RainBox

by AgriWater

RainBox (R-AOP)
Basic Scientific Explanation

Terminology

Advanced Oxidation Process (AOP):

- Water treatment process that oxidises biological, organic and inorganic impurities with highly reactive radical species that are generated during treatment.

Highly reactive radical species (HO·, hydroxyl):

- These are highly reactive species due to their unstable unpaired electron. Hydroxyl reacts rapidly and non-selective and is thus highly efficient at claiming electrons from biological, organic and other chemical pollutants or impurities in water and breaking these down.

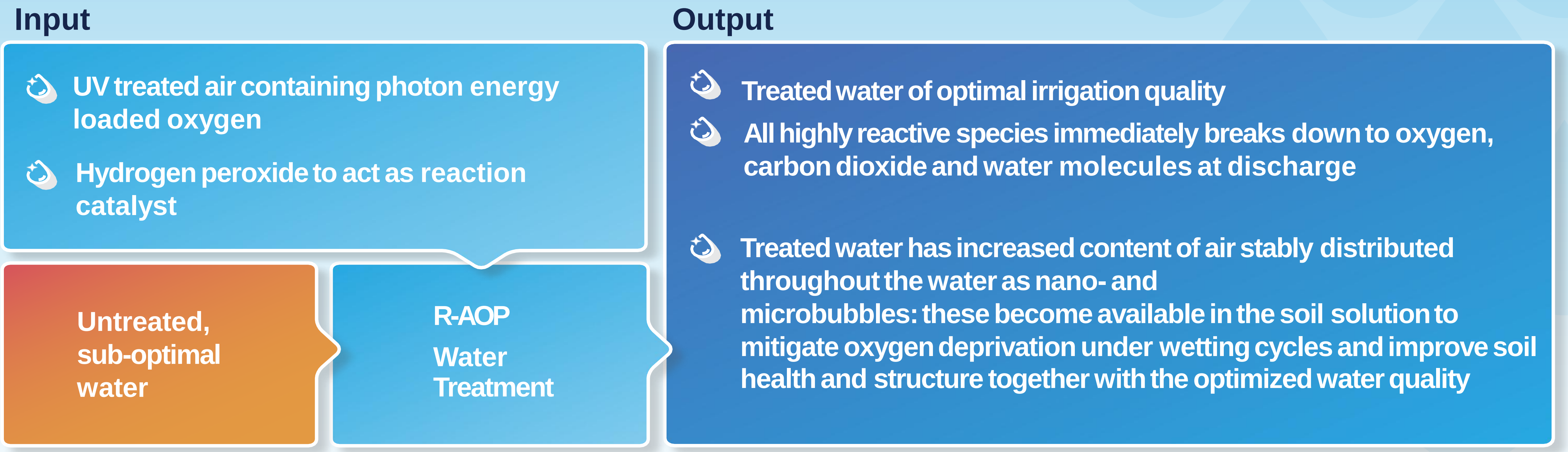
RainBox Advanced Oxidation Process (R-AOP):

- Radical species are created throughout the treatment process in flowing, pressurised water through the reaction of nano- & micro-photon energy loaded, oxygen bubbles with hydrogen peroxide (used as catalyst for radical generation).

Photon energy:

- Photon energy from a highly specific UV frequency light source is transmitted and loaded onto oxygen molecules with which it has a stable resonance. Oxygen acts as batteries and distributes the stable photon energy in micro- and nanobubbles throughout the treated water to achieve maximum availability for R-AOP reactions.

Outside overview



Input

- UV treated air containing photon energy loaded oxygen
- Hydrogen peroxide to act as reaction catalyst

Untreated, sub-optimal water

R-AOP Water Treatment

Output

- Treated water of optimal irrigation quality
- All highly reactive species immediately breaks down to oxygen, carbon dioxide and water molecules at discharge
- Treated water has increased content of air stably distributed throughout the water as nano- and microbubbles: these become available in the soil solution to mitigate oxygen deprivation under wetting cycles and improve soil health and structure together with the optimized water quality

Notes:

- ✓ R-AOP reactions are active from the point of reaction loading until final discharge of the treated water – this ensures fast, effective and continuous cleaning of complete water distribution systems as well.
- ✓ Reaction loading unit is sized according to water flowrate, pressure and quality.
- ✓ R-AOP treatment has no concentrated or hazardous extraction streams that has to be disposed of, or any harmful by-products that are formed,

On the inside

1) The breakup and prevention of microbial growth throughout the water distribution system

- It is common for water to contain living algal and bacterial material.
- These microorganisms especially flourish in water with elevated mineral and nutrient contents and can easily cause partial to complete blockages of water delivery systems.
- They achieve this by latching onto surfaces and drawing their nutritional needs from the water with dissolved salts and minerals flowing by.
- While growing and multiplying inside their biofilm, the organisms form a protective shield of depleted and recalcitrant compounds around themselves to create their own micro-environment.

- Recalcitrant compounds are easily oxidized and broken apart by the highly reactive and non-selective radical species.
- Photon energized oxygen molecules are attracted to the biofilm surface due to their difference in charge. These molecules are thus temporarily immobilized, improving their collision rate with catalytic hydrogen peroxide molecules to form radical species right at the needed reaction site for biofilm breakdown.
- Exposed microbes of damaged biofilms are easily de-activated and broken apart by the nano- and microbubbles distributed through the flowing water.
- Suspended organisms and other organic or biological material is, similar to above, easily oxidized and formation of any further biofilms are inhibited.

On the inside

2) The breakup and prevention of salt and metal precipitate formation & build-up

- Salt deposits from water with elevated concentrations of cationic (calcium and magnesium) and anionic (carbonate, phosphate and chloride) salt ions are easily formed in water delivery systems.
- Deposits actually form when these dissolved cationic and anionic ions come together and form salt molecules that precipitate.
- Metal deposits form mostly due to iron and manganese oxidation which causes precipitate formation. Metal precipitates readily attracts other dissolved metals and initiates oxidation and particle growth at their outer surface.

Calcium and Magnesium

- Calcium and magnesium ions attract photon energized oxygen molecules due to their specific difference in ionic charges.
- Photon energized oxygen molecules surround calcium and magnesium ions and act as a shield that inhibit the interaction of these ions with other anionic species, thus inhibiting calcium and magnesium salt formations.
- This photon energized oxygen shielding effect protects and enhances the activity of calcium and magnesium ions in the discharged water when entering the soil solution.

Carbonates and Phosphates

- Carbonates and phosphates readily reacts with the reactive radical species formed during R-AOP treatment.
- Reaction with these radical species generates carbonate or phosphate radicals.
- Carbonate and phosphate radicals also carry oxidation power that can react with impurities further downline.
- Carbonate radicals present at discharge will dissociate to carbon dioxide and oxygen.

Iron and Manganese

- Iron and manganese can be oxidized by both photon energized oxygen and the generated reactive radical species.

$$Fe^{2+} + O_3 + H_2O \rightarrow Fe^{3+} + O_2 + 2OH^-$$

$$Fe^{2+} + HO^{\cdot} \rightarrow Fe^{3+} + OH^-$$

- Oxidation of these metals occur at micro/nano scale.
- Particle growth of oxidized metals are inhibited during R-AOP treatment through the attraction and incorporations of phosphate, silica and calcium ions to the outer surface of the nano-/micro sized particles in the oxygen rich treated water environment.

On the inside

3) Balancing of ion activity to mitigate salinity hazard

- Salinity of water is generally measured in terms of electric conductivity, which indicates the amount of charge that can be carried by the dissolved salt/nutrient/mineral/metals in the water.
- The main ions contributing to high salinity are sodium and chloride. These are also generally the ones attributing most of the harmful effects of saline water on soil and plant health

Soduim

- In natural environments, sodium is a vital mineral that plays key roles in biological metabolic cycles and chlorophyll production.
- Sodium becomes a problem when it is out of balance and in excess of other major nutrients.
- + It easily replaces calcium and magnesium around soil colloids causing degraded and compacted soils.
- + Build-up of sodium over other nutrients in the rootzone causes plant and microbial toxicity.
- By improving the availability of calcium and magnesium ions in treated water, the preferred interaction between soil colloids and these ions can take place and excess sodium ions can leach out.

Chloride

- Chloride is generally present in water as ClO^- (hypochlorite).
- Photon energized oxygen and generated reactive radical species oxidise this ion into a less available and
- less toxic form, ClO_2^- (chlorite).
- This oxidized form of chloride is readily attracted and adsorbed to nano-/micro sized oxidized iron particles also produced during R-AOP treatment.
- This oxidized chloride association with iron particles are small and stable enough to freely move through water distribution systems and soil profiles without causing harmful interactions or build-up.

EC

- Water treatment by the
- R-AOP is designed to be a completely environmentally friendly and environmental complimentary technology.
- No salt, mineral or metal components are removed from treated water for disposal and little effect is seen in EC measurements.
- Focus is rather put on restoring balance and boosting advantageous elemental activities to optimize water quality and generate functional water.

On the inside

4) Breakdown of harmful biological and organic pollutants

- Many harmful, and sometimes severely toxic chemicals and biological compounds from pesticides, herbicides, fungicides, sewage, mining wastes and other chemical processes end up in fresh water resources above of below ground.
- Water containing these compounds can cause build-up of these compounds in rootzones and cause severe soil health and structure problems and have detrimental effects on the overall ecosystem.

- Photon energized oxygen molecules readily break double and triple bonds that are commonly found in the structures of organic and biological pollutants, breaking hazardous molecules apart into smaller, less reactive or harmful forms.

- The highly reactive, non-selective radical species generated throughout R-AOP treatment will effectively break recalcitrant pollutants down to less harmful and mineralised molecules.

- Water treated by the R-AOP transfers its enriched characteristics into the irrigated soil. Oxygen and carbon dioxide is steadily released into the soil profile by the water as it penetrates the soil structure. This creates an aerobic soil environment under which healthy soil life can flourish and help build soil structure, health and resilience to biotic and abiotic stresses it may further encounter.

On the inside

5) pH buffering effect

- Ionic imbalances in water are usually accompanied by either acidic or alkaline pH levels.
- Having either high or low pH levels in water will ultimately translate to increasing or decreasing pH levels in the soil solution.
- When altering the pH of soil, microbial population sizes, distributions and activities will also change accordingly and will ultimately limit the type of plant growth that can be supported by the altered soil environment.

High pH water

- By using atmospheric air in the R-AOP, the benefits of carbon dioxide dissolution in water can be utilized:

$$CO_2 + H_2O \rightarrow HCO_3^- + H^+$$

+ Hydrogen ions are released to the treated water to decrease pH.

- Photon activated oxygen molecules consume hydroxyl ions rapidly directly from water (without requirement for hydrogen peroxide) for radical species generation, thus causing a decrease in hydroxide concentration (pH).
- Hydrogen peroxide doesn’t readily decompose to hydroxide ions at this pH and rather directly partake in oxidation reactions whereby it releases water molecules.

Low pH water

- Carbon dioxide will either remain in nano-/microbubbles or dissolve to form carbonic acid as to not release further hydrogen ions to the water (no effect on pH):

$$CO_2 + H_2O \rightarrow H_2CO_3$$

- Photon activated oxygen molecules use hydroxide ions from hydrogen peroxide to catalyse radical generation, thus releasing hydroxide ions in the process (stimulating a pH increase).
- Hydrogen peroxide decomposes to hydroxide ions at this pH to buffer it to a more neutral-acidic level.

The various mechanisms of oxidative reactions active at different water pH levels during R-AOP treatment causes a slight water buffering effect towards a neutral-acidic level.