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.

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.

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.