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Should the EU Continue to Use Glyphosate

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Glyphosate, N-(phosphonomethyl)-glycine, is the active substance in up to 750 glyphosate-based herbicides. They are the most widely used herbicides in the world, with 700,000 tons used worldwide in 2012 (*1*), particularly with genetically modified glyphosate-resistant crop plants such as soybeans (*2*). In December 2017, the European Union reapproved the use of glyphosate-based herbicides for another 5 years. This Brief discusses the effects of glyphosate-based herbicides on humans and plants and examines whether their use should be prohibited.

Glyphosate-based herbicides were introduced in 1974 by the Monsanto company. They inhibit the essential sixth enzyme of the shikimate pathway, 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS). They thereby prevent the development of amino acids and defence functions in plants and microorganisms, resulting in their death after a few days. Glyphosate-based herbicides also contain surfactants such as polyoxyethylene amine (POEA), which increases uptake by and movement through the plants (*1*). Glyphosate, due to its C-P linkage in the molecule, is resistant to decomposition. However, it is eventually broken down through decomposition and microorganisms, which frequently metabolise to aminomethyl phosphonic acid (AMPA) (**Figure 1**). Glyphosate can also decompose in the plant, creating glyphosate and AMPA residues in the soil. Recommended application levels are between 0.72 and 2.88 kg glyphosate per hectare, with a maximum annual application of 4.32 kg glyphosate per hectare (*2*).

The first glyphosate-based herbicide was Roundup Original, which contained around 15% glyphosate isopropylamine salt and POEA of the herbicide, the most

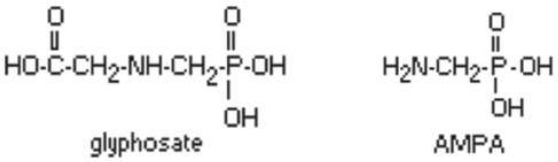

Figure 1. *Similar structure of glyphosate and AMPA*

toxic substance in the formula. The remaining 68.4% was made up of other substances, which are usually overlooked even though they can cause harm to the environment, animals, and humans. A study by Peixoto (*3*) showed that glyphosate formula reduced the activity of rat's liver, while glyphosate alone did not. Glyphosate has since been used in many different formulations, creating new blends that can be potentially more toxic and aggravate contamination (*4*).

What it is used for

Glyphosate use around the world has increased rapidly in the past two decades, rising 15-fold between 1994 and 2014. Glyphosate-based herbicides are generally used before the planting of genetically modified crops such as cotton, maize, canola and soybeans. In Europe, where genetically modified crops are not grown commercially, it is applied mainly to cereals and oilseeds as well as in vineyards and orchards (*4*). Smaller-scale uses include weed control in urban areas, e.g. along streets and parks, and in gardens. Glyphosate has also been directly applied to waterbodies to control seaweed levels or eliminate alien species.

Occurrence in Soil

The biggest factor affecting glyphosate occurrence in soil is the type and texture of the soil. Glyphosate is adsorbed by clay and organic matter, whereas it is quickly washed out of sandy soils. Thus, glyphosate and AMPA can build up and be present in some soils for up to a year before decomposing fully (*1*). In 2017, from 317 samples taken from around Europe, 45% contained measurable amounts of glyphosate or AMPA, with the latter being far more frequent. Concentrations of up to 2 mg kg^{-1} were measured (*2*).

Occurrence in water

Glyphosate-based herbicides can be found in a wide variety of freshwater bodies as a result of transport from soil to surface waters by rain and erosion. Here, the herbicide can remain as a particulate or be dissolved. As a particulate, it can travel to the bottom of the water body and join the sediment at the bottom, where it takes much longer to dissolve than whilst suspended in the water column. Glyphosate-based herbicide concentrations of up to 450 mgL^{-1} have been reported in water bodies, with concentrations in sediments of up to 470 mg kg^{-1} In Argentina, concentrations in water were only between 0.5 and 7.6 mg L^{-1}, but those in sediments were up to 200 mg kg^{-1}, with the highest concentrations measured in the vicinity of agricultural activities (*5*).

Effect on Plants

Glyphosate-based herbicides affect not only the target organisms, but also native species, reducing biodiversity. A study in Argentina recorded that, after use of a glyphosate-based herbicide for 21 days, 50% of species showed a phytotoxic response or death, with 75% showing growth reduction. This poses a severe problem for the use of glyphosate-based herbicides in forested areas (*6*). A growing concern is the rising incidence of plant resistance to glyphosate.

Effect on Animals and Humans

Glyphosate and AMPA are taken up by animals through consumption of water and plants and released again through excretion. Because they target EPSPS enzymes, which are only found in plants, glyphosate-based herbicides have a reduced direct effect on humans and animals. Nevertheless, they been shown to have a toxic effect on aquatic species. For example, Bridi et al. (*6*) have reported that glyphosate-based herbicide concentrations of 0.5 mg L^{-1} reduced the travel distance and mean speed of zebrafish during the study period (*7*). Another study, focusing on POEA, showed that exposure to Roundup reduced physiological attributes of damselfly larvae, reducing food intake and speed as well as muscle and sugar mass. POEA was not the only toxic variable. However, when the study was repeated for other glyphosate-based herbicides without POEA, similar, but reduced effects were seen (*8*).

To limit the exposure of humans to glyphosate-based herbicides, it is recommended that humans only enter fields 12 hours after application. However, this only restricts one path for the herbicide to travel: by inhalation. A 2014 study detected glyphosate residues in the urine of 44% of the general public of Europe, with an average concentration of 1 mg L^{-1} and even higher concentrations in farmers. In 2015, the WHO categorised glyphosate as a "2A Probable Carcinogenic". The report does admit to the "limited evidence" and also went against many other reports, including a subsequent report by the UN and WHO in 2016, which concluded that human health risk levels associated with glyphosate exposure from food, drinking water, and residential sources are below the agencies' levels of concern.

Conclusion

It would be challenging to implement a complete ban of glyphosate, given that it is used so widely. However, the negative effects of glyphosate-based herbicides have been well documented, and its use needs to be more carefully managed; for example, small-scale uses in urban areas should be curtailed.

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