From Toilet to Tap:
Risks of Direct Potable Reuse

As parts of the United States suffer from climate change-fueled droughts, several states — including Colorado, California and Texas — are looking to use treated municipal wastewater for drinking water.[1] Direct potable reuse — often called toilet-to-tap[2], to the dismay of industry advocates — is pitched as an alternative to environmentally damaging desalination, storage and long-distance pipeline projects. But these reuse projects are also controversial and risky.[3] Instead of prioritizing these alternative water supply schemes to allow business as usual for environmentally damaging developers and corporate water abusers, governments should focus on conserving our existing water sources and reining in wasteful practices.

An Overview: Atypical Drinking Water Source

Wastewater reuse — also called water reuse, wastewater reclamation or water recycling — refers to a broad range of ways that wastewater and sewage from cities and towns are collected and used for other purposes instead of being treated and released into waterways.[4] This can be for watering lawns or industrial processes, or it can be for drinking water — either indirectly or directly. Less than 10 percent of municipal wastewater in the U.S. is reused, and the vast majority of that is for non-potable (not for drinking) purposes, typically for landscape irrigation.[5]

Indirect potable reuse projects involve advanced treatment of wastewater to release the treated wastewater into aquifers or surface waters, which are considered environmental buffers.[6] In 2010, about 0.1 percent of treated municipal wastewater was reused by drinking water systems in the United States,[7] and almost all of that amount involved indirect potable reuse.[8]

Direct potable reuse relies on advanced treatment systems to treat sewage from cities to drinking water standards in order to deliver directly (i.e., without release to the environment as a buffer) to homes for drinking and other uses.[9] Direct potable reuse is rare and not used in most of the world. It exists mainly in Namibia, South Africa, and the U.S.[10] As of 2022, the Big Spring facility of the Colorado River Municipal Water District in Texas is the only direct potable reuse facility currently operating in the U.S.[11]

Risks

System vulnerability

Direct potable reuse systems are vulnerable to major failures because they lack environmental buffers. Buffers provide more time to respond and perform corrective action in the event of equipment failures, illegal releases of toxics into the wastewater collection system, or other emergencies.[12] Regulations may fail to adequately plan for "low probability, high consequence" system failures that could have devastating consequences for public health.[13] Planning for risks is also hampered by the lack of long-term data about system performance and events.[14] Even with redundancies and advanced monitoring systems and controls, acts of terrorism or even human error could be catastrophic. Many risks of direct potable reuse are novel and potentially unquantifiable.[15]

Staffing risks

The water sector is experiencing a staffing shortage.[16] Difficulty staffing treatment plants is an underlying factor associated with several high-profile water system failures.[17] The advanced systems necessary for wastewater reuse make these systems inherently more susceptible to workforce shortages.[18]

Environmental challenges

Wastewater reuse treatment systems have higher energy needs, have a higher carbon footprint when reliant on a fossil fuel-driven power grid, and produce toxic waste brines[19] (which coastal facilities typically discharge into the ocean to lower costs).[20] The wastes can contain per- and poly-fluoroalkyl substances (PFAS) — lab-made toxic chemicals that are known as "forever chemicals" because they do not break down naturally in the environment — that when released to the ocean compound and can accumulate in fish near outfalls.[21] For noncoastal areas, direct potable reuse can also reduce downstream flows because less wastewater is released back to the environment. This can infringe on downstream water rights.[22]

Toxic Accumulations and Other Health Concerns

No treatment system can remove all contaminants. Even the most advanced systems struggle to remove certain toxic compounds, and wear out over time with contaminants breaking through.[23] While much research into the safety of wastewater reuse focuses on microbial contamination, there are health threats posed by lab-made contaminants entering the municipal sewer system from industrial operations, businesses and homes. There is potential for the accumulation and concentration of unregulated or hard-to-remove toxics within the closed loop systems[24] because the wastewater is not released into environmental buffers and is less diluted than in natural waters.[25] Improved water efficiency by customers will further reduce dilution in wastewater streams and lead to greater concentrations of chemicals.[26]

Toxic compounds

Emerging contaminants of concern include PFAS, pharmaceuticals and personal care products, nanomaterials, disinfectant byproducts, and micro- and nano-plastics.[27] Advanced treatment systems fail to remove 1,4-Dioxane and *N*-nitrosodimethylamine (NDMA), which are industrial chemicals that are likely to cause cancer.[28] Many of these compounds have well-documented health risks but many more, like micro- and nanoplastics, lack toxicity data and urgently need more study.[29] A growing body of research has revealed potential serious health risks associated with micro- and nanoplastics: toxic effects on cells (including destruction of red blood cells), DNA damage, inflammation, metabolic changes to colon cells that could be a cancer risk, and possible harm to the intestines and immune system.[30]

Formaldehyde and other carbonyl compounds can be found in reuse water after advanced treatment. Although many carbonyls are understudied and unregulated, they are associated with cancer, neurodegenerative disease and heart diseases.[31] Some can degrade in environmental buffers, but with direct potable reuse they could pose a health risk and exceed health guidelines.[32]

PFAS

Existing reuse treatment technology can fail to remove shorter-chain PFAS.[33] Certain wastewater treatment processes can actually increase PFAS levels by degrading precursor compounds, requiring the use of reverse osmosis.[34] PFAS, however, can accumulate on the reverse osmosis and nanofiltration membranes, reducing water recovery and increasing waste brines.[35] Studies have found that even very low levels of PFAS can be toxic to human health. That is why the U.S. Environmental Protection Agency (EPA) has proposed advisory levels for the two most studied forms at near-zero levels.[36]

Unknown risks

Contaminants may interact together in a way that increases their toxicity, especially within a closed loop system.[37] It is impossible to monitor for all potential toxics within a reuse system, and many contaminants are unknown and difficult to even test for with current technology.[38] There have been few health-based studies looking at long-term exposure to low levels of unregulated contaminants of concern.[39]

Equity Challenges

Water recycling in California is about twice as expensive as traditional systems, although reuse costs are lower than desalination.[40] Direct potable reuse in Nevada can cost up to 6.5 times as much as indirect potable reuse.[41] The higher costs are borne by households and other customers through increased water bills. Across the country, millions of people are already struggling to afford their water bills.[42]

Expensive alternative supply projects worsen water affordability challenges, leaving more low-income households struggling to pay the higher prices.[43] The costs of these investments are not borne equally, with low-income households forced to pay disproportionately higher bills to pay for new water supplies.[44] According to one study, "across all drought scenarios – expanding supplies always increases costs for utilities, always reduces affordability for low-income households, but does not always reduce affordability for high-income households."[45]

Reliance on expensive treatment systems can deepen the existing divides between communities that have running water and those that do not. Costs can be too high for smaller communities,[46] so states that prioritize reuse over better water management would leave many rural or disadvantaged communities without access to water after their wells have gone dry.

More broadly, it is inequitable to force households to pay for expensive direct potable reuse schemes while continuing to allow developers, large fossil fuel and agribusiness corporations (Big Oil and Big Ag) to continue to waste water supplies. In California, expanded nut crop acres required more than 520 billion gallons more water in 2021 than just four years prior. Alfalfa irrigation guzzles about 945 trillion gallons of water per year. Mega-dairies use more than 142 million gallons per day, and climate polluting oil and gas operators have devoured 3 billion gallons of freshwater between 2018 and 2021.[47] Without reining in these abuses, these expensive alternative water supplies serve simply to enable business as usual for developers, Big Ag, and Big Oil — leaving households to pick up the tab.

Better Water Stewardship Can Preserve Our Existing Supplies

States and localities should not use expensive, risky alternative water supply projects like direct potable reuse as an excuse to allow more unrestrained sprawling development, large scale industrial agriculture, and other wasteful practices in drought-stricken regions. Water conservation and fixing water leaks are the most cost-effective options to manage water supplies and should be the first course of action.[48] States must adopt better water stewardship practices through conserving our existing supplies and stopping the abusive water practices of Big Oil and

Big Ag. It is irresponsible for governments to pursue direct potable reuse projects instead of reining in corporate water abuses.

Through better water stewardship that puts people and the planet before corporate excess, we can better ensure equitable access to water and protect the human right to water for everyone.

Endnotes

1 Peterson, Brittany. "Colorado to reuse water for drinking, creating new supply." *Associated Press.* October 21, 2022; Becker, Rachel. "How can California boost its water supply?" *Cal Matters.* November 7, 2022; Ding, Jaimie. "Los Angeles could soon put recycled water directly in your tap. It's not toilet to tap." *Los Angeles Times.* July 22, 2022; Brannstrom, Christian et al. "Not a silver bullet: social perspectives on desalination and water reuse in Texas." *Urban Water Journal.* October 2022 at 1.

2 For example, see Stone, Eric. "'Toilet to Tap' gets a second life in southern California." *NPR*. October 17, 2022; Ding (2022).

3 Binz, Christian et al. "Of dreamliners and drinking water: Developing risk regulation and a safety culture for direct potable reuse." *Water Resources Management.* Vol 32. Iss. 2. 2018 at 2 and 3.

4 U.S. Environmental Protection Agency (EPA). "2017 Potable Reuse Compendium." 2017 at 1-1; National Research Council. (2012). *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater*. Washington, DC: The National Academies Press at 1, 14 and 28.

5 EPA (2017) at 2-1; National Research Council (2012) at 28.

6 EPA (2017) at 1-1 and 1-4.

7 National Research Council (2012) at 38.

8 Pereira Santos, Ana Silvia et al. "Progress on legal and practical aspects on water reuse with emphasis on drinking water – an overview." *Water Supply.* Vol. 22. No. 3. 2022 at 11; U EPA, 2017 at 2-1 to 2-5.

9 EPA (2017) at 1-1 and 1-4; National Research Council (2012) at 38.

10 Pereira Santos et al. (2022) at 10 to 11; EPA (2017) at 2-7; Jeffrey, P. et al. "The status of potable water reuse implementation." *Water Research.* Vol. 214. February 2022 at 8 to 9.

11 Pereira Santos et al. (2022) at 10 to 11; EPA (2017) at 2-1 to 2-5.

12 Keller, Arturo et al. "Direct potable reuse: Are we ready? A review of technical, economic and environmental considerations." *American Chemical Society ES&T Engineering.* Vol. 2. Issue 3. 2022 at A to B; Jeffrey et al. (2022) at 1; National Research Council (2012) at 38.

13 Binz et al. (2018) at 2 to 4.

14 *Ibid.* at 6.

15 *Ibid.* at 7 to 8.

16 EPA. "America's Water Sector Workforce Initiative: A Call to Action." October 2020 at 2 to 4.

17 For example, see: Perlis, Wicker. "Former employee: Staffing problems at Jackson water plant at heart of city's water crisis." *Mississippi Clarion Ledger.* September 14, 2022; Kurtz, Josh. "Lawmakers tour troubled wastewater treatment plant and ponder more state help." *Maryland Matters.* September 22, 2022.

18 Brannstrom et al. 2022 at 10 to 11; Scruggs, Caroline E. and Catherine M. Heyne. "Extending traditional water supplies in inland communities with nontraditional solutions to water scarcity." *WIREs Water.* Iss. 1543. June 2021 at 4.

19 Keller et al. (2022) at C, H, and I.

20 Sim, Alison and Meagan S. Mauter. "Cost and energy intensity of U.S. potable water reuse systems." *Environmental Science: Water Research & Technology.* 2021 at 3 and 11.

21 Page, Declan et al. "Risks of perfluoroalkyl and polyfluoroalkyl substances (PFAS) for sustainable water recycling via aquifers." *Water.* Vol. 11. Iss. 1737. 2019 at 1 and 14.

22 EPA. "Mainstreaming Potable Water Reuse in the United States: Strategies for Leveling the Playing Field." April 2018 at 9; National Research Council (2012) at 165 to 166.

23 Thompson, Kyle A. and Eric R. Dickenson. "A performance-based indicator chemical framework for potable reuse." *AWWA Water Science.* July 2020 at 2.

24 Keller et al. (2022) at B; Scruggs and Heyne (2021) at 11.

25 Binz et al. (2018) at 9.

26 Schwabe, Kurt et al. "Unintended consequences of water conservation on the use of treated municipal wastewater." *Nature Sustainability.* Vol. 3. May 2020 at 7 to 8.

27 Keller et al. (2022) at B; Thompson and Dickenson (2020) at 2; Scruggs and Heyne (2021) at 11.

info@fwwatch.org
202.683.2500 (DC)
510.922.0720 (CA)
foodandwaterwatch.org

28 Keller et al. (2022) at E to F; EPA. "Technical Fact Sheet – 1,4-Dioxane." (EPA 505-F-17-011). November 2017 at 3; EPA. "Technical Fact Sheet – NDMA." (EPA 505-F-17-005). November 2017 at 3.

29 Keller et al. (2022) at B; Scruggs and Heyne (2021) at 11.

30 Campanale, Claudia et al. "A detailed review study of potential effects of microplastics and additives of concern on human health." *International Journal of Environmental Research and Public Health.* Vol. 17. February 2020 at 16 to 18; Bonanomi, Marcella et al. "Polystyrene micro and nano-particles induce metabolic rewiring in normal human colon cells: A risk factor for human health." *Chemosphere.* Vol. 303. Iss. 134947. May 2022 at Abstract and 5 to 12; Barguilla, Irene et al. "Long-term exposure to nanoplastics alters molecular and functional traits related to the carcinogenic process." *Journal of Hazardous Materials.* Vol. 438. 2022 at Abstract and 7 to 8; Hirt, Nell and Mathilde Body-Malapel. "Immunotoxicity and intestinal effects of nano- and microplastics: a review of the literature." *Particle and Fibre Toxicology.* Vo. 17. Iss. 57. 2020 at Abstract and 19.

31 Marron, Emily L. et al. "The Formation and Fate of Carbonyls in Potable Reuse Systems." *Environmental Science Technology.* September 2020 at Abstract, 2, 3, 5, and 6.

32 *Ibid.* at 8 to 9.

33 Gonzalez, Dana et al. "Granular activated carbon-based treatment and mobility of per- and polyfluoroalkyl substances in potable reuse for aquifer recharge." *AWWA Water Science.* September 2021 at Abstract, 2, 7 to 9, and 14; Page et al. (2019) at 6.

34 Page et al. (2019) at 4.

35 *Ibid.* at 6.

36 EPA. "Drinking Water Health Advisories for PFAS Fact Sheet for Communities." June 2022.

37 Thompson and Dickenson (2020) at 2.

38 *Ibid.* at 2 and 13; Marron et al. (2020) at 10.

39 Keller et al. (2022) at B; Scruggs and Heyne (2021) at 12.

40 Rupiper, Amanda et al. "Untapped potential: leak reduction is the most cost-effective urban water management tool." *Environmental Research Letters.* Vol. 17. Iss. 0304021. February 2022 at Figure 4 on 7.

41 Dow, Cory et al. "Evaluating the sustainability of indirect potable reuse and direct potable reuse: A southern Nevada case study." *AWWA Water Science.* Vol. 1153. 2019 at Abstract.

42 Cardoso, Diego S. and Casey J. Wichman. "Water Affordability in the United States." *Water Resources Research.* 2022 at Abstract .

43 Rachunok, Benjamin and Sarah Fletcher. "Socio-hydrological drought impacts on urban water affordability." *Nature Water.* Vol. 1. January 2023 at Abstract and 83.

44 *Ibid.* at 84.

45 *Ibid.* at 85 to 86.

46 Scruggs and Heyne (2021) at 3.

47 Food & Water Watch. "Big Ag, Big Oil, and the California Water Crisis." February 2023 at 2.

48 Rupiper et al. (2022) at 6 to 7 and 9; Keller et al. (2022) at A; Dow et al. (2019) at 9 and 13.

info@fwwatch.org
202.683.2500 (DC)
510.922.0720 (CA)
foodandwaterwatch.org