

FIELD GUIDE

WATER QUALITY MONITORING IN THE AUSTRALIAN SUGAR INDUSTRY



Water Quality Monitoring Field Guide

FIELD GUIDE

WATER QUALITY MONITORING IN THE AUSTRALIAN SUGAR INDUSTRY

By

Tim Wrigley¹, Andrew Wood², Tom McShane³ and Keith Phillips⁴

¹ CANEGROWERS, Brisbane

² CSR Sugar Ltd, Macknade

³ Burdekin

⁴ Herbert River



Substantial funding for this project was received from SRDC.



Technical support and assistance with the production of this guide was provided by BSES Limited.

Copyright © 2008 by Queensland Canegrowers Organisation Limited.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior permission of Queensland Canegrowers Organisation Limited.

Warning: Our tests, inspections and recommendations should not be relied on without further, independent inquiries. They may not be accurate, complete or applicable for your particular needs for many reasons, including (for example) Queensland Canegrowers Organisation Limited being unaware of other matters relevant to individual crops, the analysis of unrepresentative samples or the influence of environmental, managerial or other factors on production.

Disclaimer: The water quality monitoring guidelines in this publication are based on generalised management conditions and provide general advice only. They may not apply to the specific conditions on your farm. If you would like to adjust the guidelines to the situation on your farm, we strongly recommend that you take further water quality samples and seek professional advice. Except as required by law and only to the extent so required, none of the authors, their respective employers/organisations including directors, officers or agents, and publishers makes any representation or warranty, express or implied, as to, or shall in any way be liable (including liability in negligence) directly or indirectly for any loss, damages, costs, expenses or reliance arising out of or in connection with, the accuracy, currency, completeness or balance of (or otherwise), or any errors in or omissions from, any test results, recommendations statements or other information provided to you.

Contents

Why monitor water quality?	2
Points to remember	3
Developing a sampling strategy	4
Parameters and Methods	
• Ammonia (NH ₃)	6
• Nitrate - Nitrogen (NO ₃ -N)	8
• Orthophosphate - Phosphorus (PO ₄ -P)	10
• Turbidity (Total Suspended Solids)	12
• Electrical Conductivity (E.C.)	14
• Dissolved oxygen (D.O.)	16
• Pesticides	18
Appendix	
1. Calculation of flow rate and load	20
2. Instructions for Hach Colour Comparator	23

Why Monitor Water Quality?

A water quality monitoring program will assist growers to:

- Establish links between on-farm land and nutrient management practices and water quality
- Determine if valuable soil, fertilisers or chemicals are being lost in farm runoff.
- Evaluate the effectiveness of farm management practices.
- Assess the health of water in dams, drainage systems or nearby water courses.
- Check the quality of underground water used for irrigation.
- Build local and regional knowledge of water quality conditions and trends.
- Demonstrate good custodianship and the benefits of industry best management practices.

Points to Remember

1. Obtain equipment from industry organisations, for example BSES, CANEGROWERS, your local NRM body.
2. Plan properly and develop a strategy before starting.
3. Make sure your measurements are documented correctly in a notebook or field record sheet.
4. Keep accurate records of your farm practices in a notebook or your BSES Paddock Journal – your data is valuable.
5. Integrate your WQ data with other farm information and your experience (e.g fertiliser practices).
6. When assessing your results try to establish “cause and effect”.
7. Measure rainfall, where possible, at the site where you are monitoring water quality.

Developing a Sampling Strategy

Before commencing your water quality monitoring program think about why you are going to do it, and discuss the proposed strategy with your industry or NRM extension staff.

Together you should consider the following points:

- **What parameters will you measure?**
In the sugarcane industry nitrate nitrogen, ammonia nitrogen, phosphate phosphorus, sediment, conductivity/salinity, dissolved oxygen and pesticides are the most important parameters.
- **Where will you be sampling?**
Typical sites may be – water supply bore or supply channel, end of row or paddock, tail drain, recycle pit, or water course. Select sites that are readily accessible in all conditions.
- **What will be your sampling frequency?**
More samples provide better information, but regular routine sampling over a long period will tell a worthwhile story. When monitoring during rain periods, particularly at the beginning of the wet season it is important to measure the “first flush runoff”.
- **Do you need to estimate volume?**
Often concentration is the major factor, however if load is required an estimate of volume may be necessary. If so see **Appendix 1**.
- **What methods and equipment are most appropriate?**
Simple, cost effective methods are readily available and some of these are covered in this guide.

- **Do I need to collect and store samples?**
After field testing it is a good idea to occasionally take samples for more comprehensive analysis to check your results. These samples may need to be refrigerated. You should consult your local extension officer.
- **Where will I record and store the data?**
Record your data in a field notebook initially and in a separate database for more permanent records.
- **How will I interpret the data?**
Initially seek advice when interpreting data, but with experience you will gain skills in data interpretation.
- **Are there any safety considerations?**
Personal safety is vitally important, particularly in remote locations and near water courses.

Collecting a water sample

1. Rinse out your sample bottle 2-3 times.
2. Take the sample from the top 30 cm of the water source, being careful not to disturb the sediment on the bottom.
3. Use this sample to test for each parameter, as shown in this guide.

Ammonia

NH₃

Nitrogen (N) is an important plant nutrient. Plants take up nitrogen as both nitrate (NO₃) and ammonium (NH₄) and nitrogen fertilisers contain one or both forms. When urea is applied to the surface of soil or trash, ammonia gas can be formed. Ammonia can also be found in runoff water, particularly under anaerobic, waterlogged conditions and at high fertiliser concentrations.

Procedure

Water should be analysed immediately when using test strips. If samples for more comprehensive analyses are taken, refrigerate immediately.

1. Dip a strip into the collected water sample for **5 SECONDS** and remove. **DO NOT SHAKE** excess water from the test strip.
2. Hold the strip **LEVEL** with pad side up, for **60 SECONDS**.
3. Compare the test pad to the colour chart.
4. If the colour on the test pad falls between two colour blocks, estimate the result.
5. Complete the field record sheet and file it.



NH ₃ mg/L	Effects
< 1	Naturally occurring levels in waterways.
1 - 2	Elevated above natural levels. Continue to review your fertiliser management practices. Follow nutrient management guidelines for your farm.
> 2	Moderate risk of excessive algal and plant growth. Continue to review your fertiliser management practices. Follow nutrient management guidelines for your farm.

< Less than - > Greater than

Nitrate - Nitrogen

NO₃-N

Nitrogen (N) is an important plant nutrient. Plants absorb N as both nitrate (NO₃) and ammonium (NH₄). Nitrogenous fertilisers are used extensively for crop production, and some of this applied N may enter waterways as nitrate (NO₃) and nitrite (NO₂). This is not only wasteful, but excess nitrates in water can contribute to excessive algal growth.

Procedure

Water should be analysed immediately when using test strips. If samples for more comprehensive analysis are taken refrigerate immediately.

1. Dip a strip into the collected water sample for **2 SECONDS** and remove. **DO NOT SHAKE** excess water from the test strip.
2. Hold the strip **LEVEL** with pad side up, for **60 SECONDS**.
3. Compare the test pad on the far end of the test strip to the top colour chart on the packet or bottle.
4. If the colour on the test pad falls between two colour blocks, estimate the result.
5. Complete the field record sheet and file it.



Note: Nitrate nitrogen concentrations greater than 2 mg/L may have adverse effects on freshwater ecosystems. It is worth investigating changes to your farm practices to identify ways to reduce your nitrate runoff concentration.

NO ₃ -N mg/L	Effects
< 1	Naturally occurring levels in waterways.
1 - 2	Elevated above natural levels. Continue to review your fertiliser management practices. Follow nutrient management guidelines for your farm.
> 2	Moderate risk of excessive algal and plant growth. Continue to review your fertiliser management practices. Follow nutrient management guidelines for your farm.

< Less than - > Greater than

Orthophosphate - Phosphorus PO₄-P

Phosphorus (P) forms and utilisation in plants are complex. P is mostly absorbed by plants as soluble orthophosphate ions (H₂PO₄⁻ and HPO₄²⁻) which are present in the soil solution. P is absorbed onto clays, so the levels of P in water are often related to the turbidity and may contribute to excessive algal growth.

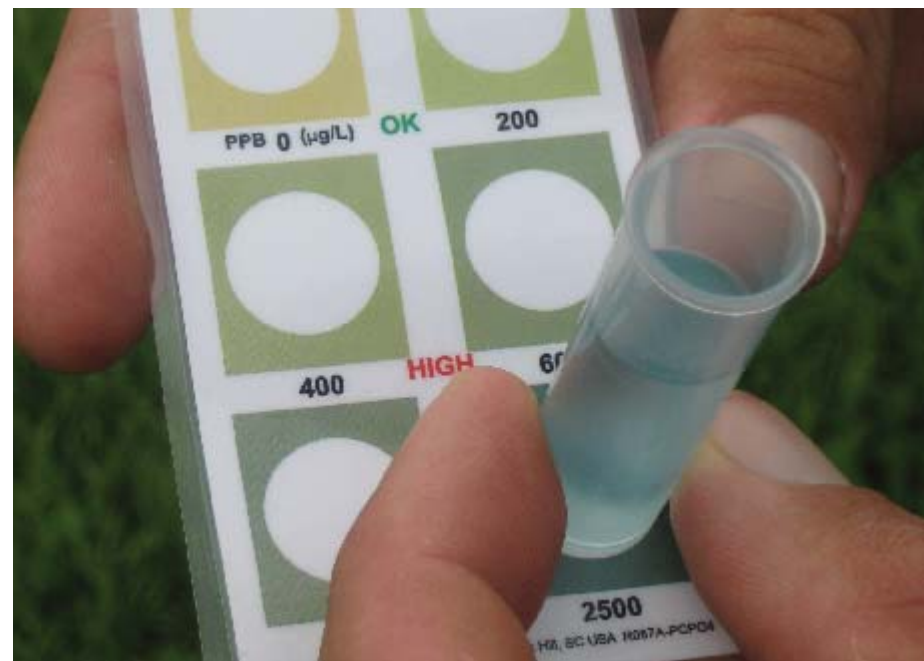
If test strips are unreliable in your circumstances, please see **Appendix 2** for an alternative sampling method using a Hach Orthophosphate Colour Comparator.

Procedure

Water should be analysed immediately.

1. Fill the small plastic vial to the top line with water from your sample bottle.
2. Dip one phosphate strip into the vial for **30 SECONDS**, with a constant up and down motion.
3. Remove strip from the vial and **DISCARD**.
4. Place the sample vial onto the white space on the colour scale.
5. By looking directly down into the vial compare the colour of water to the colour scale by sliding it around the until the best colour match is found. This will equal the phosphate concentration.
6. Complete the field record sheet and file it.

Note: To convert to orthophosphate phosphorus divide the result by 3.



PO ₄ -P mg/L	Effects
< 0.5	Naturally occurring concentrations in waterways.
0.5 - 2.0	Elevated above natural levels. Continue to review your fertiliser management practices. Follow nutrient management guidelines for your farm.
> 2.0	Risk of excessive algal and plant growth. Continue to review your fertiliser management practices.

< Less than - > Greater than

Turbidity – Total Suspended Solids

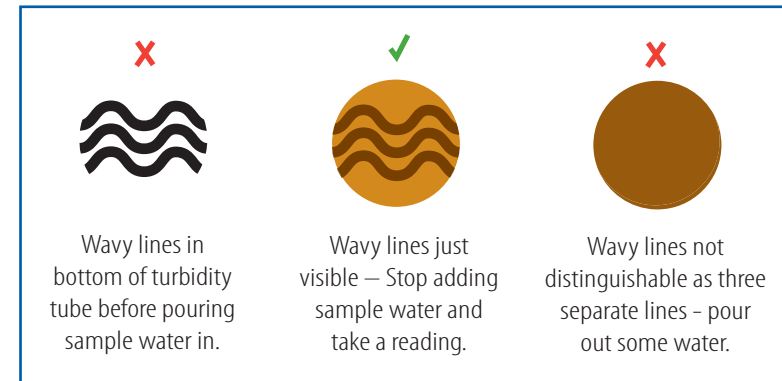
Turbidity is a measure of the transparency of water due to suspended particles. Increasing turbidity reduces the distance that light can penetrate into water. Higher turbidity levels can increase water temperature and decrease photosynthesis of submerged plants.

Turbidity and total suspended solids are related, so turbidity levels provide an indicator of soil loss in the catchment. Often phosphorus can be attached to soil particles and lost to water bodies.

Turbidity should be assessed as soon as the sample is taken. If sample is not assessed within 30 seconds after being taken, the sample will need to be shaken thoroughly to remix sediment. Turbidity tubes cannot be used in dim or artificial light conditions, at night or while wearing sunglasses.

Procedure

1. Take a 1.0 L representative sample from the sampling location taking care not to stir up any sediment from the channel edges.
2. Hold the turbidity tube at midpoint of the tube (between your thumb and forefinger). Turn so that your back is to the sun and the turbidity tube is in the shade of your body.
3. Shake your water sample vigorously. Gradually pour the sample water into the tube while looking vertically down the tube until the 3 lines become hazy, but still distinguishable as three separate lines.



4. Look at the scale on the side of the turbidity tube and record the reading on your field record sheet.
5. If the value is >200 NTU, record as 200 NTU. The turbidity tube has a logarithmic scale. Record the closest value that is marked on the tube and do not try to “estimate” an intermediate value.

Units: Nephelometric Turbidity Units (NTU)

NTU	Effects
< 10	Generally good water quality.
10 – 50	Low risk to water quality. Continue to review your farming practices to minimise sediment loss.
> 50	Moderate risk to water quality. Continue to review your farming practices to minimise sediment loss.

< Less than - > Greater than

Electrical Conductivity – E.C.

Electrical conductivity (E.C.) is an indicator of the concentration of salts in the water. Water containing excess salts can damage the structure of soil (if used for irrigation purposes) and can also affect the growth of plants and animals.

Sea water is about 53 mS/cm, whilst normal drinking water should be less than 1.5 mS/cm. Water with an E.C. value greater than 1.5 mS/cm is generally not suitable for irrigating sodic soils.

There are many brands of E.C. meters currently available, however they all function in a similar manner and are simple to use. Follow the manufacturer's instructions closely for accurate results.

All E.C. meters require calibrating with standard solutions prior to use. The calibration procedure should be carried out periodically (at least once a month).

The calibration standard should be near the range of your expected measurements.



Procedure

1. Turn your E.C. meter on a few minutes before use.
2. Remove cap and rinse the electrode in the water you will be measuring.
3. Dip electrode into sample, making sure the sensor is fully covered.
4. After several seconds reading will stabilise.
5. Record value taking special care that decimal place and units are correctly assigned.
6. Rinse electrode and shake dry, turn off and store safely.

Dissolved Oxygen - D.O.

The dissolved oxygen (D.O.) concentration depends on the physical, chemical and biological activities in a water body, and its measurement provides a good indication of water quality. Changes in D.O. concentrations can be an early indication of changing conditions in the water body.

Runoff from freshly harvested cane paddocks and stockpiles of mill mud will contain dissolved sugars. These sugars provide a substrate for bacteria which can use up much of the D.O. in the water body. Nutrients in the water can promote excessive algal growth which can affect D.O. concentrations. D.O. concentrations less than 4mg/L may be stressful to fish and should be avoided where possible.

There are many brands of D.O. meters commercially available and they all operate in a similar manner. D.O. changes rapidly in some conditions and should be measured on site. D.O. concentration may also vary with depth, particularly in low flow situations. D.O. meters should be calibrated and used according to manufacturer's instructions with particular care that the membrane is changed regularly.



Procedure

1. Turn meter on a few minutes before calibration.
2. Calibrate in saturated air as according to instructions.
3. Change membrane if necessary.
4. Place sensor in solution at pre-determined depth.

If using a membrane style D.O. meter it is necessary to move it up and down gently whilst taking the reading.

5. After several seconds the reading will stabilise.
6. Note and record the reading, taking particular note of the units of measurement.
7. Rinse sensor and turn meter off.
8. Store away in carry case.

D.O. mg/L	Effects
< 4	May cause stress to fish.
> 4	Generally supports a well functioning aquatic ecosystem.

< Less than - > Greater than

Pesticides

Pesticide runoff from farms include insecticide, herbicide and fungicide residues. If residual levels are high, they may have a direct, acute effect (e.g. a fish kill), a cumulative effect (where levels accumulate over time or in the food chain) or a long term effect (e.g. long term herbicide effect on aquatic plants).

Pesticide residue analyses have to be done at specialised laboratories. If possible, advise the laboratory you are taking a pesticide sample. Samples should be collected and stored in dark glass bottles and kept cool. These analyses are costly therefore consider an appropriate sampling strategy.



Procedure

1. Collect a sample directly into the sample bottle from the water body.
2. Hold the mouth of the bottle upstream while collecting the sample. Fill the bottle completely then pour some out so that about 75% remains. This allows room to expand when the sample is being chilled.
3. Seal the bottle and label it with the sample code, site name, date, time and person who took the sample.
4. Record details on the field record sheet. This should include sample code, site, date, time, person doing the sample and details of where the sample was taken from e.g tail water, drainage, natural flows or storm water.
5. Wipe the bottle and place in an esky filled with ice.
6. Deliver the chilled sample to the laboratory.
7. Record the sample details and analyses required on a new laboratory analysis sheet. This sheet should be copied and one copy should accompany the samples when they are sent for analysis.
8. Complete the field record sheet and laboratory analysis sheet.
9. When the results are received, discuss these with your CANEGROWERS officer, local NRM co-ordinator or your BSES extension officer.

Appendix 1

Calculation of flow rate

- (i) If flow control structures are available, flow can be calculated using the calibration equation that is appropriate for that particular structure. Height of water through the structure is required for the equation.

Some flow control structures include V Notch weirs, crested weirs and various flume configurations. Retention of crop residues on weir crest or in the throat of flumes will cause errors in the flow calculation. The san-dimas flume passes crop residues readily and is recommended in most situations.

- (ii) When no flow control structure is available flow can be estimated following the procedure as below:

Procedure

Channel cross section (width x depth)

1. Measure the average depth (metres) of the water body, using a metre stick.
2. Measure (or estimate) the width of the water body in metres.
3. Time how long it takes (seconds) for the buoyant object to travel a distance that you have measured.

Each buoyant object needs to be approximately the same size and weight to ensure the flow rate is measured accurately.

Calculations

$$F = C \times V$$

Flow rate estimate = **C** (width (m) x depth (m)) x **V**elocity (m/s)

Units: Cross section - square metres (m²)
Velocity - metres per second (m/s)
Flow rate - cubic metres per second (m³/s)

Example

Width = 2 m Depth = 1 m $W \times D = C$ $C = 2 \text{ m} \times 1 \text{ m} = 2 \text{ m}^2$

The object moved 20 m in 10 seconds $V = 20 \text{ m} / 10 \text{ secs} = 2 \text{ m/sec}$

$$\text{Flow} = C (2 \text{ m}^2) \times V (2 \text{ m/sec}) = 4 \text{ m}^3/\text{s}$$

Calculations of load

$$L = C \times F$$

Load = Concentration x Flow

Units: Load - grams per second (g/s) or kilograms per hour (kg/h)
Concentration - grams per Litre (g/L)
Flow rate - cubic metres per second (m³/s)

Example

Concentration - Convert mg/L to g/L by dividing by 1000

$$\text{Concentration} = 1 \text{ mg/L NO}_3\text{-N} \div 1000 = \mathbf{0.001 \text{ g/L NO}_3\text{-N}}$$

Flow - Convert m³/s to L/s by multiplying by 1000

$$\text{Flow} = 4 \text{ m}^3\text{/s} \times 1000 = 4000 \text{ L/s}$$

Flow - Convert L/s to L/h by multiplying by 3600

$$\text{Flow} = 4000 \text{ L/s} \times 3600 = \mathbf{14\,400\,000 \text{ L/h}}$$

$$L \text{ (g/h)} = C \text{ (g/L)} \times F \text{ (L/h)}$$

$$\mathbf{14\,400 \text{ g/h}} = \mathbf{0.001 \text{ g/L NO}_3\text{-N}} \times \mathbf{14\,400\,000 \text{ L/h}}$$

Convert g/h into kg/h by dividing by 1000

$$\mathbf{\text{Load}} = 14\,400 \text{ g/h} \div 1000 = \mathbf{14.4 \text{ kg/h NO}_3\text{-N}}$$
 in runoff

Appendix 2

Instructions for Hach Colour Comparator

To test for Orthophosphate phosphorus (PO₄-P)

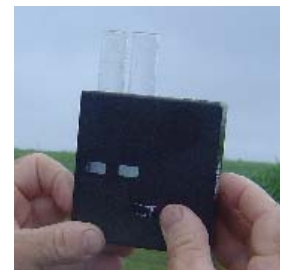
Procedure

1. Fill a viewing tube to the first (5 ml) line with sample water. This is the blank. Place this tube in the top left opening of the colour comparator.
2. Fill another viewing tube to the first (5 ml) line with sample water.
3. Add the contents of one Phos Ver 3 Phosphate Reagent Powder Pillow to the second tube.
4. Swirl to mix. Wait at least one minute for full colour development.



If phosphate is present, a blue-violet colour develops. Complete the test and read the result within five minutes of the addition of powder.

5. Place the second tube in the top right opening of the colour comparator.
6. Hold comparator up to a light source such as the sky. Look through the openings on the front. Rotate the colour disk until the colour matches in the two openings.
7. Divide the reading in the scale window by 10 to obtain the mg/L phosphate concentration or divide by 30 for mg/L orthophosphate phosphorus concentration.



See table on page 13 for recommended concentrations.



CANEGROWERS

GPO Box 1032/190-194 Edward Street

Brisbane Qld Australia

Phone: 07 3864 6444 : Fax: 07 3864 6478 : www.canegrowers.com.au

