July 16, 2021

California Air Resources Board (CARB)
1001 I Street
Sacramento, California, 95814
Submitted Online

Re: Pesticides' contribution to greenhouse gas emissions must be measured

Dear Members of the California Air Resources Board:

On behalf of the Pesticide Action Network (PAN) and the statewide coalition Californians for Pesticide Reform (CPR), we thank you for the opportunity to comment. We urge CARB to fund research aimed at measuring pesticides' contribution to greenhouse gas emissions in California. Current research already indicates that reducing pesticides mitigates climate change. However, there is a lack of scientific studies that analyze the full, cumulative effects of pesticide production, transport and application on climate change and existing measurements could be vastly underestimated.

Pesticide Action Network (PAN) North America is one of five regional centers worldwide representing hundreds of organizations in more than 90 countries. We work to promote the transition to a more just and sustainable food and agriculture system that is free from hazardous pesticides. We represent more than 5,000 California members. The statewide coalition Californians for Pesticide Reform (CPR) is a statewide coalition of 200+ organizations working together to protect public health, improve environmental quality and support a sustainable and just agricultural system by building a diverse movement across California to change statewide and local pesticide policies and practices.

Pesticide reduction strategies have been critically missing from the 2022 Scoping Plan Update under Natural and Working Lands, despite their significant potential to mitigate climate change. Reduction of pesticides would also contribute to all three of CARB's goals as outlined in the Shared Vision and Roadmap: providing healthful air for all Californians, achieving carbon neutrality, and reducing emissions in communities heavily burdened by pollution and environmental stressors.

Although pesticides and their connection to greenhouse gas emissions have not been adequately studied, current research shows pesticide reduction would significantly mitigate climate change. To more comprehensively analyze pesticides' contribution to greenhouse gas emissions, we urge CARB to:

1) Fund life cycle analyses of pesticides' greenhouse gas emissions, from production to transportation to application
2) Prioritize measuring common fumigants' impacts on climate change, particularly nitrous oxide and carbon dioxide emissions

Further details for each item can be found below:

1. Fund life cycle analyses of pesticides' total contribution to greenhouse gas emissions, from production to transportation to application

Throughout all stages of their life cycle (production, transportation, storage, application and volatilization) pesticides contribute to greenhouse gas emissions both directly and indirectly. Many of these stages -- from the extraction of raw material to the production of chemicals to transportation -- require large amounts of fossil fuels. Many pesticides themselves are a form of fossil fuels (petrochemicals) and release greenhouse gases when applied. Pesticide applications can also indirectly affect greenhouse gas emissions through their effects, particularly on soil microbial activity and greenhouse gas fluxes in the soil.

However, while many other agricultural practices, such as reduced tillage or cover cropping, have been studied in relation to greenhouse gas emissions, pest management and pesticides have not received the same level of attention. And where research exists, it typically does not focus on the full life cycle of pesticides and therefore likely underestimates pesticides' impact on climate change. For instance, one study on drip-irrigated tomato production found pesticides were responsible for 89.5% of carbon emission related to inputs (15.3 kg C/kg substance) and 61% of agrochemical-GHG emissions (5991 kg CO_2-eq/ha) in this cropping system.[1] However, the study's methodology only accounted for energy from the production, transportation and storage of pesticides.

Meanwhile, other studies focus on emissions from only the application phase of the life cycle. For example, a recent study shows that the application of the third most commonly used fumigant in California -- chloropicrin -- can increase N_2O production by 700-800%.[2] The study concluded that similar classes of fumigants would yield similar increases in emissions. However, the methodology leaves out emissions related to the production and transportation of pesticides, likely underestimating the total greenhouse gas emissions directly attributable to these fumigants.

Across the board, there have been very few studies focused on quantifying pesticides' effects on soil microbial activity and its regulation of carbon and nitrogen fluxes. However, the research is clear that soil microbial activity decreases proportionally to the amount of pesticides applied to the soil.[3] Not only are soil microbes essential for the breakdown of carbon from organic matter, but they also help form stable soil organic carbon and persistent soil organic matter (SOM) through the formation of soil microaggregates, which protect SOM from decomposition.[4] This process is essential for carbon sequestration in soils. Another recent review of almost 400 studies showed pesticide use was associated with damage to soil invertebrates in more than 70% of the studies.[5] Soil invertebrates are critical to carbon sequestration in soils, being responsible for the formation of more than 50% of soil aggregates, which

[1] Jones, C. D., Fraisse, C. W., & Ozores-Hampton, M. (2012). Quantification of greenhouse gas emissions from open field-grown Florida tomato production. *Agricultural Systems*, 113, 64-72.
[2] Spokas K., Wang D. 2003. Stimulation of nitrous oxide production resulted from soil fumigation with chloropicrin. *Atmospheric Environment* 37 (2003) 3501–3507. https://doi.org/10.1016/S1352-2310(03)00412-6
[3] AL-Ani, M. A., Hmoshi, R. M., Kanaan, I. A., & Thanoon, A. A. (2019, September). Effect of pesticides on soil microorganisms. *Journal of Physics: Conference Series* (Vol. 1294, No. 7, p. 072007). IOP Publishing.
[4] Gougoulias, C., Clark, J. M., & Shaw, L. J. (2014). The role of soil microbes in the global carbon cycle: tracking the below-ground microbial processing of plant-derived carbon for manipulating carbon dynamics in agricultural systems. *Journal of the Science of Food and Agriculture*, 94(12), 2362-2371.
[5] Gunstone et al. (2021) Pesticides and Soil Invertebrates: A Hazard Assessment, Frontiers in Environmental Science. 9, 122. https://www.frontiersin.org/article/10.3389/fenvs.2021.643847.

are essential to building soil organic carbon.[6] More studies must also incorporate the long-term effects of pesticides on indirect emissions and carbon sequestration in soils.

Much of the research with implications for pesticide reduction and climate change mitigation has focused on the benefits of organic farming in mitigating climate change. Organic agricultural systems, which avoid the use of synthetic fertilizers and pesticides, have been found to significantly reduce greenhouse emissions -- with one study showing organic management to increase soil organic carbon by 36 percent after 12 years in California cropping systems.[7] Multiple meta-analyses comparing thousands of farms have shown that organic farming results in higher stable soil organic carbon and reduced nitrous oxide emissions when compared to conventional farming.[8] One meta-analysis of 59 studies found total soil organic carbon to be on average 19% higher in organic than conventional systems.[9] Another meta-analysis found that organic farming practices could offset 36% of total emissions from the agricultural sector in the United States.[10]

These studies show that organic farming and pesticide reduction can significantly reduce greenhouse gas emissions and should be incorporated into current climate plans, even while these effects need to be better researched and more comprehensively quantified.

2. Measure common fumigants' impacts on climate change, particularly from nitrous oxide and carbon dioxide emissions

This research would determine the GHG footprint from applications of at least 4 fumigant pesticide Toxic Air Contaminants (TACs) – chloropicrin, metam sodium, metam potassium and dazomet – more than 20 million pounds of which are used annually in California. The few studies that exist indicate that use of these fumigants increases nitrous oxide emissions significantly, yet the state is not taking these data into consideration in its greenhouse gas emission reduction efforts. We believe it would be beneficial for CARB to lead or sponsor its own research in this area.

As mentioned, existing research studies indicate that fumigation with chloropicrin can increase N_2O production by 700-800%[11], and that the MITC-producing fumigants metam sodium and dazomet also significantly increase nitrous oxide emissions.[12] N_2O is a greenhouse gas 300 times more potent than

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[6] Stork, N. E., and Eggleton, P. (1992). Invertebrates as determinants and indicators of soil quality. Am. J. Altern. Agric. 7, 38–47. doi: 10.1017/S0889189300004446.

[7] Horwath, W. R., Deveˆvre, O. C., Doane, T. A., Kramer, T. W., and van Kessel, C. (2002). Soil carbon sequestration management effects on nitrogen cycling and availability. In ''Agricultural Practices and Policies for Carbon Sequestration in Soil'' (J. M. Kimble, R. Lal, and R. F. Follett, Eds.), 155–164.

[8] Ghabbour E, G. Davies G, Misiewicz T, Alami R, Askounis E, Cuozzo N, Filice A, Haskell J, Moy A, Roach A, and Shade J. 2017. National Comparison of the Total and Sequestered Organic Matter Contents of Conventional and Organic Farm Soils. *Advances in Agronomy*.146: 1-35. https://doi.org/10.1016/bs.agron.2017.07.003.

[9] Lori M., Symnaczik S., Mäder P., De Deyn G., Gattinger A. 2017. Organic farming enhances soil microbial abundance and activity – A meta-analysis and meta-regression. *PLOS ONE*. 25. https://doi.org/10.1371/journal.pone.0180442 July 12.

[10] Gattinger, A., A. Muller, M. Haeni, C. Skinner., A. Fliessbach, N. Buchmann, P. Madder, M. Stolze, P. Smith, N.E. Scialabba, and U. Niggli. 2012. Enhanced topsoil carbon stocks under organic farming, *PNAS*. 109 (44) 18826-18231. https://doi.org/10.1073/pnas.1209429109

[11] Spokas K., Wang D. 2003. Stimulation of nitrous oxide production resulted from soil fumigation with chloropicrin. *Atmospheric Environment* 37 (2003) 3501–3507. https://doi.org/10.1016/S1352-2310(03)00412-6

[12] Spokas K., Wang D., Venterea. R. 2004. Greenhouse gas production and emission from a forest nursery soil following fumigation with chloropicrin and methyl isothiocyanate. *Soil Biology & Biochemistry* 37 (2005): 475–485. https://doi.org/10.1016/j.soilbio.2004.08.010.

carbon dioxide. One study documented that elevated nitrous oxide emission rates from fumigants were still evident after 48 days, nearly four times longer than fertilizer-induced nitrous oxide emissions.[13] Altogether nearly 20 million pounds of these three fumigants are used every year on California fields.[14] These studies didn't consider metam potassium, a common MITC-producing fumigant (approximately 8.5 million pounds are applied in California each year), which we expect would produce the same impact.

Among the most toxic chemicals used in agriculture, fumigants often drift away from fields because they're applied as gases or easily become gases after application. In addition to causing acute illness, fumigant exposure over time can cause long-lasting harm, including cancer; respiratory ailments; neurological, reproductive, developmental, and immune system damage; and endocrine disruption.

Launching this research fits squarely in CARB's focus on reducing air pollutants and greenhouse gases while ensuring health co-benefits for communities. CARB has jurisdictional authority over the emissions of pesticide TACs once they've volatilized. As noted in Harbor Fumigation, Inc. v. County of San Diego Air Pollution Control Dist. (1996), ". . . it is a primary purpose of ARB and Districts to regulate emissions of TAC's, including pesticides, into the ambient air to protect human beings and the environment." Methodological methods should incorporate a comprehensive life cycle analysis of all greenhouse gas emissions from the production to volatilization of these fumigants.

Pesticide Reduction is an Environmental Justice Issue

Analysis of the latest pesticide data[15] combined with demographic data[16] reveals a pronounced racial disparity in concentration of pesticide use between counties with the largest share of Latinx residents and those with the smallest. California counties with a majority Latinx population[17] use 906% more pesticides per square mile than counties with fewer than 24% Latinx residents.[18] The two groups of counties have a similar total population and area. In the eleven counties with a majority Latinx population, there were 22 pounds of pesticides used per person in 2018, or 2,373 pounds per square mile. By contrast, for the 25 counties with the lowest proportion of Latinx residents (fewer than 24%), pesticide use was just 2.4 pounds per person, or 262 pounds per square mile.[19]

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[13] Spokas K., Wang D., Venterea. R. 2004. Greenhouse gas production and emission from a forest nursery soil following fumigation with chloropicrin and methyl isothiocyanate. *Soil Biology & Biochemistry* 37 (2005): 475–485. https://doi.org/10.1016/j.soilbio.2004.08.010.

[14] Department of Pesticide Regulation annual Pesticide Use Reports. https://www.cdpr.ca.gov/docs/pur/purmain.htm.

[15] California Department of Pesticide Regulation Pesticide Use Report, Total pesticide use in 2018 by county, https://www.cdpr.ca.gov/docs/pur/pur18rep/18sum.htm

[16] California Hispanic or Latino Origin Population Percentage by County, https://www.indexmundi.com/facts/united-states/quick-facts/california/hispanic-or-latino-population-percentage#table

[17] Imperial, Tulare, San Benito, Colusa, Merced, Monterey, Madera, Kings, Kern, San Bernardino, Fresno

[18] Sacramento, San Luis Obispo, Inyo, Alameda, Lake, Del Norte, Lassen, Butte, Marin, San Francisco, Amador, Placer, Modoc, El Dorado, Siskiyou, Tuolumne, Calavera, Sierra, Humboldt, Mariposa, Alpine, Shasta, Nevada, Plumas, Trinity

[19] A similar analysis just on the fumigant chloropicrin found that use occurs disproportionately in areas with low income and Latinx populations. Almost 70 percent of chloropicrin use occurred in zip codes with populations of Latinx (Hispanic) origin that exceeded the statewide average, and almost 75% occurred in zip codes with median household incomes less than the statewide average. Cox, C. Income and ethnic determinants of use of the soil fumigant, chloropicrin, in California. January 10, 2021.

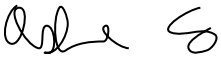
Deeper analysis of the data finds that an average person who lives in the 11 California counties with a majority Latinx population as compared to the 25 counties with the smallest Latinx proportions:

- Is more than four times (430%) as likely to suffer from an acute pesticide-related illness
- Lives where there are fourteen times (1,362%) more Carcinogenic agricultural pesticides applied per person
- Lives where there are eleven times (1,074%) more agricultural pesticides listed as Reproductive and Developmental Toxicants applied per person.

In conclusion, more comprehensive research on the link between pesticides and greenhouse gas emissions would not only help achieve the state's climate change goals, but also improve air quality and address a critical environmental justice concern that is polluting rural and Latinx communities in California.

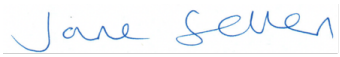
Thank you again for the opportunity to comment, and we would welcome a discussion with you or your staff on these topics to address any further questions or comments.

Sincerely,



Asha Sharma
California Organizing Director, Pesticide Action Network

Margaret Reeves
Senior Scientist, Pesticide Action Network



Jane Sellen
Co-Director, Californians for Pesticide Reform

Sarah C. Aird
Co-Director, Californians for Pesticide Reform

https://www.researchgate.net/publication/348362213_Income_and_ethnic_determinants_of_use_of_the_soil_fumigant_chloropicrin_in_California