Water You Thinking?

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This presentation will present information on mineral, sediment and organic impurities common in irrigation water supplies and will discuss filtration, sanitation and other practices which can be used to treat and improve water quality of irrigation supplies.

Production of nursery crops requires very high water quality. Irrigation supplies need to meet acceptable ranges for pH, EC, turbidity, mineral and nutrient levels to be suitable for irrigation of nursery crops.

Although red white and blue are patriotic colors, irrigation supplies that contain red, white or blue hues generally require treatment for use in irrigation of nursery crops. Water quality concerns discussed in this presentation are not unique to North Carolina.

Red White & Blue Water

Iron

Iron Bacteria

Ca & Na Bicarbonates

Iron is red, bacteria is blue,
both coat plant leaves for you
bicarbs are light and make leaves snow white
But alas, plants don’t grow right!

Analyze Irrigation Supplies and Leachates

Key Information includes nutrient levels, sulfates , chlorides on re-cyled irrigation supplies and iron, bicarbonates, sodium chloride, pH and electrical conductivity

Analyzing irrigation supplies is absolutely essential for growing nursery crops. Information gained allows growers to develop strategies and plan expenditures for treating water impurities. Knowledge of irrigation supply mineral and nutrient levels help growers make decisions related to engineering potting substrates and fertilizer programs. All irrigation supplies should be tested to determine how they might be used or blended to improve water quality.

Irrigation Quality

- **Impurities-**
  - **Iron, Iron Bacteria**
  - **Bicarbonates**
  - **NaCl**
  - **Boron**
  - **Algae**
  - **Water Molds and other pathogens**
  - **Sediment**
  - **Nutrients**

Iron and Iron bacteria can be problems in well and surface water supplies. Bicarbonates are usually problems in deep well irrigation supplies but may also be a problem in surface irrigation.

Sodium chloride (NaCl) is becoming an increasing problem in deep water supplies from aquifers in eastern NC due to large volume withdrawls over the last decades which have resulted in salt water intrusion in aquifers. High NaCl concentrations in water supplies are difficult to overcome, the best treatment solution is dilution with shallow well or surface water supplies to dilute NaCl concentrations. Other management practices include frequent irrigation to keep substrates moist and reduce concentration of salts in the container solution as substrates dry out.

High boron levels are usually associated with shallow ground water supplies in eastern NC. Blending high boron irrigation supplies with other water sources is the best choice for reducing problems due to high boron levels. Elevated calcium application and maintaining pH above 6.5 reduces B plant health problems. High boron levels cause leaf margin necrosis in many crops and may stunt growth of many crops.

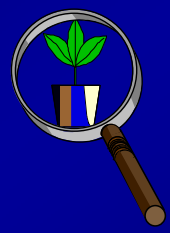
Algae growth in water supplies and irrigation lines is due to elevated nitrogen and phosphorus levels in irrigation supplies. Cultural practices such as vegetative filters, detention structures, aerators in surface water, irrigation line filtration and sanitizing chemical injection are normal treatment practices.

Fungi, bacteria and other pathogens and be re-cycled in re-used irrigation supplies. All cultural practices discussed for algae can also be employed for diseases.

Sediment in surface water and re-cycled irrigation supplies is frequently a problem. Vegetative filters, detention structures, aerators and in line filters are appropriate for reducing turbidity of irrigation supplies.

Nutrients in irrigation supplies are frequently related to re-cycled use of water and are nearly always associated with algae problems. Treatment practices mentioned for algae control are appropriate for reducing nutrients (particularly N and P) in irrigation supplies.

Irrigation Treatment



Treatment Practices

- Filtration
- Sequestering Agents, Stabilizing Agents
- Detergents
- Acid Injection-Sulfuric, Phosphoric,Nitric,Citric
- Reverse Osmosis

Nursery Design Features

- Vegetative Buffers
- Catch/Detention Structures
- Aerators
- Dilution with other water supplies

Filtration practices can include landscape features such as vegetative buffers/filter strips, constructed wetlands and detention structures. Construction of these infrastructure facilities are good investments for improving re-cycled water supplies and for reducing erosion on nursery properties. Irrigation inline filtration equipment may include cartridge filters for small volume use irrigation such as propagation houses. Larger volume filters include sand and sediment separators, screen filters, disk filters and sand media filters.

Sequestering agents, stabilizing agents and detergents are injected into irrigation supplies to chelate minerals such as iron or precipitate minerals such as phosphorus in irrigation supplies. These products may be used in place of oxidizing agents such as chlorine or bromine.

Acid injection is used to reduce pH in water supplies by reducing the solubility of calcium or sodium bicarbonates or carbonates. Sulfuric acid is generally the preferred acid for injection in irrigation supplies.

Reverse osmosis is most frequently used as a last resort for removing NaCl from water supplies. RO is likely the most expensive water treatment practice but may be affordable for treating propagation water supplies if no other water source is available. The are nurseries in southeastern NC considering this alternative.

Irrigation Treatment

Sanitation Techniques

- Chlorination- Gas ,Liquid , Chlorine Dioxide
- Bromination- Tablets and Crystals
- Ultra violet (UV) treatment (filtration required)
- Ozonation
- Hydrogen Peroxide, Zerotol
- Bactericides & Algaecides
- Copper Ion Generators

Chlorination has been the most frequent disinfection and oxidation treatment choice for nurseries in NC and in the US. Chlorine is also a strong oxidizer, therefore it is effective in reducing iron from Fe^{++} to Fe Gas chlorination is more effective than liquid chlorination treatment but gas chlorination is very dangerous and has liabilities related to use. Liquid (16 % Sodium hypochlorite-bleach) is difficult to blend with irrigation supplies in most irrigation pumping facilities and may require storage tanks, baffles and mixing boxes in line or extra coils of irrigation pipe to provide adequate contact time for disinfection. Chorine dioxide is a relatively new product for nursery irrigation water sources. Be sure to look at the assigned reading on Chlorine Dioxide.

Bromine is generally considered to be more expensive than chlorine injection, however, bromine is considered to be a better algaecide, therefore bromine is often considered a better product for injection in propagation water supplies. Formulations available for bromine injection have changed in recent years from tablet placed in an injector to crystal/powder products. The vendor for bromine is Great Lakes Chemical Company. The local vendor for bromine products is Southern Ag, Hendersonville, NC.

UV treatment requires filtration before water is passed through a transparent tube (lens) exposed to UV lamps. Water must be clean and free of sediment or the lens becomes coated and UV lights cannot penetrate into the water stream.

Ozone treatment of irrigation supplies may be the most effective sanitation treatment, however, costs of ozone units are pricey and therefore relatively few nursery operations have installed ozone units.

Zerotol is a commercially labeled product for treatment of irrigation water

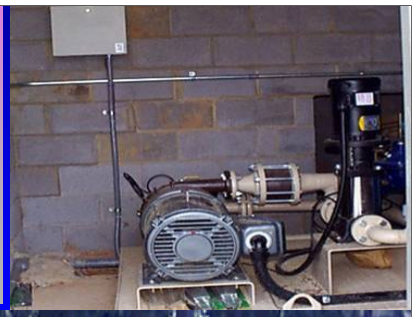
Water Supplies

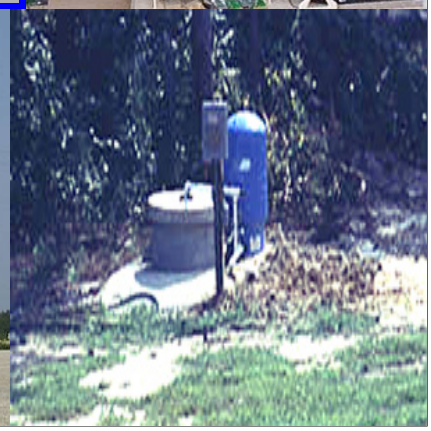
- **Deep Aquifer Ground Water**
  - –Impurities Common-
    - Salt Water- NaCl
    - Bicarbonates
    - Withdrawl permits & restrictions

Many of the areas in NC with deep aquifers are now in a 15 county Capacity Use area which limits withdrawls from aquifers due to salt water intrusion which has resulted in removal of water faster than re-charge rates in the aquifers. High sodium and calcium bicarbonate levels are also common problems in water supplies withdrawn from deep wells in eastern NC.

Deep Wells have been important sources of water for nurseries in North Carolina but increasingly have higher saltwater and bicarbonate levels

Shallow wells frequently provide needed water supplies but may require treatment for iron or iron bacteria





Nurseries in eastern NC now have to use several water sources to insure adequate water supplies for irrigation of nursery stock. Permitted deep well withdrawls are supplemented with shallow well water supplies and surface water supplies in several large nurseries in eastern NC.

Water Supplies

- **Shallow Ground Water**
  - Approximately 50 to 70 feet deep
  - Impurities Common-
    - Iron
    - Iron Bacteria
    - Boron
    - Bicarbonates

Shallow ground water may provide considerable amounts of water, however water quality may not be as pure as deep well resources and therefore require treatment before use in nurseries. Blending water resources, if possible, is likely the least expensive alternative for use of shallow well irrigation supplies.

Water Supplies

- **Surface Water**
  - –Sediment
  - –Algae
  - –Iron
  - –Iron Bacteria
  - –Water molds –phytophthora,
    - leaf spots, pythium, rhizotonia

Surface water supplies frequently require treatment for contaminants and impurities listed in the slide. Treatment procedures include those described in previous slides and slides which follow in this presentation.

Sediment is a major problem in surface water irrigation supplies from rivers and streams

Sediment is also a problem in recycled irrigation supplies

Detention Basins, filter strips, grassed waterways and aquatic wetland areas can reduce sediment entering irrigation retention basins

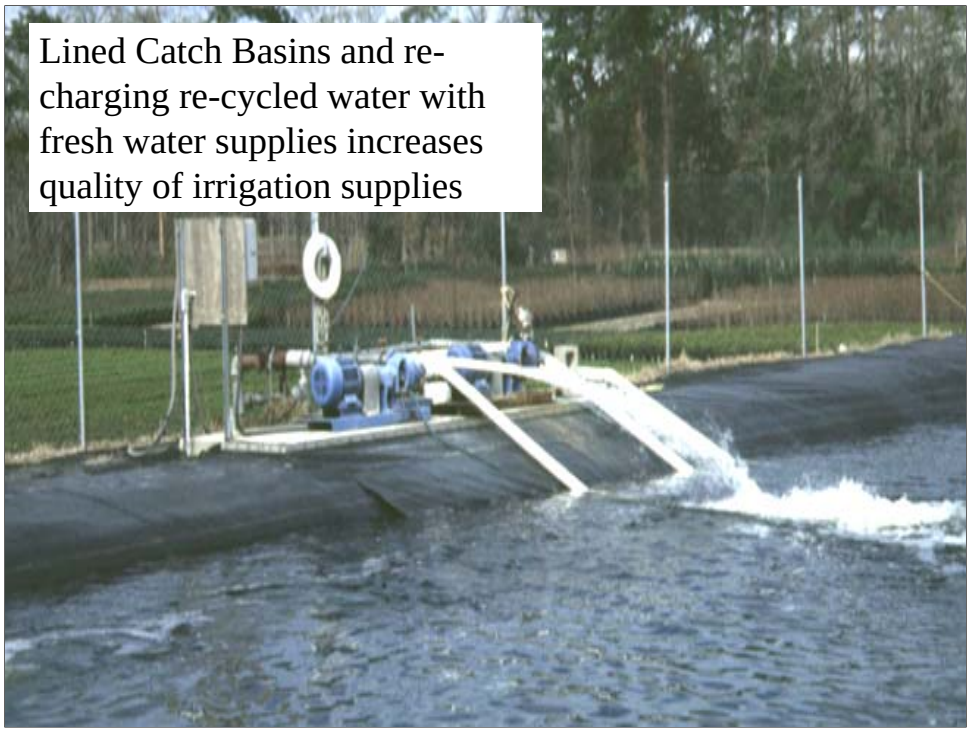
Sediment is frequently a problem when nurseries use water from streams, rivers or surface retention irrigation resources. Detention structures which allow settling of sediment, aerators and inline filtration are practices which can be used to improve water quality of surface irrigation supplies.

Surface Algae is a common problem in recycled irrigation supplies. Vegetative filters or an aeration pump may be the least expensive treatments.

Recycled irrigation supplies frequently contain nitrogen and phosphate nutrients that stimulate algae growth in undisturbed surface water detention and retention structures. Diluting surface water with well water, aerators, and vegetative filter strips can improve water quality in these surface irrigation supplies.

Burying or painting light exposed pvc distribution lines may be required if nutrients are contained in the irrigation water. Otherwise irrigation system filtration and disinfection practices may be required to control algae.

Many types of filters are available for cleaning irrigation water in nurseries. Screen filters with many choices of mesh sizes, disk filters and sand media filters are available. Most filter systems have automatic back flush mechanisms that automatically clean filters. In some cases, dual filters are required so that one filter can back flush while the other filter operates during the irrigation cycle. New systems may back flush at intervals between irrigation cycles. If filter systems are located on public water supplies, dual back flow check valves are required to prevent water flushed from the irrigation line from re-entering the watershed. Back flushed water must be captured in detention structures rather than flushing back through irrigation intake systems.



Lined irrigation structures are becoming a popular choice for nurseries which recycle water. Re-used water supplies are filtered and or disinfected and then discharged into lined irrigation structures. In this slide clean water is also being discharged into the lined structure to dilute recycled irrigation water supplies. Some nurseries use only clean well water for some crop/bed areas, combinations of fresh and recycle water on some crop areas and only recycled water on other production areas depending upon crop disease characteristics in segregated irrigation zones.

Lined beds and lined channel returns reduce sediment in irrigation supplies. Combined with filtration and disinfection practices, nurseries maintain high quality recycled irrigation supplies.

BMP : Runoff Detention Structures reduces Sediment, Nutrients and Phytophthora Zoospores in Irrigation Supplies

Detention structures used as a primary stage for containment of recycled irrigation supplies are very effective in intercepting nutrients, sediments and exposing disease organisms to conditions that de-activate infectious stages of the diseases.

Exposing runoff from beds to gravel surfaces and vegetative filters provide very effective sanitation procedures without the expense of advanced filtration and sanitation equipment. Water running over gravel drives exposes disease organisms to high light and degradation as it slowly moves through gravel. As runoff water moves into grass or vegetative filter strips, nutrient are scrubbed from the water, sediment is trapped and disease organisms are exposed to additional unfavorable environmental conditions.

Routing bed runoff through wide expanses of grass filter strips, rip rap that slows velocity and movement of water, pools water exposing it to sunlight and ultimately being trapped in detention structures before entering irrigation supplies assures high water quality for recycled irrigation supplies.

Directing runoff water through standing surface water followed by movement through aquatic plant filters removes nutrients, sediment and reduces disease organism viability.

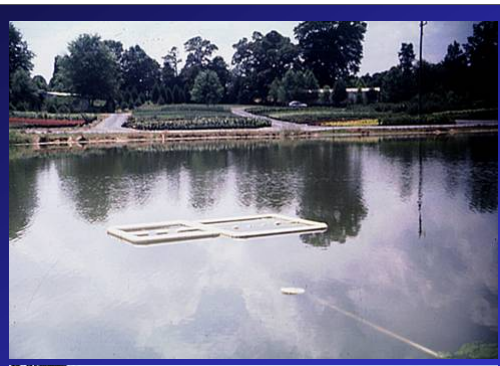
Treatment for Algae, Iron and Iron Bacteria

Float irrigation intakes 18 to 30 inches below surface of water

Keep intakes at 2 feet off bottom of pond

Use Aerator-Wave Action

Aerators help precipitate iron and increases nutrient utilization



Floating irrigation foot valves/irrigation intakes in surface water supplies increases water quality in irrigation supplies. Intakes should be suspended at least 18 to 24 inches below the surface standing water. This prevents suction of air and surface debris. Intakes should also be suspended well above the bottom of the retention structure. Intakes that are located close to the bottom of the structure pull sediment which frequently contains iron and iron bacteria which can coat plant leaves and stain plants, pots, ground cloth/gravel and irrigation risers. Occasionally, growers frantically call with reports of staining and sediment being pumped over growing beds. The most common problem is that intakes have broken loose from supports and are actually laying on the bottom of the structure or are suspended just above the bottom and are pulling sediment, iron and iron bacteria from the bottom of the water supply.

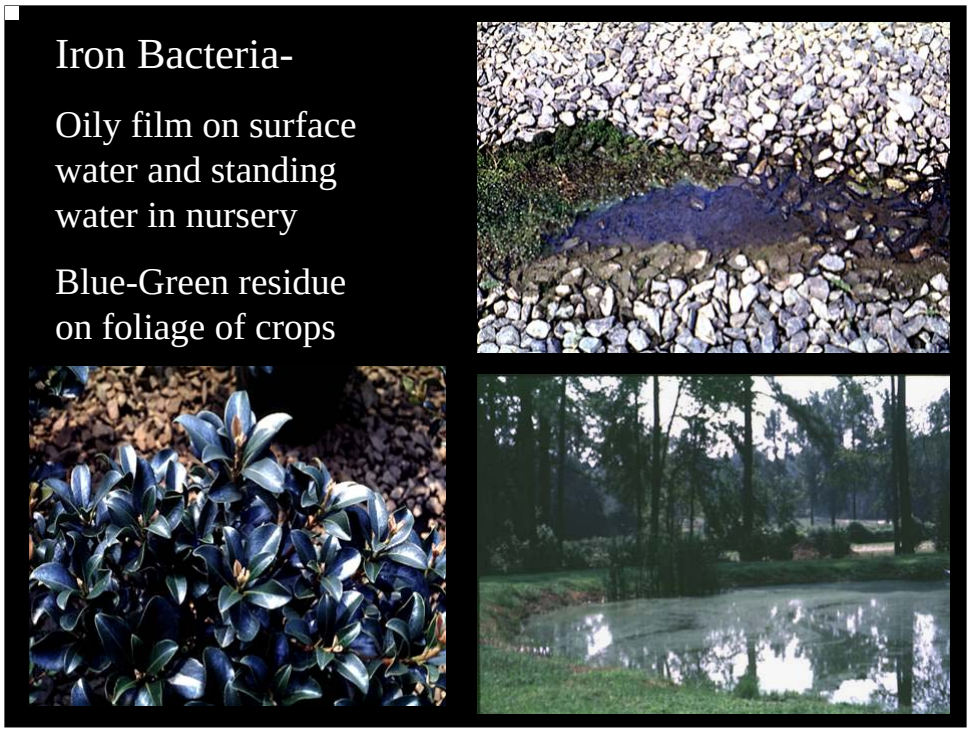
Aerators improve water supplies by introducing oxygen into the water, more by wave ripples than by the frothy aerated water located above the aerator. Aerators introduce oxygen which makes nutrients more available for use by filamentous algae and other microflora distributed throughout the water profile than surface algae. If aerators are located well, they also push surface algae and debris away from irrigation intakes improving irrigation water quality.

Floating aquatic vegetation needs to be identified. Duck weed is a common problem in surface irrigation supplies. Chemical treatments need to be applied as early as possible in the spring, otherwise problems quickly become beyond control practices. Various copper containing chemicals or glysophate aquatic products can be used, but since they may toxic to nursery crops as well, treating should be done on small areas at a time, preferably before frequent irrigation is required and before large expanses of aquatic growth occurs. (See the aquatics plant section of the NC Ag Chemicals Manual)

Dr. Jim Burton (NCSU Hort. Science) has been working with allelopathic properties of rye. Rye contains an allelopathic compound called diboa which reduces vegetative competition in rye plantings. Some nurserymen believe that placing rye or barley bales at the water edge of irrigation surface water irrigation supplies decreases algae growth.

Iron in irrigation supplies stains plastic, pvc, pots risers, ground cloth and floor surfaces and plant leaf surfaces. In propagation low concentrations <0.5 ppm can cause staining.

Iron concentrations as low as 0.5 ppm can cause staining in plant growing areas. In propagation, frequent mist cycles can result in very untidy appearing conditions quickly. In the lower slide, only a few irrigation events resulted in staining of plants, containers and risers before the grower realized that the irrigation intake had slipped to the bottom of the irrigation basin.



Iron bacteria staining is often a mystery to many nurserymen. Iron bacteria feed on the iron in water supplies. They actively utilize the Fe^{++} (ferrous) form of iron and cause a blue-green stain on plants and nursery growing areas. In propagation a yellow colored jelly may be found clogging mist nozzles, which is also a mass of iron bacteria. A blue-green oily film may be seen on standing pockets of water as well as an oily sheen over the top of surface irrigation supplies. Aerators help oxidize the iron to the ferric iron valence (Fe^{+++}) removing it from use by iron bacteria. Most disinfectant chemical systems also kill iron bacteria. Filtration may be necessary for removal of iron bacteria clumps in low volume irrigation systems with small orifices.

Propagation nozzles become easily plugged with sediment, algae, iron, iron bacteria

Since clog nozzles can have drastic effects on propagation facilities, adequate filtration is recommended based upon likely impurities that might cause clogging of nozzles.

Clean Water Supplies such as deep wells may require minimal filtration such as screen or disk filters for propagation

Since propagation greenhouses use relatively low volumes of water, cartridge filters with various types of cartridges may provide adequate filtration, particularly if water is pre-filtered before being pumped to propagation facilities.

Spray stakes used for PnP and large container irrigation have larger orifices and higher water use than drip or mist systems. Therefore, even surface water supplies may only require disk filters for adequate filtration for large container irrigation compared to sand media filtration which is required for smaller orifice irrigation systems using surface water supplies. Well water is usually a much cleaner water source and therefore may only require screen filters.

The picture in the bottom left corner of the slide is a detention structure which collects water from drain lines below the PnP production area. This run off can contain high nutrient levels and therefore must be handled in the same manner that overhead bed runoff is managed.

Disk filters provide adequate filtration for low volume spray stakes and overhead sprinkler irrigation

A bank of disk filters are seen in this slide. There are two banks of filters at this pumping station. Depending on the set up, one set may be filtering irrigation supplies while the other back flushes or each set may be filtering water pumped to different irrigation zones and back flushing occurs during intervals between irrigation cycles.

Drip Irrigation- small orifices- 0.5 to 2 gallon per hour are easily plugged. Sand media filters are required for small orifice emitters from surface water supplies

Drip irrigation nozzles have very small orifices and apply water in ranges from ½ gallon per hour to 2 gallons per hour (upto 5 g[h). A sand separator and disk filter (upper left picture) may provide adequate filtration for well irrigation supplies but sand media filters (lower left) are required for irrigation from surface water supplies.

Drip irrigation systems are most frequently used for irrigation of field grown nursery stock. In some cases, as in the lower right picture, drip tape (under plastic as in strawberry production) is used only for 1 cycle of production. Drip tape also has very low irrigation application rates.

Bicarbonates in irrigation water coat foliage, and raise substrate pH over time causing nutrient absorption problems

Acid injection is used to lower pH of water and reduce bicarbonate precipitate. NCSU recommends 35% Sulfuric Acid. Water Samples are sent to a lab to determine bicarbonate concentration, or alkalinity and pH

Calcium bicarbonate (and occasionally sodium bicarbonate) are commonly problems found in deep well irrigation supplies in eastern NC and throughout the US. Acidification of the water supply is the most common treatment. (See assigned readings on Water Considerations and Aklalinity HIL557 and HIL558 for more details).

http://www.ces.ncsu.edu/depts/hort/floriculture/software/alk.html

Bicarbonate concentrations in propagation water supplies can have a significant effect propagation results and appearance of propagation facilities. Acid injection is recommended to control bicarbonate water quality problems.

Acid Injection

High Bicarbonate Problems

High pH of Irrigation Water

Associated with fungicide activity

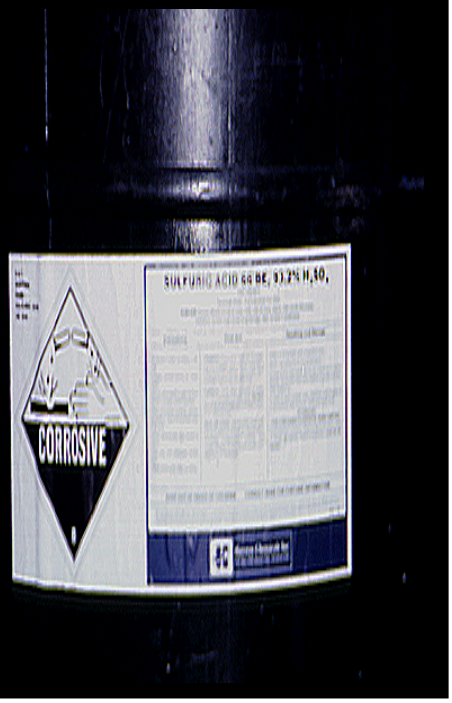
Ca, Na interactions with other elements

Coating of Foliage

Acids which can be used

Nitric, Phosphoric

93% Sulfuric; 35%Sulfuric



Acid for injection into irrigation supplies can be purchased in bulk containers. Although sulfuric acid might seem dangerous, it is actually the best acid for injection to lower pH and reduce bicarbonate concentrations. Nitric acid is very volatile and adding additional phosphorus is usually not the best choice for injection. Other acids such as citric acid is too weak to neutralize bicarbonate levels over 100 ppm bicarbonate. Muratic acid is HCL and additional chloride is usually not the best choice either.

The NCSU floriculture alkalinity calculator can be used to determine the amount of acid to inject if the bicarbonate concentration and pH from a water test report are entered into the calculator. The amount of acid required and the approximate costs for injection are shown in the calculator. (http://www.ces.ncsu.edu/depts/hort/floriculture/software/alk.html

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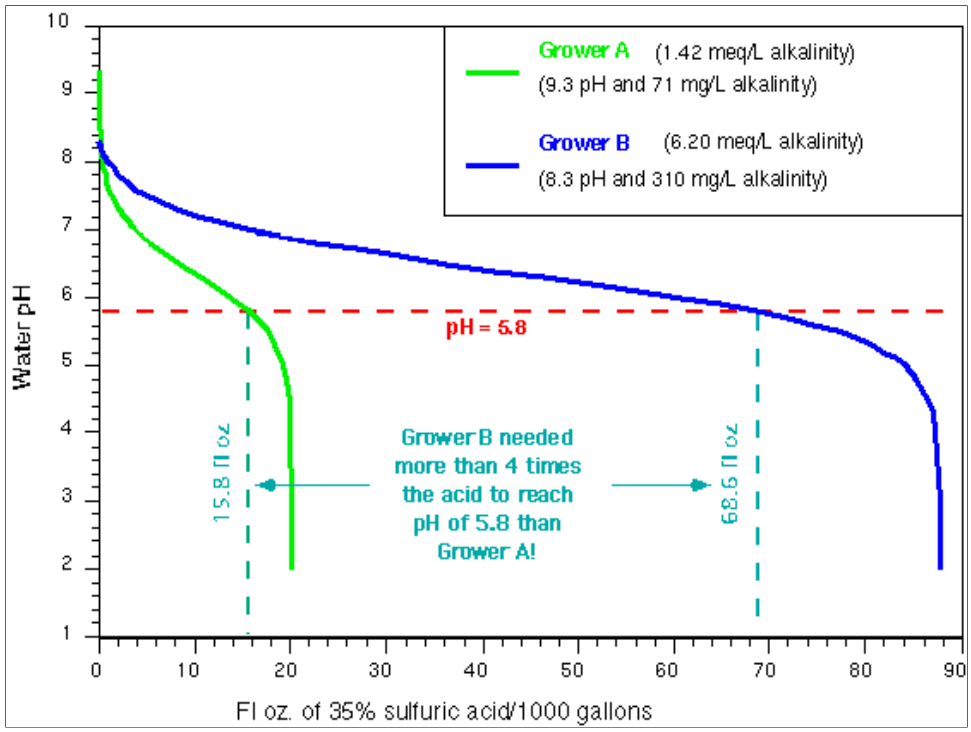
Commercial Floriculture

Alkalinity Calculator

This software allows growers to calculate the amount of acid to inject to neutralize alkalinty in irrigation water. Users can select either an endpoint pH or endpoint alkalinity concentration. The spreadsheet gives users the choice of sulfuric, nitric, and phosphoric acid as acidifying agents. If you enter your acid cost on a per gallon basis, it will calculate the cost of acidification. This spreadsheet requires Excel to run. It should run on a Windows and / or Macintosh machine.

http://www.ces.ncsu.edu/depts/hort/floriculture/software/alk.html

The NCSU alkalinity calculator can be used to determine how much acid to inject to lower pH to a desired 5.8 pH. The calculator requires that the pH and the bicarbonate levels in ppm or meq are known before entering these numbers into the calculator. This information is supplied by an irrigation water analysis. NCDA reports often include this information which they determine using the calculator mentioned in the slide.



The NCSU calculator takes into account the buffering capacity of the bicarbonate level as well as pH of irrigation supplies to determine the amount of acid required to inject into water supplies.

Your Sample Information

The pH of your sample:	6.90
The alkalinity of your sample:	3
Target alkalinity or pH :	5.8

(pH must be below 7.2)

Calculated information for your sample

Alkalinity before acid addition

	meq:	3.00
pH =6.90	ppm of HCO_3	183.1
	ppm of $CaCO_3$	150.1

Alkalinity after acid addition

	meq:	0.83
pH =5.80	ppm of HCO_3	50.9
	ppm of $CaCO_3$	41.8

The slide above is one of the worksheets in the alkalinity calculator. The pH of the sample and the alkalinity concentration are entered into the worksheet. Usually a pH of 5.8 is entered for the target pH of the treated sample. The results of the calculation show the amount of a particular acid to inject to produce the desired adjustment.

Cost Comparison of Each Acid Type.

(Average prices gives here are based on bulk purcl
of 5 to 15 gallons)

Date prices were last modified: 10/1/95

Acid	Percent	Acid Price/Gallon	Treatment Cost* per 1(	
			Gallons	Liters
Nitric	61.4	$3.00	$0.49	$0.13
	67	$2.70	$0.39	$0.10
Phosphoric	75	$6.80	$1.19	$0.32
	85	$8.00	$1.15	$0.30
Sulfuric	35	$1.90	$0.46	$0.12
	93	$2.95	$0.18	$0.05

* Reflects only treatment costs and does not include cost savings due to decr
needs associated with phosphoric and nitric acids.

The alkalinity calculator also shows an approximate cost for injection of various acids to product the desired results. In some cases it is more cost effective to inject 93% reagent grade sulfuric acid than to use 35% (battery acid) sulfuric acid. Acid injectors are generally not extremely expensive. Costs may start around $300 for injector costs and installation costs are variable depending on the vendor installing the equipment.

Liquid chlorine (bleach) can be injected as a disinfectant and as an oxidizer for treatment of irrigation supplies. Thorough mixing of the chlorine with the irrigation water is required for adequate disinfection.

Gas chlorine is very dangerous and should be housed in a locked cage, preferably out side irrigation structures. The greatest danger occurs when gas cylinders are changed. Appropriate PPE is required for workers performing this task. This facility actually needs to be covered in an open roofed structure for best safety and protection of the injection equipment.

This slide represents an extremely dangerous situation since the area around the chlorination station are not secured.

Chlorine dioxide is a new disinfection treatment for nurseries. Be sure to read the assigned readings: http://www.clo2.com/reading/waste/corrosion.html

http://www.epa.gov/pesticides/factsheets/chemicals/chlorinedioxidefactsheet.htm#bkmrk9 for details on chlorine dioxide.

Chlorination

Gas or Liquid Injection

Treatments-

Oxidizes Iron precipitate

Disinfectant- Kills Pathogenic Fungi, Bacteria, Iron Bacteria

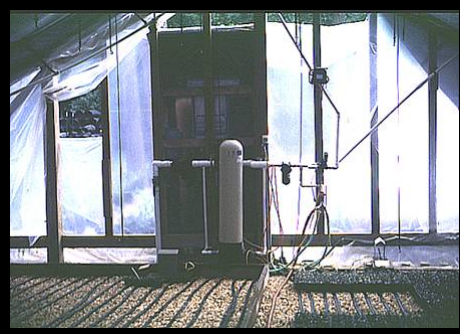
A swimming pool test kit is used to colormetrically determine free chlorine concentrations in irrigation water. Any coloration shown at the end of the irrigation line indicates the presence of free chlorine and therefore indicates that disinfection has been effective. Concentrations of0.5 pp to 2.0 ppm free chlorine are considered acceptable.

Bromination-

Bromine Crystals

Algae in Greenhouse can be controlled by Bromination

May be more effective than Chlorine in Greenhouses



Bromine is considered to be a better algaecide than chlorine and is therefore preferred by some nurseries for propagation greenhouses. The lower picture shows a bromine injector in a greenhouse. This particular injector used bromine tablets which may no longer be available.

Zerotol as discussed earlier is labeled for nursery use as a water treatment product as well as a fungicide and algaecide which can be sprayed or drenched on plant material and spayed on greenhouse benches and other production areas. See selected readings at the website links

http://www.biconet.com/disease/zt.html

http://www.biconet.com/disease/ztInfo.html

Injection Alternatives to Chlorine and Bromine

Injection of Sequestering Agents for Chelating Iron, and as Algaecides and/or Bacteriacides for Disinfection

Products such as DiSolv (designed for low volume systems) or AquaSolv designed for overhead irrigation systems can be injected into water supplies as an alternative to chlorine or bromine injection. A small injection pump is use to inject low rates of these products into the irrigation system.

UV systems are popular for municipal waste treatment systems and can be used for disinfecting irrigation supplies. Very clean water is required for penetration of UV lamps (inside the metal covered tube-lower right picture).

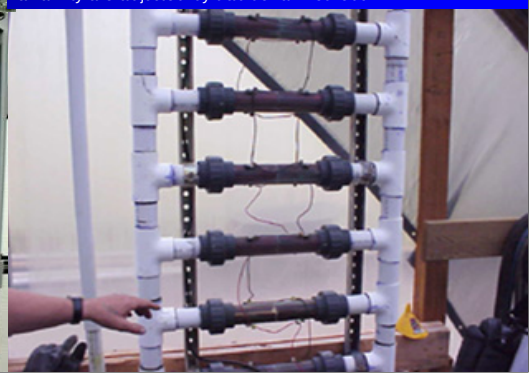
Reverse Osmosis may be one of the most expensive systems per gallon of treated water. Most RO systems have limits of water treatment such as less than 100 gallons per day. I have seen only one RO system in use at a Texas nursery with high NaCl concentrations in water supplies. The RO system was being used to purify water for a propagation greenhouse range.

Water Treatment with Copper/Silver ion generators

Copper / Silver Ioniser Systems

Copper/silver systems require the use of a copper test kit to indicate ion test levels in the water. As both copper and silver ions are being dispersed at the same time it is only necessary to check for the presence of one to know the other. The rate of ion creation is proportional to the ratio of copper and silver in the electrode. A Copper test is performed much as you would test for chlorine residue. A level of copper in the range of 0.15 through 0.20 ppM, a pH of 7.2 through 7.4 and a total buffering of 80 - 100 ppM is recommended.

The ion level is adjusted by changing the current flow across the electrodes using a manual dial on the control unit. pH and total alkalinity are adjusted by traditional methods.



Copper/Silver ion generators are occasionally used at nurseries. The free Cu ion concentration must be kept below 2.0 ppm or root inhibition will occur in nursery crops. Most Cu/Silver ion generators maintain Cu concentrations below 1.0 ppm.

Ozone Injection

Very High Priced Technology Currently

Some Use in Nurseries on West Coast and in the Netherlands in Greenhouses

Ozone injection is also an infrequent technology used for treatment of nursery irrigation water suppies. The unit pictured above was seen in a very advanced greenhouse facility in the Netherlands. Ozone was also being used at a nursery visited in Oregon for disinfection of irrigation water used for propagation greenhouses. An Ozone test kit, much like a test kit used for testing chlorine in swimming pool water is used to determine appropriate concentrations.

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Horticulture Information Leaflets

Water Considerations for Container Production of Plants

HIL #557 Revised 7/99

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http://www.ces.ncsu.edu/depts/hort/hil/hil-557.html

Much of the information presented in this presentation is discussed in the Hort Information leaflet above which is include in the assigned reading for this presentation.