ZYLYM™ WATER CONDITIONING & USE IN IRRIGATION TO INCREASE EFFICIENCY & RESULTS

The use of the ZYLYM™ catalytic water conditioning unit in irrigation water, and the resulting improvement in water use efficiency, water conservation, crop production, crop quality, and soil structure, has been demonstrated across the full range of food and fodder agriculture for over 45 years. This experience also applies to use in landscape and turf irrigation, and to greenhouse irrigation, warehouse and City Farming operations, and hydroponics. The effect of ZYLYM™ conditioned irrigation water manifests in the following characteristics:

- Increased irrigation efficiency & water conservation
- Elimination of scale & deposits on pipe, fittings, emitters, sprinklers, and irrigation equipment
- Increased uptake of water & nutrients by plants
- Increased crop health, growth & yields (crop production)
- Increased nutrient & mineral content in crops (crop quality)
- Increased market value

These results have been documented in numerous 3rd-party reports and laboratory analyses, and water savings in the range of 16-29% have been typical, a very significant factor given tightening water availability in many geographical areas. There are associated savings in pumping and energy costs as well, but perhaps the most important affect of using ZYLYM™ conditioned irrigation water occurs subsurface, in the soil. Focusing on this important area, which forms the basis of successful agriculture and landscape value, the following observations have been documented:

- Decrease in soil conductivity (EC), with a concomitant decrease in sodium
- Increase in percolation of irrigation water & depth of moisture infiltration in the soil profile
- Increase in rainfall infiltration into soils, with the resulting increase in soil moisture storage and reduced seasonal irrigation demand

- Decrease in agricultural & landscape runoff, which is subject to increasing regulation and restrictions
- Increase in available soil calcium and other minerals, and breaking up of calcareous conditions like caliche
- Elimination of use of acid to counter high alkalinity & TDS in irrigation water, and sodic conditions in soil
- Improvement in soil structure, including reflocculation (soil structure, as used here, is the geotechnical term referring to the arrangement of soil particles and pore space. Porous, *flocculated* soils are preferred, rather than powdery, *dispersed* soils lacking porosity).
- Increase in CEC (Cation Exchange Capacity), and a decrease in SAR (Sodium Absorption Ratio), as calcium and magnesium cations replace sodium in soil structure
- Increase in infiltration, soil moisture-holding capacity and fertility, unlocking stored nutrients

It has been noted in numerous applications that using ZYLYM™ in irrigation results in increased percolation, both for applied water and for rainwater, and overall better water infiltration into the soil profile. This is true for the full range of irrigation types, from micro irrigation in landscape to full-scale center pivot and linear irrigation in commercial agriculture, including large plots in side-by-side documented conparisons, under identical conditions.

In sodic soils, rainfall, which is essentially de-ionized water, tends to be rejected from the soil surface due to this ionic mismatch, and wasted as agricultural runoff. ZYLYM™ mitigates this effect. When ZYLYM™ conditioned water has previously been utilized, the reduction in sodium and EC allows percolation of water deep into the soil, and eliminates pooling of irrigation water. This is especially important in areas supplied by canal water and groundwater that has become high in TDS and alkalinity.

More recently, ZYLYM™ has been used with similar benefits to crop quantity and quality in large-scale greenhouse and warehouse grow operations. Some of these use artificial substrates such as rock wool or fibrous plastic media, coconut coir, perlite, or hydroponic and aeroponic methods not using a medium per se. The benefits have been observed with both irrigation water containing various levels of TDS from conventional municipal sources, wells, and surface water, and with RO and de-ionized water, to which minerals and fertilizer have been added.

In operations using the various types of media, sodium build-up in the media and root zone can impede the uptake of nutrients, and require flushing of extra irrigation water to rinse the grow media and periodically, and flush out sodium. But at the same time, it is also important to avoid over-saturation and anoxic conditions in the root zone that favors the development of pathogens. ZYLYM™ treated fertigation, with soluble calcium and reduced surface tension, mitigates this on multiple levels, including increased uptake of available calcium, an especially important plant nutrient in these operations, and increased plant health and disease resistance, as well as continual displacement of sodium in the root zone.

As alluded to, the measurable criteria that can readily be seen, after only a few applications of ZYLYM™ conditioned irrigation water, are a decrease in water surface tension, and a decrease in soil conductivity. The two affects are related to the almost immediate observation that there is a decrease or elimination of standing water in fields that have been exhibiting poor infiltration and drainage. A drop in conductivity (EC) can be measured over a period of a few days, as sodium is dislodged and flushed out of the upper soil profile and replaced by soluble calcium and other cations.

Laboratory analysis accounts for these readily observed field affects: Reduction in water surface tension can be verified by measuring the horizontal size (circumference) of identical drops of water on a counting grid (or by simple observation on any smooth level surface in the field). The unconditional droplet has a smaller diameter and "stands up," while the conditioned droplet flattens out with a greater diameter. "Clear water turbidity" with an inexpensive turbidity meter, though not visible to the eye, will also register higher turbidity due to the structural changes in the conditioned water and minerals.

The flow of water containing alkalinity and calcium carbonate through a ZYLYM™ unit results in a change in crystalline structure. Calcium carbonate occurs in three known forms. The most common in irrigation and in mineral supplements is calcite, which tends to come out of solution and form cementitious deposits and scale. Aragonite is the second common crystalline form of calcium carbonate, and also accretes to form very hard scale and deposits. Compression tests have registered over 9,000psi in accreted aragonite.

The third form of calcium carbonate is vaterite. Instead of forming accretions in soil, and forming scale, as occurs with calcium carbonate in the calcite and aragonite crystalline forms, calcium carbonate conditioned by ZYLYM™ converts to vaterite, a non-accreting nano-crystal that is also implicated in the bioavailability of other nutrients. Vaterite forms distinctly single, individual crystals, and combined with the loss of surface tension in water, displaces sodium, enhances bioavailability, and increases the uptake of water and nutrients. These affects account for the demonstrated increases in crop production and crop quality..

Common practice dictates that the solution to poor water infiltration and removing salts from the upper soil profile is achieved by adding gypsum (calcium sulfate) to the soil surface. Rain and irrigation water would slowly dissolve the gypsum, providing calcium cations to displace sodium cations from dispersed clay particles, in an effort to increase aggregation. Sodium can then be leached from the upper soil layers – frequently via over-irrigating - and calcium may become available to improve soil structure. Gypsum is usually applied in the fall, prior to winter rains.

The first few rains then dissolve the most soluble portion of the gypsum. When the effect on water infiltration is most needed for the following summer growing season, there may be little soluble gypsum left to provide calcium ions to dislodge sodium and improve soil structure, while irrigation with high-TDS water continues and evaporation and crop demand increase. Use of ZYLYM™ on the actual irrigation water, has the dual benefit of allowing for the cessation of irrigation and for the improved infiltration of nearly zero TDS rain water during precipitation, and the continuous application of calcium carbonate in its remedial and bioavailable vaterite form during the entire annual irrigation cycle. This equates to a continuous remediation with conditioned irrigation water.

In calcareous, impacted soils, sulfuric acid is also used to dissolve and break up calcium carbonate accretions, and to counter excess alkalinity and sodium in irrigation water by lowering the pH. If the soil is calcareous, the sulfuric acid dissociates calcium ions and recombines to actually form gypsum and help to reflocculate soil structure and porosity. Sulfuric acid use, however, is deleterious to soil structure in the long run, and continued use interferes with the uptake of potassium and can be damaging to root hair development, especially in orchard trees.

Sizing of the ZYLYM™ device is based on flow rate through the ZYLYM™, and unlike other devices on the market, the affects are permanent and do not dissipate with distance or over time. The design incorporates a combination of factors that affect water and minerals as it flows through a ZYLYM™device. These include a catalytic alloy core, which affects minerals in water, and carefully engineered turbulence and cavitation: The momentary formation of ultrafine bubbles out of solution, which then collapse upon themselves, breaking surface tension and causing chemical changes and excitation of elements dissolved in the water.

Excitation of water chemistry by cavitation can also result in the propagation of the dynamic affects. This flow-based combination of catalytic and hydrodynamic effects accounts for the permanent change in water and also goes towards accounting for the propagation of the vaterite form of calcium carbonate to other calcite and aragonite forms, and the dissolution of scale deposits on equipment and pipes, and the mitigating effects in soil and media.

The design and shape of the core, its alloy formulation, the sizing of the outer pipe section sleeve, and the sizing of the overall unit based on specific flow rates, incorporating Taylor-Couette-Poiseuille (TCP) hydrodynamics, combine to produce the permanent benefits realized from use of the ZYLYM™ device. In TCP hydrodynamic flow, the impact of laminar flow water with the catalytic core, while causing excitation of the minerals, also results in the generation of minute vortices which spin outward, and then progress into breaking down into turbulent flow. At the same time, water is also flowing around the core in laminar flow, but dragging against the outer pipe sleeve. This combination of turbulent flow interfacing with slowing laminar flow creates cavitation, accelerating the water chemistry changes that take place and incorporate, as the water returns to laminar flow and discharges from the ZYLYM™ unit. Due to the proper sizing of the units, there is no restriction in flow or head loss.

To Summarize:

ZYLYM™ causes a physical change in irrigation water, rather than removal of constituents from various types of filtration, and any filtration should be installed prior to the ZYLYM™ unit. Mineral content and TDS remain essentially the same. Proper ZYLYM™ function thus requires the presence of some calcium and bicarbonate in the water, and in addition frees up additional calcium present in the soil or formed on grow media.

The passage of water through the ZYLYM™ catalytic unit results excitation of minerals, an internal momentary pressure drop, TCP hydrodynamic affects, cavitation, and a decrease in water surface tension.. Minute crystals of the vaterite form of calcium carbonate are formed when the calcium carbonate ions are reacted with the specific metallurgical formulation of the catalytic core.

The affects are amplified by turbulence and pressure-changes within the ZYLYM™ unit, and the crystalline structure of calcium carbonate is permanently changed to the vaterite form. These minute crystals are progressively shed from the catalytic surface of the ZYLYM™ core by turbulent water flow, and move into the water. This non-accreting, “softer” vaterite crystal will not form scale, and will break down existing scale and calcium accretions on equipment and in soil, largely mitigating for high TDS and high alkalinity in irrigation water, and high EC and SAR in soils and growing substrates.

ZYLYM™ conditioned water has the advantage that it can be stored and used at a later date, and no loss of conditioning takes place in long pipe runs or delivery systems. In addition to the reduction in irrigation demand, equipment maintenance, and runoff, use of ZYLYM™ typically pays for itself in crop production gains in a single growing cycle.

These statements are the result of over 3 decades of third-party documentation, research review, University studies, laboratory testing and analysis, electron microscopy, and large-scale crop and orchard comparisons by numerous growers in every type of field condition and agricultural product.