Aquatic ecotoxicity of glyphosate and AMPA

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Important Notes to users:

This document is part of a toolbox which provides independent information on the sustainable use of Glyphosate. It cannot however be definitive and users must ensure that they assess local factors and particularly take account of any national or regional legislative requirements. At the end of the document reference sources used in its preparation and links to other relevant documents are provided.

Summary

Algae and macrophytes are amongst the most sensitive test species for glyphosate acid and the IPA salt. This is confirmed when using Species Sensitivity Distributions on the basis of acute toxicity data. The main degradation product of glyphosate, AMPA, is less toxic than glyphosate acid for all species tested. Consequently risks of AMPA are appropriately covered if concentrations of glyphosate in surface waters are at or below the threshold level for toxic effects. Formulated products that contain the adjuvant POEA may be more toxic to aquatic species than the active ingredient glyphosate. However, also for these formulated products primary producers are the most sensitive species.

Introduction

An estimation of the ecotoxicological impact of herbicides in surface water often is based on laboratory toxicity tests with standard and/or additional aquatic test species. Toxicity data of glyphosate, or any of the formulated products containing glyphosate, are usually expressed either as a concentration causing a specific effect (e.g. death or growth) in 50% of the tested organisms (Lethal Concentration or Effect Concentration, LC50 or EC50) or as the highest concentration tested not showing an effect compared to controls (No Observed Effect Concentration, NOEC). In this summary all short term (acute) toxicity data are given as LC50/EC50's, whereas longer term (chronic) toxicity data are given as a NOEC.

In toxicity tests the compound can be administered as the technical product glyphosate, in the form of an acid. However, often a salt of glyphosate (e.g. the sodium salt or the isopropylamine salt = IPA salt) or a formulated product, containing adjuvants alongside the active ingredient, is used. The result of a toxicity test (LC50/EC50 or NOEC) often reflects the type of compound or formulation used in the test, and is e.g. given as mg/L of the acid compound, mg/L of the active ingredient (often a salt of glyphosate), or mg/L of the formulated product used in the test. Because of differences in molecular weight between the various forms of glyphosate all toxicity values were converted into the same units, based on the molecular weight of the acid form of glyphosate (169.1). These 'acid equivalents' (= a.e.) constitute an unambiguous measure of the amount of glyphosate present, simply assuming that all glyphosate is present in the acid form.

Glyphosate is transformed in the environment into a number of substances, among which the metabolite aminomethylphosphonic acid (AMPA) is the most common. For reference, in this summary an assessment of the toxicity of AMPA is given as well,

A more detailed report on the aquatic ecotoxicity of glyphosate and formulated products with glyphosate, including lists of acute and chronic toxicity and references, can be found in the list of references.

Ecotoxicological effect characterisation for different taxonomic groups

Species Sensitivity Distribution (SSD) may be used to calculate the concentration at which a specified proportion of species are expected to suffer direct toxic effects. When compared with the first-tier effects assessment on the basis of standard test species, SSDs have the advantage of making more use of the available laboratory toxicity data for a larger array of species. They describe the range of sensitivity rather than focusing on a single value, they enable estimates to be made of the proportion of the species affected (within certain taxonomic groups) at different concentrations.

A statistical extrapolation technique is often used to calculate the concentration at which a specified proportion of species (*p*) are expected to suffer direct toxic effects, referred to as the Hazardous Concentration (HC) to *p*% of the species (HC*p*). The Species Sensitivity Distribution from which the HC*p* is derived can be based on either acute or chronic toxicity data. However, the smaller the number of data available for the calculation, the larger the confidence interval around the SSD (and the HC*p*) will be. In Europe it is common to take the 5th percentile of the SSD (median HC5), or the lower 90% confidence bound for it (lower limit HC5). When based on acute toxicity data the median HC5 is the concentration for which 95% of the tested species with 50% certainty have a higher L(E)C50 value, while the lower limit HC5 represents the concentration for which 95% of the species tested with 95% certainty have a higher LC50 or EC50.

Acute effects
As might be expected for an herbicide it appears that primary producers (algae and macrophytes) are amongst the most sensitive test species for glyphosate acid, and the IPA salt. The most sensitive species reported for glyphosate acid is the diatom *Skeletonema costatum* (geomean EC50 of 1.2 mg a.e./L). For the IPA salt of glyphosate this again is the diatom *Skeletonema costatum* (EC50 of 5.9 mg a.e./L). For a formulated product containing glyphosate and the adjuvant POEA, the most sensitive species reported is the macrophyte *Myriophyllum spicatum* (EC50 of 0.33 mg a.e./L). For formulated products containing glyphosate and POEA enough acute toxicity data are available to allow the SSD approach. The median and lower limit HC5 values for primary producers and these formulated products are 0.146 and 0.015 mg a.e./L, respectively.

Chronic effects
The most sensitive species reported for glyphosate acid is the diatom *Skeletonema costatum* (NOEC of 0.28 mg a.e./L). For the IPA salt of glyphosate this is the green alga *Desmodesmus subspicatus* (NOEC of 7.8 mg a.e./L). The number of available chronic toxicity data for aquatic species and glyphosate acid and the IPA salt of glyphosate are relatively low, in total 10 chronic NOECs for different species of primary producers are available. Assuming that these chronic toxicity data for glyphosate acid and the IPA salt of glyphosate can be used in the same SSD, the calculated median chronic HC5 for primary producers was 0.425 mg a.e./L while the corresponding chronic lower limit HC5 was 0.062 mg a.e./L. For a formulated product containing glyphosate and the adjuvant POEA the most sensitive species reported is the green alga *Pseudokirchneriella subcapitata* (NOEC of 0.23 mg a.e./L). Not enough chronic toxicity data are available for the formulated products to allow the SSD approach.

Threshold concentrations for direct toxic effects of glyphosate
It is reported that for herbicides and primary producers the median value of the chronic HC5 is protective of adverse effects in aquatic micro/mesocosms even under a long-term exposure regime. Assuming similar relationships between calculated HC5 values and “safe” concentrations for glyphosate, for glyphosate acid and the IPA salt of glyphosate the acceptable concentration for long-term exposure may be 0.425 mg a.e./L (425 µg/L) (median chronic HC5 for primary producers). For long-term and/or repeated pulse-exposure to a formulated product containing glyphosate and the adjuvant POEA, however, it cannot be excluded that concentrations between 0.015 and 0.146 mg a.e./L may lead to some toxic effects on algae or macrophytes.

Ecotoxicological threshold levels for the metabolite AMPA
All available toxicity data indicate that the toxicity of AMPA towards standard test organisms is less than the toxicity of glyphosate acid. Consequently risks of AMPA are appropriately covered if concentrations of glyphosate in surface waters are at or below the threshold level for toxic effects.

Reference for further detailed information:

- Extended report on “Aquatic ecotoxicity of glyphosate and formulated products containing glyphosate” (Click here)

See also:

- Monitoring results for glyphosate and AMPA in surface and groundwater
- Environmental fate and behaviour of glyphosate and its main metabolite
- EU Water framework directive

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