

Effects of Pharmaceuticals and Personal Care Products on a model terrestrial plant, *Arabidopsis thaliana*



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Undergraduate Science Research
P R O G R A M

Introduction

- We are interested in testing the effects of high volume pharmaceuticals and personal care products (PPCP's) on terrestrial plants.
- PPCPs are found in the effluent and biosolid of waste water treatment plants, and may come into contact with terrestrial plants through waste water discharge during flooding and land application of biosolid.
- PPCP's that we test include...
 - Acetaminophen (APAP)- widely used as a pain reliever and antipyretic.
 - Triclocarban (TCC)- an antimicrobial agent used in many household cleaning products.
 - Caffeine- a psychoactive stimulant, used widely around the world.
 - Paraxanthine is a major caffeine metabolite; it is produced by the enzymatic conversion in the human body (See Figure 1).
- Arabidopsis thaliana*, a commonly used model land plant, is our experimental system.

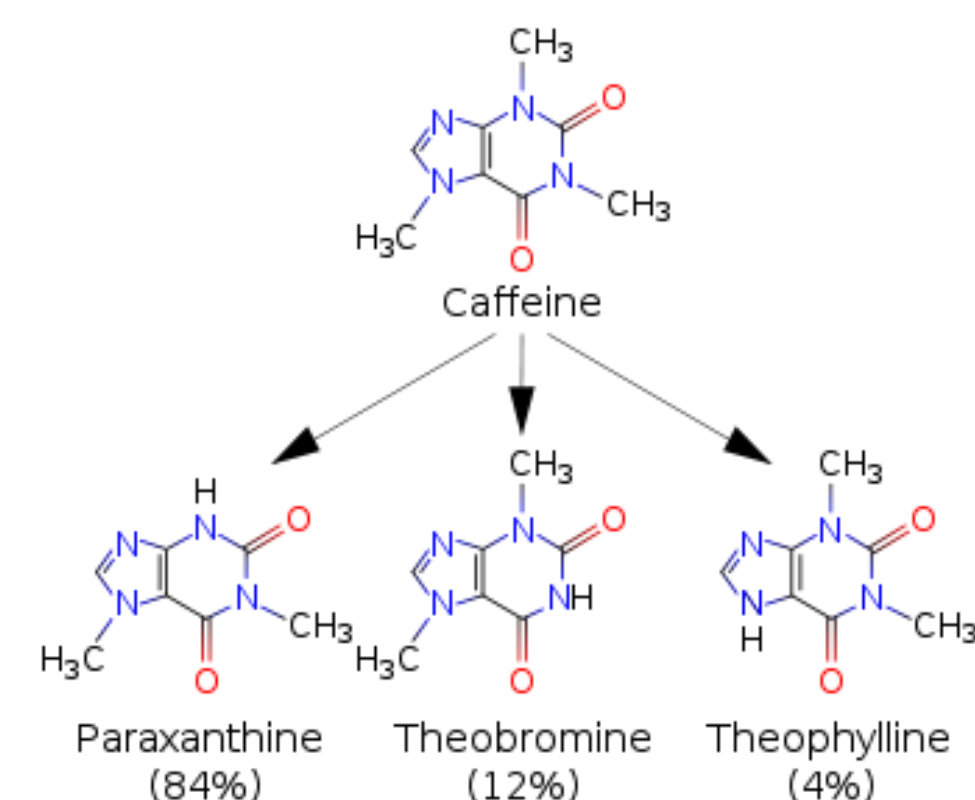
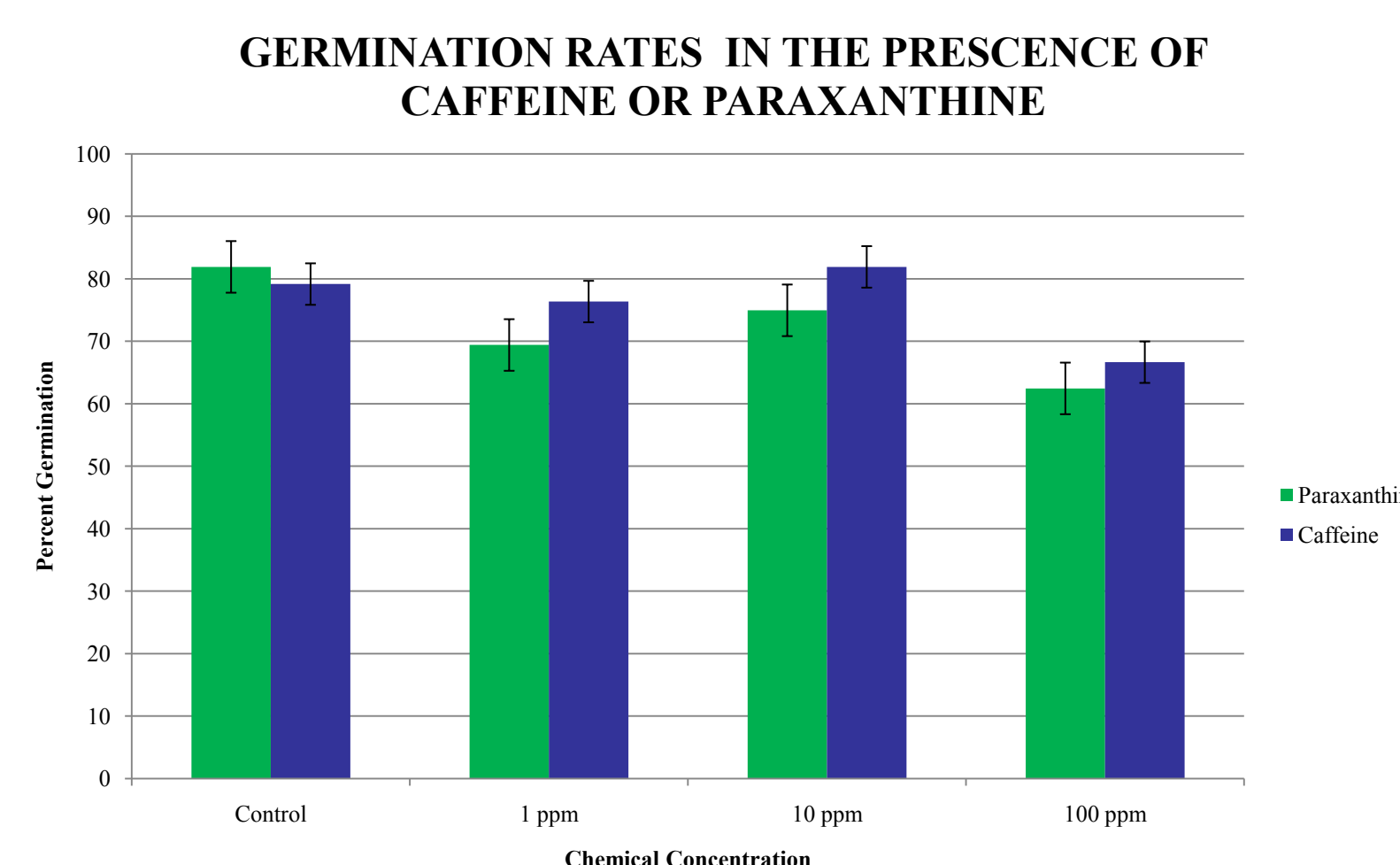


Figure 1: Caffeine undergoes an enzymatic reaction within the human body to produce 3 main metabolites, Paraxanthine being the major product.

<http://www.psycheteria.org>

Caffeine and Paraxanthine

Figure 2: Germination percentages for *A. thaliana* exposed to various concentrations of Caffeine or Paraxanthine. Preliminary results suggest that both Paraxanthine and Caffeine can inhibit germination at ~100 ppm.



AVERAGE ROOT GROWTH AFTER 3, 7, AND 10 DAYS

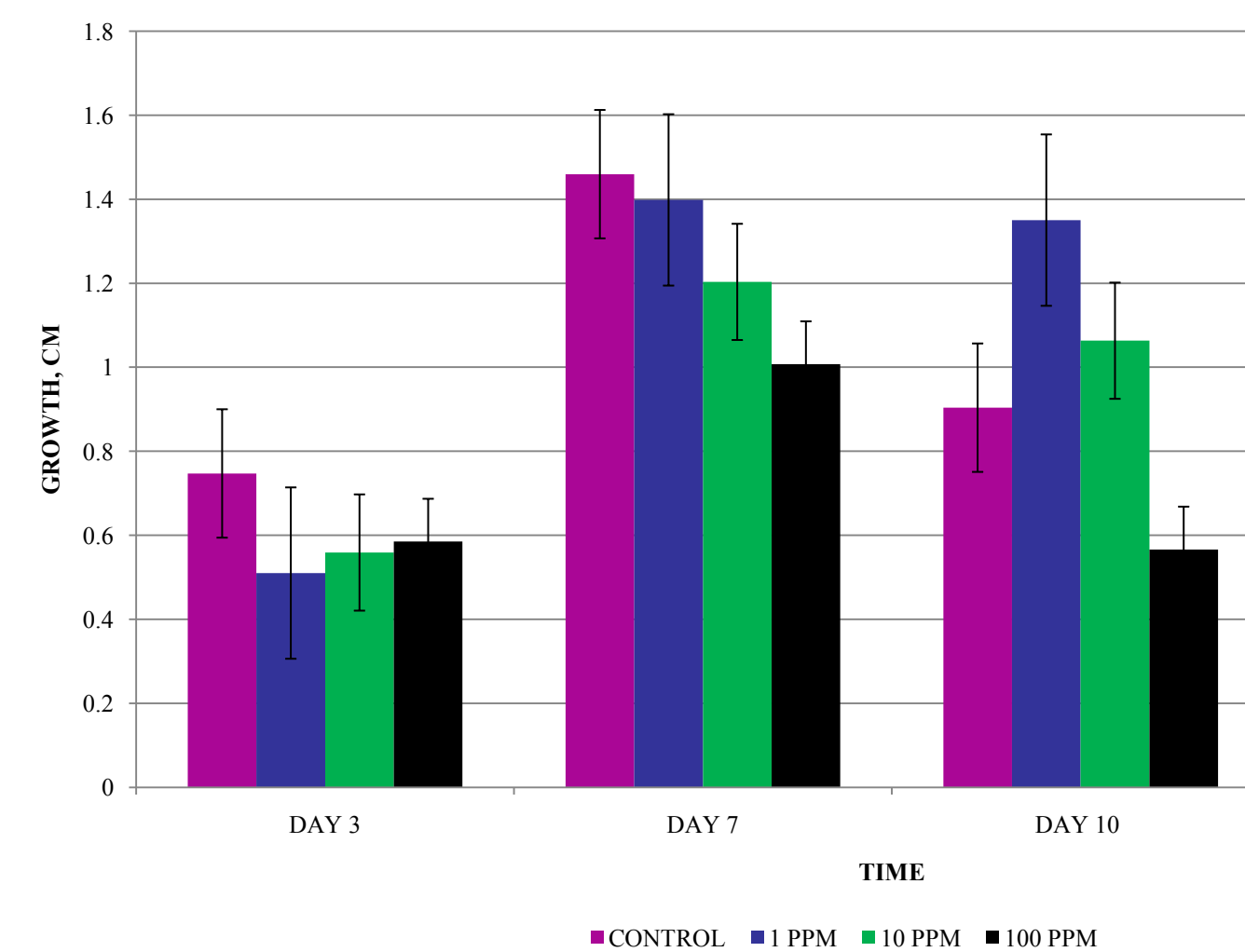


Figure 3: Primary root growth was measured with varying concentrations of Paraxanthine. Paraxanthine inhibits root growth above 10 ppm. Caffeine has a similar effect at the same range of concentrations as Paraxanthine.

Acetaminophen

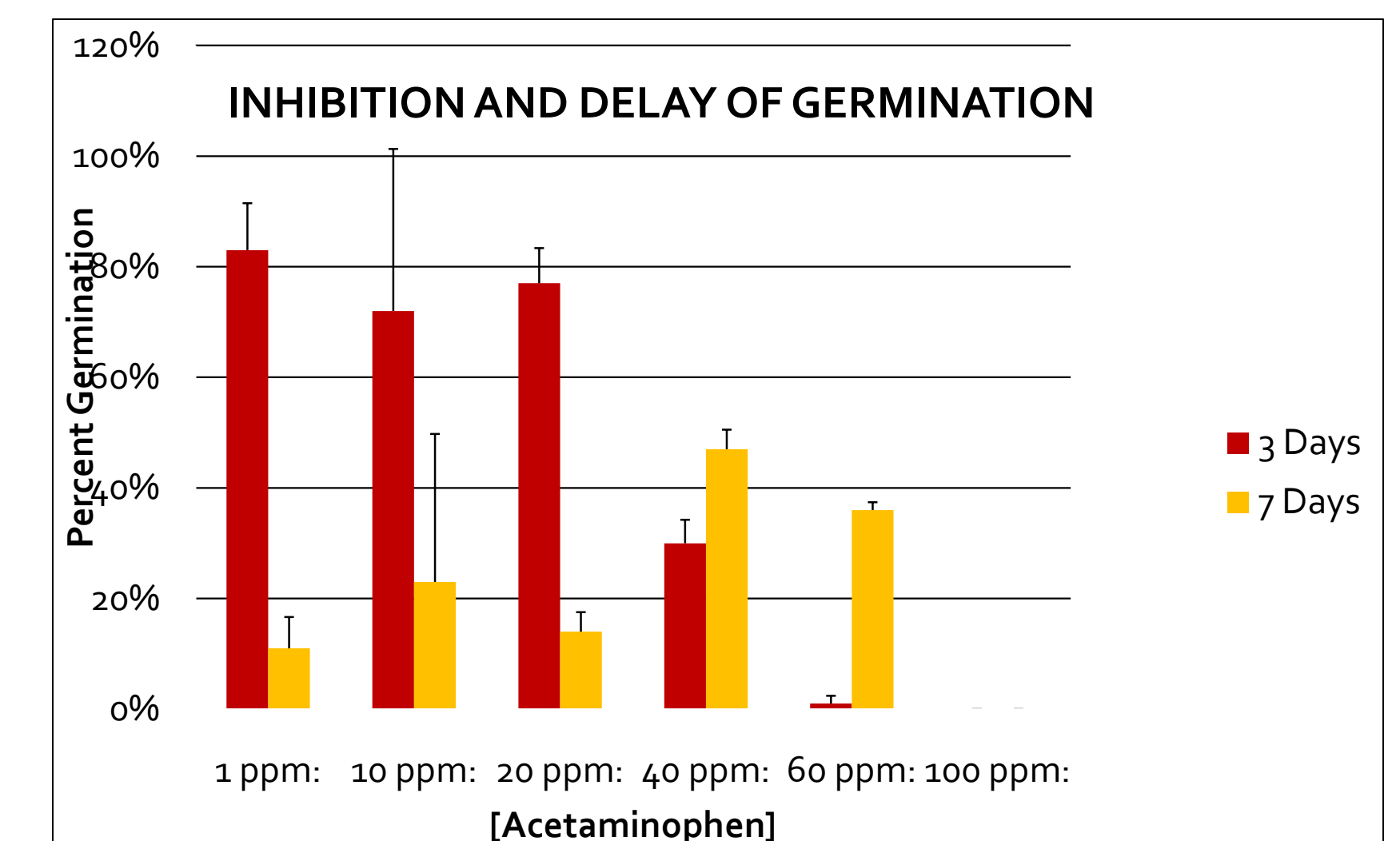


Figure 4: Germination was measured over time in the presence of Acetaminophen. Acetaminophen inhibits and delays germination at concentrations of 40 ppm and above.

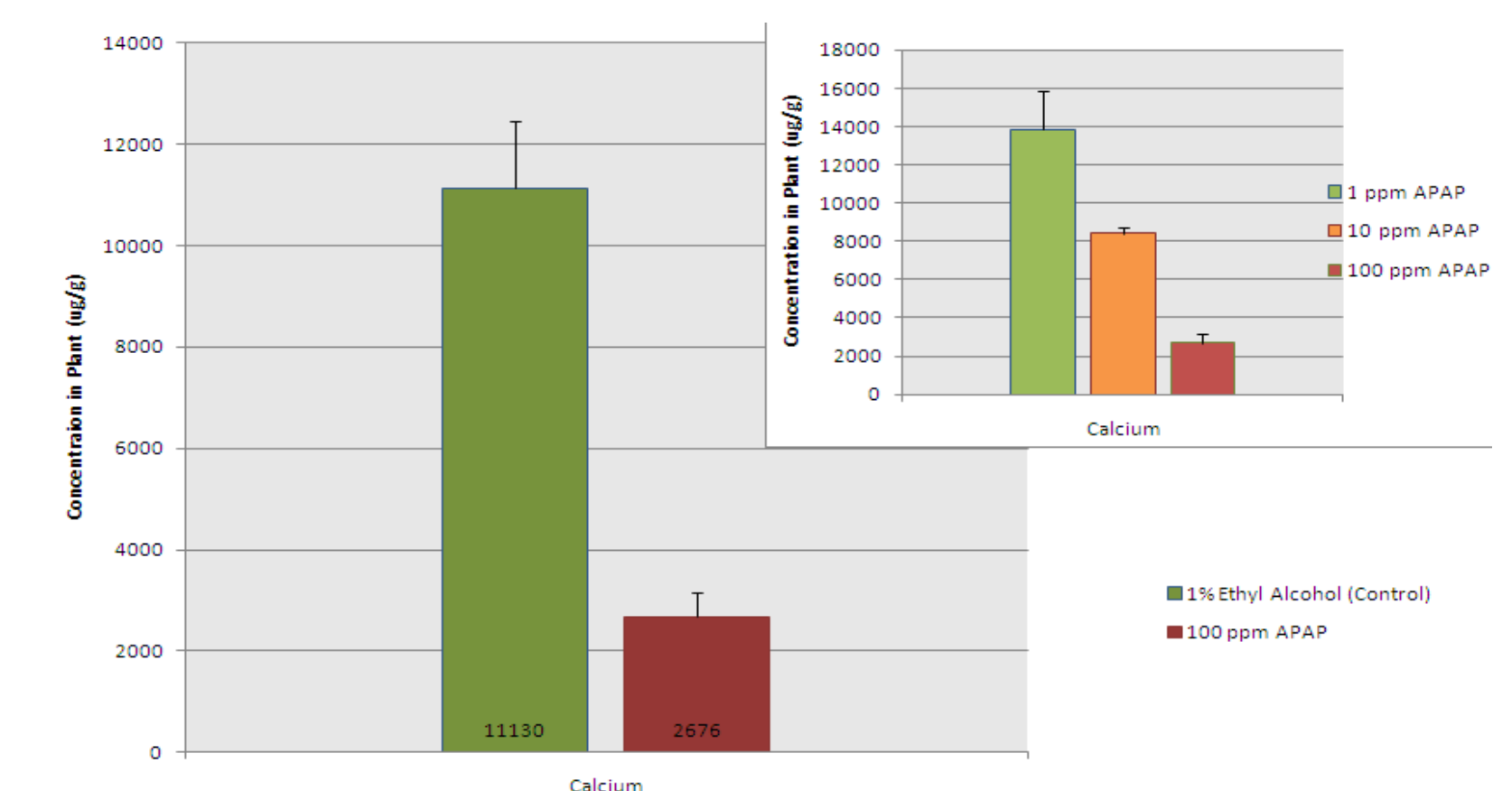


Figure 5: Concentration of calcium in *A. thaliana* samples exposed to Acetaminophen. Test shows a significant decrease in concentration of calcium from 0 ppm to 100 ppm Acetaminophen.

Methods

Germination Experiment

- Grow *A. thaliana* seeds on standard nutrient agar with various concentrations of TCC, Caffeine, Paraxanthine and Acetaminophen.
- Record germination rate after 3, 7 and 9 days.

Early Growth Experiment

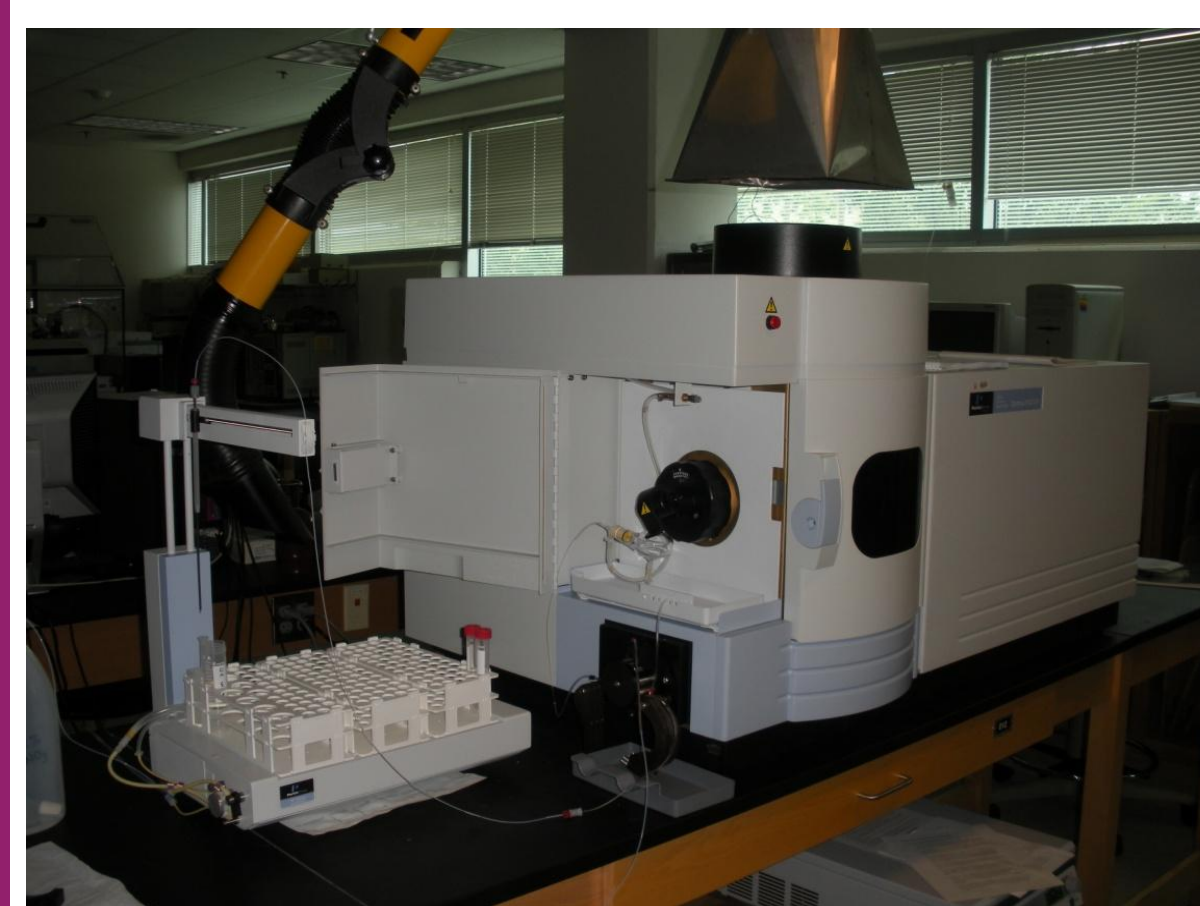
- Grow *A. thaliana* seeds on standard nutrient agar.
- Transfer seedlings to chemical containing media when root length is approximately 1.5 cm.
- Measure growth of primary root after 3 days and 7 days, and compare to plants grown in regular nutrient media.

Inductively Coupled Plasma Optical Emission Spectroscopy

- Plants were dried in an oven and dried weight recorded.
- Microwave digest dried plant samples with a mixture of 50% nitric acid, 30% hydrogen peroxide and 20% water.
- Analyze samples for macro nutrients (Ca, K, Mg, Na, P, S) and micro nutrients (Al, B, Co, Cr, Cu, Fe, Mn, Mo, Ni, V, Zn) by ICP-OES.



Microwave Digester



ICP-OES

Conclusion

- A. thaliana* is an effective screening tool for the effects of emerging PPCP's of concern on terrestrial plants.

Paraxanthine and Caffeine

- Paraxanthine and Caffeine can inhibit germination and root growth at ~100 ppm.
- Similar results were observed in acute toxicity tests conducted in aquatic invertebrates (Harrahy *et al.*, unpublished results).
- Caffeine is expected to be present at ppb levels, far below the effective concentrations that impacted root growth and germination.
- No reliable information available about the concentration of Paraxanthine in the environment.

Acetaminophen

- Acetaminophen delays and inhibits germination at ~40 ppm or higher.
- Acetaminophen-exposed plants show a decrease in calcium; calcium is an essential nutrient and an important signalling molecule in plants.
- Similar results were observed in acute toxicity tests conducted in aquatic invertebrates (Harrahy *et al.*, unpublished results).
- Acetaminophen is expected to be present at ppb levels, far below the effective concentrations that impacted germination and calcium accumulation.

TCC

- TCC up to 100 ppm did not show significant effects on all growth parameters measured.
- Aquatic invertebrates are ~1000x more sensitive in acute and chronic toxicity tests (Harrahy *et al.*, unpublished results).

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