

Environmental fate and behaviour of glyphosate and its main metabolite

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European Glyphosate Environmental Information Source

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.

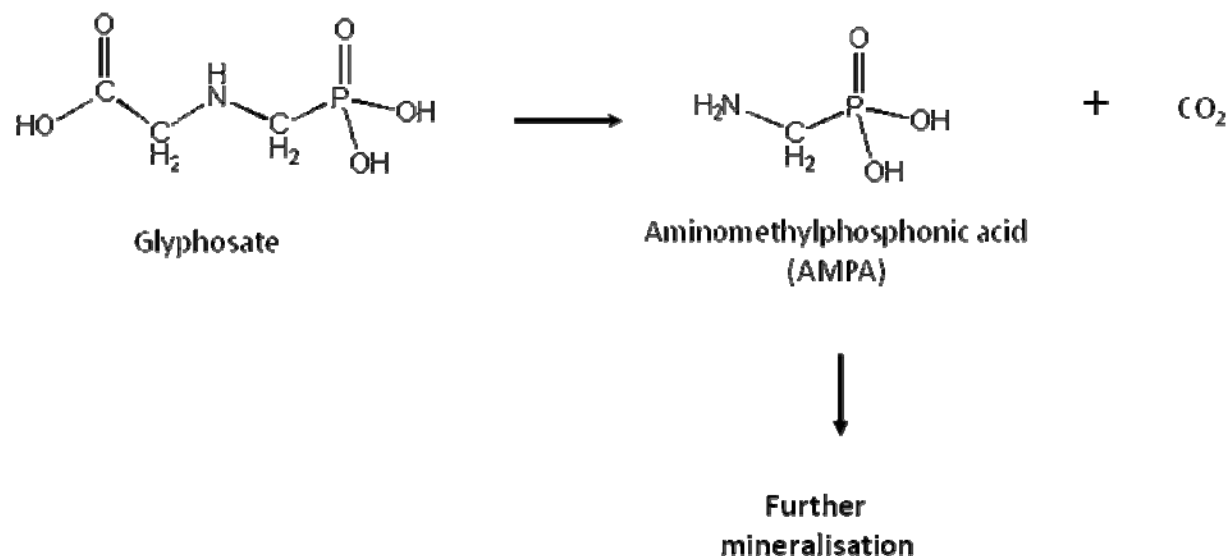
Summary

Glyphosate is readily degraded in soil, with laboratory half-lives ranging from 4 to 189 days (mean 49 days). The main metabolic pathway in soil and water leads to the formation of AMPA. AMPA is more persistent in soil with mean laboratory half-life of 120 days. Both compounds dissipate from surface water (water/sediment system) with half lives of less than 7 days. Glyphosate and AMPA are readily and strongly bound to soil. As a result, glyphosate and AMPA are characterised by very low mobility and are not prone to leaching. Run-off to surface waters mainly occur through sorption on soil particles. This note summarises available information on the environmental fate and behaviour of glyphosate.

Detailed information

Degradation in soil

Glyphosate degradation in soil has been extensively studied. Similarly to other members of the phosphonate class, which are compounds characterised by a C-P bond, glyphosate is relatively resistant to chemical hydrolysis, thermal decomposition and photolysis. Microbial degradation is considered the predominant mechanism of glyphosate transformation in soil. Microbial strains capable of growing in artificial media using glyphosate as the sole C, N or P source have been isolated. However, degradation of glyphosate in natural environments, such as the soil ecosystem, is mainly considered a non specific, co-metabolic process. The main metabolic pathway is degradation to AMPA, (aminomethylphosphonic acid), which is further mineralized to CO₂.



Glyphosate mineralisation is typically quite extensive (for example 48.8-55.3% in 28 days), but can be much lower (e.g. 5.8-9.3% in 112 days); depending on the soil type and is influenced by the soil moisture content (Grundmann *et al.*, 2008). Glyphosate mineralisation directly depends on its sorption on soils. Particularly, when soil pH and phosphate content decreased and when soil copper and iron

contents increased, glyphosate sorption increased and its mineralisation decreased (Mamy *et al.*, 2005).

Generally, Glyphosate is readily degraded in soil, with half-lives ranging from 4 to 189 days (mean 49 days) from laboratory studies, and 5 to 21 days in European field studies. Its degradation is however very dependent on soil type/condition. Thus very rarely, longer dissipation half-life values of several months have been reported, because of an overwinter persistence after an autumn application in Finland (Laitinen *et al.*, 2006).

The detection of glyphosate in soils does not mean that these residues are bioavailable. Indeed, the laboratory methods for extracting glyphosate from soil involve harsh conditions (0.1-0.5M KOH or NH₄OH) which release residues that, under normal conditions, would be bound to the soil and would not be available.

AMPA was demonstrated to be more persistent in soil than glyphosate, with half-life values ranging from 135 to 218 days under European field conditions and a mean half-life of 120 days under laboratory conditions.

Dissipation in water

In the water/sediment studies the dissipation half-life of glyphosate in water ranges from 1 to 4 days and from 27 to 146 days for the whole system. Under aerobic conditions, the main degradation pathway leads to the formation of AMPA; however, AMPA dissipates very rapidly from surface water, with half-lives from 2 to 5 days in water and from 19 to 45 days for the whole system. The original rapid dissipation of glyphosate and AMPA is through adsorption to the sediment, followed by further degradation in the sediment.

Sorption

Despite its relatively high water solubility, glyphosate is readily and strongly sorbed on soil, with partition coefficient (K_d) values between 5 and 900 mL g⁻¹. Unlike many other herbicides, glyphosate sorption to the soil does not seem to depend on soil organic matter content. Conversely, glyphosate mobility in soil largely depends on type and amount of clay, Fe and Al hydrous oxide content, pH value, inorganic phosphate concentration and ion strength of the liquid phase. Depending on the chemical-physical properties of the soil, different sorption mechanisms are involved. Several authors reported that glyphosate sorbs on soil through its phosphonic acid moiety. In general, sorption increases with decreasing of pH solution and increasing presence of Al and Fe ions at the exchange soil surface. In addition, glyphosate competes with inorganic phosphate for sorption sites. Partition coefficients (K_d) of AMPA were between 15 and 1554 mL g⁻¹.

Leaching

Available information on glyphosate mobility in soil indicates that glyphosate is characterised by very low mobility through the soil profile (Vereecken, 2005, Borgaard and Gimsing, 2008). Glyphosate mobility in soil is mainly governed by macropore flow. Since soil particle or colloidal transport of strongly adsorbed pesticides through macropores (preferential flow) should not be excluded, it could be predicted a slight increase of the low glyphosate leaching potential in soils where matrix flow is a significant process.

In a recent lysimeter study (Grundmann *et al.*, 2008) in a non structured sandy soil, even after multiple pesticide applications, leaching of glyphosate and AMPA was not increased and after 15 months more than 90% of the residues were in the upper 5 cm of the soil, with highest concentration in 0–2 cm. In another lysimeter study (Fomsgaard *et al.*, 2003), concentrations of glyphosate and AMPA above 0.1 µg L⁻¹ were found only occasionally which might be due to the leaching of particle-bound compounds.

Runoff

The strong sorption of glyphosate indicates that this compound is relatively immobile in soils and could be transported to surface waters mainly sorbed on soil particles. Unfortunately, very few studies on runoff losses of glyphosate have been carried out. In a study carried out in a USA watershed, maximum water losses of glyphosate losses ranged from 0.2 to 1.8% of the applied amount (Edwards *et al.*, 1980). In a three-year study in northern Italy, average annual water runoff losses of glyphosate were 0.003% of

the applied amount (Screpanti *et al.*, 2005). The highest glyphosate water losses were observed shortly after herbicide application, coinciding with high intensity runoff phenomena; however, the magnitude of sediment losses of glyphosate is not well known, because of lack of research.

Reference for further detailed information:

1. Borggaard OK, Gimsing AL (2008). Fate of glyphosate in soil and the possibility of leaching to ground and surface waters: a review. *Pest Manag. Sci.*, 64: 441-456.
2. Edwards WM, Triplett WB, Kramer RM (1980). A watershed study of glyphosate transport in runoff. *J. Environ. Qual.*, 9: 661-665.
3. Endpoints list of the glyphosate review report:([Click here](#))
4. Fomsgaard IS, Spliid NH, Felding G (2003). Leaching of pesticides through normal-tillage and low-tillage soil - A lysimeter study. II. Glyphosate. *J. Environ. Sci. Health Part B-Pestic. Contam. Agric. Wastes*
5. Grundmann S, Dorfler U, Ruth B, Loos C *et al.* (2008). Mineralization and Transfer Processes of ¹⁴C-labeled Pesticides in Outdoor Lysimeters. *Water Air Soil Pollut.: Focus* (2008) 8:177-185.
6. Laitinen P., Siimes K, Eronen L., Ramo S., Welling L., Oinonen S *et al.* (2006). Fate of the herbicides glyphosate, glufosinate-ammonium, phenmedipham, ethofumesate and metamitron in two Finnish arable soil. *Pest Manag. Sci.*, 62:473-491.
7. Mamy L, Barriuso E, Benoit G (2005). Environmental fate of herbicides trifluralin, metazachlor, metamitron and sulcotrione compared with that of glyphosate, a substitute broad spectrum herbicide for different glyphosate-resistant crops. *Pest Manag. Sci.*, 61:905-916.
8. Screpanti C, Accinelli C, Vicari A, Catizone P (2005). Glyphosate and glufosinate-ammonium runoff from a corn-growing area in Italy. *Agron. Sustain. Dev.*, 25:407-412.
9. Vereecken H (2005). Mobility and leaching of glyphosate: a review. *Pest Manag. Sci.*, 61:1139-1151.

See also:

- Monitoring results for glyphosate and AMPA in surface and groundwater
- Impact of glyphosate on water supply abstractions
- Aquatic ecotoxicity of glyphosate and AMPA

Document status:

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