Information Sheet

5.13 Water quality considerations for optimal performance of irrigation equipment

Irrigation water is generally used untreated and contains varying amounts of dissolved compounds and suspended particulates. These can have negative and harmful effects on the irrigation hardware, including:

- *corrosion or abrasion of the pumps, pipes and nozzles,*
- *scaling in pipelines and/or*
- *blockages in filters, drip emitters or sprinkler nozzles (with smaller orifices).*

Treating water for different problems can be a complex task. This information sheet highlights key water quality constraints and provides general guidelines and solutions for the assessment of water quality as a potential risk to irrigation equipment. However, for optimal performance it is advised that you consult with the manufacturers of irrigation equipment and product-specific advisory consultants to help with formulating a site-specific and customised plan for dealing with poor water quality to protect irrigation hardware. Every effort must be made to ensure that the necessary safety precautions are taken to minimise all health and safety hazards. Please consult with experts in the field when in doubt.

Analysis of water samples will usually form the basis of diagnosing potential problems and the development of solutions. Guidelines on collecting water samples and the frequency of water sampling (along with information on the effects of water quality on the crop and soil health) can be found in **SASRI Information sheet 5.12 Irrigation water quality for sustaining soil health and sugarcane yield.** Water samples can be submitted to the FAS Agricultural Laboratory for routine salinity and sodicity testing, or other reputable laboratories for additional tests. Water samples should ideally be collected 2 – 4 times per year, depending on fluctuation of water quality and flow characteristics of the water source.

Corrosion and scaling: Diagnosing risks posed by water quality

Corrosion and scaling lead to deterioration of the different components of irrigation systems and can result in leaks, blockages and loss of pumping efficiency. Without preventative treatment and maintenance, corrosion and scaling can lead to premature failures, impacting on irrigation performance and incurring expensive repair costs.

Corrosion may be due to chemical reactions between the water and the irrigation hardware that causes components to dissolve or degrade, or by physical abrasion (rubbing) caused by suspended sediment moving through the system (particularly at bends). In both cases, there is a deterioration and breakdown of irrigation system components that can lead to failure and will likely require replacement.

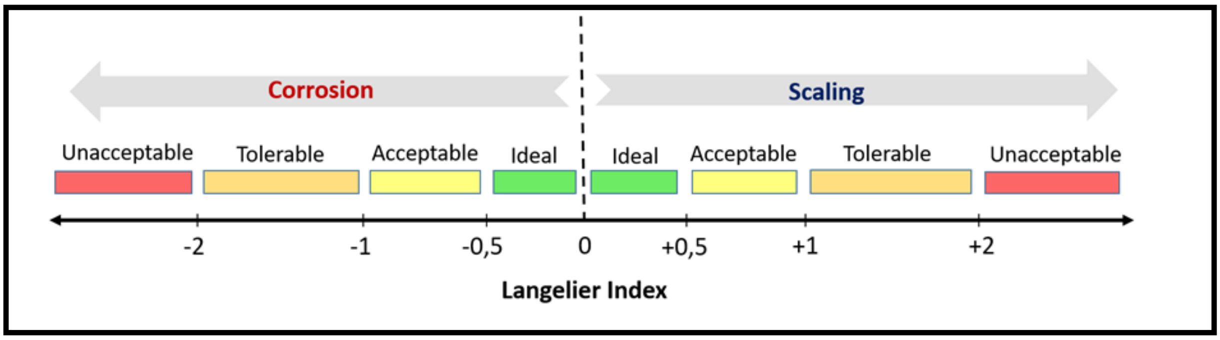
Scaling is the result of reactions that cause compounds to form insoluble solids (called precipitation) that are deposited on the inside of pipes, pumps and emitter nozzles. These deposits accumulate over time reducing flow rates and pumping efficiencies and ultimately leading to complete blockages. The most common cause is the precipitation of carbonate compounds (typically calcium) at high pH and dissolved salt concentrations. Gypsum (calcium sulphate) precipitation can occur when water with high calcium and sulphate concentration is used.

There are several indices with which the risk for corrosion and scaling can be predicted. The most commonly used index is the **Langelier Saturation Index (LI).** The LI indicates the likelihood of carbonate precipitating (scaling) or if the water is chemically corrosive (corrosion). The LI caters primarily for carbonate rather than sulphate rich waters. It is calculated as follows:

$$\textit{Langelier Saturation Index (LI)} = pH_a - pH_s$$

Where pH_a is the pH of irrigation water and pH_s is the risk of carbonate precipitating in the irrigation water. This can be calculated using data provided in your FAS Irrigation Water Quality Report. Consult with your regional Extension Specialist or Irrigation Advisor for assistance in estimating your LI value.

The LI ranges for risk of corrosion or scaling are shown below. Positive values indicate a scaling risk while negative values suggest corrosion risk.



▲ Langelier Index ranges for corrosion and scaling risk.

Mitigating the risk of corrosion or scaling

Risk of scaling is reduced by lowering the water pH through the addition of a weak acid solution while risk of corrosion is lowered by increasing water pH by adding alkalinity. In both cases the amount of acid or alkalinity added are aimed at adjusting the LI to between -0.5 and 0.5 (ideal range). In some situations, manufacturers improve resistance to corrosion by increasing the thickness of protective coatings and use of chemically non-reactive materials.

◀ Scaling inside an old pipe

Causes of blockages in drip irrigation systems

Drip irrigation systems are more susceptible to blockages than other types of irrigation systems, and are thus discussed in greater detail. Blockages can be caused by physical, chemical or biological factors, but in all cases leads to a reduction or cessation in water flow, leading to non-uniform or under-irrigation and potentially damaging irrigation equipment.

Physical: Blockage is a result of solids in the irrigation system. Very fine particles tend to remain in suspension but may settle out and be deposited in places where the water velocity is low or the water turbulence drops (such as tanks or in pipes when pumping stops). While individual fine particles are seldom problematic, where there is an accumulation of these fine particles over time (especially if compacted), these can cause blockages to develop. Often blockages occur first at the emitters at the ends of laterals due to pressure drops and thereby reduce water velocity. Large particles introduced into the system (e.g. algal filaments or pieces of plastic) have the potential to block filters, larger pipes and emitters quickly.

▲ Flushing drip lateral

▲ Blocked drip emitter

Chemical: Chemical reactions in the water that result in a deposit (scale) forming (typically metal carbonate or sulphide precipitates) can block pipes, filters and emitters. The blockage can be due to a narrowing of pipes over time as the scale develops or by pieces of scale that break-off and get lodged in pipes, filters or emitters.

Biological: Algal growth and microbiological activity may cause blockages, often originating in storage dams that are rich in nitrates and/or phosphates. Algal residues may come through the filters with clay particles, serving as a food source for bacterial slime. Fertiliser application through the irrigation system, especially where the laterals are exposed to the sun will lead to an increase in the formation of bacterial slime. These slimes can block emitters, or can serve as binding agents that combine fine silt and clay particles, leading to blockage.

The water quality guidelines against which to quantify the blockage hazard of the irrigation water, especially those of dripper systems, are shown in the table below.

Guidelines to quantify the blockage hazard of irrigation water

Cause	Blockage hazard rating			
	Ideal	Acceptable	Tolerable	Unacceptable
Physical				
Suspended solids, e.g. silt, clay and organic material (mg/ℓ)	<50	50 - 75	75 - 100	>100
Chemical				
pH	5-7	7 - 7.5	7.5-8	>8
Bicarbonate (mg/ℓ)	<100	100 - 150	150 - 200	>200
Calcium (mg/ℓ)	<10	10 - 30	30 - 50	>50
Manganese (mg/ℓ)	<0.1	0.1 - 0.5	0.5 - 1.5	>1.5
Iron (mg/ℓ)	<0.2	0.2 - 0.5	0.5 - 1.5	>1.5
Total dissolved solids (mg/ℓ)	<500	500 - 1000	1000 - 2000	>2000
Nitrates (mg/ℓ)	<10	<10	<10	>10
Biological				
Bacteria (count/mℓ)	<10000	10000-50000	10000-50000	
Some suppliers of drip irrigation systems consider water with an iron content of 0.8 mg/ℓ in storage dams and borehole water with an iron content of 0.3 mg/ℓ as a high blockage hazard for emitters. Water with a manganese content of 0.3 mg/ℓ is also considered a blockage hazard. These causes are interactive with each other, e.g. the removal of organic material will reduce biological activities.				

Proactive water treatment options to address blockage hazards in drip irrigation

Addressing blockage risks from physical factors

Sedimentation dams

In cases where the irrigation water contains solid particles in suspension in excess of 100 mg/ℓ, it is advisable to have a sedimentation dam. Therefore, it is important to ensure that the water standing time in the dam is adequate to ensure all suspended solids sink to the bottom before the water is pumped through the filter and into the pipeline. The water supply outlet to the dam should be as far away from the pump inlet. Backwash water from filters should preferably not be directed back into the dam, or as far away from the pump inlet. It also helps to install the pump suction intake on a float. Measures should also be taken to clean the sedimentation dam with minimum effort.

▲ Sediment dam with pump suction intake on a float

Filtration

Filtration systems are essential to remove suspended solids before irrigation water enters into drip systems. Irrespective of water quality, filtration system are highly recommended for all drip (or micro) irrigation systems. SABI norms encourage the installation of primary filters at the pump station and secondary filters at block inlets. Secondary filters capture material missed by primary filters, and if secondary filters get dirty regularly, it provides an indication of problems with filtration effectiveness at the primary filters. The filter banks are sized according to system flow rates, while the filtration efficiency is also dependent on correct pressure at the filter. Insufficient flushing cycle duration, incorrect setting of flushing control valves and use of filters outside of their recommended flow range are the greatest causes of filter blockage. Sand and disc filters are usually preferred for drip irrigation, while screen (mesh) filters or disc filters are typically used for micro-sprinkler systems (typically used on tree crops). The level of filtration (measured in microns) is closely related to the dirtiness of the water.

Addressing blockage risks from chemical and biological factors

Aeration

Iron-rich water (> 1.5 mg/l) should be aerated to promote formation of Fe-oxide that can settle in the holding dam. This must be done before abstracting water to prevent Fe-rich water from causing blockages in the irrigation system.

Acid application

Diluted acid solutions (typically hydrochloric, but can include phosphoric and sulphuric) are periodically used to lower water pH primarily to dissolve scales and prevent precipitates of carbonates and oxides forming. A routine water quality analysis will indicate the need for flushing with acid solutions.

Introduction of acid into the irrigation system must consider resistance of the irrigation hardware to acids and ensure proper mixing in the system. Excessive use of acid can promote chemical corrosion, where metallic components tend to dissolve. uPVC and polyethylene fittings are recommended in these cases. The injection points should apply the acid solution in the centre of the pipeline for proper mixing, preferably after the filter. After acid treatment, the system should be flushed to reduce unnecessary corrosion and dilute acids introduced into the rooting environment.

Chlorine application (OxidisingAgents)

Strong oxidising agents, such as chlorine, can be used to precipitate iron and manganese out of the irrigation water. Preferably, the chlorine should be administered before the filters, in order to prevent the precipitate/sediments from entering the system and blocking emitters.

Chlorine will also remove organic materials such as bacteria, bacterial slimes, algae, pathogens, etc. Due to low persistence of free chlorine, the application point must be close to the area of concern to improve effectiveness and reduce losses. Stabilised chlorine products can improve residence time. Laterals of drip lines must be flushed clean to remove dirt before the application of chlorine.

Chlorine can be added continuously or periodically, depending on the prevailing quality of water and the resultant water treatment needs. Chlorine is most effective at a pH of ± 6.5 and irrigation water must be acidified if necessary. The acid is applied to reduce the pH of the water for 10-20 minutes and the chlorine is applied thereafter. Recommended concentrations are provided in the table below for both options. In the table, the concentration of chlorine at the end points are also provided for monitoring the effectiveness of the process. For example, the free residual chlorine at the end of the system is an indication that the oxidation process is completed and should be 1-3 mg/l. Periodic application of chlorine usually takes place during the last 30 to 60 minutes of irrigation. Avoid chlorine concentration of more than 100 mg/l since this can possibly damage dripper diaphragms. After irrigation, the free residual chlorine in the water that remains in the pipes will suppress undesirable microbiological activities. The laterals must then be flushed thoroughly before the next irrigation cycle.

Recommended chlorine concentrations

Purpose of chlorination	Chlorination method	Recommended concentration (mg/l):	
		Injection point	End point
Prevention of sedimentation	Continuous	3-5	>1
	Periodically	10	>3
Cleansing of system of bacterial slimes	Continuous	5-10	>3
	Periodically	15	>5

Chlorine is available as chlorine gas (50 kg gas bottles), liquid sodium hypochlorite (20 litre plastic canisters) and granular calcium hypochlorite (HTH). Chlorine gas is relatively cheap, although the gas form is extremely dangerous and requires that prescribed safety precautions are used. Other oxidizing agents include bromine, ozone and activated peroxygen.

Hydrogen Peroxide

Hydrogen peroxide(H_2O_2) reduces the growth of algae and slime in irrigation systems as well as the occurrence of fungi in soils and growth mediums. It is more aggressive than chlorine in loosening residues in pipes and is not sensitive to high pH like chlorine. The point of injection should be at the block valves. Injection should be continued for an hour or for the time it takes for one drop to travel from the point of injection to the last dripper. The system is required to stand for 12 to 36 hours after the injection and the lifespan of the peroxide is a few days after which the system needs to be flushed. Hydrogen peroxide is environmentally friendly, it doesn't cause dangerous residue and it is very effective.

Dealing with blockages in drip systems after they occur (reactive)

Blockage material can often be identified by the colour of the deposit in the blocked dripper. Typically salt deposits are white, iron oxides are a rusty colour, and blockage material resulting from microbiological activities is dark-brown to black. Each type of blockage has a unique solution and usually a water analysis is required to indicate the likely cause of the blockage. Generalised solutions for different blockage problems are shown in the next table, though manufacturer guidelines will take precedence over these.

Solutions for specific clogging problems (drip irrigation systems)

Problem	Solution
Carbonate deposit (whitish colour) HCO_3>100 mg/l pH >7,5	• In extreme cases, where costs allow, continuous acid application – Maintain pH of 5 to 7. • Shock acid application at end of irrigation cycle. Maintain pH of 4 for 30 to 60 minutes. • Flush with clean water after to prevent corrosion of metal pipes and fittings.
Iron deposits (reddish colour) Iron concentration >0,2 mg/l Manganese deposit (black colour) Manganese concentration >0,1 mg/l	• Aeration and sedimentation of water at source to oxidise iron (especially suited to high iron concentration of 10 mg/l or more). • Two step acid and hydrogen peroxide application to treat iron deposits, applied at block level: - Pressurise and flush system. Irrigate for one hour, inject acid (0.6% concentration) for 10 minutes, then flush injection equipment with clean water - Thereafter, complete the hydrogen peroxide treatment (500 mg/l concentration initially, 250 mg/l follow up treatments) for one hour. - Wait for 12-36 hours and flush dripper lines. • Do one combination treatment per month; do not exceed one combination treatment per week.
Iron bacteria (reddish slime) Iron concentration >0,1 mg/l	Application of 1 mg/l chlorine (free chlorine available) continuously or 10 to 20 mg/l for up to 0-60 minutes as required.
Sulphur bacteria (white cotton-like slime) Sulphide concentration >0,1 mg/l	• Continuous application of chlorine at 1 mg/l per 4 to 8 mg/l sulphurhydroxide. • Application of chlorine as required until 1 mg/l free chlorine is available for 30 to 60 minutes.
Algae (greenish slime)	Application of chlorine at a continuous rate of 0.5 - 1 mg/l or 20 mg/l for 20 minutes at the end of each irrigation cycle.
Iron sulphide (black, sandy material) Iron and sulphide concentration >0,1 mg/l	• Dissolve iron by continuous acid application to reduce pH to between 5 and 7.

Acknowledgements

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