



Special Look at the Ubiquitous Roundup: An Herbicide Containing Glyphosate and the Surfactant POEA

There are various types of pesticides used throughout the United States that can have harmful effects on aquatic life such as weight loss, low disease resistance, and infertility. Pesticides are often referred to according to the type of pest they control. The three major groups of pesticides are herbicides, insecticides, and fungicides.

Glyphosate and Surfactants

Glyphosate is a broad spectrum, non-selective herbicide. Roundup and other herbicide formulations that include glyphosate as their active ingredient also contain surfactants that are designed to help deliver the glyphosate into the plant cells for action. In the case of some formulations, the volume of “other ingredients” including the surfactant can outweigh the volume of glyphosate in a named herbicide product. For example, Roundup Original Max, according to its label, is 51% “other ingredients” – what these other ingredients are isn’t listed. And so when considering the toxicity of glyphosate-based herbicides, one must also know and consider the impacts of the surfactants and other ingredients contained therein.

Roundup is one of the most commonly used formulations containing glyphosate and a surfactant (namely polyethoxylated tallowamine, also known as POEA). Other formulations containing glyphosate include Rodeo and Aqua Master. All three are made by Monsanto Company. Much of the research into the effects of Roundup and others in this herbicidal family seem to demonstrate that at least some of the toxic impacts to the environment are caused by the surfactant used.

Effects of Roundup Containing Glyphosate and POEA on the Environment

The effect of pesticides on water health is dependent on numerous factors that vary with each type of pesticide, such as its active ingredient, contaminants that exist as impurities in the active ingredient, additives that are mixed with the active ingredient (like wetting agents, diluents or solvents, extenders, adhesives, buffers, preservatives or emulsifiers), and the product that is formed after the active ingredients are degraded by chemical, microbial or photochemical processes once the chemical enters our environment.¹ Glyphosate is usually assumed to be quickly and tightly adsorbed to soil particles and as a result not to have adverse effects beyond its target. But glyphosate is known to enter aquatic systems, e.g. by accidental direct application, by drift of the herbicide spray, or as the result of surface runoff. Research on the effects of glyphosate in the aquatic environment has not received the same level of study or attention as its

¹ Ongley, Edwin D. “Control of Water Pollution from Agriculture: Chapter 4 Pesticides as Water Pollutants”. Food and Agriculture Organization Irrigation and Drainage. Natural Resources Management and Environment Department. 1996.

effects on land. But there is research that shows that “[o]nce in the aquatic environment, glyphosate may become toxic to living organisms, including plants, animals and microorganisms.”²

Study has shown that the introduction of glyphosate can cause a major change in water chemistry, namely a significant increase in total phosphorous concentrations.³ It has also been found that Roundup “was roughly four times more toxic” to some aquatic macrophytes (aquatic plants) than glyphosate alone⁴ -- again raising the issue of the toxicity of the surfactant alone and in conjunction with the glyphosate herbicide. Study has also shown that Roundup could actually stimulate nuisance algae, resulting in cyanobacteria blooms in freshwaters which could have an adverse affect on water quality, as well as human and animal health.⁵

Effects of Roundup Containing Glyphosate and POEA in Aquatic Ecosystems

It has been generally believed that glyphosate, which is designed to kill plants, has only minor effects on animals that may be exposed. In the case of amphibians, testing on effects has been relatively light. Testing that has occurred has been largely focused on the larval stage (i.e. tadpoles); but a large portion of amphibian life is spent in the terrestrial stage.

In one study⁶ it was found:

- ✓ “Roundup caused a large reduction in the survival of all three species of tadpoles” (i.e. toads, leopard frogs, tree frogs).
- ✓ Across all soil types “Roundup reduced tree frog tadpole survival from 75% to 2%, toad tadpole survival from 97% to 0%, and leopard frog tadpole survival from 98% to 4%. Across all species, only 2% of all tadpoles survived the Roundup application after three weeks.” (The soil types issue is important because some have claimed that by absorbing glyphosate and subjecting it to microbial breakdown, soils remove the herbicide from the aquatic environment and so prevent it from having lethal affects on aquatic life.)
- ✓ “In the terrestrial experiments, all three species suffered substantial mortality when exposed to Roundup. After 24 hours, the application of Roundup reduced juvenile wood frog survival from 96% to 32% [], juvenile tree frog survival from 100% to 18% [], and juvenile toad survival from 100% to 14%[]. Across all species, only 21% of all juvenile amphibians survived the Roundup application after one day.”
- ✓ “The most striking result from the experiments was that a chemical designed to kill plants killed 98% of all tadpoles within three weeks and 79% of all juveniles within one day.”
- ✓ “The cause of the high Roundup-associated mortality appears to result from direct toxicity (possibly due to damaged epithelial cells in the gills []) rather than any indirect effect...”
- ✓ Rapid death also occurred in terrestrial experiments. “After only 24 hours, 79% of all juvenile frogs and toads died.”

² Perez et. al. “Effects of the Herbicide Roundup on Freshwater Microbial Communities: a Mesocosm Study.” Ecological Applications, 17(8), 2007, pp 2310-2322.

³ Perez et. al. “Effects of the Herbicide Roundup on Freshwater Microbial Communities: a Mesocosm Study.” Ecological Applications, 17(8), 2007, pp 2310-2322.

⁴ Perez et. al. “Effects of the Herbicide Roundup on Freshwater Microbial Communities: a Mesocosm Study.” Ecological Applications, 17(8), 2007, pp 2310-2322.

⁵ Perez et. al. “Effects of the Herbicide Roundup on Freshwater Microbial Communities: a Mesocosm Study.” Ecological Applications, 17(8), 2007, pp 2310-2322.

⁶ Relyea, Rick A. “The Lethal Impact of Roundup on Aquatic and Terrestrial Amphibians.” Ecological Applications, 15(4) pges 1118-1124, 2005.

Studies considering the effects of Roundup on amphibian larvae suggest that the deaths caused may primarily be caused by the surfactant POEA.⁷ There is other research that back up the findings regarding the toxicity of Roundup in the environment and the contribution of the surfactant to this harmful affect.⁸ Whether the lethal effects of the herbicide Roundup is primarily due to the glyphosate or the surfactant, it is clear that the herbicide called Roundup, with the combination of ingredients it possesses “can cause high rates of mortality in several species of North American Amphibians.”⁹ The population impacts of losing 96 to 100% of tadpoles combined with 68 to 86% of juvenile frogs and toads on land could be substantial.¹⁰

When pesticides in the environment are compounded by other stressors on aquatic or animal life, such as predation or competition, the effects of the pesticides can become even more lethal.¹¹

A study conducted by the University of Pittsburgh’s Department of Biological Sciences, tested the negative effects of four well-known pesticides on the biodiversity of aquatic communities containing algae and 25 species of animals. The pesticides tested consisted of two insecticides, Sevin and malathion and two herbicides, Roundup and 2,4-D. The study found that species richness was reduced by 15% with Sevin, 30% with malathion, and 22% with Roundup. The insecticides, Sevin and malathion specifically reduced zooplankton diversity by eliminating cladocerans, which are small crustaceans commonly called water fleas, as well as reducing the diversity and biomass of predatory insects. The two herbicides, Roundup and 2,4-D had no effects on zooplankton, insect predators, or snails. However, although 2,4-D had no effect on tadpoles, Roundup completely eradicated two species of tadpoles and nearly exterminated a third species, resulting in a 70% decrease in the species richness of tadpoles overall.^{12 13}

Human Health Effects of Roundup Containing Glyphosate and POEA

There continues to be emerging research that demonstrates that glyphosate, POEA and the herbicides like Roundup containing them are not safe for humans as is often asserted. At the very least there is science which calls into question the impacts of herbicides like Roundup and support implementation of the precautionary principle whereby these herbicides are not allowed for use until they are conclusively proven safe. As with studies in the environment, studies of human effects indicate that it is the glyphosate with the surfactant that has the more toxic effects.

For example:

- A 2009 study on liver cells found that formulations of Roundup had endocrine disrupting affects at dilutions 800 times lower than the level authorized in some food or feed. “This

⁷ Relyea, Rick A. “The Lethal Impact of Roundup on Aquatic and Terrestrial Amphibians.” *Ecological Applications*, 15(4), 2005, pp 1118-1124.

⁸ See discussion and research found in Relyea, Rick A. “Pesticides and Amphibians: The Importance of Community Context”, *Ecological Applications*, 15(4), 2005, pp. 1125-1134.

⁹ Relyea, Rick A. “The Lethal Impact of Roundup on Aquatic and Terrestrial Amphibians.” *Ecological Applications*, 15(4), 2005, pp 1118-1124.

¹⁰ Relyea, Rick A. “The Lethal Impact of Roundup on Aquatic and Terrestrial Amphibians.” *Ecological Applications*, 15(4), 2005, pp 1118-1124.

¹¹ Relyea, Rick A. “The Lethal Impact of Roundup on Aquatic and Terrestrial Amphibians.” *Ecological Applications*, 15(4), 2005, pp 1118-1124.

¹² Relyea, Rick. “The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities.” *Ecological Applications*, 15(2), 2005, pp. 618–627

¹³ Another study of significance: Paganelli, A. et. al., “Glyphosate-Based Herbicides Produce Teratogenic Effects on Vertebrates by Impairing Retinoic Acid Signaling”, *Chem. Res. Toxicol.*, submitted May 20, 2010.

confirms and enhances the potential toxic action of G[lyphosate]-based herbicides that we observed in human placental and embryonic cell lines, and on fresh umbilical cord cells” The study authors wrote. “.G[lyphosate]-based herbicides present DNA damages and CMR [carcinogen, mutagen and reprotoxic] effects on human cells and *in vivo*. The direct g[lyphosate] action is most probably amplified by vesicles formed by adjuvants or detergent-like substances that allow cell penetration, stability, and probably change its bioavailability and thus metabolism.”¹⁴

(Informational note: adjuvant=surfactant; *in vivo* means in the living organism as opposed to *in vitro* which means in the laboratory).

- In 2005 researchers found that Roundup could be considered a potential endocrine disruptor. And that “ at higher doses still below the classical agricultural dilutions, its toxicity on placental cells could induce some reproduction problems”. The research found that Roundup reduced placental cell viability with concentrations 10 times lower than that of the agricultural use and that it did so to a higher degree than glyphosate. The researchers further concluded that the dilution of glyphosate in a Roundup formulation may multiply its endocrine effect.¹⁵ This study also found that the addition of surfactants “greatly facilitated” the penetration of glyphosate through animal cell membranes, as it does for plant cell membranes.
- A 2009 published study looked at the effects of different Roundup formulas on human cells including from the placenta, embryonic kidney and neonate. The results found that “the four R[oundup] herbicides and G[lyphosate] cause cellular death for all types of human cells, with comparable toxicity for each one but at different concentrations.” According to the study, the surfactant POEA, of those considered, was the most potent and “[t]hus, POEA could be considered as the active ingredient on human cell death....” And that while POEA, glyphosate or the major metabolite of glyphosate known as AMPA (aminomethylphosphonic acid), may have a “small toxic effect on embryonic cells alone at low levels, the combination of two of them at the same final concentration is significantly deleterious.” And it found that the surfactants did not appear to be necessary to “render G[lyphosate] as a death inducer” at the levels studied. In conclusion “... the proprietary mixtures available on the market could cause cell damage and even death around residual levels to be expected....”¹⁶
- The Institute of Science in Society reported on a test that “Monsanto’s glyphosate-based herbicide Roundup Bioforce as well as glyphosate alone reduced testosterone levels in testicular cells at very low concentrations; and at the higher concentrations – still 10 times below agricultural use – the cells died in 24-48 hours.”¹⁷
- Glyphosate has also been shown to be damaging and toxic to mouse bone marrow.¹⁸

Controlling the Use of Pesticides

¹⁴ Gasnier, C. et al “Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines”. *Toxicology* 262, 2009 pp 184-191.

¹⁵ Richard, S. et. al, “Differential Effects of Glyphosate and Roundup on Human Placental Cells and Aromatase.” *Environmental Health Perspectives*, Vol.

¹⁶ Nora Benachour & Gilles-Eric Seralini, “Glyphosate Formulations Induce Apoptosis and Necrosis in Human Umbilical, Embryonic, and Placental Cells,” *Chem. Res. Toxicol.* 2009, 22, 97-105.

¹⁷ “Glyphosate Kills Rat Testis Cells, ISIS Report 27/02/12, www.i-sis.org.uk/glyphosate_kills_rat_testis_cells.php

¹⁸ Prasad, S. et al. “Clastogenic Effects of Glyphosate in bone Marrow Cells of Swiss Albino Mice”, *Journal of Toxicology*, vol 2009, Article ID 308985, 2009.

Although pesticides are regulated under the Federal Insecticide, Fungicide and Rodenticide Act as well as the Federal Food, Drug and Cosmetic Act, citizens must take action to prevent the further degradation that excessive pesticide use can cause on the environment. Pesticides are merely a short term solution and do not solve the problem. There are a number of methods that can be taken to ensure that lawns and gardens remain healthy and maintained without using dangerous chemicals. Pesticides are toxic and must be avoided in order to protect local streams and aquatic life. More studies should be conducted to assess the impact that pesticides can have on aquatic ecosystems and how they contribute to the global decline in the overall biodiversity of insects, which are crucial components in the food web and are extremely beneficial due to ecosystem services like pollination.

The best strategy when it comes to pesticides of all kinds is to exercise the precautionary principle in your own life, if you can't prove to yourself it is safe perhaps you shouldn't use it. In those limited instances when there may be an overriding reason for use, such as engaging in a native plant restoration in an area overrun but invasive plants that cannot be eradicated via any other means, be sure to do your homework – make sure you are making the right chemical selection, you are applying it in the most limited amounts effective, that you are wearing proper protective clothing and following all directions for application, and that you keep your kids, pets and any wild animals you can away from the area.

Of course, the safest thing to do is go organic on your property. Rodale Institute is an excellent source of information for things like organic lawn care, e.g. <http://www.rodale.com/green-lawn-care>.