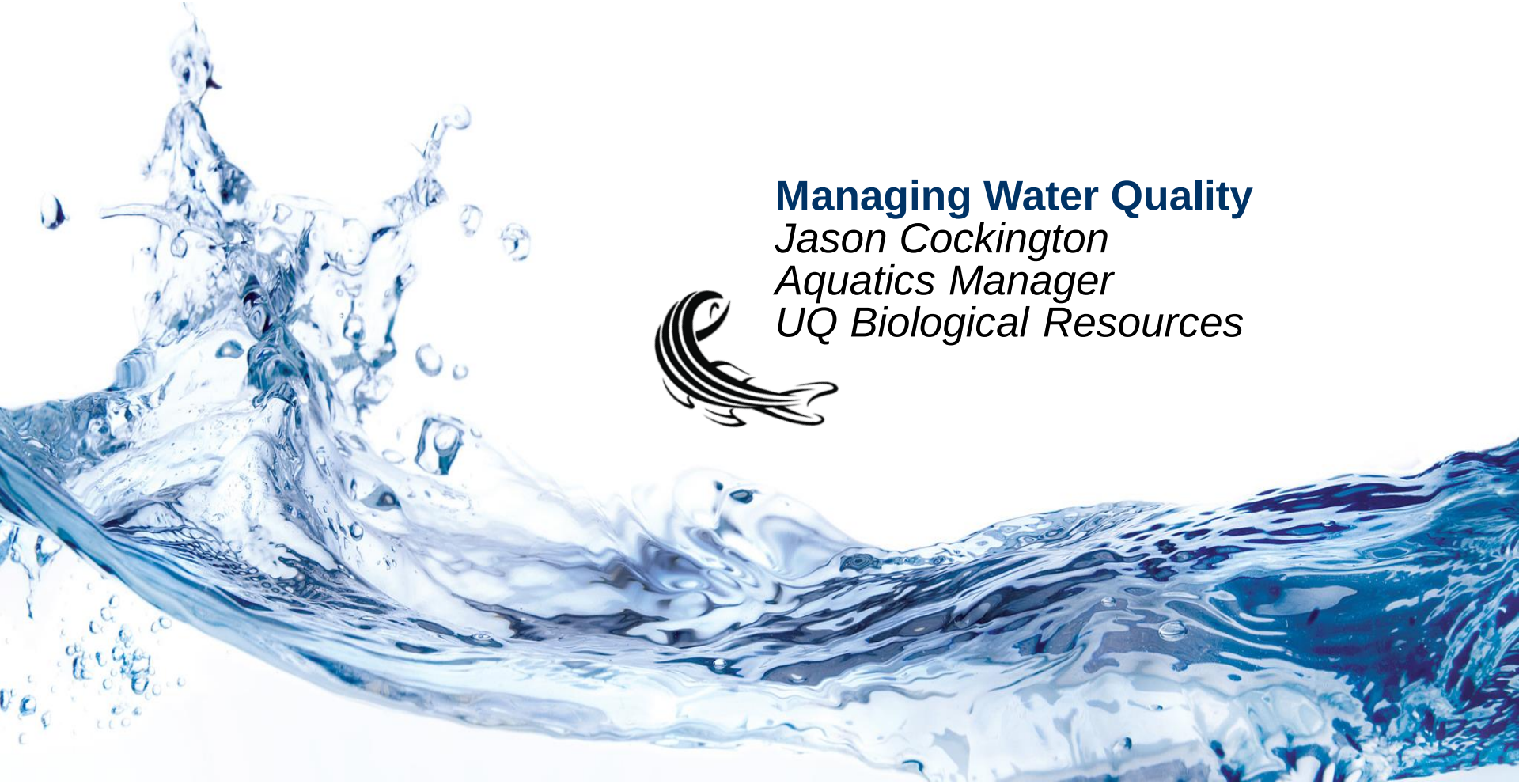
THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

UQ zebrafish



Managing Water Quality

Jason Cockington
Aquatics Manager
UQ Biological Resources

Monitoring Water Quality

- *Acute impact (daily / continual monitoring)*
  - *water temperature*
  - *pH*
  - *Conductivity (salinity)*
  - *Dissolved Oxygen / TGP (design dependent)*
  - *Ammonia (stock movement dependent)*
  - *Chlorine (source water dependent)*

Monitoring Water Quality

- *Chronic impact (weekly monitoring)*
  - *Nitrate*
  - *Nitrite*
  - *Hardness*
  - *Alkalinity*
  - *CO_2*

Monitoring Water Quality

- *Different methods for monitoring water quality*
  - *Integrated monitoring systems and probes*
  - *Handheld devices*
  - *Chemical test kits*
  - *Test strips*

Colorimetric Test Kits

- *Reagents should be in date*
- *Tester must be able to determine color change*

- *Test your team's hue differentiation abilities:*

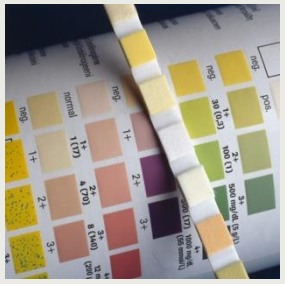
http://www.xrite.com/custom_page.aspx?pageid=77&lang=en

Colorimetric Test Kits

Hach™ "Fish Farming" Test Kit (FF-1A)

API®
– Ammonia test kit most reliable
– Wide range pH test kit

Test Strips for:
ammonia, chlorine nitrate, nitrite, general hardness (GH), alkalinity (KH) and pH



Electronic meters & probes

- *Fast test with high degree of accuracy*
- *Probes must be properly maintained and calibrated*

YSI 556 MPS – portable multiprobe

YSI 556 System Specifications (Instrument with Cable & Probe)

	Sensor Type	Range	Accuracy	Resolution
Dissolved Oxygen (%)	Polarographic	0 to 500% air saturation	0 to 200% air saturation, ± 2% of the reading or ± 2% air saturation, whichever is greater; 200 to 500% air saturation, ± 6% of the reading	0.1% air saturation
Dissolved Oxygen (mg/L)	Polarographic	0 to 50 mg/L	0 to 20 mg/L, ± 0.2 mg/L or ± 2% of reading, whichever is greater; 20 to 50 mg/L, ± 6% of the reading	0.01 mg/L
Temperature	Thermistor	-5 to 45°C	±0.15°C	0.1°C
Conductivity	Four electrode cell	0 to 200 mS/cm (auto range)	±0.5% of reading or 0.001 mS/cm, whichever is greater (4-m cable) ±1% of reading or 0.001 mS/cm, whichever is greater (20-m cable)	0.001 mS/cm to 0.1 mS/cm (range dependent)
Salinity	Calculated from conductivity and temperature	0 to 70 ppt	±1.0% of reading or 0.1 ppt, whichever is greater	0.01 ppt
pH (optional)	Glass Combination Electrode	0 to 14 units	±0.2 units	0.01 units
ORP (optional)	Platinum button	-1999 to +1999 mV	±20 mV	0.1 mV
Total Dissolved Solids (TDS)	Calculated from conductivity and temperature	0 too 100 g/L		4 digits
Barometer (optional)		500 to 800 mmHg	±3 mmHg within ±10°C temperature range from calibration point	0.1 mmHg

Spectrophotometry

- *More precise readings*
- *Slower tests*

Hach DR 3900 Benchtop Spectrophotometer

Guided Procedures
The DR 3900 guides you step-by-step through the testing procedure like a GPS, so you can get the accurate results you need every time.

Elimination of False Readings
Scratched, flawed, or dirty glassware becomes a non-issue when your machine takes 10 readings and eliminates outliers.

Hands Free Updates*
RFID technology automatically updates the program calibration factors when you place a TNTplus box near the machine.
*RFID technology currently available in US, Canada, Puerto Rico, Australia, New Zealand, and Colombia only.

Flexible Connectivity
Built with 1 ethernet and 3 USB ports, the DR 3900 easily connects to your computer and is programmed to easily interface with Hach WIMS™ or any LIMS system.

Sample Tracking*
Sample bottles with smart tags can easily be tracked with the optional Hach RFID sample-ID system, eliminating sample mix-ups and providing better sample traceability.

Integrated monitoring

- *Increased automation*
- *Independent control and alarming*
- *Remote monitoring*
- *Graphical User Interface*

Integrated monitoring

Automated System control

- Touch screen interface

Monitor various parameters in real time

- Temperature
- pH
- Conductivity
- Water level
- Flow
- Total gas pressure (TGP)
- dissolved oxygen

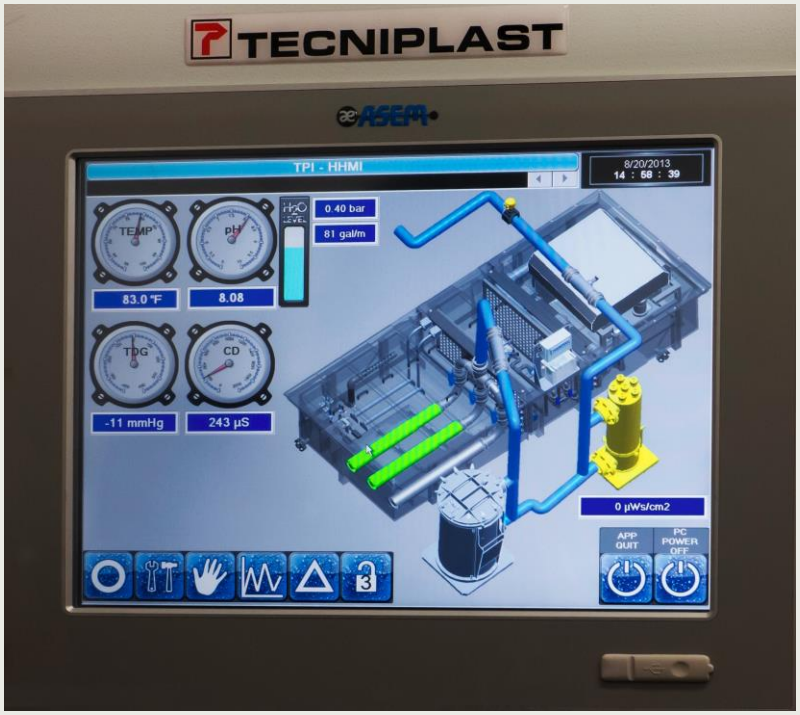
Automatic control of environment

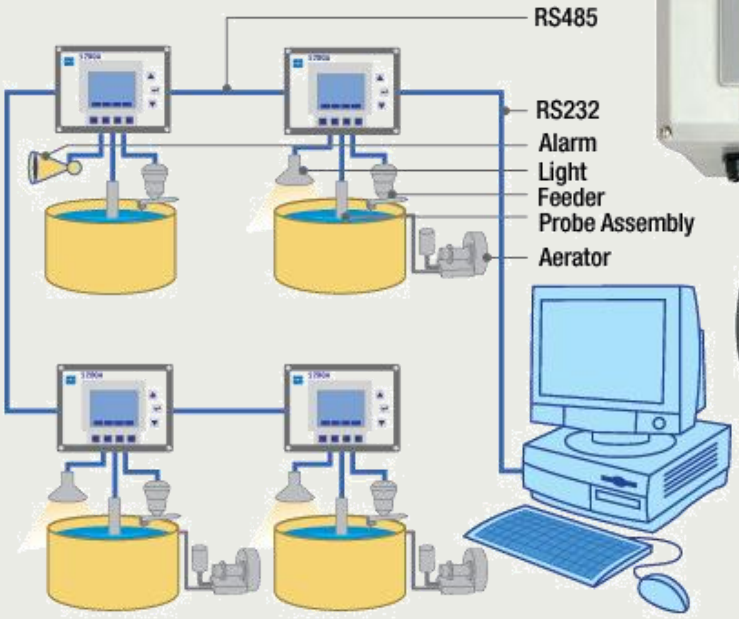
- Flow rates
- UV dosage
- Heater/chiller
- pH dosing
- Conductivity dosing
- Water exchange

Remote alarm

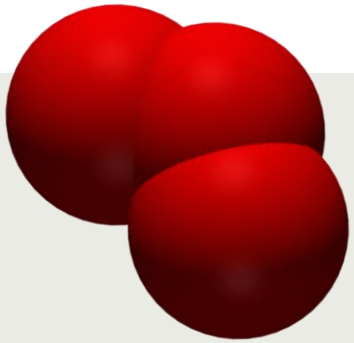
- BMS integration
- phone/email alarms

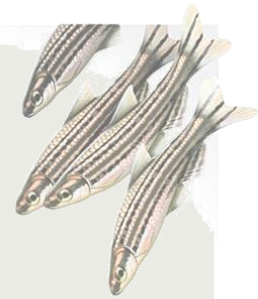
Remote monitoring





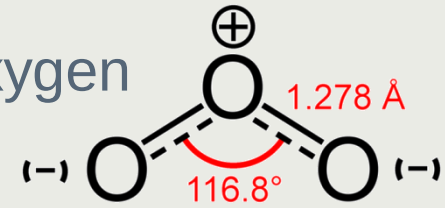
Emerging Technology





Ozone

- Triatomic oxygen



- Pale blue coloured gas
- Forms naturally from lightning/electrical sparks, with pungent odour at concentrations above 0.01mg/l
- Highly reactive oxidizer
- Extremely toxic
  - 10cm rainbow trout 96-h LC50 = 0.0093mg/l
  - Monitor both gaseous and aqueous presence

Wedemeyer et al, J. Fish. Res. Bd. Can. 1979

Ozone	UV
Constant disinfection dose	Dose ↓ over time
High capital	Low capital
Low cost consumable (electricity + silica)	High cost consumables (annual lamp replacement)
Safety monitors required (residues and leaks)	No residues or leaks
Moderate penetration (impurities consume O_3)	Weak penetration (impurities block UV)
Additional effects	Germicidal action only

Ozone in aquaculture

- Removal of fine and colloidal solids
  - 1-30 µm and 0.001-1 µm respectively
    - Microflocculation = clumping of the solids

- Removal of dissolved organic compounds (DOCs)
  - non-biodegradable and accumulate
  - High levels stress fish and reduce nitrification efficiencies of the biofilter
    - Oxidises DOCs

Ozone in aquaculture

- Biofilter supplementation (Removal of Nitrite)
  - Direct oxidation to nitrate
  - Reduces organic loading

- Disinfection (pathogen control)
  - Concentration and exposure time dependant

Ozone in aquaculture

- Rapid reaction rate (15sec half-life)
  - Few harmful reaction bi-products
  - Produces additional O_2 as a reaction end product

- Drawbacks
  - Harmful to humans and aquatic animals
    - Must be applied appropriately
  - High initial capital outlay

Bullock et al, Aquaculture 1997

Ozone application essentials

- Gas generation
  - Corona discharge
  - UV generator
- Gas-to-liquid adsorption
  - Ozone cone
  - Protein skimmer

Ozone application essentials

- Contact time for reaction
  - k = C(mg/l) . T (min)
  - IPNV – k = 2.25
    - 45sec exposure at 3mg/l

- Residual removal
  - Activated carbon or UV

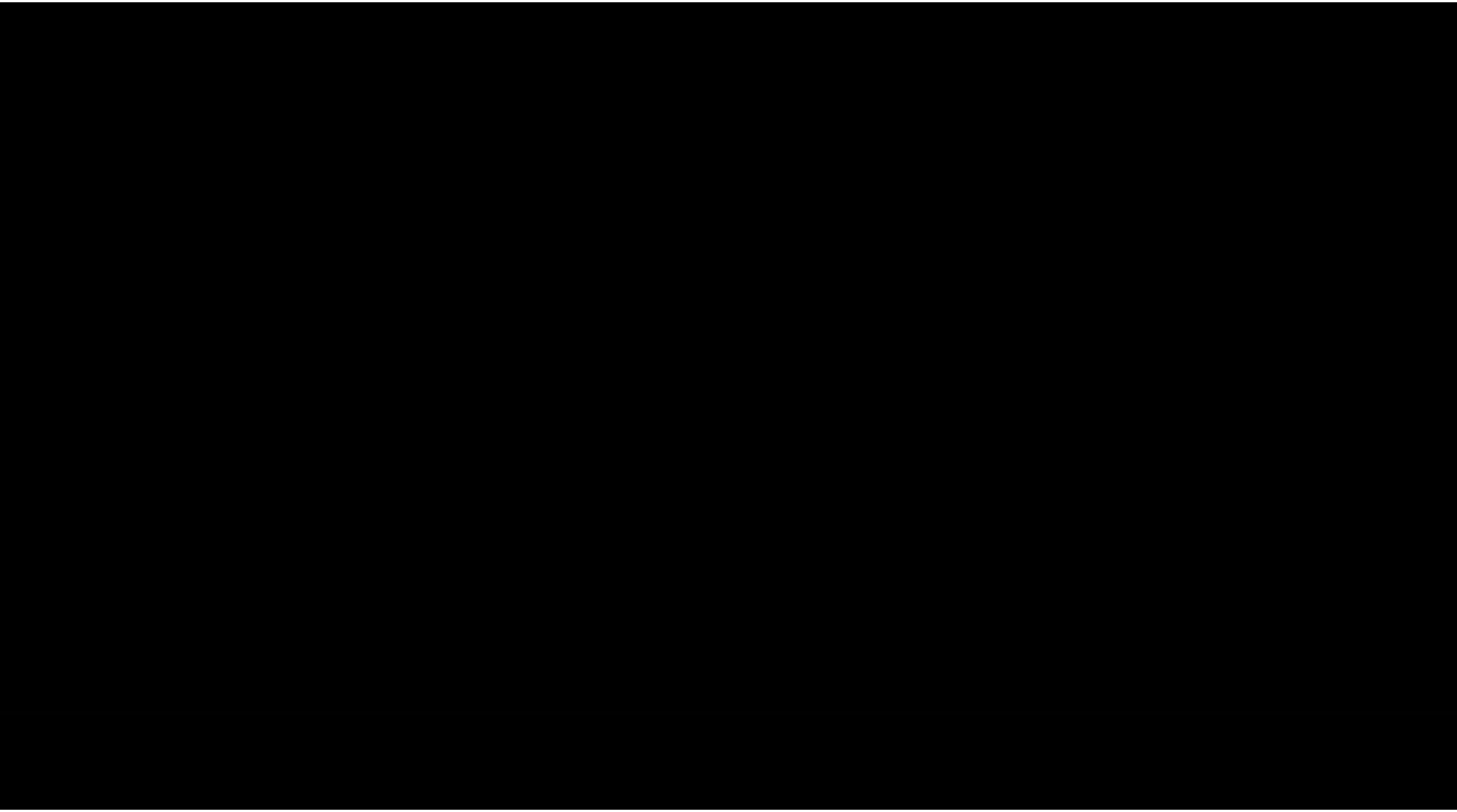
Summerfelt, Aqua. Eng. 2003

Ozone with zebrafish

- Enhance water quality processing
  - Reduce DOCs
  - Remove colloidal solids
  - Enhance UV efficacy

- Best applied in large scale facilities
  - High effluent production

Cyclonic Filtration



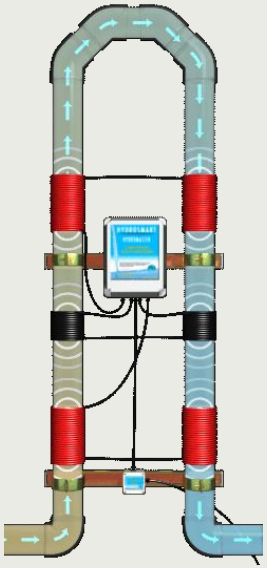
Cyclonic filtration with Zebrafish

- Multi-cyclone Sediment filter
  - Solid waste filter (>30 µm particles)
  - Flow rates 50-500L/min
  - Simple to operate and maintain
  - Isolates waste (manual step to remove)
- Pre-filter for cartridge or manual multimedia filters

Resonance Conditioning

Resonance Conditioning

- *Weak electrical field stimulates Ion Cyclotron Resonance of ion impurities in the water*
  - *Relates to the movement of ions in a magnetic field*
- *Emerged out of post war USSR*
- *Initial application focussed at lime-scale in pipes*
- *Precise mechanism of conditioning is still poorly understood*
  - *Targets ion impurities in the water*



Goldsworthy et al., Water Research 1999

Biological effects of conditioned water

- *Dardymov's sunflowers (1965)*
  - *50% growth gain in seedlings watered with conditioned water*
- *Yotvat's cows (1988)*
  - *Increased milk-yields*
  - *More rapid growth*
  - *Improved health*

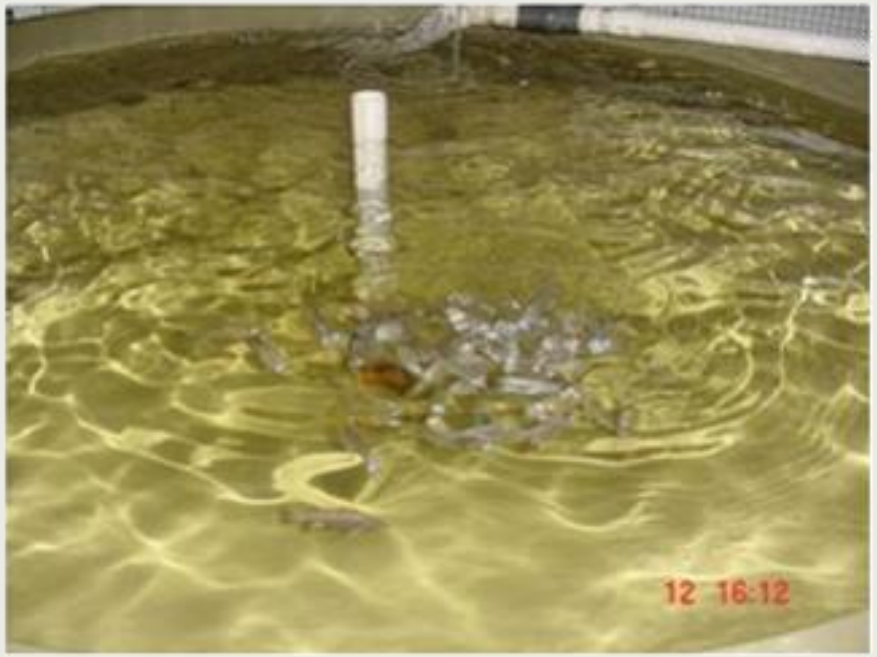
Aquaculture example - Hydrosmart

- *Barramundi farm, South Australia*
  - *Reduction in ammonia from fish*
  - *Healthier, more active fish*
  - *Higher feed conversion rate was achieved*
  - *900% reduction in mortality*
    - *Significantly reduced fingerling cannibalisation*
  - *Significant reduction of unwanted biofilm presence*

Aquaculture example - Hydrosmart

Aquaculture trials at Urrbrae Agricultural High School

Untreated "control" tank



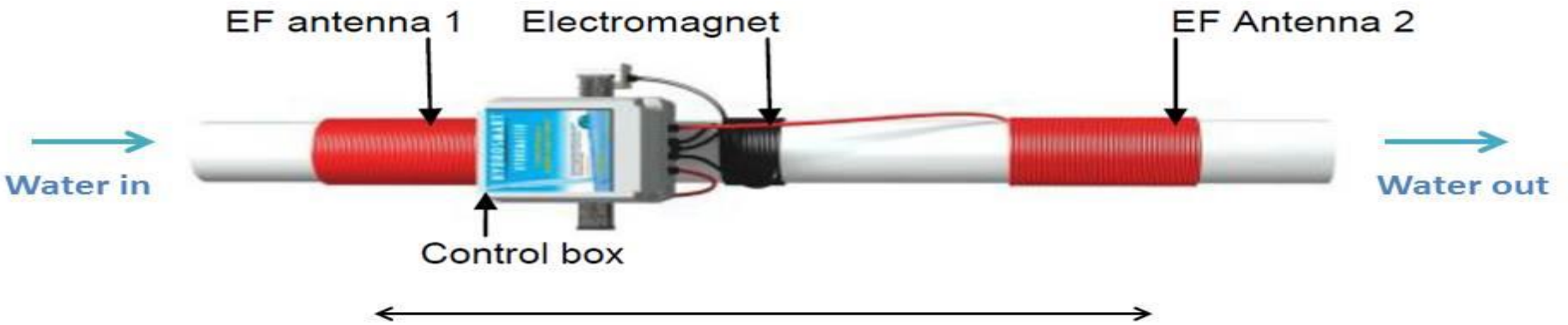
Hydrosmart treated tank

Aquaculture example - Hydrosmart

The Bio Balls in the treated system are in immaculate condition

HYDROSMART

What is it?



Electrical field produced as radio waves, between antennae.
Voltage is modulated at radio frequencies

-

Hydrosmart apparatus that emits an electric field (EF) in the ULF-VLF frequency range.

Water to be treated does not contact the apparatus

Courtesy of B. Moore, Hydrosmart

HYDROSMART

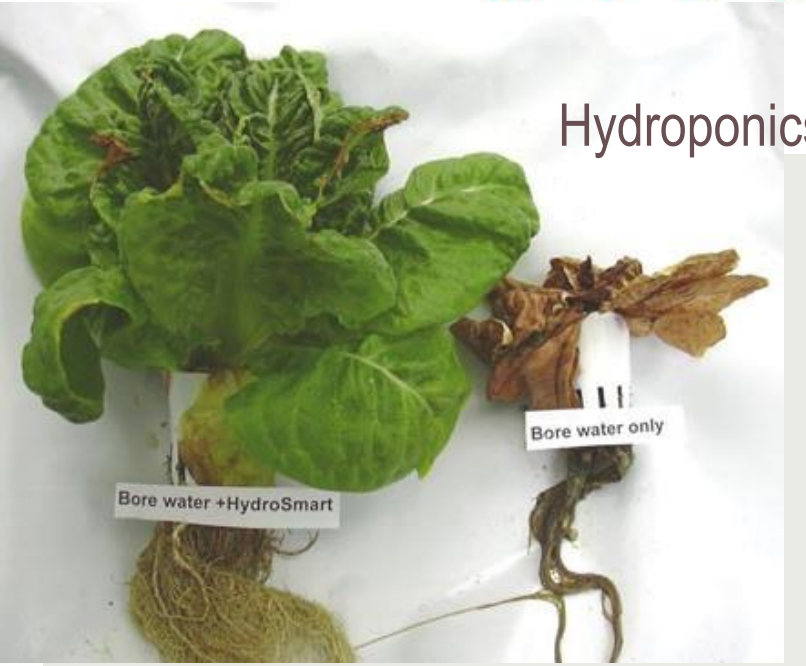
What does it do?

- Hydrosmart frequencies selectively target charged ions (minerals) that are near to water molecules
- It dissolves minerals that are present as compounds in the water
- It makes these minerals bioavailable to plants
- It therefore improves growth of plants
- It removes calcium and iron scale from pipes
- It reduces the impact of saline water on plants

Courtesy of B. Moore, Hydrosmart

HYDROSMART

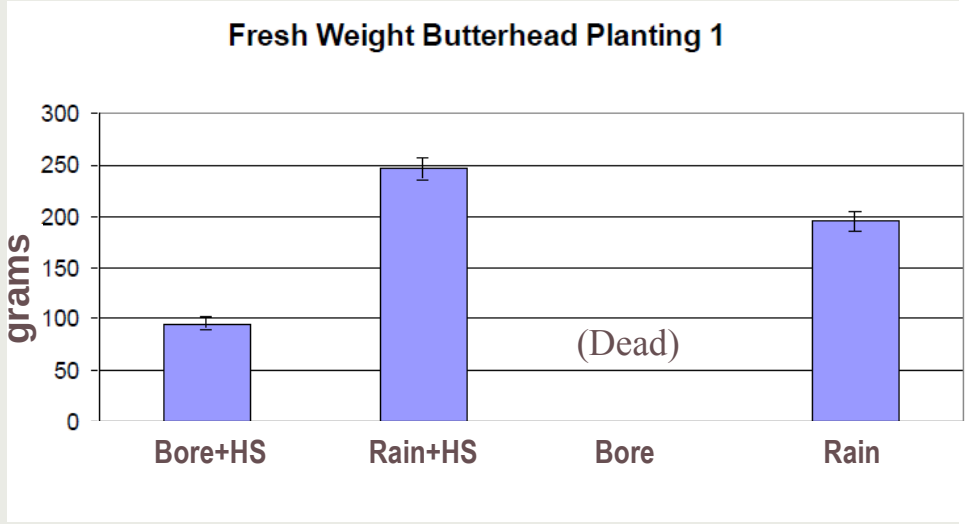
Hydroponics system with salinity of 6,000ppm



Treated with Hydrosmart

Control no Hydrosmart

Lettuce normally tolerate 800 ppm, not 6000!!



Trials were conducted in many replicates and differences were statistically significant

Courtesy of B. Moore, Hydrosmart

HYDROSMART

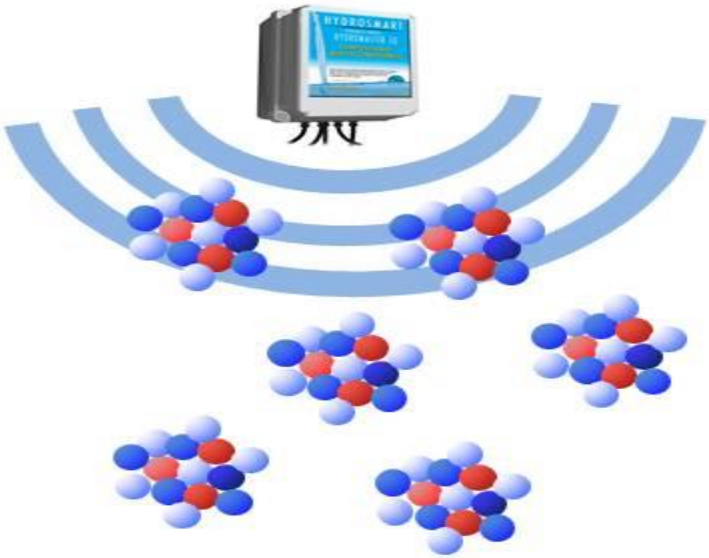
Suntec NZ Lettuce trial with rainwater at 6,000 ppm

Xylem-conductance : red dye uptake was correlated with increased calcium levels in leaves (this is a standard test)

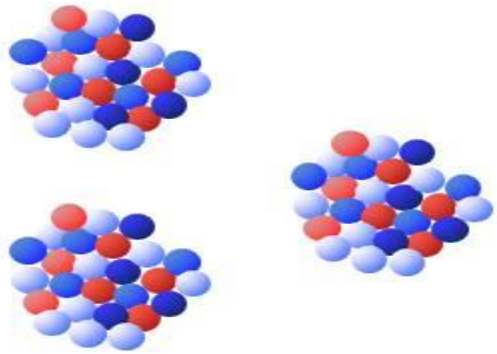
Courtesy of B. Moore, Hydrosmart

HYDROSMART

In simple terms .....



Hydrosmart



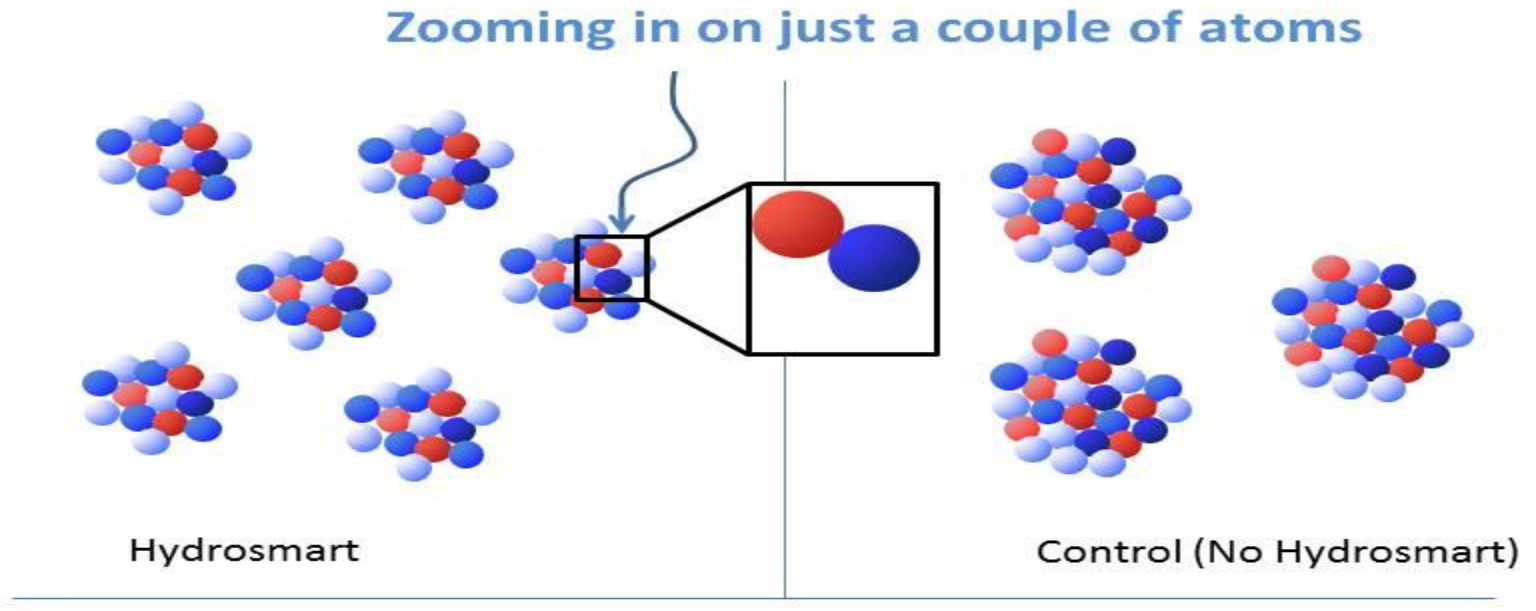
Control (No Hydrosmart)

Same amount of mineral atoms in total, but different particle size and number

Courtesy of B. Moore, Hydrosmart

HYDROSMART

Mechanism: getting down to the atomic level. This field is called Physical Chemistry

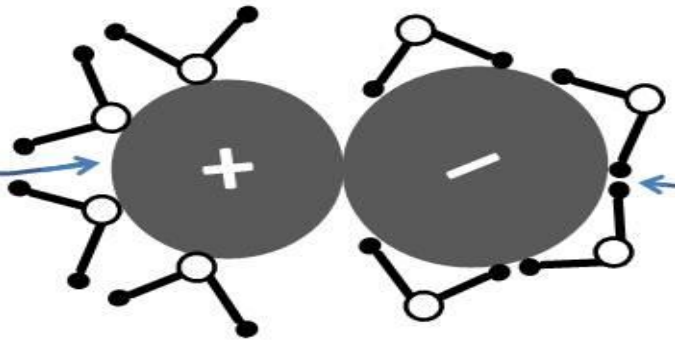


Courtesy of B. Moore, Hydrosmart

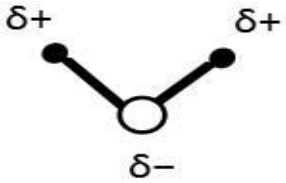
Mechanism

Stage 1: Happens naturally.
Water molecules surround and "hydrate" mineral ions.
Hydrosmart further favours this dissolving process

Positively charged ion such as Na^+ (sodium)

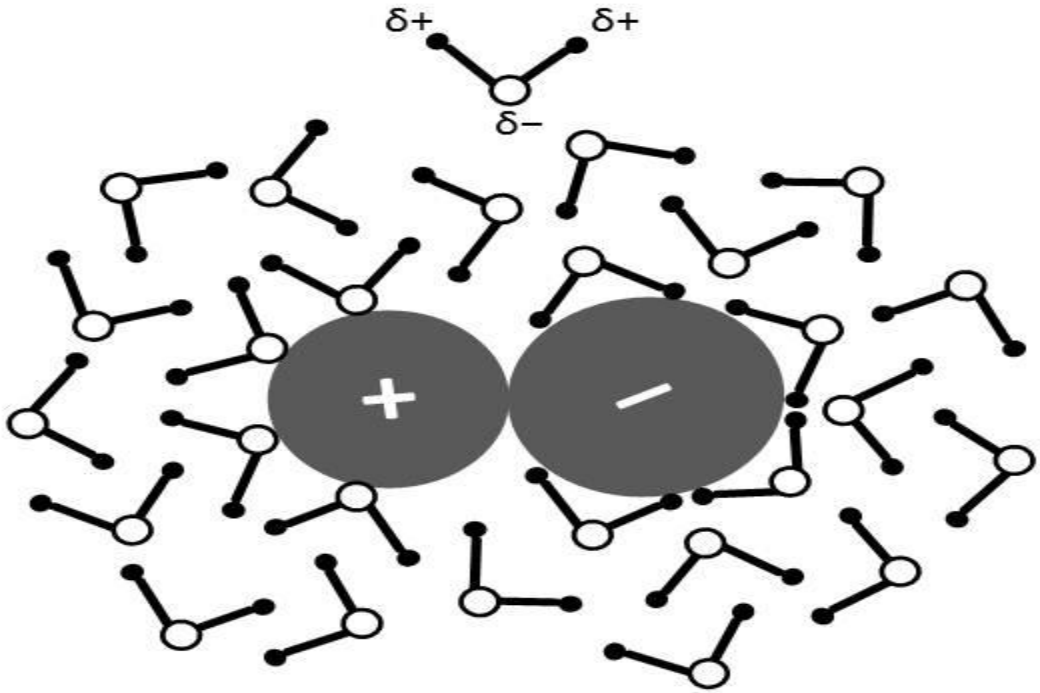


Negatively charged ion such as Cl^- (chloride)



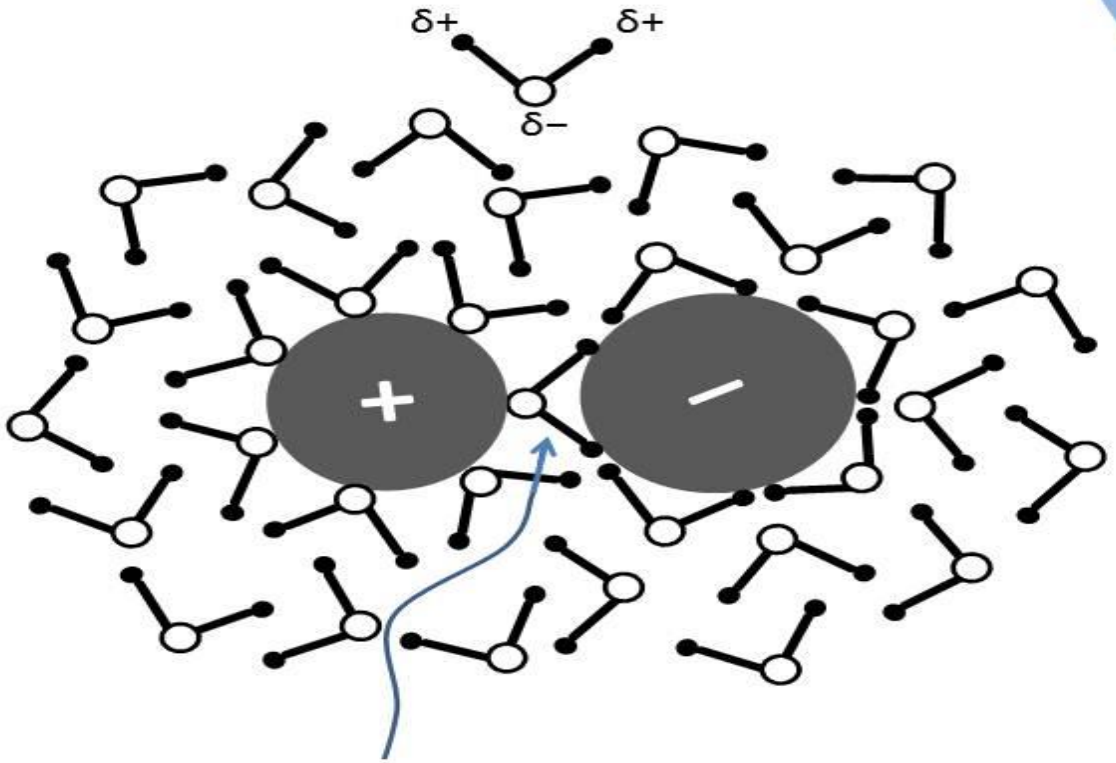
Water molecule, has a dipole (i.e. oxygen atom is negatively charged and hydrogen atoms are positively charged. Charges on water balance the charges on mineral ions, by physically attaching to them. Hydration is the process we all call "dissolving"

Courtesy of B. Moore, Hydrosmart



Stage 2: Happens naturally.
Additional water molecules surround mineral ions.
Hydrosmart favours this process by targeting the ions

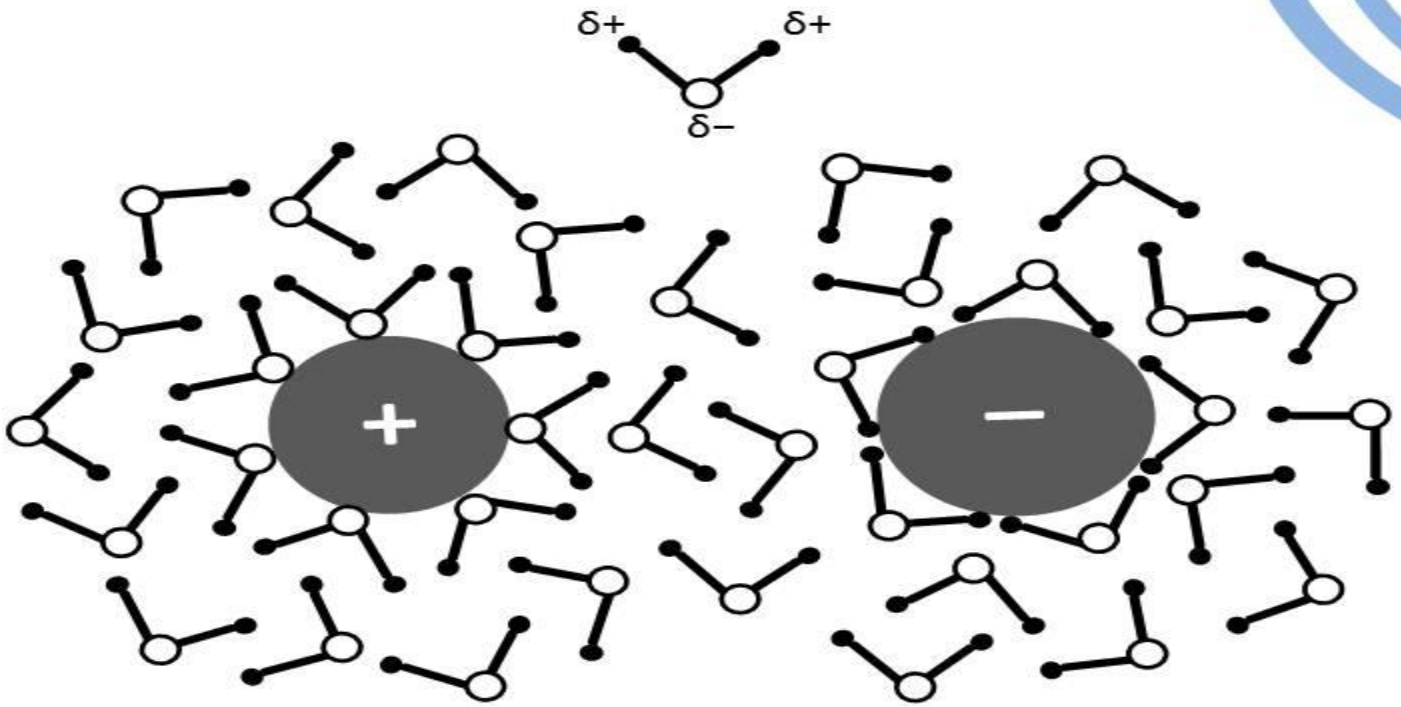
Courtesy of B. Moore, Hydrosmart



Stage 3:

A single water molecules comes between the mineral ions. Hydro-smart favours this process, accelerating it beyond the natural rate.

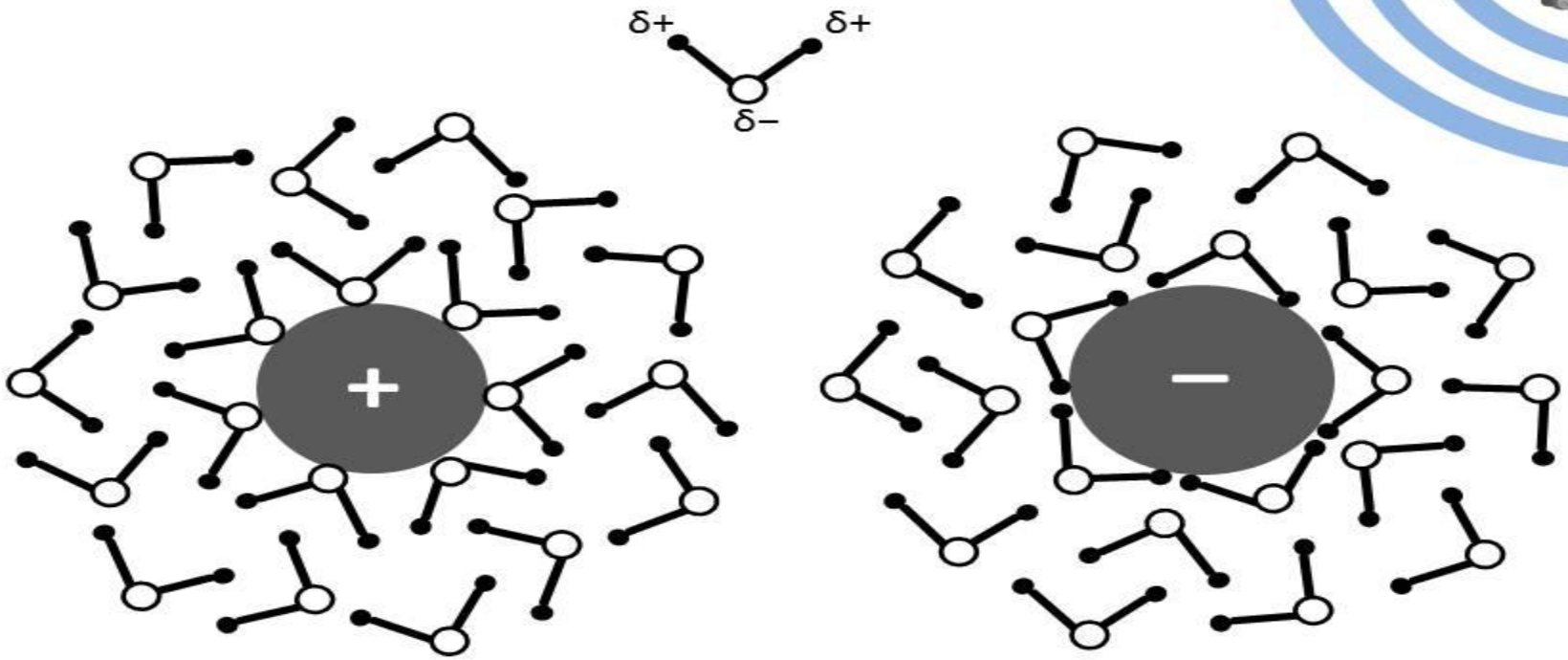
Courtesy of B. Moore, Hydrosmart



Stage 4:

Water molecules fully dissolve the mineral, but the mineral ions share some water molecules. Hydrosmart favours this process.

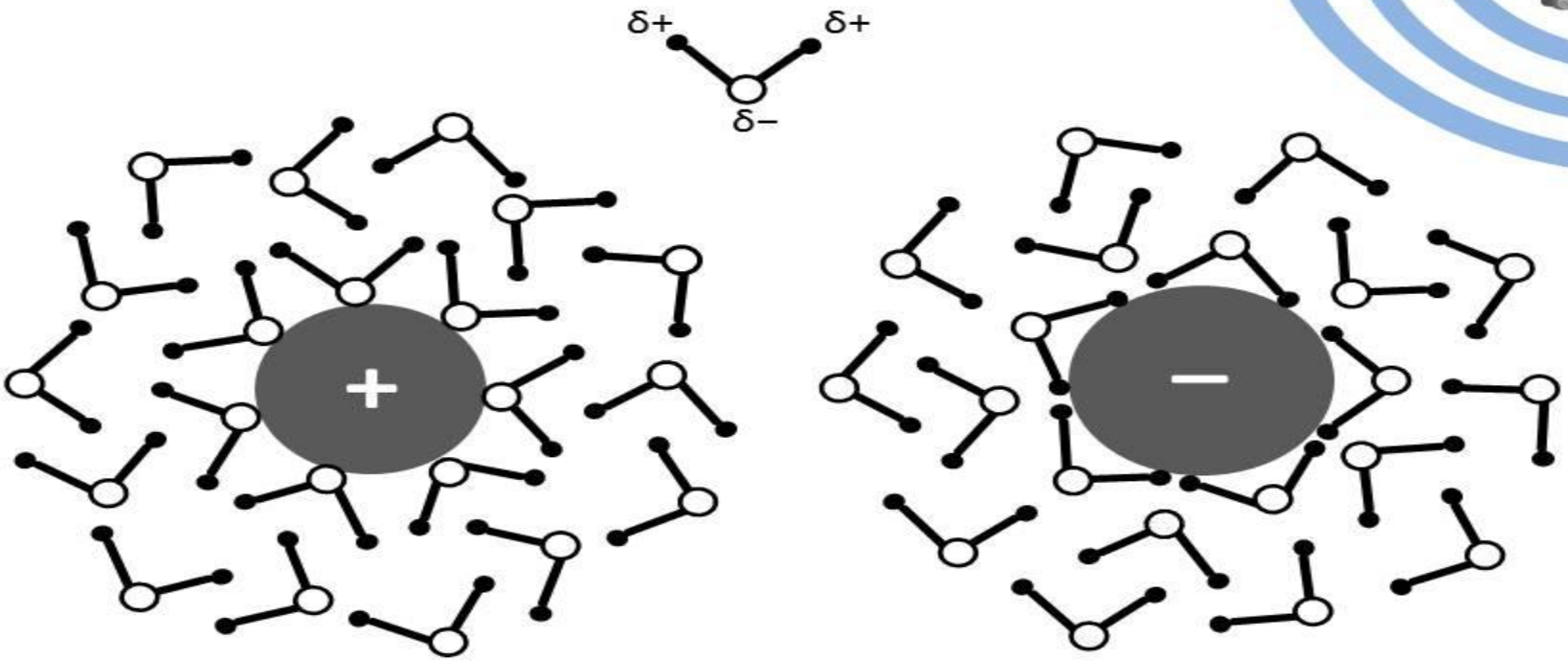
Courtesy of B. Moore, Hydrosmart



Stage 5:

Each mineral ion is independent of others and is now a free agent. Hydrosmart favours this process.

Courtesy of B. Moore, Hydrosmart

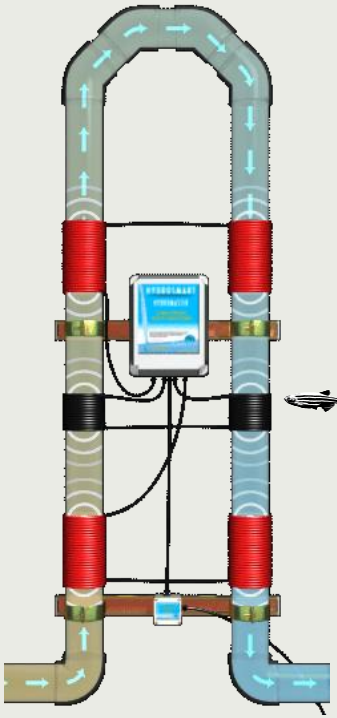


Hydrosmart favours the entire "dissolving" process

Each freed ion can scavenge unfreed ions from a mineral compound or mineral layer, in turn freeing them

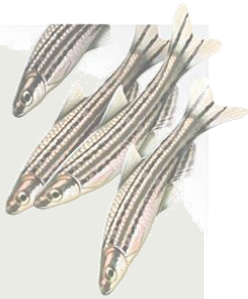
Courtesy of B. Moore, Hydrosmart

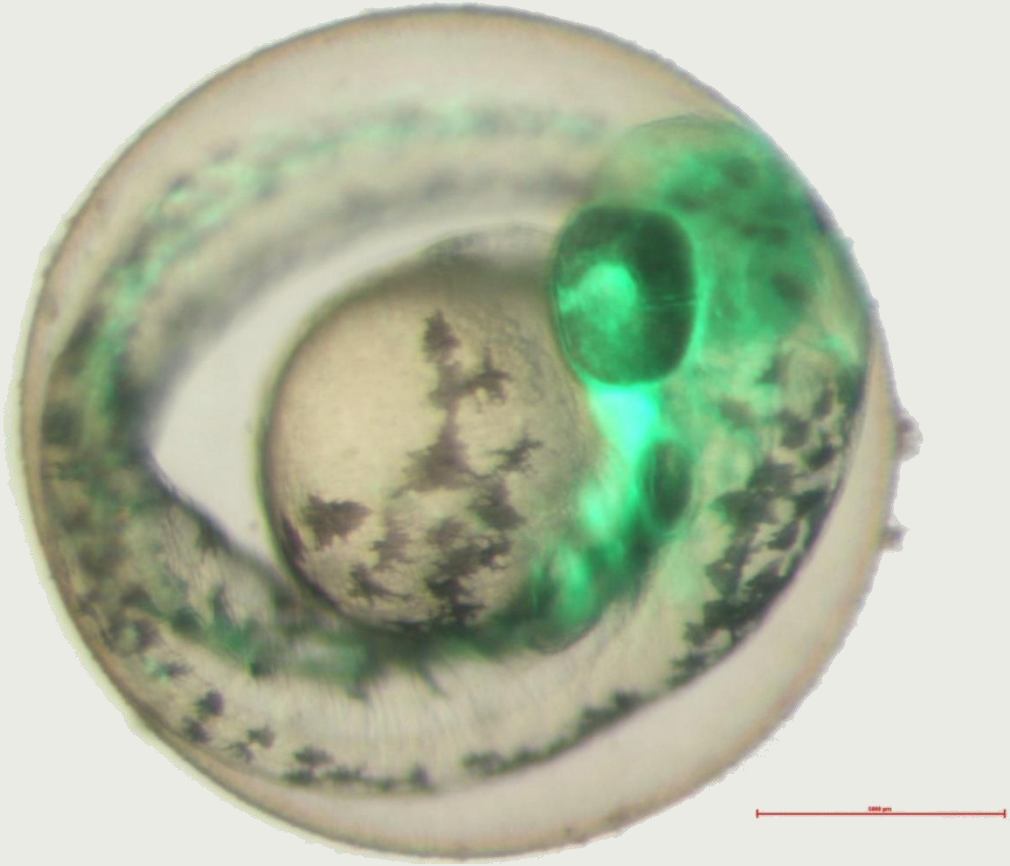
Potential zebrafish application



- *Biofilm reduction on pipework*
  - *Massive surface area compared to commercial fish farms*
  - *Typical supply outlet 5mm vs 2” diameter*
- *Studies needed to understand impact on animals*
  - *Calcium cascade impact*

Questions?





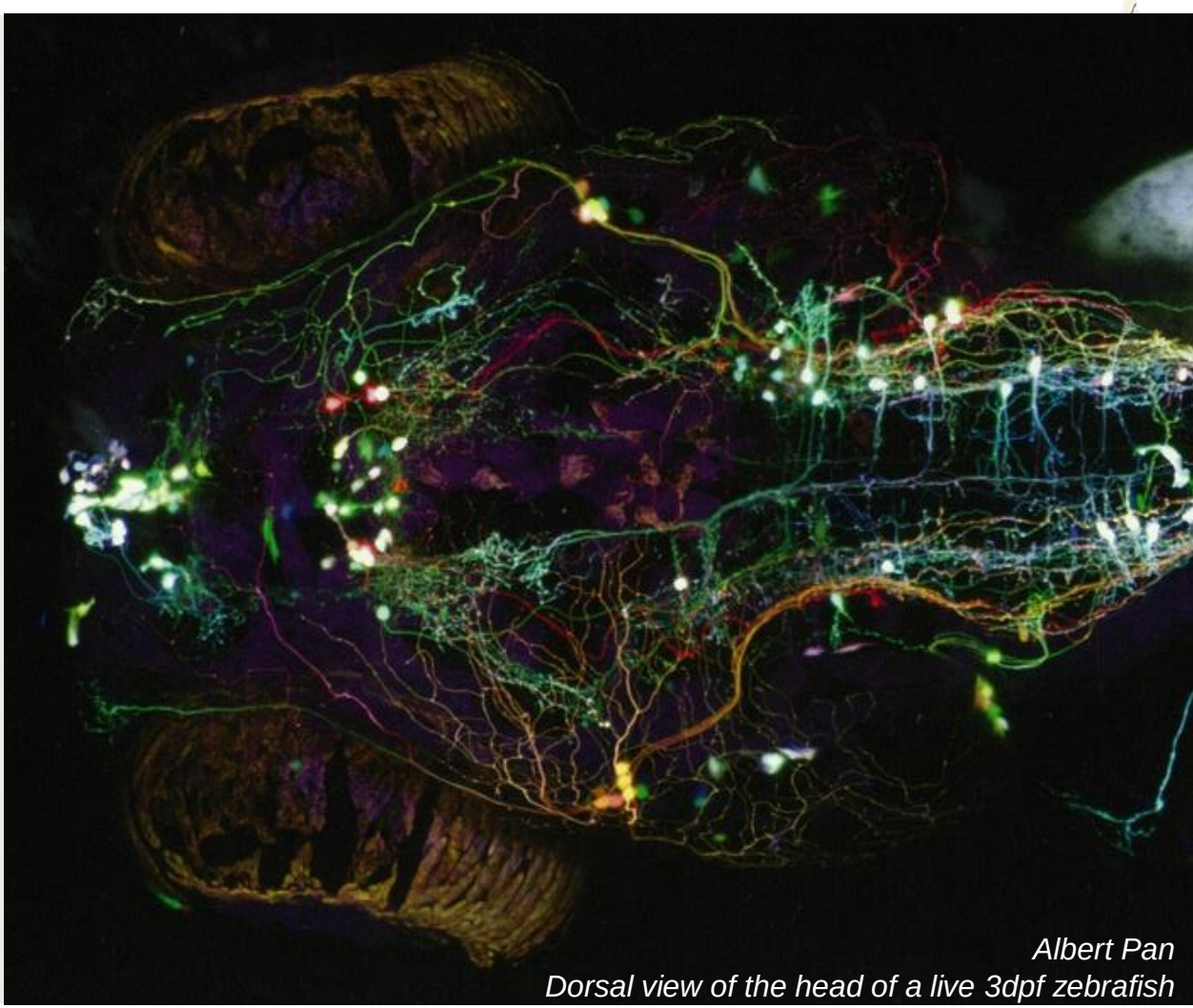
ZEBTEC
ZEBRAFISH HOUSING SYSTEM

2nd Annual International Zebrafish Husbandry Course

Aquaria Design Options

UQ Biological Resources

Questions?



Albert Pan
Dorsal view of the head of a live 3dpf zebrafish