GLYPHOSATE-BASED HERBICIDES

TOXIC TO EARTH COMMUNITY

A SELECTIVE REVIEW
OF RECENT RESEARCH

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ABOUT THE AUTHOR

Seeing relationships is integral to her work as an Earth Community Advocate: relationships between people and the watershed in which they live and work, between people, soil, and food, between those who work the land and those who benefit from that labor, between food production practices and health of the whole, sacred inter-connected community of life in Earth's biosphere, or Earth Community.

Her research and activism on pesticide issues began in August 1995 and continued for 20 years, as she interacted with the Vermont Pesticide Advisory Council, Charlotte Conservation Commission, Public Service Board, Dept. of Environmental Conservation, Vermont Railway, a citizens group in Montpelier, and the Agency of Agriculture, Food and Markets. She has also been an ally to immigrant rights groups as marginalized citizens of Earth Community. She now lives with her husband in Burlington near Lake Champlain on land managed without pesticides, and works with others for justice for Earth Community.

"...our ancient understanding of the exquisite interconnectivity of all life has been shattered…. Like a foreign species that flourishes in a new environment, we have expanded beyond the capacity of our surroundings to support us. … the path we embarked on after the Industrial Revolution is leading us increasingly into conflict with the natural world." *David Suzuki, The Sacred Balance: rediscovering our place in nature. (1999)*

INTRODUCTION & ABSTRACT

A Vermont state official once asked me: "What is the "nexus" between glyphosate and water quality?" This report could be seen as a response to that question; it is also, and primarily, an effort to share new research about glyphosate-based herbicides (GBHs) addressing rising concerns about these herbicides and their effects on soil, plants, animals, humans and aquatic ecosystems. Given large increases in its use (see Tables 1 & 2), a deeper understanding of these herbicides and their dangers to Earth Community is critical.

GBH use in all categories has increased remarkably in the last ten years. Products such as Accord, Accord Concentrate, Accord XRT II, Aquaneat, Rodeo, and Roundup PRO are used on railroad, highway and utility rights-of-way near waters of the State, in the culture of genetically-modified "Roundup-ready" corn and soybeans in Vermont, on lawns and gardens. GBHs are the most commonly used herbicides worldwide, and are coming under more scrutiny regarding their environmental and health effects and their toxicity when the whole formulation is considered.

This paper reviews the important work of international scientists since 2000 studying the environmental fate of GBHs and their adverse effects on humans and on the natural world in which we live and on which we depend for life. The relationship between food and exposure to GBHs is explored, as well as Vermont law, policy, data collection and testing capability. A special focus is the relationship between the increasing use of GBHs in Vermont, the degradate aminomethyl-phosphonic acid (AMPA), phosphorus (P), and harmful algal blooms of cyanobacteria (cyanoHABs) in surface waters.

<u>Glyphosate use in Vermont</u>

With the advent of crops (mostly corn, some soybean) that are genetically modified to be resistant to glyphosate-based herbicides (GBHs), use of GBHs has increased dramatically from 2008 to 2009, and especially in the last decade. Other categories of use have also seen significant increases, including uses close to surface water (railroads and utilities).

Two-thirds of Vermont is watershed for Lake Champlain. The majority of dairy/corn agriculture is located in Addison, Franklin and Lamoille Counties, directly affecting Otter Creek, Lewis Creek, Winooski, Lamoille, and Missisquoi Rivers, smaller tributaries and Lake Champlain, as well as Lake Carmi and Lake Memphramagog.

Table 1: *REPORTED* Glyphosate Use in Vermont 2006-2012: major uses
(pounds of active ingredient rounded to nearest whole number, not including use by residents)

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Corn	1230	222	250	*13,125*	*18,766*	*23,764*	*25,873*
Forestry	79	114	59	479	183	700	691
Highway	259	0	280	?	699	334	1880
Lawn care	224	128	439	1692	3264	1941	2404
Ornamental	157	568	301	386	435	899	974
Railroad	0	994	1879	1155	2740	3132	2607
Utility	2306	3347	845	2118	8224	5518	22,954
TOTAL	**4255**	**5373**	**4053**	**18,955**	**34,311**	**36,288**	**57,383**

Table 2: *REPORTED* Glyphosate Use in Vermont 2013-2018: major uses
(pounds of active ingredient, rounded to nearest whole number, not including use by residents)

	2013	2014	2015	2016	2017	2018
Corn	20,850	27,441	28,106	33,705	28,088	28,970
Forestry	1418	1623	1213	1527	1494	2848
Highway	1858	1612	4	2340	3255	3742
Lawn care	1735	706	1114	1526	978	809
Ornamental	1236	1820	1164	(included in Lawncare)		
Railroad	2322	1771	3183	(included in Highway)		
Utility	2990	7796	3514	3600	4762	5481
TOTAL	**32,409**	**42,769**	**38,298**	**42,698**	**38,577**	**41,850**

(VAAFM, 2020)

Data is gleaned from
https://agriculture.vermont.gov/sites/agriculture/files/documents/PHARM/Pesticides/2018-USAGE.pdf

Railroads, Highways and Utilities

The experience of other countries and states regarding GBHs entering surface waters is instructive for us in Vermont. Researchers in France found glyphosate and its degradate AMPA from urban areas, including railroads and highways, in storm-water and wastewater treatment plants and in surface waters at concentrations above European drinking water quality standards of 1ppb. The glyphosate estimated load was 179 kg/yr at the urban catchment outlet. (Botta F et al 2009).

Glyphosate movement into surface waters from railbeds was studied in England. Fifteen micrograms/ liter (ug /L or ppb) glyphosate were detected in water 6 days after treatment, and after 81 days, 0.8 ug/L was found (Ramwell CT et al 2004).

Maine Board of Pesticide Control (BPC) monitored glyphosate runoff into surface waters from railways to determine whether their 10-foot buffer adequately protects waters and whether glyphosate was leaching into groundwater. Due to several problems the results of the study were inconclusive. The State of Maine requires railroads to observe a 10 ft buffer, and requires highways to observe a 50ft buffer to water for all herbicides. The BPC decided *not* to allow variances from the 10-foot buffer until railroad applicators submitted a new water quality monitoring plan for approval. [Maine Board of Pesticide Control 2003).

GBHs are the herbicides of choice for utility, railroad, and highway rights-of-way in areas near water in Vermont. Buffers allowed in Vermont for rights-of-way GBH use are between two and ten feet (VAAFM 2020B); however, such buffers are not likely to keep herbicides out of waters of the State.

In a study of buffer efficacy for pesticide retention, only 38% of glyphosate was retained by a buffer 5 meters (16 ½ ft) wide (Syversen, N 2004) .

Created in 1970, the Vermont Pesticide Advisory Council was charged with developing policies regarding pesticide reduction in Vermont. In order to do so, they need accessible and accurate pesticide use data, a challenge still out of reach as of February 2020 (Shambaugh N, 2020).

Right-of-way permits for utilities, railroads and highways are overseen by the Vermont Pesticide Advisory Council and approved by the Secretary of Agriculture. Each permit is discussed separately without consideration of cumulative impacts from multiple permits to streams (Knight S 2013). The permits do not name the surfactants or drift retardants that may be added to herbicides used on rights of way (VAAFM 2020B). A Freedom of Information Act request to VAAFM reveals that "Lo-Drift" drift retardant was added to herbicides (including GBHs) used in May 2020 on the Vermont Rail Systems Right-of-way. "Lo-Drift" is a water-soluble polyvinyl polymer manufactured by AmChem Products (Gratkowski, 1975). The only online references to this product were dated from mid-1970s. Is the product still legal for use? A product that may be similar is “Direct”, which contains 30% polyacrylamide and 70% unidentified ingredients (Precision Laboratories 2015).

Water quality monitoring (*not* including glyphosate) between 2001 and 2007 shows that herbicides used on railways do indeed enter the waters of the State, contrary to permit conditions (Shambaugh, N 2007).

Yearly use of GBHs on large railyards in Burlington (adjacent to Lake Champlain), Rutland (adjacent to Otter Creek), St. Johnsbury (adjacent to Passumpsic River), White River Junction (White River and Connecticut River) and on railroads through the middle of towns (Barre, Essex Junction, Montpelier) have not been considered in relation to adjacent human activity or water quality values in these ecosystems.

GBHs, Water, Phosphorus and Cyanobacteria

Cyanobacteria have lived on Earth since early periods of the planet’s life, and have contributed to development of other forms of life during the planet’s history. In the last two decades, however, these phytoplankton have increased greatly in Lake Champlain and in other water bodies due to increased phosphorus (P) and nitrogen (N) loading to waters from land-based activities (Shambaugh A 2008). Vermonters are seeing water quality in our lakes degraded by cyanobacteria and harmful algae blooms earlier in summer (Gribkoff and Silberman 2019) and later in fall (Quigley A 2019) in trends related to global warming. Average August water surface temperatures in Lake Champlain have risen between 1964 and 2009 by 1.6 -3.8 degrees C; higher temperatures and changes in precipitation favor the dominance of cyanobacteria over other phytoplankton in Lake Champlain (Fortin N et al 2015).

Some types of cyanobacteria produce microcystins that are either neurotoxins or hepatotoxins (damaging to the liver) (Moore et al 2008). Humans can be exposed to them through particles in wind, in contaminated water, and in contaminated fish or clams. Cyanobacteria in surface water are a severe threat to humans, dogs and livestock (Fortin N et al 2015).

Major nutrients reaching surface waters used by cyanobacteria are phosphorus (P) and nitrogen (N). Because Lake Champlain is already overloaded with anthropogenic nutrients, US EPA has set Total Maximum Daily Load (TMDL) targets for P for each Lake Champlain segment (U.S.EPA 2016). But those targets have not been reached and the problems continue and even worsen. The International Joint Commission reports that serious cyanobacteria blooms persist in Missisquoi Bay and Lake Memphramagog (Laitta, M et al 2020).

Some strains of cyanobacteria appear to be somewhat resistant to glyphosate (Perez GL et al 2007). Scientists at Bowling Green University have identified a gene in marine and freshwater cyanobacteria enabling them to use phosphonates in the environment, including phosphonate herbicides as a nutrient (Ilikchyan IN et al 2009).

Four cyanobacteria species are able to use glyphosate as a nutrient source, promoting proliferation and blooms of cyanobacteria. They are *Nostoc (or Anabaena), Leptolyngbya boryana, Microcystis aerugina,* and *Nostoc punctiforma* (Hove-Jensen B et al, 2014). Two of these, *Anabaena spiroides* and *microcystis aeruginosa,* were heavily present in harmful blooms in Missisquoi Bay in 2006, the latter beginning in late May. Near the shore the cyanobacteria had more toxins per cell than those in the open water, creating concerns for drinking water quality and human exposure to microcystis toxins. Climate change is adding unpredictability to these bloom events with raised temperatures for longer periods, and stronger precipitation events (Fortin, N et al 2010).

Recent increases in GBH use associated with the culture of genetically modified corn as well as the practice of killing cover crops in no-till culture raises the potential for higher inputs of P into surface waters. This means that the amounts of glyphosate used on land must be considered in watershed planning processes in order to reduce phosphorus in water. (Hébert MP et al, 2018).

The ability to understand the activity of glyphosate and its break-down product in soil and water is changing as testing protocols improve. The U.S. Geological Services (USGS) have developed effective laboratory techniques for detecting glyphosate and its degradate, aminomethylphosphonic acid (AMPA) in the environment at the detection level of 0.02ug/L (ppb). This development is important in enabling scientists to understand the presence, persistence and transport of glyphosate in the environment (Meyer MT et al 2009). Others are finding glyphosate and AMPA in precipitation, snow melt, small streams, groundwater, large rivers and lakes all over this country (Scribner E et al 2007).

Applying that science in Vermont will be crucial in efforts to protect water quality. Since 2016 staff of VT Agency of Agriculture, Food & Markets (VAAFM) have tested Vermont waters for glyphosate with a detection limit of 10ppb but are not able to find it with current testing methods in surface waters of the State (VAAFM 2020).

Scientists with Ohio EPA found that spring applications of GBHs used on Ohio cornfields adjacent to Lake Erie were associated with algal blooms in the Lake. In this study, the phosphonate component averaged about 15% of glyphosate and was available as a nutrient source for algae living in the lake (Ohio Lake Erie Phosphorus Task Force Report 2010).

These scientists' findings may be useful in the Vermont discussion: 1) glyphosate can desorb phosphorus (P) in soil containing iron oxide hydroxide; 2) depending on metals in soil, *20-25% of dissolved reactive phosphorus* (DRP) *runoff is caused by glyphosate;* 3) in some areas P desorption can be negligible, in others, almost 100 %; 4) 1/3 of a pound of P can be released from an acre of glyphosate-treated land (Barrera L 2016).

GBHs and Global Climate Change

Climate change is already with us. As we noted above, higher lake water temperatures; higher air temperatures; longer summers bring longer periods of harmful algal blooms. Precipitation events are more severe and erratic with longer dry periods between. Increased use of GBHs can disturb the phosphorus balance in soils, and more P is available in runoff from more severe precipitation events (Hébert MP et al 2018).

Higher temperatures and increased CO2 concentrations in the atmosphere can reduce the sensitivity of some plants to glyphosate. In higher temperatures, plants may move glyphosate out of leaves to stems and roots more quickly, thereby reducing the plant's sensitivity. Over-reliance on GBHs in global warming may result in weed control failure (Matzrafi M et al 2019). In higher temperatures, users may be tempted to use higher than recommended concentrations, and may see an increase in weed resistance. It will be important to understand weed types for weed management in a changing climate (Fernando, N et al 2016).

GBHs in Soil, Water, Air

Soil

GBHs kill plants and plant-like biota by inhibiting the EPSP enzyme, part of the shikimic pathway in plants (and microbiota) responsible for creating proteins and other substances needed for plants' growth. Glyphosate also is able to chelate, or bind micronutrients in the soil needed by plants for successful growth and development and for their resistance to toxins and harmful biota.

Table 3: Main functions of micronutrients in plants (adapted from Mertens M et al):

Element	Symbol	Main physiological functions in plants
Boron	B	Cell wall synthesis and structure, cell membrane function, lignification, IAA formation, nodule development, other (secondary) processes
Cobalt	Co	Nodule initiation
Copper	Cu	Essential for photosynthesis, mitochondrial respiration, C, N metabolism, oxidative stress protection, catalytic metal in many oxidases, pollen fertility, plant defense, synthesis of phenolics, photosynthesis
Iron	Fe	Central part of hemoproteins (e.g., cytochromes), involved in photo-synthesis, mitochondrial respiration, N assimilation, hormone biosynthesis, osmoprotection, pathogen defense, oxidative stress protection
Manganese	Mn	Cofactor/activating role for at least 36 enzymes, protection from free radicals, involved in shikimic acid pathway and production of phenolics, fatty acid synthesis, N metabolism, C fixation, chloroplast function
Molybdenum	Mo	N assimilation and fixation (e.g., nitrogenase, nitroreductase), biosynthesis of abscisic acid
Nickel	Ni	Urease activity, hydrogenase activity in legume nodules
Zinc	Zn	Component of many proteins involved in DNA replication, transcription, translation, C fixation, carbohydrate and protein metabolism, oxidative stress protection, disease resistance

(adapted from Mertens M et al: see online article for complete chart with references.)

GBHs may impact soil life by changing the availability of essential as well as toxic metals that are bound to soil particles. This characteristic of glyphosate has not been thoroughly discussed in risk assessments for glyphosate, and has implications for health of animals and humans consuming glyphosate-treated plants (Mertens M et al 2018).

Residues of glyphosate -treated plants such as roots and harvest residues can present a toxic risk for following crops, “since accumulation of glyphosate in young growing root tissues leads to high levels of glyphosate that is subsequently released during microbial degradation of the plant residues and can be taken up by non-target plants via contact contamination” (Mertens M et al 2018).

GBHs in soil can influence soil microflora and their interactions with plants, favoring some while discouraging others. Gly can reduce nodulation and nitrogen fixation in soy and other legumes, influenced by the chemical’s chelating ability. Binding manganese (Mn) in soil or plants appears related to the insufficiency of manganese in grain crops afflicted by “take-all” disease, the fungus *Gaeuman-nomyces graminis.* The uptake and utilization of iron (Fe) and other minerals by plants is also reduced by glyphosate and AMPA, impairing root growth, nutrient uptake, and translocation processes (Mertens M et al 2018).

Glyphosate Transport to Waters

Researchers with the US Geological Services have monitored midwest waters and found approximately 50 streams contaminated with glyphosate at levels up to 8.7 ug/L (parts per billion) and its degradate AMPA (USGS 2013).

Other USGS scientists found glyphosate and its breakdown product aminomethyl-phosphonate acid (AMPA) in effluent downstream from wastewater treatment plants at higher rates than in surface waters upstream of such facilities. This study is important for its finding that urban use of GBHs contributes to glyphosate and AMPA in surface waters. It also suggests that glyphosate and AMPA are more mobile and persistent in aquatic environments than previously believed (Kolpin DW et al 2006).

In studies of glyphosate in surface waters in Indiana and Iowa, subsurface drainage was a major factor in the transport of glyphosate to streams. Subsurface drainage is used in 80% of the basin because of soil types, and about 71% of streamflow is from subsurface drainage (Coupe RH et al 2011). Subsurface drainage is a common practice in the clay soils of the Champlain Valley (VAAFM 2017).

Groundwater contamination may be less frequently found than in surface water. Research in Europe has developed testing protocols for detecting glyphosate at parts per trillion. Efforts in groundwater monitoring in Catalonia (northeast Spain) in real groundwater samples have found glyphosate in 41% of samples with concentrations as high as 2.5ug/L (above EU drinking water standard of 0.1ppb) and a mean concentration of 200 ng/L (Sanchis J et al 2012).

Glyphosate and AMPA were the most common contaminants in the Orge River watershed in France during a 2007-2008 study. Samples taken from surface water, wastewater, storm sewer and wastewater treatment plants showed glyphosate and AMPA at levels above the *European standard of 0.1ug/L (ppb) for drinking water.* Railroad and highway applications were established as the source of the contaminants, which were highest during rainfall events. During dry periods detergent seemed to be the main source of AMPA in surface waters.
(Botta F et al 2009).

<u>Atmospheric transport</u>
The atmosphere is an integral part of the hydrologic cycle, moving pesticides across wide areas through either volatilization or via pesticide-contaminated dust particles. Rain can remove such particles to the earth some distance from their original place of application. US Geological Services scientists monitored glyphosate and its degradate aminomethylphosphonic acid (AMPA) in air and rain samples during the growing season in the Mississippi delta in 1995 and again in 2007. Samples in air and rain were analyzed by online Solid Phase Extraction (SPE) coupled to liquid chromatography/ mass spectometry. Glyphosate was detected in 86% of air samples and in 77% of rain samples in 2007 but were not included in 1995 tests. Highest concentrations of glyphosate and AMPA occurred in April and May; but there were detectable amounts in the air during the rest of the season. Total herbicide contamination was greater in 2007 than in 1995, and was dominated by glyphosate, due to increase in genetically modified crops.
(Majewski MS et al 2014).

EFFECTS ON WILDLIFE

<u>Fish</u>
Glyphosate has differing toxicities to three species of sturgeon. Longer exposure times caused greater toxic effects and lower glyphosate amounts were needed to reach lethality. The POEA surfactant in Roundup formulation is the more toxic ingredient to aquatic organisms. Technical grade glyphosate is less toxic as pH increased, but Roundup becomes more toxic as pH increased from 6.5 to 9.5. With increased exposure times and higher glyphosate concentrations, abnormal behaviors increased. Glyphosate may reduce populations by decreasing fry mass and size of yolk sac, and by initiation of unsafe behaviors (Filizadeh Y et al 2010).

Roundup exposure at 10 mg/L for 6, 24 and 96 hours caused genotoxic damage in erythrocytes (red blood cells) and in gill cells of the tropical fish *Prochilodus lineatus.* Effects on bronchial cells were considerably higher than controls after 6 and 24 hours with the comet assay. The comet assay with gill cells proved to be an important tool to reveal DNA damage in fish tissues in periods of exposure not revealed by tests with erythrocytes or red blood cells (Cavalcante DGSM et al 2008).

Glyphosate caused several toxic effects in juvenile Nile tilapia fish: tissue changes in gills, liver, kidney and brain. The lethal concentration for the 96 hour EC50 value was 1.05 mg/L. At 2mg/L effects were seen in gills, liver and kidney. Respiratory distress, erratic swimming, excessive secretion of mucus, weakness, and instant death were observed at concentrations of 9, 30, 97 and 310 mg/L. In gill tissues, glyphosate caused impairment in gaseous exchange efficiency and other anomalies (Ayoola SO 2008).

Fish exposed to 4mg/L glyphosate (amount used in agriculture) for 45 days experienced severe damage, shrinkage, and degeneration of epithelial cells in the gills. Among other tissue disturbances, damage to cells in the esophagus and severe mucus secretion in the stomach were observed. Glyphosate reduced the enzymes amylase, lipase and protease involved in removing toxins and in digestive processes in the esophagus, stomach and intestine (Senapati T 2009).

Glyphosate, the surfactant POEA and the formulation Roundup were all found to be genotoxic to blood cells of the European eel. Different groups of animals were exposed to 58 and 116 ug/L Roundup, 17.9 and 35.7 ug/L glyphosate, and 9.3 and 18.6 ug/L POEA. Those eels exposed to the lower concentration of the commercial formulation showed significantly higher levels of oxidative damage than those exposed to the active ingredient. The study demonstrated that most of the genotoxicity comes from the surfactant itself as well as the genotoxic risk of both glyphosate and POEA surfactant (Guilherme S et al 2012).

Frogs

Frogs exposed to environmentally relevant concentrations of glyphosate-based herbicide formulations showed changes in length of snout, increased time to metamorphosis, tail damage and gonadal abnormalities. These effects were caused by disruption of hormone signaling. Roundup was the most toxic to frogs; the least acutely toxic formulations were Roundup Bioactive, Touchdown and Glyfos BIO, because of different surfactants. Surfactant composition must be considered in evaluation of glyphosate-based herbicides (Howe CM et al 2004).

Pollinators

Exposure of bees to field-realistic agricultural concentrations of glyphosate desensitizes bees to sucrose in their foraging areas and causes a significant decrease in memory retention, impairing the bees' learning ability. Foraging bees may be bringing glyphosate-contaminated nectar to the hive, with long-term harm for the hive (Herbert LT et al 2014). Honey bees depend on eight species of gut microbiota that utilize the shikimic pathway and are vulnerable to GBHs. Field exposures to GBHs cause reduction in gut biota, reduced weight gain, altered metabolism, and increased susceptibility to hive death from opportunistic pathogens (Motta, EVS et al, 2018).

"Surfactant composition must be considered in evaluation of glyphosate-based herbicides."

HUMAN HEALTH

<u>Unidentified ingredients in GBHs</u>

Table 4 below lists some undisclosed ingredients in GBHs. The pesticide industry calls them “inert ingredients”, but they are neither benign nor inactive as the term implies. Pesticide labels indicate the “active” ingredient and its percent content in the product. Manufacturers are not required to disclose ingredients they consider to be “proprietary information”. These ingredients actually increase the toxic effects of the whole formulation and may be more toxic in combination than glyphosate itself. For example, Roundup WeatherMax (allowed for use in Vermont) contains petroleum distillates at 540 grams/liter.

> *“The difference between “active ingredient” and “inert compound” is a regulatory assertion with no demonstrated toxicological basis.” (Defarge N et al 2018).*

Table 4: List of possible ingredients which may be present in varying combinations in GBHs :

ammonium sulfate	methyl pyrrolidinone
benzisothiazolone	pelargonic acid
5-chloro-2-methyl 3(2H)-isothiazolone	polyethoxylated tallowamine or alkylamine (POEA)
FD&C Blue No. 1	propylene glycol
3-iodo-2-propynylbutylcarbamate	sodium sulfite
isobutane	sodium benzoate
isopropylamine	sodium salt of o-phenylphenol
light aromatic petroleum distillate	sorbic acid
methyl p-hydroxybenzoate	

(Benachour N et al, 2006)

Table 5: GBH Products available at one store in Burlington, 9/8/20:

PRODUCT NAME	EPA Reg. No.	INGREDIENTS	MANUFACTURER
Roundup Precision	71995-60	glyphosate 1% pelargonic acid 2% **other 97%**	Monsanto
Roundup Extended Control	71995-47	glyphosate 1% pelargonic acid 2% imazapic .017% **other 97.983%**	Monsanto
Roundup Weed & Grass Killer Concentrate Plus	71995-29	glyphosate **18%** diquat bromide .73% **other 81.27%**	Monsanto
Roundup Poison Ivy Plus Tough Brush Killer	71995-36	glyphosate 1% triclopyr 0.1% **other 98.9%**	Monsanto
Roundup Ready to Use Weed & Grass Killer	71995-33	glyphosate 2% pelargonic acid 2%, **other, 96%**	Monsanto

Endocrine Disruption in Humans

Endocrine function is fundamental to human physiology and development and can be adversely affected by pesticides at very low concentrations, especially at very early stages of development. Study of endocrine disrupting compounds (EDCs) began in the late 1980s. Scientists such as the late Dr. Theo Colborn became concerned about the adverse effects of EDCs at very low concentrations on various aspects of animal and human development. She and scientists in several disciplines found that EDCs do not conform to assumptions of traditional toxicology, that “the dose makes the poison,” or that biological effects increase with the dose. These scientists came to an unescapable consensus, that hormone disruptors were threatening the survival of animal species and jeopardizing the human future (Colborn T et al, 1997).

Effects of EDCs include physical deformities, delayed physical or mental development, learning disabilities, cancers, or reproductive disorders. Health risk evaluations for pesticides have not yet caught up with the research in this area. Please see https://endocrinedisruption.org/ for more information.

Several European scientists have been active in studying the relationship between GBHs and endocrine disruption, as discussed below.

"Glyphosate is toxic to human placental cells within 18 hours with concentrations lower than those found in agricultural use, and this effect increases with concentration and time or in the presence of Roundup adjuvants." Glyphosate inhibited aromatase activity with a concentration of 0.04% with Roundup. The added ingredients in Roundup greatly facilitated glyphosate penetration of the cell membrane. Exposure of cells to Roundup also resulted in a decrease of the cytochrome P450 enzymes at concentrations 100 times lower than the recommended use in agriculture. Cytochrome P450 enzymes are present in most tissues of the body and play important roles in hormone synthesis (Richard, S et al 2005). [For context, according to EPA, the recommended use of Glyphosate 41% on GMO corn is between 1 and 5 quarts per acre mixed with water, and no more than 8 quarts per year (U.S.EPA 2016).]

Other researchers found that Roundup at 0.01% field concentration (210 micromolar or approximately *36ppb*) causes a 19% reduction of estrogen in embryonic cells. Estrogen is necessary for normal fetal development. Glyphosate was able to inhibit aromatase, including cytochrome P450 aromatase in cells; other ingredients in the formulation increased the toxicity to cells. Only partial elimination of Roundup occurs from the body, leaving additives in Roundup formulations to penetrate and adhere to cells; therefore, accumulation of mixtures of toxins in the body can occur. The scientists confirmed that Roundup causes endocrine disruption in mammalian embryonic cells and mammalian testicle cells. Exposure of pregnant women to Roundup during pregnancy can expose the placenta and embryo, which could be vulnerable to endocrine disrupting effects by these compounds. Roundup exposure may affect human reproduction and fetal development in case of contamination. Chemical mixtures in formulations are underestimated regarding their toxic or hormonal impact. (Benachour N et al 2006).

DeFarge et al studied the whole formulation of several pesticides, that is, all of the ingredients in the product. They found that glyphosate is actually less toxic than the additives (formulants) and never reached the toxicity levels of the formulants. These formulants acted on human cells in several ways: membrane disruption, cell death, inhibition of mitochondrial respiration, and DNA damage, all below toxic thresholds. (Mitochrondrial respiration is the process by which parts of the cell are able to use chemical energy in glucose to create energy-carrying molecules.) (Biology LibreTexts 2020) The formulants were found to bio-accumulate in the tissue. The formulants caused endocrine disruption on the androgen/estrogen balance controlled by aromatase, from both short-term and long-term exposure. Regulatory testing of glyphosate alone without formulants is clearly not adequate to establish reference doses for daily intake (DeFarge N et al 2018).

<u>Damage to Human Gut Microbiome & Relation to Human Health</u>

Cytochrome P450 or CYP enzymes have a critical role in helping the human body to detoxify foreign organisms and toxic substances. Glyphosate inhibits CYP enzymes and thus enhances the damaging effects of other environmental toxins in our bodies, making us more susceptible to disease. Its mode of action is disruption of the shikimate pathway used by plants and our gut bacteria, which are biologically similar to plants. These gut bacteria aid in digestion, synthesize vitamins, detoxify xenobiotics, and assist the immune system in maintaining health. Clear evidence is offered that glyphosate disrupts gut biota and suppresses the CYP enzyme class, contributes to serious chronic diseases such as obesity, autism, Alzheimer's, depression, Parkinson's, liver disease, cancer. Periodically EPA raises the level of accepted residues in animal feed and food for humans in order to accommodate increased industry use, without monitoring actual food levels or consideration of human health (Samsel A, S. Seneff 2013).

When rat mothers were treated with doses of a GBH considered safe (by EPA) for humans (1.75 ppb/ kg of body weight), there were changes in reproductive health and detrimental effects in the gut bacteria of their male pups. Exposure to GBHs at currently acceptable levels can change urine metabolites, affect cardiovascular disease through the gut biome, and can indirectly lead to abnormal neurological development. The gut microbiome is key to successful mammalian metabolism (Mao, Q et al, 2018).

<u>Chronic Kidney Disease</u>

Glyphosate can combine with metals in hard drinking water supplies to cause chronic kidney disease (CKD), destroying kidney tissue in farmers living where certain metals in water are toxic to the liver. This syndrome has been observed in

Sri Lanka and in Central America, where men in the prime years of their lives are succumbing to debilitating kidney disease with no solution in sight. Contaminants in the water contributing to CKD are arsenic, cadmium and pesticides which may also be contaminated with these metals (Defarge et al, 2018). Dehydration due to high temperatures, drinking hard water and lack of adequate hydration appear to be associated factors.(Jayasumana C et al 2014; Gunatilake, S et al, 2019).

Naturally occurring arsenic is present above EPA drinking water standards in Vermont groundwater wells in Waterbury and Stowe, Troy, Newport and Coventry, in Castleton, Poultney, Wells, Pawlet, Rupert and Whiting (Environmental Studies Senior Seminar, 2010). Higher summer temperatures, working without proper hydration, exposure to glyphosate in air and in food, and arsenic in water could contribute to chronic kidney disease in Vermont.

<u>Reproductive issues</u>

Glyphosate contamination of mothers' urine has been associated with significantly shorter pregnancies and lower birth weights, potentially leading to health problems later in life. Higher caffeine levels may concentrate glyphosate content in the urine due to a diuretic effect (Parvez S et al, 2018). A physician in Indiana, where mothers are exposed to GBHs from several sources, is studying the effects of glyphosate on 69 pregnant mothers and on their children (Gillam C, 2017).

<u>Non-Hodgkins Lymphoma</u>

The association between glyphosate, Roundup and different types of cancer has been the subject of much research and disagreement internationally. The International Agency for Research on Cancer has come to a consensus that glyphosate is a Class 2A, or probable human carcinogen, based on what they have learned from a survey of many studies. Researchers in Sweden found a significant association between exposure to glyphosate and small lymphocytic lymphoma, chronic lymphocytic leukemia, as well as with B-cell lymphoma. T-cell lymphomas were associated with exposure to all GBHs. (Eriksson M et al 2008). While the discussion about the carcinogenicity of GBHs continues, other risks of GBHs to human health continue to be revealed.

Residues in food: avenue for human exposure

EPA sets the Allowable Daily Intake or ADI for pesticides in foods, taking industry interests into consideration. In 2013 EPA raised the food allowance for glyphosate in several foods: in oil-seed crops including sesame, flax and soybean, from 20 parts per million (ppm) to 40 ppm; in sweet potatoes and carrots, from 0.2 ppm to 3ppm for sweet potatoes and 5ppm for carrots. That's 15 and 25 times the previous levels (GMOinside, 2013). Food tolerances for glyphosate in many foods can be viewed on this website:
www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol24/xml/CFR-2014-title40-vol24-part180.xml.

EPA's process of setting the Allowable Daily Intake or ADI for foods relies on science from chemical manufacturers, rather than toxicologists, a process which does not take into consideration recent findings on carcinogenicity, endocrine

disruption, toxicity of substances added to the pesticide after registration to make it more effective, or the cumulative effects of the wide distribution of glyphosate in food and water. For these reasons, some are questioning the margin of safety for consumers provided by ADIs. The Alliance for Natural Health tested several foods for glyphosate residues: flour, corn flakes, instant oatmeal, bagels, yogurt, bread, frozen hash browns, potatoes, hot cereal, eggs, non-dairy creamers, and dairy based coffee creamers. Results show residues of between 1300 and 86 ppm in these food items. Even organic eggs were tainted (ANH, 2016).

In 2017 the Organic Consumers Union found that 10 out of 11 samples of Ben & Jerry's ice cream tested positive for low concentrations of glyphosate and its breakdown product, aminomethylphosphonic acid or AMPA. The highest amount of glyphosate was 1.74 ppb, and the highest amount of AMPA was .91 ppb (Strom, S 2017). While these amounts are very small and much lower than EPA food allowances for glyphosate, they are close to the European Union's maximum contaminant level of 0.*1ppb* for glyphosate in water.

A study of glyphosate residues in urine and flesh of livestock and urine in humans found that concentrations of glyphosate were lower in cows kept in an area free of genetically-modified feed. Glyphosate residues were higher in urine of humans who ate conventional foods, and these subjects were less healthy than those with lower residues, whose food was raised without pesticides. Glyphosate cannot be removed from food by washing, and is not removed by cooking (Kruger M 2014).

Food tolerances for glyphosate can be viewed on this website: www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol24/xml/CFR-2014-title40-vol24-part180.xml. Do a "find" command for glyphosate to get the food tolerances.

EPA's Maximum Contaminant Level of 700 ppb for glyphosate in water is not protective of human health when we know of its health effects at 500ppb and less.

European Union's maximum contaminant level for glyphosate in water is 0.1ppb.

"Our ability to use chemicals greatly surpasses our ability to ... understand their cumulative impacts on the community of life."

Sylvia Knight to VPAC, 2013

IN CONCLUSION

GBHs are neither benign to humans nor immobile in the environment. They can move into water and supply P for dangerous cyanobacteria. GBHs are toxic to human cells at low concentrations (far below EPA's lax drinking water standard of 700ppb), damage digestive biota and enzymes necessary for digestive and immune function and for metabolism. GBHs reduce newborn viability, and are toxic to fish and pollinators. Is our drinking water via Lake Champlain safe for us all?

The State's inability to detect glyphosate and AMPA in surface waters does not mean an absence of these compounds in waters of the State. VT Agency of Agriculture, Farm & Markets should reserve its laboratory capacity for monitoring other toxins and seek assistance from US Geological Services with appropriate technology to detect glyphosate and AMPA.

Determinants of public benefit and public accountability call for a serious revision of pesticide policy, in relation to global warming, ecology and alternatives:

1. **The Public Trust Doctrine:** waters are essential for life and are to be protected by the State for all people and for future generations.

2**. VT Law (6VSA sec.1102ff):** instructs VT Pesticide Advisory Council (VPAC) to develop benchmarks for the reduction of pesticide use and an increase in areas managed by non-toxic methods, a work not yet engaged by VPAC. Pesticide use permits must consider cumulative uses in affected watersheds, in accordance with anti-degradation laws.

3. **Vermont Pesticide Regulations 1991:** must be revised through a public process to include strong IPM alternatives and relationship to global warming.https://agriculture.vermont.gov/sites/agriculture/files/documents/PHARM/Pesticides/Vermont%20Regulations%20for%20Control%20of%20Pesticides%20August%202-1991.pdf

4. **U.S.EPA. Phosphorus TMDLs for Vermont Segments in Lake Champlain:** reductions of P in Lake Champlain must include all sources (US EPA, 2016).

5. **Earth Charter:** urges responsible entities to "ensure that decision making addresses the cumulative, long-term, indirect, long distance and global consequences of human activities." (www.earthcharter.org)

Independent researchers are warning us about the dangers of GBHs to life:

- source of phosphorus (P) in our surface waters
- promoter of harmful algal blooms with neural and hepatotoxins
- a probable carcinogen (IARC)
- an endocrine disruptor
- reproductive toxicant
- air and rain contaminant
- food contaminant
- toxin to mammal gut biota
- danger for pollinators
- surface water contaminant, toxic to aquatic life

- groundwater contaminant

Whatever befalls the earth, befalls the children of the earth.
Chief Seattle

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