

RESOURCE SUMMARY

Pollution Prevention (P2): Closed Loop Systems and Other Options for Wastewater Reuse

While 71% of Earth's surface is covered in water, only about three percent of that water is fresh water—including glaciers and ice caps. Arizona, a desert state, receives a small amount of rain per year, requiring supplemental resources from several nearby reservoirs.

Arizona's rapidly growing population of roughly 6.5 million people uses about 2.3 trillion gallons of water per year.¹ Wastewater recycling can be used to extend the lifespan of utilized water and reduce consumption at the source.

Closed loop systems technologies can be beneficial to any industry and business such as reusing wastewater generated in the food manufacturing industry for cooling and heating purposes. Depending on the type of wastewater reused, this may require an initial (or continuing investment) and a knowledge of the quality of water reused. This resource summary offers general information on closed loop systems.

What Is a Closed Loop System?

A closed loop system is a process for wastewater or other input reuse where all water or other inputs used are indefinitely recycled. The system is made possible via chemical additives and/or electrical currents to neutralize and remove all contaminants and particulates from wastewater repeatedly, which returns the water to its original usable state.²

The purpose of closed loop technology is to maximize the use of natural resources and other materials. In this manner, all resources from beginning to end are utilized and repurposed, thereby reducing the use of new materials and creating an overall reduction in source pollution.³

Closed Loop System Examples

Closed-loop systems can be incorporated in many industries, activities and scenarios. For example, the Sebatier System on NASA's International Space Station (ISS) incorporates a closed loop system that reacts byproducts carbon dioxide and hydrogen to produce up to 530 gallons of water per year. Without the ability to recycle wastewater, the ISS would have to ferry approximately 5,000 gallons of water per year to support basic functions.⁶

A public rest stop in Dunnigan, CA runs a closed loop waste water system which uses recycled plastics as the ideal filtration materials. So far, the system has utilized 400 cubic feet of 100% recycled plastics.⁷

Applications and Benefits of Recycled Wastewater

The U.S. Environmental Protection Agency (EPA) outlines several ways in which reclaimed water can be reused (some processes may be closed loop)⁴:

- Industrial processes
- Pre-washing tools/equipment
- Re-use of water in heating/cooling systems
- Replenishing a groundwater basin (also known as a groundwater recharge, wherein groundwater supplies are supplemented with wastewater, which has been extensively treated to meet and surpass drinking water standards)⁵

The following are benefits of water reuse:

- Conserving potable water and costs
- Mitigating discharge of wastewater into ground water and surface waters by recirculating utilized water

Stages of Treatment and Repurposing of Contaminants and Particulates

The National Academies of Science, Engineering and Medicine describe the stages of the closed loop water treatment process as follows:⁵ **Primary** -- removal of portion of suspended solids and organic matter **Secondary** -- biological treatment; removes biodegradable organic matter and solids. This step usually incorporates disinfection of water.

Advanced⁵ -- nutrient removal, filtration, complete disinfection, final removal of organic matter and solids as well as dissolved solids and trace constituents. Throughout the process of these stages, all extracted contaminants and particulates are examined for repurposing. Oxidized metals, for example, are added to fertilizers and recovered oils are recycled.

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Closed Loop Methodologies

There are various technologies through which the closed loop system for wastewater reuse can be implemented:²

- Electrocoagulation (EC): utilizes electricity to propel chemical reactions in a solution, thereby removing 99.9% contaminants
- Biocides: disinfectant used to eradicate pathogenic (disease-causing) fungus and mold
- Polishing filter, such as reverse osmosis or membrane reactors (semipermeable to pore-sized membranes in conjunction with biological treatment process)

Source Reduction

Closed-loop technology enables recycling of not only wastewater, but also chemicals and other process input materials. Recycling these can reduce the need for additional amounts at the source. These source reduction opportunities include:

- Freshwater requirement reduction
- Reduction in chemical use via solvent reuse
- Hazardous waste generation reduction through re-use of the material instead of classifying it as a hazardous waste⁴

Compliance and Exclusions

The exemption allowed by closed-loop recycling, found in 40 CFR 261.4(a)(8), enables waste generators to qualify their wastewater reuse as an exclusion to hazardous waste generation.⁸ Secondary materials, or byproducts, that are reclaimed and returned to their original generation processes are excluded from the total amount of hazardous waste generation accounted for and thereby incentivize generators to focus on wastewater recycling processes.

Though RCRA enables exclusions for amount of hazardous waste generated via closed loop recycling, companies must ensure compliance with all regulations regarding exclusions, cited in 40 CFR 261.4(a)(8) (i-iv).



NASA Astronaut Doug Wheelock works to install the Sabatier System to extract water out of the ISS atmosphere. Photo credit: NASA

References

¹Arizona Department of Water Resources. Water Your Facts.

²Els, Patricia. WaterWorld.com. *Embracing Closed-Loop Technology for Recycling and*

<u>Reuse.</u>

³Fedkin, Mark. Technologies for Sustainability Systems. *Recycling: Open-Loop vs.*

Closed-Loop Thinking.

⁴EPA. Potable Water Reuse and Drinking Water

⁵National Research Council. *Water Reuse: Potential for Expanding the Nation's Supply*

through Reuse of Municipal Wastewater.

⁶NASA. The Sebatier System: Producing Water on the Space Station.

⁷Waymouth, Belinda. Huffington Post Blog. *Poop* + *Plastic* = *Good News for H2O*

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⁸EPA. Criteria for the Definition of Solid Waste and Solid and Hazardous Waste

Exclusions.

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