

# Onsite production of concentrated urine-derived fertilizer in building-scale systems using remote process monitoring and control



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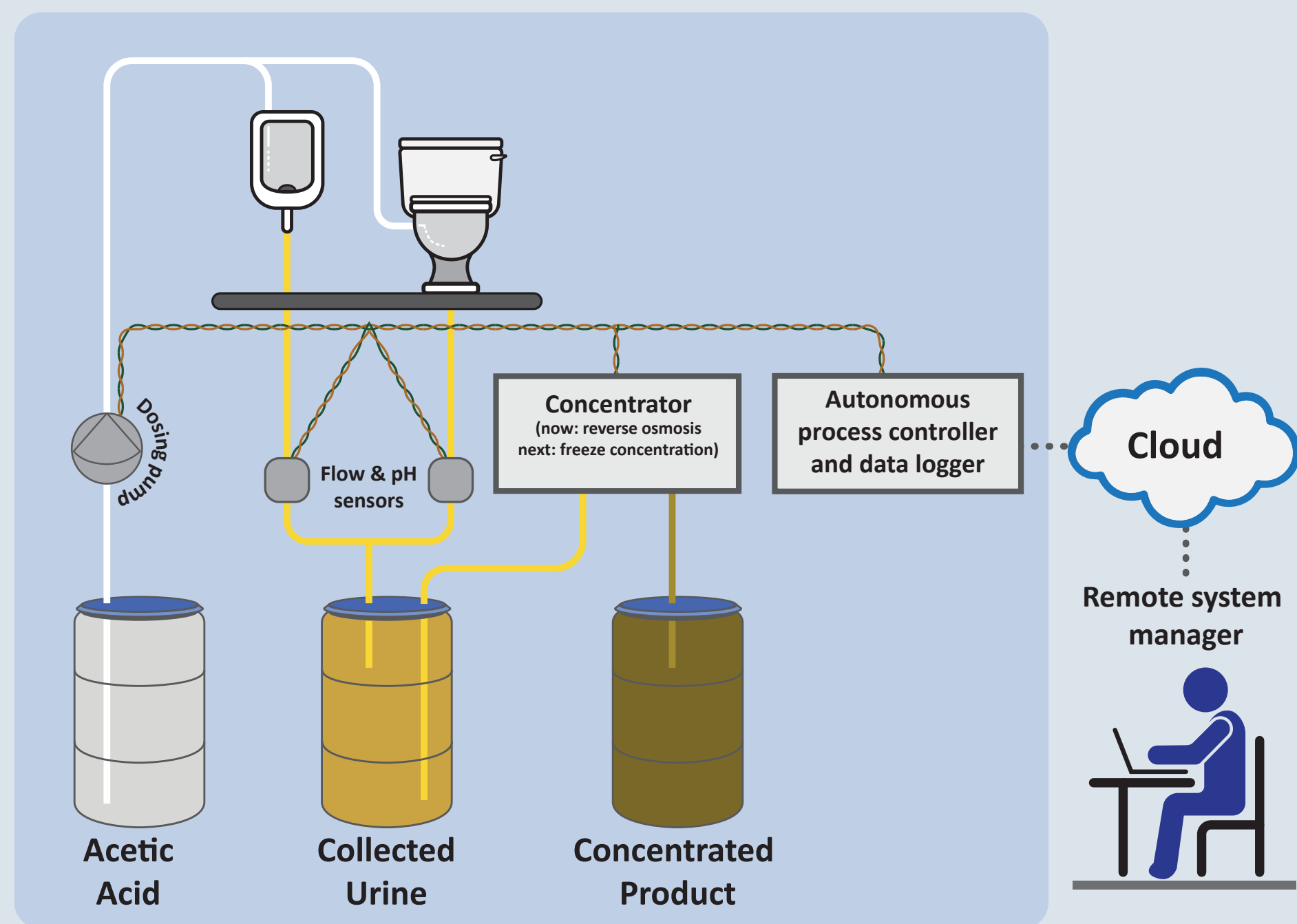
## The problem

Diverting human urine from the wastewater stream enables nutrient recovery, but its dilute nature complicates storage and transport.

## Our solution

Concentrating urine at the building scale produces a low-volume fertilizer product that can be stored for periodic collection. Our research has employed freeze concentration and reverse osmosis to reduce the volume of urine, with and without acidification for urease inhibition and odor control. Coupled with pasteurization, the product is a concentrated, sanitized fertilizer.

### Cyber-physical system for diverting urine and producing concentrated fertilizer at building scale

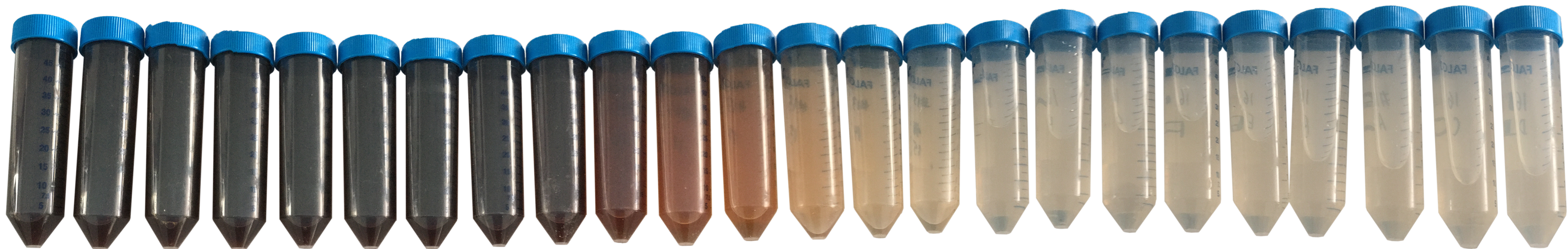


### Functions:

- Doses acid as needed to urine diversion fixtures to achieve urease inhibition.
- Measures a range of physical and performance parameters and logs to a remote server.
- Autonomously adjusts system operation in response to measured conditions.
- Sends alerts when service is required.

### Purpose:

- Maintain efficient and effective performance.
- Quantify nutrient recovery rates in real time.
- Produce a valuable concentrated fertilizer.



Results of freeze concentration

## Acidification and urease inhibition

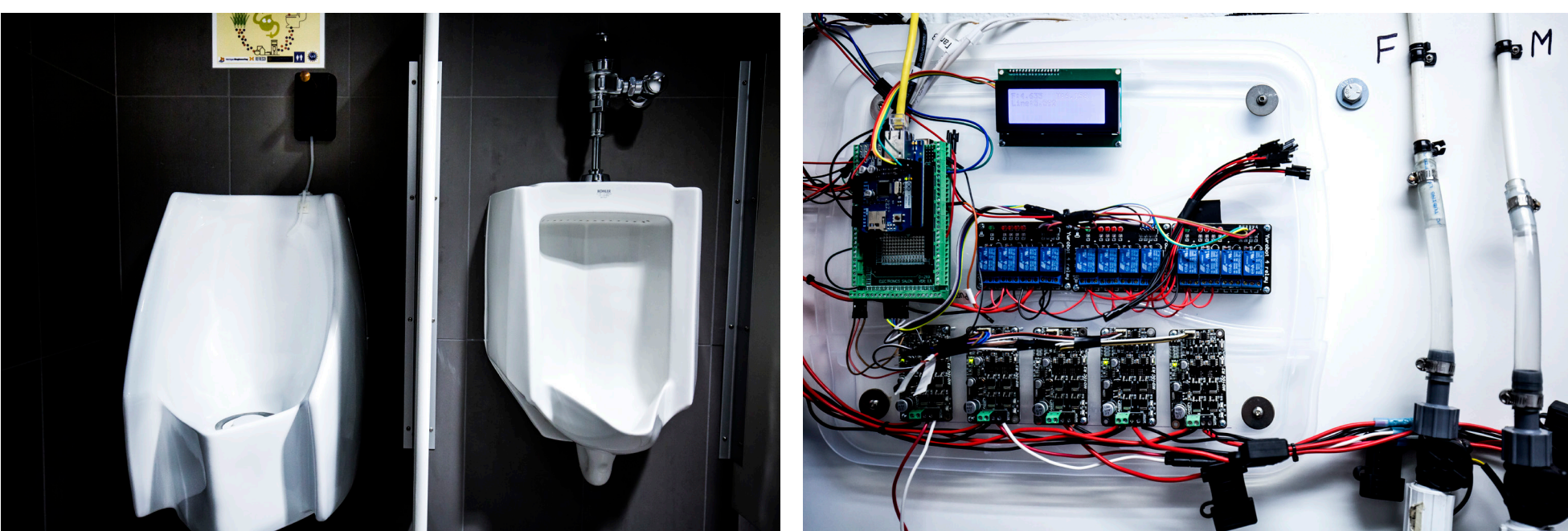
Adding acetic acid to fresh urine reduces pH and prevents urea from hydrolyzing into ammonia.

### Benefits of urease inhibition:

- **Volume reduction** – preventing urea hydrolysis keeps the mol/L of solute in the urine low, which aids water removal
- **Stabilization** – urea is a much less volatile fertilizer than ammonia
- **Maintenance** – reduces mineral scale in pipes and drains of urine-diverting toilets/urinals. No mineral clogging in 2.5 years.

### Challenges:

- **Timing** – acid must be added immediately to fresh urine to be effective.



Urine-diverting waterless urinal with acetic acid dosing pipe on left.

Photo: Joseph Xu (AP)

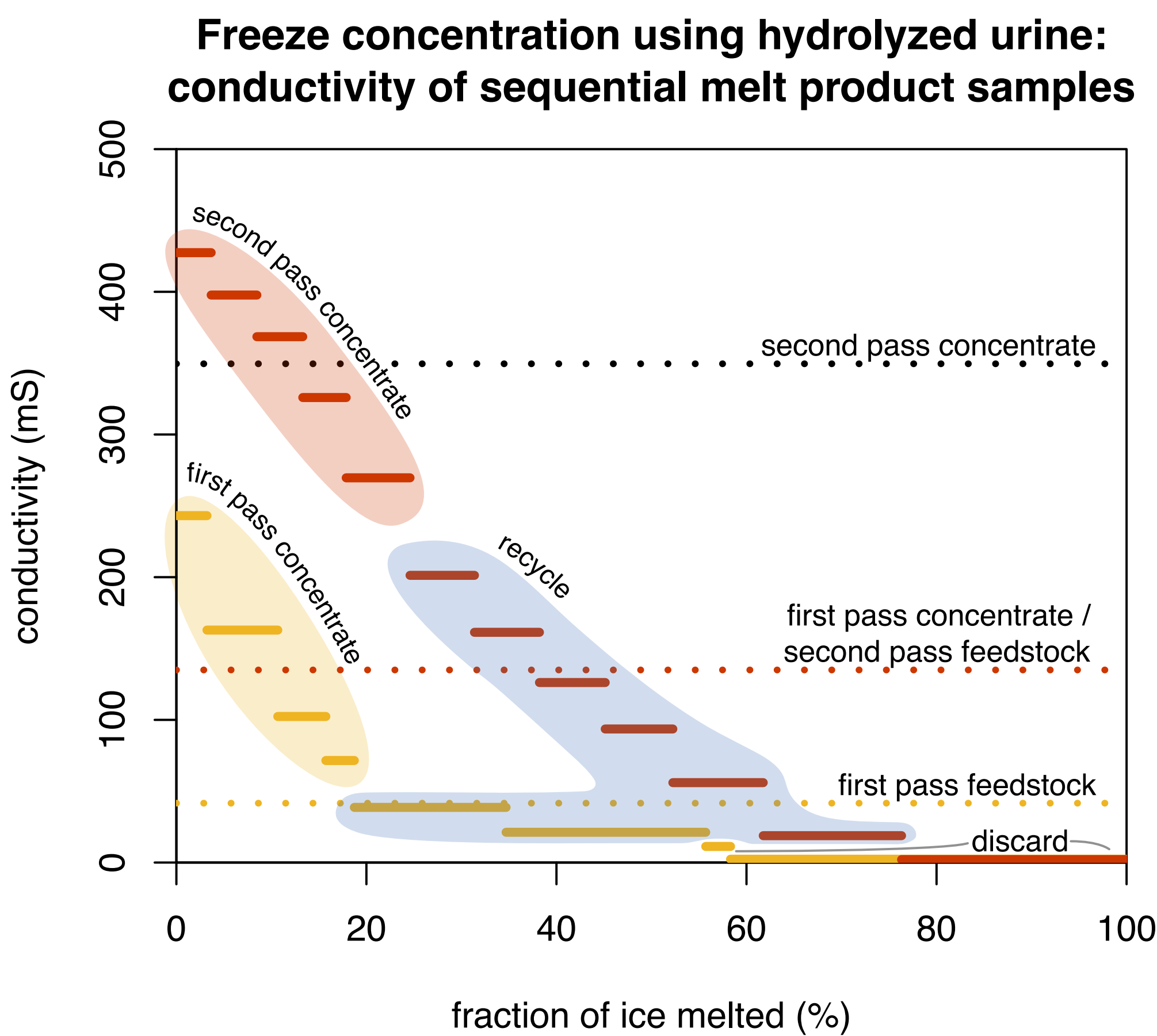
Microcontroller with motor drivers and flow meters for acid dosing.

Photo: Joseph Xu (AP)

## Reverse osmosis vs. freeze concentration

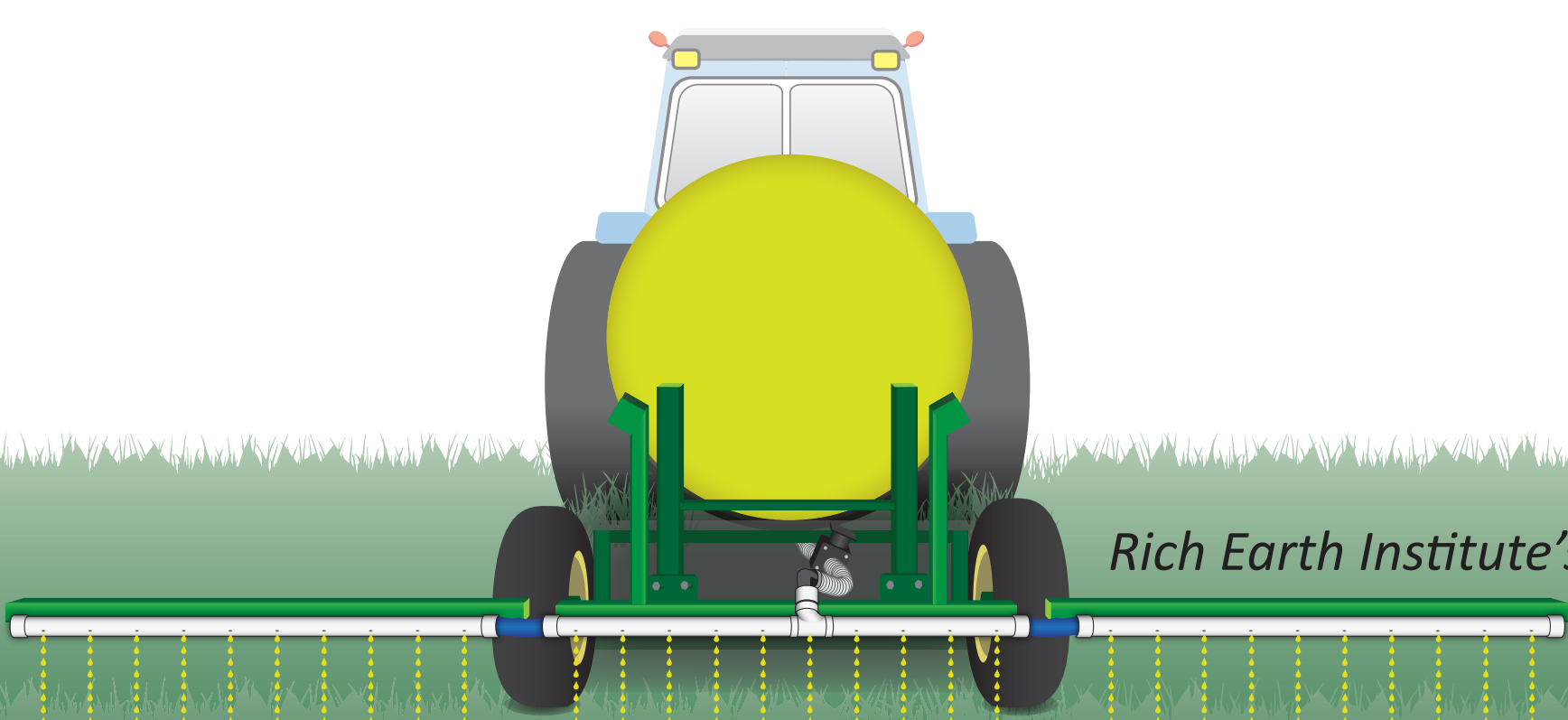
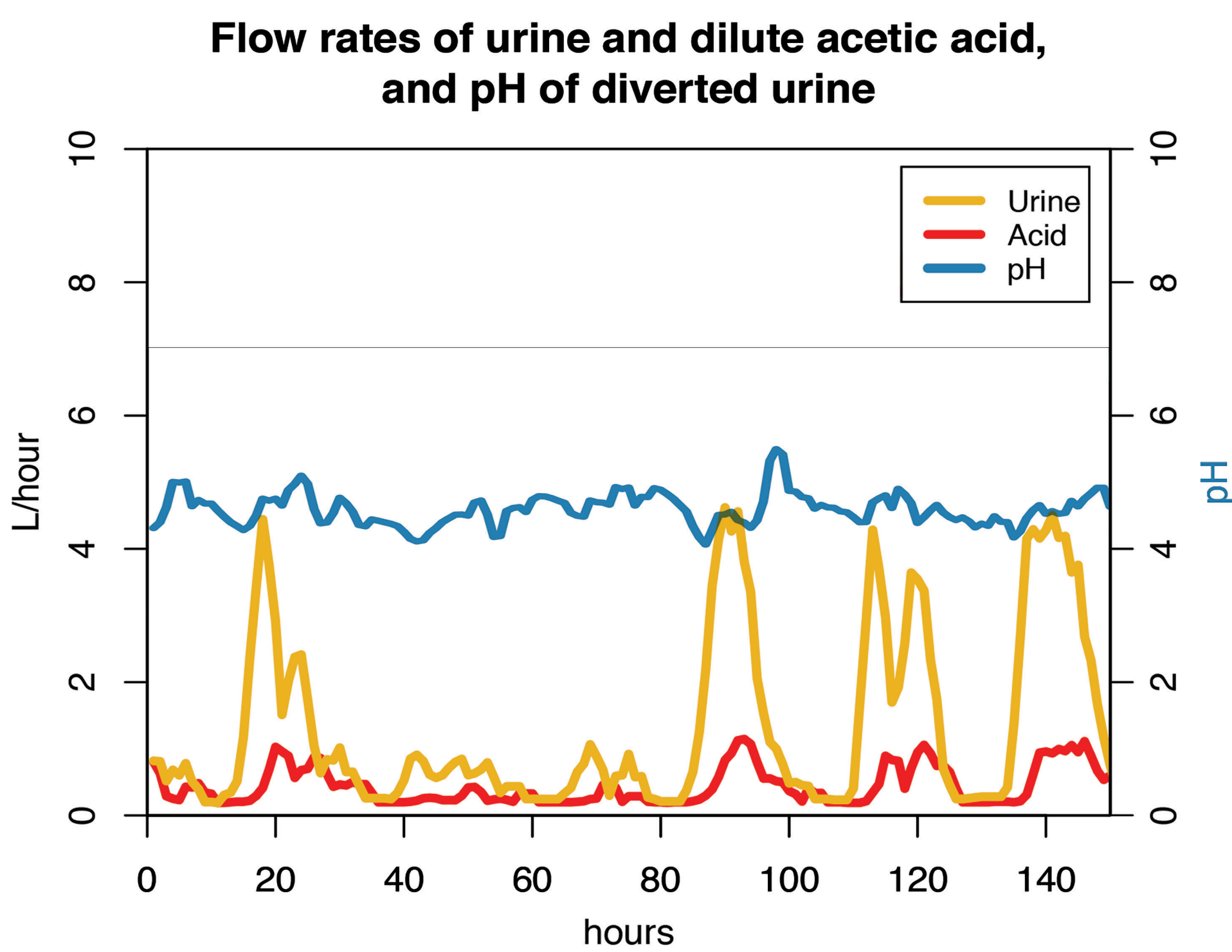
Reverse osmosis treatment of urease inhibited urine achieved 5x concentration in benchtop tests, but membrane clogging was a problem in the building-scale implementation.

Freeze concentration achieved 8.5x concentration (using hydrolyzed urine) and has no clogging risk. Because urease-inhibited urine has fewer mol/L of solute than hydrolyzed urine, >10x concentration is likely achievable.



## Next steps:

To make the system more robust and reliable, we are switching from using reverse osmosis to freeze concentration. Coupled with urease inhibition, we expect to achieve a concentration factor of above 10. With this new configuration in place, we will quantify energy consumption, maximum attainable concentration, and reliability.



Rich Earth Institute's 500-gallon urine-derived fertilizer applicator