The Relative Sensitivity of Macrophyte and Algal Species to Herbicides and Fungicides: An Analysis Using Species Sensitivity Distributions

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ABSTRACT

In January 2008, at a SETAC workshop on Aquatic Macrophyte Risk Assessment for Pesticides (AMRAP), a Species Sensitivity Distribution (SSD) working group was formed to address uncertainties about the sensitivity of Lemma and other standard test species to pesticides relative to other aquatic macrophyte species. For 13 herbicides and 3 fungicides for which relevant and reliable data were available, 6 macrophyte species (considered the minimum for SSD analysis), 9 SSDs were fitted using lognormal regression. The position of L. gibba in each SSD was determined. The sensitivity of standard algal test species relative to the macrophytes in each SSD was also considered (algae were not included in the SSD). In recognition of the known sensitivity of Myriophyllum species towards some herbicides and ongoing activities to develop standardized test methods for these species, the position of M. spicatum in each SSD was also determined where data were available. Results indicate that L. gibba is among the most sensitive macrophyte species for approximately half of the chemicals examined. In the majority of cases, the least sensitive algal test species endpoint was lower than the most sensitive macrophyte endpoint. M. spicatum was among the most sensitive macrophytes for approximately one-quarter of the chemicals. While no single species consistently represents the most sensitive aquatic plants for all chemicals, it is possible that a data point based on a non-standard measurement parameter could unduly influence the SSD.

BACKGROUND AND OBJECTIVE

For various practical and historical reasons, the macrophytes were widely used in toxicity tests with pesticides because of the genus Lemma. However, the sensitivity of Lemma spp. relative to other aquatic macrophyte species is largely unknown. The primary objective of the SSD working group was to investigate this question using available data on the toxicity of pesticides, especially herbicides, to aquatic macrophytes.

METHODS

We collected macrophyte and algal toxicity data for nearly 60 herbicides and fungicides from the open literature and confidential company reports. We reviewed each data source according to predefined criteria, and only data sources that satisfied all criteria were included in the analysis. (In a few cases data were taken from reliable secondary sources and data quality was not independently confirmed.) For 11 herbicides and 3 fungicides, usable toxicity data were found for at least 6 macrophyte species, which was considered the minimum needed for SSD analysis. SSD analysis

DATA SELECTION

The database of 13 chemicals contained a variety of statistical endpoints, but only median effect concentrations (EC50s) were available for a sufficient number of species to support SSD analysis. The EC50s were based on a wide variety of biological measurements, and these had to be pooled for SSD analysis. Basing SSDs on a variety of measurements was necessary because differences in toxicity of the test species necessitate differences in measured responses (e.g., frond number, root length, plant dry weight), but all SSDs were based on a single measurement (EC50) for each chemical. Since the response varies for different species (e.g., brave the database by categories of measured data points severely reduces the number of SSDs that can be evaluated, because equivalent data are only available for 6 or more species.

Given the difficulties of restricting data selection for SSDs based on categories of measurement data points, the SSDs examined in this project used the lowest reported EC50 for each species, regardless of the biological measurement upon which the EC50 was based. While selection of the lowest available EC50 is standard regulatory practice (e.g., US EPA 2004), it leaves open the possibility that a data point based on a non-standard measurement parameter could unduly influence the SSD.

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RESULTS

For the exceptional chemicals for which the EC50s of L. gibba and M. spicatum were available, the test organisms were healthy at the beginning of the exposure for all chemicals. Were the test organisms healthy at the beginning of the exposure for all chemicals.

USABILITY CRITERIA

Each study was evaluated according to the following criteria.

• Test organisms must be identified at least to genus. Test concentration units must be unambiguous. Exposure duration must be specified. Are methods documented sufficiently?

FINDINGS

(a) When the most sensitive species of interest (e.g., L. gibba, the 4 FITRA algae, and M. spicatum) are considered, the lowest of these E50s is within the lower 25th percentile of the macrophyte SSD for nearly all chemicals.

(b) The E50 for the most sensitive of these species is at or below the corresponding macrophyte HCS for 6 of 14 chemicals. The lowest E50 of these species is within a factor of 10 of the HCS for all chemicals.

(c) The lowest of these EC50s is at or below the EC50 of the most sensitive macrophyte for all chemicals except chemicals D2 and F2. For even these exceptions, the difference is in a factor of 5.

CONCLUSIONS

Neither Lemma gibba nor Myriophyllum spicatum is consistently among the most sensitive macrophyte species for all herbicides and fungicides.

SSD Examples

The SSD for Chemical F4

The SSD for Chemical B

The report, “The Relative Sensitivity of Macrophyte and Algal Species to Herbicides and Fungicides: An Analysis Using Species Sensitivity Distributions,” is available from the author and will also be made available through the SETAC Aquatic Macrophyte Ecotoxicology Group (AMEG).