Tablet Chlorination Systems Solve Common Irrigation Problems

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Abstract:
Simpler and safer methods of chlorination are increasingly being applied to a variety of common irrigation problems. Recent water shortages and conservation efforts have led to the increased use of recycled water in nurseries and on farms. While this practice has successfully reduced overall water use, it has unfortunately increased the cross-contamination risk for *phytophthora* and other plant diseases. Plants may also suffer from iron problems and other water quality issues. Additional water saving practices that include drip and micro irrigation often require countless hours of maintenance due to algae growth and other types of bio-fouling. Most serious of all, *E. coli O157:H7* may infect surface water used for irrigating food crops. Food safety experts have stated that dirty irrigation water is one of several possible contamination sources that may have caused serious illness in humans and required costly recalls of leafy green food products, incidents that were highly publicized in recent news reports. Chlorination science is well established, though it is often overlooked. New methods of chlorination are leading to its rediscovery as an effective means for addressing water quality problems, including drip emitter maintenance.

Introduction:
The *Accu-Tab* System is designed for irrigation use at nurseries, greenhouses, agriculture, golf courses, and landscaping. The *Accu-tab* System can help fight some common problems that nursery owners face.

1. *Phytophthora* and other plant diseases in recycled nursery water, creeks, and rivers
2. *E. coli* O157:H7 from water in irrigation canals and infected wells
3. Increased maintenance from algae in drip emitters
4. Iron and iron bacteria in iron-rich areas (well water)

Chlorine Chemistry
Chlorine is available in gas, liquid, and solid form. All three forms of chlorine deliver hypochlorous acid, or HOCl — the sanitizing form of chlorine — upon dissolution in water. Chlorine is also the only chemical that provides residual protection which is so important to irrigation applications.

Gas Chlorine:	$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$
Liquid Bleach:	$NaOCl + H_2O \rightarrow HOCl + Na^+ + OH-$
Accu-Tab Tablets:	$Ca(OCl)_2 + 2H_2O \rightarrow 2HOCl + Ca^{+2} + 2OH^-$

***Phytophthora* and Plant Disease Control**
Phytophthora from the Greek phytón (plant) and phthorá (destruction) are a genus of plant-damaging water mold. They spread by infecting ponds and rivers from infected plants and fields via rainwater runoff. Many nurseries recycle irrigation water by building reuse ponds or they irrigate directly from streams and rivers. The ponds collect runoff water from the nursery fields

and can become infected with plant diseases especially *Phytophthora. Phytophthora* can destroy entire fields by causing root rot and other plant disease.

With this much to risk, why would anyone recycle irrigation water? "Recycling irrigation water is of critical importance to the ornamental crop nursery due to increasing global water scarcity…" (Hong 2003) Recycling is risky, however because "...using non-disinfected, recycled water for irrigation can result in serious disease epidemics and crop losses…" (Hong 2003) In summary, plant disease spread through irrigation water is a serious problem caused innocently by nursery operators attempting to make the most of their scarce water resources.

How Chlorine Helps:
Fortunately, a low-cost solution is available: simply treat recycled irrigation water with a low (0.5 to 2 ppm) chlorine residual before reusing it, and many plant diseases are controlled. Hong summarizes in his chlorine effectiveness study, that a "free available chlorine residual of 2 ppm at sprinklers or risers is required to achieve good control of *Phytophthora spp.* in irrigation water." And "Chlorine at 2 ppm poses little or no risk of phytotoxicity to the majority of ornamental crops."

Chlorine is fast enough to kill the microorganisms while the water is being pumped. A detailed look at Hong's paper listed below reveals that:

1. It is safe and effective to recycle nursery water
2. Chlorine at 2 ppm will not hurt the majority of ornamental crops
3. A chlorine concentration in the pipe kills *Phytophthora* quickly and effectively.

***E. coli* O157:H7**
Escherichia coli (*E. coli*) is one of many species of bacteria living in the lower intestines of mammals. Of hundreds of strains of *E. coli* the strain O157:H7 is toxigenic, causing illness in humans. They can cause food poisoning usually associated with eating cheese and contaminated meat (contaminated during or shortly after slaughter or during storage or display). *O157:H7* is also notorious for causing serious, even life-threatening complications like HUS (Hemolytic Uremic Syndrome). This particular strain is believed to be associated with the 2006 United States *E. coli* outbreak linked to fresh spinach. The presence of *E. coli* bacteria in surface irrigation water (and contaminated well water) is a common indicator of fecal contamination, which can cause contamination of agricultural crops such as spinach and lettuce.

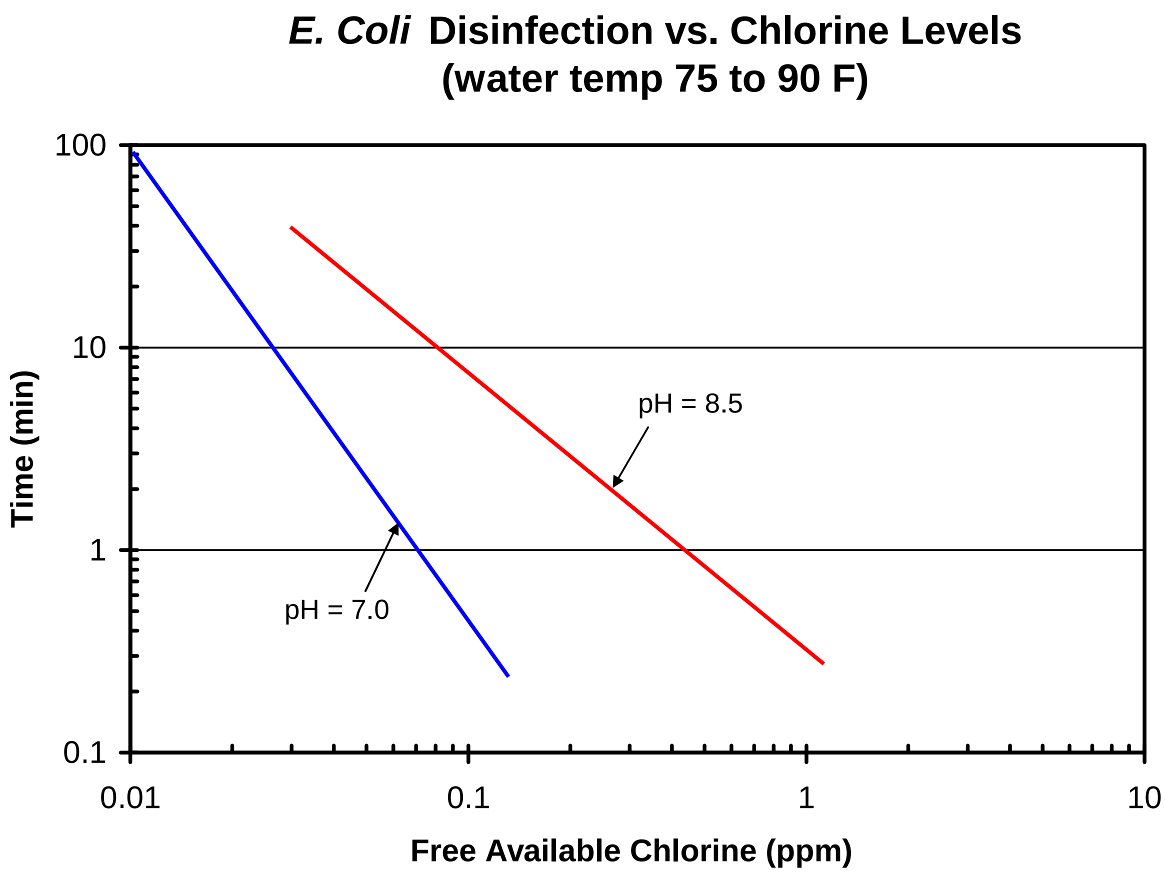
How Chlorine Helps
Chlorine is a universally accepted disinfectant of water-borne pathogens. According to the US Environmental Protection Agency (EPA), chlorine treatment of water acts "to kill or inactivate *E. coli*"(US EPA, 2007). So how much free chlorine is required to kill 99.6 to 100% of E*. coli* in water? The factors include:

1. Free chlorine concentration
2. Water temperature
3. Water pH
4. Contact time

The following charts (White, 1999) from original research (Butterfield, 1943), demonstrate the free chlorine concentration vs. contact time required to kill *E. coli* in water as it varies with temperature and pH. As a general rule, a free chlorine residual of 2 PPM is sufficient to kill *E.*

coli in irrigation water systems. Consult these charts if the irrigation water has high pH or cold water. Chlorine should be injected at the surface water source (at the water pump) and the free chlorine residual should be measured at the far end of the irrigation piping network. This will give the maximum contact time for the chlorine to disinfect before the irrigation water comes in contact with the plant surface.

1. Treat at 2 ppm as measured at the end of the pipe system
2. Inject chlorine as close to the water source as possible



Reduced Maintenance

Irrigation systems are complicated piping networks which require a certain level of maintenance. Obviously it is the goal of every owner to minimize the cost of operation and some networks can develop algae and biofilm problems. Some water sources including surface and some well water contain nutrients which can feed algae and biofilm. To complicate matters, white PVC pipe (schedule 40) is translucent to sunlight, providing the light to help algae grow. Nutrients plus sunlight can cause massive algae blooms inside irrigation pipe networks. (Clark, 1996) Algae can build up on pipe walls and then “break off,” plugging small orifices such as drip emitters and micro sprays. Once algae or a biofilm is established in the pipe system it is hard to remove without expensive chemicals and drip emitter cleaning can be expensive and time-consuming. Some plants require constant water or they can die quickly. Water flow to the plant must be uninhibited!

How Chlorine Helps
Chlorine is a lethal algaecide. Just maintain a trace of free chlorine residual in the irrigation water at all times, and algae will never gain a foothold. If you already have an algae problem, you may have to "superchlorinate." PPG's recommendations for algae control are: If the irrigation water has high levels of nutrients causing bacterial, algal, or other bio-fouling that reduces system performance, continuous use of this product may be necessary. The recommended level of free residual chlorine for continuous feed is 1 to 2 ppm, measured at the end of the **farthest** lateral using a good quality test kit for free chlorine

Iron Bacteria Control
Iron deposits can create severe clogging problems in irrigation systems for two basic reasons:

1. Mineral deposits precipitate as ferric oxide.
2. Iron bacteria, which feed on dissolved iron, can form massive, dendritic growths in pipes.

Severe precipitation can plug drip tubing. Iron bacteria produce a brown-reddish slime that precipitates from water that contains iron. The sticky iron deposits clog the drippers and can cause complete plugging.

This problem exists in well water areas where the groundwater aquifers are formed mainly of sandy soils or organic muck soils (very common in Florida) usually with a pH of below 7.0 and in the absence of dissolved oxygen.

Also, where iron is present but iron precipitation is not a problem, chlorine can be used to prevent the growth of iron-eating bacteria.

How Chlorine Helps
Constant chlorination of well water can force precipitation of iron according to the following formula:

$$2Fe^{2+} + HOCl + 5HCO_3^- \rightarrow Fe_2O_3 + Cl^- + 5CO_2 + 3H_2O$$

1. By forcing precipitation *before* the filter, reducing the amount of iron available for later precipitation which could cause plugging. The solid ferric oxide (**Fe_2O_3**) can then be removed with filtration or settling. The optimum pH is 7.0 for this reaction. According to White, "Each part of iron as Fe oxidized requires 0.64 mg/L chlorine." In practice, it will often take as much as 2 **ppm chlorine per ppm of iron** as Fe, since chlorine may be used up oxidizing other dissolved metals.
2. By removing the dissolved iron as a food source for iron bacteria and killing the bacteria outright. Even where filtration is not employed, a free chlorine concentration of 2 ppm at the end of the irrigation line will control iron bacteria.

The *Accu-Tab* System:
The design of the *Accu-Tab* tablet chlorination system provides a level of safety unachievable with gas or liquid chlorine. The tablets are easy to handle and simple to load into the chlorinators. The unit itself is compact, uses minimal floor space, and can be installed quickly. There are no moving parts to maintain or small orifices to clog.

Chlorinators are available in several different sizes for high or low chlorine demand


Chlorinators are easy to load and simple to run


325 gram calcium hypochlorite tablets

PPG has an *Accu-Tab* chlorinator for nearly every requirement – from less than a pound per day to a few hundred pounds a day.

Accu-Tab tablets are approximately 3 inches in diameter consisting of 68% nominal available chlorine and require no special handling equipment or techniques. In fact, filling an *Accu-Tab* chlorinator is as easy as removing the lid and emptying a bucket of tablets into the unit.

How the Chlorinator Works:
Accu-Tab chlorinators consist of a rigid PVC cylinder with a Sieve Plate resting above the bottom of the unit. Incoming water from a side stream contacts only the tablets at the bottom of the feeder, so remaining tablets stay dry and do not dissolve prematurely. *Accu-Tab* tablets erode at a predictable rate dependent upon water flow to the unit; therefore highly accurate chlorine dosage can be achieved by controlling the water flow rate *through* the chlorinator. The chlorinator effluent is then returned to the un-chlorinated main system flow providing the desired level of available chlorine to meet the operational requirements.

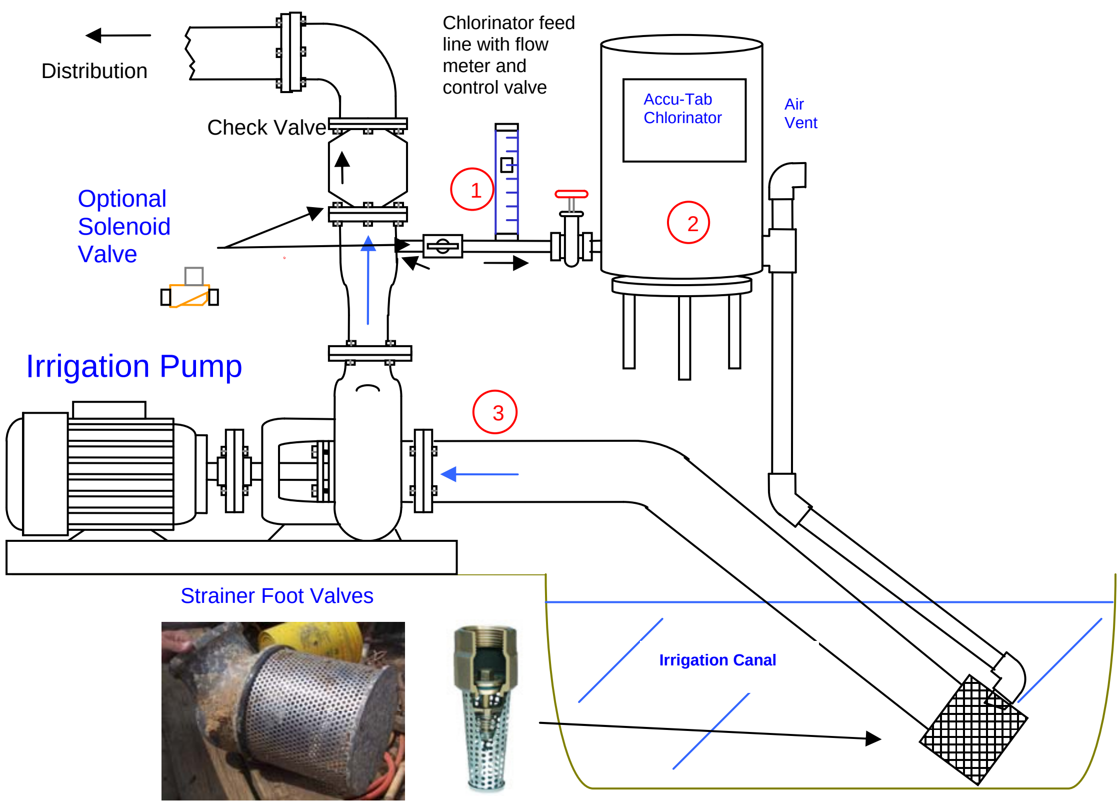
Chlorinator Key Attributes

- Specific chlorine delivery is achieved by adjusting the water flow rate *through* the chlorinator
- Only the bottom layer of tablets contact the flowing water surface—consistent chlorine delivery whether chlorinator is completely or partially full
- No moving parts
- Water withdraws from tablets in between cycles...no chlorine spike at start-up
- Most installations do not require electricity
- Chlorinator can hold up to 1-weeks worth of tablets at one time
- No dual containment required—no risk of large chlorine spill
- Low installation cost with very little maintenance

How the *Accu-Tab* Tablet Chlorinator Works in your System

The *Accu-Tab* tablet chlorinator can be attached to existing circulation equipment using simple PVC pipe. Below is an example of the chlorinator plumbed into a typical greenhouse installation system. Of course the chlorinators can be installed to any irrigation system regardless of configuration or size.

Irrigation Canal *Accu-Tab* Chlorinator



1) When the pump starts, a small side stream of water flows through the chlorinator. 2) The water contacts the *Accu-Tab* tablets in the chlorinator and erodes a controlled, predictable amount of chlorine. 3) Once the water is chlorinated, it flows back into the main water line, and is distributed through the network. The chlorinator automatically stops when the water flow is

shut off. A control valve at the inlet allows precise chlorine residual control: high flow rates for "shock" treatments or lower flow rates for maintenance chlorination.

Summary:

Chlorine has been proven to solve common irrigation problems that growers face. Traditional chlorine sources such as liquid bleach and gas chlorine are often hard to use in the agricultural environment. The simplicity of the *Accu-Tab* system allows growers to reconsider the use of chlorine, especially with new challenges such as plant disease and *E. coli*. *Accu-Tab* tablet chlorinators allow growers to utilize the benefits of traditional chlorine chemistry in an easy-to-use manner.

References:

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