

Potential Designated Chemicals: Organophosphorus Pesticides

Materials for July 20, 2017 Meeting of the Scientific Guidance Panel
for Biomonitoring California¹

Introduction

At the July 2016 meeting of the Scientific Guidance Panel (SGP), the Office of Environmental Health Hazard Assessment (OEHHA) presented a preliminary screen of pesticide classes for possible future consideration as designated chemicals for Biomonitoring California (OEHHA, 2016). The SGP recommended that OEHHA prepare a potential designated chemical document on organophosphorus pesticides.

Organophosphorus pesticides are broadly defined here as a structure-based class, i.e., phosphorus-containing organic compounds used as pesticides. Subclasses include organophosphates, organophosphinates, and organophosphonates.

Some organophosphate insecticides are currently on the list of designated chemicals (see Attachment A). This set of organophosphates was designated based on their inclusion in the National Reports on Human Exposure to Environmental Chemicals program of the Centers for Disease Control and Prevention (CDC). In March 2009, the SGP recommended that this set of organophosphate insecticides be added as priority chemicals.

There is a fairly extensive body of literature on organophosphorus pesticides. This summary provides a brief overview of recent information relevant to the criteria for considering this class as potential designated chemicals. We specifically highlight available findings for organophosphorus pesticides currently used in California that are not already included as designated chemicals: bensulide, ethephon, ethoprop, fosetyl-aluminum, glufosinate-ammonium, glyphosate, and S,S,S-tributyl phosphorotrithioate (tribufos).

If the Panel were to recommend adding organophosphorus pesticides as a class to the list of designated chemicals, Biomonitoring California would have the flexibility to choose appropriate analytes in response to market shifts in pesticide use. For example, supply chain issues resulted in significantly decreased agricultural use of glufosinate-ammonium in California during 2012 and 2013, leading to increased use of alternate herbicides (California Department of Pesticide Regulation [DPR], 2012; 2013). The emergence of glyphosate-resistant weeds is another example of a factor that can affect herbicide selection (Bain et al., 2017; Green, 2016; Wechsler et al., 2017). Regulatory pressures can also determine pesticide availability and introduction of substitutes. For

¹ California Environmental Contaminant Biomonitoring Program, codified at Health and Safety Code section 105440 *et seq.*

example, chlorpyrifos was formerly widely used in homes for termite and ant control, but those uses have been dramatically restricted, with concomitant increases in the use of pyrethroids (which are already on the list of designated chemicals as a class). By considering the group of organophosphorus pesticides, we capture structurally similar substitutes that may increase in use or be newly introduced in the future.

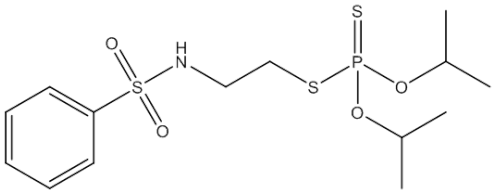
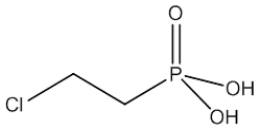
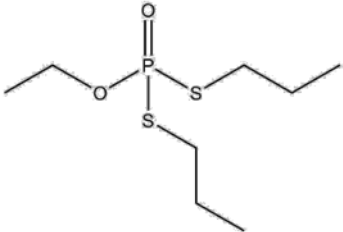
Chemical identity and use information

Several members of the class of organophosphorus pesticides that are already on Biomonitoring California's designated list are among the top 100 pesticides used agriculturally statewide in 2015, including acephate, chlorpyrifos, dimethoate, malathion, and naled (DPR, 2015a). Of these, chlorpyrifos was the most highly used (1,108,386 pounds, rank 26). Chlorpyrifos is commonly used agriculturally on such crops as tree nuts, oranges, and alfalfa (DPR, 2015b). DPR (2015c) extended existing federal restrictions on chlorpyrifos to make it a "state-restricted material² when labeled for the production of an agricultural commodity" in July 2015. Ant and roach baits in child-resistant packaging are the only residential chlorpyrifos products permitted in the state (DPR, 2015c). Other organophosphorus pesticides on the designated list that are used residentially, and for which we identified retail products, include acephate (ant killer products), and malathion (insect spray concentrates). Prescription medication containing malathion may be used to treat head lice, and tetrachlorvinphos is in some pet products for flea and tick control.

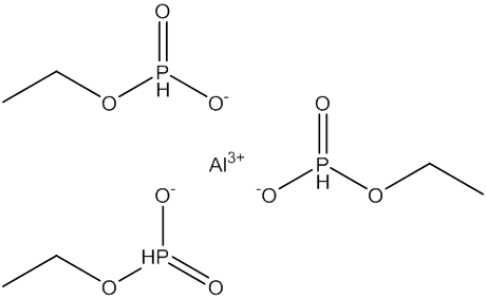
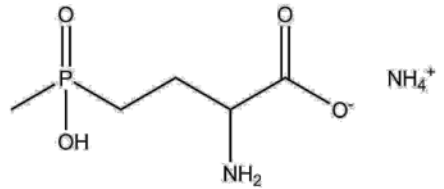
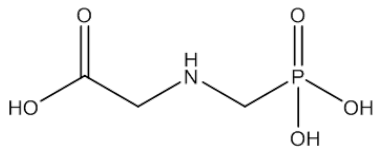
Table 1 (on pages 3-5) provides chemical structures and use information for seven organophosphorus pesticides that are in current use in California but are not on the list of designated chemicals. Five of these are in the top 100 pesticides used agriculturally in the state (DPR, 2015a).

² Restricted materials in California are pesticides deemed to have a higher potential to cause harm to public health, farm workers, domestic animals, honeybees, the environment, wildlife, or other crops compared to other pesticides. With certain exceptions, restricted materials may be purchased and used only by or under the supervision of a certified commercial or private applicator under a permit issued by the County Agricultural Commissioner. See <http://www.cdpr.ca.gov/docs/enforce/permitting.htm> for more information.

Table 1. Summary of California use information on highlighted organophosphorus pesticides not on designated list

| Organophosphorus pesticide | Type and uses ^{1,2,3} | Rank in top 100 pesticides used statewide in 2015 ⁴ | Pounds applied in CA (2011-2015) ⁵ | Pounds sold in CA (2011-2015) ⁶ |
|---|--|--|---|---|
| <p>Bensulide</p>  | <p>Type: Herbicide Example crops: Lettuce, broccoli Other uses: Landscape maintenance (e.g., golf courses) Registered products: 10 Retail products identified: Yes</p> | 57 | 2015: 345,261 2014: 318,705 2013: 284,152 2012: 267,262 2011: 288,344 | 2015: 399,053 2014: 372,092 2013: 331,862 2012: 280,663 2011: 325,580 |
| <p>Ethephon</p>  | <p>Type: Plant growth regulator Example crops: Cotton, walnuts Other uses: Landscape maintenance Registered products: 29 Retail products identified: Yes</p> | 58 | 2015: 320,938 2014: 346,796 2013: 396,665 2012: 483,676 2011: 548,802 | 2015: 467,917 2014: 448,865 2013: 488,621 2012: 590,301 2011: 768,861 |
| <p>Ethoprop</p>  | <p>Type: Insecticide Crops: Cabbage, sweet potato Other uses: Outdoor-grown transplants Registered products: 3 Retail products identified: No⁷</p> | -- | 2015: 1,751 2014: 1,228 2013: 2,434 2012: 2,077 2011: 7,475 | 2015: 6,287 2014: 2,100 2013: 654 2012: 8,248 2011: 11,944 |

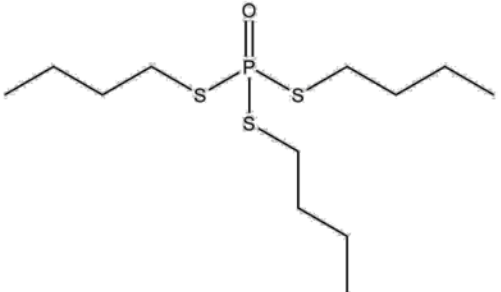
Organophosphorus pesticides

| Organophosphorus pesticide | Type and uses ^{1,2,3} | Rank in top 100 pesticides used statewide in 2015 ⁴ | Pounds applied in CA (2011-2015) ⁵ | Pounds sold in CA (2011-2015) ⁶ |
|---|--|--|---|---|
| <p>Fosetyl-aluminum</p>  | <p>Type: Fungicide Example crops: Lettuce, spinach Other uses: Landscape maintenance Registered products: 10 Retail products identified: Yes</p> | 77 | <p>2015: 216,136 2014: 230,655 2013: 235,194 2012: 280,414 2011: 285,185</p> | <p>2015: 652,562 2014: 276,289 2013: 217,531 2012: 352,950 2011: 348,020</p> |
| <p>Glufosinate-ammonium</p>  | <p>Type: Herbicide Example crops: Grapes, tree nuts Other uses: Rights-of-way Registered products: 15 Retail products identified: Yes</p> | 33 | <p>2015: 716,463 2014: 139,368 2013: 48,004 2012: 234,390 2011: 740,327</p> | <p>2015: 1,586,374 2014: 723,798 2013: 203,025 2012: 228,384 2011: 1,299,405</p> |
| <p>Glyphosate</p>  | <p>Type: Herbicide Example crops: Tree nuts, grapes, corn, cotton Other uses: Rights-of-way, landscape maintenance, forest timberland Registered products: 227 Retail products identified: Yes</p> | 7 [†] | <p>2015: 11,463,943[‡] 2014: 10,605,865 2013: 10,370,148 2012: 10,473,329 2011: 10,745,583</p> | <p>2015: 24,487,089 2014: 22,524,790 2013: 21,480,479 2012: 22,086,272 2011: 21,016,705</p> |

[†] The potassium salt of glyphosate was rank 7; the isopropylamine salt was rank 8.

[‡] For glyphosate, the values shown for pounds applied and pounds sold are for the parent compound and all its salts.

Organophosphorus pesticides

| Organophosphorus pesticide | Type and uses ^{1,2,3} | Rank in top 100 pesticides used statewide in 2015 ⁴ | Pounds applied in CA (2011-2015) ⁵ | Pounds sold in CA (2011-2015) ⁶ |
|---|--|--|---|---|
| Tribufos  | Type: Defoliant Crop: Cotton Other uses: -- Registered products: 4 Retail products identified: No ⁸ | -- | 2015: 6,472 2014: 11,683 2013: 19,077 2012: 21,960 2011: 30,745 | 2015: 31,417 2014: 9,821 2013: 34,070 2012: 23,596 2011: 51,792 |

¹ Information on crops and other uses was obtained from the DPR (2015b) Pesticide Use Report (available online: <http://www.cdpr.ca.gov/docs/pur/pur15rep/chmrpt15.pdf>). This report covers “agricultural use” of pesticides, which is broadly defined to include use on crops as well as landscape maintenance, for example. For further explanation, refer to pages 6-8 of this Pesticide Use Report.

² The DPR Product/Label database (available online: <http://www.cdpr.ca.gov/docs/label/labelque.htm>) lists all pesticide products registered for use in California, including pesticides for consumer home and garden use. The number of active products registered for use in California is shown in the table for each example organophosphorus pesticide.

³ Several retail websites selling home, lawn, and garden supplies were scanned for commercially available products containing the selected organophosphorus pesticides. In instances where we did not locate retail products containing the pesticide, the category of “Retail products identified” is shown as “No”.

⁴ Ranks were obtained from the DPR list of the top 100 pesticides used in California in 2015 (available online: http://www.cdpr.ca.gov/docs/pur/pur15rep/top_100_ais_lbs_2015.pdf), based on pounds applied for “agricultural use” of pesticides (see footnote 1 above).

⁵ DPR Summaries of Pesticide Use Report Data, Indexed by Chemical (available online: <http://www.cdpr.ca.gov/docs/pur/purmain.htm>) provide data on pounds of “agricultural use” of pesticides (see footnote 1 above).

⁶ DPR Reports of Pesticides Sold in California (available online: <http://www.cdpr.ca.gov/docs/mill/nopdsold.htm>) contain self-reported data from pesticide registrants, pest control dealers, and pesticide brokers on the total pounds of each active ingredient they sell for any use in California (i.e., agricultural, institutional, and/or home use). Reporting is required for the first point of sale in the state by any seller registered with DPR, including, for example, retail stores and on-line purveyors. Because these data are self-reported, however, DPR cannot attest to their complete accuracy.

⁷ The US Environmental Protection Agency (US EPA, 2016a) classifies some products containing ethoprop as restricted use products, which are not available for purchase or use by the general public. See <https://www.epa.gov/sites/production/files/2016-02/documents/rupreport-sec3-update-jan2016.pdf>.

⁸ All active products registered in California containing tribufos are designated by DPR as restricted materials. See page 2, footnote 2.

Exposure or potential exposure to the public or specific subgroups

Organophosphorus pesticide exposure can occur through occupational use (Fenske et al., 1987; Jomichen et al., 2017; Lesmes-Fabian and Binder, 2013; Lotti et al., 1983; Suratman et al., 2015); living, working, or going to school near agricultural areas or other areas where pesticides are applied (Bradman et al., 1997; Fenske et al., 2000; Gibbs et al., 2017; Gunier et al., 2016; Salvatore et al., 2015; Smith et al., 2017; Whyatt et al., 2003); home use of some products (Deziel et al., 2015a); and diet (Bradman et al., 2015; Holme, et al., 2016; Lu et al., 2006). Take-home exposures by agricultural workers can lead to higher pesticide exposures for family members, particularly children (Deziel et al., 2015b; Hyland and Laribi, 2017). For example, some organophosphorus pesticides have been detected more frequently and at higher levels in dust samples collected from farm homes compared with dust samples from non-farm homes (Lu et al., 2000; Quirós-Alcalá et al., 2011; Simcox et al., 1995; Thompson et al., 2003).

Selected exposure studies on organophosphorus pesticides not already designated are discussed below; findings on already designated chemicals from these studies are also noted. We describe all of the recent California studies that we located in our literature search. We also review studies from other states and other countries, if relevant for illustrating potential exposure pathways; the specific findings of exposure studies from other locations may not apply to California.

Dust:

We did not identify California dust studies of the highlighted pesticides. Curwin et al. (2005) collected dust samples from home carpets and rugs, and surface wipes from the kitchen counter, top of the washing machine, various rooms with hard surface floors, and primary family vehicles. The study included both farm and non-farm homes in Iowa and samples were collected in 2001. Glyphosate was detected in 100% of dust samples from farm homes (n = 31 samples from 5 homes; range: 0.0081-2.7 ng/cm²) and in 85% of samples from non-farm homes (n = 28 samples from 6 homes; range: 0.0012-13 ng/cm²). It was not detected in any house or vehicle wipes. Glyphosate levels in dust were highest in samples collected from the child's bedroom in both farm (geometric mean [GM]: 1,500 ng/g) and non-farm (GM: 510 ng/g) homes. To put these dust findings in context, the study reported detections of chlorpyrifos in 84% of dust samples from farm homes (n = 116 samples from 20 homes; range: 0.00049-10 ng/cm²) and in 81% of samples from non-farm homes (n = 114 samples from 19 homes; range: 0.00021-3.6 ng/cm²).

Air:

As part of the Air Monitoring Network, DPR (2017a) included the highlighted pesticides bensulide and tribufos in their 2015 study of 155 air samples collected at three sites:

Organophosphorus pesticides

Salinas, Shafter, and Ripon. Bensulide was detected in one Salinas sample at a level below the limit of quantitation (LOQ) of 9.3 ng/m³. Tribufos was not detected.

Majewski et al. (2014) collected air samples (n = 21) in 2007 from the Mississippi Delta agricultural region and reported detections of glyphosate (DF: 86%; median: 0.567 ng/m³), aminomethylphosphonic acid (AMPA, the major breakdown product of glyphosate) (DF: 86%; median: 0.074 ng/m³), and tribufos (DF: 10%; median: non-detect [ND]; maximum: 0.274 ng/m³). This study also detected the already designated organophosphorus pesticides chlorpyrifos, dicotophos, malathion, and methyl parathion in air samples.

Chang et al. (2011) measured glyphosate and AMPA in air samples collected from Iowa and Mississippi. Glyphosate was detected in 61% of Iowa air samples (n = 18; median: 0.08 ng/m³) collected in 2007 and in 72% of samples (n = 18; median: 0.22 ng/m³) collected in 2008. AMPA was detected in 56% of Iowa air samples (n = 18; median: 0.02 ng/m³) collected in 2007 and in 61% (n = 18; median: 0.04 ng/m³) collected in 2008. Glyphosate was detected in 86% of Mississippi air samples (n = 22; median: 0.48 ng/m³) collected in 2007 and in 100% of samples (n = 27; median: 0.24 ng/m³) in 2008. AMPA was detected in 86% of Mississippi air samples (n = 22; median: 0.06 ng/m³) collected in 2007 and in 70% of samples (n = 27; median: 0.02 ng/m³) collected in 2008.

Coscollà et al. (2010) collected air samples between 2006-2008 from 2 urban and 3 rural sites in France, and tested them for a variety of pesticides. Ethoprop was detected in 2 (1%) of 262 samples analyzed, at levels of 0.21 and 0.48 ng/m³. Both detections were in samples collected from the same rural site. Coscollà et al. noted that the detections at the rural site were most likely associated with ethoprop use on potato fields. Other organophosphorus pesticides detected in the air samples included chlorpyrifos, diazinon, and phosmet.

Hart et al. (2012) collected particulate matter (PM₁₀) from air samples in 2010 from various sites (1 urban, 3 rural, and 1 remote) in Spain, and tested them for a variety of pesticides. Ethoprop was detected in 13% of 217 total samples analyzed. The majority of ethoprop detections were in PM₁₀ from the urban site samples (DF in urban site samples: 56%; mean: 153.1 pg/m³; range: 15.2-1196.8 pg/m³). The highest levels of ethoprop were measured by a sampler situated in a park with extensive gardens. The study authors noted that ethoprop is used in ornamental gardens. Other organophosphorus pesticides detected in the PM₁₀ samples in this study included chlorpyrifos, diazinon, and malathion.

Water:

The maximum contaminant level (MCL) for glyphosate in drinking water is 700 µg/L (State Water Resources Control Board [SWRCB], 2014; US EPA, 2009a). The current Public Health Goal in California is 900 µg/L (OEHHA, 2007).

Organophosphorus pesticides

The Environmental Working Group (EWG) compiled tap water testing data from state water offices in their National Drinking Water Database, which covers 2004 to 2009 (EWG, 2009). The database listed two water utilities in California that found glyphosate in drinking water during that time period. The Imperial Irrigation District (in Imperial, CA) detected glyphosate once at a level of 16.5 µg/L in 2005. The City of Bakersfield reported one detection of 32 µg/L in 2006. There were 218 US water suppliers that reported testing for ethoprop, but none detected the chemical (EWG, 2009).

SWRCB maintains the on-line GeoTracker GAMA (Groundwater Ambient Monitoring and Assessment) Information System (SWRCB, 2015). Two detections of glyphosate in groundwater were reported in the last ten years. A level of 1.3 µg/L was found in an environmental monitoring well in Los Angeles County in 2009. In 2013, 20 µg/L glyphosate was measured in a water supply well at the Vandenberg Air Force Base in Santa Barbara County.

DPR (2016) summarized results from 2015 groundwater monitoring for pesticide residues, including bensulide and glyphosate. These compounds were not detected in any sample. Bensulide was tested in 64 wells across three counties (reporting limit 0.05 µg/L), and glyphosate was tested in 644 wells across 38 counties (reporting limit 0 to 25 µg/L). AMPA was not measured.

Glyphosate and AMPA have been commonly detected in surface water, ground water, and/or precipitation samples in other areas of the US (Battaglin et al., 2014; Chang et al., 2011; Coupe et al., 2012) and in Ontario, Canada (Struger et al., 2008; 2015). Majewski et al. (2014) reported detections of tribufos, in addition to glyphosate and AMPA, in rain samples collected in 2007 from the Mississippi Delta agricultural region. They also found the already designated organophosphorus pesticides chlorpyrifos, dichlorvos, dicrotophos, malathion, and methyl parathion in the rain samples. Mahler et al. (2017) detected glyphosate more frequently in urban stream samples collected in 2013 compared to streams impacted by agricultural land use in the Midwestern US. Measured concentrations were comparable in both types of streams.

Pesticide use near school sites:

The California Environmental Health Tracking Program (CEHTP, 2014) examined the use of agricultural pesticides near California public schools in 2010 as a way to understand the potential for pesticide exposure among children in school settings. Of the selected organophosphorus pesticides that are not currently on Biomonitoring California's designated list of chemicals, bensulide, ethephon, and glufosinate-ammonium were among the top ten pesticides applied within a quarter mile of schools in one or more of the counties assessed. Bensulide was additionally one of the top ten pesticides classified as a cholinesterase inhibitor used within a quarter mile of schools in the 15 counties assessed overall. For the already designated organophosphate pesticides, CEHTP (2014) found that chlorpyrifos and malathion were among the top

Organophosphorus pesticides

ten pesticides applied within a quarter mile of schools, and acephate, chlorpyrifos, diazinon, dimethoate, malathion, naled, and oxydemeton-methyl were in the top ten pesticides classified as cholinesterase inhibitors used within a quarter mile of schools in the counties assessed overall.

DPR (2015c) made chlorpyrifos a restricted material in 2015. On March 16, 2017, DPR announced revised proposed rules on agricultural pesticide use near schools and child day-care centers in an effort to provide an extra measure of protection from pesticide exposures (DPR, 2017b). Additional data collection will improve the available information about pesticide use near schools.

Food residues:

Of the highlighted organophosphorus pesticides, bensulide, ethoprop, and tribufos are included in DPR's multi-residue screens of fresh produce samples (DPR, 2014). None of these organophosphorus pesticides were detected in DPR's most recent analysis of residues on produce (DPR, 2015d).

In their most recent annual analyses, the US Food and Drug Administration (FDA, 2014a; 2014b) and the US Department of Agriculture (USDA, 2015) detected residues of several of the highlighted organophosphorus pesticides in food samples. FDA (2014b) found trace levels of ethoprop in 2 samples of leaf and stem vegetables imported from Korea. FDA (2014b) also detected tribufos in one sample of cilantro imported from Mexico at 0.121 ppm. Of 4,204 food samples analyzed for bensulide by USDA (2015), the compound was detected in 3 lettuce samples, ranging from 0.004-0.007 ppm. Of 2,560 food samples analyzed for bensulide oxon, a breakdown product of bensulide, the compound was detected in 11 lettuce samples, ranging from 0.003-0.022 ppm. None of the 7,786 samples tested by USDA (2015) for ethoprop, nor any of the 2,574 samples tested for tribufos had detectable levels of these compounds.

As part of their annual pesticide data program report, USDA (2011) included the results of a specialty analysis conducted on soybean samples for glyphosate and AMPA. Of 300 soybean samples evaluated, glyphosate was detected in 271 samples (DF: 90.3%) ranging from 0.26-18.6 ppm, and AMPA was detected in 287 samples (DF: 95.7%) ranging from 0.26-20 ppm.

In 2015-2016, the Canadian Food Inspection Agency (CFIA) tested 3,188 domestic and imported food samples for glyphosate and AMPA (detection limits not reported), and found the highest detection frequencies for the sum of the two chemicals in bean, pea, and lentil products (47.4%), grain products (36.6%), and infant cereals (31.7%) and foods (30.7%) (CFIA, 2017). CFIA (2017) found that 98.7% of the samples tested did not exceed the glyphosate maximum residue limit (MRLs), which Canada sets for a variety of food products. The few samples in exceedance of the glyphosate MRLs were

primarily grain products, with other exceedances in the categories of “juice and other beverages”, and “bean, pea, and lentil products”.

Known or suspected health effects

There is an extensive body of literature on organophosphate pesticides that show associations between human exposure to these compounds and a range of adverse health outcomes: neurotoxicity, including cognitive effects (Engel et al., 2016; Gunier et al., 2017; Kamel et al., 2007; Ophir et al., 2014; Rowe et al., 2016; Starks et al., 2012a; 2012b; Stokes et al., 1995; Voorhees et al., 2017); developmental toxicity (Harley et al., 2016; Rauch et al., 2012); diabetes (Saldana et al., 2007; Starling et al., 2014); other endocrine effects (Goldner et al., 2013); respiratory effects (Hoppin et al., 2008; 2009; Raanan et al., 2015; 2016; Valcin et al., 2007); and other effects (Mostafalou and Abdollahi, 2017; Ranjbar et al., 2015; Rusiecki et al., 2017; Wang et al., 2016).

Table 2 on the next page shows organophosphorus pesticides that are listed as causing cancer or reproductive toxicity under Proposition 65 (State of California, 2017), some of which have also been classified by the International Agency for Research on Cancer (IARC) (IARC, 2017a).

Table 2. Proposition 65 and IARC classifications for selected organophosphorus pesticides

| | Organophosphorus pesticide | Proposition 65 ¹ | | IARC classification ² |
|--|----------------------------|-----------------------------|------------------------------------|----------------------------------|
| | | Carcinogen | Reproductive toxicant | |
| Highlighted pesticide not on designated list | Ethoprop | Yes | -- | Not classified |
| | Glyphosate | Yes ³ | -- | Group 2A |
| | Tribufos | Yes | -- | Not classified |
| Pesticide already on designated list | Diazinon | -- | -- | Group 2A |
| | Dichlorvos (DDVP) | Yes | -- | Group 2B |
| | Malathion | Yes | -- | Group 2A |
| | Oxydemeton-methyl | -- | Yes (Reproductive-female, male) | Not classified |
| | Parathion | Yes | -- | Group 2B |
| | Tetrachlorvinphos | Yes | -- | Group 2B |

¹ Proposition 65 List of Chemicals. January 27, 2017 version. Available online:

<https://oehha.ca.gov/media/downloads/proposition-65/p65single01272017.pdf>

² IARC List of classifications. Group 2A agents are considered “probably carcinogenic to humans” and Group 2B agents are considered “possibly carcinogenic to humans”. Available online:

http://monographs.iarc.fr/ENG/Classification/latest_classif.php

³ Glyphosate is listed under Proposition 65 as known to the state to cause cancer effective July 7, 2017.

See notice at: <https://oehha.ca.gov/proposition-65/cmrn/glyphosate-listed-effective-july-7-2017-known-state-california-cause-cancer>

Selected studies on known or suspected health effects of organophosphorus pesticides not already on the list of designated chemicals are briefly outlined below. We primarily cover non-cancer effects, and do not discuss the cancer studies that were the basis for the listings in Table 2. The epidemiological studies involved exposures to pesticide formulations. For animal and *in vitro* studies, we focused on those that tested the pesticide active ingredient. For full study details, refer to the published papers (citations provided in the reference list).

Selected human studies

Starks et al. (2012a) found that use of ethoprop and malathion by pesticide applicators in the Agricultural Health Study (AHS) was associated with reduced performance in neurobehavioral function tests. Use of chlorpyrifos, diazinon, dichlorvos, glyphosate, and malathion by AHS pesticide applicators was associated with rhinitis (Slager et al., 2010). Hoppin et al. (2017) found that use of glyphosate and malathion in the AHS was associated with both allergic and non-allergic wheeze. Uses of glufosinate-ammonium and other organophosphates evaluated were not associated with either wheeze

outcome. Use of glyphosate was associated with incident rheumatoid arthritis in AHS farmers' spouses who themselves used the pesticide (Parks et al., 2016).

In a case-control study of pesticide applicators and their children in Minnesota, Garry et al. (2002) reported that parental glyphosate use was linked with increased odds of attention-deficit disorders in children.

In a case-control study in an agricultural area in Spain, García et al. (1998) found that paternal exposure to glufosinate-ammonium was linked with increased odds of child congenital malformations. This study also evaluated exposures to the highlighted organophosphorus pesticides fosetyl-aluminum and glyphosate, but did not observe a link between paternal exposure to these pesticides and congenital malformations. The already listed organophosphorus pesticides, azinphos-methyl, dimethoate, malathion, and methidathion, were also evaluated, and no link was observed.

In a study of pesticide sprayers in Greece, use of glufosinate-ammonium was associated with elevated levels of serum 8-hydroxydeoxyguanosine (8-OHdG), a marker of oxidative stress-induced DNA damage. Glyphosate use, and use of already designated organophosphorus pesticides (chlorpyrifos, dimethoate, phosmet), were also evaluated in this study, but were not found to have an effect on serum 8-OHdG (Koureas et al., 2014).

In a case-control study in central California, Narayan et al. (2013) reported that frequent use of household products containing organophosphorus pesticides increased the odds of Parkinson's disease by 71%. The study involved assessing exposure retrospectively, based on self-reporting of historical household pesticide use by participants and additional research by the study authors on active ingredients in the products. The organophosphorus pesticides identified as being in the household products used included bensulide, chlorpyrifos, demeton, diazinon, dichlorvos, disulfoton, glufosinate-ammonium, glyphosate, malathion, methidathion, oxydemeton-methyl, parathion, and tetrachlorvinphos.

Selected toxicity information – by individual pesticide

Bensulide: In US EPA's (2016b) human health risk assessment for bensulide, neurotoxicity (via inhibition of red blood cell and brain acetylcholinesterase) was identified as the most sensitive toxic effect. Recent *in vitro* findings for bensulide are described in the section below ("Additional laboratory and *in vitro* studies").

Ethephon: US EPA (2015a) reviewed toxicity data for ethephon in their human health risk assessment for registration review, and reported that it inhibited red blood cell and plasma cholinesterase and induced bacterial mutagenesis. Toxicity studies of ethephon that we located in the literature are briefly outlined here. El Raouf and Girgis (2011) found that pregnant mice and their fetuses exposed to ethephon via drinking water had increased chromosomal aberrations, decreased brain cholinesterase activity, and

altered biochemistry. Wang et al. (2017) reported that ethephon affected the developing immune system in mice treated via gavage. Ethephon has also been found to inhibit human and mouse plasma cholinesterases (Haux et al., 2002; Liyasova et al., 2013). In a rat *ex-vivo* study, chlorpyrifos and ethephon were found to have both single and combined effects on altered small intestine muscle contraction due to acetylcholinesterase inhibition (Çetinkaya and Baydan, 2010).

Ethoprop: DPR (1995) summarized the chronic effects of ethoprop, which included brain cholinesterase inhibition in mice and rats treated via diet, and hepatotoxicity in dogs administered oral capsules containing the pesticide. US EPA (2008a) conducted a scoping human health assessment for registration review, describing similar toxic effects as DPR. US EPA (2008a) also noted the classification of ethoprop as a likely human carcinogen. Recent *in vitro* findings for ethoprop are described in the section below (“Additional laboratory and *in vitro* studies”).

Fosetyl-aluminum: In long-term studies reviewed by US EPA (2014a), dogs exposed to fosetyl-aluminum developed testicular degeneration, and exposed rats displayed urinary tract effects. The European Food Safety Authority (EFSA) (2013) also described these effects, noting that they were observed at “higher doses”. US EPA had previously classified fosetyl-aluminum as a possible human carcinogen based on bladder tumors observed in rats treated via diet at the highest dose only (40,000 ppm, then reduced to 30,000 ppm) (Quest et al., 1991); however, US EPA (2016a) now lists it as “not likely to be carcinogenic to humans” based on a 1999 evaluation.

Glufosinate-ammonium: In an updated human health risk assessment conducted to evaluate new uses of glufosinate-ammonium, US EPA (2012) provided a short summary of the toxicity data considered, including developmental toxicity and inhibition of brain glutamine synthetase in exposed rats. Some published studies on glufosinate-ammonium are described briefly here. Mice treated via intraperitoneal (IP) injection with glufosinate-ammonium developed structural changes in the brain and mild memory impairments (Calas et al., 2008; Meme et al., 2009). Laugeray et al. (2014) reported that intranasal exposure to glufosinate-ammonium during pre- and post-natal periods led to autism spectrum disorder-like behaviors in mice. Herzine et al. (2016) exposed mouse dams to glufosinate-ammonium via intranasal administration and evaluated brain tissues from the perinatally exposed mouse pups. The study authors found that perinatal exposure to glufosinate-ammonium altered neurogenesis. Watanabe and Iwase (1996) observed evidence of embryotoxicity in cultured mouse embryos treated with glufosinate-ammonium.

Glyphosate: The toxicity and carcinogenicity of glyphosate have been reviewed in a number of reports and publications (see for example, US EPA, 2009b; Mesnage et al., 2015; IARC, 2017b). Here we summarize some recent animal and *in vitro* studies of glyphosate’s potential non-cancer effects. Kumar et al. (2014) reported that mice

exposed to glyphosate via nasal aspiration while anesthetized developed increased airway inflammation. This study found that glyphosate-rich air samples collected from farms during spraying season also increased airway inflammation in mice. Proteomic analyses of mouse livers following exposure to a single IP injection of glyphosate revealed altered lipid metabolism pathways (Ford et al., 2017). Chłopecka et al. (2014) reported that glyphosate altered intestinal motor activity in a rat *ex-vivo* study. Studies of zebrafish exposed to glyphosate showed evidence of effects on the developing heart and brain (Roy et al., 2016a; 2016b); other developmental effects (Zhang et al., 2017); reproductive effects (Lopes et al., 2014); and increased oxidative stress and decreased levels of brain and muscle acetylcholinesterase (though cholinesterase activity was not affected) (Lopes et al., 2017). In cell culture, glyphosate is a partial aromatase inhibitor (Benachour et al., 2007; Richard et al., 2005) and can alter DNA methylation (Kwiatkowska et al., 2017).

Tribufos: DPR (1998; 2004) summarized the chronic effects of tribufos exposure via the diet, which included brain cholinesterase inhibition in mice, rats, and dogs, and gastrointestinal and liver effects in mice and rats. US EPA (2009c) conducted a human health risk assessment of tribufos, describing similar toxic effects as DPR. US EPA (2009c) also noted the classification of tribufos as a likely carcinogen at high doses. Recent *in vitro* findings for tribufos are described in the section below.

Additional laboratory and *in vitro* studies

Studies have found that a number of organophosphorus pesticides, including chlorpyrifos, ethoprop, glyphosate, and tribufos, can disrupt lipid metabolism in treated mice (Ford et al., 2017 [also summarized above for glyphosate]; Medina-Cleghorn et al., 2014). These studies exposed the mice to the pesticides via a single IP injection.

Andersen et al. (2002) found that the highlighted organophosphorus pesticides ethephon and fosetyl-aluminum were not active in a screen of pesticide activity for estrogenicity, androgenicity, and aromatase activity in cell culture.

Based on the Endocrine Disruptor Screening Program (EDSP) Tier 1 results for ethoprop and glyphosate, US EPA (2015b; 2015c) did not recommend either compound for Tier 2 testing. No other highlighted organophosphorus pesticides were included in EDSP's Tier 1.

We consulted US EPA's high-throughput chemical Toxicity Forecaster (ToxCast™) Dashboard (Dix et al., 2007; Kavlock et al., 2012) for bioactivities of the highlighted organophosphorus pesticides. Of these, bensulide, ethephon, and ethoprop were tested in over 1,000 ToxCast assays. Bensulide was active in 169 ToxCast assays, including assays evaluating endocrine pathway effects, metabolic enzyme binding, and immune and inflammation targets. Ethephon was active in 11 assays, including assays evaluating DNA damage and altered cell cycle. Ethoprop was active in 28 assays,

including assays evaluating upregulation of metabolic enzymes and immune and inflammation targets. We also consulted US EPA's Endocrine Disruptor Screening Program for the 21st Century (EDSP21) Dashboard, which contains data intended to assist with chemical prioritization for EDSP. Tribufos was evaluated in 26 assays testing for endocrine effects and was active in 2 assays measuring increased estrogen receptor activity.

Potential to biomonitor

Bioaccumulation and persistence:

OEHHA (2012) has specified a log octanol-water partition coefficient ($\log K_{ow}$) of ≥ 4 as indicating potential for bioaccumulation. US EPA's (2016c) PBT Profiler tabulated experimental $\log K_{ow}$ values that are close to or above this benchmark for the following highlighted pesticides: bensulide (4.2), ethoprop (3.6), and tribufos (5.7). None of the highlighted pesticides had bioconcentration factors (BCFs) in fish above 1000, which is another indicator used to evaluate potential for bioaccumulation. US EPA (2015d) reported a BCF close to 1000 for tribufos (730 L/kg-whole fish), and stated that it may bioaccumulate in aquatic or terrestrial organisms. However, US EPA also noted that the metabolism and rapid elimination of tribufos are expected to mitigate the bioaccumulation concern.

Potential environmental persistence for the highlighted pesticides was examined by reviewing data on half-lives in environmental media, and selected findings are described below.

US EPA (2008b) indicated that bensulide dissipates primarily via aerobic soil metabolism, with a reported half-life of 1 year, and predicted that bensulide would be extremely persistent in terrestrial ecosystems. More recently, Antonious (2010) found that bensulide had a half-life of 27-44 days in field studies, depending on soil type.

US EPA (2015e) reported that the dissipation half-lives for ethoprop in soil field studies ranged from 3-60 days, which was more rapid than predicted based on the 100-day half-life measured for aerobic soil metabolism. US EPA concluded, based on studies across various media, that ethoprop is "moderately to strongly persistent in the environment." However, they also noted that there is significant uncertainty in the estimates of ethoprop's environmental half-lives, because of observed variability in persistence measured at different sites and potential impact of previous use history at the sites (US EPA, 2015e).

Laboratory and field studies have found that glufosinate-ammonium degrades in soil to 3-methylphosphinopropionic acid (3-MPPA) (Smith, 1988; Smith and Belyk, 1989). US EPA (2014b) reported that glufosinate had field dissipation half-lives ranging from 8-17 days, which were comparable to aerobic soil metabolism rates. They also concluded that glufosinate residues may persist in aquatic environments, resulting in chronic

exposure to aquatic organisms. Glufosinate is expected to remain primarily in the water column, rather than sediment, with concentrations decreasing over time via dilution and metabolic degradation (US EPA, 2014b).

WHO (1994) reported that the DT_{50} (the time required to dissipate to half the original concentration) for glyphosate in soil experiments was between 3 and 174 days, depending on soil and climate conditions; US EPA (2009d) reported similar information. More recently, Bento et al. (2016) found that glyphosate DT_{50} values in soil experiments varied between 1.5-53.5 days, noting that it persists up to 30 times longer in soil under cold and dry conditions. This study also reported soil DT_{50} values for AMPA (the degradate of glyphosate) ranging between 26.4-44.5 days. AMPA persisted in soil longer than glyphosate did, even under warm and moist conditions. Bento et al. (2017) characterized glyphosate and AMPA distribution in soil and found that the highest concentrations of both compounds were found in the smallest soil fractions (i.e., PM_{10} and less). In laboratory experiments, Mercurio et al. (2014) determined that the half-life of glyphosate in seawater ranged from 47-315 days, depending on light and temperature conditions.

DPR (2004) reported that tribufos had an estimated half-life of at least 60 days in soil, depending on soil type and anaerobic or aerobic conditions. US EPA (2015d) concluded that tribufos is persistent in aerobic and anaerobic soil, with a reported half-life of 745 days in a study of aerobic sandy loam soil. US EPA noted that tribufos appears to be “more persistent than is typical for most organophosphate chemicals.”

Metabolites and breakdown products:

Information on metabolites and/or environmental breakdown products located for the organophosphorus pesticides not already designated is summarized in Table 3 on the next page.

Table 3. Summary of metabolite and breakdown product information for highlighted organophosphorus pesticides

| Organophosphorus pesticide | Metabolite/breakdown products | Reference |
|-----------------------------------|--|--|
| Bensulide | Rat metabolite and breakdown product: bensulide oxon | US EPA (2016b) |
| Ethephon | Major breakdown products: ethylene and phosphoric acid | Cunha et al. (2017); Maynard and Swan (1963) |
| Ethoprop | Major human and rat metabolite: O-ethyl-S-propyl phosphorothioate Other rat metabolites: O-ethyl phosphoric acid, S-propyl phosphorothioate, S,S-dipropyl phosphorodithioate, and ethyl phosphate | Lunchick et al. (2005); DPR (1995) |
| Fosetyl-al | Major plant metabolites: phosphonic acid and ethanol | EFSA (2013) |
| Glufosinate-ammonium | Major human metabolite and breakdown product: 3-MPPA | Aris and Leblanc (2011) |
| Glyphosate | Human metabolite, major plant metabolite, and breakdown product: AMPA Mouse metabolite: glyoxylate | Hoppe (2013); Borggaard and Gimsing (2008); Ford et al. (2017) |
| Tribufos | Proposed metabolites: S,S-dibutyl phosphorodithioate, S-butyl phosphorothioate, phosphate, n-butyl mercaptan, and others Breakdown product: 1-butane sulfonic acid | DPR (2004); US EPA (2015d) |

Past biomonitoring studies:

Exposure to organophosphate pesticides has been demonstrated via measurement of non-specific dialkyl phosphate (DAP) metabolites in a wide range of biomonitoring studies (CDC, 2017; Barr et al., 2004; Bradman et al., 2005; 2015; Harley et al., 2016). Specific metabolites, including for chlorpyrifos and diazinon, have also been measured (CDC, 2017; Barr et al., 2005; Camann et al., 2013; Whyatt et al., 2003). Less biomonitoring data are available for the organophosphorus pesticides that are not currently on the list of designated chemicals. We briefly discuss below the biomonitoring studies located for the highlighted pesticides. Where appropriate, we converted units to µg/L for consistency.

Glyphosate and glufosinate-ammonium

A recent review summarizes a number of studies measuring glyphosate in human urine (Niemann et al., 2015). Various public health researchers have recently commented on the need for additional biomonitoring data on glyphosate, given its extensive use (Myers et al., 2016; Vandenberg et al., 2017). This section outlines selected studies that measured glyphosate and AMPA in a variety of matrices, including urine and serum,

and one study that also included glufosinate-ammonium and its breakdown product 3-MPPA.

Adams et al. (2015) detected urinary glyphosate in 93% (n = 131) of samples collected from members of the US general population (average: 3.1 µg/L). The method detection limit was 0.2 µg/L. AMPA levels were not measured.

Curwin et al. (2007a) used an immunoassay approach to evaluate urinary glyphosate levels in members of 25 farm households (24 fathers, 24 mothers, and 66 children) and 25 non-farm households (23 fathers, 24 mothers, and 51 children) in samples collected in 2001 in Iowa. Up to 4 urine samples were collected per study participant. The limit of detection was 0.9 µg/L. Of the urine samples collected from farm households, detectable levels of glyphosate were found in 69 of 92 samples from fathers (DF: 75%; GM: 1.9 µg/L; range: 0.02-18 µg/L), 63 of 94 samples from mothers (DF: 67%; GM: 1.5 µg/L; range: 0.10-11 µg/L), and 191 of 235 samples from children (DF: 81%; GM: 2 µg/L; range: 0.022-18 µg/L). Of the urine samples collected from non-farm households, detectable levels of glyphosate were observed in 59 of 89 fathers (DF: 66%; GM: 1.4 µg/L; range: 0.13-5.4 µg/L), 60 of 93 mothers (DF: 65%; GM: 1.2 µg/L; range: 0.062-5 µg/L), and 160 of 182 children (DF: 88%; GM: 2.7 µg/L; range: 0.10-9.4 µg/L).

Acquavella et al. (2004) evaluated glyphosate levels in urine samples collected from South Carolina and Minnesota pesticide applicators (n = 48), their spouses (n = 48), and their children (n = 79). Urine samples were collected pre-application, on pesticide application day, and daily for 3 days post-application. The method detection limit for urinary glyphosate was 1 µg/L. Seven of 47 (15%) pesticide applicators had detectable pre-application urinary glyphosate levels. On pesticide application day, 29 applicators (60%) had detectable urinary glyphosate levels, ranging from 1-233 µg/L (GM: 3.2 µg/L). On post-application day 1, 23 (48%) of applicators had detectable urinary glyphosate levels, ranging from 1-126 µg/L (GM: 1.7 µg/L). On post-application day 2, 16 (33%) of applicators had detectable urinary glyphosate levels, ranging from 1-81 µg/L (GM: 1.1 µg/L). On post-application day 3, 13 (27%) of applicators had detectable urinary glyphosate levels, ranging from 1-68 µg/L (GM: 1.0 µg/L). The highest numbers of detectable levels for spouses and children were on application day, with 2 (4%) spouses having urinary glyphosate ranging from 1-2 µg/L, and 9 (12%) children having urinary glyphosate ranging from 1-29 µg/L. AMPA levels were not reported in this study.

Conrad et al. (2017) investigated time trends of glyphosate and AMPA in urine samples collected between 2001-2015 (n = 40 for each year samples were collected) and stored in the German Environmental Specimen Bank. The method LOQ was 0.1 µg/L. Sixteen (40%) of the samples collected in 2015 had quantifiable glyphosate (95th percentile: 0.45 µg/L; max: 0.57 µg/L), and 17 (42.5%) samples had quantifiable AMPA (95th percentile: 0.38 µg/L; max: 0.41 µg/L). In contrast, 4 (10%) and 6 (15%) of the samples

collected in 2001 had quantifiable glyphosate (95th percentile: 0.26 µg/L; max: 0.40 µg/L) and AMPA (95th percentile: 0.25 µg/L; max: 0.29 µg/L) levels, respectively. The highest measured levels of glyphosate and AMPA were observed in 2013. For glyphosate, detected in 22 of 39 samples (56.4%), the 95th percentile concentration was 1.25 µg/L and the maximum was 2.8 µg/L. For AMPA, detected in 19 of 39 samples (48.7%) in 2013, the 95th percentile concentration was 1.54 µg/L and the maximum was 1.88 µg/L.

A subset of urine samples from 13 Danish mothers and 14 Danish child participants in the DEMOCOPHES (Demonstration of a study to Coordinate and Perform Human biomonitoring on a European Scale) project were evaluated for glyphosate using an immunoassay approach. Samples were collected in 2011-2012. The mean urinary glyphosate level in mothers was 1.28 µg/L (range: 0.49-3.22 µg/L) and the mean level in children was 1.96 µg/L (range: 0.85-3.31 µg/L). All samples evaluated for glyphosate had detectable levels and no difference in levels was observed between urban and rural residences (Knudsen et al., 2017).

Aris and Leblanc (2011) developed an analytical method to measure glyphosate, AMPA, glufosinate-ammonium, and 3-MPPA simultaneously in serum samples. They reported results for serum samples from pregnant women (n = 30), umbilical cords (n = 30), and non-pregnant women (n = 39) in Québec, Canada. The method detection limits for glyphosate, AMPA, glufosinate-ammonium, and 3-MPPA were 15, 10, 10, and 5 µg/L, respectively. Glyphosate, AMPA, and glufosinate-ammonium were not detected in serum samples collected from pregnant women or from umbilical cords. 3-MPPA was detected in 100% of the samples from pregnant women (mean: 120 µg/L; range: 21.9-417 µg/L) and from umbilical cords (mean: 57.2 µg/L; range: 8.8-193 µg/L). Of the non-pregnant women, 2 (5%) had detectable serum glyphosate (range: ND-93.6 µg/L), none had detectable serum AMPA, 7 (18%) had detectable glufosinate-ammonium (mean: 28.7 µg/L; range: ND-53.6 µg/L), and 26 (67%) had detectable 3-MPPA (mean: 84.1 µg/L; range: ND-337 µg/L).

Kongtip et al. (2017) measured glyphosate levels in serum samples collected from Thai women at childbirth (n = 82) and umbilical cord samples (n = 75). Of the serum samples collected from the women, 53.7% (n = 44) had glyphosate levels greater than the LOD of 0.4 µg/L. Of the umbilical cord serum samples analyzed, 49.3% (n = 37) had glyphosate levels greater than the LOD. The median levels of glyphosate measured were 17.5 µg/L (range: 0.2-189.1 µg/L) in the women and 0.2 µg/L (range: 0.2-94.9 µg/L) in the cord serum. AMPA was not measured in this study.

McGuire et al. (2016) tested for glyphosate and AMPA in breast milk (n = 41) and urine (n = 40) samples collected from 41 women living in Idaho and Washington. The LODs for glyphosate and AMPA in breast milk were both 1.0 µg/L, with LOQs of 10.0 µg/L for both analytes. The LODs and LOQs for glyphosate in urine were 0.02 and 0.10 µg/L,

Organophosphorus pesticides

respectively; those for AMPA in urine were 0.03 and 0.10 µg/L, respectively. Glyphosate and AMPA were not detected in breast milk samples, but were detected in over 90% of the urine samples. Urinary levels of both were quantifiable in 72.5% (n = 29) of samples. The authors reported mean urinary glyphosate at 0.28 µg/L (SD: 0.38 µg/L; range: < LOD-1.93 µg/L) and mean urinary AMPA at 0.30 µg/L (SD: 0.33 µg/L; range: < LOD-1.33 µg/L).

Steinborn et al. (2016) tested for glyphosate in breast milk samples (n = 114) collected from German women in 2015. All glyphosate values in breast milk were below the reported LOD of 0.5 µg/L. AMPA was not measured in this study.

Other highlighted organophosphorus pesticides

Lunchick et al. (2005) measured ethoprop and its primary metabolite, O-ethyl-S-propyl phosphorothioate, in urine samples collected from pesticide applicators (n = 20) in Washington. Samples were collected on the day of ethoprop application and for each of the consecutive 3 days (total of 4 days of sample collection). None of the urine samples had ethoprop levels that exceeded the LOD of 1.6 µg/L, but the metabolite O-ethyl-S-propyl phosphorothioate was detected (reported as a total mass during the 4-day collection period; range of 4.2-982 µg).

In work conducted for a dissertation, Kuklenyik (2009) developed an analytical method to measure the parent chemicals for 39 organophosphorus pesticides in human serum. The pesticide panel included bensulide, ethoprop, and tribufos, and the LODs were 1.0, 85, and 27 ng/L, respectively. Kuklenyik applied the method to samples collected from farm workers using organophosphorus pesticides, but did not report those results.

Analytical considerations

The Environmental Health Laboratory (EHL) of the California Department of Public Health (one of Biomonitoring California's laboratories) has developed two analytical methods for organophosphate pesticides. EHL's universal pesticide method measures a number of specific urinary metabolites, including 3,5,6-trichloro-2-pyridinol (TCPy, a metabolite of chlorpyrifos and chlorpyrifos-methyl) and 2-isopropyl-6-methyl-4-pyrimidinol (IMPY, a metabolite of diazinon), using an isotope dilution high-performance liquid chromatography (HPLC)/tandem mass spectrometer (MS/MS) approach (Behniwal and She, 2017). The LOD for TCPy is 0.5 µg/L and for IMPY is 0.05 µg/L. EHL also measures four non-specific DAP metabolites in urine, using an isotope dilution gas chromatography (GC)/tandem mass spectrometer (MS/MS) method (Wang et al., 2013).

For Biomonitoring California to measure any of the highlighted organophosphorus pesticides, additional method development would be required.

Need to assess efficacy of public health action

Adding organophosphorus pesticides as a class to Biomonitoring California's list of designated chemicals would allow any member of the class to be included in a future study. The Program would have the flexibility to choose analytes appropriate to the particular scenario of interest. By measuring these pesticides in California residents, we can track the levels of exposure and how they change over time and by region. The results of biomonitoring studies can inform ongoing state efforts to reduce pesticide exposures of concern.

Organophosphorus pesticides

Attachment A: Organophosphate insecticides currently on the list of designated chemicals. Metabolites are shown indented underneath the parent compounds.

| | |
|---|---|
| Acephate | Isazophos-methyl |
| Methamidophos | 5-Chloro-1,2-dihydro-1-isopropyl-[3H]-1,2,4-triazol-3-one |
| Azinphos methyl | Dimethylphosphate |
| Dimethyldithiophosphate | Dimethylthiophosphate |
| Dimethylphosphate | Malathion |
| Dimethylthiophosphate | Dimethyldithiophosphate |
| Chlorethoxyphos | Dimethylphosphate |
| Diethylphosphate | Dimethylthiophosphate |
| Diethylthiophosphate | Malathion dicarboxylic acid |
| Chlorpyrifos | Methamidophos |
| Diethylphosphate | Methidathion |
| Diethylthiophosphate | Dimethyldithiophosphate |
| 3,5,6-Trichloro-2-pyridinol (TCPy) | Dimethylphosphate |
| Chlorpyrifos-methyl | Dimethylthiophosphate |
| Dimethylphosphate | Methyl parathion |
| Dimethylthiophosphate | Dimethylphosphate |
| 3,5,6-Trichloro-2-pyridinol (TCPy) | Dimethylthiophosphate |
| Coumaphos | <p>-Nitrophenol</p> |
| 3-Chloro-7-hydroxy-4-methyl-2H-chromen-2-one/ol | Naled |
| Diethylphosphate | Dimethylphosphate |
| Diethylthiophosphate | Oxydemeton-methyl |
| Diazinon | Dimethylphosphate |
| Diethylphosphate | Dimethylthiophosphate |
| Diethylthiophosphate | Parathion (Ethyl parathion) |
| 2-Isopropyl-4-methyl-6-hydroxypyrimidine | Diethylphosphate |
| Dichlorvos (DDVP) | Diethylthiophosphate |
| Dimethylphosphate | <p>-Nitrophenol</p> |
| Dicrotophos | Phorate |
| Dimethylphosphate | Diethyldithiophosphate |
| Dimethoate | Diethylphosphate |
| Dimethyldithiophosphate | Diethylthiophosphate |
| Dimethylphosphate | Phosmet (Imidan) |
| Dimethylthiophosphate | Dimethyldithiophosphate |
| Omethoate | Dimethylphosphate |
| Disulfoton | Dimethylthiophosphate |
| Diethyldithiophosphate | Pirimiphos-methyl |
| Diethylphosphate | 2-(Diethylamino)-6-methylpyrimidin-4-ol/one |
| Diethylthiophosphate | Dimethylphosphate |
| Ethion | Dimethylthiophosphate |
| Diethyldithiophosphate | Sulfotepp |
| Diethylphosphate | Diethylphosphate |
| Diethylthiophosphate | Diethylthiophosphate |
| Fenitrothion | Temephos |
| Dimethylphosphate | Dimethylphosphate |
| Dimethylthiophosphate | Dimethylthiophosphate |
| Fenthion | Terbufos |
| Dimethylphosphate | Diethyldithiophosphate |
| Dimethylthiophosphate | Diethylphosphate |
| | Diethylthiophosphate |
| | Tetrachlorvinphos |
| | Dimethylphosphate |

References consulted (not all references are cited in the text)

- Acquavella JF, Alexander BH, Mandel JS, Gustin C et al. (2004). Glyphosate biomonitoring for farmers and their families: results from the Farm Family Exposure Study. *Environ Health Perspect* 112:321-326.
- Adams A, Friesen M, Olson A, and Gerona R (2015). Biomonitoring of glyphosate across the United States in urine and tap water using high-fidelity LC-MS/MS method. Asia Pacific Association of Medical Toxicology International Scientific Conference, Perth, Australia.
- Andersen HR, Vinggaard AM, Rasmussem TH, Gjermansen IM et al. (2002). Effects of currently used pesticides used in assays for estrogenicity, androgenicity, and aromatase activity *in vitro*. *Toxicol Appl Pharmacol* 179:1-12.
- Antonious GF (2010). Mobility and half-life of bensulide in agricultural soil. *J Environ Sci Health B* 45:1-10.
- Aris A and Leblanc S (2011). Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern Townships of Québec, Canada. *Reprod Toxicol* 31:528-533.
- Bain C, Selfa T, Dandachi T, and Velardi S (2017). 'Superweeds' or 'survivors'? Framing the problem of glyphosate resistant weeds and genetically engineered crops. *J Rural Stud* 51:211-221.
- Barr DB, Bravo R, Weerasekera G, Caltabiano LM et al. (2004). Concentrations of dialkyl phosphate metabolites of organophosphorus pesticides in the US population. *Environ Health Perspect* 112:186-200.
- Barr DB, Allen R, Olsson AO, Bravo R et al. (2005). Concentrations of selective metabolites of organophosphorus pesticides in the United States population. *Environ Res* 99:314-326.
- Battaglin WA, Meyer MT, Kuivila KM, and Dietze JE (2014). Glyphosate and its degradation product AMPA occur frequently and widely in US soils, surface water, groundwater, and precipitation. *J Am Water Resour Assoc* 50:275-290.
- Beard JD, Umbach DM, Hoppin JA, Richards M et al. (2014). Pesticide exposure and depression among male private pesticide applicators in the Agricultural Health Study. *Environ Health Perspect* 122:984-991.
- Behniwal PK and She J (2017). Development of HPLC-MS/MS method for the simultaneous determination of metabolites of organophosphate pesticides, synthetic pyrethroids, herbicides and DEET in human urine. *Int J Environ Anal Chem*. Epub ahead of print.
- Benachour N, Sipahutar H, Moslemi S, Gasnier C et al. (2007). Time- and dose-dependent effects of Roundup on human embryonic and placental cells. *Arch Environ Contam Toxicol* 53:126-133.
- Bento CP, Yang X, Gort G, Xue S et al. (2016). Persistence of glyphosate and aminomethylphosphonic acid in loess soil under different combinations of temperature, soil moisture and light/darkness. *Sci Total Environ* 572:301-311.
- Bento CP, Goossens D, Rezaei M, Riksen M et al. (2017). Glyphosate and AMPA distribution in wind-eroded sediment derived from loess soil. *Environ Pollut* 220:1079-1089.
- Blacker A, Breum R, Dacus S, Kwiatkowski P et al. (2011). Bayer CropScience's position on the findings of glufosinate and its metabolite. *Reprod Toxicol* 32:494-495.
- Borggaard OK and Gimsing AL (2008). Fate of glyphosate in soil and the possibility of leaching to ground and surface waters: a review. *Pest Manag Sci* 64:441-456.
- Bradman A, Harnly ME, Draper W, Seidel S et al. (1997). Pesticide exposures to children from California's Central Valley: Results of a pilot study. *J Expo Anal Environ Epidemiol* 7:217-234.

Organophosphorus pesticides

- Bradman A, Eskenazi B, Barr DB, Bravo R et al. (2005). Organophosphate urinary metabolite levels during pregnancy and after delivery in women living in an agricultural community. *Environ Health Perspect* 113:1802-1807.
- Bradman A, Quirós-Alcalá L, Castorina R, Aguilar Schall R et al. (2015). Effect of organic diet intervention on pesticide exposures in young children living in low-income urban and agricultural communities. *Environ Health Perspect* 123:1086-1093.
- Calas AG, Richard O, Mème S, Beloeil JC et al. (2008). Chronic exposure to glufosinate-ammonium induces spatial memory impairments, hippocampal MRI modifications and glutamine synthetase activation in mice. *Neurotoxicology* 29:740-747.
- Camann DE, Schultz ST, Yau AY, Heilbrun LP et al. (2013). Acetaminophen, pesticide, and diethylhexyl phthalate metabolites, anandamide, and fatty acids in deciduous molars: potential biomarkers of perinatal exposure. *J Expo Sci Environ Epidemiol* 23:190-196.
- Casida J and Quistad GB (2005). Serine hydrolase targets of organophosphorus toxicants. *Chem Biol Interact* 157-158:277-283.
- Casida J (2017). Organophosphorus xenobiotic toxicology. *Annu Rev Pharmacol Toxicol* 57:309-327.
- CDC (Centers for Disease Control and Prevention) (2017). Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables, January 2017, Volume One. Available at: https://www.cdc.gov/exposurereport/pdf/FourthReport_UpdatedTables_Volume1_Jan2017.pdf
- CEHTP (California Environmental Health Tracking Program) (2014). Agricultural Pesticide Use Near Public Schools in California. Available at: <http://cehtp.org/download/pesticides/pesticides-schools-report-april2014>.
- Çetinkaya and Baydan (2010). Investigation of *in vitro* effects of ethephon and chlorpyrifos, either alone or in combination, on rat intestinal muscle contraction. *Interdiscip Toxicol* 3:35-39.
- CFIA (Canadian Food Inspection Agency) (2017). Safeguarding with Science: Glyphosate Testing in 2015-2016. Available at: http://www.inspection.gc.ca/DAM/DAM-food-aliments/STAGING/text-texte/chem_testing_report_2015-2016_glyphosate_srvy_rprt_1491855525292_eng.pdf.
- Chang FC, Simcik MF, and Capel PD (2011). Occurrence and fate of the herbicide glyphosate and its degradate aminomethylphosphonic acid in the atmosphere. *Environ Toxicol Chem* 30:548-555.
- Chłopecka M, Mendel M, Dziekan N, and Karlik W (2014). Glyphosate affects the spontaneous motoric activity of intestine at very low doses- *In vitro* study. *Pestic Biochem Physiol* 113:25-30.
- Chłopecka M, Mendel M, Dziekan N, and Karlik W (2017). The effect of glyphosate-based herbicide Roundup and its co-formulant, POEA, on the motoric activity of rat intestine- *In vitro* study. *Environ Toxicol Pharmacol* 49:156-162.
- Conrad A, Schröter-Kermani C, Hoppe HW, Rüter M et al. (2017). Glyphosate in German adults- Time trend (2001 to 2015) of human exposure to a widely used herbicide. *Int J Hyg Environ Health* 220:8-16.
- Coscollà C, Colin P, Yahyaoui A, Petrique O et al. (2010). Occurrence of currently used pesticides in ambient air of Centre Region (France). *Atmos Environ* 44:3915-3925.
- Coupe RH, Manning MA, Foreman WT, Goolsby DA et al. (2000). Occurrence of pesticides in rain and air in urban and agricultural areas of Mississippi, April-September 1995. *Sci Total Environ* 248:227-240.
- Coupe RH, Kalkhoff SJ, Capel PD, and Gregoire C (2012). Fate and transport of glyphosate and aminomethylphosphonic acid in surface waters of agricultural basins. *Pest Manag Sci* 68:16-30.

Organophosphorus pesticides

- Cunha CP, Roberto GG, Vicentini R, Lembke CG et al. (2017). Ethylene-induced transcriptional and hormonal responses at the onset of sugarcane ripening. *Sci Rep*. Epub ahead of print. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5339719/pdf/srep43364.pdf>
- Curwin BD, Hein MJ, Sanderson WT, Nishioka MG et al. (2005). Pesticide contamination inside farm and nonfarm homes. *J Occup Environ Hyg* 2:357-367.
- Curwin BD, Hein MJ, Sanderson WT, Striley C et al. (2007a). Urinary pesticide concentrations among children, mothers and fathers living in farm and non-farm households in Iowa. *Ann Occup Hyg* 51:53-65.
- Curwin BD, Hein MJ, Sanderson WT, Striley C et al. (2007b). Pesticide dose estimates for children of Iowa farmers and non-farmers. *Environ Res* 105:307-315.
- Dai P, Hu P, Tang J, Li Y et al. (2016). Effect of glyphosate on reproductive organs in male rat. *Acta Histochem* 118:519-526.
- de Ávila RI, Teixeira GC, Veloso DFMC, Moreira LC et al. (2017). *In vitro* assessment of skin sensitization, photosensitization and phototoxicity potential of commercial glyphosate-containing formulations. *Toxicol In Vitro*. Epub ahead of print.
- de Souza JS, Kizys MM, da Conceição RR, Glebocki G et al. (2017). Perinatal exposure to glyphosate-based herbicide alters the thyrotrophic axis and causes thyroid hormone homeostasis imbalance in male rats. *Toxicology* 377:25-37.
- Defarge N, Takács E, Lozano VL, Mesnage R et al. (2016). Co-formulants in glyphosate-based herbicides disrupt aromatase activity in human cells below toxic levels. *Int J Environ Res Public Health* 13:1-17.
- DeSesso JM and Williams AL (2012). Comment on “Glyphosate impairs male offspring reproductive development by disrupting gonadotropin expression” by Romano et al. 2012. *Arch Toxicol* 86:1791-1793.
- Deziel NC, Colt JS, Kent EE, Gunier RB et al. (2015a). Associations between self-reported pest treatments and pesticide concentrations in carpet dust. *Environ Health* 14:1-11.
- Deziel NC, Friesen MC, Hoppin JA, Hines CJ et al. (2015b). A review of nonoccupational pathways for pesticide exposure in women living in agricultural areas. *Environ Health Perspect* 123:515-524.
- Deziel NC, Freeman LE, Graubard BI, Jones RR et al. (2017). Relative contributions of agricultural drift, para-occupational, and residential use exposure pathways to house dust pesticide concentrations: Meta-regression of published data. *Environ Health Perspect* 125:296-305.
- Dix DJ, Houck KA, Martin MT, Richard AM, et al. (2007). The ToxCast program for prioritizing toxicity testing of environmental chemicals. *Toxicol Sci* 95:5-12.
- DPR (California Department of Pesticide Regulation) (1989-2015). Summaries of Pesticide Use Report Data, Indexed by Chemical. Available at: <http://www.cdpr.ca.gov/docs/pur/purmain.htm>.
- DPR (1995). Ethoprop Risk Characterization Document. Available at: <http://www.cdpr.ca.gov/docs/risk/rcd/ethoprop.pdf>.
- DPR (1998). S,S,S-Tributyl Phosphorotrithioate (DEF) Risk Characterization Document. Available at: <http://www.cdpr.ca.gov/docs/risk/rcd/def.pdf>.
- DPR (2004). S,S,S-Tributyl Phosphorotrithioate (Tribufos) Risk Characterization Document (Revision No. 1). Available at: http://www.cdpr.ca.gov/docs/risk/rcd/def_r1.pdf.
- DPR (2012). Summary of Pesticide Use Report Data, Indexed by Chemical. Available at: <http://www.cdpr.ca.gov/docs/pur/pur12rep/chmrpt12.pdf>.

Organophosphorus pesticides

DPR (2013). Summary of Pesticide Use Report Data, Indexed by Chemical. Available at: <http://www.cdpr.ca.gov/docs/pur/pur13rep/chmrpt13.pdf>.

DPR (2014). California Pesticide Residue Monitoring Program Manual, Appendix 4: Partial list of pesticides detected by multi-residue screens. Available from DPR upon request.

DPR (2015a). The Top 100 Pesticides by Pounds, Used Statewide (All Sites Combined) in 2015. Available at: http://www.cdpr.ca.gov/docs/pur/pur15rep/top_100_ais_lbs_2015.pdf.

DPR (2015b). Summary of Pesticide Use Report Data, Indexed by Chemical. Available at: <http://www.cdpr.ca.gov/docs/pur/pur15rep/chmrpt15.pdf>.

DPR (2015c). Notice of Final Decision Concerning the Reevaluation of Chlorpyrifos. Available at: <http://www.cdpr.ca.gov/docs/registration/canot/2015/ca2015-08.pdf>.

DPR (2015d). Pesticide Residues in Fresh Produce- 2015 Annual Residue Data. Available at: <http://www.cdpr.ca.gov/docs/enforce/residue/rsmonmnu.htm>.

DPR (2016). Sampling for Pesticide Residues in California Well Water. Available at: <http://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/eh2016.pdf>.

DPR (2017a). Air Monitoring Network Results for 2015, Volume 5. Available at: http://www.cdpr.ca.gov/docs/emon/airinit/amn_2015_report_final.pdf.

DPR (2017b). News Release: California Announces Revised Proposed Rules on Agricultural Pesticide Use Near Schools and Child Day-care Centers. Available at: <http://www.cdpr.ca.gov/docs/pressrls/2017/031617.htm>.

EFSA (European Food Safety Authority) (2013). Conclusion on the peer review of the pesticide risk assessment of the active substance fosetyl. Available at: <http://onlinelibrary.wiley.com/doi/10.2903/j.efsa.2006.54r/epdf>.

El Raouf AA and Girgis SM (2011). Mutagenic, teratogenic, and biochemical effects of ethephon on pregnant mice and their fetuses. *Glob Vet* 6:251-257.

Engel SM, Bradman A, Wolff MS, Rauh VA et al. (2016). Prenatal organophosphorus pesticide exposure and child neurodevelopment at 24 months: An analysis of four birth cohorts. *Environ Health Perspect* 124:822-830.

EWG (Environmental Working Group) (2009). National Drinking Water Database. Available at: <http://www.ewg.org/tap-water/>.

FDA (US Food and Drug Administration) (2014a). Pesticide Residue Monitoring Program Fiscal Year 2014 Pesticide Report. Available at: <https://www.fda.gov/downloads/Food/FoodborneIllnessContaminants/Pesticides/UCM546325.pdf>.

FDA (2014b). Pesticide Residue Monitoring Analytical Data File- Sample Data 2014. Available at: <https://www.fda.gov/Food/FoodborneIllnessContaminants/Pesticides/ucm546327.htm>.

Fenske RA, Hamburger SJ, and Guyton CL (1987). Occupational exposure to fosetyl-al fungicide during spraying of ornamentals in greenhouses. *Arch Environ Contam Toxicol* 16:615-621.

Fenske RA, Lu C, Simcox NJ, Loewenherz C et al. (2000). Strategies for assessing children's organophosphorus pesticide exposures in agricultural communities. *J Expo Anal Environ Epidemiol* 10:662-671.

Organophosphorus pesticides

- Fenske RA, Kedan G, Lu C, Fisker-Andersen JA et al. (2002). Assessment of organophosphorus pesticide exposures in the diets of preschool children in Washington State. *J Expo Anal Environ Epidemiol* 12:21-28.
- Ford B, Bateman LA, Gutierrez-Palominos L, Park R et al. (2017). Mapping proteome-wide targets of glyphosate in mice. *Cell Chem Biol* 24:133-140.
- GAO (US Government Accountability Office) (2014). Food Safety- FDA and USDA Should Strengthen Pesticide Residue Monitoring Programs and Further Disclose Monitoring Limitations. Available at: <http://www.gao.gov/assets/670/666408.pdf>.
- Gallegos CE, Bartos M, Bras C, Gumilar F et al. (2016). Exposure to a glyphosate-based herbicide during pregnancy and lactation induces neurobehavioral alterations in rat offspring. *Neurotoxicology* 53:20-28.
- García AM, Benavides FG, Fletcher T, and Orts E (1998). Paternal exposure to pesticides and congenital malformations. *Scand J Work Environ Health* 24:473-480.
- Garry VF, Harkins ME, Erickson LL, Long-Simpson LK et al. (2002). Birth defects, season of conception, and sex of children born to pesticide applicators living in the Red River Valley of Minnesota, USA. *Environ Health Perspect* 110:441-449.
- Gasnier C, Dumont C, Benachour N, Clair E et al. (2009). Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines. *Toxicology* 262:184-191.
- Gibbs JL, Yost MG, Negrete M, and Fenske RA (2017). Passive sampling for indoor and outdoor exposures to chlorpyrifos, azinphos-methyl, and oxygen analogs in a rural agricultural community. *Environ Health Perspect* 125:333-341.
- Goldner WS, Sandler DP, Yu F, Shostrom V et al. (2013). Hypothyroidism and pesticide use among male private pesticide applicators in the Agricultural Health Study. *J Occup Environ Med* 55:1171-1178.
- Green JM. (2016). The rise and future of glyphosate and glyphosate-resistant crops. *Pest Manag Sci*. Epub ahead of print.
- Guerrero Schimpf M, Milesi MM, Ingaramo PI, Luque EH et al. (2017). Neonatal exposure to a glyphosate based herbicide alters the development of the rat uterus. *Toxicology*. Epub ahead of print.
- Gunier RB, Nuckols JR, Whitehead TP, Colt JS et al. (2016). Temporal trends of insecticide concentrations in carpet dust in California from 2001 to 2006. *Environ Sci Technol* 50:7761-7769.
- Gunier RB, Bradman A, Harley KG, Kogut K et al. (2017). Prenatal residential proximity to agricultural pesticide use and IQ in 7-year-old children. *Environ Health Perspect*. Epub ahead of print. Available at: <https://ehp.niehs.nih.gov/wp-content/uploads/advpub/2016/7/EHP504.acco.pdf>.
- Harley KG, Engel SM, Vedar MG, Eskenazi B et al. (2016). Prenatal exposure to organophosphorus pesticides and fetal growth: Pooled results from four longitudinal birth cohort studies. *Environ Health Perspect* 124:1084-1092.
- Hart E, Coscollà C, Pastor A, and Yusà V (2012). GC-MS characterization of contemporary pesticides in PM₁₀ of Valencia Region, Spain. *Atmos Environ* 62:118-129.
- Haux JE, Lockridge O, and Casida JE. (2002). Specificity of ethephon as a butyrylcholinesterase inhibitor and phosphorylating agent. *Chem Res Toxicol* 15:1527-1533.
- Hermann BW and Selber JN (1981). Sampling and determination of S,S,S-tributyl phosphorotrithioate, dibutyl disulfide, and butyl mercaptan in field air. *Anal Chem* 53:1077-1082.

Organophosphorus pesticides

Herzine A, Laugeray A, Feat J, Menuet A et al. (2016). Perinatal exposure to glufosinate ammonium herbicide impairs neurogenesis and neuroblast migration through cytoskeleton destabilization. *Front Cell Neurosci* 10:1-18.

Holme F, Thompson B, Holte S, Vigoren EM et al. (2016). The role of diet in children's exposure to organophosphate pesticides. *Environ Res* 147:133-140.

Honeycutt Z and Rowlands H (2014). Glyphosate Testing Full Report: Findings in American Mothers' Breast Milk, Urine and Water. Available at: http://d3n8a8pro7vhm.cloudfront.net/yesmaam/pages/774/attachments/original/1396803706/Glyphosate_Final_in_the_breast_milk_of_American_women_Draft6_.pdf?1396803706.

Hoppe HW (2013). Determination of glyphosate residues in human urine samples from 18 European countries. Available at: https://www.foeeurope.org/sites/default/files/glyphosate_studyresults_june12.pdf.

Hoppin JA, Umbach DM, London SJ, Henneberger PK et al. (2008). Pesticides and atopic and nonatopic asthma among farm women in the Agricultural Health Study. *Am J Respir Crit Care Med* 177:11-18.

Hoppin JA, Umbach DM, London SJ, Henneberger PK et al. (2009). Pesticide use and adult-onset asthma among male farmers in the Agricultural Health Study. *Eur Respir J* 34:1296-1303.

Hoppin JA, Umbach DM, Long S, London SJ et al. (2017). Pesticides are associated with allergic and non-allergic wheeze among male farmers. *Environ Health Perspect* 125:535-543.

Hyland C and Laribi O (2017). Review of take-home pesticide exposure pathway in children living in agricultural areas. *Environ Res* 156:559-570.

IARC (International Agency for Research on Cancer) (2017a). List of Classifications. May 19, 2017 version. Available at: http://monographs.iarc.fr/ENG/Classification/latest_classif.php.

IARC (2017b). Some Organophosphate Insecticides and Herbicides, Volume 112. Available at: <http://monographs.iarc.fr/ENG/Monographs/vol112/mono112.pdf>.

Jauhiainen A, Räsänen K, Sarantila R, Nuutinen J et al. (1991). Occupational exposure of forest workers to glyphosate during brush saw spraying work. *Am Ind Hyg Assoc J*. 52:61-64.

Jensen PK, Wujcik CE, McGuire MK, and McGuire MA (2016). Validation of reliable and selective methods for direct determination of glyphosate and aminomethylphosphonic acid in milk and urine using LC-MS/MS. *J Environ Sci Health B* 51:254-259.

Jomichen J, El-Zaemey S, Heyworth JS, Carey RN et al. (2017). Australian work exposures studies: occupational exposure to pesticides. *Occup Environ Med* 74:46-51.

Kamel F, Engel LS, Gladen BC, Hoppin JA et al. (2007). Neurologic symptoms in licensed pesticide applicators in the Agricultural Health Study. *Hum Exp Toxicol* 26:243-250.

Kavlock R, Chandler K, Houck K, Hunter S et al. (2012). Update on EPA's ToxCast program: providing high throughput decision support tools for chemical risk management. *Chem Res Toxicol* 25:1287-1302.

Knudsen LE, Hansen PW, Mizrak S, Hansen HK et al. (2017). Biomonitoring of Danish school children and mothers including biomarkers of PBDE and glyphosate. *Rev Environ Health*. Epub ahead of print. Available at: <https://www.degruyter.com/downloadpdf/j/reveh.ahead-of-print/reveh-2016-0067/reveh-2016-0067.pdf>.

Kongtip P, Nankongnab N, Phupancharoensuk R, Palarach C et al. (2017). Glyphosate and paraquat in maternal and fetal serums in Thai women. 22:282-289.

Organophosphorus pesticides

- Koureas M, Tsezou A, Tsakalof A, Orfanidou T et al. (2014). Increased levels of oxidative DNA damage in pesticide sprayers in Thessaly Region (Greece). Implications of pesticide exposure. *Sci Total Environ* 496:358-364.
- Krüger M, Schledorn P, Schrödl W, Hoppe HW et al. (2014). Detection of glyphosate residues in animals and humans. *J Environ Anal Toxicol* 4:1-5.
- Kuklennyik P (2009). Detection and quantification of organophosphate pesticides in human serum. Dissertation, Georgia State University. Available at: http://scholarworks.gsu.edu/cgi/viewcontent.cgi?article=1045&context=chemistry_diss.
- Kumar S, Khodoun M, Kettleson EM, McKnight C et al. (2014). Glyphosate-rich air samples induce IL-33, TSLP and generate IL-13 dependent airway inflammation. *Toxicology* 325:42-51.
- Kwiatkowska M, Reszka E, Woźniak K, Jabłońska E et al. (2017). DNA damage and methylation induced by glyphosate in human peripheral blood mononuclear cells (*in vitro* study). *Food Chem Toxicol* 105:93-98.
- Laitinen P, Siimes K, Eronen L, Rämö S et al. (2006). Fate of herbicides glyphosate, glufosinate-ammonium, phenmedipham, ethofumesate and metamitron in two Finish arable soils. *Pest Manag Sci* 62:473-491.
- Larsen K, Najle R, Lifschitz A, and Virkel G (2012). Effect of sub-lethal exposure of rats to the herbicide glyphosate in drinking water: Glutathione transferase enzyme activities, levels of reduced glutathione and lipid peroxidation in liver, kidneys and small intestine. *Environ Toxicol Pharmacol* 34:811-818.
- Laugeray A, Herzine A, Perche O, Hébert B et al. (2014). Pre- and postnatal exposure to low dose glufosinate ammonium induces autism-like phenotypes in mice. *Front Behav Neurosci* 8:1-14.
- Lesmes-Fabian C and Binder CR (2013). Pesticide flow analysis to assess human exposure in greenhouse flower production in Colombia. *Int J Environ Res Public Health* 10:1168-1185.
- Liyasova MS, Schopfer LM, Kodani S, Lantz SR et al. (2013). Newly observed spontaneous activation of ethephon as a butyrylcholinesterase inhibitor. *Chem Res Toxicol* 26:422-431.
- Lopes FM, Varela Junior AS, Corcini CD, da Silva AC et al. (2014). Effect of glyphosate on the sperm quality of zebrafish *Danio rerio*. *Aquat Toxicol* 155:322-326.
- Lopes FM, Caldas SS, Primel EG, and da Rosa CE (2017). Glyphosate adversely affects *Danio rerio* males: Acetylcholinesterase modulation and oxidative stress. *Zebrafish* 14:97-105.
- Lotti M, Becker CE, Aminoff MJ, Woodrow JE et al. (1983). Occupational exposure to the cotton defoliant DEF and merphos. A rational approach to monitoring organophosphorus-induced delayed neurotoxicity. *J Occup Med* 25:517-522.
- Lu C, Fenske RA, Simcox NJ, and Kalman D (2000). Pesticide exposure of children in an agricultural community: Evidence of household proximity to farmland and take home exposure pathways. *Environ Res* 84:290-302.
- Lu C, Toepel K, Irish R, Fenske RA et al. (2006). Organic diets significantly lower children's dietary exposure to organophosphorus pesticides. *Environ Health Perspect* 114:260-263.
- Lunchick C, Honeycutt R, and Klonne D (2005). Biological monitoring use in refining the exposure assessment of agricultural workers. *Scan J Work Environ Health* 31:82-89.
- Luo L, Wang F, Zhang Y, Zeng M et al. (2017). *In vitro* cytotoxicity assessment of roundup (glyphosate) in L-02 hepatocytes. *J Environ Sci Health B* 52:410-417.

Organophosphorus pesticides

- Mahler BJ, Van Metre PC, Burley TE, Loftkin KA et al. (2017). Similarities and differences in occurrence and temporal fluctuations in glyphosate and atrazine in small Midwestern streams (USA) during the 2013 growing season. *Sci Total Environ* 579:149-158.
- Majewski MS, Foreman WT, and Goosby DA (2000). Pesticides in the atmosphere of the Mississippi River Valley, part I- rain. *Sci Total Environ* 248:201-212.
- Majewski MS, Coupe RH, Foreman WT, and Capel PD (2014). Pesticides in Mississippi air and rain: A comparison between 1995 and 2007. *Environ Toxicol Chem* 33:1283-1293.
- Maynard JA and Swan JM (1963). Organophosphorus compounds I. 2-Chloroalkylphosphonic acids as phosphorylating agents. *Aust J Chem* 16:596-608.
- McGuire MK, McGuire MA, Price WJ, Shafii B et al. (2016). Glyphosate and aminomethylphosphonic acid are not detectable in human milk. *Am J Clin Nutr* 103:1285-1290.
- Medina-Cleghorn D, Heslin A, Morris PJ, Mulvihill MM et al. (2014). Multidimensional profiling platforms reveal metabolic dysregulation caused by organophosphorus pesticides. *ACS Chem Biol* 9:423-432.
- Meme S, Calas AG, Montécot C, Richard O et al. (2009). MRI characterization of structural mouse brain changes in response to chronic exposure to the glufosinate ammonium herbicide. *Toxicol Sci* 111:321-330.
- Mercurio P, Flores F, Mueller JF, Carter S et al. (2014). Glyphosate persistence in seawater. *Mar Pollut Bull* 85:385-390.
- Mesnager R, Defarge N, Spiroux de Vendômois J, and Séralini GE (2015). Potential toxic effects of glyphosate and its commercial formulations below regulatory limits. *Food Chem Toxicol* 84:133-153.
- Mesnager R, Renney G, Séralini GE, Ward M et al. (2017). Multiomics reveal non-alcoholic fatty liver disease in rats following chronic exposure to an ultra-low dose of Roundup herbicide. *Sci Rep* 7:1-15.
- Morshed MM, Omar D, Mohamad RB, and Wahed SBA (2011). Determination of glyphosate through passive and active sampling methods in a treated field atmosphere. *Afr J Agric Res* 6:4010-4018.
- Mostafalou S and Abdollahi M (2017). Pesticides: an update of human exposure and toxicity. *Arch Toxicol* 91:549-599.
- Myers JP, Antoniou MN, Blumberg B, Carroll L et al. (2016). Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement. *Environ Health* 15:1-13.
- Narayan S, Liew Z, Paul K, Lee PC et al. (2013) Household organophosphorus pesticide use and Parkinson's disease. *Int J Epidemiol* 42:1476-1485.
- Nardi J, Moras PB, Koeppe C, Dallegrave E et al. (2017). Prepubertal subchronic exposure to soy milk and glyphosate leads to endocrine disruption. *Food Chem Toxicol* 100:247-252.
- Niemann L, Sieke C, Pfiel R, and Solecki R (2015). A critical review of glyphosate findings in human urine samples and comparison with the exposure of operators and consumers. *J Verbr Lebensm* 10:3-12.
- Office of Environmental Health Hazard Assessment (OEHHA) (2007). Public Health Goal for Glyphosate in Drinking Water. Available at:
https://oehha.ca.gov/media/downloads/water/chemicals/phg/glyphg062907_0.pdf.
- OEHHA (2012). Green Chemistry Hazard Traits for California's Toxics Information Clearinghouse. California Code of Regulations, Title 22, Division 4.5, Chapter 54, §§ 69401–69407.2. Available at:
<https://oehha.ca.gov/media/downloads/risk-assessment/gcregtext011912.pdf>.

Organophosphorus pesticides

OEHHA (2016). Preliminary Screening Information on Possible Pesticide Classes for Future Consideration. Available at:

http://biomonitoring.ca.gov/sites/default/files/downloads/PossiblePesticideClasses_072816.pdf.

OEHHA (2017). Glyphosate to be Listed under Proposition 65 as Known to the State to Cause Cancer. Available at: <https://oehha.ca.gov/proposition-65/cnr/glyphosate-be-listed-under-proposition-65-known-state-cause-cancer>.

Ophir A, Karakis I, Richter ED, Abarbanel JM et al. (2014). An uncommon pattern of polyneuropathy induced by lifetime exposures to drift containing organophosphate pesticides. *Neurotoxicology* 45:338-346.

Owagboriaye FO, Dedeke GA, Ademolu KO, Olujimi OO et al. (2017). Reproductive toxicity of Roundup herbicide exposure in male albino rat. *Exp Toxicol Pathol*. Epub ahead of print.

Paganelli A, Gnazzo V, Acosta H, López SL et al. (2010). Glyphosate-based herbicides produce teratogenic effects on vertebrates by impairing retinoic acid signaling. *Chem Res Toxicol* 23:1586-1595.

Parks CG, Hoppin JA, De Roos AJ, Costenbader KH et al. (2016). Rheumatoid arthritis in Agricultural Health Study spouses: Associations with pesticides and other farm exposures. *Environ Health Perspect* 124:1728-1734.

Quest JA, Hamernik KL, Engler R, Burnam WL et al. (1991). Evaluation of the carcinogenic potential of pesticides. 3. Alette. *Regul Toxicol Pharmacol* 14:3-11.

Quirós-Alcalá L, Bradman A, Nishioka M, Harnly ME et al. (2011). Pesticides in house dust from urban and farmworker households in California: an observational measurement study. *Environ Health* 10:1-15.

Quistad GB, Nomura DK, Sparks SE, Segall Y et al. (2002). Cannabinoid CB1 receptor as a target for chlorpyrifos oxon and other organophosphorus pesticides. *Toxicol Lett* 135:89-93.

Raanan R, Harley KG, Balmes JR, Bradman A et al. (2015). Early-life exposure to organophosphate pesticides and pediatric respiratory symptoms in the CHAMACOS cohort. *Environ Health Perspect* 123:179-185.

Raanan R, Balmes JR, Harley KG, Gunier RB et al. (2016). Decreased lung function in 7-year-old children with early-life organophosphate exposure. *Thorax* 71:148-153.

Ranjbar M, Rotondi MA, Ardern CI, and Kuk JL (2015). The influence of urinary concentrations of organophosphate metabolites on the relationship between BMI and cardiometabolic health risk. *J Obes*. Epub ahead of print. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4558452/pdf/JOBE2015-687914.pdf>.

Rauch SA, Braun JM, Barr DB, Calafat AM et al. (2012). Associations of prenatal exposure to organophosphate pesticide metabolites with gestational age and birth weight. *Environ Health Perspect* 120:1055-1060.

Rendón-von Osten J and Dzul-Caamal R (2017). Glyphosate residues in groundwater, drinking water and urine of subsistence farmers from intensive agricultural localities: A survey in Hopelchén, Campeche, Mexico. *Int J Environ Res Public Health* 14:1-13.

Richard S, Moslemi S, Sipahutar H, Benachour N et al. (2005). Differential effects of glyphosate and Roundup on human placental cells and aromatase. *Environ Health Perspect* 113:716-720.

Romano RM, Romano MA, Bernardi MM, Furtado PV et al. (2010). Prepubertal exposure to commercial formulation of the herbicide glyphosate alters testosterone levels and testicular morphology. *Arch Toxicol* 84:309-317.

Organophosphorus pesticides

Romano MA, Romano RM, Santos LD, Wisniewski P et al. (2012). Glyphosate impairs male offspring reproductive development by disrupting gonadotropin expression. *Arch Toxicol* 86:663-673.

Rowe C, Gunier R, Bradman A, Harley KG et al. (2016). Residential proximity to organophosphate and carbamate pesticide use during pregnancy, poverty during childhood, and cognitive functioning in 10-year-old children. *Environ Res* 150:128-137.

Roy NM, Ochs J, Zambrzycka E, and Anderson A (2016a). Glyphosate induces cardiovascular toxicity in *Danio rerio*. *Environ Toxicol Pharmacol* 46:292-300.

Roy NM, Carneiro B, and Ochs J (2016b). Glyphosate induces neurotoxicity in zebrafish. *Environ Toxicol Pharmacol* 42:45-54.

Rusiecki JA, Beane Freeman LE, Bonner MR, Alexander M et al. (2017). High pesticide exposure events and DNA methylation among pesticide applicators in the Agricultural Health Study. *Environ Mol Mutagen* 58:19-29.

Saldana TM, Basso O, Hoppin JA, Baird DD et al. (2007). Pesticide exposure and self-reported gestational diabetes mellitus in the Agricultural Health Study. *Diabetes Care* 30:529-534.

Salvatore AL, Castorina R, Camacho J, Morga N et al. (2015). Home-based community health worker intervention to reduce pesticide exposures to farmworkers' children: A randomized-controlled trial. *J Expo Sci Environ Epidemiol* 25:608-615.

Schulte-Hermann R, Wogan GN, Berry C, Brown NA et al. (2006). Analysis of reproductive toxicity and classification of glufosinate-ammonium. *Regul Toxicol Pharmacol* 44:S1-S76.

Simcox NJ, Fenske RA, Wolz SA, Lee IC et al. (1995). Pesticides in household dust and soil: exposure pathways for children of agricultural families. *Environ Health Perspect* 103:1126-1134.

Slager RE, Simpson SL, Levan TD, Poole JA et al. (2010). Rhinitis associated with pesticide use among private pesticide applicators in the Agricultural Health Study. *J Toxicol Environ Health A* 73:1382-1393.

Smith AE (1988). Persistence and transformation of the herbicide [¹⁴C] glufosinate-ammonium in prairie soils under laboratory conditions. *J Agric Food Chem* 36:393-397.

Smith AE and Belyk MB (1989). Field persistence studies with the herbicide glufosinate-ammonium in Saskatchewan soils. *J Environ Qual* 18:475-479.

Smith MN, Workman T, McDonald KM, Vredevoogd MA et al. (2017). Seasonal and occupational trends of five organophosphate pesticides in house dust. *J Expo Sci Environ Epidemiol* 27:372-378.

Starks SE, Gerr F, Kamel F, Lynch CF et al. (2012a). Neurobehavioral function and organophosphate insecticide use among pesticide applicators in the Agricultural Health Study. *Neurotoxicol Teratol* 34:168-176.

Starks SE, Hoppin JA, Kamel F, Lynch CF et al. (2012b). Peripheral nervous system function and organophosphate pesticide use among licensed pesticide applicators in the Agricultural Health Study. *Environ Health Perspect* 120:515-520.

Starling AP, Umbach DM, Kamel F, Long S et al. (2014). Pesticide use and incident diabetes among wives of farmers in the Agricultural Health Study. *Occup Environ Med* 71:629-635.

State of California (2017). Chemicals Known to the State to Cause Cancer or Reproductive Toxicity. Title 27, California Code of Regulations, section 27001. Available at: <https://oehha.ca.gov/media/downloads/proposition-65/p65single01272017.pdf>.

Organophosphorus pesticides

Steinborn A, Alder L, Michalski B, Zomer P et al. (2016). Determination of glyphosate levels in breast milk samples from Germany by LC-MS/MS and GC-MS/MS. *J Agric Food Chem* 64:1414-1421.

Stokes L, Stark A, Marshall E, and Narang A (1995). Neurotoxicity among pesticide applicators exposed to organophosphates. *Occup Environ Med* 52:648-653.

Struger J, Thompson D, Staznik B, Martin P et al. (2008). Occurrence of glyphosate in surface waters of Southern Ontario. *Bull Environ Contam Toxicol*. 80:378-384.

Struger J, Van Stempvoort DR, and Brown SJ (2015). Sources of aminomethylphosphonic acid (AMPA) in urban and rural catchments in Ontario, Canada: Glyphosate or phosphonates in wastewater? *Environ Pollut* 204:289-297.

Sulukun E, Köktürk M, Ceylan H, Beydemir Ş et al. (2017). An approach to clarify the effect mechanism of glyphosate on body malformations during embryonic development of zebrafish (*Danio rerio*). *Chemosphere* 180:77-85.

Suratman S, Edwards JW, and Babina K. (2015). Organophosphate pesticides exposure among farmworkers: pathways and risk of adverse health effects. *Rev Environ Health* 30:65-79.

SWRCB (State Water Resources Control Board) (2014). Maximum Contaminant Levels and Regulatory Dates for Drinking Water, Last Updated July 2014. Available at: http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Documents/DWdocuments/MCLsEPAvsDWP-2014-07-01.pdf.

SWRCB (2015). GeoTracker GAMA (Groundwater Ambient Monitoring and Assessment) Information System. Available at: <http://geotracker.waterboards.ca.gov/gama/>.

Thompson B, Coronado GD, Grossman JE, Puschel K et al. (2003). Pesticide take-home pathway among children of agricultural workers: Study design, methods, and baseline findings. *J Occup Environ Med*. 45:42-53.

USDA (US Department of Agriculture) (2011). Pesticide Data Program Annual Summary, Calendar Year 2011. Available at: <https://www.ams.usda.gov/sites/default/files/media/2011%20PDP%20Annual%20Summary.pdf>.

USDA (2015). Pesticide Data Program Annual Summary, Calendar Year 2015. Available at: <https://www.ams.usda.gov/sites/default/files/media/2015PDPAnnualSummary.pdf>.

US EPA (US Environmental Protection Agency). Endocrine Disruption Screening Program for the 21st Century- EDSP21 Dashboard. Available at: <https://actor.epa.gov/edsp21/>.

US EPA. ToxCast Dashboard. Available at: <https://actor.epa.gov/dashboard/>.

US EPA (2008a). Ethoprop- Human Health Assessment Scoping Document in Support of Registration Review. Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0560-0005&contentType=pdf>.

US EPA (2008b). Registration Review Preliminary Problem Formulation for the Ecological Risk Assessment of Bensulide. Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0022-0006&contentType=pdf>.

US EPA (2008c). EFED Revised Problem Formulation for Registration Review for Ethoprop (Ethoprophos). Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0560-0004&contentType=pdf>.

Organophosphorus pesticides

US EPA (2009a). National Primary Drinking Water Regulations. Available at:

https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf.

US EPA (2009b). Glyphosate. Human-Health Assessment Scoping Document in Support of Registration Review. Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2009-0361-0006&contentType=pdf>.

US EPA (2009c). Tribufos. Revised Human Health Assessment Scoping Document in Support of Registration Review. Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0883-0003&contentType=msw8>.

US EPA (2009d). Registration Review- Preliminary Problem Formulation for the Ecological Risk and Drinking Water Exposure Assessments for Glyphosate and Its Salts. Available at:

<https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2009-0361-0007&contentType=pdf>.

US EPA (2012). Glufosinate Ammonium. Updated Human Health Risk Assessment for the Proposed New Use of Glufosinate Ammonium in/on Citrus Fruit (Crop Group 10), Pome Fruit (Crop Group 11), Stone Fruit (Crop Group 12), Olives and Sweet Corn. Available at:

<https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0190-0027&contentType=pdf>.

US EPA (2014a). Fosetyl-Aluminum: Registration Review Preliminary Risk Assessment. Available at:

<https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2007-0379-0025&contentType=pdf>.

US EPA (2014b). Environmental Fate and Ecological Risk Assessment for the Registration Review of Glufosinate. Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0190-0049&contentType=pdf>.

US EPA (2015a). Ethephon: Human Health Risk Assessment for Registration Review of Ethephon.

Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2010-0098-0018&contentType=pdf>.

US EPA (2015b). EDSP Weight of Evidence Analysis if Potential Interaction With the Estrogen, Androgen or Thyroid Pathways- Chemical: Ethoprop. Available at:

<https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0560-0019&disposition=attachment&contentType=pdf>.

US EPA (2015c). EDSP Weight of Evidence Analysis of Potential Interaction With the Estrogen, Androgen or Thyroid Pathways- Chemical: Glyphosate. Available at:

<https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2009-0361-0047&disposition=attachment&contentType=pdf>.

US EPA (2015d). Transmittal of the Preliminary Environmental Fate and Ecological Risk Assessment for the Registration Review of the Organophosphate Tribufos. Available at:

<https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0883-0010&contentType=pdf>.

US EPA (2015e). Environmental Fate and Ecological Risk Assessment for the Registration Review of Ethoprop. Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0560-0030&contentType=pdf>.

US EPA (2016a). Restricted Use Product Summary Report. Available at:

<https://www.epa.gov/sites/production/files/2016-02/documents/rupreport-sec3-update-jan2016.pdf>.

Organophosphorus pesticides

US EPA (2016b). Bensulide Human Health Risk Assessment to Support Registration Review. Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2008-0022-0019&contentType=pdf>.

US EPA (2016c). Persistent, Bioaccumulative, and Toxic Profiles Estimated for Organic Chemicals- PBT Profiler. Last updated September 28, 2016. Available at: <http://www.pbtprofiler.net/>.

US EPA (2016d). Office of Pesticide Programs Annual Cancer Report 2016. Available at: http://npic.orst.edu/chemicals_evaluated.pdf.

US EPA (2016e). Updated Literature Review on Neurodevelopment Effects & FQPA Safety Factor Determination for the Organophosphate Pesticides. Available at: <https://www.regulations.gov/contentStreamer?documentId=EPA-HQ-OPP-2010-0119-0060&contentType=pdf>.

US EPA (2017). Chlorpyrifos; Order Denying PANNA and NRDC's Petition to Revoke Tolerances. Docket ID EPA-HQ-OPP-2007-1005. Federal Register 82:16581-16592.

Valcin M, Henneberger PK, Kullman GJ, Umbach DM et al. (2007). Chronic bronchitis among nonsmoking farm women in the Agricultural Health Study. *J Occup Environ Med* 49:574-583.

Vandenberg LN, Blumberg B, Antoniou MN, Benbrook CM et al. (2017). Is it time to reassess current safety standards for glyphosate-based herbicides? *J Epidemiol Community Health* 71:613-618.

Voorhees JR, Rohlman DS, Lein PJ, and Pieper AA (2017). Neurotoxicity in preclinical models of occupational exposure to organophosphorus compounds. *Front Neurosci*. Epub ahead of print. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5241311/pdf/fnins-10-00590.pdf>.

Wang D, Behniwal P, Fan R, Ip S, et al. (2013). Matrix effects in analysis of dialkyl phosphate metabolites of organophosphate pesticides in urine by gas chromatography/tandem mass spectrometer. *J Environ Sci Health B* 48:177-182.

Wang L, Liu Z, Zhang J, Wu Y et al. (2016). Chlorpyrifos exposure in farmers and urban adults: Metabolic characteristic, exposure estimation, and potential effect of oxidative damage. *Environ Res* 149:164-170.

Wang S, Jin H, Tang Q, Fu J et al. (2017). The effect of ethephon on immune system in male offspring of mice. *Environ Toxicol Pharmacol* 49:119-123.

Watanabe T and Iwase T (1996). Developmental and dysmorphogenic effects of glufosinate ammonium on mouse embryos in culture. *Teratog Carcinog Mutagen* 16:287-299.

Wechsler SJ, McFadden JR, and Smith DJ. (2017). What do farmers' weed-control decisions imply about glyphosate resistance? Evidence from surveys of US corn fields. *Pest Manag Sci*. Epub ahead of print.

WHO (World Health Organization) (1994). Environmental Health Criteria 159. Glyphosate. Available at: <http://apps.who.int/iris/bitstream/10665/40044/1/9241571594-eng.pdf>.

Whyatt RM, Barr DB, Camann DE, Kinney PL et al. (2003). Contemporary-use pesticides in personal air samples during pregnancy and blood samples at delivery among urban minority mothers and newborns. *Environ Health Perspect* 111:749-756.

Zhang S, Xu J, Kuang X, Li S et al. (2017). Biological impacts of glyphosate on morphology, embryo biomechanics and larval behavior in zebrafish (*Danio rerio*). *Chemosphere* 181:270-280.