



Glyphosate, the active ingredient in Roundup® brand agricultural herbicides, is degraded over time in the environment, primarily by soil microbes and fungi. The primary environmental degradate of glyphosate in soil and water is aminomethylphosphonic acid (AMPA). AMPA is further degraded to naturally occurring substances such as carbon dioxide and phosphate.

The U.S. Environmental Protection Agency, in the September 1993 Glyphosate Reregistration Eligibility Decision (RED)<sup>1</sup>, states: “Glyphosate is readily degraded by soil microbes to AMPA, which is degraded to carbon dioxide. Glyphosate and AMPA are not likely to move to ground water due to their strong adsorptive characteristics.”

Anti-pesticide groups have, over the years, repeatedly and incorrectly implied that formaldehyde is the predominant final degradate of AMPA in the environment. This statement is quoted from a 1988 review of glyphosate data by Monroe<sup>2</sup>. However, the reviewer apparently misunderstood a reference he cited. Rueppel *et al.*<sup>3</sup> proposed that formation of carbon dioxide from the degradation of AMPA in soil may involve formaldehyde as a transitory precursor, a theoretical possibility that had not been confirmed experimentally. Since that possibility was suggested in 1977, detailed studies using radiolabeled glyphosate have uniformly failed to detect formaldehyde as a distinct intermediate or final decomposition product of either glyphosate or AMPA in soil, plants or aquatic environment.<sup>4</sup>

Similar to other amino acids and natural organic matter, glyphosate can be selectively oxidized under certain laboratory conditions to form aqueous formaldehyde. For instance, laboratory experiments have indicated that both aqueous formaldehyde and carbon dioxide are formed during glyphosate chlorination with sodium hypochlorite<sup>5</sup>. Similarly, under intense artificial light, glyphosate may convert to both aqueous formaldehyde and carbon dioxide via oxidative transformation induced by photochemical excitation of humic acids as reported for other pesticides<sup>6</sup>.

Production of formaldehyde under certain laboratory conditions is not unique to glyphosate and would also be expected from oxidative fragmentation of many carbon containing small molecules, amino acids, and other natural organic compounds such as humic and fulvic acids<sup>7</sup>. However, in the field where glyphosate is used, there is overwhelming evidence that glyphosate is degraded by soil microbes primarily to AMPA, which is degraded over time to carbon dioxide and other naturally-occurring

<sup>1</sup> U.S. Environmental Protection Agency (EPA). (1993) Reregistration eligibility decision (RED): Glyphosate. Office of Prevention, Pesticides and Toxic Substances, Washington, DC. [http://www.epa.gov/oppsrrd1/REDs/old\\_rede/glyphosate.pdf](http://www.epa.gov/oppsrrd1/REDs/old_rede/glyphosate.pdf).

<sup>2</sup> Monroe D. (1988) Ecological and public health implications associated with the use of glyphosate herbicides. Environmental Consultants Northwest, Stanwood, WA.

<sup>3</sup> Rueppel, ML, Brightwell, BB, Schaefer, J, Marvel JT. (1977) Metabolism and degradation of glyphosate in soil and water. *J Agric Food Chem* 25 (3): 517-528.

<sup>4</sup> Franz JE, Mao MK, Sikorski JA. (1997) Uptake, Transport, and Metabolism of Glyphosate in Plants (Chapter 6). In: Glyphosate: a unique global herbicide. *ACS Monograph 189*. American Chemical Society, Washington DC. pp. 143-186 (chapter); pp 177-181 (degradate discussion).

<sup>5</sup> Mehrsheikh A, Bleeke M, Brosillon S, Laplanche A, Roche P. (2006) Investigation of the chlorination of glyphosate and glycine in water. *Water Research* 40(16): 3003-3014.

<sup>6</sup> Aguer J, Richard C. (1996) Transformation of fenuron induced by photochemical excitation of humic acids. *Pesticide Science* 46: 151-155.

<sup>7</sup> Owen BA, Dudley CS, Tan E, Easterly CE. (1990) Formaldehyde in drinking water: comparative hazard evaluation and an approach to regulation. *Regul Toxicol Pharmacol* 11(3):220-36; Can ZS, Gurol M. (2003) Formaldehyde formation during ozonation of drinking water. *Ozone: Science & Engineering* 25(1): 41-51.

substances. There is no indication of any accumulation of formaldehyde in the environment as a result of glyphosate degradation.