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THE POTENTIAL FOR REDUCING THE UNCERTAINTY OF DETERMINISTIC ENVIRONMENTAL QUALITY STANDARDS (EQS) BY INCREASING THE MINIMUM ECOTOXICITY DATASET

Graham Merrington, Dean Leverett, Adam Peters, Peter Simpson

wca environment limited, Volunteer Way, Faringdon, Oxfordshire, UK

ABSTRACT

A review of guidance documents from Australia, Canada, the US and Europe on the derivation of long-term, aquatic chemical standards has shown that the minimum ecotoxicity dataset requirement is smallest in Europe, where an annual average Environmental Quality Standard (EQS) may be derived deterministically from just a single chronic data point (so long as acute data are also available). Conversely, the European data requirements for the derivation of an EQS using a probabilistic approach are the largest of all the jurisdictions reviewed (10-15 chronic values from 8 taxonomic groups).

A review of the EQS for the current 33 priority substances under the Water Framework Directive (WFD) shows that those derived using deterministic approaches (i.e. where data for too few species are available to allow the use of a Species Sensitivity Distribution) have assessment factors ranging from 2 to 500 and that 5 of the 33 substances have EQS derived from datasets which include five or fewer chronic data points.

Using four chemicals for which large chronic datasets are readily available and for which EQS derivation is commonly undertaken across regulatory jurisdictions we undertook a simple exercise to assess the effect of dataset size on the EQS value according to the current Technical Guidance Document for deriving EQS under the WFD. The variability of the EQS calculated from randomly selected data points from each dataset is shown to sharply decrease when using seven or more chronic data points from three trophic levels, even when the same assessment factor (10) was used. Given the implications of introducing an EQS, we suggest that it would be appropriate to require more data for the derivation of a determinstic EQS. From the data reviewed here, it appears that deterministic calculations based on a greater number of chronic data points will reduce uncertainty in the derived EQS (even though this would not be reflected in the size of the assessment factor which would remain at 10). A significant reduction in uncertainty would be achieved with seven chronic values from three trophic levels.

HOW MUCH DATA IS NEEDED TO DERIVE AN ENVIRONMENTAL QUALITY STANDARD?

An EQS is generally derived from a relatively limited number of laboratory ecotoxicity data using an extrapolation step to provide a numerical value that is deemed protective of an aquatic ecosystem. Depending on the regulatory jurisdiction (and often data availability, i.e. number, exposure duration and taxonomic coverage of ecotoxicity test results) the extrapolation step is performed using assessment or uncertainty factors (Table 1). It can be seen from Table 1 that when using deterministic approaches the EU EQS Guidance (EC 2011) provides for the greatest range of factors. These factors are often considered to have limited scientific foundation (e.g. Chapman et al. 1998), but are generally applied to the lowest chronic value (EC10 or No Observed Effect Concentration) in order to account for the possibility that the most sensitive species in the ecosystem is more sensitive than the most sensitive species tested.

MORE DATA MORE CERTAINTY?

The specific challenge associated with the use of assessment factors in the EU EQS TGD are that the factor does not change when there are between three and nine chronic data available. This means that the increased understanding, and relative reduction in uncertainty, gained through having more data does not result in a change in the EQS. One could reasonably view this as disincentive to generate more data beyond the minimum three chronic studies, and is certainly an unintended consequence of assessment factor use in the deterministic approach, which was originally designed to highlight data needs and information requirements (OECD 1992).

Here we examine how an EQS, for four chemicals for which EQS are commonly derived and which have large chronic datasets, may change in relation to the size and composition of the chronic dataset using the deterministic approach outlined in the EU EQS TGD. In this exercise, 'certainty' is indicated by the standard deviation around the calculated mean for each data availability scenario (Table 2).

METHODOLOGY

Chronic ecotoxicity datasets for glyphosate, copper, chloride and cadmium were taken from publically available regulatory dossiers from the UK, CCME, Alberta and the EU, respectively. For the metals no correction for (bio)availability was undertaken. The datasets used here are relatively large but, to ensure that data selection is reflective of scenarios where few data may be available, random sub-sampling (using Microsoft Excel™) was used to create datasets indicative of six data availability scenarios (ranging from one to many ecotoxicity data points (Table 2)). For each scenario, each row of data in the spreadsheet containing the NOEC/EC10 is randomly allocated a number between 0 and 1. By sorting the random numbers allocated to the data row by size and selecting the x largest random numbers (depending on the size of the dataset required) a NOEC/EC10 can be randomly selected from the dataset. Each scenario was undertaken ten times and the result meaned. The rules applied in the scenarios, in relation to assessment factor applied and dataset composition and size, are taken directly from the EU EQS TGD.

RESULTS AND DISCUSSION

Results for two of the chemicals assessed are shown in Figures 1 and 2 for the scenarios outlined in Table 2 (the results of the other two chemicals displayed similar patterns). The HC5-50s (Median Hazardous Concentration that affects 5% of the organisms) divide by an AF of 3 are shown in both figures ringed by red circles. The variability in the derived EQS, as described by the standard deviation across the 10 random sub-samples, decreases as the dataset size increases and that this is generally when five or more data points are available (although for chloride there is low relative variability with low data numbers too).

If the HC5-50 represents the EQS with the greatest ecological relevance and certainty (which is arguable), then a comparison with the values for each substance derived using between three and five data highlights the potential to significantly over and underestimate this value. Therefore, rather than delivering a consistently precautionary value when using assessment factors the value derived using smaller datasets for all the substances considered are just consistently variable. This suggests that a sliding scale of assessment factors, more closely linked to dataset size and composition would be more appropriate.

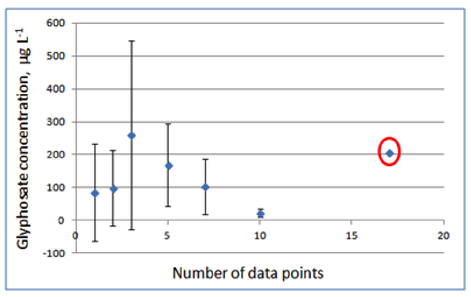

Figure 1. Mean concentrations of glyphosate derived as EQS using different randomly selected numbers of data points. The bars represent ±1 standard deviation. The circled dot is the HC5-50 derived from an SSD with an AF of 3.

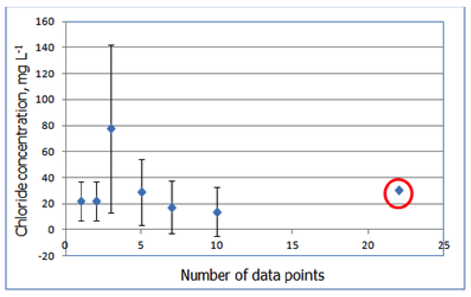

Figure 2. Mean concentrations of chloride derived as EQS using different randomly selected numbers of data points. The bars represent ±1 standard deviation. The circled dot is the HC5-50 derived from an SSD with an AF of 3.

Table 1. Assessment Factors used in Deriving EQS (for freshwaters)

Jurisdiction	Assessment Factors
Alberta, Canada	Short-term: 5 (applied to chronic data) Long-term: 10
CCME (Canada)	Short-term: 10 Long-term: 10
British Columbia, Canada	Short-term: 2 to 10 Long-term: 2 to 10
US EPA	Approach not used
EC	Short-term: 10-100 Long-term: 10-1000
UK	Short-term: 10-50 Long-term: 10-50
ANZECC	Long-term: 10-100

Table 2. Scenarios Assessed with the previously published ecotoxicity datasets

Scenario number	Chronic dataset size (number of NOEC/EC10s)	Assessment Factor applied (and assumption in line with Table 2 in EC 2011)
1	1	100
2	2	50
3	3	10
4	5	10
5	7	10
6	10	10

CONCLUSIONS

- The specific challenges associated with the use of assessment factors in EU EQS TGD are that the factor does not change if there are just three chronic data or up to nine chronic data available.
- Increased understanding, and relative reduction in uncertainty, gained through having more data does not result in a change in the EQS - a considerable disincentive to generate more data beyond the three chronic studies.
- Based on the analysis reported here, a minimum requirement under the EU EQS TGD in excess of the current requirement for a base set of three acute values from three trophic levels would greatly reduce uncertainty in EQS. Reduced uncertainty could be achieved using datasets comprised of perhaps seven chronic EC10 or NOEC values selected from across three trophic levels.
- There are methods under development that more closely link the assessment factor size to the sample size and these have the considerable advantage over the existing EU EQS TGD methods in that the assessment factors tend to reduce as data availability increases and are linked to an *explicit* level of ecological protection (Ad Ragas pers. comm).

References:

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wca environment
Brunel House, Volunteer Way, Faringdon, Oxfordshire, SN7 7YR
Tel: 01367 246026 Fax: 01367 246041
www.wca-environment.com solutions@wca-environment.com