Glyphosate (Roundup)

SUMMARY

Despite the prevalent myth that this widely-used herbicide is harmless, glyphosate (N-phosphono-methyl glycine) is associated with a wide range of illnesses, including non-Hodgkin's lymphoma (NHL), genetic damage, liver and kidney damage, endocrine disruption, as well as environmental damage, including water contamination and harm to amphibians. Researchers have also determined that the "inert" ingredients in glyphosate products, especially polyethoxylated tallow amine or POEA —a surfactant commonly used in glyphosate and other herbicidal products—are even more toxic than glyphosate itself. Monsanto, manufacturer of glyphosate, formulates many products such as Roundup™ and Rodeo™ and markets formulations exclusively used on genetically engineered (GE) crops. Glyphosate, one of the most widely used herbicides in the world, due in large part to the increased cultivation of GE crops that are tolerant of the herbicide.

ChemicalWATCH Summary Stats

CAS Registry Number: 1071-83-6

Trade Name: Roundup, Rodeo

Use: Nonselective herbicide for broadleaf weed and grass control on food and non-food field crop sites.

Toxicity rating: Toxic

Signal Words: Caution

Health Effects: Eye and skin irritation, associated with non-Hodgkin's Lymphoma, and spontaneous abortions. Other ingredients in formulated products are linked to developmental abnormalities, decreased sperm count, abnormal sperm, and cell death of embryonic, placental and umbilical cord cells. Functions as an antibiotic.

Environmental Effects: Weed resistance due to use in genetically engineered crop production, water contamination, soil quality degradation, toxic to soil microorganisms and aquatic organisms. A source of phosphate pollution in water.

GENERAL

First registered for use in 1974, glyphosate is used to kill a variety of broadleaf weeds and grasses. Labeled uses of glyphosate account for approximately 276 million pounds applied in 2014 on over 100 terrestrial food crops, as well as other non-food sites, including forestry, greenhouses, rights-of-way, turf, garden beds, and hardscapes.[1]

The greatest overall glyphosate use by acreage is in the Mississippi River basin where most applications are for weed control on GE corn, soybeans, and cotton, as well as other crops. Contrary to industry claims that GE crops would result in lower pesticide use rates, glyphosate use in agriculture rose 300-fold from 1974 to 2014, with non-agricultural uses increasing by 43-fold during the same time.[2]

Plants treated with glyphosate translocate the systemic herbicide to their roots, growing points, and fruit, where it blocks the activity of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), a key enzyme in the shikimate pathway of aromatic amino acid production, ultimately leading to the plant's death by starvation.[3] Because plants absorb glyphosate, it cannot be completely removed by washing or other food preparation. It persists in food products for up to two years.[4]

GLYPHOSATE FORMULATED PRODUCTS AND OTHER INGREDIENTS

Glyphosate products (Roundup) are more toxic than glyphosate alone, resulting in a number of chronic, developmental, and endocrine-disrupting impacts.[5,6,7,8,9,10] The "inert" ingredients in Roundup formulations kill human cells at very low concentrations.[11] At least some glyphosate-based products are genotoxic.[12] One "inert," polyethoxylated tallow amine (POEA), is extremely toxic to aquatic organisms.[13,14] It accounts for more than 86% of Roundup toxicity observed in microalgae and crustaceans.[15]

ACUTE EXPOSURE TO GLYPHOSATE

Although EPA considers glyphosate to be "of relatively low oral and dermal acute toxicity,"[16] symptoms following exposure to glyphosate formulations include: swollen eyes, face and joints; facial numbness; burning and/or itching skin; blisters; rapid heart rate; elevated blood pressure; chest pains, congestion; coughing; headache; and nausea.[17] In developmental toxicity studies using pregnant rats and rabbits, effects of glyphosate in high dose groups include diarrhea, decreased body weight gain, nasal discharge and death.[18]

CHRONIC EXPOSURE TO GLYPHOSATE

Since EPA's classification of glyphosate as a Group E carcinogen—or "evidence of non-carcinogenicity for humans," the International Agency for Research on Cancer (IARC) in 2015 classified glyphosate as a Group 2A "probable" carcinogen, which means that the chemical is probably carcinogenic to humans based on sufficient evidence of carcinogenicity in experimental animals.[19] As of July 7, 2017, glyphosate is listed as a cancer-causing chemical under California's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). This requires cancer warning labels be placed on end-use glyphosate products in California.[20] It has been specifically linked to non-Hodgkin's Lymphoma (NHL).[21,22,23] and multiple myeloma. [24]

Glyphosate causes DNA and chromosomal damage in human cells.[25] Glyphosate and its formulated products adversely affect embryonic, placental and umbilical cord cells, affect fetal development, and increase the risk for spontaneous abortions.[26] Detectable concentrations of glyphosate have been found in the urine of farm children.[27] Chronic, ultra-low dose exposure to glyphosate in drinking water results in adverse impacts on the health of liver and kidneys.[28] Glyphosate is considered to be an endocrine disruptor.[29] It can cause changes to DNA function resulting in the onset of chronic disease.[30]

GLYPHOSATE IS AN ANTIBIOTIC

Glyphosate works by disrupting a crucial pathway for manufacturing aromatic amino acids in plants—but not animals—and, therefore, many have assumed that it does not harm humans. However, many bacteria use the shikimate pathway, and glyphosate has been patented as an antibiotic.[31] The destruction of bacteria in the human gut is a major contributor to disease, and the destruction of soil microbiota leads to unhealthy agricultural systems with an increasing dependence on agricultural chemicals.[32] Disturbing the microbiota can contribute to a whole host of "21st century diseases," including diabetes, obesity, food allergies, heart disease, antibiotic-resistant infections, cancer, asthma, autism, irritable bowel syndrome, multiple sclerosis, rheumatoid arthritis, celiac disease, inflammatory bowel disease, and more. The rise in these same diseases is tightly correlated with the use of the herbicide glyphosate, and glyphosate exposure can result in the inflammation that is at the root of these diseases.[33] Glyphosate appears to have more negative impacts on beneficial bacteria, allowing pathogens to flourish.[34,35]

ANTIBIOTIC RESISTANCE

Bacteria resistant to the most commonly prescribed antibiotics result in longer-lasting infections, higher medical expenses, the need for more expensive or hazardous medications, and the inability to treat life-threatening infections. The development and spread of antibiotic resistance is the inevitable effect of the use of antibiotics.[36,37] Use of antibiotics like glyphosate in agriculture allows residues of antibiotics and antibiotic-resistant bacteria on agricultural lands to move through the environment, contaminate waterways, and ultimately reach consumers in food.[38] Both the human gut and contaminated waterways provide incubators for antibiotic resistance.

ENVIRONMENTAL FATE

Glyphosate has the potential to contaminate surface waters and is not broken down readily by water or sunlight in surface water,[39] with a half-life of 70 to 84 days.[40] U.S. Geological Survey (USGS) surveys detect glyphosate and its degradate aminomethylphosphonic acid (AMPA) in the majority of samples,[41] persisting from spring through to fall.[42] Glyphosate and/or AMPA have also been detected in significant levels in rain in agricultural areas across the Mississippi River watershed, in more than 50 percent of soil and sediment samples, in water samples from ditches and drains, and in more than 80 percent of wastewater treatment plant samples.[43] Glyphosate also contributes to phosphorous pollution of waterbodies.

Residues of glyphosate may persist for months in anaerobic soils deficient in microorganisms. Heavy use of Roundup on GE crops appears to cause harmful changes in soil, potentially hindering yields of crops.[44] Concerns for soil health from long-term glyphosate use include reduction of nutrient availability for plants and organisms; disruption of organism diversity, especially in the areas around plant roots; reductions of beneficial soil bacteria; increases in plant root pathogens; disturbed earthworm activity; reduced bacterial nitrogen fixation; and compromised growth and reproduction in some soil and aquatic organisms.[45,46]

EFFECTS ON NONTARGET ANIMALS

Glyphosate use directly impacts a variety of nontarget animals, including insects, earthworms, and fish, and indirectly impacts birds and small mammals.[47] Roundup kills beneficial insects, including parasitoid wasps, lacewings and ladybugs.[48] Repeated applications of glyphosate significantly affect the growth and survival of earthworms.[49] Environmental factors, such as high sedimentation, increases in temperature and pH levels increase the toxicity of Roundup, especially to young fish.[50]

Roundup, in sublethal and environmentally relevant concentrations, causes morphological changes in two species of amphibians by interfering with hormones.[51] It is "extremely lethal" to amphibians in concentrations found in the environment.[52,53,54]

FOOD RESIDUES

Sampling by the U.S. Food and Drug Administration), under pressure after the release of the IARC report, found residues of glyphosate in honey and oats.[55] Residues, which have no established legal allowance in honey, were found in all samples and in some cases at double the allowable limit set in the European Union. FDA also found residues in oat products, including cereals for babies. These tests follow European findings of glyphosate residues in German beer and British bread, in addition to private testing in the U.S. in Cheerios, cookies, crackers, and wine.[56,57, 58, 59, 60, 61]

ENDNOTES

1 USEPA. 2009. Glyphosate Final Work Plan. Registration Review Case No 0178. Office of Pesticide Programs. Washington, DC.

2 Ibid.

3 Industry Task Force on Glyphosate, 2017. Glyphosate: mechanism of action. http://www.glyphosate.eu/glyphosate-mechanism-action.

4 Pesticide Action Network, 1997. Glyphosate fact sheet. For more information about glyphosate visit http://data.pesticideinfo.org/4DAction/GetRecord/PC33138.

5 Marco, P., Armelle, M., Claudia, B., & Silvio, P. 1998. 32P-postlabeling detection of DNA adducts in mice treated with the herbicide roundup. *Environmental and Molecular Mutagenesis*, 31(1), 55–59.

6 Dallegrave, E., et al. 2003. The teratogenic potential of the herbicide glyphosate-Roundup® in Wistar rats. *Toxicology Letters*, 142(1–2), 45-52.; Dallegrave, E., et al. 2007. Pre- and postnatal toxicity of the commercial glyphosate formulation in Wistar rats. *Arch Toxicol*, 81(9), 665–673.

7 Marc, J., Mulner-Lorillon, O., & Bellé, R. (2004). Glyphosate-based pesticides affect cell cycle regulation. *Biology of the Cell*(96), 245–249.

8 Benachour N, Sipahutar H, Moslemi S, Gasnier C, Travert C, & Séralini GE. 2007. Time- and dose-dependent effects of roundup on human embryonic and placental cells. *Arch Environ Contam Toxicol.*, 53(1), 126–133.

9 Richard S, Moslemi S, Sipahutar H, Benachour N, & Seralini GE. 2005. Differential effects of glyphosate and roundup on human placental cells and aromatase. *Environ Health Perspect*, 113(6), 716–720.

10 Gasnier, C., et al. 2008. Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines. *Toxicology*, doi:10.1016/j.tox.2009.06.006.

11 Benachour, N., & Seralini, G.-E. 2008. Glyphosate Formulations Induce Apoptosis and Necrosis in Human Umbilical, Embryonic, and Placental Cells. *Chemical Research in Toxicology*, 22(1), 97–105.

12 EFSA. EFSA explains the carcinogenicity assessment of glyphosate. 12 November 2015. https://www.efsa.europa.eu/sites/default/files/4302_glyphosate_complementary.pdf.

13 Brausch, J. M., & Smith, P. N. 2007. Toxicity of Three Polyethoxylated Tallowamine Surfactant Formulations to Laboratory and Field Collected Fairy Shrimp, Thamno-cephalus platyurus. *Archives of Environ-mental Contamination and Toxicology*, 52(2), 217–221.

14 Wang, N., et al. 2005. Influence of sediment on the fate and toxicity of a polyethoxylated tallowamine surfactant system (MON 0818) in aquatic microcosms. *Chemosphere.*, 59(4), 545–551; Brausch, J. M., Beall, B., & Smith, P. N. 2007. Acute and Sub-Lethal Toxicity of Three POEA Surfactant Formulations to Daphnia magna. *Bull Environ Contam Toxicol*, 78, 510–514.

15 Tsui, M., & Chu, L. 2003. Aquatic toxicity of glyphosate-based formulations: comparison between different organisms and the effects of environmental factors. *Chemosphere.*, 52(7), 1189–1197.

16 USEPA. 1993. Reregistration Eligibility Decision (RED) Document: Glyphosate. Office of Pesticide Programs.

17 Northwest Coalition for Alternatives to Pesticides (NCAP). 1998. Herbicide Factsheet: Glyphosate (Roundup). Journal of Pesticide Reform.18(3):4.

18 EPA. 1993.

19 IARC. IARC Monographs Volume 112: evaluation of five organophosphate insecticides and herbicides. 20 march 2015. http://www.iarc.fr/en/media-centre/iarcnews/pdf/MonographVolume112.pdf.

20 OEHHA. Notice of Intent to List: Tetrachlorvinphos, Parathion, Malathion, Glyphosate. September 2015 https://oehha.ca.gov/proposition-65/crnr/notice-intent-list-tetrachlorvinphos-parathion-malathion-glyphosate.

21 Hardell, L., & Eriksson, M. 1999. A Case-Control Study of Non-Hodgkin Lymphoma and Exposure to Pesticides. *Cancer*, 85(6), 1353–1360.

22 Hardell L, Eriksson M, & Nordstrom M. 2002. Exposure to pesticides as risk factor for non-Hodgkin's lymphoma and hairy cell leukemia: pooled analysis of two Swedish case-control studies. *Leuk Lymphoma*, 43(5), 1043–1049.

23 De Roos, et al. 2003. Integrative assessment of multiple pesticides as risk factors for non-Hodgkin's lymphoma among men. *Occup Environ Med*, 60(9).

24 De Roos, A. J. D., Blair, A., et al .2005. Cancer Incidence among Glyphosate-Exposed Pesticide Applicators in the Agricultural Health Study. *Environmental Health Perspectives,* 113(1), 49–54.

25 IARC. IARC Monographs Volume 112: evaluation of five organophosphate insecticides and herbicides. 20 march 2015. http://www.iarc.fr/en/media-centre/iarcnews/pdf/MonographVolume112.pdf.

26 Arbuckle, T. E., Lin, Z., & Mery, L. S. (2001). An Exploratory Analysis of the Effect of Pesticide Exposure on the Risk of Spontaneous Abortion in an Ontario Farm Population. *Environ Health Perspect,* 109, 851–857.

27 Acquavella, J. F., et al. (2004). Glyphosate Biomonitoring for Farmers and Their Families: Results from the Farm Family Exposure Study. *Environmental Health Perspectives*, 112(3), 321–326.

28 Mesnage, R, Arno, M, Contanzo, M, et al. 2015. Transcriptome profile analysis reflects rat liver and kidney damage following chronic ultra-low dose Roundup exposure. *Environmental Health*. 14:70.

29 Gasnier C, Dumont C, Benachour N, et al. 2009. Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines. Toxicology. 262:184–91. The Endocrine Disruption Exchange, https://endocrinedisruption.org/enews/tedx-list-pesticides.

30 Samsel, A and Seneff, S. 2016. Glyphosate pathways to modern diseases V: Amino acid analogue of glycine in diverse proteins. *J. Biological Physics and Chemistry.* 16:9-46.

31 U.S. Patent number US7771736 B2. Glyphosate formulations and their use for the inhibition of 5-enolpyruvylshikimate-3-phosphate synthase. https://www.google.com/patents/US7771736.

32 Littman, D.R. and Pamer, E.G., 2011. Role of the commensal microbiota in normal and pathogenic host immune responses. *Cell host & microbe, 10*(4), 311–323.

33 Swanson, N.L., Leu, A., Abrahamson, J. and Wallet, B., 2014. Genetically engineered crops, glyphosate and the deterioration of health in the United States of America. *Journal of Organic Systems, 9*(2), 6–37.

34 Shehata AA, Schrödl W, Aldin AA, Hafez HM, Krüger M. 2013. The effect of glyphosate on potential pathogens and beneficial members of poultry microbiota in vitro. Curr Microbiol 66(4):350-8. Krüger, M., Shehata, A.A., Schrödl, W. and Rodloff, A., 2013. Glyphosate suppresses the antagonistic effect of Enterococcus spp. on Clostridium botulinum. Anaerobe, 20, pp.74-78. Schrödl, W., Krüger, S., Konstantinova-Müller, T., Shehata, A.A., Rulff, R. and Krüger, M., 2014. Possible effects of glyphosate on Mucorales abundance in the rumen of dairy cows in Germany. Current microbiology, 69(6), 817–823.

35 Shehata AA, Schrödl W, Aldin AA, Hafez HM, Krüger M. 2013. The effect of glyphosate on potential pathogens and beneficial members of poultry microbiota in vitro. Curr Microbiol 66(4):350-8.

36 CDC, "Get Smart: Know When Antibiotics Work." http://www.cdc.gov/getsmart/antibiotic-use/fast-facts.html.

37 Thomas F. O'Brien, 2002. Emergence, Spread, and Environmental Effect of Antimicrobial Resistance: How Use of an Antimicrobial Anywhere Can Increase Resistance to Any Antimicrobial Anywhere Else, Clinical Infectious Diseases 2002; 34(Suppl 3):S78–84.

38 See *GMOs, Glyphosate, and Antibiotic Resistance* below.

39 EPA.1993.

40 Extension Toxicology Network. 1996. Pesticide Information Profiles: Glyphosate. http://ace.orst.edu/cgi-bin/mfs/01/pips/glyphosa.htm.

41 Kolpin, D. W., et al. 2006. Urban contributions of glyphosate and its degradate AMPA to streams in the United States *Science of The Total Environment*, 354(2-3), 191–197.

42 Scribner, E. A., Battaglin, W. A., Dietze, J. E., & Thurman, E. M. 2003. Reconnaissance Data for Glyphosate, Other Selected Herbicides, Their Degradation Products, and Antibiotics in 51 Streams in Nine Midwestern States, 2002 *U.S. Geological Survey*, Open-File Report 03–217(101 p).43 USGS. Common Weed Killer is Widespread in the Environment. https://toxics.usgs.gov/highlights/2014-04-23-glyphosate_2014.html.

44 Beyond Pesticides Daily News Blog. August 22, 2011. Roundup May Be Damaging Soil and Reducing Yields, Says USDA.

45 Kremer, R.J. 2017. Soil and Environmental Health after Twenty Years of Intensive Use of Glyphosate. Adv Plants Agric Res. 6(5): 00224.

46 Blackshaw, RE and Harker, KN. 2016. Wheat, Field Pea, and Canola Response to Glyphosate and AMPA Soil Residues. Weed Technology. 30(4):985–991.

47 Northwest Coalition for Alternatives to Pesticides (NCAP). 1998. Herbicide Factsheet: Glyphosate (Roundup). Journal of Pesticide Reform.18(3):4.

48 Hassan, S.A. et al. 1988. Results of the fourth joint pesticide testing programme carried out by the IOBC/WPRS-Working Group "Pesticides and Beneficial Organisms." J. Appl. Ent. 105: 321–329.

49 Springett, J.A. and R.A.J. Gray. 1992. Effect of repeated low doses of biocides on the earthworm *Aporrectodea caliginosa* in laboratory culture. *Soil Biol. Biochem.* 24(12): 1739–1744.

50 Folmar, L. C., Sanders, H. O., & Julin, A. M. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates *Archives of Environmental Contamination and Toxicology,* 8(3), 269-278.

51 Relyea, R. 2012. New effects of Roundup on amphibians: Predators reduce herbicide mortality; herbicides induce antipredator morphology. *Ecological Applications* 22:634–647.

52 Relyea, R. 2005. "The lethal impact of Roundup on aquatic and terrestrial amphibians." *Ecological Applications,* 15(4), 1118–1124.

53 Howe CM, B. M., Pauli BD, Helbing CC, Werry K, and Veldhoen N. 2004. Toxicity of glyphosate-based pesticides to four North American frog species. *Environ Toxicol Chem,* 23(8), 1928–1938.

54 U.S.EPA. 2009. Glyphosate Summary Document Reregistration Review: Initial Docket (p10). Office of Prevention, Pesticides and Toxic Substances.

55 Carey Gillam, 2017. USDA Drops Plan to Test for Monsanto Weed Killer in Food. Huffington Post. 03/23/2017. http://www.huffingtonpost.com/entry/usda-drops-plan-to-test-for-monsanto-weed-killer-in_us_58d2db4ee4b062043ad4af84.

56 Glyphosat-Rückstände im deutschen Bier. http://www.umweltinstitut.org/fileadmin/Mediapool/Downloads/02_Mitmach-Aktionen/11_Rettet_das_Reinheitsgebot/Glyphosat_Untersuchung_Umweltinstitut_2016.pdf.

57 Damian Carrington. 2014. Over 60% of breads sold in the UK contain pesticide residues, tests show https://www.theguardian.com/environment/2014/jul/17/pesticide-residue-breads-uk-crops.

58 Moms Across America. 2014. Glyphosate Testing Full Report: Findings in American Mothers' Breast Milk, Urine and Water. http://www.momsacrossamerica.com/glyphosate_testing_results.

59 Moms Across America. 2016. Widespread Contamination of Glyphosate Weedkiller in California Wine.

60 Food Democracy Now! And The Detox Project. *Glyphosate: Unsafe on Any Plate:* Food Testing Results and Scientific Reasons for Concern. https://s3.amazonaws.com/media.fooddemocracynow.org/images/FDN_Glyphosate_FoodTesting_Report_p2016.pdf.

61 CIFA. Safeguarding with Science: Glyphosate Testing in 2015-2016. Science Branch Survey Report http://static.producer.com/wp-content/uploads/2017/04/CFIA_ACIA-9123346-v1-FSSD-FSSS-Glyphosate-Final-Report-15-16_0184101.pdf#_ga=1.196489061.892407858.1492107204.

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