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Managing water for berry irrigation

NSW PRIMARY INDUSTRIES MANAGEMENT GUIDE

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Cover photo

Mechanically removing weeds from a dam using an excavator. Photo: Melinda Simpson, NSW DPIRD.

How to cite

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Managing water for berry irrigation

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Contents

Why looking after your water source is important

Maintaining a high quality water source is important to promote healthy and productive crops and soil, food safety, and to avoid clogging irrigation systems (Figure 1).

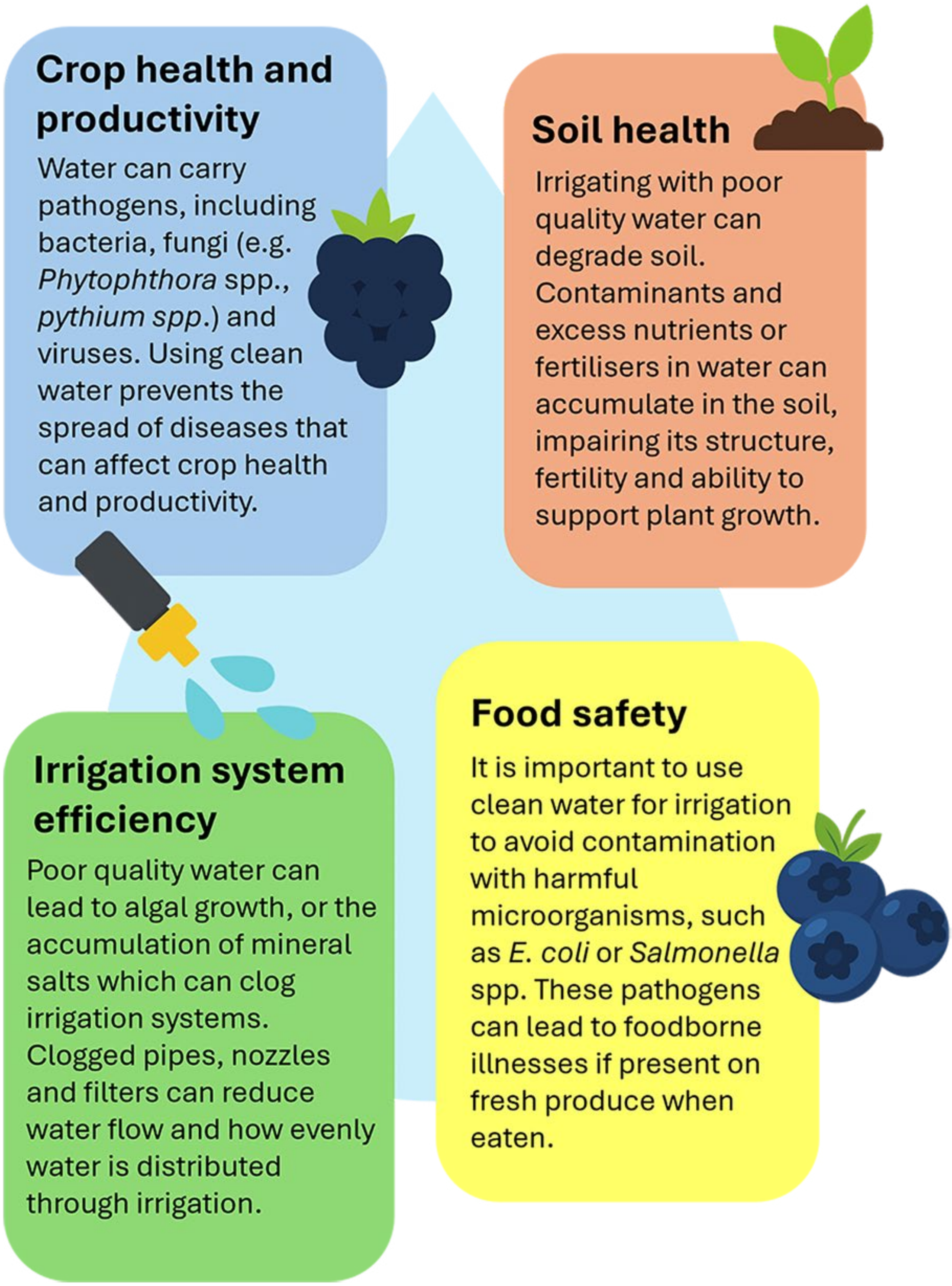

Figure 1. High quality water promotes crop and soil health, food safety and irrigation system efficiency.

Checking the quality of your water source

Understanding your water quality is essential to knowing its limitations and how it will affect your berry plants, soil, irrigation system, and overall farm operations. Regular water analysis helps identify potential or existing salinity issues, detects any toxicities or nutrient imbalances and supports the development of effective fertigation programs.

The key chemical properties that dictate the quality of irrigation water include:

- pH, acidity and alkalinity
- salinity (electrical conductivity, sodium, and sodium adsorption ratio)
- hardness
- mineral concentrations (for example, calcium, magnesium, iron)
- turbidity and total dissolved solids (TDS).

How often and when should you test your water

Water quality in irrigation dams should be tested regularly, with routine tests conducted at least yearly. As a guide, conduct additional testing before each irrigation season, after significant rainfall, and during drought. Collect a representative sample (5 small [250 mL] volume sub-samples) of the body of water, ideally in the early morning or late afternoon, to ensure reliable data. Take and send samples earlier in the week, as having samples sit in transit is not ideal for reliable results.

How to collect water samples

1. Contact the laboratory you intend to use before sampling as they often have test kits available.
2. Where to collect samples to get a representative sample will depend on the type of water source being tested:
   - For dams, take the sample as far away from the edge and, ideally, as close as possible to where your pumping system draws water. If you cannot access this area easily, take the sample from the first inlet along the pump line. Do not take the sample from the edge.
   - For creeks and rivers, take the sample where there is constant water flow and movement. Avoid taking samples from non-moving or backwater areas.
   - For bores that have been in use, allow the water to flow for a period to remove all standing water from the length of the pipe before sampling.
   - For bores that have not been used in several months, allow the pump to run for at least one hour before taking the sample.
   - For a new bore or well, sample after the pump has run for several hours or days.
3. Collect a 250 mL sample and store it in a clean plastic bottle. Triple rinse this bottle with the water source to be analysed. Include your name and the location of where the water sample was taken, for example 'Surname – site/dam'. If multiple containers have been used for water from one source, this should be noted with ‘A’ or ‘B’.
4. Chill samples immediately when collected and store them away from direct sunlight. Send them to the laboratory as soon as possible.

Interpreting water analysis results

Parameter: this lists what was tested in the water sample, for example, pH, EC

Limit of reporting (LOR): this indicates the lowest concentration of a substance that can be reliably measured by the testing method used. This helps ensure the accuracy and reliability of the test results, as measurements below this threshold might not be precise.

Units: some parameters can be expressed in multiple units so it is important to check the units being used when interpreting the results.

Result: this column shows the result for each of the parameters tested, for example, the pH of the water.

Parameter	Limit of reporting	Units	Result: dam 1
pH	na	pH units	8.100
Electrical conductivity	10	µS/cm	150
TDS (calc)	6	mg/L	100
Turbidity	0.070	NTU	21.000
Chloride	0.500	mg/L	10.000
Hardness	1	mg/L $CaCO_3$	39.000
Calcium carbonate saturation index	na	na	-0.660
Alkalinity	14	mg/L $CaCO_3$	28.000
Sodium adsorption ratio	na	na	0.760
Ammonium nitrogen	0.020	mg/L	0.068
Nitrite nitrogen	0.020	mg/L	0.014
Nitrate nitrogen	0.020	mg/L	0.370
Free reactive phosphorus	0.008	mg/L	0.310
Dissolved aluminium	0.050	mg/L	0.130
Dissolved arsenic	0.020	mg/L	<0.050
Dissolved boron	0.040	mg/L	0.051
Dissolved calcium	0.030	mg/L	6.000
Dissolved cadmium	0.002	mg/L	<0.002
Dissolved cobalt	0.030	mg/L	<0.100
Dissolved chromium	0.005	mg/L	<0.005
Dissolved copper	0.004	mg/L	0.005
Dissolved iron	0.003	mg/L	0.130
Dissolved potassium	0.060	mg/L	8.100
Dissolved magnesium	0.006	mg/L	5.700
Dissolved manganese	0.001	mg/L	0.003
Dissolved molybdenum	0.010	mg/L	<0.010
Dissolved sodium	0.050	mg/L	11.000
Dissolved nickel	0.007	mg/L	<0.007
Dissolved phosphorus	0.030	mg/L	0.340
Dissolved lead	0.010	mg/L	<0.002
Dissolved sulfur	0.060	mg/L	10.000
Dissolved selenium	0.040	mg/L	<0.04
Dissolved zinc	0.008	mg/L	0.011

Table 1. Example water test results and what each column means.

Water sample interpretation summary for berries

Table 2. Water sample interpretation summary.

Test description	Satisfactory	Unsatisfactory	Comment
pH	5.5 to 7.5	<5.5 or >8.5	pH can affect the availability of certain nutrients: • low pH water can contribute to soil acidity and corrode metal pipes and fittings. • high pH water can affect chemical spray mixes.
Electrical conductivity (µS/cm)	<1,000	>1,500	Maintaining a relatively low EC in irrigation water is crucial to preventing salt stress.
Turbidity (NTU)	<5	>6	To avoid sludge forming in pipes and tanks, turbidity levels should be kept below 5 NTU; greater than 50 indicates very cloudy water.
Chloride (mg/L)	<100	>100	Leaf or tip burn can occur at high levels, especially if evapotranspiration is also high.
Hardness (mg/L)	<100	>100	In hard water, a precipitate might form when phosphorus fertilisers and/or sulfate are injected into the irrigation water. Hard water can also cause encrustations that can block metal pipes and irrigation fittings, as well as reduce soil structure.
Alkalinity (mg/L $CaCO_3$)	<100	>100	At levels between 100 and 335, there is a moderate risk of soil problems (declining soil structure), and prolonged use can reduce plant growth. Raspberries and blackberries can tolerate slightly higher alkalinity than blueberries. At levels >335, there is a high risk of soil problems, reduced plant growth, and a build-up of scale, which blocks metal pipes.
Sodium adsorption ratio	<3	>3	Levels >6 can effect all soil types. Even low to moderate sodicity can reduce the growth of most crop plants.
Boron (mg/L)	<0.5	>0.5	Berries can show leaf burn or reduced root growth at high levels.
Calcium (mg/L)	<100	>200	High calcium levels can lead to some nutrient imbalances, such as lime-induced chlorosis.
Iron (mg/L)	<0.3	>0.3	Iron-loving bacteria will develop in water where the concentration range of iron is 0.3–1.5 mg/L.
Magnesium (mg/L)	<50	>100	Continually using irrigation water high in magnesium might deteriorate soil structure, especially on poorly drained, heavy-textured soil types.
Sodium (mg/L)	<70	>100	If levels exceed 70 mg/L, leaf or tip burn might occur, especially in high evapotranspiration conditions.

Understanding water analysis

pH

pH relates to the concentration/amount of hydrogen in water. The pH scale, spanning 0 to 14, classifies substances as acidic (pH <7), basic (pH >7) or neutral (pH = 7).

Suitable pH levels for irrigation water

The generally accepted pH for irrigation water is between 5.5 and 7.5 (Figure 2).

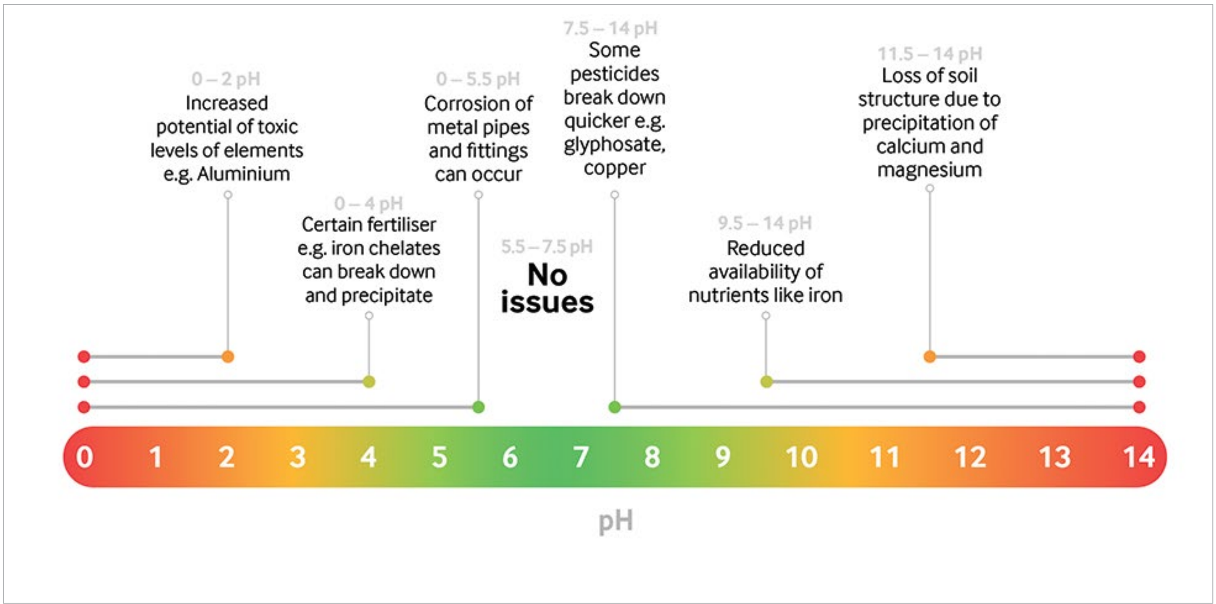

Figure 2. Water source pH ranges and their effect on plant growth or production.

Issues with low pH water

- Water with pH of <5 has a high corrosion potential and can cause issues with pumps, metal tanks and irrigation fittings.
- Continually irrigating with strongly acidic water (pH <4) can contribute to soil acidification (soil pH decreases over time).
- Certain fertilisers are prone to precipitation when mixed with acidic water (low pH). This precipitation can reduce their effectiveness and cause blockages in equipment. For example, iron chelates (EDTA, DTPA) can break down and precipitate if the pH drops too low. For instance, iron EDTA is most stable at a pH above 4.5, and in highly acidic water, it might release free iron, which can precipitate (Table 3).

Table 3. Iron chelate and its associated stability in relation to pH.

Chelate type	Stability in relation to pH
EDTA	4.0–6.5
DTPA	4.0–7.0
EDDHA	4.0–9.0

Issues with high pH water

- When water with high pH is used for irrigation, it can reduce the availability of some nutrients, such as iron. If water used for irrigation has a high pH and this is not adjusted, it can lead to iron chlorosis. This is where plants show yellowing of leaves due to iron deficiency. It is especially common in acid-loving plants such as blueberries.
- High pH water can cause some pesticides and foliar sprays to break down or degrade more quickly. For example, glyphosate and dimethoate are less effective when mixed with high pH water (above 7).

Electrical conductivity

Electrical conductivity (EC) refers to the ability of the water or the soil solution to conduct electricity. It measures the concentration of ions (positively charged cations and negatively charged anions) that comprise salts, for example, fertiliser.

> Several units are used to quantify EC:
>
> - deciSiemens per metre (dS/m)
> - milliSiemens per cm (mS/cm)
> - microSiemens per cm (µS/cm)
>
> 1 dS/m = 1 mS/cm = 1000 µS/cm
>
> 1 µS/cm = 0.001 dS/m

Suitable electrical conductivity

A suitable EC level for a water source such as a dam or bore is <1,000 µS/cm (Figure 3). If fertigating crops, this is especially important because you will most likely be adding fertilisers (salts) to the water used for irrigation. If you do not consider the initial EC, it could lead to salts accumulating in the soil.

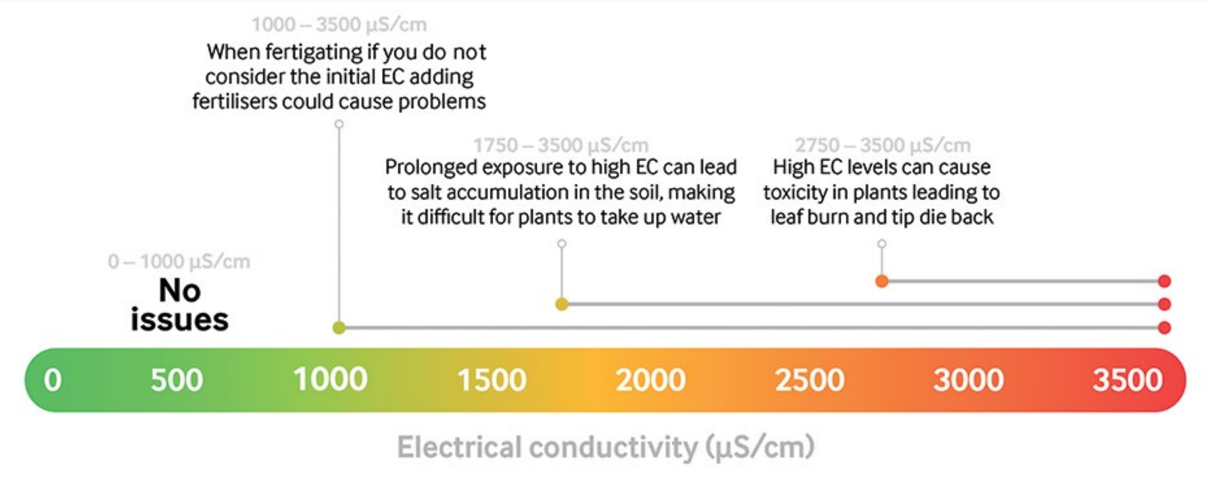

Figure 3. Water source electrical conductivity (µS/cm) ranges and their effect on plant growth.

Issues with high EC

- **Salt accumulation**: high EC indicates a high level of dissolved salts. Over time, as plants absorb water and leave salts behind, these salts can build up in the soil, leading to salinity issues.
- **Reduced water uptake**: high salt concentrations in the soil can make it difficult for plants to absorb water, which can cause them to dehydrate, even when water is present.
- **Leaf burn and tip dieback**: high levels of dissolved salts, especially chloride and sodium, can cause toxicity in plants, leading to symptoms such as leaf burn and tip dieback.
- **Root burn**: high EC levels can burn sensitive roots.

Alkalinity

Alkalinity refers to the water's ability to neutralise acids, that is, the water's capacity to resist changes in pH when acids are added. It is primarily determined by the presence of bicarbonate, carbonate and hydroxide ions in the water. Surface and groundwater sources in areas with limestone formations are highly likely to have high alkalinity due to the dissolution of bicarbonates and carbonates.

Suitable alkalinity levels

Suitable alkalinity levels in water sources used for irrigation are <100 mg/L $CaCO_3$ (Figure 4). Prolonged use of water with alkalinity levels between 100 and 335 mg/L $CaCO_3$ creates a moderate risk of soil problems (declining soil structure) and reduced plant growth. Raspberries and blackberries can tolerate slightly higher alkalinity than blueberries. With alkalinity levels >335 mg/L $CaCO_3$, there is a high risk of soil problems, reduced plant growth, and scale build-up.

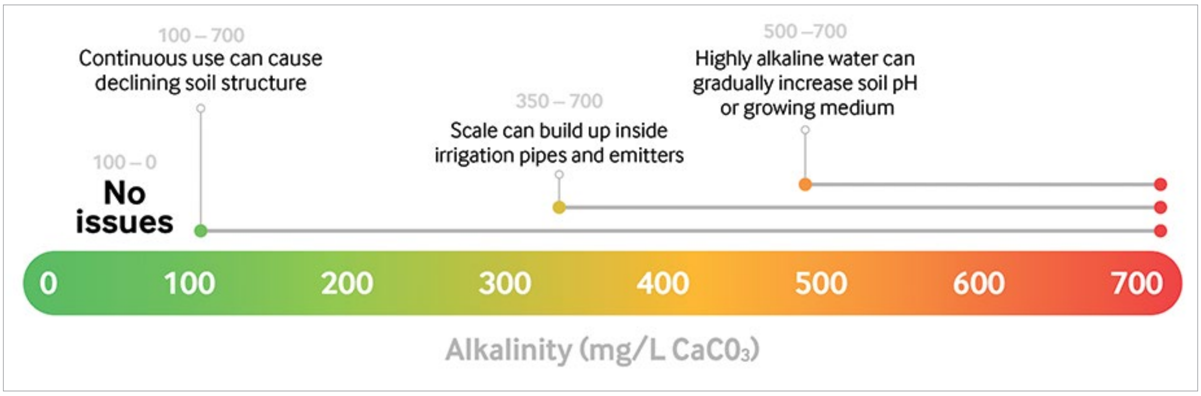

Figure 4. Water source alkalinity ranges (mg/L $CaCO_3$) and their effect on plant growth.

Issues with alkaline water

- **Scale formation**: highly alkaline water often contains high levels of calcium and magnesium (as carbonates), which can precipitate out of solution and form scale deposits. This scale can build up inside irrigation pipes (Figure 5), emitters and equipment, leading to blockages, reduced water flow, and increased maintenance costs.
- **Nutrient deficiencies**: water with high carbonate and bicarbonate levels can affect the plant's ability to take up calcium, magnesium, phosphorus and some trace elements.
- **Increased substrate or soil pH**: using highly alkaline water can gradually increase the pH of the soil or growing medium over time if enough is applied. However, the amount of growing medium (based on the size of the container) can be a factor in the effect of alkaline irrigation water on the pH of the medium; that is, the pH will rise faster in a smaller pot than a larger pot.

Figure 5. Scale build-up inside a pipe.

Turbidity

Turbidity is a measure of water clarity and is measured in nephelometric turbidity units (NTUs). High turbidity indicates solid materials are suspended in the water (Figure 7). These materials include clay, silt, fine organic matter and microscopic organisms (predominately living algae).

Suitable turbidity levels

To avoid sludge forming in pipes and tanks, the water should have <5 NTU (Figure 6). Turbidity levels >50 NTU indicate very cloudy water with a high chance of causing issues.

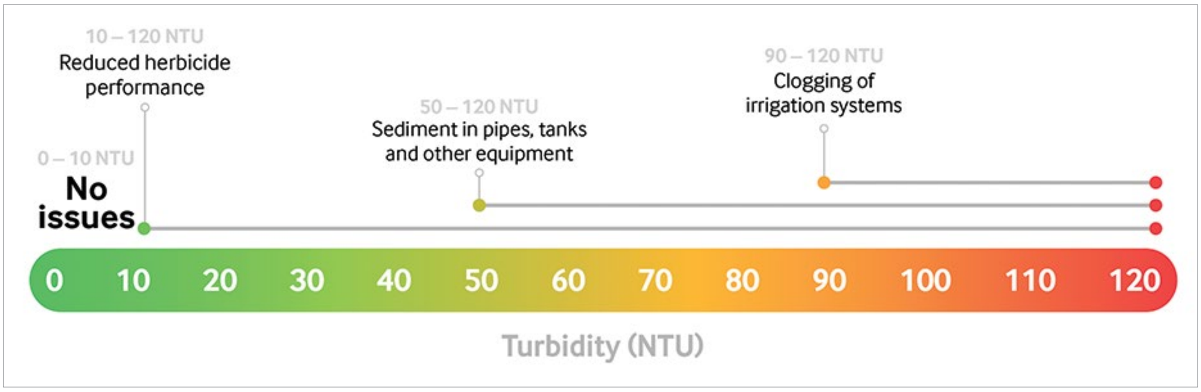

Figure 6. Water source turbidity (nephelometric turbidity units) ranges and their effect on filters and clogging.

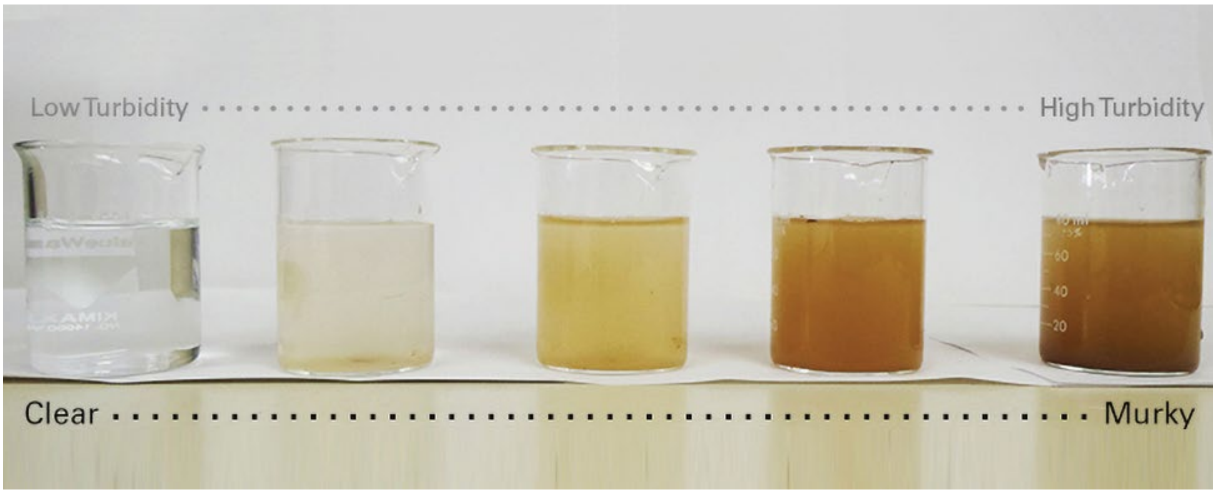

Figure 7. The difference between low (clear) and high turbidity water (brown and murky). Photo: Village of Chase, British Columbia.

Issues with high turbidity

Highly turbid water can lead to:

- sediment forming in pipes, tanks, and other equipment
- clogged spray nozzles and irrigation systems
- reduced herbicide performance
- ineffective chlorination systems.

Sodium adsorption ratio

Sodium adsorption ratio (SAR) is a measure of the amount of sodium relative to the amount of calcium and magnesium in a water sample. SAR can be used to indicate a possible sodium hazard.

Suitable sodium adsorption ratio levels

When irrigating berries, if a water test returns the SAR as >3, it indicates the water is sodic and, if used for irrigating, can increase the amount of sodium ions on the surface of soil particles.

The summary guidelines for interpreting water SAR values (Figure 8) are:

- <3: no problems as the water is not sodic
- 3–6: medium risk to soil structure and penetration on clay soil types
- >6: increasing effect on all soil types at low to moderate salinity and starts to reduce growth of most plants.
- >9: severe risk of increasing soil sodicity on most soil types.

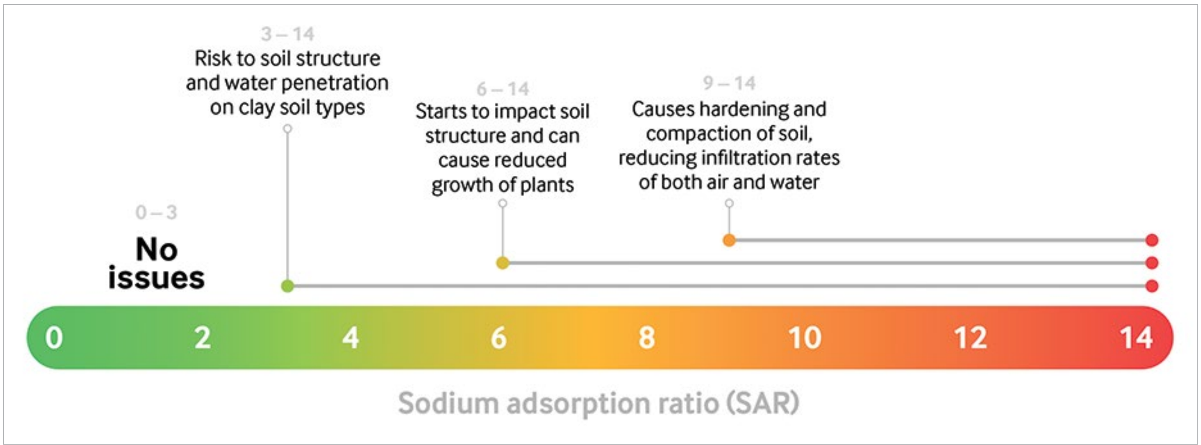

Figure 8. Water source sodium adsorption ratio (%) ranges and their effect on plant production.

Issues with high sodium adsorption ratio

High levels of sodium ions in water will affect soil permeability and can lead to water infiltration issues (Figure 9). If water has a high SAR, it generally means sodium will cause soil hardening and compaction, reducing infiltration rates of both water and air.

When growing berries in a substrate, excess sodium can create osmotic stress, making it harder for plants to absorb water. It can also cause nutrient imbalances, which can lead to nutrient disorders or toxicities.

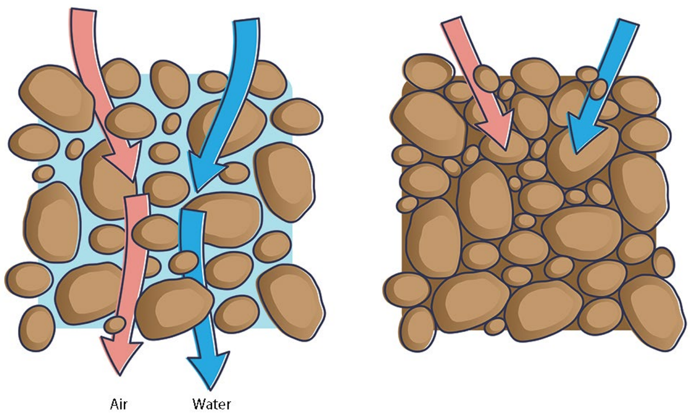

Figure 9. Soil with good structure (left) and soil with poor and dense structure (right) due to being irrigated with water that has a high sodium adsorption ratio.

Minerals

The main minerals to look at when testing a water source for irrigation are sodium (Na), chloride (Cl–), iron (Fe), boron (B), calcium (Ca), and magnesium (Mg).

Suitable mineral levels

The suitable levels of these minerals for berry irrigation water are listed in Table 4.

Table 4. Suitable mineral levels for berry irrigation water.

Mineral	Suitable levels (mg/L)
Sodium	<70
Chloride	<100
Iron	<0.3
Boron	<1
Calcium	<100
Magnesium	<50

Issues with high mineral content

Sodium

Excessive Na levels in irrigation water can lead to increased soil salinity, reduced plant water uptake, and potential nutrient imbalances. The first sign of Na toxicity is usually stunted growth and plant leaves looking bluish–green. As salt levels in the soil increase to more toxic levels, the tips and edges of the older leaves are scalded or burnt (Figure 10). The leaves die and fall off, and finally, the plant dies.

Chloride

High chloride (Cl–) levels in water can burn the leaves, cause poor plant growth and even death. It is a greater problem with overhead irrigation than drip or surface irrigation.

Iron

Soluble Fe and iron-loving bacteria can block pipes (Figure 11), drippers and sprinklers and damage equipment such as pressure gauges. If water containing levels of soluble Fe is applied by spray, it can discolour leaves and reduce the efficiency of transpiration and photosynthesis.

Figure 10. Blueberry plant with with dead and burnt leaf tips consistent with toxicity symptoms.

Figure 11. Iron and iron-loving bacteria blocking an irrigation pipe. Photo: Water Well Solutions.

Calcium

Calcium is an essential nutrient for plant growth and is particularly important for maintaining cell structure and membrane integrity. Excessively high Ca levels can lead to lime-induced chlorosis or nutrient imbalances.

Magnesium

Excessive Mg levels in irrigation water can lead to nutrient imbalances and affect plant growth and productivity.

Boron

Boron is an essential micronutrient for plant growth, but excessive levels in irrigation water can lead to B toxicity, which can damage plants and reduce productivity.

Fixing common water quality issues

pH

When adjusting pH, it is crucial to monitor both the pH of the water and the pH of the soil to prevent overcorrection and maintain the desired pH range.

> The pH of water affects its suitability for irrigation and chemical use. **For irrigation, the pH should be between 5.5 and 7.5**.

How to increase pH in water sources

The ideal bicarbonate range is between 30 and 60 ppm, with the lower end being for younger plants. This level allows for an adequate buffering capacity while minimising the influence on media pH. To increase the pH of water sources, use $CaCO_3$ (for example, calcium carbonate, calcite, limestone) or $KHCO_3$ (potassium bicarbonate).

How to decrease pH in water sources

The alkalinity of water also affects how much acid is required to change the pH. The following example might help explain the importance of alkalinity when trying to make water more acidic:

> Grower A has water with a pH of 9.3 and an alkalinity of 71 mg/L $CaCO_3$. To reduce the pH of this water to 5.8, it takes 448 g of 35% sulfuric acid per 3,785 L of water.
>
> Grower B has water with a pH of 8.3 and an alkalinity of 310 mg/L $CaCO_3$. To reduce the pH of this water to 5.8, it takes 1,944 g of 35% sulfuric acid per 3,785 L of water.
>
> Even though Grower B's water is a full pH unit lower than Grower A's, it takes more than 4 times the amount of acid to lower the pH to 5.8. Both alkalinity and pH are important to consider when adjusting the water pH.

Phosphoric, nitric, and sulfuric acids are often used to acidify irrigation water. Working with acids is dangerous, so use caution and always wear appropriate personal protective equipment (PPE). Acids can also damage irrigation systems if not used properly with the correct equipment. Systems can be automated to add the acid needed to lower the pH to the desired level.

> Acids should be added to the water before fertilisers or pesticide solutions. Phosphoric and nitric acids are sources of phosphorus (P) and nitrogen (N), respectively, and the levels contributed by adding the acid should be considered when determining fertiliser rates.

Salinity

Determine which salts are causing the high salinity

Salinity can be made up of different salts such as chloride salts (sodium chloride and potassium chloride) and sulfate salts (calcium sulfate and magnesium sulfate).

High levels of chloride salts can be toxic to many plants, affecting the osmotic balance and making it harder for plants to absorb water. While sulfate salts can contribute to the overall salinity of water, they are less likely to cause toxicity issues than chloride salts.

How to manage salinity issues

Dilution

One of the simplest methods to reduce the salinity of irrigation water is dilution with low-salinity water sources. This can include blending high-salinity water with freshwater sources such as rainwater, surface water, or low-salinity groundwater.

Leaching

Leaching involves applying excess water to the soil to flush out accumulated salts from the root zone. This method is particularly effective for soil with good drainage and permeability but might require significant amounts of water.

The formula for determining the minimum leaching requirement (MLR) is:

$$\mathbf{MLR = ECWA \div [(7.5 \times ECWY\ \%) - ECWA]}$$

ECWA is the EC of the available irrigation water.

ECWY (%) is the salinity level of the irrigation water that results in a specified percentage yield loss.

Example: we need to use water with an EC of 1,800 µS/cm (1.8 dS/m). We are prepared to accept a 10% yield loss, and we know that water of 1,700 µS/cm (1.7 dS/m) EC would cause this (acceptable) yield loss.

$$\mathbf{MLR = 1.8 \div [(7.5 \times 1.7) - 1.8] = 0.16}$$

This means that, in this example, 16% more water (than is strictly required by the crop) should be applied when irrigating.

When flushing substrate, using a dilute concentration (24–50% of regular strength) is advised. If fresh water is used to flush substrates, the rapid drop in the concentration of the root zone solution can cause osmotic shock. In this case, water moves rapidly into the root cells, causing swelling and potential root damage.

Soil amendments and mulching

Incorporating organic matter into the soil will improve soil structure and water retention capacity. Organic matter can also enhance microbial activity, contributing to the breakdown of salts.

Checking the salt index of fertilisers

All fertilisers have a salt index that indicates what the fertiliser contributes to soil salinity (Table 5). If the irrigation water or soil is saline, changing to fertilisers with similar nutrients but a lower salt index might help. For example, potassium chloride has a salt index of 116, but potassium sulfate has a lower salt index of 46, therefore, choosing potassium sulfate would be the better option. Information on the salt index of each fertiliser should be available from your local supplier. It is beneficial to avoid chloride-based fertilisers if your source water has high salinity.

Reverse osmosis desalination

Reverse osmosis desalination plants can provide on-site salt water purification that can be used in farm irrigation systems. This method is highly effective but can be costly and requires maintenance.

Table 5. How some common inorganic fertilisers influence the salt index and relative salinity, each expressed as relative to the effect of sodium nitrate.

Fertiliser	Analysis	Salt index[a]	Relative salinity[b]
Sodium nitrate	16.5 N	100.0	100.0
Ammonium nitrate	35 N	104.7	49.4
Ammonium sulphate	21 N	69.0	53.7
Calcium nitrate	11.9 N, 17 Ca	52.5	30.1
Urea	46 N	75.4	26.7
Diammonium phosphate	21 N, 23 P	34.2	12.7
Monoammonium phosphate	12 N, 27 P	29.9	12.7
Superphosphate (single)	7.8 P	7.8	16.5
Superphosphate (triple)	19.6 P	10.1	8.5
Potassium chloride	49.8 K	116.3	38.5
Potassium nitrate	13 N, 38 K	73.6	23.6
Potassium sulphate	45 K	46.1	17.0
Calcium carbonate	40 Ca	4.7	1.9
Calcium sulphate	23 Ca	8.1	5.8
Magnesium sulphate	16 Mg	44.0	44.5

[a]Calculated from the increase in osmotic pressure of equal weights of fertiliser.
[b]Calculated from the increase in osmotic pressure per unit of plant nutrient.
Note that actual increases in osmotic potential from a given amount of fertiliser will vary depending on medium characteristics.
Adapted from Bunt (1988) and Jacobs and Timmer (2005).

Turbidity

How to reduce turbidity in water sources

Reducing turbidity in water sources for irrigation is crucial to maintain the effectiveness of irrigation systems and to ensure the water is suitable for plant growth. Some strategies to reduce turbidity in water sources include the following.

Erosion control practices

Maintain ground cover: this protects the soil from raindrop impact and loss of soil particles. It also slows the movement of water over the ground surface. The roughness of the surface slows down water flow and encourages any suspended soil particles to drop out of the water. For inter-rows, use perennial grasses (Figure 12) or herbs with a mix of species (both tropical and temperate grasses) to ensure year-round growth. For farm tracks, use grass cover on minor tracks and gravel or concrete where grass does not grow well. Herbicide strips along the edges of blueberry mounds should be as narrow as possible, with the aim being to control grass runners only. Aim to maintain grass cover as close to the mound edge as possible and control this with mowing. Dead zones from herbicide use along weed mats are prone to gully erosion.

Figure 12. Well-maintained ground cover (grass) in a blueberry block.

Vegetation buffer strips: these are very effective at trapping sediment that is being transported by overland flow, such as water moving as a wide sheet rather than along a defined channel. There should be a minimum of 90% stable ground cover. Ideally, a mix of local native trees, shrubs, grasses and other ground cover should be used where possible. Grass needs to be 150 mm high to trap sediment, so regular mowing is not encouraged in buffer strips using grass.

Sediment retention basins: construct sedimentation basins or settling ponds to allow suspended particles to settle before the water is used for irrigation. This can be particularly effective for trapping larger particles and improving water clarity. Where a sediment basin has been installed, the discharge point from the basin requires careful attention. Spillways are very prone to erosion and might require an energy-dissipation structure known as a rock ramp to be included.

Avoid over-irrigating

Over-irrigation can lead to water run-off, carrying soil particles into water sources. Implement efficient irrigation practices to reduce excess water application and associated erosion.

Filtering

Filtration systems (Figure 13) remove suspended solids and finer particles from water to reduce turbidity. Filters can be divided into 3 types: screen, media, and disc. Each filter has advantages and disadvantages for different situations.

Talk to irrigation designers, equipment suppliers and advisers before purchasing equipment. Make sure the filters are large or numerous enough to handle the system flow rate so the pressure through a clean filter does not drop. Optimal filtration is achieved by using filters at the pump and when backed-up with secondary filters in the field; that is, filtering twice.

Figure 13. A dirty filter due to poor dam water quality.

Using coagulants and flocculants

Coagulants and flocculants (Table 6) can be added to water to help particles clump together, forming larger particles that can settle more easily. Alum, available in liquid or solid form, is one of the most common flocculating agents used to clarify water. Ferric alum is also widely used, as the small amount of iron it contains increases the effectiveness of alum over a wider pH range.

Table 6. Common flocculating agents and their typical dose rates.

Flocculating agent	Typical dose for every 10,000 L of water	Comments
Alum (aluminium sulfate)	0.5 to 0.75 kg	Alum is most effective between pH 6.8 and 7.5; it still works outside this range, but not as well. It will increase water acidity slightly. Floc formation is slow in acidic water. It takes between 2 and 24 hours to flocculate and settle into a stable sludge. Do not use if water pH is <5.5 due to the likely release of toxic levels of dissolved aluminium.
Ferric alum (crude alum with iron impurities	0.5 to 0.75 kg	As above, but is most effective over a wider pH range of 5.5 to 8.5.
Ferric sulfate	Up to 2.5 kg	pH >5 is required, or it might lower oxygen levels.
Ferric chloride	Up to 3 kg	pH >5 is required, or it might lower oxygen levels. Very corrosive.

Synthetic coagulants are being used increasingly to treat water as replacements for inorganic coagulants such as alum. They generally form a stronger floc that is more likely to settle than inorganic coagulants and reduce the overall amount of coagulant needed. Organic coagulants include polyamines, polyDADMAC, dicyandiamide and melamine formaldehyde.

If possible, treat the water in a tank rather than in a dam. Tanks should have 2 outlets: one near the base to drain off the sludge deposited in the bottom and a higher one for the clear water. The treatment tank should preferably be made of concrete or other non-corrosive material.

As an alternative, blocks of ferric alum can be placed in channels feeding the dam. Run-off water flowing over these blocks will dissolve enough alum to clear the water. Place the block close to the entry point of the running water source. The water flow should gradually disperse enough of the polymer.

Iron

How to reduce iron in water sources

Iron is soluble in water where there is little or no oxygen. Oxidising the iron makes it form solid particles that can settle out of the solution or be caught in a filter. The recommended treatment options for removing iron are oxidation, sedimentation and filtration.

Irrigation systems used for fertigation should not use water high in iron. Injecting unchelated phosphates or calcium salts into the water will accelerate the precipitation of iron and should be avoided.

Iron levels in water sources should be <0.3 mg/L. Iron-loving bacteria will develop in water where the concentration range of iron is 0.3–1.5 mg/L.

Aeration and settling

Aeration and settling is an inexpensive and almost foolproof method of iron removal. Aeration means the water is mixed with air by spraying it into the air, bleeding air into the intake side of a pump, agitating the water with propellers or paddles, or cascading it over baffles into a settling tank. The iron then settles out of the aerated water. As iron is more soluble at lower pH values, the best precipitation is likely to occur at a pH of 7.2. Hydrated lime (calcium hydroxide) can also be used to raise the pH.

In dams, problems caused by iron can often be reduced or eliminated by attaching the pump's suction pipe to a raft or drum to bring it within 200 to 300 mm of the surface.

High levels of soluble iron are usually associated with deep bores and dams where oxygen supply is limited.

Oxidation

Iron is often in water in a soluble, ferrous (Fe^{2+}) form. Oxidising agents such as chlorine, potassium permanganate, or hydrogen peroxide can convert soluble ferrous iron into insoluble ferric (Fe^{3+}) iron, which can then be removed by filtration. Chlorination can be used to control iron deposits if pH is <6.5 and the iron concentration is <3.5 mg/L (3.5 ppm). If pH is >6.5, the iron concentration must be <1.5 mg/L (1.5 ppm) to use chlorination effectively. Chlorine kills iron bacteria on contact.

Potassium permanganate is often used with manganese greensand, which acts as a filter, trapping the oxide. The main advantage of potassium permanganate oxidation is the high rate of reaction, which is many times faster than that of chlorine. The reaction is not sensitive to pH between 5 and 9.

Filtration

Filtration alone does not remove iron efficiently because it only removes particles of oxidised iron. Filter media such as sand or anthracite are the most effective for removing ferric oxide. Remember that aeration and oxidation should take place before the water is filtered.

Algae

Algae are small forms of plant life that exist in a wide range of habitats. In water sources, algae occur naturally in both fresh and brackish waters. Like all plant life, algae respond to sunlight and fertilisers, and when environmental conditions are right, excessive algal growth will occur (Figure 14).

As little as 0.01 mg/L phosphate in freshwater sources stimulates the growth of algae and other aquatic life that might clog irrigation systems.

When algae die, their decomposition depletes the oxygen levels in the water source. If too much oxygen is lost, further water quality problems can arise, including releasing iron and nutrients from sediment into the water.

Figure 14. Algae on a dam. Photo: Lynn Greyling, Public Domain Pictures.

How to prevent algal blooms in water sources

The best way to manage algal blooms is to prevent them from happening. A good long-term strategy is to improve nutrient management and erosion control on your farm.

Nutrient management

Algal blooms are often fuelled by excessive nutrient levels, particularly phosphorus and nitrogen. Implementing best management practices, such as optimising nutrient use by reducing excessive or untimely nutrient application to reduce nutrient inputs into the dam, can help prevent algal growth.

Wetlands and bioreactors can also be used to remove nutrients from drainage/run-off water.

Vegetative buffer zones

Establishing vegetative buffer zones around the dam can help filter out nutrients and sediment before they reach the water. Planting native vegetation along the shoreline can also help stabilise soil, reduce erosion, and provide habitat for wildlife, further improving water quality.

Aerobic bacteria

Aerobic 'oxygen-loving' bacteria are naturally occurring organisms living in dams; but their populations are limited but should be encouraged to grow so they consume more organic material (that is, sludge) and pull more nutrients from the water. Eventually, these microbes consume so much nutrition, the algae starve and die.

Aerobic bacteria feed on the organic material in sludge (for example, dead leaves, aquatic weed seeds, and algae spores) breaking it down, so it disappears.

How to treat algal blooms

Aeration

Aeration systems can help increase oxygen levels in dams, inhibiting algal growth and promoting the growth of beneficial aerobic organisms. Surface aerators, diffused aeration systems, or fountain aerators (Figure 15) can be installed to enhance oxygenation and circulation in the water.

Figure 15. Aeration systems in dams help increase oxygenation. Photo: Water Quality Solutions.

Probiotic treatments

A probiotic treatment (for example, Biostim®, REGEN-Sediment® or Bioenzymes Pond Maintain®) involves actively feeding the 'good' microbes in a dam. This encourages populations of aerobic bacteria to grow. They eat the sludge on the floor of the dam and consume nutrients such as nitrogen and phosphorus, thus outcompeting the algae (Figure 16).

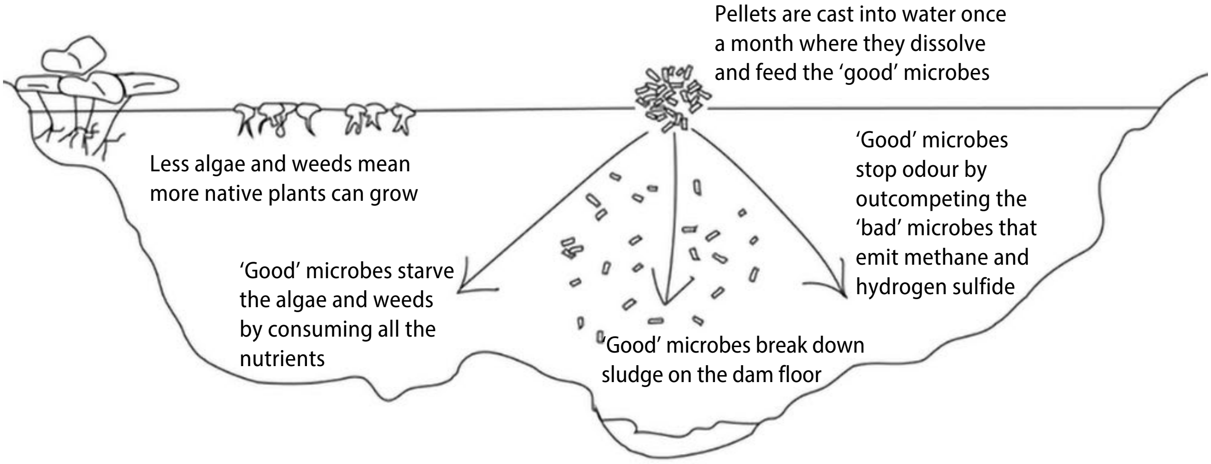

Figure 16. How probiotics help to reduce algae build-up in water sources. Source: Water Quality Solutions.

Floating islands

Floating islands are made up of buoyant mats planted with vegetation (Figure 17). The islands help reduce nutrient content in a similar way to aeration and biological treatments. The key is the large, exposed root mass, which draws phosphorus directly from the water and provides a habitat for bacterial populations that consume nitrogen.

Figure 17. A floating island mat (left) and the mat planted with plants (right) to help reduce nutrients in dams. Photo: Water Quality Solutions.

Algaecides and peroxide-based treatments

Algaecides work by releasing chemicals that attack algal cells and break them down, preventing them from reproducing and spreading. Some commercially available products in Australia include COPTROL®, Cupricide®, Kuparimine® and REGEN-Algaemaster®. Importantly, algaecides do not clean up the algae once it is dead. This dead material eventually decays, adding more nutrients to the dam to feed future algal blooms. Therefore, these products should be used with a probiotic treatment that will help to break down the dead algae before it adds additional nutrients to the water.

Peroxide-based treatments (for example, AlgaeLift) help lift algae off surfaces and make it easier for it to be degraded by naturally occurring bacteria. AlgaeLift is best used with probiotic treatments and aeration.

Aquatic weeds

Aquatic weeds invade watercourses, dams (Figure 18) and wetlands. These weeds are extremely detrimental to the aquatic environment, where they choke waterways, alter oxygen levels and reduce light penetration.

> Some water weeds need to be reported. Report suspicious weeds to the local council weeds officer or phone the NSW Invasive Plants and Animals hotline on **1800 680 244**.

How to treat/prevent aquatic weeds

Aeration

Aeration systems can help increase oxygen levels in dams, inhibiting algal growth (Figure 19) and promoting the growth of beneficial aerobic organisms. Surface aerators, diffused aeration systems, or fountain aerators can be installed to enhance oxygenation and circulation in the water.

Figure 18. An invasive weed that has taken over a dam in Woolgoolga.

Figure 19. An aeration system was installed in this dam to help increase oxygen and improve dam health.

Probiotic treatments

A probiotic treatment (for example, Biostim® or REGEN-Sediment®) involves actively feeding the 'good' microbes in a dam. This encourages populations of aerobic bacteria to grow. They eat the sludge on the floor of the dam and consume nutrients such as nitrogen and phosphorus, thus outcompeting algae.

Mechanical removal

Mechanical removal involves using specially designed harvesters or equipment to remove the plant biomass (Figure 20) from the water body. With mechanical removal, there is less plant material to break down and provide nutrients for aquatic weed growth. Furthermore, the water can be used immediately compared to restricted use following herbicide use.

Figure 20. Mechanical removal of weed from a dam using an excavator and net.

Herbicide

Killing weeds and leaving them in the dam is likely to release nutrients and make the water less healthy; therefore, herbicides should only be used in extreme cases or for spot spraying.

There are specially designed herbicides for aquatic environments, so you should always read the label before use. Table 7 lists some herbicides that can be used for aquatic purposes.

Table 7. Herbicide products that can be used on aquatic weeds and their target species.

Product	Active ingredient	Targeted aquatic weeds	Comments
AQ200 aquatic herbicide	Diquat as diquat dibromide	Submerged aquatic weeds	Spray the diluted product evenly over the water surface
AQ200 aquatic herbicide and wetting agent	Diquat as diquat dibromide and wetting agent	Free-floating aquatic weeds	Spray the mix of diluted product and wetting agent directly onto the aquatic weeds
Weedpro Bioaqua 360	Glyphosate	Aquatic weeds	Avoid spraying over moving bodies of water or where there are no weeds

Summary

Maintaining high-quality water sources is vital for the health and productivity of berry crops, as well as for conserving soil, protecting irrigation infrastructure and ensuring food safety. Clean irrigation water helps prevent the spread of plant diseases caused by pathogens such as fungi and bacteria, which can negatively affect crop yields. Contaminated or poor-quality water can degrade soil by introducing excess nutrients, salts, or other contaminants that impair soil structure and fertility. It can also lead to the build-up of sediment, algae, and minerals in irrigation systems, causing blockages that reduce efficiency. Additionally, using unsafe water for irrigation can introduce harmful microorganisms such as *E. coli* or *Salmonella*, posing risks to food safety, especially when growing fresh produce.

To manage these risks, regular water quality testing is essential. Key chemical properties to monitor include pH, electrical conductivity, alkalinity, turbidity, and concentrations of minerals such as sodium, calcium, and boron. Testing should be conducted at least annually, and more frequently during critical times, such as the start of the irrigation season or after severe weather. The location and method of sample collection play a significant role in obtaining reliable results. Once analysed, interpreting the data correctly is crucial to assess potential issues, such as soil salinity, nutrient imbalances, or system clogging. For example, water with high pH can limit nutrient availability, while elevated EC levels might lead to salt stress in plants.

Managing common water quality issues in agricultural irrigation involves assessing several key parameters that can affect crop health and system efficiency. Adjusting water pH is critical, as both pH and alkalinity influence plant nutrient availability and the effectiveness of agrochemicals. Alkaline water may require acidification with agents such as sulfuric or phosphoric acid, but the amount needed depends heavily on the water's buffering capacity (alkalinity). Conversely, raising pH might require adding calcium or potassium bicarbonate compounds. Managing salinity starts with identifying which salts are contributing to the problem; chloride salts are more toxic to plants than sulfate salts. Methods such as dilution with low-salinity water, leaching, using lower-salt-index fertilisers, and even reverse osmosis can help mitigate salinity problems. Additionally, soil amendments such as organic matter can improve soil structure and help reduce salt stress.

Other water quality challenges include turbidity, iron, and algae. Turbidity, often caused by erosion, can be reduced by maintaining ground cover, buffer strips, sediment basins, and proper filtration. In more severe cases, coagulants and flocculants, including alum or synthetic polymers, can help clarify water. Iron in water, particularly from low-oxygen sources, such as deep bores or stagnant dams, is best managed through oxidation and filtration. Aeration or chemical oxidisers convert soluble iron to insoluble forms that can be filtered out. Algal blooms, which are made worse by excess nutrients, especially phosphorus, can be prevented by effectively managing nutrients, controlling erosion, and having vegetative buffers. Encouraging aerobic bacteria that consume organic material and nutrients in dam sludge also helps improve long-term water quality. Each of these strategies contributes to maintaining a stable, clean irrigation supply, which is essential for productive and sustainable farming.

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