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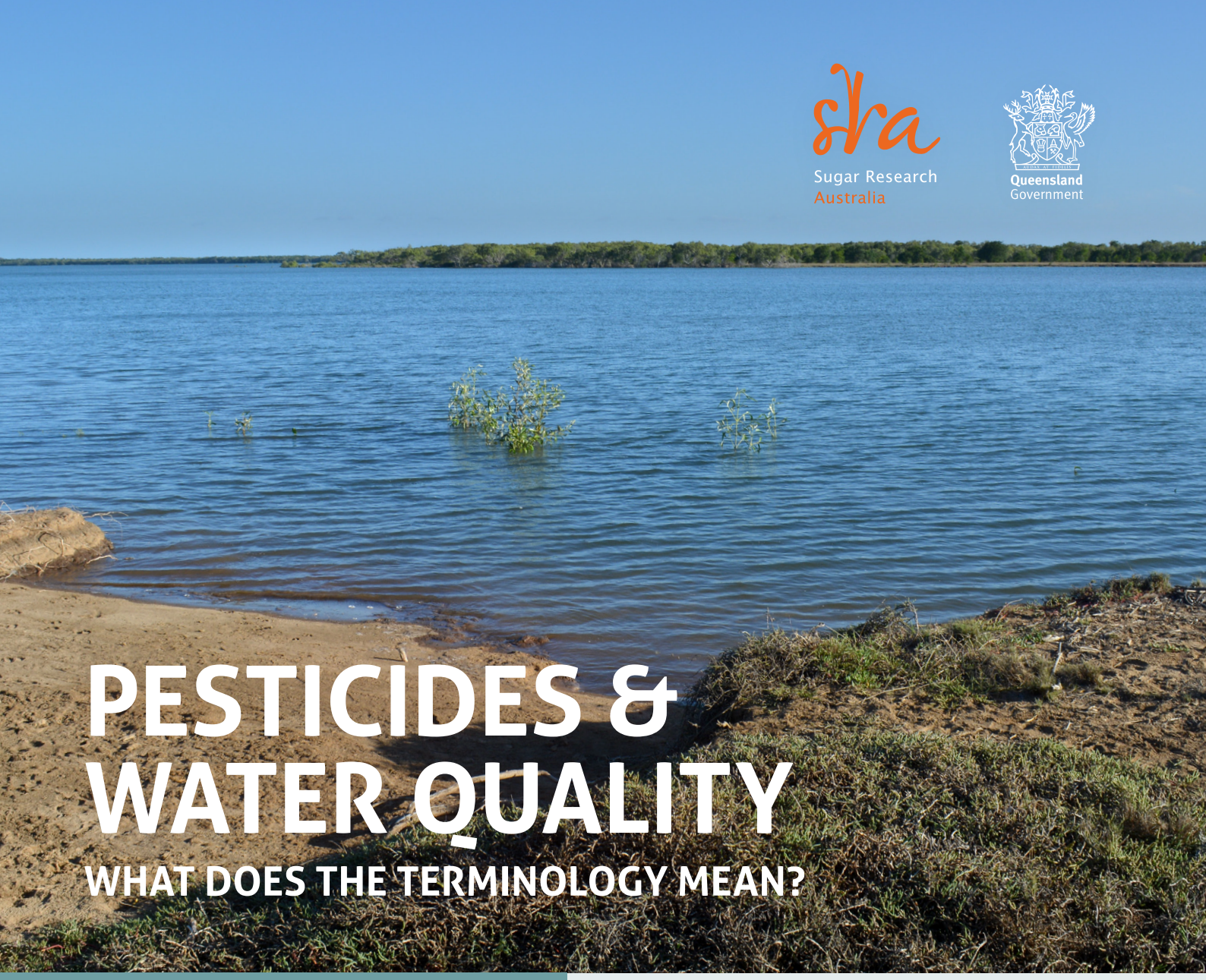

PESTICIDES & WATER QUALITY

WHAT DOES THE TERMINOLOGY MEAN?

The science behind water quality can be complex. As farmers and advisors we are used to talking about how herbicides and insecticides affect weeds and insect pests in our cane fields; after all we are generally trying to kill them!

When it comes to understanding the impact of these pesticides on aquatic organisms that live in our creeks and in the marine environment, sometimes it seems like a different language is being used.

Here we will explain some terminology that you are likely to come across when reading about water quality or attending water quality meetings.

PESTICIDES

Pesticides is a general term that includes herbicides, insecticides and fungicides.

WATER QUALITY

Water quality refers to the chemical, physical, biological and radiological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and/or to any human need or purpose.

Improving the quality of water entering the Great Barrier Reef (GBR) is fundamental to building resilience of the ecosystems which support significant biodiversity and species of conservation concern such as turtles and dugongs, and drive fisheries productivity. It is also likely to reduce the frequency of future crown-of-thorns starfish outbreaks, with one line of evidence suggesting these are driven by elevated concentrations of nutrients[1].

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AQUATIC ECOSYSTEM WATER QUALITY GUIDELINE VALUES

An aquatic ecosystem guideline value is the threshold concentration of a pesticide (or other toxicant) - below this threshold concentrations are considered to be a low risk of unacceptable effects occurring.

HOW ARE THE GUIDELINE VALUES DEVELOPED?

Different organisms have different tolerances to pesticides, so it can be challenging to work out what concentration of a pesticide would be safe for the entire community of organisms in our waterways. To do this, scientists test a range of freshwater or marine species exposed to different concentrations of toxicants (e.g. pesticides) in the laboratory (commonly referred to as 'toxicity tests').

The results of those tests are usually expressed as concentrations of the pesticide that caused death within a specific time period (e.g. 96-hour Median Lethal Concentration or LC50) or as a harmful effect on growth or reproduction (e.g. 14-day Median Effect Concentration or EC50). For the development of a guideline to help ensure waterways do not exceed harmful levels, small or no effect data are used (e.g. the 10% Effect Concentration (EC10) or No Observable Effect Concentration (NOEC)).

When enough of these kinds of toxicity data are available, they are plotted on a graph called a species sensitivity distribution (SSD), and a line of best fit is then calculated to describe the distribution (see Figure 1).

For example, the species sensitivity distribution in Figure 1, represents results for 21 different freshwater species exposed to metolachlor (square, circle and triangle symbols on the graph). The 21 species here are labelled according to the six phyla to which they belong – phyla is a much broader grouping of organisms than species, genus or family.

See reference section for the source publication. It is available at **waterquality.gov.au/sites/default/files/documents/metolachlor_fresh_dgv-technical-brief.pdf.** Many other toxicant guidelines are available at **waterquality.gov.au/anz-guidelines/guideline-values/default/water-qualitytoxicants/toxicants.**

The line of best fit (e.g. red line in Figure 1) is used to set guideline values that would protect a proportion of the aquatic community (the percentage of species potentially affected shown on the vertical axis in Figure 1).

The line of best fit, e.g. the red line in the metolachlor SSD shown in Figure 1, can be used to calculate guideline values for the protection of ecosystems of different ecological value (see Table 1).

Most freshwater systems in the Great Barrier Reef (GBR) catchments are classified as moderately disturbed, and as a general rule (with some exceptions), the concentration that affects 5% of the whole aquatic community is used as a guideline for the protection of 95% of the community. This guideline is often referred to as the PC95.

Aquatic ecosystems classified as having high ecological value or as slightly disturbed, have guideline values set at a level that will protect 99% of species. At the end of each catchment, where the waterways meet the high ecological value GBR World Heritage Area, the accepted guideline values for pesticides in GBR waters are based on the 99% of species protection level (PC99). End-of-catchment is the estuarine area where freshwater meets the marine environment.

WHO DECIDES WHAT THE GUIDELINE VALUES ARE?

The Australian and New Zealand governments work together with states and territories to set water quality guidelines for both fresh and marine waters. This is done through the framework set in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) **(waterquality.gov.au/anz-guidelines)**, and in relevant jurisdictional legislation.

(Figure 1) *Species sensitivity distribution generated using Burrlioz 2.0 (2016) of the sensitivity of freshwater species exposed to metolachlor.[2] The red line represents the line of best fit and the blue lines represent the concentration that would protect 95% of species.*

(Figure 2) *Daily ms-PAF of a river in the GBR catchment. (Source: DES). Note that the vertical axis represents the proportion of species affected rather than the proportion protected. The coloured bands are the same as the ecological condition categories defined with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

(Table 1) *Guideline values for different ecological values using metolachlor as the example*

(Table 2) *Pesticides and insecticides used to calculate Pesticide Risk Metrics for GBR catchments.*

Fig. 1

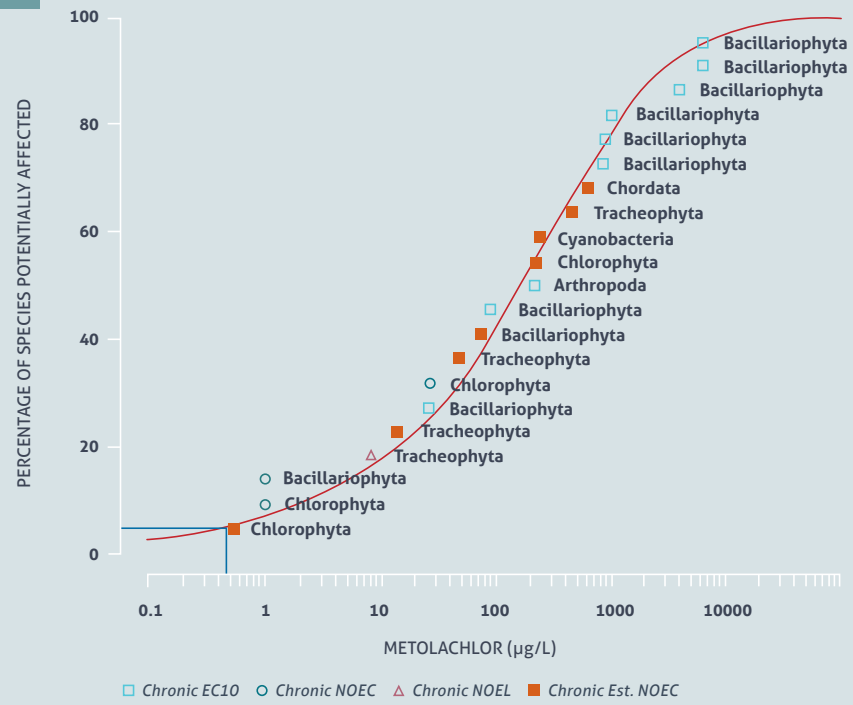
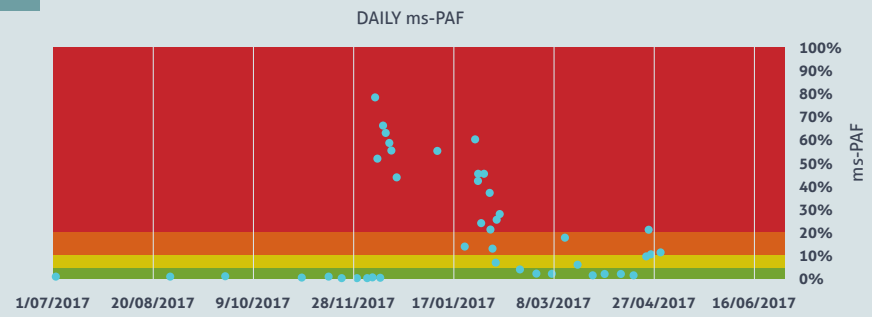


Fig. 2



Toxicants under the ANZG are currently undergoing a major review and update process. Draft toxicant materials are being progressively released on the ANZG website for a minimum of three months for public comment to finalisation. Refer to the ANZG site for more details **(waterquality.gov.au/anz-guidelines/guideline-values/default/draft-dgvs#draft-default-guideline-values).**

The Queensland Department of Environment and Science (DES) is updating toxicant guidelines so they meet the requirements for accreditation as national guidelines under the ANZG. These build on the substantial technical work by DES that resulted in the derivation of proposed guidelines for 27 pesticides used within the GBR catchment. These proposed guidelines can be found at: **publications.qld.gov.au/dataset/proposed-guideline-values-27-pesticides-used-in-the-gbr-catchment/resource/12e1b6af-9b71-40aa-bb50-163fe577a2c1.**

WHAT UNITS OF MEASUREMENT ARE USED?

For pesticides, the default guideline values are reported in micrograms per litre (µg/L), which is the same as parts per billion (ppb).

Tab. 1

Guideline Type	Percentage of species protected	Guideline Value (µg/L)
Guideline for protection of High Ecological Value ecosystems (PC99)	99%	0.0084
Guideline for the protection of Moderately Disturbed ecosystems (PC95)	95%	0.46
Guideline for protection of Highly Disturbed ecosystems (PC90)	90%	2.6
Guideline for protection of Highly Disturbed ecosystems (PC80)	80%	15

Tab. 2

Herbicides			
2,4-D	Ametryn	Atrazine	Hexazinone
Diuron	Fluroxypyr	Haloxyfop	Metribuzin
Imazapic	Isoxaflutole	MCPA	Prometryn
Metolachlor	Metsulfuron-methyl	Pendimethalin	Triclopyr
Simazine	Tebuthiuron	Terbuthylazine	
Insecticides			
Chlorpyrifos	Fipronil	Imidacloprid	

PROTECTION CONCENTRATION VALUES

The Protection Concentration (PC) values are the short-hand term for those guideline values that are estimated to offer a level of protection to a given percentage of aquatic species:

- **PC95:** if the concentration in the water body is below this concentration, it is expected that at least 95% of species will be protected. The PC95 is most often applied as the guideline for protection of slightly-moderately disturbed aquatic ecosystems.
- **PC99:** if the concentration in the water body is below this concentration, it is expected that at least 99% of species will be protected. The PC99 is most often applied as the guideline for protection of high ecological value aquatic ecosystems.

The whole of the GBR marine park (including end-of-catchment estuarine systems) are classified as either slightly disturbed or high ecological value, both of these classifications are given a level of protection of 99% of species (PC99).

PESTICIDE RISK

For reporting pesticide risk in GBR catchments and marine ecosystems, pesticide indicator scores were developed using the Pesticide Risk Metric (PRM) approach. This approach builds on from the methods used for the water quality guidelines, but differs in that it accounts for the potential effects of multiple pesticides together, as they are often detected in GBR waterways as mixtures.

The terms used are the same as those used when referring to guidelines for individual pesticides. Measured concentrations of up to 22 different pesticides in a given sample are converted to a PRM value that expresses risk as either the percentage of aquatic species potentially affected by the mixture of pesticides or conversely the percentage of aquatic species protected from the mixture of pesticides.

The Reef 2050 Water Quality Improvement Plan has set a target ***"to protect at least 99% of aquatic species at the end-of-catchments"*** **(reefplan.qld.gov.au/).** This target aligns with the high ecological value protection level assigned to the waterbodies of the GBR. To measure the achievement towards meeting this target, the PRM approach is used, as the target is to protect 99% of species from all pesticides not just individual pesticides.

Currently 22 pesticides are included when calculating the PRM for GBR catchments (Table 2).

The PRM is the annual wet season average of daily values of a calculated statistic called the multi substance – Potentially Affected Fraction (ms-PAF). The ms-PAF represents the percentage of species potentially affected of a mixture of up to 22 different pesticides. Further information about the how ms-PAF and the Pesticide Risk Metric is calculated can be found in *Australian and Queensland governments (2019)*[3]. Figure 2 shows an example of measuring ms-PAF in a river in Central Queensland.

The percentage of aquatic species affected varies over time, from almost no impact in low flow conditions (i.e. prior to the first run-off of the wet season) and increasing to around 80% of species impacted with the first summer rainfall.

The PRM can be compared between catchments and between years to track changes in the condition of the waterway.

REFERENCES

[1] Brodie JE, Fabricius K, De'ath G, Okaji K (2005) Are increased nutrient inputs responsible for more outbreaks of crown of thorns starfish? an appraisal of the evidence. Mar Pollut Bull 51: 266-278.

[2] ANZG 2020, Toxicant default guideline values for aquatic ecosystem protection: Metolachlor in freshwater. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. CC BY 4.0. Australian and New Zealand Governments and Australian state and territory governments, Canberra, ACT, Australia.

[3] Australian and Queensland governments (2019). Pesticide Risk Baseline Methods: Reef Water Quality Report Card 2017 and 2018. State of Queensland, Brisbane.

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MORE INFORMATION

Belinda Billing **Principle Researcher** E BBilling@sugarresearch.com.au T 07 4056 4512
Molly O'Dea **Adoption Officer** E MODea@sugarresearch.com.au M 0439 619 082