Factsheet 15/06

Ornamentals

Horticultural Development Council

Bradbourne House
East Malling
Kent ME19 6DZ
T: 01732 848383
F: 01732 848498
E: hdc@hdc.org.uk

Water quality for the irrigation of ornamental crops

By Susie Holmes, ADAS and John Adlam, Dove Associates

This factsheet describes the chemical and physical properties of irrigation water of relevance to ornamental plant production, including bedding plants, pot plants and hardy ornamentals. Water hardness, conductivity levels and a range of potential impurities and their effects are outlined and appropriate corrective measures summarised.

Action Points

- Analyse water from new sources before use and monitor chemical water quality at least twice a year irrespective of source. Record changes in the conductivity, bicarbonate and salts level. When suggested maximum levels are exceeded, undertake the appropriate corrective action.
- Reserve the highest quality water (generally rainwater) for more salt sensitive crops, for the purposes of propagation or for application over plug plants or liners.
- Cover water storage tanks to prevent physical contamination of the stored water.
- Keep grassed areas around reservoirs regularly mown to prevent weed seeds from being blown into the water.
- To ensure accuracy, regularly calibrate acid and liquid feed dosing equipment.
- If calcium bicarbonate levels are sufficient to lead to deposition, clean irrigation pipe work and nozzles on a regular basis.

1 Reservoir water can contain both chemical and biological contaminants

Background

There are numerous potential sources of water that can be used for irrigation purposes. Mains water is still the most common, but there is widespread use of other sources, most notably bore hole water, collected rainwater and recycled water from the nursery. Irrigation water sourced from local rivers or streams is another potential option but is still only used on a few nurseries. Each source of water has its own unique chemical and physical properties that require careful consideration before use.

The term ‘chemical quality’ of irrigation water refers to the type and amounts of compounds contained in the water such as carbonates and bicarbonates, sulphates, iron, chlorides etc. The term ‘physical quality’ refers to the type and amounts of inorganic or organic particles in the water, such as sand, silt, peat, precipitated iron, algae, bacterial slimes and mosses/liverwort/ weed seeds.

The chemical quality of water used to irrigate container-grown plants can have a significant effect on plant nutrition and growth, particularly for protected ornamentals where irrigation water is not supplemented by rainfall. The physical quality of irrigation water can affect the treatment, distribution and application of water in irrigation systems.

If there are large amounts of unwanted compounds or impurities in the water, then it may make the source in question unsuitable for the purposes of irrigation, especially if corrective action is expensive.

Chemical water quality

Main considerations

The main problems associated with each source of water are summarised in Table 1.

Rainwater is usually regarded as being the best quality for the purposes of crop irrigation, as its pH and content of soluble chemical ions is generally low. However, care should be taken with rainwater collected from roof areas near to oil boiler chimneys, as oil deposits may build up on the glass and be washed off with the water into the storage tank. Glasshouse shading materials can also be washed off into the tank, although most proprietary shading materials do not affect crops.

The quality and monitoring of **mains water** by water supply companies is driven by drinking water requirements and not plant requirements. Depending upon the prevailing geology in the area covered by the water supply company, the presence of high carbonate/bicarbonate levels can be a problem which may require remedial treatment.

The quality of **borehole water** is also determined by the local geology, conductivity levels and/or the presence of sulphate or iron.

Irrigation water extracted from **river sources** has a number of potential issues including boron and nitrate contamination.

Recycled water collected from container beds and other nursery areas requires careful consideration: high chloride or sulphate levels for example may be a concern.

Dealing with high carbonate/bicarbonate levels

Alkalinity is a measure of the carbonate/bicarbonate content or 'temporary hardness' of water. Water with a high carbonate/bicarbonate content is termed 'hard' and that with a low content 'soft'. Much of the mains and borehole water in the south-east of England especially along the south coast, East Anglia and other chalk/limestone areas is 'hard'. Such water also has a high pH, but it is the alkalinity of the water that is important, not the pH. A summary of how to interpret alkalinity and whether there is a need to correct it can be found in Table 2.

Irrigation water with a high carbonate/bicarbonate content will:

- Increase the pH of the growing medium over time, reducing the availability of certain nutrients, particularly phosphate and iron leading to leaf chlorosis and generally poor growth
- Lead to the deposition of calcium carbonate ('limescale') on the foliage of longer term crops and reduce saleability (Figure 2)
- Result in the deposition of calcium carbonate in irrigation lines and nozzles creating blockages, and on the surface of capillary matting, reducing capillary efficiency
- Limit the strength of liquid feeds that can be applied to crops (the irrigation water will already have a relatively high conductivity before any feed product is added)
- Reduce the efficacy of certain pesticides and may necessitate the use of more spreader/sticker in spray mixtures.

The crops grown and the irrigation system employed will influence the maximum permissible alkalinity level of the irrigation water. The size of container or cell that a plant is grown in and the ability of the growing medium to 'buffer' against a rise in pH, will also have an influence: watering with 'hard' water is effectively adding a low rate of lime at every watering so the

2 Limescale deposits on the leaves of Pittosporum 'Tom Thumb'

Table 1 Potential issues associated with different water sources

Water source	Potential issue
Rain water	Low calcium content
Mains water	High carbonate/bicarbonate content
Borehole water	High salts, sulphate or iron content
River water	High boron or nitrate content
Recycled water	High chloride or sulphate content

Table 2 Interpretation of water hardness

Interpretation	Alkalinity (ppm)	Need for correction
Very soft	0–50	None
Soft	51–100	None
Moderately soft	100–200	Use acidifying liquid feeds and/or less lime in the media mix/blend water sources
Hard	200–300	Blend water sources/acid injection
Very hard	300 and above	Find an alternative source if possible

substrate pH will gradually increase. Plants grown in small volumes of growing media with a low buffering capacity are at greatest risk.

Assuming there are no alternative water sources, for water with a high carbonate/bicarbonate level, the only commercial option to reduce the alkalinity level is to use strong acids to remove most of the bicarbonate. If the level is more moderate (for example up to 200 mg/litre) then it could be reduced by the use of acidifying fertilisers. Alternatively, the starting pH of the growing medium could be lowered by 0.5–1.0 pH unit to allow for the rise in pH over time.

Acidification

Adding strong acid to hard water reduces the carbonate/bicarbonate levels by neutralising them to produce carbon dioxide. The aim is not to remove all of the alkalinity but to leave around 50–60 mg/l bicarbonate in the water. Various acids can be used but 60% nitric acid is the most common in the UK. A summary of the types of acids that can be used is shown in Table 3.

Concentrated acids are dangerous substances and appropriate Health and Safety precautions are essential. **Always refer to the supplier's safety instructions when handling acid containers. Bulk acid tanks require less direct handling of acids and should be used where possible.**

Acid can either be added to water by a continuous direct injection at a fixed rate or by pre-mixing water with acid in a tank. The former is cheaper but doesn't automatically adjust the injection rate if the bicarbonate level of the incoming water changes. Also, it may not mix the acid into the water thoroughly. The tank system uses in-line probes for monitoring and is more accurate but the water in the tank may get used faster than it can be treated.

Most acid dosing systems monitor the pH of the incoming water and inject acid to maintain a set pH (typically 5.8–6.2). The amount of acid required can be calculated from the bicarbonate content of the water. One mol of bicarbonate is neutralised by one mol of acid, so if the molecular weight and strength of the acid are known, the quantity (mg/litre acid) per 1000 litres of water needed can be worked out. Depending upon the alkalinity of the irrigation water, the use of nitric acid to acidify water typically adds between 50 and 90 mg/l of nitrate. This should be taken into account when calculating liquid feed requirements.

Dealing with high conductivity

The total salts (ions) content of a solution is measured by its ability to conduct electricity (electrical conductivity – EC). High EC levels in the water of the growing medium can reduce water uptake by the plant and damage the root hairs, leading to leaf tip scorch, stunted growth and plant wilting (Figure 3). Irrigation water with a high EC adds to the overall solution strength of the substrate and requires careful management.

Irrigation water may have a high EC for several reasons. In the case of borehole water, seawater ingress near coastal areas can give rise to high chloride levels. In addition, high sulphate levels may result if the borehole is situated in an area with rocks that are rich in sulphur minerals. In the case of mains water, a high EC may be a direct result of high carbonate/bicarbonate levels. Table 4 provides guidance on the suggested maximum EC in irrigation water for a range of crops.

3 High EC levels in the substrate can reduce water uptake by the plant and damage the root hairs, leading to leaf tip scorch and stunted growth

Table 3 Types of acid used for acidification

Acid	Comments
60% Nitric acid	Suitable for use with very hard water. Available nitrate can be useful. Very caustic, so avoid contact with fumes as well as acid.
75% Phosphoric acid	Not suitable for very hard water as excessive amounts of phosphate are applied
35% Sulphuric acid	Widely used in USA, less available in UK. Sulphate is added but not needed by plants. Must be used with care but less hazardous than 60% nitric acid to handle.
Citric acid	Not suitable for bulk acidification of very hard water due to expense but can be used to neutralise liquid feed stock tank alkalinity. Less likely to react with fertiliser salts or pesticides than other acids.

Table 4 Suggested maximum water EC level by crop type

Crop/system	Maximum EC (micro-siemens/cm)
Plug plants, seedlings	300
Ericaceous plants	500
Ornamental plants under protection	700
Outdoor container shrubs/trees	800

Dilution

A high EC cannot be lowered with the use of chemicals. Therefore, where the EC level is high (for example in excess of 900 micro-siemens/cm) the only remedial action possible is to dilute the water with another source of water which has a low EC. Wherever possible, the water source with the lowest EC (generally rainwater) should be used over the most sensitive crops – seedlings, plug plants etc.

Dealing with high iron levels

High levels of iron in irrigation water can be a problem where borehole water is extracted from an area where the rocks are rich in iron. Iron is soluble in water held deep underground where there is little or no oxygen. However, when the water is brought to the surface, the iron oxidises to form an insoluble reddish brown sediment, which is unsightly. It is this sediment which blocks irrigation pipes and nozzles and marks the foliage of plants.

Aeration

Iron levels in water can be lowered by aeration of the water to produce ferric oxides, followed by filtration or dilution. Aeration systems can be created using a simple nozzle blowing water into the air over a tank or reservoir (Figure 4), or by introducing a series of weirs in a stream. Other systems can be created using water sprayed into a tank or tumbled over a corrugated material. Storing the water for 24 hours after aeration will give the iron time to settle out of the water, reducing filtration requirements.

Manganese dioxide and sodium silicate

There are also chemical options for the removal of iron using manganese dioxide and sodium silicate systems. Manganese dioxide grains can be used as a replacement for sand in pressurised sand filters to oxidise iron-laden water passing through it. Sodium silicate can be injected into iron-laden water to bind the iron in a silica complex. This system is not as popular in the UK as it is in some European countries.

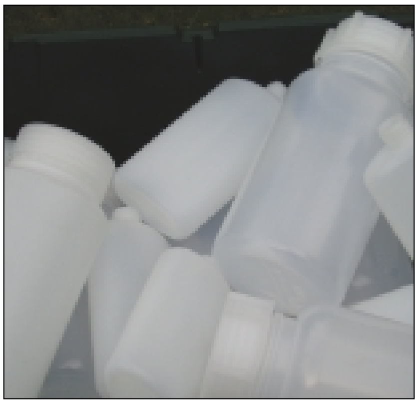
Dealing with other chemical quality issues

Other less common problems in irrigation water include high boron, sulphate, chloride, nitrate, sodium and trace element levels. These are summarised in Table 5. Dilution is often the only practical solution for treating water containing high levels of any such impurities. Reverse osmosis is an option, but is expensive so rarely commercially viable.

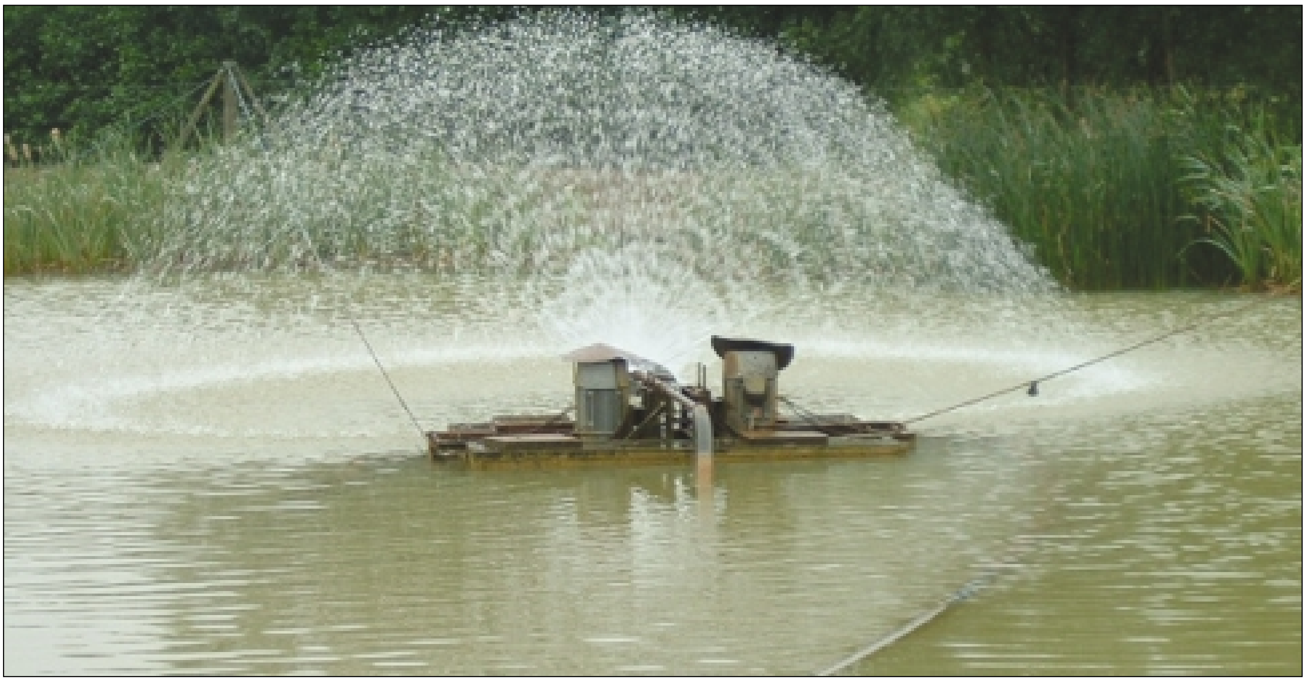
Monitoring of chemical water quality

It is important to check the quality of new water sources (including the water on new sites) before use. This is particularly important prior to committing to the expense of a new borehole. Routine monitoring of water quality (ie at least twice a year) is also important, as there are often seasonal variations, even in the case of mains water (Figure 5).

In systems where water is recycled, more frequent analysis of water is needed to monitor salt accumulation, particularly chlorides and sulphates. Where salts do accumulate, it may be necessary to drain systems occasionally and start with fresh water. Table 6 summarises the maximum levels (that should not be exceeded) for a range of parameters.



5 Routine monitoring of water quality is important



4 High levels of iron in water intended for irrigation purposes, can be lowered by aerating it

Table 5 Common water quality problems and their treatments

Chemical property	Occurrence	Problems caused
Chlorides	Borehole water in coastal areas and some mains water. Chlorides can accumulate in recycling systems.(Chloride added in the chlorination of drinking water is negligible)	High conductivity which can damage plant roots and stunt growth. Reduces the amount of fertiliser that can be added
Nitrates	River water in some areas (rare)	Increased conductivity. Must be allowed for when designing liquid feed programmes
Sulphates	Borehole water in some areas (around spa towns) and can accumulate in recycled water	Increases conductivity, as for chlorides
Boron	River water in some areas (from detergent contamination)	Excess boron is toxic to plants
Sodium	Usually associated with chloride in borehole waters	It is the chloride element that damages the plant
Other trace elements	Occasionally high in borehole waters due to local geology or industrial pollution	Trace element toxicities in sensitive crops, usually due to accumulation over time

Table 6 Suggested maximum levels for irrigation water

Parameter	Maximum
Electrical Conductivity (µS, 20°C)	850 (650 for propagation/plug plants)
Alkalinity, mg/l	250 (200 for ericaceous plants and propagation/plug plants)
Nitrate, mg/l	60 (10 for propagation/plugs)
Ammonium, mg/l	10
Potassium, mg/l	100
Calcium, mg/l	120 (minimum of 40 preferred)
Magnesium, mg/l	50
Sodium, mg/l	40
Chloride, mg/l	70 (50 for propagation/plugs)
Boron, mg/l	0.5
Iron, mg/l	0.4
Manganese, mg/l	3.0
Zinc, mg/l	0.3
Copper, mg/l	0.5
Molybdenum, mg/l	0.05
Aluminium, mg/l	2.0
Fluoride, mg/l	1.0

Physical water quality

Main considerations

The physical quality of water must also be considered carefully when sourcing irrigation water. Water can contain both **solid or particulate contaminants** (which often tend to be large in size such as sand, silt, peat or precipitated iron particles) and **biological contaminants** including plant and microbial organisms (bacteria and fungi). A number of systems can be deployed to remove these physical contaminants, but consideration must first be given to the types of contaminants likely to be encountered before choosing the optimum system.

For example, rivers, ponds and reservoirs can contain large particles such as sand, silt or clay that need to be removed before the water is used for irrigation. Failure to remove them can lead to their build up in irrigation pipes, drippers and capillary matting, resulting in blockages both in the system and in spray nozzles. This all leads to reduced irrigation efficiency. Similarly, water from these same sources can carry algae, bacterial slimes, mosses/liverworts and weed seeds which can also result in blockages. Water used in recycling systems may contain plant pathogens such as *Phytophthora* or *Pythium* species and these need to be removed before the water is re-applied to plants.

Dealing with solid or particulate contaminants

To ensure that irrigation systems continue to work effectively, it is essential that solid or particulate contaminants are removed from the water before it passes through irrigation pipes, drip or sprinkler nozzles. There are various means of removing them, including the use of centrifuge units, filters and parabolic screens.

Considerable thought should go into decisions on which systems to employ. The more often particles are removed from the water, the less the irrigation pipes and nozzles block up with the result that the irrigation system remains fully effective for longer. In deciding upon which systems to employ to remove particles, the size and distribution of the particles in their water supply need to be estimated.

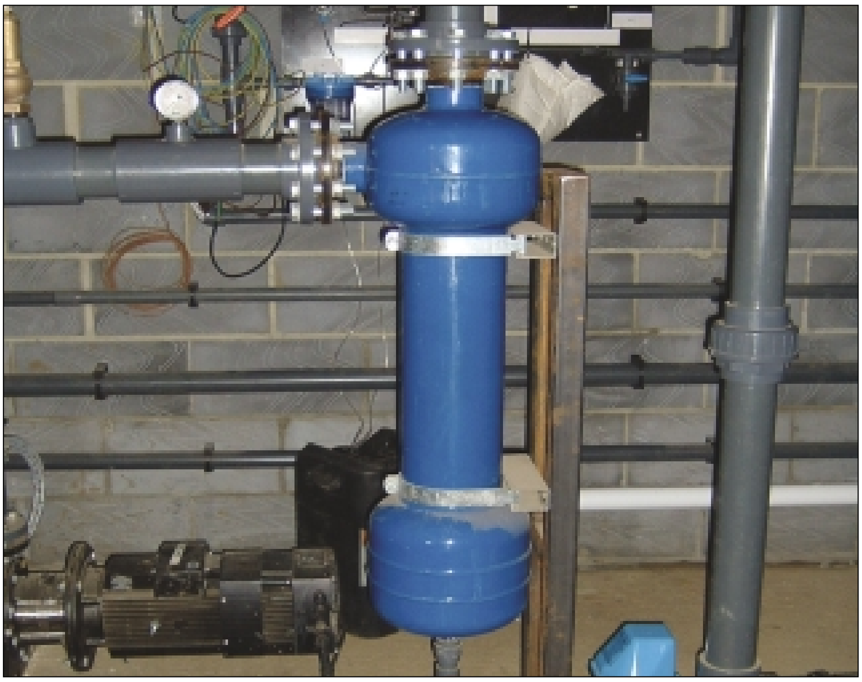
Table 7 summarises the obstruction risks from various contaminants.

Filters are generally employed in irrigation systems to provide routine removal of particles in the water. However, large particle sizes such as sand, silt and clay can cause premature blockages in filtration units that require frequent attention. This may necessitate the use of pre-filtration systems to remove these large contaminants prior to application. One of the most effective systems is the **centrifuge unit** (Figure 6) which is being increasingly used in the UK. This works on the principle that sand, silt and clay are heavier than water. The water is passed into the unit at a tangent that causes it to spin at a very high speed. This results in the heavy particles being thrown to the outside, where they are collected for disposal.

Irrespective of whether centrifuge units are required initially to remove the largest solids or particles, all irrigation systems must still have a filtration system fitted to avoid smaller particles from blocking the system. There are several types, but screen filters are currently the most commonly used in the UK. A mesh is used in screen filters to catch and remove particles from the water supply. Ideally, any screen filter in the irrigation system should have a mesh with an orifice size that is at least smaller than the smallest nozzle or jet in the system. For example, in the case of drip irrigation, a mesh with a minimum orifice size of 100 μm is required. For mini sprinklers, a 200 μm mesh should suffice whereas large impact driven sprinklers can be successfully operated with a 500 μm mesh (1 μm = one hundredth of a millimetre).

Table 7 Irrigation system obstruction risk from a range of potential solid contaminants

Contaminant	Irrigation system obstruction risk		
	Minor	**Moderate**	**Severe**
Suspended solids (mg/l)	<50	50–100	>100
Dissolved solids (mg/l)	<500	500–2000	>2000
Iron (mg/l)	<0.2	0.2–1.5	>1.5



6 Centrifuge units are suitable for removing particles of sand, silt and clay from water intended for crop irrigation

Inevitably as time passes and the filters remove particles from the water, they will become blocked and require cleaning to improve the flow of water through the system. Small filters tend to block up quickly so large mesh areas are advisable to reduce the frequency of cleaning required. As an alternative, automatic cleaning systems that are based on time or a pressure differential can be fitted to many filter systems, thus avoiding frequent manual cleaning operations.

As an alternative to screen filters, **sand** or **glass** filters can be employed. Although very useful for removing certain biological contaminants (see later), they are less suitable for removing large amounts of physical contaminants. The heavy contaminant particles are more difficult to back wash and can sometimes build up in the filter.

A third type of filter that is increasingly being used is the **disc filter**, which is constructed with a series of grooves (200–300). The water percolates through these grooves and particles are filtered out. Disc filters are effective at removing both large and small particles. They use less water to backwash than other filters and so can be cleaned very quickly when filtering heavy solid particles. Disc filters are sometimes chosen in preferance to centrifuge units. Although less effective than the centrifuge at removing large particles, they are a cheaper option so are seen by growers as a compromise.

The **parabolic screen** is a further option that can be used by growers to remove large contaminants from water. Like a centrifuge, it can be used for primary or pre-filtration, but is more commonly used to filter water that is being re-cycled and that has already passed through the irrigation system. It consists of a sheet of stainless steel with slits cut into it and works by allowing the water to pass through the slits whilst the solids are held back. They are excellent at removing old plastic or polystyrene debris from pots and containers. Unlike some other filter systems, they don't have a constant need for back washing. The debris is constantly removed from the screen and can be discharged directly into suitable containers for disposal. Having been filtered, the water is returned to the reservoir.

Main biological quality issues

Water sources from reservoirs, ponds and rivers can have varying levels of both large and small biological contaminants.

Those in the large category come in the form of algae, bacterial slimes, mosses/liverworts and large weed seeds. These can all cause irrigation systems to malfunction if they are not dealt with. Their removal can often be complex and sometimes requires several stages to complete the process. Many of these contaminants are biologically active and small amounts of them passing into the irrigation system can multiply up rapidly causing blockages.

Table 8 highlights the risk of obstruction occurring in irrigation systems caused by a range of bacterial populations.

Smaller biological contaminants include fungal disease spores, moss shoot tips and certain species of weed seeds.

Dealing with larger biological contaminants

Dealing with the problem at source is the most effective method. Several systems are on offer including suction filters, graded sand or glass filters.

A self-cleaning suction filter fitted to the pump inlet position keeps most of the larger biological products out of the system. These filters are attached to the pump suction pipe and are continuously cleaned by a water supply from the pump. Fine filter screens can be used and even in highly contaminated waters they are kept clean and fully operational.

Using graded sand or glass filters with backwashing facilities is an effective method for removing the larger biological contaminants found in water (Figure 7). Regular backwashing is important to avoid growth of the products in the filter body.

The grade of sand used should be assessed relative to the size of the contaminant to be removed. Sharp

Table 8 Irrigation system obstruction risk from a range of bacterial populations

Bacterial population (count/litre)	Risk of obstruction
< 10,000	Minor
10,000–50,000	Moderate
> 50,000	Severe

7 Graded sand filters are an effective way of removing larger biological contaminants from water

sand is a better filter medium than soft sand and current trials suggest that recycled glass, with a very sharp edge is proving even more effective as a filtration medium.

Dealing with smaller biological contaminants

Several biological contaminants including fungal disease spores, moss shoot tips or certain species of weed seeds are too small to be removed by normal methods of filtration and generally require different techniques to remove them from the water. The main three methods employed in the UK include UV sterilisation, chlorination and slow sand filtration.

UV sterilisation can be effective, but should only be used after initial filtration. This process, whilst simple and relatively environmentally friendly, does necessitate a continuous supply of electricity so it is expensive.

Chlorination is usually carried out following physical filtration. Specialised equipment that will automatically monitor free chlorine in the water and then inject the required amount of chlorine to maintain a pre-determined concentration is now available for safe and effective use of this technique. Adequate mixing of the chlorine and sufficient contact time with the water are essential and physical filtration prior to treatment is particularly important with heavily contaminated water. Appropriate health and safety precautions should be established and followed when using this technique.

Where disease spores are a specific concern, for example with recycled nursery run-off water, slow sand filters offer a very good option to provide effective control of the disease pathogens *Phytophthora* and *Pythium*. With this environmentally friendly system, filtration is essentially a biological rather than physical or chemical process although with heavily contaminated water, pre-filtration by physical means is usually necessary. The HDC Grower Guide *Slow Sand Filtration: A flexible, economic biofiltration method for cleaning irrigation water,* provides further information.

Future developments for controlling biological contaminants

Work is currently under way to investigate the efficacy of copper ionisation of water for the control of biological contaminants (Project HNS 142). Copper is toxic to many plant pathogens, mosses and liverworts and can be effective at sanitising water. Copper ions that are present in the water flow through the system, coating the inside of pipe work and nozzle surfaces, providing a long lasting cleansing effect.

Further information

Contact points for equipment suppliers and analytical laboratories

Suppliers of acid dosing equipment:

Phoenix Instrumentation
Unit 2, Ivel Road, Shefford,
Bedfordshire SG17 5AE
Tel. (01462) 851747

Flowering Plants
11–12 Homeground, Buckingham
Industrial Park, Buckinghamshire
MK18 1UH
Tel. (01280) 813764

Water Horticultural Products Ltd
69 Ramley Road, Lymington,
Hampshire SO41 8GY
Tel. (01590) 679911

Lubron Water Technologies
Lubron House, Commerce Way,
Colchester, Essex CO2 8HL
Tel. (01206) 866444

Suppliers of reverse osmosis units:

J M Water Systems
Unit 29, Priors Way, Coggeshall
Industrial Park, Coggeshall,
Colchester, Essex CO6 1TW
Tel. (01376) 564404

Suppliers of iron removal filters:

J M Water Systems
Unit 29, Priors Way, Coggeshall
Industrial Park, Coggeshall,
Colchester, Essex CO6 1TW
Tel. (01376) 564404

Culligan International (UK) Ltd
Culligan House, The Gateway Centre,
Coronation Road, High Wycombe,
Buckinghamshire HP12 3SU
Tel. (01494) 838100

Lubron Water Technologies Ltd
Lubron House, Commerce Way,
Colchester, Essex CO2 8HL
Tel. (01206) 866444

Laboratories for water analysis:

Gooch Garforth
Ipswich Road, Needham Market,
Ipswich IP6 8EL
Tel. (01449) 721192

CSL
Central Science Laboratory, Sand
Hutton, York YO41 1LZ
Tel. (01904) 462324

Eurofins Laboratories Ltd
Woodthorne, Wergs Road,
Wolverhampton WV6 8TQ
www.eurofins.co.uk
Tel. (01902) 743222
Fax. (01902) 746183

NRM
Coopers Bridge, Braziers Lane,
Bracknell, Berkshire RG42 6NS
Tel. (01344) 886338

December 2006

Design and production: HDR Visual Communication