Novel Treatment Process Makes Fertilizer from Human Waste

Excess nitrogen and phosphorus in surface waters cause harmful algae blooms, and in densely populated watersheds, human urine and feces in wastewater significantly contribute to this nutrient pollution. Many wastewater plants are at capacity and struggle to meet tightening nutrient removal regulations, prompting them to pass on the cost of related sewer upgrades, in the form of connection and usage fees, to building developers.

When blackwater, including water, urine, feces, and toilet paper, is collected as a separate stream and fully treated onsite, new buildings can dramatically reduce their environmental impact. This option increases climate resilience, saves energy, and produces a natural fertilizer product. Blackwater separation allows new buildings to greatly reduce sewer connection and usage fees, especially when paired with onsite systems that recycle greywater for non-potable reuse, which are increasingly common in certified green buildings and water-scarce regions.

Brightwater Tools (a Vermont-based start-up company supported by the U.S. National Science Foundation) has developed a treatment process to manage digested blackwater onsite, using automated block freeze concentration, pasteurization, and activated carbon filtration processes.

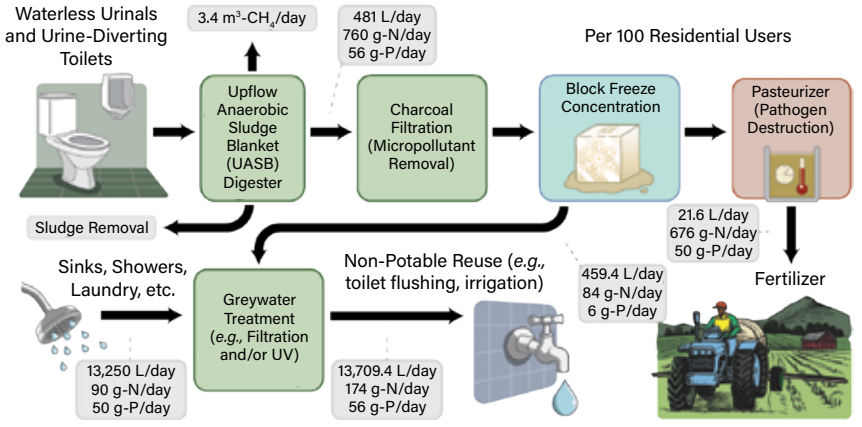
Blackwater separation is achieved using vacuum flush toilets, which collect all toilet waste using 83% less water than conventional toilets. The diverted blackwater is pre-processed in an upflow anaerobic sludge blanket (UASB) reactor to reduce its chemical oxygen demand (COD) by 92%, yielding a liquid digestate with a low COD and a high nutrient content. The digestate is filtered to remove suspended solids and organic micropollutants.

The digestate contains a majority of nutrients found in a building's wastewater, but it is still over 98% water, requiring a process to separate this reusable water from dissolved nutrients. Block freeze concentration is a batch process that involves partially freezing digestate (or source-separated urine) to form pure ice that is then separated from the remaining unfrozen, concentrated nutrient solution. The end products are a 3% nitrogen liquid concentrate that retains 89% of the total nutrients, and an effluent stream with a tenfold reduction in nutrient concentration.

Block freeze concentration is mechanically and operationally simpler than other continuous freeze concentration techniques (*e.g.,* suspended and falling film freeze concentration). The Brightwater block freeze concentration process extracts heat from the digestate using an array of flat heat exchange surfaces, resulting in the formation of multiple 2-in.-thick slabs of ice over twelve hours. Energy use is reduced by recovering latent and sensible heat by operating two freeze chambers out of phase (one chamber melting while the other one freezes), using a heat pump to extract heat from the freezing chamber and dump it into the melting one.

After pathogen reduction via pasteurization, the liquid concentrate is a sanitized and purified Class A fertilizer product that is collected and distributed by Brightwater Tools through a service contract. The effluent stream is recombined with the building's greywater for light treatment and non-potable reuse to achieve circular onsite wastewater treatment.

Wastewater management companies have expressed that water reuse and nutrient recovery are fundamental to the creation and implementation of sustainable water infrastructure. According to Amelia Luna, a principal engineer at Sherwood Design Engineers, "A technology that could concentrate nutrients in a high-strength wastewater would be of high value in my clients' infrastructure portfolios." With a global water recycling market estimated to grow to $30.5 billion by 2030, and municipalities subsidizing new urine-separation infrastructure, Brightwater Tools is poised to implement next-generation sanitation solutions to achieve a circular economy and a sustainable future. CEP



▲ Brightwater Tools' innovative equipment presents an integrated system for nutrient recovery and non-potable water production from residential wastewater. In this flowchart, g-N/day and g-P/day stand for grams of nitrogen or phosphorus per day, respectively.

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