

Rehbein

ENVIRONMENTAL SOLUTIONS

Hard Water and EPIC systems

An occasional question that is raised for underground EPIC beds is – **Will hard water eventually clog the capillary sand bed or affect any other portion of the system?** The answer is **no**, but the science dynamics behind the answer take a little more reading.

Ground water – All water that we derive from groundwater sources (wells, springs) is actually ancient to reasonably recent rainwater, which has percolated through the earth's crust ending in water bearing rock formations. These below ground formations are often sand and gravel veins that have the void space between the particles to hold substantial amounts of free water. By intercepting these formations by drilled wells we create a larger collection void, a path of least resistance, and simply pump the water to the surface.

Hard water – The generic term “hard water” means that water contains dissolved minerals that can precipitate out to form mineral crusts. The term had its derivative from the term “boiler plate” which was the encrustation of hard limestone deposits on metal in contact with hot water systems. “Hard water” is actually the presence of two primary chemicals in solution – Calcium Carbonate (CaCO_3) and Calcium Sulfate (CaSO_4). The dominant Calcium Carbonate is one of the most stable, common, and widely dispersed materials. It occurs in nature as aragonite, oyster shells, calcite, chalk, limestone, marble, marl, and travertine. It is very slightly soluble in water. As rainwater (distilled water) percolates through the earth's crust it slowly picks up a certain amount of the minerals and holds them in solution. Depending on the pass through rock formations, other minerals such as Iron, Magnesium etc. may also be dissolved in trace amounts and added to the general mix of “hard water” that we term total dissolved solids (TDS).

Sand – The primary chemical component of most sands is Silicon Dioxide (SiO_2), (also the chief component of glass). Sand may additionally also contain other stable rock components, as sand is nothing more than crushed and occasionally polished rock. There is no chemical interaction between Calcium Carbonate and Silicon dioxide, just as a covered glass containing well water can remain clear and unreactive for years. The simple passage of hard water through a sand bed does not cause clogging. Water bearing strata (aquifers) have existed for millions of years with enumerable volumes of “hard water” passing through the sand particles without a clogging effect. ECS beds are essentially manmade aquifers very close to the surface.

Irrigation/Evaporation – The use of “hard water” for irrigation will entail an evaporation loss where water molecules enter the atmosphere as water vapor, leaving dissolved solids at the surface. With sprinkler irrigation we have a high evaporation loss and all of the dissolved minerals remain at the soil surface, or adhere to other surfaces leaving a tell tale white film behind. Subsequent additional sprinkler irrigation with “hard water” only adds more minerals, as the water itself cannot dissolve the previous minerals that were deposited earlier. Small emitter areas such as sprinkler orifices, dripper openings, or the common aerator screen on the kitchen faucet are areas that can encrust with minerals to a point where they become clogged. These areas are transition zones where minerals in solution are left behind by evaporation. Very hard water may be at saturation (at equilibrium), and unable to dissolve more minerals, thus continued passage of this water simply adds to the crust. The consequence is “mineral buildup”. The only reliable remedy is dilution with demineralized rainwater that can re-dissolve the minerals, or the intentional addition of acid that can increase the amount of dissolved minerals remaining in solution.

The use of Underground EPIC systems with “hard water” has several obvious advantages:

- a) Because there is little evaporation at the surface, the mineral concentrations remain in solution below ground.
- b) Because EPIC systems have shown water requirement reductions by better than 50% over sprinklers, also means that a proportional reduction of minerals occurs in the soil matrix.
- c) Sand (Silicon dioxide) has little ability to adhere to Calcium Carbonate, thus rinsing by rainwater is not difficult.
- d) Since sand beds drain very efficiently, even very light rain events get captured and dilute mineral concentrations.
- e) Since EPIC beds are not totally enclosed systems, winter rains or storm events rinse the sand and flush out excess mineral concentrations (if present) at the overflow drainage points.
- f) EPIC components have no moving parts, and the holes are simply too large to be affected by mineral deposition.

Biological factors – “Hard water” actually has a beneficial aspect in plant biology. Calcium and Sulfur ions, derived from Calcium Carbonates and Calcium Sulfates (Gypsum) are two of the primary nutrients along with Iron, Magnesium, Manganese, Phosphorus, Potassium and Nitrogen. These nutrients are absorbed through root hairs and are incorporated in growing plant tissue. Plant tissue that may be harvested and removed from the surface also depletes the minerals from the soil bed. The bulk of these nutrients are derived from soil minerals, minerals present in irrigation water, and intentionally applied soil amendment (fertilizers) formulas.

The aerobic condition of EPIC sand beds facilitate an efficient decomposition process for dead organic material. Organic material, in the presence of

microorganisms, combines with Oxygen and reverts back to Carbon Dioxide (CO₂) and Water (H₂O), - the reverse of photosynthesis. Rainwater combines with CO₂ and forms a mild acidic solution that increases the capacity for water to hold minerals in solution. The lower pH also helps other normally insoluble trace minerals in the soil to become ions and be available to plants.

How Water Dissolves Limestone

When a molecule of solid limestone dissolves, it breaks into two charged ions: one of calcium and one of carbonate, composed of a carbon atom tightly bonded to three oxygen atoms. In pure water the strong attraction between these ions holds most limestone in the solid state; a gallon of pure water dissolves only .001 ounce of limestone.

As carbon dioxide mixes with water, the oxygen atom and one hydrogen atom from a water molecule join the carbon dioxide to form a bicarbonate ion. The free hydrogen ion left by the process is the chemical hallmark of an acid—in this case, carbonic acid.

When carbonic acid dissolves limestone, carbonate ions and hydrogen ions from the two vertical reactions at left combine (bottom row) to form a second bicarbonate ion, thus creating a momentary shortage of carbonate ions at far left. To restore equilibrium, extra limestone dissolves—perhaps 25 times the amount that would dissolve in pure water.

How Water Dissolves Limestone

Caves are carved by water; but acting by itself, in the process diagrammed at far left, water cannot dissolve enough of limestone's main component, calcium carbonate, to create caves. The key to cave building is a chemical reaction that occurs as groundwater seeps downward, through decaying plant and animal matter, dissolving carbon dioxide gas released by the decomposition. As illustrated at near left, some of the gas reacts with water to form dilute carbonic acid.

Independently, both processes—the dissolution of limestone and the formation of carbonic acid—would virtually halt when they reached a state of equilibrium. But one product from each process—a carbonate ion and a hydrogen ion—combine in a third reaction (bottom row). This third reaction enables the original limestone reaction to dissolve much more limestone—up to 1/10 inch per year in some caves.

When limestone-laden water begins dripping through a cavern, however, the chemical reactions are reversed. Much of the carbon dioxide bubbles away into the subterranean atmosphere. Thus weakened, the carbonic acid rapidly becomes saturated with dissolved ions and begins to drive the limestone dissolution backward, forcing calcium carbonate to gradually precipitate from the solution in sparkling subterranean stalactites and stalagmites.