Determining the Lethal Dose of Perfluoroalkyl Acids to *Arabidopsis* Plants

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Introduction

- **Short-chain perfluoroalkyl acids (PFAA's)** are man-made chemicals historically used in fire fighting foams, refrigerants, non-stick coatings for pans, and clothing manufacturing. [1]
- They are highly resistant to degradation in the environment due to strong C-F bonds[2], they persist in the environment for an extended time. These are known as **"forever chemicals".**
- Although easily excreted by most animals, short-chain PFAA's may bioaccumulate in plants, potentially leading to adverse effects the environment. [3]

Objective

The purpose of this experiment was to determine the LD_{50} of short chain PFAAs in *Arabidopsis* (*Arabidopsis thaliana)*. The LD_{50} is the dose required to kill 50% of plants.

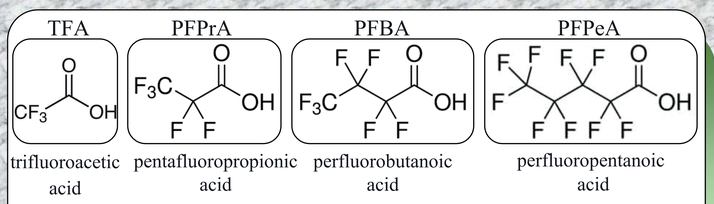
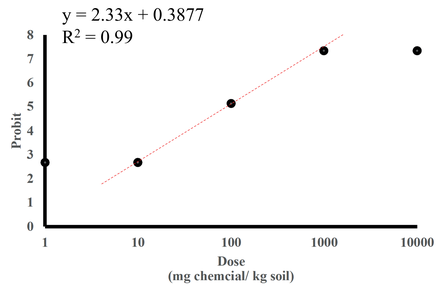


Figure 1. PFPPAs were included in the experiment.

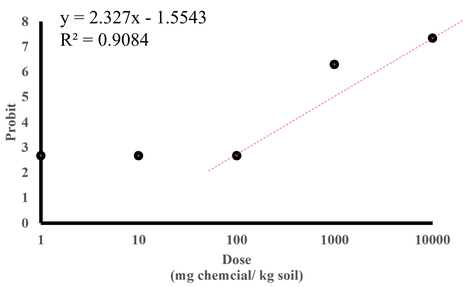
Methods

- Glass vials were filled with 40g of Sonoran desert soil and ultra pure water (18.2 MΩ•cm).
- Each vial was given 3 seeds and then covered with parafilm and chilled (4°C) for one week and then germinated.
- Vials were thinned to one plant per.
- 120 plants were randomly assigned to 6 treatments groups: control, 1, 10, 100, 1,000, 10,000 mg chemical/kg of soil.
- Plants were scored as alive or dead every other day to calculate the LD_{50}.

Results



Figures 1. The dose-response of PFPrA in *Arabidopsis*. PFBA has a similar dose-response.



Figures 2. The dose-response of TFA in *Arabidopsis*.

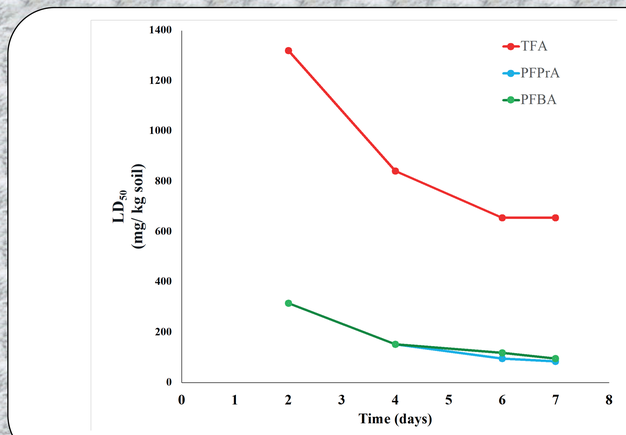


Figure 3. LD_{50} for three different short-chain PFAAs in *Arabidopsis* as a function of time.

Discussion

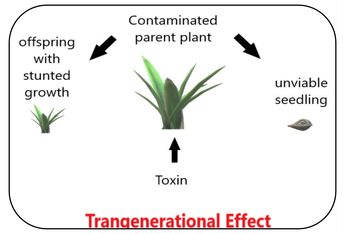
• TFA's toxicity was significantly lower than the other acids.
• The lethality is increasing over time, which suggests bioaccumulation.
• The mechanism of action (MOA) for the PFAA toxicity in plants is unknown.
• Recent testing shows values in the environment to date are typically much lower than the LD_{50}. [4]
• *Arabidopsis* proves to be a good test subject for toxicity experiments due to its ease of culture and short life cycle.

Conclusion

- Concentration at 656 ppm TFA, 84.1 ppm PFPrA, and 96.0 ppm PFBA killed over 50% of the plants (Fig 2).
- Lethality increased over time, suggesting possible bioaccumulation.
- Stunted growth patterns of low dose plants suggests sublethal effects.

Future Research

- More research is needed to narrow down the LD_{50}.
- Potential research will involve the transgenerational effects of TFA has on the seedlings of the contaminated.
- PFPeA testing is currently in progress.



Acknowledgements

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References

1. Ellis, D. A.; Mabury, S. A.; Martin, J. W.; Muir, D. C. G., Thermolysis of fluoropolymers as a potential source of halogenated organic acids in the environment. Nature 2001, 412 (6844), 321-324.
2. Brendel, S., Fetter, É., Staude, C., Vierke, L., & Biegel-Engler, A. (2018). Short-chain perfluoroalkyl acids: Environmental concerns and a regulatory strategy under reach. Environmental sciences Europe.
3. Benesch, J. A.; Gustin, M. S.; Cramer, G. R.; Cahill, T. M., Investigation of effects of trifluoroacetate on vernal pool ecosystems. Environmental Toxicology and Chemistry 2002, 21 (3), 640-647.
4. Cahill. (2022). Increases in Trifluoroacetate Concentrations in Surface Waters over Two Decades. Environmental Science & Technology, 56(13), 9428–9434. https://doi.org/10.1021/acs.est.2c01826.