DOVE ASSOCIATES
Horticultural Consultants
Weggs Farm
Common Road
Dickleburgh, DISS
Norfolk IP21 4PJ
Tel: 01379 741200
Fax: 01379 741800
Email: info@dovebugs.co.uk
www.dovebugs.co.uk

Information

Chlorine injection systems

Chlorine is used in many water supply systems and home swimming pools to prevent algae and other micro-organisms from growing. Chlorine is also used for cleaning and maintaining irrigation systems. Proper injection methods and amounts of chemical must be used to provide an effective water treatment program without damaging the irrigation system or the crop being grown. Because chlorine can react with some metals and plastics, always check with the supplier of your irrigation system components to make sure that problems will not occur if chlorine is injected.

Irrigation systems can become partially or completely clogged from biological growths of bacteria, fungi, or algae which are often present in surface and ground water. Bacteria, fungi, and algae use chemical elements such as nitrogen, phosphorus, sulphur, or iron as nutrient sources to grow and develop. Generally, filtration alone cannot effectively remove these micro-organisms. Chlorination can be used to minimize the growth of micro-organisms within the pipes and other components of irrigation systems.

If water is not properly treated, clogging of pipes, fittings, sprinklers, drippers, mist nozzles and jets can occur, resulting in decreased crop growth and development because of reduced water application amounts, uniformity, and efficiency. Water used from contaminated sources or recycling schemes can also contain plant pathogens. These pathogens can build up over a period of years and become more widespread over the crop.

A wide range of sterilising methods has been used on irrigation water including ozonation, UV, Jet 5, Ter Spezial and Chlorine. Of these, chlorine has been used the most extensively and is the easiest to monitor.

SOURCES OF CHLORINE

Chlorine is available in gas, liquid, and solid (granular or tablet) forms. Each of these different chlorine forms reacts differently with the irrigation water, depending on the other chemicals or elements in the water. Reactions may be changes in the pH of the water, or precipitation of some element, which could result in clogging of drip irrigation components.

Chlorine Gas

Chlorine gas (Cl_2) is commonly used in municipal water treatment systems. As chlorine gas reacts with water, hypochlorous acid (HOCl), hydrogen (H+), and chloride (Cl) are formed. This reaction lowers the pH of the irrigation water. The change in pH depends on how much chlorine gas is injected and on the buffering capacity of the water.

Chlorine gas is used in municipal water treatment systems because it provides chlorine in the most concentrated and economical form. Only 1 gram of chlorine gas (Cl_2) is required to provide a 1ppm concentration of $C1_2$ to 1,000lts (220 gallons) of water. Similarly, an injection of 100 grams of chlorine gas per hour will provide a 1ppm concentration of Cl_2 to a water supply with a flow rate of about 1,800 litres per minute.

Chlorine gas is a respiratory irritant which affects the mucous membranes. It can be detected as an odour at a concentration of 3.5ppm and can be fatal after a few breaths at 1,000ppm. Therefore, the user of chlorine gas must exercise extreme caution to ensure that it is safely injected. Maximum air concentrations should not exceed 1ppm for prolonged exposure. Chlorine gas should only be used in well-ventilated areas so that any leaking gas cannot concentrate. This form of chlorine is commonly used in municipal water treatment systems. Its use should be limited to experienced or licensed users.

To ensure safety, manufacturers have developed chlorine gas injectors that work on a vacuum principle. A venturi injector is used to create a vacuum which actuates the injector. This design prevents chlorine gas from being injected unless the irrigation system is operating so that the gas is immediately dissolved in the irrigation water.

Solid Chlorine

Granular (powdered or tablet) forms of chlorine are commonly used to chlorinate swimming pools. Calcium hypochlorite found at local swimming pool supply stores is the form that is typically used. Dissolving calcium hypochlorite in water will result in the formation of hypochlorous acid (HOCl) and hydroxyl ions (OH), a reaction that raises the pH of the water.

Calcium hypochlorite is used to treat swimming pool water because the solid chlorine form is inexpensive, easy to store, and easy to use. It generally has 65 to 70 percent of available chlorine. Thus, approximately 700 grams of calcium hypochlorite will treat $550m^3$ (120,000 gallons) of water with a 1ppm concentration of $C1_2$.

Calcium hypochlorite may react with other elements in irrigation water to form precipitates which could clog micro-irrigation emitters and thus defeat the purpose for chlorination. Thus, liquid chlorine (sodium hypochlorite) rather than solid calcium hypochlorite should be used in irrigation systems, especially when the water source is high in minerals, such as when water from the Floridan aquifer is used.

Liquid Chlorine

Liquid sodium hypochlorite is most commonly used as bleach. Mixing liquid sodium hypochlorite in water results in the formation of hypochlorous acid (HOCL) and hydroxyl ions (OH), a reaction that raises the pH of the water. Unlike the calcium added in the solid chlorine form, the sodium added in this liquid form does not contribute to clogging problems. Neither the sodium nor the chlorine added to the water would be detrimental to crops or soils at the typical low concentrations used.

Chlorine dioxide

Chlorine Dioxide Generating and Metering Equipment -Acid/ Chlorite Process using dilute reagents
As basic chemicals for the generation of chlorine dioxide, this unit uses dilute hydrochloric acid (9 % HCl) and dilute sodium chlorite (7.5% $NaClO_2$). Both reagents are metered directly from commercial carboys or intermediate storage tanks into the reaction tower where a chlorine dioxide solution is produced. The resultant solution is then pumped into the water supply in a regulated way. The strength of the two basic chemicals is balanced in a ratio that ensures an optimal yield of chlorine dioxide. The chlorine dioxide solution produced is directly metered via an injection unit into the water to be treated. This method is less affected by pH. This product is much more efficient, needing only 10% material to achieve the same result as hypochlorite. The equipment however is considerably more expensive.

EFFECTS OF CHLORINE

Hypochlorous acid (HOCl) is the effective agent that controls bacterial growths. The amount of HOCl that will be present in solution, and thus active, will be larger at lower pH levels (more acidic conditions). At pH 8, only about 22% of the chlorine injected will be in the active HOCl form, at pH 7, about 73% will be in the HOCl form, and at pH 6, about 96% will be in the HOCl form.

Thus, if the irrigation water pH is high, which is often the case when pumping from the UK boreholes or rivers, injecting an acid to reduce the pH of the water before injecting chlorine, may enhance the effectiveness of chlorine. In addition to increasing the effectiveness of chlorine, acid injection can also prevent the precipitation of minerals which may plug drip irrigation systems. However, it is normally only necessary to reduce the pH one or two units to achieve these desirable benefits.

At extremely low pH levels (or high acidity) chlorine gas (Cl_2) will form. Therefore, for safety, it is very important to store chlorine and acid sources separately. Also, storage and use areas should be well-ventilated so that gasses cannot concentrate and become a hazard in a building or other enclosed area.

Hypochlorous acid will react with iron in solution to oxidize the ferrous iron to the ferric form. The ferric iron then becomes the insoluble ferric hydroxide as a precipitate. Chlorine should be injected before (upstream from) the filters so that these precipitates may be trapped in the filters.

Chlorine will also react with hydrogen sulphide to form elemental sulphur. Because some of the chlorine is used up by reacting with the sulphide or ferrous ions, additional chlorine must be provided for these reactions to occur. Enough residual chlorine must be injected to control sulphur or iron bacteria, or algae, which can clog drip irrigation systems.

Most micro-organisms will be inactivated and controlled at free residual chlorine concentrations of 1ppm. However, higher concentrations must be injected due to the inherent chlorine demand of different water sources. As a start, use 2ppm of chlorine for each ppm of hydrogen sulphide, plus 0.6ppm of chlorine for each ppm of ferrous iron. A chemical water test can be used to determine the levels of hydrogen sulphide or ferrous iron present in solution. Water from surface sources such as lakes, ponds, or canals should be treated with approximately 5 to 10ppm of chlorine. Higher levels may be needed for water with high amounts of microbial activity such as may occur during the warmer months of the year.

The chlorine injection rate should be checked by testing the treated water at the most distant part of the irrigation system using a test kit designed to measure "free" residual chlorine. Residual concentrations of 1 to 2ppm at this location indicate that active chlorine still exists after the water and system parts have been appropriately treated. Test for active chlorine using a D.P.D. colour indicating test kit that measures "free" residual chlorine. Do not use a test kit that only measures total chlorine. While levels of total chlorine may appear to be adequate, the active "free" residual form may not be adequate. Therefore, ask for a D.P.D. test kit from a swimming pool supply company.

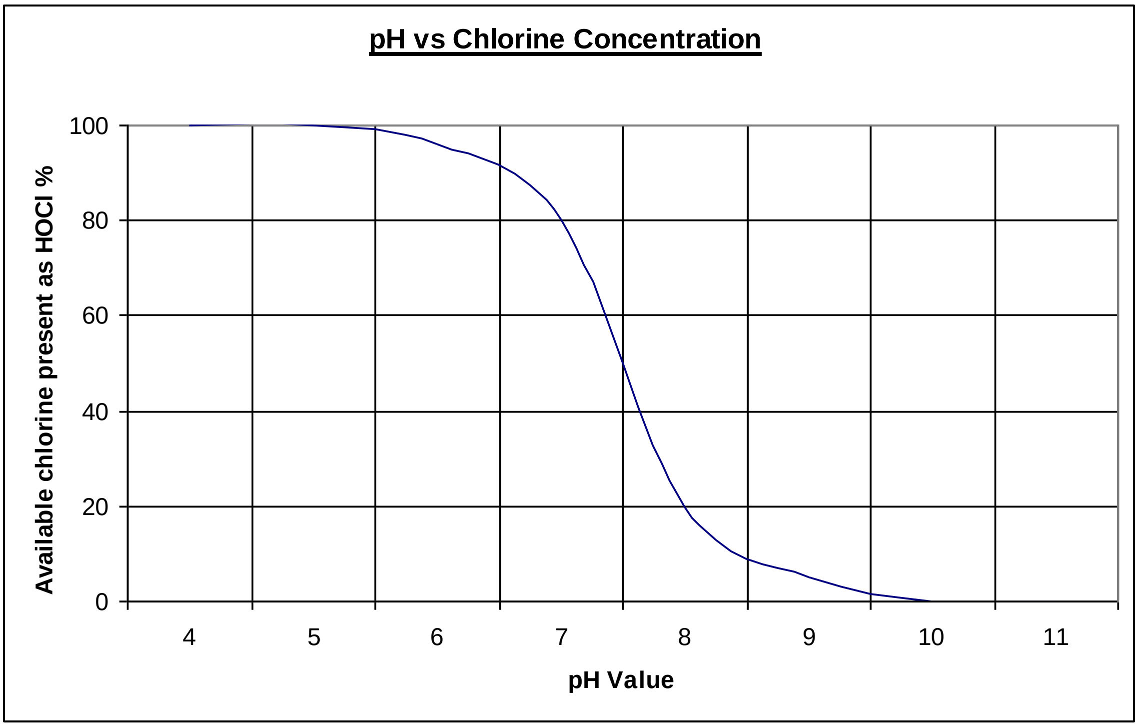
CHLORINE INJECTION RATES

After determining the desired chlorine concentration, the proper amount to be injected must be determined. The amount of chlorine to apply per litre of irrigation water will depend on the desired concentration in the irrigation system and the concentration or strength of the chlorine source.

Liquid sodium hypochlorite is the most convenient and safe form of chlorine available to inject into irrigation systems. Stock solutions can be bought with concentrations of 5.25, 10, or 15 percent available chlorine. It is available from local swimming pool supplies, farm supplies, and industrial chemical suppliers. It is available in small 40litre plastic drums of large 1,000lts IBC containers. IBC systems can be purchased or leased on an exchange scheme.

CHLORINE AND WATER pH

The effectiveness of chlorine is affected by the pH of water. The higher the pH the less efficient chlorine becomes at sanitising the water. The graph below shows the relationship between chlorine efficacy and water pH.



SAFE HANDLING OF LIQUID CHLORINE

Delivery and off-loading

Before any container is moved check that is has not been damaged and that the stopper is secure. One of the greatest hazards in the use of all containers is that created by a loose stopper, particularly where any part of the contents has been used. A combination of a loose stopper and a bump as the container is put down on the floor may cause a forceful ejection of some of the contents, which is likely to splash the operator with most serious results.

Any handling of the container must always be a two-person operation. This will apply at the delivery stage from the lorry and onwards.

If a forklift trunk is used ensure that containers are prevented from moving about on the pallet by strapping it in position. Standing the container on a sack on the pallet is helpful in limiting movement, and also acts as a buffer in the case of physical shock.

Storage

Store in a well-ventilated, secure place e.g. a compound or purpose built building. Keep out of direct sunlight as this can have a detrimental effect on the container and the heat can cause pressure rises of the gases contained in part empty containers. Check containers regularly for leaks.

INJECTION SYSTEMS

Simple water powered injection pumps are suitable for diluted chlorine but they can fail prematurely through corrosion. The most effective systems are electrical powered variable speed injection pumps either linked to a water meter proportional system or a fixed duty water pump. WE can provide suitable systems or recommend s