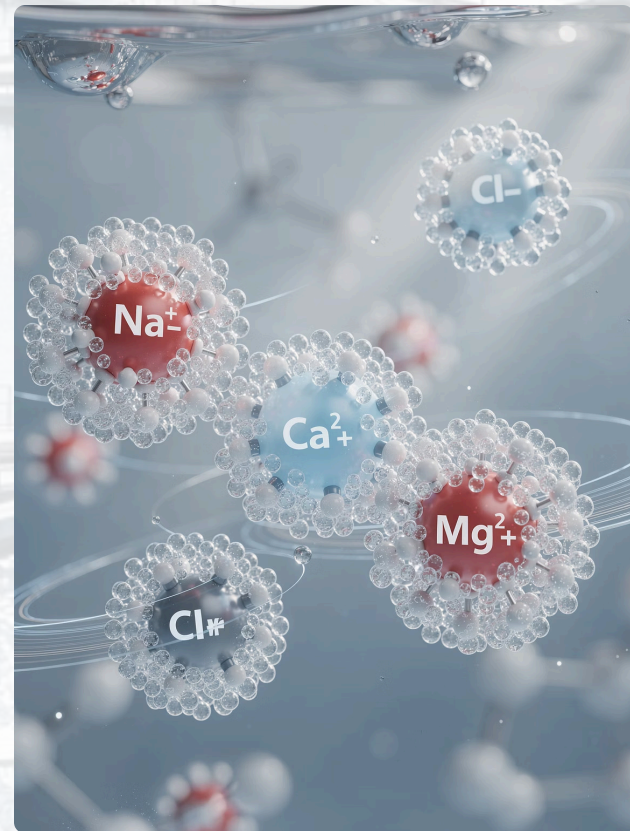


Addressing Dissolved Oxygen Levels in High-Salinity Ponds

About Ions Solubility:

When ionic salts such as sodium chloride, calcium chloride, and magnesium sulfate dissolve in water, they dissociate into charged ions that generate strong localized electrostatic fields in the aqueous medium.

- These charged ions strongly attract nearby water molecules.
- Water molecules reorganize to form structured hydration shells around each ion.
- Within this shell, water molecules align in a fixed direction (the oxygen side faces positive ions; the hydrogen side faces negative ions).
- This rigid hydration structuring reduces water molecular freedom, suppresses diffusion rates, and constrains overall water molecules mobility



Why Salinity Reduces Dissolved Oxygen: The Structural Logic

Oxygen behaves very differently from dissolved salts because it does not carry an electrical charge and interacts weakly with water. **Molecular oxygen (O₂)** is non-polar and carries no charge. When oxygen enters water, it does not form hydration shells or induce strong molecular ordering. Instead, it occupies transient, weakly stabilized cavities formed by momentary fluctuations in the hydrogen-bond network. The interaction is mediated only by weak van der Waals forces — making oxygen's presence in water inherently fragile and easily disrupted by competing ionic activity.

Fewer Molecular Cavities Form

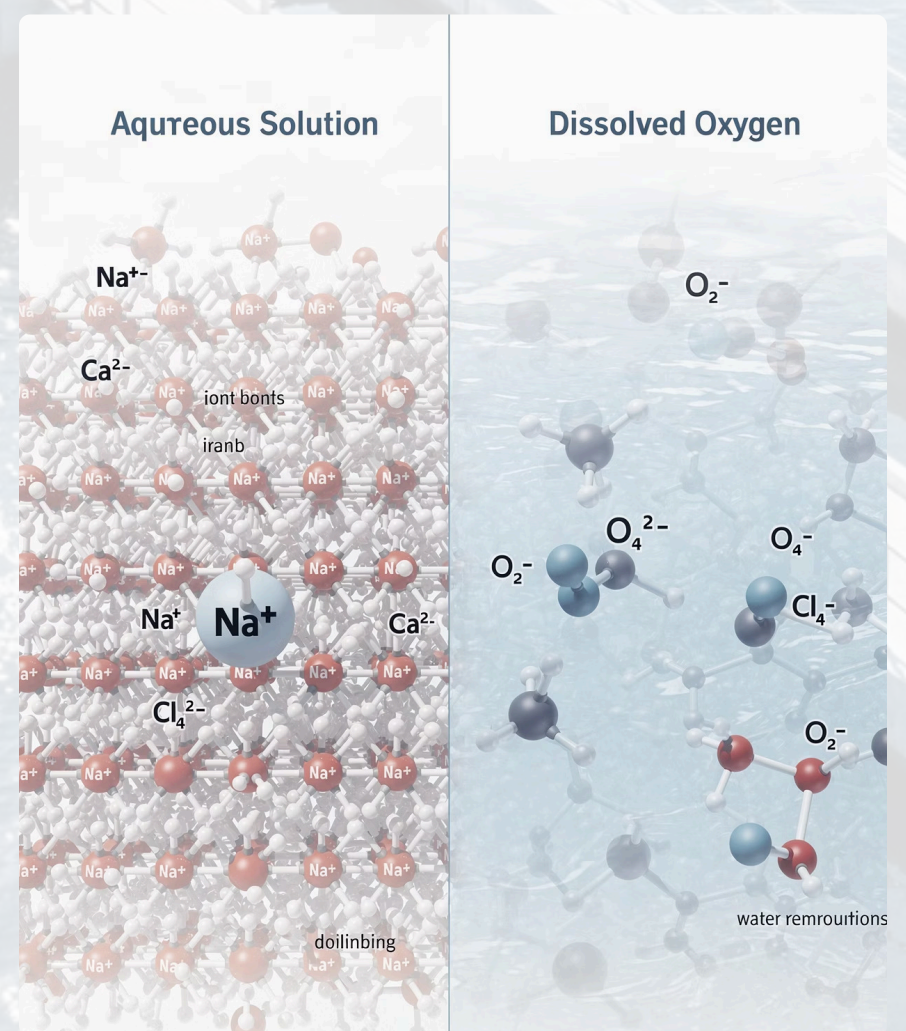
Rigid ion hydration structures crowd out the transient void spaces that oxygen needs to enter and remain dissolved. The structural density of ionic water simply leaves less room for gas accommodation.

Cavities Collapse More Rapidly

Even when transient cavities do form, the stiffened hydrogen-bond network causes them to collapse before oxygen molecules can fully diffuse inward and stabilize, shortening oxygen residence time dramatically.

Higher Energetic Cost of Entry

Oxygen molecules require significantly more energy to enter and remain dissolved in saline water. At the air-water interface, a larger fraction of collisions fail to result in dissolution, and those that do enter escape more rapidly.



- ❑ The decline in dissolved oxygen with rising salinity is **not** due to any change in oxygen chemistry — it is a direct result of water losing the structural flexibility required to form and sustain the transient molecular cavities oxygen depends upon for solubility.

Henry's Law on Oxygen Solubility

How Water Structure Changes the Outcome

The Core Principle

Henry's Law explains that, at a given temperature, the amount of oxygen that can remain dissolved in water depends on both the oxygen pressure above the water and the **water's inherent ability** to accommodate oxygen.

In Aquaculture terms:

Aeration effectiveness is constrained by the water's intrinsic ability to retain oxygen:

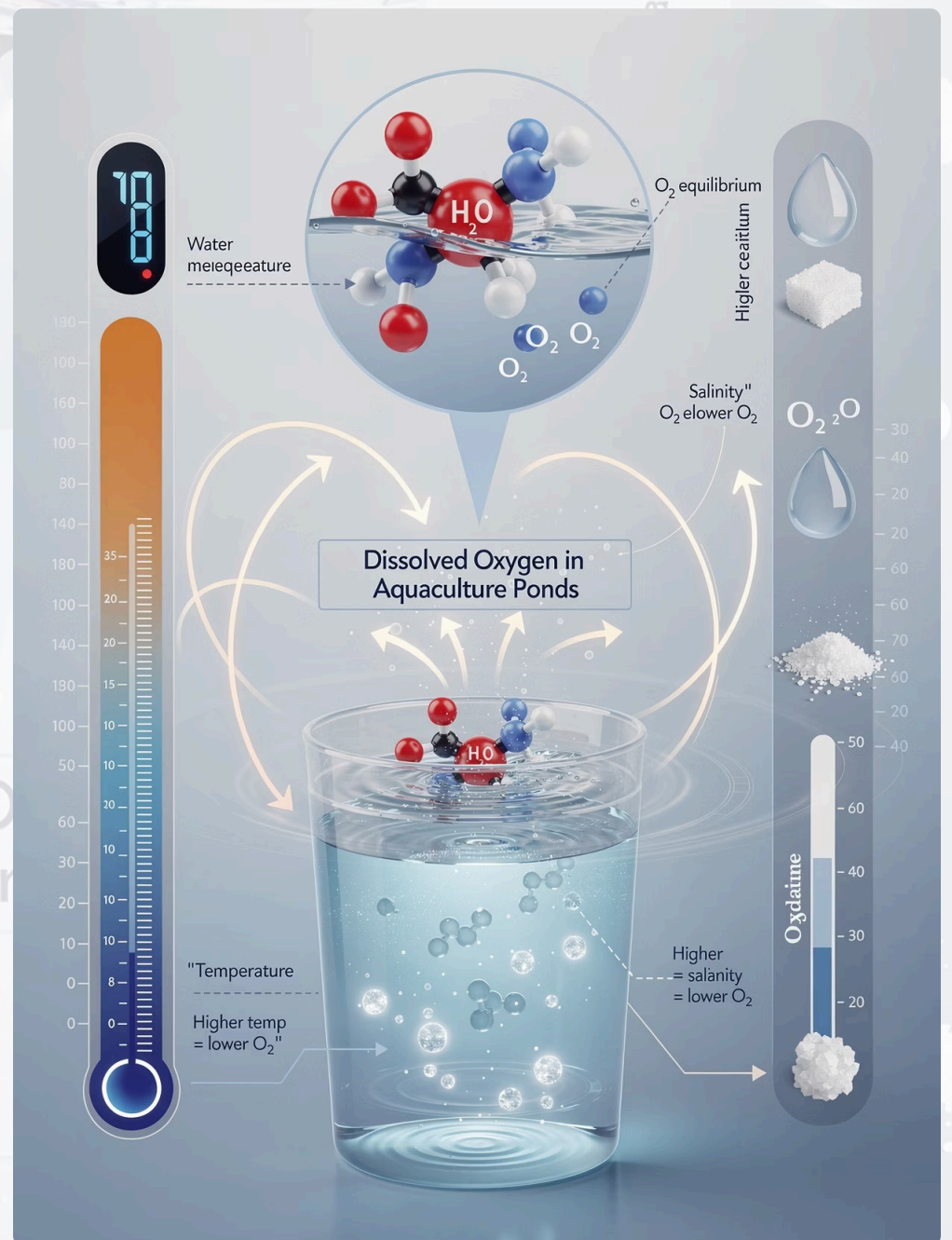
- Aeration increases dissolved oxygen only up to the water's natural solubility limit.
- Once equilibrium is reached, additional aeration increases turbulence—but **does not increase dissolved oxygen concentration**
- Oxygen limitation is therefore a **water-structure challenge**, not merely an aeration constraint.

Why Henry's Law Matters in Ponds

Two ponds with identical aeration systems can exhibit very different dissolved oxygen (DO) levels because oxygen solubility is governed by:

- **Temperature**
- **Salinity / Total Dissolved Solids (TDS)**
- **Water molecular structure**

Optimizing water structure can therefore unlock greater oxygen availability without increasing aeration intensity or energy input



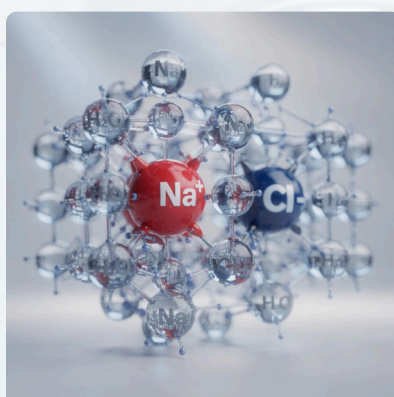
Key Constrains Limiting Dissolved Oxygen:

Temperature Increase



- Water molecules move faster
- Dissolved gases escape more easily
- Oxygen solubility decreases

High Salinity



- Dissolved salts bind surrounding water molecules
- Hydrogen-bond networks become more rigid
- Water's capacity to host oxygen decreases

Lower D.O Equilibrium



- Animals operate closer to hypoxic stress, appearing earlier at night.
- Feed conversion efficiency declines
- Prolonged oxygen stress increases disease susceptibility.

Since oxygen limitation is governed by water structure rather than aeration intensity, meaningful improvement must arise from modifying the physicochemical conditions that define oxygen equilibrium within the water itself.

Implications for High-Salinity Grow-Out Ponds

In grow-out ponds with high mineral content, the structural limitation on oxygen solubility becomes a critical operational bottleneck. The consequences compound rapidly as ionic strength rises and stocking density increases.

Reduced Aeration Efficiency

Even with continuous mechanical aeration, oxygen uptake efficiency declines in high-salinity water. More energy input delivers proportionally less dissolved oxygen to the water column.

Shorter Oxygen Residence Time

Oxygen that does enter the water column escapes more rapidly. Effective oxygen availability to stocked animals drops well below measured surface-level concentrations.

Constrained Stocking Density

Lower effective dissolved oxygen directly limits safe stocking densities, forcing managers to underutilize pond capacity to avoid hypoxic events and mass mortality.

Elevated Metabolic Stress

Chronic sub-optimal oxygen levels increase metabolic stress, worsen feed conversion ratios, suppress immune function, and heighten disease susceptibility across the production cycle.



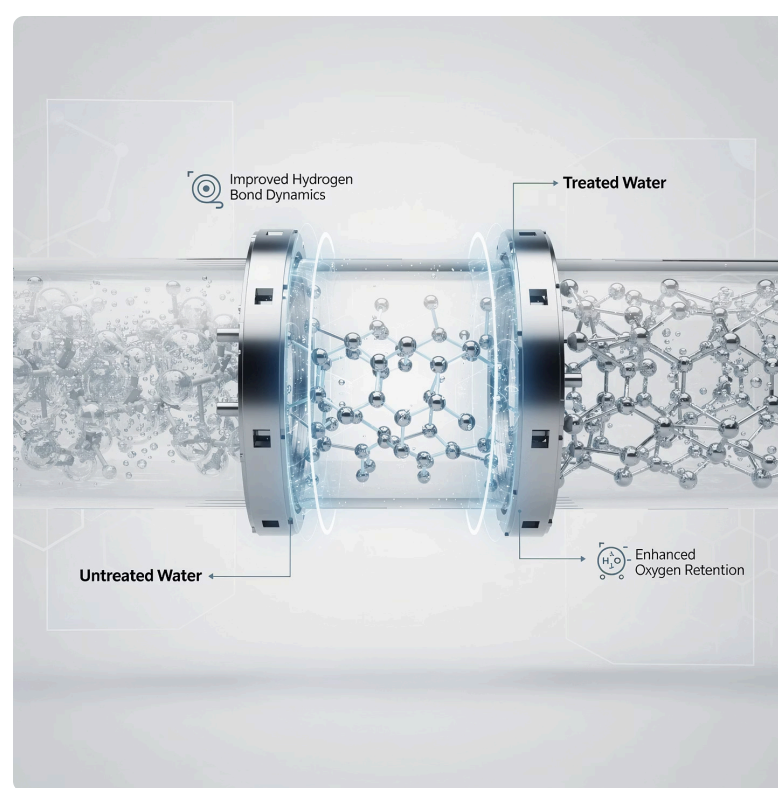
Enhancing Oxygen Retention and Diffusion in Water Through MWT

Magnetic Water Treatment Operates within Henry's Law, not against it.

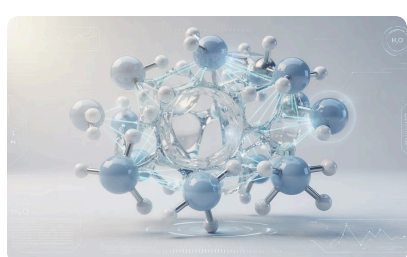
Magnetic Water Treatment (MWT) enhances dissolved oxygen stability by optimizing water's molecular organization rather than by mechanically increasing oxygen concentration.

- As water passes through a controlled magnetic field, hydrogen-bond interactions between water molecules become more dynamic and better balanced.
- The proportion of monomeric and weakly associated water molecules increases.
- The dominance of large, rigid molecular clusters is reduced.
- Water reorganizes into smaller, more mobile molecular assemblies.
- These structural adjustments are particularly beneficial in saline or high-TDS environments, where water structure is otherwise constrained and oxygen stability is compromised.

This format maintains a solution-focused tone while preserving technical clarity and mechanistic credibility.



Structural and Oxygen-Transfer Advantages



More Frequent Cavity Formation

In magnetically treated saline water, transient cavities form more often as the hydrogen-bond network gains configurational flexibility. The probability of oxygen successfully entering the water phase increases measurably at the air-water interface.



Extended Oxygen Residence Time

Cavities collapse less abruptly, and water reorganizes around dissolved oxygen with lower energetic cost. Oxygen molecules remain dissolved for longer periods before escaping back to the atmosphere — a key factor in maintaining stable DO levels.



Higher Net Dissolved Oxygen

The combined effect — more frequent entry, reduced escape rate, lower energetic cost of retention — produces measurably higher and more stable dissolved oxygen levels even under high salinity conditions, with no chemical modification of the water.

↑ DO

Dissolved Oxygen

Higher and more stable DO levels maintained across the water column under elevated ionic strength conditions.

↑ FCR

Feed Conversion

Improved oxygen availability reduces metabolic stress, directly improving feed conversion ratios and growth performance.

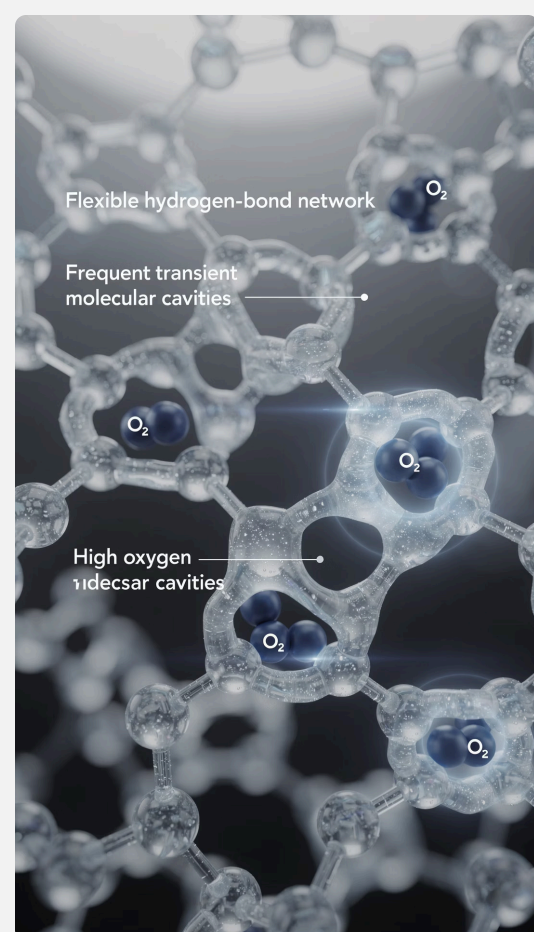
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Chemical Inputs

No additional chemical inputs, oxidants, or aeration energy required — the intervention is purely physical and structural.

Oxygen Equilibrium Across Water Types

Freshwater

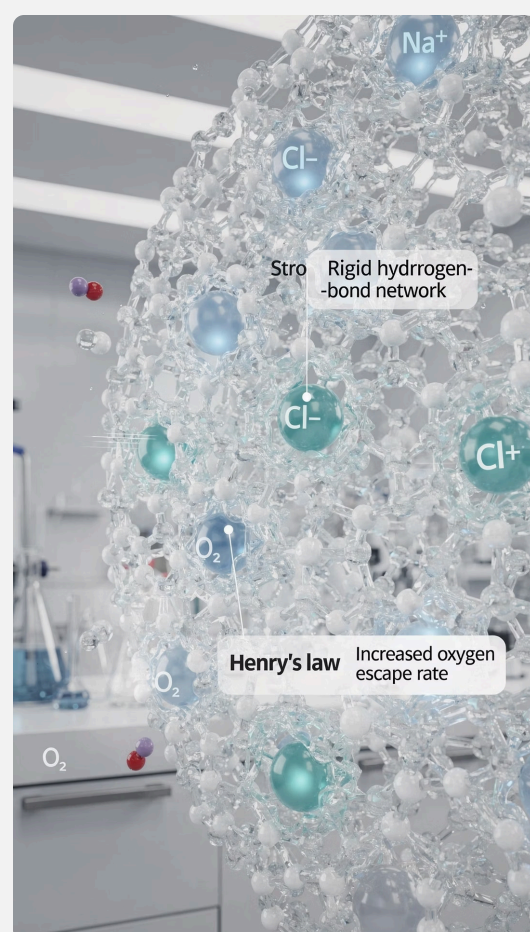


High Oxygen Accommodation:

In freshwater, dynamic water structure allows oxygen to enter easily and remain dissolved. Equilibrium dissolved oxygen is relatively high.

- Flexible hydrogen-bond network
- Frequent transient molecular cavities
- High oxygen residence time.

Saline Water

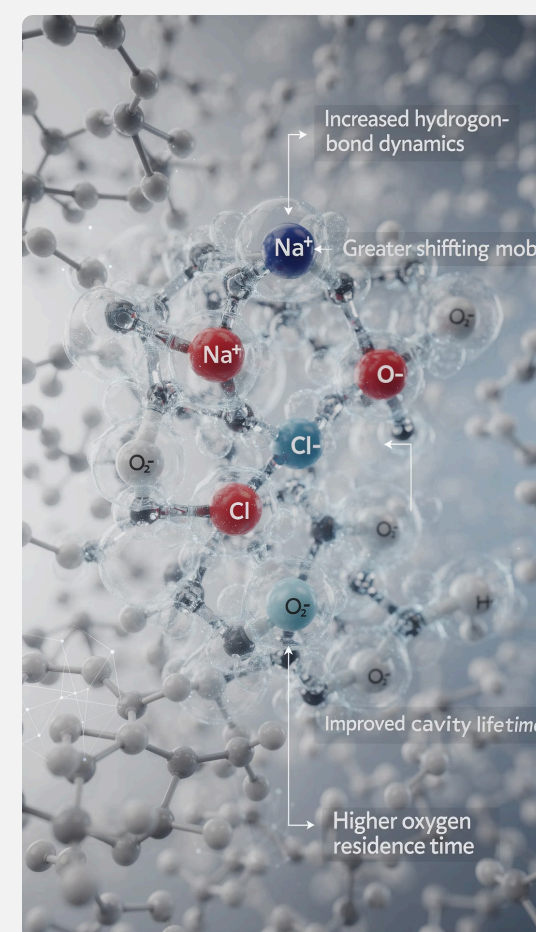


Henry's Law Limitation:

Salinity does not prevent oxygen from entering water, but it limits how long oxygen remains dissolved. Equilibrium dissolved oxygen is lower even with aeration

- Strong ion hydration shells
- Rigid hydrogen-bond network
- Reduced cavity formation
- Increased oxygen escape rate

Saline Water + MWT



Optimized Equilibrium:

Magnetic Water Treatment increases molecular flexibility, shifting the **effective oxygen equilibrium upward** and allowing more usable oxygen under saline conditions.

- Increased hydrogen-bond dynamics
- Greater molecular mobility
- Improved cavity lifetime
- Higher oxygen residence time