UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL
SAFETY AND POLLUTION PREVENTION

September 21, 2022

MEMORANDUM

SUBJECT: Withdrawal of the *Glyphosate Interim Registration Review Decision*

TO: Glyphosate Registration Review Docket (EPA-HQ-OPP-2009-0361)

FROM: Cathryn Britton, Branch Chief
Risk Management and Implementation Branch V
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On June 17, 2022, the United States Court of Appeals for the Ninth Circuit vacated and remanded the human health portion of EPA's interim registration review decision for glyphosate (ID), held that EPA's failure to make an effects determination before issuing the ID violated the Endangered Species Act (ESA), and remanded without vacating the ecological portion of the ID but imposed an October 1, 2022 deadline for EPA to complete the remand. *Natural Resources Defense Council et al. v. EPA*, 38 F.4th 34 (9th Cir. 2022). In light of the court's decision, this memorandum announces EPA's withdrawal of all remaining portions of the glyphosate ID, including the remanded ecological portion.

A copy of the glyphosate ID, now vacated in part and the remainder withdrawn, is posted to the glyphosate registration review public docket (EPA-HQ-OPP-2009-0361) at https://www.regulations.gov.

Background

Issuance of the Glyphosate Interim Registration Review Decision

Registration review is EPA's periodic review of pesticide registrations to ensure that each pesticide registration continues to satisfy the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) standard for registration, that is, that the pesticide can perform its intended function without unreasonable adverse effects on human health or the environment. Under FIFRA section 3(g), each pesticide is required to be reviewed every 15 years.

EPA regulations establish procedures for the registration review program required in FIFRA section 3(g). Under 40 C.F.R. § 155.56, EPA may issue, when it determines it to be appropriate, an interim registration review decision before completing a registration review. Among other things, the interim registration review decision may require new risk mitigation measures, impose interim risk mitigation measures, identify data or information required to complete the review, and include schedules for submitting the required data, conducting the new risk assessment, and completing the registration review. Procedures for issuing an interim registration review decision are set forth in § 155.58.

On February 3, 2020, EPA published a notice in the Federal Register (85 Fed. Reg. 5957) announcing the availability of the glyphosate ID. EPA issued the ID pursuant to 40 C.F.R. §§ 155.56 and 155.58, explaining that it was doing so to "(1) move forward with aspects of the registration review case that are complete and (2) implement interim risk mitigation." The ID finalized EPA's draft risk assessments supporting registration review, *Glyphosate Draft Human Health Risk Assessment for Registration Review* and *Registration Review—Preliminary Ecological Risk Assessment for Glyphosate and Its Salts*. The ID did not identify any human health risks of concern from exposure to glyphosate but did identify potential ecological risks. It also identified interim risk mitigation measures, in the form of label changes, including spray drift management language, herbicide resistance management language, a non-target organism advisory, and certain label consistency measures. It concluded that, under FIFRA, the benefits of glyphosate outweigh the potential ecological risks when glyphosate is used in accordance with labels.

The glyphosate ID did not make findings under section 7 of the ESA or under the Endocrine Disruptor Screening Program (EDSP) pursuant to section 408(p) of the Federal Food, Drug, and Cosmetic Act (FFDCA), nor did it respond to a 2018 administrative petition submitted by the Environmental Working Group and others (EWG et al.) to reduce the tolerance level for glyphosate residues on oats and require certain label changes based on concerns regarding dietary exposure and carcinogenicity. EPA explained that it would do so before completing registration review for glyphosate, and that the "final registration review decision for glyphosate will be dependent upon the result of the agency's ESA assessment and any needed section 7 consultation with the [U.S. Fish and Wildlife Service and the National Marine Fisheries Service], an EDSP FFDCA section 408(p) determination, and after a resolution of the EWG et al. petition." The glyphosate ID also did not solicit label changes from registrants to implement the interim risk mitigation measures. EPA explained that it would do so once it responded to the EWG et al. petition.

For further background on glyphosate and its registration review history, see the end of this memorandum.

Endangered Species Act Assessment for Glyphosate

ESA section 7(a)(2) requires that federal agencies ensure that the actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of species listed as

threatened or endangered under the ESA (listed species) or destroy or adversely modify their designated critical habitat. For pesticides in registration review, EPA's responsibility includes evaluating potential effects to listed species and their designated critical habitat, often through a biological evaluation (BE). If EPA determines that a pesticide's registration "may affect" and is "likely to adversely affect" listed species or designated critical habitat, the Agency initiates formal consultation with the U.S. Fish and Wildlife Service (FWS) and/or the National Marine Fisheries Service (NMFS) (together, the Services). The Services prepare their respective biological opinions (BiOps) regarding whether the pesticide's registration is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitats and describing any reasonable and prudent measures or reasonable and prudent alternatives. EPA then uses its authorities under FIFRA to implement, as necessary, any such measures or alternatives described in the BiOps.

On November 25, 2020, EPA released the draft BE for glyphosate for public comment. On November 12, 2021, EPA released the final BE for glyphosate, which found that glyphosate may affect 1,795 listed species and 792 critical habitats and is likely to adversely affect 1,676 of those species and 759 of those habitats. EPA initiated formal consultation with the Services in November 2021. As noted in the declaration filed in support of EPA's August 1, 2022 petition for panel rehearing of the Ninth Circuit's decision, discussed below, consultation with the Services is ongoing.

For further information on EPA's ESA assessment for glyphosate, see https://www.epa.gov/endangered-species/final-national-level-listed-species-biological-evaluation-glyphosate.

Challenges to Glyphosate Interim Registration Review Decision

On March 20, 2020, two groups of petitioners filed petitions for review of the glyphosate ID in the Ninth Circuit. *See Natural Resources Defense Council et al. v. EPA*, No. 20-70787 and *Rural Coalition et al. v. EPA*, No. 20-70801. Together these petitions challenged EPA's analysis of the human health and ecological risks and costs of glyphosate, weighing of such risks against the benefits of glyphosate, and the interim risk mitigation measures identified in the ID, and alleged that EPA violated the ESA by issuing the ID before completing consultation with the Services.

While EPA defended its analysis of human health risks and the alleged ESA violation, it moved for partial voluntary remand without vacatur of its analysis of ecological risks and costs, weighing of such risks against benefits, and interim risk mitigation measures. EPA sought remand to:

- Consider how the glyphosate ID may be impacted by the (then) draft BE and whether additional or different risk mitigation measures may be necessary.
- Reconsider its analysis of ecological risks as it relates to in-field effects of glyphosate on monarch butterfly habitat in light of the court decision in *National Family Farm Coalition v. EPA*, 966 F.3d 893 (9th Cir. 2020).

- Consider whether the court decision in *National Family Farm Coalition v. EPA*, 960 F.3d 1120 (9th Cir. 2020) regarding EPA's analysis of spray drift risks and other potential costs of another pesticide (dicamba) affected EPA's analysis of glyphosate.
- Evaluate the glyphosate ID in light of the change in Administration and policy priorities, as reflected in the January 20, 2021 "Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis" (86 FR 7037, 1/25/21) and, in particular, consider whether there are other aspects of its analysis of ecological risks and costs related to glyphosate that should be reassessed or for which additional explanation should be provided.
- Consider what risk mitigation measures may be necessary to reduce potential risks following completion of analyses left outstanding in the ID.

The Ninth Circuit heard oral argument on these challenges on January 10, 2022 and issued its decision on June 17, 2022. The court vacated and remanded the human health portion of the glyphosate ID, held that EPA's failure to make an effects determination before issuing the ID violated the ESA, and granted EPA's motion for partial voluntary remand but imposed an October 1, 2022 deadline for EPA "to issue a new ecological portion." *Natural Resources Defense Council et al. v. EPA*, 38 F.4th 34 (9th Cir. 2022).

On August 1, 2022, EPA filed a petition for panel rehearing that sought relief only from the court's imposition of a deadline to complete remand of the ecological portion of the ID. EPA explained that, while the court did not define what it meant by "issue a new ecological portion," the Agency would not be able to finalize a new ecological portion in a registration review decision for glyphosate by the October 1, 2022 deadline because of the time needed to address the issues for which EPA sought remand and to complete consultation under the ESA. In a declaration filed in support of the petition, EPA set forth its anticipated schedule for completing registration review for glyphosate. EPA also stated that if the court did not lift the deadline, the Agency might exercise its discretion to withdraw the remanded ecological portion of the ID and focus its efforts on the required final registration review decision for glyphosate. A copy of EPA's August 1, 2022 petition for panel rehearing and declaration filed in support of the petition is posted to the glyphosate registration review public docket (EPA-HQ-OPP-2009-0361) at https://www.regulations.gov.

On August 5, 2022, the court denied EPA's petition for panel rehearing without opinion.

Withdrawal

In its June 17, 2022 decision, the Ninth Circuit vacated and remanded the human health portion of the glyphosate ID. EPA is now withdrawing all remaining portions of the ID, including the remanded ecological portion consisting of the Agency's analysis of the ecological risks and costs of glyphosate, the weighing of such risks against the benefits of glyphosate, and interim risk mitigation measures. Because the ID is an informal adjudication that EPA issued at its discretion, EPA may withdraw all or a portion of it without public comment. Moreover, it would be impracticable for EPA to take public

comment here because of the October 1, 2022 deadline imposed by the court to complete remand of the ecological portion of the ID.

EPA has determined that withdrawal is appropriate in light of the Ninth Circuit's June 17, 2022 decision and the particular circumstances of glyphosate's registration review and ESA assessment. Insofar as the court has ordered EPA to finalize a "new ecological portion," doing so through another interim registration review decision or a final registration review decision would involve significant and lengthy steps. As detailed in EPA's August 1, 2022 petition for panel rehearing and declaration filed in support of the petition, the Agency is unable to finalize a new ecological portion in a registration review decision for glyphosate by the court-imposed October 1, 2022 deadline because of the time needed to address the issues for which EPA sought remand and to complete consultation under ESA. Moreover, before issuing such a decision, EPA must first prepare a proposed decision, make it available for a period of public comment of at least 60 days, and consider any comments received. 40 C.F.R. § 155.58. For reference, EPA received approximately 283,300 public comments comprising over 12,000 unique submissions when it published the glyphosate proposed ID in May 2019, and it then took nine months to finalize and publish the ID in February 2020. EPA cannot complete these processes by the court-imposed October 1, 2022 deadline.

To date, EPA has not solicited label changes from registrants to implement the interim risk mitigation measures identified in the ID. The Agency has not solicited such label changes because EPA's continued work towards completing registration review for glyphosate could affect what risk mitigation measures EPA may determine are necessary, as noted in the declaration filed in support of EPA's August 1, 2022 petition for panel rehearing of the Ninth Circuit's decision. Moreover, the Agency continues to work on a response to the EWG et al. petition, which asks EPA to reduce the tolerance level for glyphosate residues on oats and require certain label changes based on concerns regarding dietary exposure and carcinogenicity. Because of the court's vacatur and remand of the human health portion of the ID, EPA believes it would be appropriate to respond to the EWG et al. petition once it completes its review on remand. To avoid multiple, and potentially conflicting, rounds of label changes, EPA expects to defer solicitation of label changes until it issues a final registration review decision for glyphosate.

For these reasons, EPA believes it is appropriate to withdraw all remaining portions of the glyphosate ID, including the remanded ecological portion, and focus its efforts on completing the required final registration review decision for glyphosate.

Although the glyphosate ID is now vacated in part and the remainder withdrawn, that does not automatically mean that EPA's underlying scientific findings regarding glyphosate, including its finding that glyphosate is not likely to be carcinogenic to humans, are either incorrect or cannot be used as support for a future decision following reconsideration in accordance with the court's decision.

Next Steps

With respect to the vacated human health portion of the ID, in accordance with the Ninth Circuit's June 17, 2022 decision, EPA intends to revisit and better explain its evaluation of the carcinogenic potential of glyphosate and to consider whether to do so for other aspects of its human health analysis. With respect to the withdrawn ecological portion of the ID, EPA intends to address the issues for which it sought remand, including:

- Consider whether additional or different risk mitigation measures may be necessary based on the outcome of ESA consultation for glyphosate.
- Prepare an analysis of in-field effects of glyphosate on monarch butterfly habitat.
- Consider whether EPA's analysis of spray drift risks and other potential costs of dicamba are relevant to EPA's analysis of glyphosate's risk from spray drift.
- Consider whether there are other aspects of EPA's analysis of ecological risks and costs related to glyphosate that should be reassessed or for which additional explanation should be provided.
- Consider what risk mitigation measures may be necessary to reduce potential risks following completion of analyses left outstanding in the ID.

EPA also intends to complete ESA consultation with the Services, respond to the EWG et al. petition, and make an FFDCA section 408(p) EDSP determination before issuing a final registration review decision for glyphosate. As noted in the declaration filed in support of EPA's August 1, 2022 petition for panel rehearing of the Ninth Circuit's decision, EPA anticipates issuing a final registration review decision for glyphosate in 2026.

Glyphosate Background and Registration Review History

Glyphosate is a non-selective, systemic herbicide with products registered for use in a wide array of both agricultural and non-agricultural settings. Agricultural uses include stone and pome fruits, citrus fruits, berries, nuts, vegetables, cereal grains, and other field crops. Non-agricultural uses include residential spot treatments, aquatic areas, forests, rights-of-way, recreational turf, ornamentals, non-food tree crops, and Conservation Reserve Program land. Glyphosate products are also registered for use on the glyphosate-resistant crops, including alfalfa, corn, soybean, cotton, canola, and sugar beets.

EPA formally initiated registration review for glyphosate in 2009 with the opening of the registration review docket for the case. The following summary highlights significant milestones that have occurred during the registration review of glyphosate

- July 2009 - The *Glyphosate Preliminary Work Plan (PWP)*, the *Glyphosate Human-Health Assessment Scoping Document in Support of Registration Review*, and the *Registration Review–Preliminary Problem Formulation for the Ecological Risk and Drinking Water Exposure Assessments for Glyphosate and Its Salts* were posted to the docket for a 60-day public comment period.

- December 2009 - The *Glyphosate Final Work Plan (FWP)* was issued. Comments received on the PWP covered the following topics: opposition to the use of glyphosate, the toxicity of glyphosate formulations and inert ingredients, use and usage trends, human health risks, ecological risks, endocrine disruption, and the benefits of glyphosate. The public comments received did not change the schedule, risk assessment needs, or anticipated data requirements in the FWP.

- September 2010 - A Generic Data Call-In (GDCI) for glyphosate was issued for data needed to conduct the registration review risk assessments. All required data were submitted and reviewed. The registration review GDCI for glyphosate is considered satisfied.

- September 2015 – The Agency completed its evaluation of Tier 1 endocrine data submitted under the EDSP and published the *Glyphosate: Weight of Evidence Analysis of Potential Interaction with the Estrogen, Androgen, or Thyroid Pathways*. EPA found no convincing evidence of potential interaction with the estrogen, androgen, or thyroid pathways and glyphosate was not recommended for further EDSP testing.

- December 2016 – The agency convened a FIFRA Scientific Advisory Panel meeting to consider and review a set of scientific issues related to the EPA's evaluation of the carcinogenic potential of glyphosate. The meeting agenda, the agency's cancer issue paper, charge questions for the panel, transcript, and final report are available on EPA's website: https://www.epa.gov/sap/meeting-materials-december-13-16-2016-scientific-advisory-panel. Additional supporting materials and comments received from the public can be found in docket EPA-HQ-OPP-2016-0385 at www.regulations.gov.

- December 2017 – The agency published the *Revised Glyphosate Issue Paper: Evaluation of Carcinogenic Potential* (dated December 12, 2017), the *Response to the Final Report of the Federal Insecticide, Fungicide, and Rodenticide Act Scientific Advisory Panel (FIFRA SAP) on the Evaluation of the Human Carcinogenic Potential of Glyphosate* (dated December 12, 2017), the *Glyphosate Draft Human Health Risk Assessment for Registration Review* (dated December 12, 2017), and the *Registration Review – Preliminary Ecological Risk Assessment for Glyphosate and its Salts* (dated September 8, 2015) on EPA's website: https://www.epa.gov/ingredients-used-pesticide-products/draft-human-health-and-ecological-risk-assessments-glyphosate.

- February 2018 - The agency announced the availability of the human health and ecological risk assessments for a 60-day public comment period. Over 238,000 comments were received during the comment period, most of which came from various mass mail campaigns. Approximately 2,244 unique submissions were received from various stakeholders, including pesticide registrants, industry groups, farmers, grower groups, private citizens, non-governmental organizations, states, and the U.S. Department of Agriculture. The comments did not change the risk assessments or registration review timeline for glyphosate.

- September 2018 – The Environmental Working Group, joined by Ben & Jerry's Homemade, Inc., Happy Family Organics, MegaFood, MOM's Organic Market, National Co+op Grocers, Nature's Path Foods Inc., One Degree Organic Foods USA, Inc., and Stonyfield Farm, Inc. submitted an administrative petition to the Agency. The petition requested that EPA lower the tolerance for residues of glyphosate on oats and require label changes to prohibit the preharvest use of glyphosate on oats. On May 6, 2019, the Agency published a Notice of Filing of the petition in the Federal Register for a 30-day public comment period in docket EPA-HQ-OPP-2019-0066. 103,447 comments were received on the petition, most of which came from mass mail campaigns and 419 of which represented unique comments. The Agency continues to work on its response to the petition.

- May 2019 - The Agency announced the availability of the *Glyphosate Proposed Interim Registration Review Decision* (PID) for a 60-day public comment period, which was later extended to 120 days. Along with the PID, the following documents were posted to the docket:

    - *Glyphosate: Response to Comments, Usage, and Benefits* (dated April 18, 2018)
    - *Glyphosate: Response to Comments on the Human Health Draft Risk Assessment* (dated April 23, 2019)
    - *Response to Public Comments on the Preliminary Ecological Risk Assessment for Glyphosate* (dated November 21, 2018)

  During the 120-day comment period on the PID, the agency received roughly 283,300 comments. Over 12,000 unique submissions were received from various stakeholders, including glyphosate registrants, grower groups, non-governmental organizations, pesticide industry groups, states, the U.S. Department of Agriculture and members of the general public. Most comments came from mass mailer campaigns, and approximately 120 unique substantive comments were received from various stakeholders. Public comments did not change the Agency's risk conclusions but resulted in changes to the spray drift management labeling and rotational crop instructions.

- February 2020 – The Agency announced the availability of the ID. Along with the ID, the following documents were published in the docket:
    - *Response from the Pesticide Reevaluation Division to Comments on the Glyphosate Proposed Interim Decision* (dated January 16, 2020)
    - *Glyphosate Response to Comments on the Proposed Interim Decision Regarding the Human Health Risk Assessment* (dated January 13, 2019)
    - *Glyphosate: Epidemiological Review of Zhang et al. (2019) and Leon et al. (2019) publications for Response to Comments on the Proposed Interim Decision* (dated January 6, 2020)

- November 2020 - The Agency released the draft BE for glyphosate for public comment. Approximately 870 comments that pertained to the draft BE for

glyphosate were submitted, including 11 requests for extensions of the public comment period. Additionally, six mass mail campaigns were submitted with approximately 110,000 signatures.

- November 2021 - The Agency released the final BE for glyphosate evaluating potential effects to listed species and critical habitats.

Revista Cultivar®

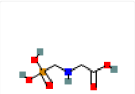
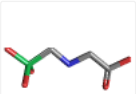
Informações sobre

Glifosato

PubChem

COMPOUND SUMMARY

Glyphosate

PubChem CID	3496
Structure	 2D  3D Find Similar Structures
Chemical Safety	 Corrosive  Environmental Hazard Laboratory Chemical Safety Summary (LCSS) Datasheet
Molecular Formula	$C_3H_8NO_5P$ or $HOOCCH_2NHCH_2PO(OH)_2$
Synonyms	glyphosate 1071-83-6 N-(Phosphonomethyl)glycine N-Phosphonomethyl-glycine Roundup More...
Molecular Weight	169.07
Dates	Modify 2022-09-17 Create 2004-09-16

Glyphosate is the active ingredient in weed killer products such as RoundUp™. Glyphosate products are one of the most widely used weed killers worldwide in farms and in home gardens and lawns. These products typically contain glyphosate in combination with other ingredients that help improve the absorption of the glyphosate into the plant. Glyphosate-based formulations (GBFs) are easily bought in most stores. These products can have different combinations of other ingredients or different concentrations of glyphosate.

▸ CDC-ATSDR Toxic Substances Portal

Glyphosate is a phosphonic acid resulting from the formal oxidative coupling of the methyl group of methylphosphonic acid with the amino group of glycine. It is one of the most commonly used herbicides worldwide, and the only one to target the enzyme 5-enolpyruvyl-3-shikimate phosphate synthase (EPSPS). It has a role as an agrochemical, an EC 2.5.1.19 (3-phosphoshikimate 1-carboxyvinyltransferase) inhibitor and a herbicide. It is a phosphonic acid and a glycine derivative. It is a conjugate acid of a glyphosate(2-) and a glyphosate(1-).

▸ ChEBI

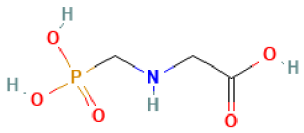
Glyphosate is an odorless white powder. Decomposition begins at approximately 419°F (darkens). pH (1% solution in water) 2.5. (NTP, 1992)

▸ CAMEO Chemicals

1 Structures

1.1 2D Structure

Chemical Structure Depiction

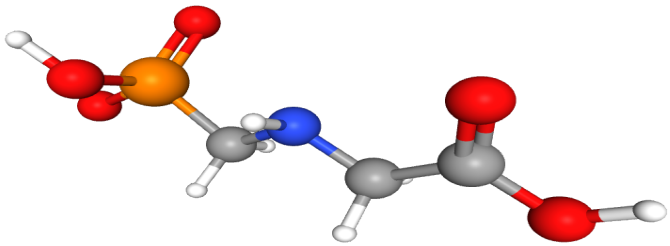


PubChem

1.2 3D Conformer

Interactive Chemical Structure Model

- (•) Ball and Stick
- ( ) Sticks
- ( ) Wire-Frame
- ( ) Space-Filling
- [x] Show Hydrogens
- [ ] Animate



PubChem

2 Biologic Description

SVG Image

IUPAC Condensed	(HO)2P(O)Me-Gly-OH
Sequence	G
HELM	PEPTIDE1{[C(C(=O)O)NCP(=O)(O)O]}$$$$
IUPAC	N-phosphonomethyl-glycine

PubChem

3 Names and Identifiers

3.1 Computed Descriptors

3.1.1 IUPAC Name

2-(phosphonomethylamino)acetic acid

Computed by Lexichem TK 2.7.0 (PubChem release 2021.10.14)

PubChem

3.1.2 InChI

InChI=1S/C3H8NO5P/c5-3(6)1-4-2-10(7,8)9/h4H,1-2H2,(H,5,6)(H2,7,8,9)

Computed by InChI 1.0.6 (PubChem release 2021.10.14)

PubChem

3.1.3 InChIKey

XDDAORKBJWWYJS-UHFFFAOYSA-N

Computed by InChI 1.0.6 (PubChem release 2021.10.14)

PubChem

3.1.4 Canonical SMILES

C(C(=O)O)NCP(=O)(O)O

Computed by OEChem 2.3.0 (PubChem release 2021.10.14)

PubChem

3.2 Molecular Formula

C3H8NO5P

CAMEO Chemicals; Wikipedia; PubChem

C3H8NO5P

HOOCCH2NHCH2PO(OH)2

ILO International Chemical Safety Cards (ICSC)

3.3 Other Identifiers

3.3.1 CAS

1071-83-6

CAMEO Chemicals; CAS Common Chemistry; ChemIDplus; DTP/NCI; EPA DSSTox; European Chemicals Agency (ECHA); Hazardous Substances Data Bank (HSDB); ILO International Chemical Safety Car

3.3.2 Related CAS

34494-03-6 (mono-hydrochloride salt)

40465-66-5 (mono-ammonium salt)

70393-85-0 (hydrochloride salt)

ChemIDplus

3.3.3 Deprecated CAS

37337-60-3, 42618-09-7, 75241-08-6, 1585457-94-8

ChemIDplus

1585457-94-8, 42618-09-7, 75241-08-6

EPA DSSTox

3.3.4 European Community (EC) Number

213-997-4

European Chemicals Agency (ECHA)

3.3.5 ICSC Number

0160

ILO International Chemical Safety Cards (ICSC)

3.3.6 NSC Number

151063

- DTP/NCI

3.3.7 RTECS Number

MC1075000

- The National Institute for Occupational Safety and Health (NIOSH)

3.3.8 UN Number

3077

- CAMEO Chemicals

2783

- NJDOH RTK Hazardous Substance List

3.3.9 UNII

4632WW1X5A

- FDA/SPL Indexing Data

3.3.10 DSSTox Substance ID

DTXSID1024122

- EPA DSSTox

3.3.11 Wikipedia

Glyphosate

- Wikipedia

3.3.12 Wikidata

Q407232

- Wikidata

3.4 Synonyms

3.4.1 MeSH Entry Terms

gliphosate
glyphosate
glyphosate hydrochloride (2:1)
glyphosate, calcium salt
glyphosate, calcium salt (1:1)
glyphosate, copper (2+) salt
glyphosate, dilithium salt
glyphosate, disodium salt
glyphosate, magnesium salt
glyphosate, magnesium salt (2:1)
glyphosate, monoammonium salt
glyphosate, monopotassium salt
glyphosate, monosodium salt
glyphosate, sodium salt
glyphosate, zinc salt
Kalach 360 SL
N-(phosphonomethyl)glycine
Roundup
yerbimat

- Medical Subject Headings (MeSH)

3.4.2 Depositor-Supplied Synonyms

glyphosate	NSC151063	NSC-151063	Kickdown	Bu
1071-83-6	2-((Phosphonomethyl)amino)acetic acid	994-61-6	Phorsat	Gl
N-(Phosphonomethyl)glycine	Glialka	Silglif	Accord	Re
N-Phosphonomethyl-glycine	UNII-4632WW1X5A	MON 0573	Atila	Gl
Roundup	CP 67573	Roundup Max	Forsat	Gl
Glyphosphate	Mon 6000	Caswell No. 661A	Glyfos	Ml
2-(phosphonomethylamino)acetic acid	Phosphonomethyliminoacetic acid	2-[(phosphonomethyl)amino]acetic acid, 40% aqueous solution	Hockey	Gr
Glycine, N-(phosphonomethyl)-	CHEMBL95764	Buccaneer	Klinik	M(
N-Phosphonomethylglycine	CHEBI:27744	Folusen	Leone	C3
Pondmaster	Glyphosate 40% aqueous solution	Glifoglex	Safal	La
N-Phosphomethylglycine	4632WW1X5A	Glyphomax	((phosphonomethyl)amino)acetic acid	Gl
MON 2139	[(phosphonomethyl)amino]acetic acid	Herbatop	Gliz	Gl
N-(Phosphonomethyl) Glycine	2-[(phosphonomethyl)amino]acetic acid	HM 2028; Herbatop; Hockey; Kickdown; Klinik;NSC 151063	GlyGran	Gl

- PubChem

4 Chemical and Physical Properties

4.1 Computed Properties

Property Name	Property Value	Reference
Molecular Weight	169.07	Computed by PubChem 2.2 (PubChem release 2021.10.14)
XLogP3-AA	-4.6	Computed by XLogP3 3.0 (PubChem release 2021.10.14)
Hydrogen Bond Donor Count	4	Computed by Cactvs 3.4.8.18 (PubChem release 2021.10.14)
Hydrogen Bond Acceptor Count	6	Computed by Cactvs 3.4.8.18 (PubChem release 2021.10.14)
Rotatable Bond Count	4	Computed by Cactvs 3.4.8.18 (PubChem release 2021.10.14)
Exact Mass	169.01400935	Computed by PubChem 2.2 (PubChem release 2021.10.14)
Monoisotopic Mass	169.01400935	Computed by PubChem 2.2 (PubChem release 2021.10.14)
Topological Polar Surface Area	107 Å²	Computed by Cactvs 3.4.8.18 (PubChem release 2021.10.14)
Heavy Atom Count	10	Computed by PubChem
Formal Charge	0	Computed by PubChem
Complexity	162	Computed by Cactvs 3.4.8.18 (PubChem release 2021.10.14)
Isotope Atom Count	0	Computed by PubChem
Defined Atom Stereocenter Count	0	Computed by PubChem
Undefined Atom Stereocenter Count	0	Computed by PubChem
Defined Bond Stereocenter Count	0	Computed by PubChem
Undefined Bond Stereocenter Count	0	Computed by PubChem
Covalently-Bonded Unit Count	1	Computed by PubChem
Compound Is Canonicalized	Yes	Computed by PubChem (release 2021.10.14)

PubChem

4.2 Experimental Properties

4.2.1 Physical Description

Glyphosate is an odorless white powder. Decomposition begins at approximately 419°F (darkens). pH (1% solution in water) 2.5. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

CAMEO Chemicals

White solid; [Merck Index] Colorless solid; [ICSC]

Haz-Map, Information on Hazardous Chemicals and Occupational Diseases

COLOURLESS CRYSTALS.

ILO International Chemical Safety Cards (ICSC)

4.2.2 Color/Form

White crystals

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

Hazardous Substances Data Bank (HSDB)

White solid

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 834

Hazardous Substances Data Bank (HSDB)

4.2.3 Odor

Odorless

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

Hazardous Substances Data Bank (HSDB)

4.2.4 Melting Point

446 °F (decomposes) (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

CAMEO Chemicals

189.5 °C

EPA DSSTox

230 °C (dec)

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 834

Hazardous Substances Data Bank (HSDB)

Gilfonos, Roundup: Clear, viscous amber-colored solution; pH 4.4-4.9. Practically odorless to slight amine-like odor. Lider: Colorless crystals. MW: 169.09; MP: 200 °C

Crop Protection Handbook Volume 99, Meister Media Worldwide, Willoughby, OH 2013, p. 476

- Hazardous Substances Data Bank (HSDB)

4.2.5 Solubility

5 to 10 mg/mL at 64° F (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

0.06 M

TOMLIN,C (2003)

- EPA DSSTox

Solubility in water (20 °C): 1050 g/L /Glyphosate trimethylammonium salt/

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 834

- Hazardous Substances Data Bank (HSDB)

In water, 10.5 g/L in water at pH 1.9 and 20 °C

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

- Hazardous Substances Data Bank (HSDB)

Practically insoluble in common organic solvents, e.g. acetone, ethanol and xylene

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

- Hazardous Substances Data Bank (HSDB)

Solubility in water, g/100ml at 25 °C: 1.2

- ILO International Chemical Safety Cards (ICSC)

4.2.6 Density

1.74 (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

1.705 at 20 °C

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

- Hazardous Substances Data Bank (HSDB)

1.7 g/cm³

- ILO International Chemical Safety Cards (ICSC)

4.2.7 Vapor Pressure

1.94e-07 mm Hg at 113 °F (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

9.80e-08 mmHg

- EPA DSSTox

0.0000001 [mmHg]

- Haz-Map, Information on Hazardous Chemicals and Occupational Diseases

9.8X10-8 mm Hg /1.31X10-2 mPa/ at 25 °C

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

- Hazardous Substances Data Bank (HSDB)

Vapor pressure at 20 °C: negligible

- ILO International Chemical Safety Cards (ICSC)

4.2.8 LogP

-3.4 (LogP)

SANGSTER (2006)

- EPA DSSTox

log Kow = -3.40

Sangster J; LOGKOW Database. A databank of evaluated octanol-water partition coefficients (Log P). Available from database query at https://logkow.cisti.nrc.ca/logkow/search.html as of DATE.

Hazardous Substances Data Bank (HSDB)

-1.0

ILO International Chemical Safety Cards (ICSC)

4.2.9 Stability/Shelf Life

Negligible volatility

Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 317

Hazardous Substances Data Bank (HSDB)

Glyphosate and all its salts are non-volatile, do not photochemically degrade and are stable in air. Glyphosate is stable to hydrolysis at pH 3, 6 and 9 (5-35 °C).

Tomlin CDS, ed. Glyphosate (1071-83-6). In: The e-Pesticide Manual, 13th Edition Version 3.2 (2005-06). Surrey UK, British Crop Protection Council.

Hazardous Substances Data Bank (HSDB)

Stable 5 days at pH 4, 5, and 9 (50 °C).

Tomlin CDS, ed. Glyphosate (1071-83-6). In: The e-Pesticide Manual, 13th Edition Version 3.2 (2005-06). Surrey UK, British Crop Protection Council.

Hazardous Substances Data Bank (HSDB)

Stable under recommended storage conditions.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

4.2.10 Decomposition

When heated to decomposition it emits very toxic fumes of /nitrogen and phosphorus oxides/.

Lewis, R.J. Sr. (ed) Sax's Dangerous Properties of Industrial Materials. 11th Edition. Wiley-Interscience, Wiley & Sons, Inc. Hoboken, NJ. 2004., p. 2947

Hazardous Substances Data Bank (HSDB)

4.2.11 Dissociation Constants

pKa1 = 2.34 (20 °C) /phosphate acid/; pKa2 = 5.73 (20 °C) /secondary amine/; pKa3 =10.2 (25 °C) /carboxylic acid/

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

Hazardous Substances Data Bank (HSDB)

pKa1 = 2.0; pKa2 = 2.6; pKa3 = 5.6; pKa4 = 10.6

Caceres-Jensen L et al; J Environ Qual 38: 1449-1457 (2009)

Hazardous Substances Data Bank (HSDB)

4.2.12 Collision Cross Section

141.17 Å² $[M+Na]^+$ [CCS Type: DT, Method: stepped-field]

https://pubs.rsc.org/en/content/articlelanding/2017/sc/c7sc03464d

CCSbase

129.03 Å² $[M-H]^-$ [CCS Type: DT, Method: stepped-field]

https://pubs.rsc.org/en/content/articlelanding/2017/sc/c7sc03464d

CCSbase

128.6 Å² $[M-H]^-$

140.3 Å² $[M+Na]^+$

S50 | CCSCOMPEND | The Unified Collision Cross Section (CCS) Compendium | DOI:10.5281/zenodo.2658162

NORMAN Suspect List Exchange

4.2.13 Other Experimental Properties

Pure glyphosate has a zwitterion structure.

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

Hazardous Substances Data Bank (HSDB)

The alkali metal and amine salts are readily soluble in water

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

Hazardous Substances Data Bank (HSDB)

White powder. MP: decomposes >190 °C without melting; VP: 9X10-3 mPa (25 °C); density: 1.433 at 20 °C). Solubility in water 144 g/L (pH 9). Essentially insoluble in organic solvents. Stable over 5 days at 50 °C, (pH 4, 7 and 9) /Glyphosate-ammonium/

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

Hazardous Substances Data Bank (HSDB)

Odorless, white powder. MP: decomposes >260 °C; VP: 7.56X10-3 mPa (25 °C); logP: -4.58 (tech 25 °C); density: 1.622 at 20 °C (glyphosate sodium). Solubility in water 335 g glyphosate-sodium/L solution or 414 g glyphosate sodium/L water (20 °C, pH 4.2). Stable over5 days at pH 4, 7 and 9 (50 °C) /Glyphosate-sesquisodium/

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

- Hazardous Substances Data Bank (HSDB)

4.2.14 Chemical Classes

Pesticides -> Herbicides, Other

- Haz-Map, Information on Hazardous Chemicals and Occupational Diseases

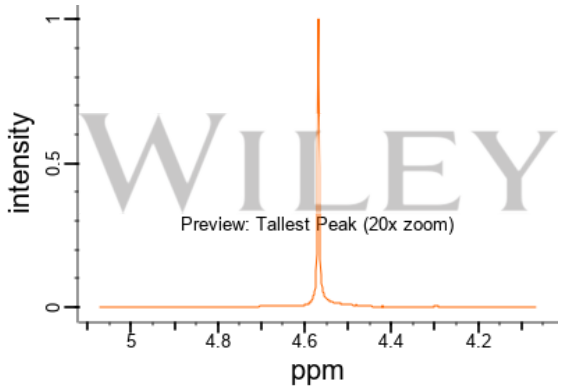
5 Spectral Information

5.1 1D NMR Spectra

1D NMR Spectra	NMRShiftDB Link

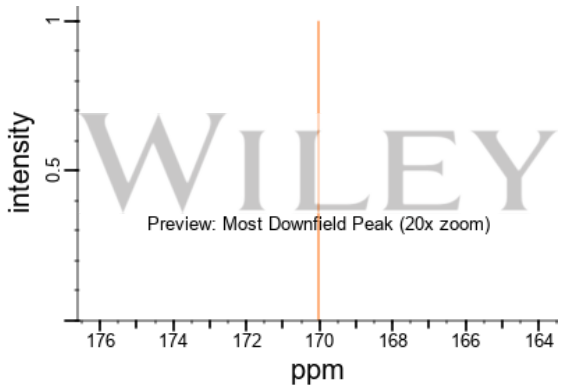
NMRShiftDB

5.1.1 1H NMR Spectra

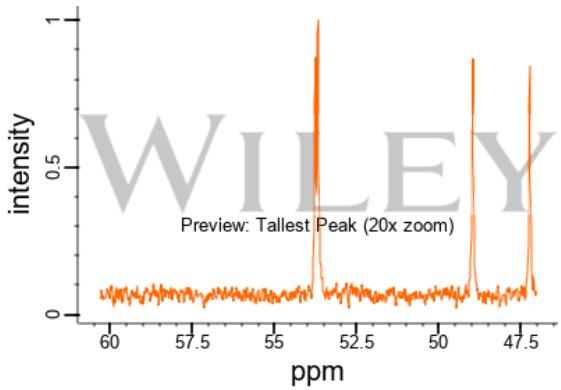
Source of Spectrum	Sigma-Aldrich Co. LLC.
Source of Sample	Sigma-Aldrich Co. LLC.
Catalog Number	337757
Copyright	Copyright © 2021 Sigma-Aldrich Co. LLC. - Database Compilation Copyright © 2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

5.1.2 13C NMR Spectra

Instrument Name	Jeol FX-90
Copyright	Copyright © 2002-2021 Wiley-VCH Verlag GmbH & Co. KGaA. All Rights Reserved.
Thumbnail	

SpectraBase

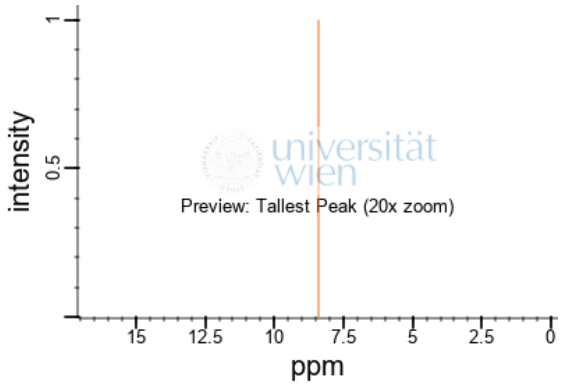
Source of Spectrum	Sigma-Aldrich Co. LLC.
Source of Sample	Sigma-Aldrich Co. LLC.
Catalog Number	337757
Copyright	Copyright © 2021 Sigma-Aldrich Co. LLC. - Database Compilation Copyright © 2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

5.1.3 31P NMR Spectra

Copyright	Copyright © 2016-2021 W. Robien, Inst. of Org. Chem., Univ. of Vienna. All Rights Reserved.
Thumbnail	

SpectraBase

Copyright	Copyright © 2016-2021 W. Robien, Inst. of Org. Chem., Univ. of Vienna. All Rights Reserved.
Thumbnail	

SpectraBase

5.2 Mass Spectrometry

5.2.1 GC-MS

Copyright	Copyright © 2020-2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

Source of Spectrum	PG-1982-833-0
Copyright	Copyright © 2020-2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

5.2.2 MS-MS

NIST Number	1006472
Instrument Type	IT/ion trap
Collision Energy	0
Spectrum Type	MS2
Precursor Type	[M+H]+
Precursor m/z	170.0213
Total Peaks	8
m/z Top Peak	88
m/z 2nd Highest	87
m/z 3rd Highest	60
Thumbnail	

NIST Mass Spectrometry Data Center

NIST Number	1021342
Instrument Type	IT/ion trap
Collision Energy	0
Spectrum Type	MS2
Precursor Type	[M-H]-
Precursor m/z	168.0067
Total Peaks	5
m/z Top Peak	150
m/z 2nd Highest	124
m/z 3rd Highest	168
Thumbnail	

NIST Mass Spectrometry Data Center

5.2.3 LC-MS

Showing 2 of 4 View More

MoNA ID	CCMSLIB00004684327
MS Category	Experimental
MS Type	LC-MS
MS Level	MS2
Precursor Type	[M+H]+
Precursor m/z	170.021

Instrument	Orbitrap
Ionization Mode	positive
Top 5 Peaks	88.039902 100 124.021568 1.92 170.061249 0.62 109.077789 0.03 92.050079 0.03
SPLASH	splash10-000i-9000000000-3ff49f8a8513949a9add
Thumbnail	
Submitter	GNPS Team, University of California, San Diego

MassBank of North America (MoNA)

MoNA ID	CCMSLIB00004721842
MS Category	Experimental
MS Type	LC-MS
MS Level	MS2
Precursor Type	[M+H]+
Precursor m/z	170.021
Instrument	qTof
Ionization Mode	positive
Top 5 Peaks	88.039551 100 60.045464 6.97 124.015831 3.61 89.042412 3.50
SPLASH	splash10-000i-9000000000-eee37a2b08795f494fc9
Thumbnail	
Submitter	GNPS Team, University of California, San Diego

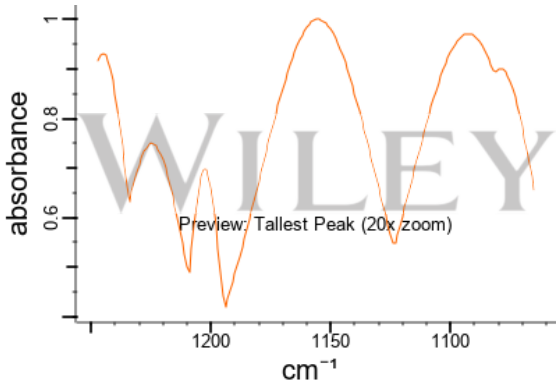
MassBank of North America (MoNA)

5.3 IR Spectra

5.3.1 FTIR Spectra

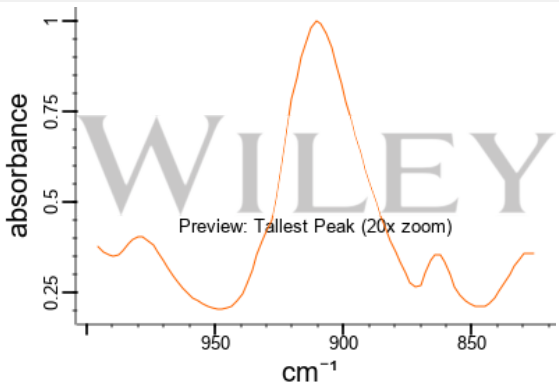
Technique	KBr WAFER
Source of Sample	U.S. Epa Repository, Research Triangle Park, North Carolina
Copyright	Copyright © 1980, 1981-2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

Instrument Name	Bruker IFS 85
Technique	KBr-Pellet
Copyright	Copyright © 1989, 1990-2021 Wiley-VCH Verlag GmbH & Co. KGaA. All Rights Reserved.
Thumbnail	

SpectraBase

5.3.2 ATR-IR Spectra

Source of Sample	Aldrich
Catalog Number	337757
Copyright	Copyright © 2018-2021 Sigma-Aldrich Co. LLC. - Database Compilation Copyright © 2018-2021 John Wiley & Sons, Inc. All Rights Reserved.
Thumbnail	

SpectraBase

6 Related Records

6.1 Related Compounds with Annotation

PubChem

6.2 Related Compounds

Same Connectivity	19 Records
Same Parent, Connectivity	173 Records
Same Parent, Exact	155 Records
Mixtures, Components, and Neutralized Forms	1,313 Records
Similar Compounds	85 Records
Similar Conformers	717 Records

PubChem

6.3 Substances

6.3.1 Related Substances

All	2,092 Records
Same	222 Records
Mixture	1,870 Records

PubChem

6.3.2 Substances by Category

PubChem

6.4 Entrez Crosslinks

PubMed	1,318 Records
Protein Structures	13 Records
Taxonomy	18 Records
OMIM	8 Records
Gene	1,516 Records

PubChem

6.5 Associated Chemicals

Glyphosate sesquisodium salt; 70393-85-0

Hazardous Substances Data Bank (HSDB)

6.6 NCBI LinkOut

NCBI

7 Chemical Vendors

PubChem

8 Drug and Medication Information

8.1 FDA National Drug Code Directory

▸ National Drug Code (NDC) Directory

GLYPHOSATE is an active ingredient in 8 products including: 'BIOTOX PEST DETOX', 'D3 ORGAN SUPPORT', and 'GRAIN AND SOY ALLERGEN MIX'.

▸ National Drug Code (NDC) Directory

9 Agrochemical Information

9.1 Agrochemical Category

Herbicide

- EPA Pesticide Ecotoxicity Database

Herbicides

- EU Pesticides Database; NORMAN Suspect List Exchange

9.2 Agrochemical Transformations

Glyphosate has known environmental transformation products that include aminomethylphosphonic acid.

S78 | SLUPESTTPS | Pesticides and TPs from SLU, Sweden | DOI:10.5281/zenodo.4687924

- NORMAN Suspect List Exchange

Glyphosat-trimesium has known environmental transformation products that include aminomethylphosphonic acid.

Glyphosate has known environmental transformation products that include AMPA.

S60 | SWISSPEST19 | Swiss Pesticides and Metabolites from Kiefer et al 2019 | DOI:10.5281/zenodo.3544759

- NORMAN Suspect List Exchange

9.3 EU Pesticides Data

Active Substance	glyphosate
Status	Date of Approval: 16/12/2017 Expiration of Approval: 15/12/2022 [Reg. (EC) No 1107/2009]
Categories	Herbicides
ADI	0.5 mg/kg bw/day [Reg. (EU) 2017/2324]
ARfD	0.5 mg/kg bw [Reg. (EU) 2017/2324]
AOEL	0.1 mg/kg bw/day [Reg. (EU) 2017/2324]

- EU Pesticides Database

10 Pharmacology and Biochemistry

10.1 MeSH Pharmacological Classification

Herbicides

Pesticides used to destroy unwanted vegetation, especially various types of weeds, grasses (POACEAE), and woody plants. Some plants develop HERBICIDE RESISTANCE. (See all compounds classified as Herbicides.)

Medical Subject Headings (MeSH)

Uncoupling Agents

Chemical agents that uncouple oxidation from phosphorylation in the metabolic cycle so that ATP synthesis does not occur. Included here are those IONOPHORES that disrupt electron transfer by short-circuiting the proton gradient across mitochondrial membranes. (See all compounds classified as Uncoupling Agents.)

Medical Subject Headings (MeSH)

Enzyme Inhibitors

Compounds or agents that combine with an enzyme in such a manner as to prevent the normal substrate-enzyme combination and the catalytic reaction. (See all compounds classified as Enzyme Inhibitors.)

Medical Subject Headings (MeSH)

Antifungal Agents

Substances that destroy fungi by suppressing their ability to grow or reproduce. They differ from FUNGICIDES, INDUSTRIAL because they defend against fungi present in human or animal tissues. (See all compounds classified as Antifungal Agents.)

Medical Subject Headings (MeSH)

10.2 Absorption, Distribution and Excretion

The toxicokinetics of glyphosate after single 100 mg/kg intravenous (i.v.) and 400 mg/kg oral doses were studied in rats. Serial blood samples were obtained after i.v. and oral administration. Plasma concentrations of glyphosate and its metabolite aminomethyl phosphonic acid (AMPA) were determined by HPLC method. After i.v. and oral administration, plasma concentration-time curves were best described by a two-compartment open model. For glyphosate, the elimination half-lives (T(1/2beta)) from plasma were 9.99 hr after i.v. and 14.38 hr after oral administration. The total plasma clearance was not influenced by dose concentration or route and reached a value of 0.995 L/hr/kg. After i.v. administration, the apparent volume of distribution in the second compartment (V(2)) and volume of distribution at steady state (V(ss)) were 2.39 and 2.99 L/kg, respectively, suggesting a considerable diffusion of the herbicide into tissues. After oral administration, glyphosate was partially and slowly absorbed with a T(max) of 5.16 hr. The oral bioavailability of glyphosate was found to be 23.21%. Glyphosate was converted to AMPA. The metabolite AMPA represented 6.49% of the parent drug plasma concentrations. The maximum plasma concentrations of glyphosate and AMPA were 4.62 and 0.416 microg/mL, respectively. The maximum plasma concentration of AMPA was achieved at 2.42 hr. For AMPA, the elimination half-life (T(1/2beta)) was 15.08 hr after oral administration of glyphosate parent compound.

PMID:19607892
Anadon A et al; Toxicol Lett 190 (1): 91-5 (2009)

Hazardous Substances Data Bank (HSDB)

The disposition of glyphosate was studied in rats. Male F344/N rats were gavaged with 5.6 or 56 mg/kg radiolabeled glyphosate. Urine and feces were collected at 24 hour intervals for 72 hr and analyzed for activity. Selected rats were killed 3 to 96 hr post dosing to determine the tissue distribution of radioactivity. Approximately 20 to 30% of either dose was eliminated in the urine and 70 to 80% in the feces over 72 hr. Only about 1% of the dose remained in the tissues, mostly in the liver and small intestine.

DHHS/NTP; Toxicology and Carcinogenesis Studies of Glyphosate p.55 (1992). Technical Rpt Series No.16. NIH Pub #92-3135. Available from, as of November 10, 2014: https://ntp-server.niehs.nih.gov/

Hazardous Substances Data Bank (HSDB)

... There is rapid elimination, no biotransformation, and minimal tissue retention of glyphosate in various species, including mammals, birds, and fish.

Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1668

Hazardous Substances Data Bank (HSDB)

Greater than 90% of an orally administered dose of glyphosate is rapidly eliminated in 72 hr /by laboratory animals/. ... Typically, approximately 70% of the administered dose is eliminated in the feces, with the remainder eliminated in the urine. In all cases, less than 0.5% of the administered dose is found in the tissue and organs, demonstrating that glyphosate does not bioaccumulate in edible tissues.

Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1668

Hazardous Substances Data Bank (HSDB)

For more Absorption, Distribution and Excretion (Complete) data for GLYPHOSATE (11 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

10.3 Metabolism/Metabolites

...In rats, > 97% of the (14)C/glyphosate/ in excreta, after a single oral dose, was shown to be unchanged compound. AMPA was the only metabolite, covering only 0.2-0.3% of the applied (14)C...

WHO/International Programme on Chemical Safety; Environmental Health Criteria 159, Glyphosate, (1994). Available from, as of November 10, 2014: https://www.inchem.org/pages/ehc.html

Hazardous Substances Data Bank (HSDB)

Following a single oral dose of 14C-glyphosate, amino methyl phosphonic acid (AMPA) was the only metabolite found in urine (0.2-0.3% of the administered dose) and feces (0.2-0.4% of the administered dose) /of male and female Sprague-Dawley rats/.

USEPA; Reregistration Eligibility Decision (RED) Database for Glyphosate (38641-94-0). EPA 738-R-93-014 (September 1993). Available from, as of January 25, 2006: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

Studies of the metabolism of glyphosate in experimental animals (rats, rabbits, lactating goats, and chickens) indicate that it is not biotransformed, with essentially all the administered dose excreted as unchanged parent molecule.

Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1669

▸ Hazardous Substances Data Bank (HSDB)

Biotransformation of glyphosate occurs to a very low degree only. In rats it was shown that all of the carbon-14 in urine and feces, after a single oral application of (14)C-glyphosate, was present as unchanged parent compound. Also in rats, > 97% of the carbon-14 in excreta, after a single oral dose, was shown to be unchanged compound. AMPA was the only metabolite, covering only 0.2-0.3% of the applied carbon-14. In laying hens also, AMPA was the only metabolite, accounting for only a minor part of the applied amount.

WHO/International Programme on Chemical Safety; Environmental Health Criteria 159, Glyphosate, (1994). Available from, as of November 10, 2014: https://www.inchem.org/pages/ehc.html

▸ Hazardous Substances Data Bank (HSDB)

10.4 Biological Half-Life

Male and female Sprague-Dawley rats received single intraperitoneal injections of radiolabeled (14)C glyphosate. The dose level of glyphosate used for male and female rats was 1150 mg/kg. Blood samples were collected 0.25, 0.50, 1, 2, 4, 6 and 10 hours after injection. ... Assuming first order kinetics, the decrease in radioactivity in bone marrow occurred with a half-life of 7.6 and 4.2 hours for males and females, respectively. Similarly, the half-lives of the radioactivity in plasma were approximately 1 hour for both sexes.

USEPA; Reregistration Eligibility Decision (RED) Database for Glyphosate (38641-94-0). EPA 738-R-93-014 (September 1993). Available from, as of January 25, 2006: https://www.epa.gov/pesticides/reregistration/status.htm

▸ Hazardous Substances Data Bank (HSDB)

The kinetics of whole body elimination were estimated using the radioactivity (14)C measured in urine and feces after a single oral dose of (14)C-glyphosate (10 or 1000 mg/kg body weight). Because of the lack of biotransformation of glyphosate it is valid to base kinetics on total radioactivity. The elimination appeared to be biphasic. The half-life of the alpha elimination phase at 10 mg/kg body weight was 5.87 hr (males) or 6.22 hr (females); at 1000 mg/kg body weight this was 5.26 hr (males)or 6.44 hr (females). The half-life of the beta phase at 10 mg/kg body weight was 79 hr (males) or 106 hr (females); at 1000 mg/kg body weight this was 181 hr (males) or 337 hr (females).

WHO/International Programme on Chemical Safety; Environmental Health Criteria 159, Glyphosate, (1994). Available from, as of November 10, 2014: https://www.inchem.org/pages/ehc.html

▸ Hazardous Substances Data Bank (HSDB)

The toxicokinetics of glyphosate after single 100 mg/kg intravenous (i.v.) and 400 mg/kg oral doses were studied in rats. ... For glyphosate, the elimination half-lives (T(1/2beta)) from plasma were 9.99 hr after i.v. and 14.38 hr after oral administration.

PMID:19607892
Anadon A et al; Toxicol Lett 190 (1): 91-5 (2009)

▸ Hazardous Substances Data Bank (HSDB)

10.5 Mechanism of Action

Previous studies demonstrate that glyphosate exposure is associated with oxidative damage and neurotoxicity. Therefore, the mechanism of glyphosate-induced neurotoxic effects needs to be determined. The aim of this study was to investigate whether Roundup (a glyphosate-based herbicide) leads to neurotoxicity in hippocampus of immature rats following acute (30min) and chronic (pregnancy and lactation) pesticide exposure. Maternal exposure to pesticide was undertaken by treating dams orally with 1% Roundup (0.38% glyphosate) during pregnancy and lactation (till 15-day-old). Hippocampal slices from 15 day old rats were acutely exposed to Roundup (0.00005-0.1%) during 30min and experiments were carried out to determine whether glyphosate affects (45)Ca(2+) influx and cell viability. Moreover, /this study/ investigated the pesticide effects on oxidative stress parameters, (14)C-alpha-methyl-amino-isobutyric acid ((14)C-MeAIB) accumulation, as well as glutamate uptake, release and metabolism. Results showed that acute exposure to Roundup (30min) increases (45)Ca(2+) influx by activating NMDA receptors and voltage-dependent Ca(2+) channels, leading to oxidative stress and neural cell death. The mechanisms underlying Roundup-induced neurotoxicity also involve the activation of CaMKII and ERK. Moreover, acute exposure to Roundup increased (3)H-glutamate released into the synaptic cleft, decreased GSH content and increased the lipoperoxidation, characterizing excitotoxicity and oxidative damage. /This study/ also observed that both acute and chronic exposure to Roundup decreased (3)H-glutamate uptake and metabolism, while induced (45)Ca(2+) uptake and (14)C-MeAIB accumulation in immature rat hippocampus. Taken together, these results demonstrated that Roundup might lead to excessive extracellular glutamate levels and consequently to glutamate excitotoxicity and oxidative stress in rat hippocampus.

PMID:24636977
Cattani D et al; Toxicology 320: 34-45 (2014)

▸ Hazardous Substances Data Bank (HSDB)

Glyphosate is the primary active constituent of the commercial pesticide Roundup. The present results show that acute Roundup exposure at low doses (36 ppm, 0.036 g/L) for 30 min induces oxidative stress and activates multiple stress-response pathways leading to Sertoli cell death in prepubertal rat testis. The pesticide increased intracellular Ca(2+) concentration by opening L-type voltage-dependent Ca(2+) channels as well as endoplasmic reticulum IP3 and ryanodine receptors, leading to Ca(2+) overload within the cells, which set off oxidative stress and necrotic cell death. Similarly, 30 min incubation of testis with glyphosate alone (36 ppm) also increased (45)Ca(2+) uptake. These events were prevented by the antioxidants Trolox and ascorbic acid. Activated protein kinase C, phosphatidylinositol 3-kinase, and the mitogen-activated protein kinases such as ERK1/2 and p38MAPK play a role in eliciting Ca(2+) influx and cell death. Roundup decreased the levels of reduced glutathione (GSH) and increased the amounts of thiobarbituric acid-reactive species (TBARS) and protein carbonyls. Also, exposure to glyphosate-Roundup stimulated the activity of glutathione peroxidase, glutathione reductase, glutathione S-transferase, gamma-glutamyltransferase, catalase, superoxide dismutase, and glucose-6-phosphate dehydrogenase, supporting downregulated GSH levels. Glyphosate has been described as an endocrine disruptor affecting the male reproductive system; however, the molecular basis of its toxicity remains to be clarified. We propose that Roundup toxicity, implicated in Ca(2+) overload, cell signaling misregulation, stress response of the endoplasmic reticulum, and/or depleted antioxidant defenses, could contribute to Sertoli cell disruption in spermatogenesis that could have an impact on male fertility.

PMID:23820267
de Liz Oliveira Cavalli VL et al; Free Radic Biol Med 65: 335-46 (2013)

▸ Hazardous Substances Data Bank (HSDB)

A deregulation of programmed cell death mechanisms in human epidermis leads to skin pathologies. We previously showed that glyphosate, an extensively used herbicide, provoked cytotoxic effects on cultured human keratinocytes, affecting their antioxidant capacities and impairing morphological and functional cell characteristics. The aim of the present study, carried out on the human epidermal cell line HaCaT, was to examine the part of apoptosis plays in the cytotoxic effects of glyphosate and the intracellular mechanisms involved in the apoptotic events. /This study/ conducted different incubation periods to reveal the specific events in glyphosate-induced cell death. /It/ observed an increase in the number of early apoptotic cells at a low cytotoxicity level (15%), and then, a decrease, in favor of late apoptotic and necrotic cell rates for more severe cytotoxicity conditions. At the same time, /the study/ showed that the glyphosate-induced mitochondrial membrane potential disruption could be a cause of apoptosis in keratinocyte cultures.

PMID:22522424
Heu C et al; Environ Toxicol Pharmacol 34 (2): 144-53 (2012)

▸ Hazardous Substances Data Bank (HSDB)

Herbicides have been recognized as the main environmental factor associated with human neurodegenerative disorders such as Parkinson's disease(PD). Previous studies indicated that the exposure to glyphosate, a widely used herbicide, is possibly linked to Parkinsonism, however the underlying mechanism remains unclear. We investigated the neurotoxic effects of glyphosate in differentiated PC12 /rat/ cells and discovered that it inhibited viability of differentiated PC12 cells in dose-and time-dependent manners. Furthermore, the results showed that glyphosate induced cell death via autophagy pathways in addition to activating apoptotic pathways. Interestingly, deactivation of Beclin-1 gene attenuated both apoptosis and autophagy in glyphosate treated differentiated PC12 cells, suggesting that Beclin-1 gene is involved in the crosstalk between the two mechanisms.

PMID:22504123
Gui YX et al; Neurotoxicol Teratol 34 (3): 344-9 (2012)

Hazardous Substances Data Bank (HSDB)

For more Mechanism of Action (Complete) data for GLYPHOSATE (7 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

10.6 Transformations

NORMAN Suspect List Exchange

11 Use and Manufacturing

11.1 Uses

EPA CPDat Chemical and Product Categories

The Chemical and Products Database, a resource for exposure-relevant data on chemicals in consumer products, Scientific Data, volume 5, Article number: 180125 (2018), DOI:10.1038/sdata.2018.125

- EPA Chemical and Products Database (CPDat)

Sources/Uses

A systemic herbicide commonly used for roadside and forest applications; [EXTOXNET]

- Haz-Map, Information on Hazardous Chemicals and Occupational Diseases

Industrial Processes with risk of exposure

Farming (Pesticides) [Category: Industry]

- Haz-Map, Information on Hazardous Chemicals and Occupational Diseases

For glyphosate (USEPA/OPP Pesticide Code: 417300) ACTIVE products with label matches. /SRP: Registered for use in the U.S. but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./

National Pesticide Information Retrieval System's Database on Glyphosate (1071-83-6). Available from, as of September 30, 2014: https://npirspublic.ceris.purdue.edu/ppis/

- Hazardous Substances Data Bank (HSDB)

Glyphosate is a non-selective herbicide registered for use on many food and non-food field crops as well as non-crop areas where total vegetation control is desired. When applied at lower rates, glyphosate also is a plant growth regulator.

USEPA/Office of Pesticide Programs; Reregistration Eligibility Decision Document - Glyphosate. EPA 738-R-93-014 September 1993. Available from, as of February 6, 2006: https://www.epa.gov/pesticides/reregistration/status.htm

- Hazardous Substances Data Bank (HSDB)

Control of annual and perennial grasses and broad-leaved weeds, pre-harvest, in cereals, peas, beans, oilseed rape, flax and mustard, at 1.5-2 kg/ha; control of annual and perennial grasses and broad-leaved weeds in stubble and post-planting/pre-emergence of many crops; as a directed spray in vines and olives, at up to 4.3 kg/ha; in orchards, pasture, forestry and industrial weed control, at up to 4.3 kg/ha. As an aquatic herbicide, at 2 kg/ha.

MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

- Hazardous Substances Data Bank (HSDB)

For control of annual and perennial weeds, woody brush, and trees on over 150 crops. Use postdirected in tree and plantation crops, postemergence over Roundup Ready soybeans, and postharvest in fallow periods and noncropland.

Crop Protection Handbook Volume 100, Meister Media Worldwide, Willoughby, OH 2014, p. 339

- Hazardous Substances Data Bank (HSDB)

11.1.1 Use Classification

Chemical Classes -> Pesticides (chemicals used for killing pests, such as rodents, insects, or plants)

- CDC-ATSDR Toxic Substances Portal

Agrochemicals -> Herbicides

- EU Pesticides Database

Herbicides

S69 | LUXPEST | Pesticide Screening List for Luxembourg | DOI:10.5281/zenodo.3862688

- NORMAN Suspect List Exchange

Environmental transformation -> Pesticides (parent, predecessor)

S60 | SWISSPEST19 | Swiss Pesticides and Metabolites from Kiefer et al 2019 | DOI:10.5281/zenodo.3544759

- NORMAN Suspect List Exchange

HERBICIDES

- USGS Columbia Environmental Research Center

11.1.2 Household Products

Household & Commercial/Institutional Products

Information on 9 consumer products that contain Glyphosate in the following categories is provided:

- Pesticides

Consumer Product Information Database (CPID)

11.2 Methods of Manufacturing

Glyphosate is produced by heating a mixture of phosphorous acid and a-amino acetic acid, and then adding formaldehyde.

Muller F, Applebyki AP; Weed Control, 2. Individual Herbicides. Ullmann's Encyclopedia of Industrial Chemistry 7th ed. (1999-2014). NY, NY: John Wiley & Sons. Online Posting Date: September 15, 2010

Hazardous Substances Data Bank (HSDB)

Preparation: J. E. Franz, German patent 2152826; idem, United States of America patent 3799758 and United States of America patent 3853530 (1972, 1974, 1974 all to Monsanto).

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 834

Hazardous Substances Data Bank (HSDB)

11.3 Formulations/Preparations

The National Pesticide Information Retrieval System (NPIRS) identifies 42 companies with active labels for products containing the chemical glyphosate. To view the complete list of companies, product names and percent glyphosate in formulated products click the following url and enter the CAS Registry number in the Active Ingredient field.

National Pesticide Information Retrieval System's Database on Glyphosate (1071-83-6). Available from, as of September 30, 2014: https://npirspublic.ceris.purdue.edu/ppis/

Hazardous Substances Data Bank (HSDB)

Glyphosate Acid Technical (Syngenta Crop Protection, LLC): Active ingredient: glyphosate 88.0%.

National Pesticide Information Retrieval System's Database on Glyphosate (1071-83-6). Available from, as of September 30, 2014: https://npirspublic.ceris.purdue.edu/ppis/

Hazardous Substances Data Bank (HSDB)

Touchdown Herbicide (Syngenta Crop Protection, LLC): Active ingredient: glyphosate 28.3%.

National Pesticide Information Retrieval System's Database on Glyphosate (1071-83-6). Available from, as of September 30, 2014: https://npirspublic.ceris.purdue.edu/ppis/

Hazardous Substances Data Bank (HSDB)

Touchdown Ready-to-Use Herbicide (Syngenta Crop Protection, LLC): Active ingredient: glyphosate 0.81%.

National Pesticide Information Retrieval System's Database on Glyphosate (1071-83-6). Available from, as of September 30, 2014: https://npirspublic.ceris.purdue.edu/ppis/

Hazardous Substances Data Bank (HSDB)

For more Formulations/Preparations (Complete) data for GLYPHOSATE (32 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

11.4 General Manufacturing Information

The WHO Recommended Classification of Pesticides by Hazard identifies glyphosate (technical grade) as unlikely to present an acute hazard in normal use; Main Use: herbicide.

WHO International Programme on Chemical Safety; The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification 2009 p.36 (2010)

Hazardous Substances Data Bank (HSDB)

Glyphosate is among the most widely used pesticides by volume. It ranked eleventh among conventional pesticides used in the U.S. during 1990- 91. In recent years, approximately 13 to 20 million acres were treated with 18.7 million pounds of glyphosate annually. The largest use sites include hay/pasture, soybeans and field corn. /Glyphosate and its salts/

USEPA/Office of Pesticide Programs; Reregistration Eligibility Decision Document - Glyphosate. EPA 738-R-93-014 September 1993. Available from, as of February 6, 2006: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

The glyphosate (N-phosphonomethyl glycine) salts are nonselective herbicides and plant growth regulators.The techical sodium salt is a white crystalline solid which decomposes at 140 °C with a bulk density of 30 lb/ cu ft.

USEPA/Office of Pesticide Programs; Reregistration Eligibility Decision Document - Glyphosate. EPA 738-R-93-014 September 1993. Available from, as of February 6, 2006: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

Crop safety evident when applied prior to planting or after harvest or when directed applications made to tree and vine crops.

Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982., p. 317

Hazardous Substances Data Bank (HSDB)

For more General Manufacturing Information (Complete) data for GLYPHOSATE (6 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

12 Identification

12.1 Analytic Laboratory Methods

Method: OSHA PV2067; Procedure: high performance liquid chromatography using an ultraviolet detector; Analyte: glyphosate; Matrix: air; Detection Limit: 1 ug/cu m.

U.S. Department of Labor/Occupational Safety and Health Administration's Index of Sampling and Analytical Methods. Glyphosate (1071-83-6). Available from, as of October 2, 2014: https://www.osha.gov/dts/sltc/methods/toc.html

Hazardous Substances Data Bank (HSDB)

Method: Abraxis 500081; Procedure: immunoassay, magnetic particle; Analyte: glyphosate; Matrix: water (groundwater, surface water, well water); Detection Limit: 0.1 ppb.

National Environmental Methods Index; Analytical, Test and Sampling Methods. Glyphosate (1071-83-6). Available from, as of October 2, 2014: https://www.nemi.gov

Hazardous Substances Data Bank (HSDB)

Method: Abraxis 500086; Procedure: immunoassay, microtiter plate; Analyte: glyphosate; Matrix: water (groundwater, surface water, well water); Detection Limit: 0.1 ppb.

National Environmental Methods Index; Analytical, Test and Sampling Methods. Glyphosate (1071-83-6). Available from, as of October 2, 2014: https://www.nemi.gov

Hazardous Substances Data Bank (HSDB)

Method: AOAC 991.08; Procedure: high performance liquid chromatography with post column derivitization and fluorescence detection; Analyte: glyphosate; Matrix: ground water, drinking water, and surface water; Detection Limit: 25 ug/L.

National Environmental Methods Index; Analytical, Test and Sampling Methods. Glyphosate (1071-83-6). Available from, as of October 2, 2014: https://www.nemi.gov

Hazardous Substances Data Bank (HSDB)

For more Analytic Laboratory Methods (Complete) data for GLYPHOSATE (12 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

12.2 Clinical Laboratory Methods

Glyphosate serum concentration greater than 1000 mg/L is associated with severe poisoning, although the relevance of this is debated since glyphosate is not thought to induce clinical toxicity itself. It might, however, be a reasonable biomarker of exposure to the product, but more research is required to explore this relationship.

Goldfrank, L.R., Goldfrank's Toxicologic Emergencies 9th Ed. 2011., McGraw-Hill, New York, N.Y., p. 1509

Hazardous Substances Data Bank (HSDB)

13 Safety and Hazards

13.1 Hazards Identification

13.1.1 GHS Classification

Showing 1 of 6 View More

Pictogram(s)	 Corrosive  Environmental Hazard
Signal	Danger
GHS Hazard Statements	H318: Causes serious eye damage [Danger Serious eye damage/eye irritation] H411: Toxic to aquatic life with long lasting effects [Hazardous to the aquatic environment, long-term hazard]
Precautionary Statement Codes	P264+P265, P273, P280, P305+P354+P338, P317, P391, and P501 (The corresponding statement to each P-code can be found at the GHS Classification page.)

EU REGULATION (EC) No 1272/2008

13.1.2 Hazard Classes and Categories

Showing 2 of 5 View More

Eye Dam. 1

Aquatic Chronic 2

EU REGULATION (EC) No 1272/2008

Eye Dam. 1 (99.76%)

Aquatic Chronic 2 (99.76%)

European Chemicals Agency (ECHA)

13.1.3 Health Hazards

SYMPTOMS: Symptoms of exposure to this compound include irritation of the skin, gastrointestinal tract and respiratory tract, convulsions and coma. It may also cause enhanced breathing. ACUTE/CHRONIC HAZARDS: This compound is an irritant of the skin, respiratory tract and gastrointestinal tract. When heated to decomposition it emits very toxic fumes of nitrogen oxides and phosphorus oxides. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

CAMEO Chemicals

13.1.4 Fire Hazards

Flash point data for this chemical are not available; however, it is probably combustible. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

CAMEO Chemicals

Combustible. Gives off irritating or toxic fumes (or gases) in a fire. Finely dispersed particles form explosive mixtures in air.

ILO International Chemical Safety Cards (ICSC)

13.1.5 Hazards Summary

Glyphosate is the active ingredient in weed killer products such as RoundUp™. Glyphosate products are one of the most widely used weed killers worldwide in farms and in home gardens and lawns. These products typically contain glyphosate in combination with other ingredients that help improve the absorption of the glyphosate into the plant. Glyphosate-based formulations (GBFs) are easily bought in most stores. These products can have different combinations of other ingredients or different concentrations of glyphosate.

CDC-ATSDR Toxic Substances Portal

An irritant to the eyes, skin, and upper respiratory tract; [EPA Pesticides] The following herbicides have an oral LD50 of >1 gm/kg and have little or no acute toxicity in humans: Alachlor, Amitrole, Ammonium sulfamate, Atrazine, Dalapon, Dicamba, Glyphosphate, Monuron, Oryzalin, Picloram, Propanil, Simazine, etc. [LaDou, p. 613] A severe eye and mild skin irritant; [ICSC] It was found not to be a skin sensitizer after extensive investigation. [Kanerva, p. 782] In the AHS [Agricultural Health Study], there was no association between glyphosate exposure and NHL [non-Hodgkin lymphoma] . . . there is little evidence of biologic effects of glyphosate in humans; therefore, no clear biologic mechanism has been proposed. [Occupational Cancers, p. 505] There was no pattern of increasing risk of NHL overall with increasing years of use of glyphosate. [PMID 31246262] See Glyphosate isopropylamine salt.

LaDou - LaDou J, Harrison R (eds). Current Occupational & Environmental Medicine, 5th Ed. New York: McGraw-Hill, 2014., p. 613
Kanerva - Rustemeyer L, Elsner P, John SM, Maibach HI (eds). Kanerva's Occupational Dermatology, 2nd Ed. Berlin: Springer-Verlag, 2012., p. 782
Occupational Cancers - Anttila S, Boffetta P (eds). Occupational Cancers. London: Springer-Verlag, 2014., p. 505
PMID:31246262

Haz-Map, Information on Hazardous Chemicals and Occupational Diseases

13.1.6 Skin, Eye, and Respiratory Irritations

Glyphosate in the formulated product can cause eye and skin irritation. /Formulated herbicide/

Sullivan, J.B., Krieger G.R. (eds). Clinical Environmental Health and Toxic Exposures. Second edition. Lippincott Williams and Wilkins, Philadelphia, Pennsylvania 1999., p. 663

Hazardous Substances Data Bank (HSDB)

Concentrated solutions /of glyphosate/ can cause dermal irritation.

Sullivan, J.B., Krieger G.R. (eds). Clinical Environmental Health and Toxic Exposures. Second edition. Lippincott Williams and Wilkins, Philadelphia, Pennsylvania 1999., p. 190

Hazardous Substances Data Bank (HSDB)

Some glyphosate end-use products are in Toxicity Categories I or II form primary eye irritation or skin irritation. In California, glyphosate ranks high among pesticides causing illness or injury to workers, who report numerous incidents of eye and skin irritation from splashes during mixing and loading.

USEPA; Reregistration Eligibility Decision (RED) Database for Glyphosate (38641-94-0). EPA 738-R-93-014 (September 1993). Available from, as of January 25, 2006: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

13.2 Safety and Hazard Properties

13.2.1 Physical Dangers

Dust explosion possible if in powder or granular form, mixed with air. If dry, it can be charged electrostatically by swirling, pneumatic transport, pouring, etc.

ILO International Chemical Safety Cards (ICSC)

13.3 First Aid Measures

13.3.1 First Aid

EYES: First check the victim for contact lenses and remove if present. Flush victim's eyes with water or normal saline solution for 20 to 30 minutes while simultaneously calling a hospital or poison control center. Do not put any ointments, oils, or medication in the victim's eyes without specific instructions from a physician. IMMEDIATELY transport the victim after flushing eyes to a hospital even if no symptoms (such as redness or irritation) develop. SKIN: IMMEDIATELY flood affected skin with water while removing and isolating all contaminated clothing. Gently wash all affected skin areas thoroughly with soap and water. If symptoms such as redness or irritation develop, IMMEDIATELY call a physician and be prepared to transport the victim to a hospital for treatment. INHALATION: IMMEDIATELY leave the contaminated area; take deep breaths of fresh air. If symptoms (such as wheezing, coughing, shortness of breath, or burning in the mouth, throat, or chest) develop, call a physician and be prepared to transport the victim to a hospital. Provide proper respiratory protection to rescuers entering an unknown atmosphere. Whenever possible, Self-Contained Breathing Apparatus (SCBA) should be used; if not available, use a level of protection greater than or equal to that advised under Protective Clothing. INGESTION: DO NOT INDUCE VOMITING. If the victim is conscious and not convulsing, give 1 or 2 glasses of water to dilute the chemical and IMMEDIATELY call a hospital or poison control center. Be prepared to transport the victim to a hospital if advised by a physician. If the victim is convulsing or unconscious, do not give anything by mouth, ensure that the victim's airway is open and lay the victim on his/her side with the head lower than the body. DO NOT INDUCE VOMITING. IMMEDIATELY transport the victim to a hospital. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

CAMEO Chemicals

13.3.2 Inhalation First Aid

Fresh air, rest.

ILO International Chemical Safety Cards (ICSC)

13.3.3 Skin First Aid

Remove contaminated clothes. Rinse and then wash skin with water and soap.

ILO International Chemical Safety Cards (ICSC)

13.3.4 Eye First Aid

First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then refer for medical attention.

ILO International Chemical Safety Cards (ICSC)

13.3.5 Ingestion First Aid

Rinse mouth. Do NOT induce vomiting.

ILO International Chemical Safety Cards (ICSC)

13.4 Fire Fighting

Fires involving this material can be controlled with a dry chemical, carbon dioxide or Halon extinguisher. A water spray may also be used. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

CAMEO Chemicals

Use water spray, powder, alcohol-resistant foam, carbon dioxide.

ILO International Chemical Safety Cards (ICSC)

13.4.1 Fire Fighting Procedures

/To fight fire use/ powder, alcohol-resistant foam, water spray, carbon dioxide.

IPCS,CEC; International Chemical Safety Card on Glyphosate (April 2005). Available from, as of January 28, 2006: https://www.inchem.org/documents/icsc/icsc/eics0160.htm

Hazardous Substances Data Bank (HSDB)

Suitable extinguishing media: Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

Advice for firefighters: Wear self contained breathing apparatus for fire fighting if necessary.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

13.4.2 Firefighting Hazards

Special hazards arising from the substance or mixture: Carbon oxides, nitrogen oxides (NOx), oxides of phosphorus.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

Dust explosion possible if in powder or granular form, mixed with air. If dry, it can be charged electrostatically by swirling, pneumatic transport, pouring, etc.

International Program on Chemical Safety/European Commission; International Chemical Safety Card (ICSC) on Glyphosate (1071-83-6), ICSC No. 0160 (Peer Review Status: April 19, 2005, Validated). Available from, as of February 2, 2015: https://www.inchem.org/pages/icsc.html

Hazardous Substances Data Bank (HSDB)

13.5 Accidental Release Measures

13.5.1 Isolation and Evacuation

Excerpt from ERG Guide 171 [Substances (Low to Moderate Hazard)]: As an immediate precautionary measure, isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids. SPILL: Increase, in the downwind direction, as necessary, the isolation distance shown above. FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2016)

U.S. Department of Transportation, Transport Canada, and Secretariat of Communications and Transport of Mexico, with collaboration from Argentina's Centro de Información Química para Emergencias. 2016 Emergency Response Guidebook. https://www.phmsa.dot.gov/hazmat/outreach-training/erg (accessed April 26, 2016).

CAMEO Chemicals

13.5.2 Spillage Disposal

Personal protection: particulate filter respirator adapted to the airborne concentration of the substance. Do NOT let this chemical enter the environment. Sweep spilled substance into covered plastic containers. If appropriate, moisten first to prevent dusting. Carefully collect remainder. Then store and dispose of according to local regulations.

ILO International Chemical Safety Cards (ICSC)

13.5.3 Cleanup Methods

Sweep spilled substance into plastic containers; if appropriate, moisten first to prevent dusting. Carefully collect remainder, then remove to safe place. Do NOT let this chemical enter the environment.

IPCS,CEC; International Chemical Safety Card on Glyphosate (April 2005). Available from, as of January 28, 2006: https://www.inchem.org/documents/icsc/icsc/eics0160.htm

Hazardous Substances Data Bank (HSDB)

If a spill occurs, clean it up promptly. Don't wash it away. Instead, sprinkle the spill with sawdust, vermiculite, or kitty litter. Sweep it into a plastic garbage bag, and dispose of it as directed on the pesticide product label.

USEPA/Prevention, Pesticides, and Toxic Substances; Citizen's Guide to Pest Control and Pesticide Safety p.20 (Septemper 1995) EPA 730-K-95-001

Hazardous Substances Data Bank (HSDB)

After Applying a Pesticide, Indoors or Outdoors. To remove pesticide residues, use a bucket to rinse tools or equipment three times, including any containers or utensils that you used when mixing the pesticide. Then pour the rinsewater into the pesticide sprayer and reuse the solution by applying it according to the pesticide product label directions. After applying any pesticide wash your hands and any other parts of your body that may have come in contact with the pesticide..To prevent tracking pesticides inside, remove or rinse your boots or shoes before entering your home. Wash any clothes that have been exposed to a lot of pesticide separately from your regular wash.

USEPA/Prevention, Pesticides, and Toxic Substances; Citizen's Guide to Pest Control and Pesticide Safety p.22 (Septemper 1995) EPA 730-K-95-001

Hazardous Substances Data Bank (HSDB)

Accidental Release Measures: Personal precautions, protective equipment and emergency procedures: Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust. Environmental precautions: Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided. Methods and materials for containment and cleaning up: Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

13.5.4 Disposal Methods

SRP: The most favorable course of action is to use an alternative chemical product with less inherent propensity for occupational harm/injury/toxicity or environmental contamination. Recycle any unused portion of the material for its approved use or return it to the manufacturer or supplier. Ultimate disposal of the chemical must consider: the material's impact on air quality; potential migration in soil or water; effects on animal and plant life; and conformance with environmental and public health regulations.

Hazardous Substances Data Bank (HSDB)

Safe Disposal of Pesticides. The best way to dispose of small amounts of excess pesticides is to use them - apply them - according to the directions on the label. If you cannot use them, ask your neighbors whether they have a similar pest control problem and can use them. If all of the remaining pesticide cannot be properly used, check with your local solid

waste management authority, environmental agency, or health department to find out whether your community has a household hazardous waste collection program or a similar program for getting rid of unwanted, leftover pesticides. These authorities can also inform you of any local requirements for pesticide waste disposal.

USEPA/Prevention, Pesticides, and Toxic Substances; Citizen's Guide to Pest Control and Pesticide Safety p.24 (Septemper 1995) EPA 730-K-95-001

Hazardous Substances Data Bank (HSDB)

Safe Disposal of Pesticides. An empty pesticide container can be as hazardous as a full one because of residues left inside. Never reuse such a container. When empty, a pesticide container should be rinsed carefully three times and the rinsewater thoroughly drained back onto the sprayer or the container previously used to mix the pesticide. Use the rinsewater as a pesticide, following label directions. Replace the cap or closure securely. Dispose of the container according to label instructions. Do not puncture or burn a pressurized container like an aerosol - it could explode. Do cut or puncture other empty pesticide containers made of metal or plastic to prevent someone from reusing them. Wrap the empty container and put it in the trash after you have rinsed it.

USEPA/Prevention, Pesticides, and Toxic Substances; Citizen's Guide to Pest Control and Pesticide Safety p.25 (Septemper 1995) EPA 730-K-95-001

Hazardous Substances Data Bank (HSDB)

Waste treatment methods. Product: Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Contaminated packaging: Dispose of as unused product.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

13.5.5 Preventive Measures

Wear the items of protective clothing the label requires: for example, non-absorbent gloves (not leather or fabric), rubber footwear (not canvas or leather), a hat, goggles, or a dust-mist filter. If no specific clothing is listed, gloves, long-sleeved shirts and long pants, and closed shoes are recommended. You can buy protective clothing and equipment at hardware stores or building supply stores.

USEPA/Prevention, Pesticides, and Toxic Substances; Citizen's Guide to Pest Control and Pesticide Safety p.19 (Septemper 1995) EPA 730-K-95-001

Hazardous Substances Data Bank (HSDB)

Outdoor Applications. Never apply pesticides outdoors on a windy day (winds higher than 10 mph). Position yourself so that a light breeze does not blow pesticide spray or dust into your face.

USEPA/Prevention, Pesticides, and Toxic Substances; Citizen's Guide to Pest Control and Pesticide Safety p.21 (Septemper 1995) EPA 730-K-95-001

Hazardous Substances Data Bank (HSDB)

SRP: The scientific literature for the use of contact lenses by industrial workers is inconsistent. The benefits or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.

Hazardous Substances Data Bank (HSDB)

Worker Protection Standard (WPS) Requirements. Any product whose labeling permits use in the production of an agricultural plant on any farm, forest, nursery or greenhouse must comply with the labeling requirements of: PR Notice 93-7, "Labeling Revisions Required by the Worker Protection Standard (WPS)," andPR Notice 93-11, "Supplemental Guidance for PR Notice 93-7." Unless specifically directed in the RED, all statements required by these two PR Notices must appear on product labeling exactly as instructed in the Notices. Labels /for glyphosate/ were required to/ be revised by April 21, 1994, for products distributed or sold by the primary registrant or supplementally registered distributors, and by October 23, 1995, for products distributed or sold by anyone.

USEPA; Reregistration Eligibility Decision (RED) Database for Glyphosate (38641-94-0). EPA 738-R-93-014 (September 1993). Available from, as of January 25, 2006: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

For more Preventive Measures (Complete) data for GLYPHOSATE (9 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

13.6 Handling and Storage

13.6.1 Nonfire Spill Response

SMALL SPILLS AND LEAKAGE: If you spill this chemical, you should dampen the solid spill material with water, then transfer the dampened material to a suitable container. Use absorbent paper dampened with water to pick up any remaining material. Seal your contaminated clothing and the absorbent paper in a vapor-tight plastic bag for eventual disposal. Wash all contaminated surfaces with a soap and water solution. Do not reenter the contaminated area until the Safety Officer (or other responsible person) has verified that the area has been properly cleaned. STORAGE PRECAUTIONS: You should protect this material from exposure to light, and store it under ambient temperatures. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

CAMEO Chemicals

13.6.2 Safe Storage

Provision to contain effluent from fire extinguishing. Separated from food and feedstuffs. Well closed. Do NOT store or transport in containers made from galvanized steel or unlined steel. Store in an area without drain or sewer access.

ILO International Chemical Safety Cards (ICSC)

13.6.3 Storage Conditions

Safe Storage of Pesticides. Always store pesticides in their original containers, complete with labels that list ingredients, directions for use, and first aid steps in case of accidental poisoning. Never store pesticides in cabinets with or near food, animal feed, or medical supplies. Do not store pesticides in places where flooding is possible or in places where they might spill or leak into wells, drains, ground water, or surface water.

USEPA/Prevention, Pesticides, and Toxic Substances; Citizen's Guide to Pest Control and Pesticide Safety p.23 (Septemper 1995) EPA 730-K-95-001

Hazardous Substances Data Bank (HSDB)

Conditions for safe storage, including any incompatibilities: Keep container tightly closed in a dry and well-ventilated place.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

Dust explosion possible if in powder or granular form, mixed with air. If dry, it can be charged electrostatically by swirling, pneumatic transport, pouring, etc.

International Program on Chemical Safety/European Commission; International Chemical Safety Card (ICSC) on Glyphosate (1071-83-6), ICSC No. 0160 (Peer Review Status: April 19, 2005, Validated). Available from, as of February 2, 2015: https://www.inchem.org/pages/icsc.html

Hazardous Substances Data Bank (HSDB)

13.7 Exposure Control and Personal Protection

13.7.1 Inhalation Risk

A harmful concentration of airborne particles can be reached quickly on spraying.

ILO International Chemical Safety Cards (ICSC)

13.7.2 Effects of Short Term Exposure

The substance is severely irritating to the eyes. The substance is mildly irritating to the skin.

ILO International Chemical Safety Cards (ICSC)

13.7.3 Allowable Tolerances

Tolerances are established for residues of glyphosate, including its metabolites and degradates, in or on the commodities listed below resulting from the application of glyphosate, the isopropylamine salt of glyphosate, the ethanolamine salt of glyphosate, the dimethylamine salt of glyphosate, the ammonium salt of glyphosate, and the potassium salt of glyphosate. Compliance with the following tolerance levels is to be determined by measuring only glyphosate (N-(phosphonomethyl)glycine).

Commodity	Parts per million
Acerola	0.2
Alfalfa, seed	0.5
Almond, hulls	25
Aloe vera	0.5
Ambarella	0.2
Animal feed, nongrass, group 18	400
Artichoke, globe	0.2
Asparagus	0.5
Atemoya	0.2
Avocado	0.2
Bamboo, shoots	0.2
Banana	0.2
Barley, bran	30
Beet, sugar, dried pulp	25
Beet, sugar, roots	10
Beet, sugar, tops	10
Berry and small fruit, group 13-07	0.20
Betelnut	1.0
Biriba	0.2
Blimbe	0.2
Breadfruit	0.2
Cacao bean, bean	0.2
Cactus, fruit	0.5
Cactus, pads	0.5
Canistel	0.2
Carrot	5.0
Chaya	1.0
Cherimoya	0.2
Citrus, dried pulp	1.5
Coconut	0.1
Coffee, bean, green	1.0
Corn, pop, grain	0.1
Corn, sweet, kernel plus cob with husk removed	3.5
Cotton, gin byproducts	210
Custard apple	0.2
Date, dried fruit	0.2
Dokudami	2.0
Durian	0.2
Epazote	1.3
Feijoa	0.2
Fig	0.2

Commodity	Parts per million
Fish	0.25
Fruit, citrus, group 10-10	0.50
Fruit, pome, group 11-10	0.20
Fruit, stone, group 12	0.2
Galangal, roots	0.2
Ginger, white, flower	0.2
Gourd, buffalo, seed	0.1
Governor's plum	0.2
Gow kee, leaves	0.2
Grain, cereal, forage, fodder and straw, group 16, except field corn, forage and field corn, stover	100
Grain, cereal, group 15 except field corn, popcorn, rice, sweet corn, and wild rice	30
Grass, forage, fodder and hay, group 17	300
Guava	0.2
Herbs subgroup 19A	0.2
Hops, dried cones	7.0
Ilama	0.2
Imbe	0.2
Imbu	0.2
Jaboticaba	0.2
Jackfruit	0.2
Kava, roots	0.2
Kenaf, forage	200
Leucaena, forage	200
Longan	0.2
Lychee	0.2
Mamey apple	0.2
Mango	0.2
Mangosteen	0.2
Marmaladebox	0.2
Mioga, flower	0.2
Noni	0.20
Nut, pine	1.0
Nut, tree, group 14	1.0
Oilseeds, group 20, except canola	40
Okra	0.5
Olive	0.2
Oregano, Mexican, leaves	2.0
Palm heart	0.2
Palm heart, leaves	0.2
Palm, oil	0.1
Papaya	0.2
Papaya, mountain	0.2
Passionfruit	0.2
Pawpaw	0.2
Pea, dry	8.0
Peanut	0.1
Peanut, hay	0.5
Pepper leaf, fresh leaves	0.2
Peppermint, tops	200
Perilla, tops	1.8
Persimmon	0.2
Pineapple	0.1
Pistachio	1.0
Pomegranate	0.2
Pulasan	0.2
Quinoa, grain	5.0
Rambutan	0.2
Rice, grain	0.1
Rice, wild, grain	0.1
Rose apple	0.2
Sapodilla	0.2
Sapote, black	0.2
Sapote, mamey	0.2
Sapote, white	0.2
Shellfish	3.0
Soursop	0.2

Commodity	Parts per million
Spanish lime	0.2
Spearmint, tops	200
Spice subgroup 19B	7.0
Star apple	0.2
Starfruit	0.2
Stevia, dried leaves	1.0
Sugar apple	0.2
Sugarcane, cane	2.0
Sugarcane, molasses	30
Surinam cherry	0.2
Sweet potato	3.0
Tamarind	0.2
Tea, dried	1.0
Tea, instant	7.0
Teff, forage	100
Teff, grain	5.0
Teff, hay	100
Ti, leaves	0.2
Ti, roots	0.2
Ugli fruit	0.5
Vegetable, bulb, group 3-07	0.20
Vegetable, cucurbit, group 9	0.5
Vegetable, foliage of legume, subgroup 7A, except soybean	0.2
Vegetable, fruiting, group 8-10 (except okra)	0.10
Vegetable, leafy, brassica, group 5	0.2
Vegetable, leafy, except brassica, group 4	0.2
Vegetable, leaves of root and tuber, group 2, except sugar beet tops	0.2
Vegetable, legume, group 6 except soybean and dry pea	5.0
Vegetables, root and tuber, group 1, except carrot, sweet potato, and sugar beet	0.20
Wasabi, roots	0.2
Water spinach, tops	0.2
Watercress, upland	0.2
Wax jambu	0.2
Yacon, tuber	0.2

40 CFR 180.364 (a)(1) (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of September 8, 2014: https://www.ecfr.gov

▸ Hazardous Substances Data Bank (HSDB)

Tolerances are established for residues of glyphosate, including its metabolites and degradates, in or on the commodities listed below resulting from the application of glyphosate, the isopropylamine salt of glyphosate, the ethanolamine salt of glyphosate, the dimethylamine salt of glyphosate, the ammonium salt of glyphosate, and the potassium salt of glyphosate. Compliance with the following tolerance levels is to be determined by measuring only glyphosate (N-(phosphonomethyl)glycine) and its metabolite N-acetyl-glyphosate (N-acetyl-N-(phosphonomethyl)glycine; calculated as the stoichiometric equivalent of glyphosate).

Commodity	Parts per million
Canola, seed	20
Cattle, meat byproducts	5.0
Corn, field, forage	13
Corn, field, grain	5.0
Corn, field, stover	100
Egg	0.05
Goat, meat byproducts	5.0
Grain aspirated fractions	310.0
Hog, meat byproducts	5.0
Horse, meat byproducts	5.0
Poultry, meat	0.10
Poultry, meat byproducts	1.0
Sheep, meat byproducts	5.0
Soybean, forage	100.0
Soybean, hay	200.0
Soybean, hulls	120.0
Soybean, seed	20.0

40 CFR 180.364(a)(2) (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of September 8, 2014: https://www.ecfr.gov

▸ Hazardous Substances Data Bank (HSDB)

13.7.4 Personal Protective Equipment (PPE)

RECOMMENDED RESPIRATOR: Where the neat test chemical is weighed and diluted, wear a NIOSH-approved half face respirator equipped with an organic vapor/acid gas cartridge (specific for organic vapors, HCl, acid gas and SO2) with a dust/mist filter. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

CAMEO Chemicals

Eye/face protection: Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

Skin protection: Handle with gloves.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

Body Protection: Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

Respiratory protection: Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

Hazardous Substances Data Bank (HSDB)

13.7.5 Fire Prevention

NO open flames, NO sparks and NO smoking. Prevent build-up of electrostatic charges (e.g., by grounding). Closed system, dust explosion-proof electrical equipment and lighting. Prevent deposition of dust.

ILO International Chemical Safety Cards (ICSC)

13.7.6 Exposure Prevention

PREVENT DISPERSION OF DUST!

ILO International Chemical Safety Cards (ICSC)

13.7.7 Inhalation Prevention

Avoid inhalation of dust and mist.

ILO International Chemical Safety Cards (ICSC)

13.7.8 Skin Prevention

Protective gloves.

ILO International Chemical Safety Cards (ICSC)

13.7.9 Eye Prevention

Wear safety goggles.

ILO International Chemical Safety Cards (ICSC)

13.7.10 Ingestion Prevention

Do not eat, drink, or smoke during work. Wash hands before eating.

ILO International Chemical Safety Cards (ICSC)

13.8 Stability and Reactivity

13.8.1 Air and Water Reactions

Slightly water soluble.

CAMEO Chemicals

13.8.2 Reactive Group

Acids, Carboxylic

Amines, Phosphines, and Pyridines

Sulfonates, Phosphonates, and Thiophosphonates, Organic

CAMEO Chemicals

13.8.3 Reactivity Profile

GLYPHOSATE may react with galvanized steel or unlined steel (except stainless steel) containers to produce hydrogen gas which may form a highly combustible or explosive gas mixture. It can react with caustic (basic) materials to liberate heat. It is corrosive to iron. (NTP, 1992)

National Toxicology Program, Institute of Environmental Health Sciences, National Institutes of Health (NTP). 1992. National Toxicology Program Chemical Repository Database. Research Triangle Park, North Carolina.

- CAMEO Chemicals

13.8.4 Hazardous Reactivities and Incompatibilities

Incompatible materials: Strong oxidizing agents, metals, bases.

Sigma-Aldrich; Material Safety Data Sheet for Glyphosate. Product Number: 45521, Version 5.1 (Revision Date 07/02/2014). Available from, as of October 8, 2014: https://www.sigmaaldrich.com/safety-center.html

- Hazardous Substances Data Bank (HSDB)

13.9 Transport Information

13.9.1 DOT Label

Class 9

- CAMEO Chemicals

13.9.2 Packaging and Labelling

Do not transport with food and feedstuffs.

- ILO International Chemical Safety Cards (ICSC)

13.9.3 EC Classification

Symbol: Xi, N; R: 41-51/53; S: (2)-26-39-61

- ILO International Chemical Safety Cards (ICSC)

13.10 Regulatory Information

13.10.1 Federal Drinking Water Standards

Maximum contaminant levels (MCL) for synthetic organic contaminants apply to community water systems and non-transient, non-community water systems: Glyphosate, MCL 0.7 mg/L.

40 CFR 141.61(c) (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of September 8, 2014: https://www.ecfr.gov

- Hazardous Substances Data Bank (HSDB)

13.10.2 Federal Drinking Water Guidelines

Maximum contaminant level goal (MCLG) for organic contaminants: Glyphosate, MCLG 0.7 mg/L.

40 CFR 141.50(b) (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of September 8, 2014: https://www.ecfr.gov

- Hazardous Substances Data Bank (HSDB)

13.10.3 State Drinking Water Guidelines

(AZ) ARIZONA 700 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

- Hazardous Substances Data Bank (HSDB)

(ME) MAINE 700 ug/L

USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93) To Present

- Hazardous Substances Data Bank (HSDB)

13.10.4 FIFRA Requirements

Tolerances are established for residues of glyphosate, including its metabolites and degradates, in or on the commodities listed below resulting from the application of glyphosate, the isopropylamine salt of glyphosate, the ethanolamine salt of glyphosate, the dimethylamine salt of glyphosate, the ammonium salt of glyphosate, and the potassium salt of glyphosate. Compliance with the following tolerance levels is to be determined by measuring only glyphosate (N-(phosphonomethyl)glycine).

Commodity
Acerola
Alfalfa, seed
Almond, hulls
Aloe vera
Ambarella
Animal feed, nongrass, group 18
Artichoke, globe
Asparagus

Commodity
Atemoya
Avocado
Bamboo, shoots
Banana
Barley, bran
Beet, sugar, dried pulp
Beet, sugar, roots
Beet, sugar, tops
Berry and small fruit, group 13-07
Betelnut
Biriba
Blimbe
Breadfruit
Cacao bean, bean
Cactus, fruit
Cactus, pads
Canistel
Carrot
Chaya
Cherimoya
Citrus, dried pulp
Coconut
Coffee, bean, green
Corn, pop, grain
Corn, sweet, kernel plus cob with husk removed
Cotton, gin byproducts
Custard apple
Date, dried fruit
Dokudami
Durian
Epazote
Feijoa
Fig
Fish
Fruit, citrus, group 10-10
Fruit, pome, group 11-10
Fruit, stone, group 12
Galangal, roots
Ginger, white, flower
Gourd, buffalo, seed
Governor's plum
Gow kee, leaves
Grain, cereal, forage, fodder and straw, group 16, except field corn, forage and field corn, stover
Grain, cereal, group 15 except field corn, popcorn, rice, sweet corn, and wild rice
Grass, forage, fodder and hay, group 17
Guava
Herbs subgroup 19A
Hops, dried cones
Ilama
Imbe
Imbu
Jaboticaba
Jackfruit
Kava, roots
Kenaf, forage
Leucaena, forage
Longan
Lychee
Mamey apple
Mango
Mangosteen
Marmaladebox
Mioga, flower
Noni
Nut, pine
Nut, tree, group 14

Commodity
Oilseeds, group 20, except canola
Okra
Olive
Oregano, Mexican, leaves
Palm heart
Palm heart, leaves
Palm, oil
Papaya
Papaya, mountain
Passionfruit
Pawpaw
Pea, dry
Peanut
Peanut, hay
Pepper leaf, fresh leaves
Peppermint, tops
Perilla, tops
Persimmon
Pineapple
Pistachio
Pomegranate
Pulasan
Quinoa, grain
Rambutan
Rice, grain
Rice, wild, grain
Rose apple
Sapodilla
Sapote, black
Sapote, mamey
Sapote, white
Shellfish
Soursop
Spanish lime
Spearmint, tops
Spice subgroup 19B
Star apple
Starfruit
Stevia, dried leaves
Sugar apple
Sugarcane, cane
Sugarcane, molasses
Surinam cherry
Sweet potato
Tamarind
Tea, dried
Tea, instant
Teff, forage
Teff, grain
Teff, hay
Ti, leaves
Ti, roots
Ugli fruit
Vegetable, bulb, group 3-07
Vegetable, cucurbit, group 9
Vegetable, foliage of legume, subgroup 7A, except soybean
Vegetable, fruiting, group 8-10 (except okra)
Vegetable, leafy, brassica, group 5
Vegetable, leafy, except brassica, group 4
Vegetable, leaves of root and tuber, group 2, except sugar beet tops
Vegetable, legume, group 6 except soybean and dry pea
Vegetables, root and tuber, group 1, except carrot, sweet potato, and sugar beet
Wasabi, roots
Water spinach, tops
Watercress, upland
Wax jambu

Commodity
Yacon, tuber

40 CFR 180.364 (a)(1) (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of September 8, 2014: https://www.ecfr.gov

Hazardous Substances Data Bank (HSDB)

Tolerances are established for residues of glyphosate, including its metabolites and degradates, in or on the commodities listed below resulting from the application of glyphosate, the isopropylamine salt of glyphosate, the ethanolamine salt of glyphosate, the dimethylamine salt of glyphosate, the ammonium salt of glyphosate, and the potassium salt of glyphosate. Compliance with the following tolerance levels is to be determined by measuring only glyphosate (N-(phosphonomethyl)glycine) and its metabolite N-acetyl-glyphosate (N-acetyl-N-(phosphonomethyl)glycine; calculated as the stoichiometric equivalent of glyphosate).

Commodity
Canola, seed
Cattle, meat byproducts
Corn, field, forage
Corn, field, grain
Corn, field, stover
Egg
Goat, meat byproducts
Grain aspirated fractions
Hog, meat byproducts
Horse, meat byproducts
Poultry, meat
Poultry, meat byproducts
Sheep, meat byproducts
Soybean, forage
Soybean, hay
Soybean, hulls
Soybean, seed

40 CFR 180.364(a)(2) (USEPA); U.S. National Archives and Records Administration's Electronic Code of Federal Regulations. Available from, as of September 8, 2014: https://www.ecfr.gov

Hazardous Substances Data Bank (HSDB)

The Agency made its reregistration eligibility determination based upon the target data base required for reregistration, the current guidelines for conducting acceptable studies to generate such data and the data identified in Appendix B. Although the Agency has found that all uses of glyphosate (isopropylamine and sodium salt formulations) are eligible for reregistration, it should be understood that the Agency may take appropriate regulatory action, and/or require the submission of additional data to support the registration of products containing glyphosate, if new information comes to the Agency's attention or if the data requirements for registration (or the guidelines for generating such data) change. ... Based on the reviews of the generic data for the active ingredient glyphosate, the Agency has sufficient information on the health effects of glyphosate and on its potential for causing adverse effects in fish and wildlife and the environment. The Agency concludes that products containing glyphosate for all uses are eligible for reregistration. The Agency has determined that glyphosate products, labeled and used as specified in this Reregistration Eligibility Document, will not pose unreasonable risks or adverse effects to humans or the environment.

USEPA/Office of Prevention, Pesticides and Toxic Substances; Reregistration Eligibility Decision Document for Glyphosate p.57 EPA 738-R-93-014 (September 1993). Available from, as of October 1, 2014: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

As the federal pesticide law FIFRA directs, EPA is conducting a comprehensive review of older pesticides to consider their health and environmental effects and make decisions about their continued use. Under this pesticide reregistration program, EPA examines newer health and safety data for pesticide active ingredients initially registered before November 1, 1984, and determines whether the use of the pesticide does not pose unreasonable risk in accordance to newer safety standards, such as those described in the Food Quality Protection Act of 1996. Glyphosphate is found on List A, which contains most food use pesticides and consists of the 194 chemical cases (or 350 individual active ingredients) for which EPA issued registration standards prior to FIFRA, as amended in 1988. Case No: 0178; Pesticide type: herbicide (growth regulator); Registration Standard Date: 06/01/86; Case Status: RED Approved 09/93; OPP has made a decision that some/all uses of the pesticide are eligible for reregistration, as reflected in a Reregistration Eligibility Decision (RED) document.; Active ingredient (AI): isopropylamine glyphosate; Data Call-in (DCI) Date(s): 01/24/94, 02/16/94; AI Status: OPP has completed a Reregistration Eligibility Decision (RED) document for the case/AI.

United States Environmental Protection Agency/ Prevention, Pesticides and Toxic Substances; Status of Pesticides in Registration, Reregistration, and Special Review. (1998) EPA 738-R-98-002, p. 123

Hazardous Substances Data Bank (HSDB)

13.11 Other Safety Information

13.11.1 Special Reports

DHHS/NTP; NTP Technical Report on Toxicity Studies of Glyphosate Administered in Dosed Feed to F344/N Rats and B6C3F1 Mice (NTP Tox 16) (1992)[Available from, as of April 4, 2003: http://ntp.niehs.nih.gov/ntp/htdocs/ST_rpts/tox016.pdf]

Hazardous Substances Data Bank (HSDB)

USEPA/Office of Prevention, Pesticides and Toxic Substances; Reregistration Eligibility Decision Document - Glyphosate, EPA 738-R-93-014 (September 1993). The RED summarizes the risk assessment conclusions and outlines any risk reduction measures necessary for the pesticide /including isopropylamine and sodium salt formulations/ to continue to be registered in the U.S.[Available from, as of October 1, 2014: http://www.epa.gov/pesticides/reregistration/status.htm]

Hazardous Substances Data Bank (HSDB)

WHO; Environ Health Criteria 159: Glyphosate (1994)[Available from, as of March 15, 2006: http://www.inchem.org/documents/ehc/ehc/ehc159.htm]

Hazardous Substances Data Bank (HSDB)

14 Toxicity

14.1 Toxicological Information

CDC-ATSDR Toxicological Profile

- CDC-ATSDR Toxic Substances Portal

14.1.1 Toxicity Summary

IDENTIFICATION AND USE: Glyphosate is an odorless white solid. Glyphosate is a non-selective herbicide registered for use on many food and non-food field crops as well as non-crop areas where total vegetation control is desired. When applied at lower rates, glyphosate is also a plant growth regulator. HUMAN EXPOSURE AND TOXICITY: Glyphosate is an active ingredient of the most widely used herbicide and it is believed to be less toxic than other pesticides. However, several studies showed its potential adverse health effects to humans as it may be an endocrine disruptor. Concentrated solutions of glyphosate can also cause dermal irritation. Most intoxicated cases are from ingestion, inhalation, and skin exposure. Pulmonary edema, shock, and arrhythmia were the reported causes of mortality. Ingestion of glyphosate-surfactant herbicides can result in acute kidney injury, electrolyte abnormalities, acidosis, cardiovascular collapse, and death. In severe toxicity, the use of hemodialysis is reported, but largely unsupported by kinetic analysis. Commercial formulations were more cytotoxic than the active component alone, supporting the concept that additives in commercial formulations play a role in the toxicity attributed to glyphosate-based herbicides. Glyphosate was found nongenotoxic in human lymphocytes with or without metabolic activation. However it induced micronuclei formation and DNA damage in a buccal epithelial cell line (TR146). In addition, glyphosate was toxic to human placental JEG3 cells. ANIMAL STUDIES: Glyphosate did not produce dermal sensitization in guinea pigs. It produced moderate to severe eye irritation in rabbits. In a 13-week study with glyphosate administration, lesions of the salivary glands were found in rats and mice. A study in a 2-stage mouse skin carcinogenesis model and proteomic analysis suggested that glyphosate has tumor promoting potential in skin carcinogenesis. Studies in rats and rabbits indicated that technical glyphosate is not teratogenic. In the first /multigenerational/ study, the only effect noted was an increased incidence of unilateral renal tubular dilation in F3b male pups at 30 mg/kg body weight. Maternal exposure to glyphosate disturbed the masculinization process in the offsping and promoted behavioral changes and histological and endocrine problems in reproductive parameters. These changes associated with the hypersecretion of androgens increased gonadal activity and sperm production. The entire body of the developmental toxicity data reviewed fails to support a potential risk for increased cardiovascular defects as a result of glyphosate exposure during pregnancy. A broad array of in vitro and in vivo assays has consistently demonstrated that glyphosate and glyphosate-containing herbicide formulations are not genotoxic. Occasionally, however, related and contradictory data are reported, including findings of mouse liver and kidney DNA adducts and damage following intraperitoneal (ip) injection. ECOTOXICITY STUDIES: Gene expression data (mRNA levels) suggests that glyphosate-based herbicides have the potential to alter hormonal pathways during tadpole development. Roundup exposure had negative impact on the immune system of European sea bass. Roundup at environmentally relevant concentrations has lethal and genotoxic impact on the Indian skittering frog. Roundup also altered normal histology of the studied organs and caused a significant decrease in the number of copulations and mating success in male fish exposed to the herbicide in the neotropical native fish, Jenynsia multidentata.

- Hazardous Substances Data Bank (HSDB)

14.1.2 NIOSH Toxicity Data

- The National Institute for Occupational Safety and Health (NIOSH)

14.1.3 Evidence for Carcinogenicity

Classification - D; not classifiable as to human carcinogenicity. Basis - Inadequate evidence for oncogenicity in animals. Glyphosate was originally classified as C, possible human carcinogen, on the basis of increased incidence of renal tumors in mice. Following independent review of the slides the classification was changed to D on the basis of a lack of statistical significance and uncertainty as to a treatment-related effect.

EPA; Integrated Risk Information System (IRIS) Glyphosate (CAS 1071-83-6), Revised Oct 1993; Available from, as of November 19, 2014: https://www.epa.gov/iris/

- Hazardous Substances Data Bank (HSDB)

The herbicide glyphosate and the insecticides malathion and diazinon were classified as probably carcinogenic to humans (Group 2A). For the herbicide glyphosate, there was limited evidence of carcinogenicity in humans for non-Hodgkin lymphoma. The evidence in humans is from studies of exposures, mostly agricultural, in the USA, Canada, and Sweden published since 2001. In addition, there is convincing evidence that glyphosate also can cause cancer in laboratory animals. On the basis of tumours in mice, the United States Environmental Protection Agency (US EPA) originally classified glyphosate as possibly carcinogenic to humans (Group C) in 1985. After a re-evaluation of that mouse study, the US EPA changed its classification to evidence of non-carcinogenicity in humans (Group E) in 1991. The US EPA Scientific Advisory Panel noted that the re-evaluated glyphosate results were still significant using two statistical tests recommended in the IARC Preamble. The IARC Working Group that conducted the evaluation considered the significant findings from the US EPA report and several more recent positive results in concluding that there is sufficient evidence of carcinogenicity in experimental animals. Glyphosate also caused DNA and chromosomal damage in human cells, although it gave negative results in tests using bacteria. One study in community residents reported increases in blood markers of chromosomal damage (micronuclei) after glyphosate formulations were sprayed nearby.

WHO; IARC Monographs Volume 112: evaluation of five organophosphate insecticides and herbicides (March 20, 2015); Available from, as of March 23, 2015: https://www.iarc.fr/en/media-centre/iarcnews/pdf/MonographVolume112.pdf

- Hazardous Substances Data Bank (HSDB)

14.1.4 Carcinogen Classification

IARC Carcinogenic Agent	Glyphosate
IARC Carcinogenic Classes	Group 2A: Probably carcinogenic to humans
IARC Monographs	Volume 112: (2017) Some Organophosphate Insecticides and Herbicides

- International Agency for Research on Cancer (IARC)

14.1.5 Inhalation Symptoms

Cough.

- ILO International Chemical Safety Cards (ICSC)

14.1.6 Skin Symptoms

Redness.

- ILO International Chemical Safety Cards (ICSC)

14.1.7 Eye Symptoms

Redness. Pain.

- ILO International Chemical Safety Cards (ICSC)

14.1.8 Ingestion Symptoms

Burning sensation in the throat and chest.

- ILO International Chemical Safety Cards (ICSC)

14.1.9 Target Organs

Gastrointestinal (Stomach and Intestines, part of the digestive system), Respiratory (From the Nose to the Lungs)

- CDC-ATSDR Toxic Substances Portal

14.1.10 Acute Toxicity Link

Chemical: GLYPHOSATE

- USGS Columbia Environmental Research Center

14.1.11 Adverse Effects

Occupational hepatotoxin - Secondary hepatotoxins: the potential for toxic effect in the occupational setting is based on cases of poisoning by human ingestion or animal experimentation.

IARC Carcinogen - Class 2: International Agency for Research on Cancer classifies chemicals as probable (2a), or possible (2b) human carcinogens.

- Haz-Map, Information on Hazardous Chemicals and Occupational Diseases

14.1.12 Acute Effects

- ChemIDplus

14.1.13 Interactions

/This study/ investigated whether glyphosate influences the cellular toxicity of the surfactants TN-20 and LN-10 on the mouse fibroblast-like cells, alveolar epithelial cells, and a heart cell line. The cytotoxicity of TN-20 and LN-10 (0.4-100 uM), in the presence or absence of glyphosate was determined by assessing membrane integrity. TN-20 toxicity was significantly lower in the presence of 50 uM glyphosate for the fibroblast-like cell (6.25 uM; 3.9% +/- 3.4% vs -4.8%+/-0.7%), for the alveolar cells (0.78 uM; 5.7% +/- 0.9% vs 0.1% +/- 0.6%), and for the heart cell line (25.0 uM; 7.9% +/-3.0% vs 19.4% +/- 0.7%) compared to that of TN-20 alone. The cellular toxicity of LN-10 towards the fibroblast-like cells was found to be increased in the presence of 50 uM glyphosate when LN-10 concentrations of 50 uM (31.3% +/- 3.9% vs 19.2% +/-0.9%) and 100 uM (62.1% +/- 3.4% vs 39.0% +/- 0.7%) were compared to that of LN-10 alone. These results suggest that the mixture toxicity may be a factor in glyphosate-surfactant toxicity in patients with acute glyphosate herbicide intoxication.

PMID:22787363
Full text: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3390716
Song HY et al; J Korean Med Sci 27 (7): 711-5 (2012)

- Hazardous Substances Data Bank (HSDB)

Glyphosate, a common herbicide, is not toxic under normal exposure circumstances. However, this chemical, when combined with a surfactant, is cytotoxic. In this study, the mechanism of the additive effect of glyphosate and TN-20, a common surfactant in glyphosate herbicides, was investigated. After exposure of rat H9c2 cells to glyphosate and TN-20 mixtures, following assays were performed: flow cytometry to determine the proportion of cells that underwent apoptosis and necrosis; western blotting to determine expression of mitochondrial proteins (Bcl-2 and Bax); immunological methods to evaluate translocation of cytochrome C; luminometric measurements to determine activity of caspases 3/7 and 9; and tetramethyl rhodamine methyl ester assay to measure mitochondrial membrane potentials. Bcl-1 intensity decreased while Bax intensity increased with exposure to increasing TN-20 and/or glyphosate concentrations. Caspase activity increased and mitochondrial membrane potential decreased only when the cells were exposed to a mixture of both TN-20 and glyphosate, but not after exposure to either one of these compounds. The results support the possibility that mixtures of glyphosate and TN-20 aggravate mitochondrial damage and induce apoptosis and necrosis. Throughout this process, TN-20 seems to disrupt the integrity of the cellular barrier to glyphosate uptake, promoting glyphosate-mediated toxicity.

PMID:23099315
Kim YH et al; Toxicol In Vitro 27 (1): 191-7 (2013)

▸ Hazardous Substances Data Bank (HSDB)

14.1.14 Antidote and Emergency Treatment

Immediate first aid: Ensure that adequate decontamination has been carried out. If patient is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask, as trained. Perform CPR as necessary. Immediately flush contaminated eyes with gently flowing water. Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration. Keep patient quiet and maintain normal body temperature. Obtain medical attention. /Glyphosate (Roundup) and Related Compounds/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3rd revised edition, Elsevier Mosby, St. Louis, MO 2007, p. 358

▸ Hazardous Substances Data Bank (HSDB)

Basic treatment: Establish a patent airway (oropharyngeal or nasopharyngeal airway, if needed). Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with 0.9% saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 mL/kg up to 200 mL of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . Monitor body temperature and treat if necessary. Cover skin burns with dry sterile dressings after decontamination ... . /Glyphosate (Roundup) and Related Compounds/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3rd revised edition, Elsevier Mosby, St. Louis, MO 2007, p. 358-9

▸ Hazardous Substances Data Bank (HSDB)

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious, has severe pulmonary edema, or is in severe respiratory distress. Positive-pressure ventilation techniques with a bag valve mask device may be beneficial. Consider drug therapy for pulmonary edema ... . Monitor and treat cardiac arrhythmias if necessary ... . Start IV administration of D5W /SRP: "To keep open", minimal flow rate/. Use 0.9% saline (NS) or lactated Ringer's(LR) if signs of hypovolemia are present. For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors if patient is hypotensive with a normal fluid volume. Watch for signs of fluid overload ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Glyphosate (Roundup) and Related Compounds/

Currance, P.L. Clements, B., Bronstein, A.C. (Eds).; Emergency Care For Hazardous Materials Exposure. 3rd revised edition, Elsevier Mosby, St. Louis, MO 2007, p. 359

▸ Hazardous Substances Data Bank (HSDB)

EXPERIMENTAL: BACKGROUND: Although glyphosate intoxication has been considered minimally toxic in animals, severe toxicity has been observed in humans due to surfactant. /This study/ aimed to examine the potential therapeutic effects of intravenous lipid emulsion (ILE) on the patients with acute glyphosate intoxication. METHODS: This study enrolled 64 glyphosate-intoxicated patients with allocation to two groups: those treated with ILE (ILE group, n = 22), and control patients treated with only supportive (conservative) care. Control patients were selected by matching for the amount ingested and time since ingestion. Twenty-two control patients were separately selected from the 42 patients receiving supportive care only. In ILE group, 20% lipid emulsion product was injected intravenously ... for the patients who ingested less than 100 mL of glyphosate. In the patients who ingested more than 100 mL of glyphosate, the loading dose was ... according to the status of the patients, followed by a maintenance dose ... for the next 24 hr. RESULTS: Thirteen patients received high dose of ILE because the ingestion amount was more than 100 ml. None of the ILE group suffered from the complication of hypotension, while approximately 41% of the control group developed the complication. Additionally, arrhythmia was not observed in the ILE group. The incidence of mental change, respiratory failure, and acute kidney injury was similar between the two groups. CONCLUSIONS: ILE administration was associated with lower incidence of hypotension and arrhythmia in patients with acute glyphosate intoxication. ILE administration seems to be an effective treatment modality in patients who ingested sufficient amount of glyphosate herbicide that is expected to bring about significant toxicity.

PMID:23869655
Gil HW et al; Clin Toxicol (Phila) 51 (8): 767-71 (2013)

▸ Hazardous Substances Data Bank (HSDB)

For more Antidote and Emergency Treatment (Complete) data for GLYPHOSATE (11 total), please visit the HSDB record page.

▸ Hazardous Substances Data Bank (HSDB)

14.1.15 Medical Surveillance

Glyphosate serum concentration greater than 1000 mg/L is associated with severe poisoning, although the relevance of this is debated since glyphosate is not thought to induce clinical toxicity itself. It might, however, be a reasonable biomarker of exposure to the product, but more research is required to explore this relationship.

Goldfrank, L.R., Goldfrank's Toxicologic Emergencies 9th Ed. 2011., McGraw-Hill, New York, N.Y., p. 1509

▸ Hazardous Substances Data Bank (HSDB)

14.1.16 Human Toxicity Excerpts

/HUMAN EXPOSURE STUDIES/ A reasonable dose-effect relationship was established ... /The data suggested/ the volume(s) of formulation (concentrate) ingested causing asymptomatic, mild, moderate or severe poisoning in humans to be 17, 58, 128 and 184 mL, respectively. This could be converted to glyphosate concentrations of 87, 298, 658, and 946 mg/kg based on the formulation containing 360 g/L of free glyphosate and a 70-kg body weight.

Klaassen, C.D. (ed). Casarett and Doull's Toxicology. The Basic Science of Poisons. 6th ed. New York, NY: McGraw-Hill, 2001., p. 795

▸ Hazardous Substances Data Bank (HSDB)

/SIGNS AND SYMPTOMS/ Concentrated solutions /of glyphosate/ can cause dermal irritation.

Sullivan, J.B., Krieger G.R. (eds). Clinical Environmental Health and Toxic Exposures. Second edition. Lippincott Williams and Wilkins, Philadelphia, Pennsylvania 1999., p. 190

▸ Hazardous Substances Data Bank (HSDB)

/CASE REPORTS/ INTRODUCTION: Glyphosate-surfactant herbicide (GlySH) is widely used as a non-selective herbicide. Most intoxicated cases are from ingestion, inhalation, and skin exposure. Intramuscular injection of GlySH has never been reported. /This study presents/ a case of GlySH intoxication via intramuscular injection. CASE REPORT: A 42-year-old woman came to the emergency department complaining of painful swelling of left upper limb for 12 hr. She had performed an intramuscular injection of 6 mL of GlySH over the

lateral aspect of the left elbow 15 h previously. Physical examination disclosed painful swelling over left distal arm, elbow, and forearm with three needle punctures. CT scan revealed ill-defined areas of heterogeneous high density with marked swelling at subcutaneous tissue over posterior aspect of the elbow. DISCUSSION: The mechanism of toxicity of GlySH is complicated and surfactant was thought to play an important role in GlySH intoxication. Intramuscular GlySH poisoning is different from oral GlySH intoxication. Care should be taken when monitoring acute rhabdomyolysis and compartment syndrome, which may develop rapidly and contribute to the surfactant component of glyphosate formulation.

PMID:18787996
Weng SF et al; Clin Toxicol (Phila) 46 (9): 890-1 (2008)

Hazardous Substances Data Bank (HSDB)

/CASE REPORTS/ Glyphosate-surfactant (GlySH) is a commonly used herbicide that has been used in attempted suicide. Most reports of GlySH toxicity in patients have followed ingestion of the commercial product "Round-up" (Monsanto Ltd; Melbourne, Victoria, Australia), which consists of a mixture of glyphosate (as a isopropylamine salt) and a surfactant (polyoxyethyleneamine). Ingestion of Round-up is reported to cause significant toxicity including nausea, vomiting, oral and abdominal pain. Renal and hepatic impairment and pulmonary edema may also occur. Impaired consciousness and encephalopathy have been reported as sequelae but there are limited data on the central nervous system (CNS) effects of Round-up toxicity. /In this case/ report a 71-year-old male who attempted suicide with GlySH and developed a prolonged but reversible encephalopathy suggestive of acute CNS toxicity.

PMID:20655231
Malhotra RC et al; J Clin Neurosci 17 (11): 1472-3 (2010)

Hazardous Substances Data Bank (HSDB)

For more Human Toxicity Excerpts (Complete) data for GLYPHOSATE (35 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

14.1.17 Non-Human Toxicity Excerpts

/LABORATORY ANIMALS: Acute Exposure/ A study was undertaken by /researchers/ to investigate the effects of glyphosate, surfactant, and their combination in Roundup on cardiovascular function in female beagles. /The study/ found that glyphosate alone at plasma levels ranging from 923 to 3,450 mg/litre, which simulates the human ingestion situation, were shown to increase the myocardial contractility. The surfactant alone considerably reduced the cardiac output, the left ventricular stroke work index and the mean arterial pressure. The joint effect of both glyphosate and the surfactant in Roundup formulation resulted in cardiac depression, which was mostly due to the surfactant since glyphosate itself increased myocardial contractility. The /results/ indicated that the probable cause of the observed increases in pulmonary vascular resistance index and pulmonary artery pressure was a direct vasoactive effect of glyphosate on the pulmonary artery.

WHO/International Programme on Chemical Safety; Environmental Health Criteria 159, Glyphosate, (1994). Available from, as of November 10, 2014: https://www.inchem.org/pages/ehc.html

Hazardous Substances Data Bank (HSDB)

/LABORATORY ANIMALS: Acute Exposure/ ... Glyphosate did not produce dermal sensitization in guinea pigs.

Krieger, R. (ed.). Handbook of Pesticide Toxicology. Volume 2, 2nd ed. 2001. Academic Press, San Diego, California., p. 1668

Hazardous Substances Data Bank (HSDB)

/LABORATORY ANIMALS: Acute Exposure/ /Glyphosate/ administration to /the/ conjunctival sac of one eye of rabbits /produced/ moderate to severe ocular irritation in all animals. One rabbit died study day 20; not treatment related. Scoring per Draize method at 1, 24, 48, and 72 hours and days 7, 14, and 21 after treatment. Irritation persisted in 4/5 remaining animals at day 21.

European Chemicals Bureau; IUCLID Dataset, Glyphosate (1071-83-6) (2000 CD-ROM edition). Available from, as of January 27, 2006: https://ecb.jrc.it/IUCLID-Data-Sheet/1071836.pdf

Hazardous Substances Data Bank (HSDB)

/LABORATORY ANIMALS: Subchronic or Prechronic Exposure/ Pesticides are the main environmental factor associated with the etiology of human neurodegenerative disorders such as Parkinson's disease. /Research/ has previously demonstrated that the treatment of rats with low doses of dimethoate, zineb or glyphosate alone or in combination induces oxidative stress (OS) in liver and brain. The aim of the present work was to investigate if the pesticide-induced OS was able to affect brain and liver cell survival. The treatment of Wistar rats with the pesticides (i.p. 1/250 LD50, three times a week for 5 weeks) caused loss of mitochondrial transmembrane potential and cardiolipin content, especially in substantia nigra (SN), with a concomitant increase of fatty acid peroxidation. The activation of calpain apoptotic cascade (instead of the caspase-dependent pathway) would be responsible for the DNA fragmentation pattern observed. Thus, these results may contribute to understand the effect(s) of chronic and simultaneous exposure to pesticides on cell survival.

PMID:19493570
Astiz M et al; Ecotoxicol Environ Saf 72 (7): 2025-32 (2009)

Hazardous Substances Data Bank (HSDB)

For more Non-Human Toxicity Excerpts (Complete) data for GLYPHOSATE (54 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

14.1.18 Non-Human Toxicity Values

LD50 Rabbit percutaneous >5000 mg/kg

Tomlin CDS, ed. Glyphosate (1071-83-6). In: The e-Pesticide Manual, 13th Edition Version 3.2 (2005-06). Surrey UK, British Crop Protection Council.

Hazardous Substances Data Bank (HSDB)

LC50 Rat inhalation >4.98 mg/L air/4 hr

Tomlin CDS, ed. Glyphosate (1071-83-6). In: The e-Pesticide Manual, 13th Edition Version 3.2 (2005-06). Surrey UK, British Crop Protection Council.

Hazardous Substances Data Bank (HSDB)

LD50 Goat oral 3530 mg/kg

Tomlin CDS, ed. Glyphosate (1071-83-6). In: The e-Pesticide Manual, 13th Edition Version 3.2 (2005-06). Surrey UK, British Crop Protection Council.

Hazardous Substances Data Bank (HSDB)

LD50 Mouse oral 1568 mg/kg

O'Neil, M.J. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Cambridge, UK: Royal Society of Chemistry, 2013., p. 834

Hazardous Substances Data Bank (HSDB)

For more Non-Human Toxicity Values (Complete) data for GLYPHOSATE (8 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

14.1.19 Ecotoxicity Values

LC50; Species: /Oncorhynchus mykiss/ (Rainbow trout) weight 0.8 g; Conditions: static bioassay without aeration, 12 °C, pH 7.2-7.5, water hardness 40-50 mg/L as calcium carbonate and alkalinity of 30-35 mg/L Concentration: 130 mg/L for 96 hr (95% confidence interval: 108-156 mg/L) /Technical material, 96.7%/

U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government Printing Office, 1980., p. 43

Hazardous Substances Data Bank (HSDB)

LC50; Species: Pimephales promelas (Fathead minnow) weight 0.6 g; Conditions: static bioassay without aeration, 20 °C, pH 7.2-7.5, water hardness 40-50 mg/L as calcium carbonate and alkalinity of 30-35 mg/L; Concentration: 97 mg/L for 96 hr (95% confidence interval: 79-120 mg/L) /Technical material, 96.7%/

U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government Printing Office, 1980., p. 43

Hazardous Substances Data Bank (HSDB)

LC50; Species: Ictalurus punctatus (Channel catfish) weight 2.2 g; Conditions: static bioassay without aeration, 22 °C, pH 7.2-7.5, water hardness 40-50 mg/L as calcium carbonate and alkalinity of 30-35 mg/L; Concentration: 130 mg/L for 96 hr (95% confidence interval: 108-156 mg/L) /Technical material, 96.7%/

U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government Printing Office, 1980., p. 43

Hazardous Substances Data Bank (HSDB)

LC50; Species: Lepomis macrochirus (Bluegill) weight 0.9 g; Conditions: static bioassay without aeration, 22 °C, pH 7.2-7.5, water hardness 40-50 mg/L as calcium carbonate and alkalinity of 30-35 mg/L; Concentration: 135 mg/L for 96 hr (95% confidence interval 113-162 mg/L) /Technical material, 96.7%/

U.S. Department of Interior, Fish and Wildlife Service. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. Resource Publication No. 137. Washington, DC: U.S. Government Printing Office, 1980., p. 43

Hazardous Substances Data Bank (HSDB)

For more Ecotoxicity Values (Complete) data for GLYPHOSATE (50 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

14.1.20 Ecotoxicity Excerpts

/BIRDS and MAMMALS/ Male marsupials (Sminthopsis macroura) showed significant body weight loss after exposure to feed contaminated with concentrations of up to 5000 mg a.i/kg feed. No other treatment-related effects were found in the male marsupials.

WHO/International Programme on Chemical Safety; Environmental Health Criteria 159, Glyphosate, (1994). Available from, as of November 10, 2014: https://www.inchem.org/pages/ehc.html

Hazardous Substances Data Bank (HSDB)

/BIRDS and MAMMALS/ No subchronic toxicity or effects on reproduction were noted when glyphosate technical was fed to Bobwhite quail for 22 weeks at dose levels up to 1000 ppm. Several deaths occurred during the course of the study, but these did not follow a dose related trend and were not considered related to treatment. There were no treatment-related effects on behavior, body weight or food consumption of adult birds. The numbers of eggs laid, eggs cracked, viable embryos, live 3-week embryos, normal hatchlings, and 14-day survivors, as well as egg shell thickness hatchling body weight and 14-day hatchling body weight were unaffected by treatment with glyphosate. A statistically significant reduction in egg weight occurred at 1000 ppm. However, no effect was noted in the reproductive success of adults, chick body weight gain or survivability at this dose level. Therefore, the reduced egg weight was not considered toxicologically significant.

European Chemicals Bureau; IUCLID Dataset, Glyphosate (1071-83-6) (2000 CD-ROM edition). Available from, as of January 27, 2006: https://ecb.jrc.it/IUCLID-Data-Sheet/1071836.pdf

Hazardous Substances Data Bank (HSDB)

/BIRDS and MAMMALS/ Five zebra finches, Poephila guttata (Gould), allowed unrestricted access to seed containing 5,000 ug glyphosate/g all died in 3 to 7 days, but they may well have died from starvation since their food consumption was drastically reduced. Six finches survived after ingesting seed containing 2,500 ug glyphosate/g for 5 days. The marsupial Sminthopsis macroura (Gould), and two species of hopping-mouse, Notomys alexis Thomas and Notomys mitchelli (Ogilby) (N = 5 controls and 5 treated, for each species) survived on a diet in which the concentration of glyphosate was increased from 625 ug/g to 5,000 ug/g by doubling the concentration of glyphosate in the food every few days during a 23-day period. The only toxic effect observed in the mammals was a marked body weight loss in the treated N. alexis. The data indicate that glyphosate for these four species is in the probably not toxic to slightly toxic category for rating the relative acute toxicity of chemicals.

Evans DD, Batty MJ; Environ Toxicol Chem 5 (4): 399-401 (1986)

Hazardous Substances Data Bank (HSDB)

/AQUATIC SPECIES/ The spraying of coca (Erythroxylum coca) with glyphosate in Colombia has raised concerns about possible impacts on amphibians. There are few toxicity data for species other than those from temperate regions, and these have not been generated with the combination of formulated glyphosate (Glyphos) and the adjuvant, Cosmo-Flux (coca mix) as used in coca control in Colombia. In order to characterize toxicity of the spray mixture to frogs from Colombia, Gosner stage-25 tadpoles of Scinax ruber, Dendropophus microcephalus, Hypsiboas crepitans, Rhinella granulosa, Rhinella marina, Rhinella typhonius, Centrolene prosoblepon, and Engystomops pustulosus were exposed to the coca mix at concentrations of glyphosate ranging from 1 to 4.2 mg a.e./L diluted in dechlorinated tap water in glass containers. Cosmo-Flux was added to Glyphos in the proportion of 2.3% v/v, as used in aerial application for coca control. Exposures were for 96 hr at 23 +/- 1.5 degrees C with 12:12-hr light/dark cycle. Test solutions were renewed every 24 hr. Concentrations, measured within the first hour and at 24 and 96 hr using enzyme-linked immunosorbent assay (ELISA) (Abraxis, LLC), ranged from 70 to 130% of nominal values. LC50 values ranged from 1200 to 2780 ug glyphosate acid equivalents (a.e.)/L for the 8 species tested. Data suggest that sensitivity to Roundup-type formulations of glyphosate in these species is similar to that observed in other tropical and temperate species. In addition, sensitivity of larval amphibians to Roundup-type formulations spans a relatively narrow range. Finally, toxicity of the mixture as used to spray coca was likely driven by the surfactant in the glyphosate formulation, as the addition of Cosmo-Flux did not enhance toxicity above those reported for Vision = Roundup. /Formulation/

PMID:19672764
Bernal MH et al; J Toxicol Environ Health 72 (15-16): 961-5 (2009)

Hazardous Substances Data Bank (HSDB)

For more Ecotoxicity Excerpts (Complete) data for GLYPHOSATE (43 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

14.1.21 Ongoing Test Status

The following link will take the user to the National Toxicology Program (NTP) Test Agent Search Results page, which tabulates all of the "Standard Toxicology & Carcinogenesis Studies", "Developmental Studies", and "Genetic Toxicity Studies" performed with this chemical. Clicking on the "Testing Status" link will take the user to the status (i.e., in review,

in progress, in preparation, on test, completed, etc.) and results of all the studies that the NTP has done on this chemical.[Available from, as of October 1, 2014: http://ntp-apps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=ntpsearch.searchresults&searchterm=1071-83-6]

Hazardous Substances Data Bank (HSDB)

14.1.22 National Toxicology Program Studies

... B6C3F1 mice were administered 3125, 6250, 12,500, 25,000, or 50,000 ppm glyphosate in their diet for 13 weeks. ... Glyphosate mutagenicity was evaluated in the Ames/Salmonella assay with or without S9 metabolic activation and by the mouse peripheral blood micronucleus test. ... Glyphosate was not mutagenic.

NTP; Toxicology and Carcinogenesis Studies of Glyphosate p.55 Report #16 (1992) NIH Pub #92-3135

Hazardous Substances Data Bank (HSDB)

The salivary gland lesions could also be induced in rats by 14-day exposure at feed levels of 50 000 mg/kg diet. The salivary glands lesions induced by glyphosate were similar to those which could be induced by exposure to high subcutaneous doses of the /nonselective/ beta-adrenergic agonist isoproterenol and could be partially ameliorated with the beta-adrenergic antagonist propanolol. This indicates that glyphosate may induce the salivary gland lesions by acting as a weak adrenergic agonist.

DHHS/NTP; Toxicology and Carcinogenesis Studies of Glyphosate p.55 (1992). Technical Report #16. NIH Pub #92-3135. Available from, as of November 10, 2014: https://ntp-server.niehs.nih.gov

Hazardous Substances Data Bank (HSDB)

Ten F344/N rats and B6C3F1 mice were administered 3125, 6250, 12,500, 25,000, or 50,000 ppm glyphosate in their diet for 13 weeks. Surviving animals were killed at the end of the study and necropsied. Blood samples were collected from the rats at necropsy to determine hematological and serum chemistry parameters. ... All rats survived until the end of the study. Glyphosate doses of 12,500 ppm or higher caused slight increases in hematocrit and hemoglobin. Serum bile acid concentrations and alkaline phosphatase and alanine aminotransferase activities were significantly increased. One mouse treated with 50,000 ppm died. The major pathological change induced by glyphosate was a dose related increase in basophilic changes and hypertrophy of acinar cells (cytoplasmic alterations) in the parotid and submandibular salivary glands of rats and the parotid salivary glands in mice. All doses caused these changes in rats. In mice, doses of 6250 ppm or higher caused these effects. No histopathological changes were seen in the liver...

DHHS/NTP; Toxicology and Carcinogenesis Studies of Glyphosate p.55 (1992). Technical Report #16. NIH Pub #92-3135. Available from, as of November 10, 2014: https://ntp-server.niehs.nih.gov

Hazardous Substances Data Bank (HSDB)

14.2 Ecological Information

14.2.1 EPA Ecotoxicity

Pesticide Ecotoxicity Data from EPA

EPA Pesticide Ecotoxicity Database

14.2.2 US EPA Regional Screening Levels for Chemical Contaminants

Resident Soil (mg/kg)	6.30e+02
Industrial Soil (mg/kg)	8.20e+03
Tapwater (ug/L)	2.00e+02
MCL (ug/L)	7.00e+02
Risk-based SSL (mg/kg)	8.80e-01
MCL-based SSL (mg/kg)	3.10e+00
Chronic Oral Reference Dose (mg/kg-day)	1.00e-01
Fraction of Contaminant Absorbed in Gastrointestinal Tract	1
Fraction of Contaminant Absorbed Dermally from Soil	0.1

EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites

14.2.3 US EPA Regional Removal Management Levels for Chemical Contaminants

Resident Soil (mg/kg)	1.90e+04
Industrial Soil (mg/kg)	2.50e+05
Tapwater (ug/L)	6.00e+03
MCL (ug/L)	7.00e+02
Chronic Oral Reference Dose (mg/kg-day)	1.00e-01
Fraction of Contaminant Absorbed in	1

Gastrointestinal Tract	
Fraction of Contaminant Absorbed Dermally from Soil	0.1

EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites

14.2.4 ICSC Environmental Data

The substance is toxic to aquatic organisms. This substance does enter the environment under normal use. Great care, however, should be taken to avoid any additional release, for example through inappropriate disposal.

ILO International Chemical Safety Cards (ICSC)

14.2.5 Environmental Fate/Exposure Summary

Glyphosate's production may result in its release to the environment through various waste streams; its use as a herbicide will result in its direct release to the environment. If released to air, a vapor pressure of 9.8X10-8 mm Hg at 25 °C indicates glyphosate will exist solely in the particulate phase in the atmosphere. Particulate-phase glyphosate will be removed from the atmosphere by wet and dry deposition. Glyphosate does not degrade by direct photolysis. If released to soil, glyphosate is expected to have slight mobility based upon a Koc range of 2,600 to 4,900. The pKa values of glyphosate are 2.0, 2.6, 5.6 and 10.6, indicating that this compound will exist almost entirely in the zwitterion form in the environment and zwitterions generally adsorb more strongly to soils containing organic carbon and clay than their neutral counterparts. Volatilization from moist soil is not expected because the compound exists as an ion and ions do not volatilize. Glyphosate is not expected to volatilize from dry soil surfaces based upon its vapor pressure. Biodegradation half-lives in soil of 1.85 to 7 days under aerobic conditions indicate that biodegrdation is an important environmental fate process in soil. If released into water, glyphosate is expected to adsorb to suspended solids and sediment based upon the Koc range. The aerobic and anaerobic biodegradation half-life of glyphosate in a flooded silty clay loam sediment was 7 and 8.1 days, respectively, suggesting that biodegradation is an important environmental fate process in sediment. Biodegradation data in water were not available. Volatilization from water surfaces is not expected to be an important fate process because glyphosate exists as a zwitterion in water and ionic species do not volatilize. A BCF of 0.52 suggests bioconcentration in aquatic organisms is low. Glyphosate is stable to hydrolysis at pH 5, 7, and 9 at temperatures ranging from 5 to 35 °C. Occupational exposure to glyphosate may occur through inhalation and dermal contact with this compound at workplaces where glyphosate is produced or used. Monitoring data indicate that the general population may be exposed to glyphosate via ingestion of drinking water and dermal contact with consumer products containing glyphosate. The greatest potential for dermal and inhalation exposure to glyphosate is expected for pesticide applicators, farm workers, and members of the general population that have frequent contact with products containing glyphosate for commercial farming or home use. (SRC)

Hazardous Substances Data Bank (HSDB)

14.2.6 Artificial Pollution Sources

Glyphosate's production may result in its release to the environment through various waste streams; it's use as a broad spectrum non-selective, post-emergent herbicide(1) will result in its direct release to the environment(SRC).

(1) MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

Hazardous Substances Data Bank (HSDB)

14.2.7 Environmental Fate

TERRESTRIAL FATE: Based on a classification scheme(1), Koc values of 2,600 to 4,900(2), indicate that glyphosate is expected to have slight mobility in soil(SRC). Volatilization of glyphosate from moist soil surfaces is not expected to be an important fate process because it exists in zwitterionic form in the environment and ionic compounds do not volatilize(3). Glyphosate is not expected to volatilize from dry soil surfaces based on a vapor pressure of 9.8X10-8 mm Hg(4). Biodegradation half-lives in soil of 1.85 to 7 days under aerobic conditions(5), indicate that biodegrdation is an important environmental fate process in soil(SRC).

(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Glass RL; J Agric Food Chem 35: 497-500 (1987) (3) Spankle P; Weed Sci 23: 224-8 (1975) (4) MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010) (5) USEPA; Reregistration Eligibility Decision (RED) Glyphosate EPA 738-R-93-014. September 1993. Available from, as of Sept 4, 2014: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

TERRESTRIAL FATE: The median dissipation half-time (DT50) of glyphosate applied at 7.95 to 10.7 lbs ai/A to 8 bare ground fields in different locations of the US was 13.9 days. The shortest DT50 was observed in Texas (2.6 days), and the longest values from the field studies were in the coldest climates, Minnesota, New York and Iowa, at 28.7, 127.8 and 140.6 days respectively. These data indicate that glyphosate residues in the field are somewhat more persistent in cooler climates as opposed to milder ones(1).

(1) USEPA; Reregistration Eligibility Decision (RED) Glyphosate EPA 738-R-93-014. September 1993. Available from, as of Sept 4, 2014: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

TERRESTRIAL FATE: After glyphosate is applied to forests, fields, and other land by spraying, its mobility in soil is limited and is affected by pH and phosphate levels, as well as by soil type(3). In addition to binding to organic matter and clay in soil, it may also form insoluble complexes with metal ions in the soil. Distribution data for glyphosate after spraying in a coastal forest ecosystem indicate that glyphosate is strongly adsorbed to the upper layers of soil and has a low propensity for leaching(2). Glyphosate residues dissipated with a half-life of 45-60 days. After 360 days, residues levels were 6-18% of initial levels(2). Field studies on eleven different soils covering a full range of soil types and geographical areas indicates an avg half-life of 60 days for glyphosate in soil(4). Other sources also report an avg half-life of 60 days from literature surveys(1,5).

(1) Neary DG et al; Environ Toxicol Chem 12: 411-28 (1993) (2) Feng JC, Thompson; J Agric Food Chem 38: 1118-25 (1990) (3) Spankle P; Weed Sci 23: 224-8 (1975) (4) Rueppel ML et al J Agric Food Chem 25: 517-28 (1977) (5) Reinert KH, Rodgers JH; Rev Environ Contam Toxicol 98: 61-98 (1987)

Hazardous Substances Data Bank (HSDB)

TERRESTRIAL FATE: The half-life of glyphosate applied to forest foliage was 14.4 days(1) and that applied to two Finnish agricultural fields were 69 and 127 days, respectively(2). Persistence studies with glyphosate in sandy test sites in a boreal forest in Ontario, Canada indicate that the half-life of glyphosate was 24 days and residues were reduced to <10% of that applied after 78 days(3). More than 95% of residues were found in the upper organic layer of soil. In aerially treated forest brush fields in the Oregon coast range, the half-life of glyphosate ranged from 10.4-26.6 days in foliage and litter. The half-life of glyphosate on exposed soil and litter-covered soil was 40.2 and 29.2 days, respectively(4).

(1) Willis GH, McDowell LL; Rev Environ Contam Toxicol 100: 23-73 (1987) (2) Muller MM et al; Bull Environ Contam Toxicol 27: 724-30 (1981) (3) Roy DN et al; J Agric Food Chem 37: 437-40 (1989) (4) Newton M et al; J Agric Food Chem 32: 1144-51 (1984)

Hazardous Substances Data Bank (HSDB)

For more Environmental Fate (Complete) data for GLYPHOSATE (9 total), please visit the HSDB record page.

Hazardous Substances Data Bank (HSDB)

14.2.8 Environmental Biodegradation

AEROBIC: When glyphosate was incubated in Williams silt loam soil (pH 6.4, 1.9% organic matter), 19% degradation occurred in 9 days. No degradation was noted in sterilized soil(1). In shake-flask metabolism studies, glyphosate was rapidly and completely biodegraded in the presence of soil microorganisms under both aerobic and anaerobic conditions(2). After 28 days under aerobic conditions, 45-55% of the glyphosate was mineralized using Ray silt loam soil, Lintonia sandy loam soil, and Drummer silty clay loam soil. Norfolk sandy loam mineralized glyphosate at a much slower, but still significant, rate. In greenhouse experiments, the half-lives of glyphosate in Ray, Drummer and Norfolk soil was 3, 27, and 130 days, respectively(2). The biodegradation half-life of glyphosate in a Kickapoo sandy loam and Dupo silt loam soil were 1.85 and 2.06 days, respectively, under aerobic conditions. The major degradation product observed was aminomethyl phosphonic acid. The aerobic and anaerobic biodegradation half-life of glyphosate in a flooded silty clay loam sediment was 7 and 8.1 days, respectively(3).

(1) Tate RL, Alexander M; Soil Sci 118: 317-21 (1974) (2) Rueppel ML et al; J Agric Food Chem 25: 517-28 (1977) (3) USEPA; Reregistration Eligibility Decision (RED) Glyphosate EPA 738-R-93-014. September 1993. Available from, as of Sept 4, 2014: https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

AEROBIC: In experiments in which C14-glyphosate was incubated with several soils, 17.4 to 45.5% of the glyphosate was released as CO2 in 28 days(2). CO2 release did not occur in sterilized soil. The addition of phosphate, which competes with glyphosate for soil binding sites, increased the rate of CO2 release, although both bound and free glyphosate were degraded(2). The pattern of biodegradation suggests that glyphosate does not support microbial growth, but is co-metabolized(2). Glyphosate's only significant metabolite is aminomethylphosphonic acid (AMPA), which also rapidly degrades in soil(1,3). When radiolabeled glyphosate was incubated in three Saskatchewan soils, 50% of the herbicide was mineralized in 30-40 days; the half-life of glyphosate, itself, would be shorter(4). After 90 days when 69-75% of radioactivity had been released, 7-16% of the activity was in a solvent-extractable fraction and 7-14% was in a non-extractable fraction.

(1) Feng JC, Thompson; J Agric Food Chem 38: 1118-25 (1990) (2) Spankle P; Weed Sci 23: 224-8 (1975) (3) Rueppel ML et al J Agric Food Chem 25: 517-28 (1977) (4) Smith AE, Aubin AJ; Bull Environ Contam Toxicol 50: 499-505 (1993)

Hazardous Substances Data Bank (HSDB)

AEROBIC: Glyphosate was 97.3% removed in 30 days using an activated sludge inoculum from a winemaking biological treatment plant (biological treatment and sand filter)(1).

(1) Massot A et al; Water Res 46(6): 1785-1792 (2012)

Hazardous Substances Data Bank (HSDB)

ANAEROBIC: Under anaerobic conditions, 37.3% of glyphosate incubated with Ray silt loam soil was released as CO2(1). The anaerobic biodegradation half-life of glyphosate in a flooded silty clay loam sediment was 8.1 days(2). A half-life of 30.5 days (dissipation rate of 0.032/day) was measured using glyphosate at 10 mg/kg filter substrate in a sediment sample of 450 g wet material under redox conditions to simulate slowly flowing groundwater; loss could not be entirely attributed to biodegradation(3).

(1) Rueppel ML et al J Agric Food Chem 25: 517-28 (1977) (2) USEPA; Reregistration Eligibility Decision (RED) Glyphosate EPA 738-R-93-014. September 1993. Available from, as of Sept 4, 2014: (3) Litz NT et al; Water Res 45(10): 3047-3054 (2011) https://www.epa.gov/pesticides/reregistration/status.htm

Hazardous Substances Data Bank (HSDB)

14.2.9 Environmental Abiotic Degradation

Glyphosate is zwitterionic with pKa values of 2.3, 5.7 and 10.2(1,2). In the environmental pH range, 5 to 9, glyphosate has a net negative charge that increases with pH. The nitrogen atom is positively charged and both the carboxylic acid group and phosphonic acid group are deprotonated; above pH 5.6 the latter is predominantly doubly ionized and below pH 5.6 it is singly ionized(1). Glyphosate has three groups (amine, carboxylate and phosphonate) that may coordinate strongly as tridentate or tetradentate ligands with transition metal and alkaline earth ions(3). It has been demonstrated that insoluble complexes are formed between glyphosate and ferric, cupric, calcium, and magnesium ions at near neutral pH. Ferrous salts are oxidized to the ferric salt yielding the ferric-glyphosate complex. Since groundwater may contain high concentrations of iron, calcium, and magnesium, glyphosate would form insoluble complexes with these ions and precipitate out. A similar fate would occur to glyphosate in soil and some surface waters.

(1) Spankle P; Weed Sci 23: 224-8 (1975) (2) MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)(3) Subramaniam V, Hoggaard PE; J Agric Food Chem 36: 1326-9 (1988)

Hazardous Substances Data Bank (HSDB)

Glyphosate is stable to hydrolysis at pH 5, 7, and 9 at temperatures ranging from 5 to 35 °C(1). Experiments using sterile controls indicate that glyphosate does not chemically degrade in soil(2). Glyphosate photodegrades when exposed to UV radiation, but not visible light(3). The photolytic half-life of glyphosate in deionized water exposed outdoors to sunlight was approximately 5 wk at 100 ppm and 3 wk at 2000 ppm(3). The degradation product was aminomethylphosphonic acid. In contrast, no degradation occurred when exposed to light equivalent of 16 eight hour days of sunlight in a photoreactor(2). Another source reports that negligible losses of glyphosate on soil occur as a result of photodegradation(4).

(1) MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010) (2) Rueppel ML et al J Agric Food Chem 25: 517-28 (1977) (3) Lund-Hoie K, Friestad HO; Bull Environ Contam Toxicol 36: 723-9 (1986) (4) WSSA; Herbicide Handbook 7th ed.; Champaign, IL: Weed Sci Soc Amer pp. 149-151 (1994)

Hazardous Substances Data Bank (HSDB)

14.2.10 Environmental Bioconcentration

In controlled laboratory studies using glyphosate at levels 3 to 4 times the recommended application rates, BCF values in fish tissue 10-14 days post application ranged from 0.2 to 0.3(1). A BCF value of 0.52 (whole body) was measured in bluegill (Lepomis macrochirus) exposed for 28 days(2). BCF values of 0.38 for edible tissues and 0.63 for non-edible tissues have been reported(3). According to a classification scheme(4), these BCF data suggest that bioconcentration in aquatic organisms is low(SRC).

(1) Reinert KH, Rodgers JH; Rev Environ Contam Toxicol 98: 61-98 (1987) (2) Jackson SH; J Agric Food Chem 57: 958-67 (2009) (3) USEPA; Reregistration Eligibility Decision (RED) Glyphosate EPA 738-R-93-014. September 1993. Available from, as of Sept 4, 2014: https://www.epa.gov/pesticides/reregistration/status.htm (4) Franke C et al; Chemosphere 29: 1501-14 (1994)

Hazardous Substances Data Bank (HSDB)

14.2.11 Soil Adsorption/Mobility

Soil Adsorption Coefficient

2.09e+03 L/kg

EPA DSSTox

When applied to clay loam or muck soil at an application rate of 56 kg/ha, glyphosate was rapidly inactivated. This inactivation was probably the result of reversible adsorption to clay and organic matter. Iron and aluminum clays and organic matter adsorbed more glyphosate than sodium and calcium clays and was readily bound to kaolinite, illite, bentonite, charcoal and muck but not to ethyl cellulose. (14)C-Labeled glyphosate was degraded in soil and (14)CO2 was released.

Menzie, C.M. Metabolism of Pesticides, Update II. U.S. Department of the Interior, Fish Wildlife Service, Special Scientific Report - Wildlife No. 2I2. Washington, DC: U.S. Government Printing Office, 1978., p. 146

Hazardous Substances Data Bank (HSDB)

The Koc values for Houston clay loam (pH 7.5, OC 1.56%), Muskingum silt loam (pH 5.8, OC 1.64%), and Sassafras sandy loam (pH 5.6, OC 1.24%) were 4900, 3400, and 2600, respectively(1). According to a suggested classification scheme(2), these Koc values indicates that glyphosate is expected to have slight mobility in soil(SRC). Glyphosate exists in zwitterion form in the environment and interactions with soil and sediment are primarily ionic, rather than hydrophobic(3). Soil factors such as clay mineral type and content, organic matter content, soil pH, and cation exchange capacity have major effects on adsorption. It has been shown that adsorption of glyphosate on variable-charge, volcanic ash-derived

soils in Chile strongly increased when pH decreased(4). The Freundlich soil adsorption coefficient (Kf) Houston clay loam, Muskingum silt loam, and Sassafras sandy loam were 76, 56, and 33, respectively. The adsorptivity correlated with clay content, cation exchange capacity (CEC) and pH(1). Decreasing adsorption to five clays with increasing pH is due to decreased interaction as the clay surface and glyphosate become more negatively charged(5). Another investigator found that the extractability of glyphosate from soil and various clay minerals increased with pH, but the degree of adsorption did not correlate with CEC or surface area of the sorbent, indicating that adsorption to clays was via a specific sorption mechanism, rather than a general one and that the mechanism is H-bonding and ion exchange(6).

(1) Glass RL; J Agric Food Chem 35: 497-500 (1987) (2) Swann RL et al; Res Rev 85: 23 (1983) (3) Reinert KH; pp. 335-48 in Reactions & Movement of Organic Chemicals in Soils. Soil Sci Soc Amer Spec Publ.22 (1989) (4) Caceres-Jensen L et al; J Environ Qual 38: 1449-1457 (2009) (5) McConnell JS, Hossner LR; J Agric Food Chem 33: 1075-8 (1985) (6) Miles CJ, Moye HA; J Agric Food Chem 36: 486-91 (1988)

Hazardous Substances Data Bank (HSDB)

In soil column studies, no glyphosate was detected in leachate after elution with water for 45 days. It is adsorbed at positively charged sites in clay minerals and other soil components. Laboratory and field studies indicate that glyphosate is strongly and reversibly adsorbed by soil, sediment and suspended sediment(1). The Freundlich adsorption coefficient (Kf) for 9 soils ranged from 18 to 377, while that to suspended solids from Australian waters ranged from 1260 to 2080(1). Glyphosate was strongly adsorbed to Drummer silty clay loam, Norfolk sandy loam, and Ray silt loam soil in soil thin layer chromatography experiments and would, therefore, possess no propensity for leaching(2).

(1) Reinert KH; pp. 335-48 in Reactions & Movement of Organic Chemicals in Soils. Soil Sci Soc Amer Spec Publ.22 (1989) (2) Rueppel ML et al; J Agric Food Chem 25: 517-28 (1977)

Hazardous Substances Data Bank (HSDB)

When released to soils, glyphosate has been shown to compete with phosphate for binding sites, suggesting that adsorption may occur through the phosphonic acid moiety(1). Analysis of soil core samples from a coastal forest watershed in British Columbia that had been sprayed with glyphosate indicated that >90% of glyphosate residues were found in the 0-15 cm organic soil layer both in seasonally flooded and well drained sites(2). Using sand filters, glyphosate yielded a Kf of 1.9, possibly due to the low organic matter content and low iron and aluminum oxide content(3).

(1) Spankle P; Weed Sci 23: 224-8 (1975) (2) Feng JC, Thompson DG; J Agric Food Chem 38: 1118-25 (1990) (3) Litz NT et al; Water Res 45(10): 3047-3054 (2011)

Hazardous Substances Data Bank (HSDB)

14.2.12 Volatilization from Water/Soil

Glyphosate is a multi-protic chemical which exists as a zwitterion in the environment(1). Volatilization from water and moist soils will not be an important environmental fate process since ionic species do not volatilize(SRC). Volatilization from dry soil surfaces is not expected to be important based on a vapor pressure of 9.8X10-8 mm Hg at 25 °C(2).

(1) Spankle P; Weed Sci 23: 224-8 (1975) (2) MacBean C, ed; e-Pesticide Manual. 15th ed., ver. 5.1, Alton, UK: British Crop Protection Council. Glyphosate (1071-83-6) (2008-2010)

Hazardous Substances Data Bank (HSDB)

14.2.13 Environmental Water Concentrations

GROUNDWATER: Glyphosate was detected in groundwater and water supply monitoring programs in Texas(1). The concentration and site details were not reported(2). In a survey of farm wells in Ontario, Canada, 103 in 1986 and 76 in 1987, glyphosate was not detected in any wells(2). However, glyphosate was only used on crops on 28 farms in 1986 and 1987(2). As a result of a comprehensive survey of the United States, encompassing 3,732 environmental samples collected between 2001 and 2010 from 38 states, glyphosate and/or aminomethylphosphonic acid were detected in 8.4% of 820 groundwater sites. Concentrations have increased from the 2001-2005 sturdy results to the 2006-2010 study results(3).

(1) Hallberg GR; Agr Ecossys Environ 26: 299-367 (1989) (2) Frank R et al; Bull Environ Contam Toxicol 44: 410-9 (1990) (3) USGS; Common Weed Killer is Widespread in the Environment. Available from, as of Sept 4, 2014: https://toxics.usgs.gov/highlights/glyphosate_2014.html

Hazardous Substances Data Bank (HSDB)

DRINKING WATER: Glyphosate was detected at very low concentrations in 27 of 289 water supply wells in Zealand, Denmark. The detection limit = 0.01 ug/L(1). Glyphosate was detected at a range of 0.1 to 2 ug/L (max 5 ug/L) in the River Havel, a potential drinking water source, Berlin Germany(2).

(1) Malaguerra F et al; Sci Total Environ 414: 433-444 (2012) (2) Litz NT et al; Water Res 45(10): 3047-3054 (2011)

Hazardous Substances Data Bank (HSDB)

SURFACE WATER: Glyphosate was detected in 54 of 154 water samples analyzed by the US Geological Survey in a 2002 study focused on nine US midwestern states. The highest concentration was 8.7 mg/L; glyphosate degradation product aminomethylphosphonic acid was present in 69% of the samples(1). As a result of a comprehensive survey of the United States, encompassing 3,732 environmental samples collected between 2001 and 2010 from 38 states, glyphosate and/or aminomethylphosphonic acid were detected in 59% of 470 surface water sites sites. Glyphosate was detected in water samples from ditches and drains, large rivers and streams. Concentrations have increased from the 2001-2005 sturdy results to the 2006-2010 study results(2).

(1) USGS; Glyphosate Herbicide Found in Many Midwestern Streams, Antibiotics No Common. Available from, as of Sept 9, 2014: https://toxics.usgs.gov/highlights/glyphosate02.html (2) USGS; Common Weed Killer is Widespread in the Environment. Available from, as of Sept 4, 2014: h ttp://toxics.usgs.gov/highlights/glyphosate_2014.html

Hazardous Substances Data Bank (HSDB)

SURFACE WATER: Glyphosate was detected in 1 out of 45 surface water samples at golf course in the US at 8.2 ug/L(1). Glyphosate was detected in 1 out of 6 ponds at a concentration of 42 ug/L in Ontario, Canada(2). Glyphosate was detected in surface water of the Wuchuan River, China at levels of 0.67-1.39 ng/L(3). Glyphosate concentration was below the detection limit to 1.3, below the detection limit to 3.6 and below the detection limit to 7.60 ug/L in water samples from streams in a farming region of the Province of Buenos Aires, Argentina, collected in April, August and September, 2012, respectively(4). Dry weather concentrations in the Boele River and Orge River, France ranged from 0.138 to 1.082 and not detected to 0.196 ug/L, respectively, in 2007 through 2008. Wet weather concentrations were not detected to <0.1 and not detected to <0.1, respectively(5). The mean concentration of glyphosate was 15.2 ug/L in surface waters of 30 different river, small streams and low flow wetlands from Southern Ontario sampled in 2004 and 2005(6).

(1) Cohen S et al; J Environ Qual 28: 798-809 (1999) (2) Frank R et al; Bull Environ Contam Toxicol 44: 410-419 (1990) (3) Zhang ZL et al; J Environ Monit 4: 498-504 (2002) (4) Aparicio VC et al; Chemosphere 93(9): 1866-1873 (2013) (5) Botta F et al; Chemosphere 77: 133-139 (2009) (6) Struger J et al; Bull Environ Contam Toxicol 80: 378-384 (2008)

Hazardous Substances Data Bank (HSDB)

RAIN/SNOW: As a result of a comprehensive survey of the United States, encompassing 3,732 environmental samples collected between 2001 and 2010 from 38 states, glyphosate was detected in precipitation. Concentrations have increased from the 2001-2005 sturdy results to the 2006-2010 study results(1).

(1) USGS; Common Weed Killer is Widespread in the Environment. Available from, as of Sept 4, 2014: https://toxics.usgs.gov/highlights/glyphosate_2014.html

Hazardous Substances Data Bank (HSDB)

14.2.14 Effluent Concentrations

Glyphosate was detected in runoff water along a California highway at an average concentration of 2.69 ug/L (1.36 to 9.44 ug/L range) from November 29, 2000 to January 26, 2001(1).

PMID:15260322

(1) Huang X et al; Environ Sci Technol 38: 3263-3271 (2004)

Hazardous Substances Data Bank (HSDB)

14.2.15 Sediment/Soil Concentrations

SOIL: The concentration of glyphosate on barley fields, two days after application in September, 58 days post treatment, and 7 months posttreatment were 1.6 ppm, 0.5, and 0.2 ppm(1). The corresponding levels of its main metabolite, aminomethylphosphonic acid were 0.2, 0.14, and 0.1 ppm(1). It was detected in soil samples collected near the Wuchuan River, China at levels of 0.03 to 0.73 ng/g(2). Glyphosate and its principal metabolite are present at 35 to 1,502 and 299 to 2,256 ug/kg, respectively, in soils of the farming region of the Province of Buenos Aires, Argentina(3).

(1) Heinonen-Tanski H et al; Pestic Sci 16: 341-8 (1985) (2) Zhang ZL et al; J Environ Monit 4: 498-504 (2002) (3) Aparicio VC et al; Chemosphere 93(9): 1866-1873 (2013)

Hazardous Substances Data Bank (HSDB)

SEDIMENT: Glyphosate was detected in sediment of the Wuchuan River, China at levels of 0.02 to 0.12 ng/g(1). As a result of a comprehensive survey of the United States, encompassing 3,732 environmental samples collected between 2001 and 2010 from 38 states, the following trends were noted: Glyphosate and/or aminomethylphosphonic acid were detected in 59% of 470 surface water sites and 8.4% of 820 groundwater sites Glyphosate was detected in more than 50% of soil and sediment samples as well as water samples from ditches and drains, precipitation, large rivers and streams Concentrations have increased from the 2001-2005 sturdy results to the 2006-2010 study results(2). Glyphosate concentration was less than the detection limit to 125.7, less than the detection limit to 298.4, and less than the detection limit to 94.80 uk/kg in suspended particulate matter samples from streams in a farming region of the Province of Buenos Aires, Argentina, collected in April, August and September, 2012, respectively. The concentration in sediment ranged from below the detection limit to 98.9 ug/kg(3).

(1) Zhang ZL et al; J Environ Monit 4: 498-504 (2002) (2) USGS; Common Weed Killer is Widespread in the Environment. Available from, as of Sept 4, 2014: https://toxics.usgs.gov/highlights/glyphosate_2014.html (3) Aparicio VC et al; Chemosphere 93: 1866-1873 (2013)

Hazardous Substances Data Bank (HSDB)

14.2.16 Food Survey Values

Glyphosate enters plants through its foliage and moves throughout the plant and into the root system(1,2). Therefore all parts of the plant treated with glyphosate may contain the herbicide(1). Glyphosate is applied to crops before emergence as otherwise crop destruction would result(1,2). Uptake through the root system is precluded by soil inactivation(2).

(1) Crop Protection Chemicals Reference 8th ed., Chemical & Pharmaceutical Press pp. 1309-12, 1423-4, 14351444-61 (1992) (2) WSSA; Herbicide Handbook 6th ed.; Champaign, IL: Weed Sci Soc Amer pp. 146-9 (1989)

Hazardous Substances Data Bank (HSDB)

14.2.17 Plant Concentrations

Glyphosate resides in cowberries and billberies that were treated at 0.75 kg/ha in mid July, August, and September were 1.6 ppm and 2.1 ppm, respectively, 6-7 days after application and 0.1 to 0.3 ppm, when sampled 1 to 2 months after application(2). No residue were found in cowberries treated at 0.25 kg/ha and sampled 1 year later. No residues of aminomethylphosphonic acid (AMPA), the glyphosate metabolite were found in cowberries and billberries at any of the sampling intervals. Glyphosate residues in reindeer lichen, sampled in the spring, 9 months after application at rates of 0.25, 0.75 and 2.25 kg/ha were 2.5, 14, and 45 ppm, respectively; the residue increased with dose(2). The concentration of AMPA were 0.25, 0.85, and 2.1 ppm, respectively. Thirteen months after being treated with glyphosate at a rate of 0.75 kg/ha, residues of glyphosate and AMPA in one sample of reindeer lichen was 6.4 and 0.3 ppm, respectively. Initial foliar residues on alder and salmonberry sprayed with glyphosate at 2.0-2.1 kg/ha were 262 and 448 ppm (dry wt), respectively(1). Leaf litter collected 15 days post application were 12.5 and 19.2 ppm, respectively, which declined logarithmically with a 50% dissipation time of about 8 days for alder and 9 days for salmonberry. AMPA levels in litter also declined and were undetectable 29 days postapplication(1).

(1) Feng JC, Thompson; J Agric Food Chem 38: 1118-25 (1990) (2) Siltanen H et al; Bull Environ Contam Toxicol 27: 731-7 (1981)

Hazardous Substances Data Bank (HSDB)

Weeds that are resistant to glyphosate(1).

Weed	Year First Reported	Location of Resistant Populations
United States		
Rigid ryegrass	1998	California, other countries
Horseweed (marestail)	2000	14 states
Italian ryegrass	2004	Oregon, other countries
Common ragweed	2004	Missouri, Arkansas
Palmer amaranth	2005	Georgia, North Carolina, Tennessee
Waterhemp	2005	Missouri
World		
Goosegrass	1997	Malaysia
Hairy fleabane	2003	South Africa, Spain
Broadleaf plantain	2003	South Africa
Johnsongrass	2005	Argentina
Wild poinsetta	2005	Brazil

(1) Boerboom C, Owen M; Facts About Glyphosate-Resistant Weeds. The Glyphosate, Weeds, and Crop Series. GWC-1. Lafayette, IN: Purdue Univ. Available from, as of Jan 30, 3015: https://www.extension.purdue.edu/extmedia/gwc/gwc-1.pdf

Hazardous Substances Data Bank (HSDB)

14.2.18 Other Environmental Concentrations

Glyphosate was detected, with a maximum concentration of 232 ug/L reported; median concentration of 1.11 ug/L, in all stormwater runoff samples from three catchments in the Paris, France metropolitan area, collected following 20 storms between February 2008 and March 2010(1). Glyphosate was detected at a concentration range of 75-90 ug/L in storm sewer water collected during 2007 and 2008 in the Orge watershed, France. It's use along roads and railways was identified as the probable source in urban settings(2).

(1) Zgheib S et al; Water Res 46(20): 6683-6692 (2012) (2) Botta F et al; Chemosphere 77: 133-139 (2009)

Hazardous Substances Data Bank (HSDB)

14.2.19 Probable Routes of Human Exposure

Occupational exposure to glyphosate may occur through inhalation and dermal contact with this compound at workplaces where glyphosate is produced or used. Occupational workers and home gardeners may be exposed to glyphosate by inhalation and dermal contact during spraying, mixing, and cleanup. They may also be exposed by touching soil and plants to which glyphosate was applied. Dermal exposure may also occur during glyphosate's manufacture, transport, storage, and disposal. In a 1987 California survey of pesticide-related occupational exposures, exposures to glyphosate were (work activity, number exposed): ground applicator, ground, 13; applicator hand-held, 8; applicator, other, 1; coincidental exposure, 4; mixer/loader, ground application, 4(1). Monitoring data indicate that the general population may be exposed to glyphosate via ingestion of drinking water and dermal contact with consumer products containing glyphosate(SRC).

PMID:2403691
(1) Maddy KT et al; Rev Environ Contam Toxicol 114: 57-123 (1990)

Hazardous Substances Data Bank (HSDB)

15 Associated Disorders and Diseases

- Comparative Toxicogenomics Database (CTD)

16 Literature

16.1 Coronavirus Studies

PubChem

16.2 NLM Curated PubMed Citations

PubChem

16.3 Springer Nature References

Springer Nature

16.4 Thieme References

Thieme Chemistry

16.5 Wiley References

Wiley

16.6 Depositor Provided PubMed Citations

PubChem

16.7 Metabolite References

Human Metabolome Database (HMDB)

16.8 Chemical Co-Occurrences in Literature

PubChem

16.9 Chemical-Gene Co-Occurrences in Literature

PubChem

16.10 Chemical-Disease Co-Occurrences in Literature

PubChem

17 Patents

17.1 Depositor-Supplied Patent Identifiers

PubChem

Link to all deposited patent identifiers

PubChem

17.2 WIPO PATENTSCOPE

Patents are available for this chemical structure:

https://patentscope.wipo.int/search/en/result.jsf?inchikey=XDDAORKBJWWYJS-UHFFFAOYSA-N

PATENTSCOPE (WIPO)

18 Biomolecular Interactions and Pathways

18.1 Protein Bound 3D Structures

▸ RCSB Protein Data Bank (RCSB PDB)

View 13 proteins in NCBI Structure

▸ PubChem

18.1.1 Ligands from Protein Bound 3D Structures

PDBe Ligand Code	GPF
PDBe Structure Code	3FJZ
PDBe Conformer	

▸ Protein Data Bank in Europe (PDBe)

18.2 Chemical-Gene Interactions

18.2.1 CTD Chemical-Gene Interactions

▸ Comparative Toxicogenomics Database (CTD)

19 Biological Test Results

19.1 BioAssay Results

PubChem

20 Classification

20.1 MeSH Tree

Medical Subject Headings (MeSH)

20.2 ChEBI Ontology

ChEBI

20.3 KEGG: Pesticides

KEGG

20.4 ChemIDplus

ChemIDplus

20.5 CAMEO Chemicals

CAMEO Chemicals

20.6 ChEMBL Target Tree

ChEMBL

20.7 UN GHS Classification

UN Globally Harmonized System of Classification and Labelling of Chemicals (GHS)

20.8 EPA CPDat Classification

EPA Chemical and Products Database (CPDat)

20.9 NORMAN Suspect List Exchange Classification

NORMAN Suspect List Exchange

20.10 CCSBase Classification

CCSbase

20.11 EPA DSSTox Classification

Showing 5 of 57 View More

CompTox Chemicals Dashboard Chemical Lists > ATSDR >

[ATSDRPROFILES] ATSDR Toxicological Profiles

Short_Description: Toxicological Profiles (Tox Profiles) are a unique compilation of toxicological information on a given hazardous substance.

Long_Description: Toxicological Profiles (Tox Profiles) are a unique compilation of toxicological information on a given hazardous substance. Each peer-reviewed Tox Profile reflects a comprehensive and extensive evaluation, summary, and interpretation of available toxicological and epidemiological information on a substance. A full list of Toxicological Profiles is available online.

CompTox Chemicals Dashboard Chemical Lists > LIST >

[BLOODEXPOSOME] LIST: BLOODEXPOSOME

Short_Description: Chemicals identified as part of the blood exposome

Long_Description: Barupal et al report on Generating the Blood Exposome Database Using a Comprehensive Text Mining and Database Fusion Approach. The database can be used for prioritizing chemicals for systematic reviews, developing target assays in exposome research, identifying compounds in untargeted mass spectrometry, and biological interpretation in metabolomics data.

CompTox Chemicals Dashboard Chemical Lists > LIST >

[BMDHHA] ARTICLE; Bench-Mark Dose Human Health Assessment List (Wignall et al., 2014)

Short_Description: Chemicals associated with the article "Standardizing Benchmark Dose Calculations to Improve Science-Based Decisions in Human Health Assessments" by Wignall et al., 2014

Long_Description: Chemicals associated with the article "Standardizing Benchmark Dose Calculations to Improve Science-Based Decisions in Human Health Assessments" by Wignall et al., 2014. 880 dose#??response data sets for 352 environmental chemicals with existing human health assessments were examined.

CompTox Chemicals Dashboard Chemical Lists > NORMAN >

[CCSCOMPEND] NORMAN|MASSPECDB: The Unified Collision Cross Section (CCS) Compendium

Short_Description: Chemicals associated with >3800 experimental collision cross section (CCS) values

Long_Description: Chemicals associated with >3800 experimental collision cross section (CCS) values (drift tube MS), provided to the NORMAN Suspect List Exchange by Jackie Picache and John McLean, Vanderbilt University. Mapped to DTXSIDs by CAS Registry Number by E. Schymanski (Luxembourg Center for Systems Biomedicine); further curation ongoing. Further details available here

CompTox Chemicals Dashboard Chemical Lists > LIST >

[CECSCREEN] METABOLITES: HBM4EU CECscreen: Screening List for Chemicals of Emerging Concern

Short_Description: HBM4EU CECscreen is a suspect screening list for Chemicals of Emerging Concern (CECs) plus metadata and predicted Phase 1 metabolites

Long_Description: HBM4EU CECscreen is a suspect screening list for Chemicals of Emerging Concern (CECs) plus metadata and predicted Phase 1 metabolites; this list contains the CECs only. CECScreen is part of the HBM4EU project (coord. UBA) > WP16 "emerging chemicals" (lead INRA, JP Antignac/L Debrauwer) > Task 16.1 (lead IRAS, J Vlanderen / R Vermeulen) > Main contributor (J Meijer) > Involved Partners (M Lamoree, T Hamers, S Hutinet, A, Covaci, C Huber, M Krauss, DI Walker, EL Schymanski) and hosted on the NORMAN Suspect List Exchange.Further details in Meijer et al (2021) DOI: 10.1016/j.envint.2021.106511. Dataset DOI: 10.5281/zenodo.3956586.

EPA DSSTox

20.12 International Agency for Research on Cancer (IARC) Classification

Showing 1 of 1

IARC Classification >

Group 2A: Probably carcinogenic to humans

This category is used when there is limited evidence of carcinogenicity in humans and either sufficient evidence of carcinogenicity in experimental animals or strong mechanistic evidence, showing that the agent exhibits key characteristics of human carcinogens. Limited evidence of carcinogenicity means that a positive association has been observed between exposure to the agent and cancer but that other explanations for the observations (technically termed "chance", "bias", or "confounding") could not be ruled out with reasonable confidence. This category may also be used when there is inadequate evidence regarding carcinogenicity in humans but both sufficient evidence of carcinogenicity in experimental animals and strong mechanistic evidence in human cells or tissues.

International Agency for Research on Cancer (IARC)

20.13 Consumer Product Information Database Classification

Showing 2 of 2

Consumer Products Category Classification >

Landscaping/Yard

Consumer Products Category Classification >

Pesticides

Consumer Product Information Database (CPID)

20.14 FDA Drug Type and Pharmacologic Classification

Showing 1 of 1

FDA Drug Type and Pharmacologic Classification > Drug Type >

HUMAN OTC DRUG

National Drug Code (NDC) Directory

20.15 EPA Substance Registry Services Tree

Showing 5 of 32 View More

EPA SRS List Classification > Ad Hoc >

Regional Screening Levels

RSL :: The RSL website is now the source of screening levels for all the EPA regions. The RSL tables provide comparison values for residential and commercial/industrial exposures to soil, air, and tapwater (drinking water). The unified use of the RSLs, to screen chemicals at Superfund sites, promotes national consistency. Here you will find tables of risk-based screening levels, calculated using the latest toxicity values, default exposure assumptions and physical and chemical properties, and a calculator where default parameters can be changed to reflect site-specific risks.

EPA SRS List Classification > Ad Hoc >

Wisconsin Department of Natural Resources

WDNR :: Substances compiled by WDNR

EPA SRS List Classification > EPA Application/System >

CAMEO Chemicals

CAMEO Chemicals is an emergency response and planning tool. This program includes an extensive chemical database with critical response information for thousands of chemicals, as well as a reactivity prediction tool that allows you to see what hazards might occur if chemicals in your collection were mixed together. CAMEO Chemicals is available as a website, mobile website, and a desktop application. CAMEO Chemicals is part of a software suite of programs called CAMEO (Computer-Aided Management of Emergency Operations). The CAMEO suite also includes a hazard modeling tool (ALOHA), a mapping program (MARPLOT), and two database applications (CAMEOfm and Tier2 Submit) designed to assist with the data management requirements under the Emergency Planning and Community Right-to-Know Act (EPCRA, also known as SARA Title III). The CAMEO suite programs can be used (individually or together) to help first responders and emergency planners access and manage crucial chemical property and emergency response information for hazardous chemical releases. The CAMEO programs are developed jointly by EPA#?s Office of Emergency Management and NOAA#?s Office of Response and Restoration.

EPA SRS List Classification > EPA Application/System >

Comprehensive Environmental Response, Compensation and Liability Information System - 3

CERCLIS3 :: The Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) is an automated inventory of abandoned, inactive, or uncontrolled hazardous waste sites regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The system also tracks areas where there has been a hazardous substance release that may require evaluation or cleanup by the Superfund program. CERCLIS3 is used to record information about all aspects of hazardous waste sites from initial discovery to listing on the National Priorities List (NPL). The CERCLIS3 data elements registered in the EDR are only a subset of the CERCLIS3 system data elements. The investment is a legacy system and is nearing the end of its projected life. EPA will begin planning for the next generation of the system as part of its review of the Superfund program already committed to and the continued development of the Agency's and Superfund's Enterprise Architecture. At that time EPA will evaluate the alternatives available using many tools, including benefit/cost analysis. These efforts will be reported through the CPIC process and a benefit/cost analysis will include an evaluation of outsourcing, COTS, and other appropriate alternatives.

EPA SRS List Classification > EPA Application/System >

Ecotoxicology Database

ECOTOX :: Comprehensive database providing adverse effects of single chemical stressors to ecologically relevent aquatic and terrestrial species.

EPA Substance Registry Services

21 Information Sources

FILTER BY SOURCE: ALL SOURCES

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   Glyphosate [ANSI:BSI:ISO]
   https://chem.nlm.nih.gov/chemidplus/sid/0001071836

   ChemIDplus Chemical Information Classification
   https://chem.nlm.nih.gov/chemidplus/

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   https://dtp.cancer.gov/dtpstandard/servlet/dwindex?searchtype=NSC&outputformat=html&searchlist=151063

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   Glyphosate
   https://comptox.epa.gov/dashboard/DTXSID1024122

   CompTox Chemicals Dashboard Chemical Lists
   https://comptox.epa.gov/dashboard/chemical-lists/

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   https://echa.europa.eu/web/guest/legal-notice

   Glyphosate
   https://echa.europa.eu/substance-information/-/substanceinfo/100.012.726

   Glyphosate
   https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/119564

7. Hazardous Substances Data Bank (HSDB)

   GLYPHOSATE
   https://pubchem.ncbi.nlm.nih.gov/source/hsdb/3432

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   https://www.ilo.org/dyn/icsc/showcard.display?p_version=2&p_card_id=0160

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   Glycine, N-(phosphonomethyl)-
   https://www.cdc.gov/niosh-rtecs/MC106738.html

10. Wikipedia

    glyphosate
    https://en.wikipedia.org/wiki/Glyphosate

11. NJDOH RTK Hazardous Substance List

    glyphosate
    http://nj.gov/health/eoh/rtkweb/documents/fs/3139.pdf

12. Haz-Map, Information on Hazardous Chemicals and Occupational Diseases

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    https://haz-map.com/About

    Glyphosate
    https://haz-map.com/Agents/723

13. CDC-ATSDR Toxic Substances Portal

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https://www.cdc.gov/Other/disclaimer.html

Glyphosate
https://wwwn.cdc.gov/TSP/substances/ToxSubstance.aspx?toxid=293

14. ChEBI

Glyphosate
http://www.ebi.ac.uk/chebi/searchId.do?chebiId=CHEBI:27744

ChEBI Ontology
http://www.ebi.ac.uk/chebi/userManualForward.do#ChEBI%20Ontology

15. CCSbase

Glyphosate

CCSbase Classification
https://ccsbase.net/

16. NORMAN Suspect List Exchange

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glyphosate

NORMAN Suspect List Exchange Classification
https://www.norman-network.com/nds/SLE/

17. EU Pesticides Database

Glyphosate
https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/active-substances/?event=as.details&as_id=811

18. USGS Columbia Environmental Research Center

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https://www.usgs.gov/foia

GLYPHOSATE
https://www.cerc.usgs.gov/data/acute/qrychemdesc.asp?Chemical=G0060

19. Comparative Toxicogenomics Database (CTD)

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http://ctdbase.org/about/legal.jsp

https://ctdbase.org/detail.go?type=chem&acc=C010974

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https://www.whatsinproducts.com/contents/view/1/6

Glyphosate
https://www.whatsinproducts.com/chemicals/view/1/5014/001071-83-6

Consumer Products Category Classification
https://www.whatsinproducts.com/

21. EPA Chemical and Products Database (CPDat)

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https://www.epa.gov/privacy/privacy-act-laws-policies-and-resources

https://comptox.epa.gov/dashboard/DTXSID1024122#exposure

EPA CPDat Classification
https://www.epa.gov/chemical-research/chemical-and-products-database-cpdat

22. EPA Pesticide Ecotoxicity Database

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https://ecotox.ipmcenters.org/

23. EPA Regional Screening Levels for Chemical Contaminants at Superfund Sites

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https://www.epa.gov/privacy/privacy-act-laws-policies-and-resources

Glyphosate
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Glyphosate
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search?tool=rml

24. EU REGULATION (EC) No 1272/2008

glyphosate (ISO);N-(phosphonomethyl)glycine
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008R1272-20211001

25. Hazardous Chemical Information System (HCIS), Safe Work Australia

glyphosate (ISO)
http://hcis.safeworkaustralia.gov.au/HazardousChemical/Details?chemicalID=2335

26. NITE-CMC

N-(phosphonomethyl)glycine [glyphosate] - FY2016
https://www.nite.go.jp/chem/english/ghs/16-mhlw-0095e.html

glyphosate (ISO); N-(phosphonomethyl)glycine - FY2008
https://www.nite.go.jp/chem/english/ghs/08-mhlw-0209e.html

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http://www.hmdb.ca/citing

Glyphosate
http://www.hmdb.ca/metabolites/HMDB0252891

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Glyphosate
https://monographs.iarc.who.int/list-of-classifications

IARC Classification
https://www.iarc.fr/

30. MassBank of North America (MoNA)

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Glyphosate [M+H+]
https://mona.fiehnlab.ucdavis.edu/spectra/browse?query=compound.metaData%3Dq%3D%27name%3D%3D%22InChIKey%22%20and%20value%3D%3D%22XDDAORKBJWWYJS-UHFFFAOYSA-N%22%27

31. National Drug Code (NDC) Directory

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https://www.fda.gov/about-fda/about-website/website-policies#linking

GLYPHOSATE
https://www.fda.gov/drugs/drug-approvals-and-databases/national-drug-code-directory

32. NIST Mass Spectrometry Data Center

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https://www.nist.gov/srd/public-law

N-(Phosphonomethyl)glycine
http://www.nist.gov/srd/nist1a.cfm

33. NMRShiftDB
https://pubchem.ncbi.nlm.nih.gov/substance/114915818

34. Protein Data Bank in Europe (PDBe)
http://www.ebi.ac.uk/pdbe-srv/pdbechem/chemicalCompound/show/GPF

35. PubChem
https://pubchem.ncbi.nlm.nih.gov

36. RCSB Protein Data Bank (RCSB PDB)

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https://www.rcsb.org/pages/policies

https://www.rcsb.org/

37. SpectraBase

GLYPHOSATE
https://spectrabase.com/spectrum/JS0XmPWmmFY

Carboxymethylamino-methylphosphonic acid; Glycine, N-(phosphonomethyl)-
https://spectrabase.com/spectrum/Hw2O4Wd4eJg

PHOSPHONOMETHYL-GLYCINE
https://spectrabase.com/spectrum/4gEAAx054fY

XDDAORKBJWWYJS-UHFFFAOYSA-N
https://spectrabase.com/spectrum/8hS1e1mwBWX

Carboxymethylamino-methylphosphonic acid
https://spectrabase.com/spectrum/7AA3R64LIzE

N-(Phosphonomethyl)glycine
https://spectrabase.com/spectrum/Dm8d2a2vxfX

Glycine, N-(phosphonomethyl)-
https://spectrabase.com/spectrum/15J9PBFUwvg

Glycine, N-(phosphonomethyl)-
https://spectrabase.com/spectrum/B6SLSewdKds

N-(Phosphonomethyl)glycine
https://spectrabase.com/spectrum/6xojWD55ioR

N-(Phosphonomethyl)glycine
https://spectrabase.com/spectrum/8IWcgKWkVPf

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https://www.wikidata.org/wiki/Q407232

41. Wiley

https://pubchem.ncbi.nlm.nih.gov/substance/?source=wiley&sourceid=60481

42. Medical Subject Headings (MeSH)

glyphosate
https://www.ncbi.nlm.nih.gov/mesh/67010974

MeSH Tree
http://www.nlm.nih.gov/mesh/meshhome.html

Herbicides
https://www.ncbi.nlm.nih.gov/mesh/68006540

Uncoupling Agents
https://www.ncbi.nlm.nih.gov/mesh/68014475

Enzyme Inhibitors
https://www.ncbi.nlm.nih.gov/mesh/68004791

Antifungal Agents
https://www.ncbi.nlm.nih.gov/mesh/68000935

43. KEGG

Pesticides
http://www.genome.jp/kegg-bin/get_htext?br08007.keg

44. UN Globally Harmonized System of Classification and Labelling of Chemicals (GHS)

GHS Classification Tree
http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html

45. ChEMBL

ChEMBL Protein Target Tree
https://www.ebi.ac.uk/chembl/g/#browse/targets

46. EPA Substance Registry Services

EPA SRS List Classification
https://sor.epa.gov/sor_internet/registry/substreg/LandingPage.do

47. PATENTSCOPE (WIPO)

SID 403383431
https://pubchem.ncbi.nlm.nih.gov/substance/403383431

48. NCBI
https://www.ncbi.nlm.nih.gov/projects/linkout