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Review Article

Water Recycling: Benefits and Risks

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Abstract *- Water is one of the most precious resources in the world. The ability to protect the world's water supply is an essential priority for encouraging water reuse, and developing strategies to encourage water recycling is a key action to help achieve this priority. Water recycling means using water again previously used for another purpose. Recycled water can fulfill most water demands as long as it is adequately treated to guarantee that its quality is appropriate for use. Recycling water reduces the demand for drinkable water, such as irrigation, which does not require highly treated water. The quality of recycled water determines how it can be used to protect public health and the environment. This article provides basic information about water recycling. In this article, I outline the basics of water recycling related to value, terminology, types, benefits, risks, future, and regulations in the United States.*

Keywords *- Water Recycling, Water Reclamation, Water Reuse, Wastewater Reuse.*

1. Introduction

Water reclamation is also known as water recycling, recycled water, water reuse, wastewater reuse, and reclaimed water [1]. It is a growing practice in many regions of the world. Countries and regions in which water reuse is on the rise include the United States (U.S.), Western Europe, Australia, and Israel. In the U.S., the practice of recycling water is a large and growing industry [2]. Communities all through the U.S. have safely used recycled water for many years. Los Angeles County's sanitation districts have provided treated wastewater for landscape irrigation in parks and golf courses since 1929. California's first recycled water facility was built at San Francisco's Golden Gate Park in 1932 [3].

Thirty-two billion gallons of municipal wastewater are produced daily in the United States, but less than 10 percent is intentionally reused [4]. Strategies and programs that encourage water reuse are key actions to help meet this priority. Recycled water can satisfy most water demands as long as it is adequately treated to ensure appropriate water quality [5]. Reusing water reduces the demand for drinkable water, such as irrigation, which does not require highly treated water. The quality of reused water determines how it can be used to protect public health and the environment [6].

According to the U.S. Environmental Protection Agency's (EPA) report (2000) [7], Watershed Needs Survey, a total of 34.9 bgd (132 million m3 /d) of municipal wastewater effluent is produced. Thus, the proportion currently reused amounts to only 9.7%, suggesting that future potential for recycling treated wastewater is enormous [2]. The use of recycled water on a volume basis is growing at an estimated 15% per year in the U.S. All evidence suggests that water recycling will play an expanded role in water management in the 21st century, not only in the semi-arid western states and "sunbelt" states but perhaps in all 50 states. At a compound annual growth rate of 15%, the volume of recycled water would amount to 12 bgd (45 million m3 /d) by 2015 [2].

2. Water Recycling Value

According to a report by the Department of Environmental Quality (DEQ) (2011) [6], in recent decades, water has been treated to very high standards, used for a primary purpose, and then discharged to a river or stream as "wastewater." Although this water is typically lower quality following primary use, used water has resource value. It can often be safely reused for additional purposes without adverse effects on public health or the environment. Reusing appropriately treated "wastewater" for irrigation, industrial, commercial, and construction applications help to conserve drinking water supplies and improve the water quality of surface waters. Water reuse reclaims water from various sources and then treats and reuses it for beneficial purposes such as agriculture and irrigation, potable water supplies, groundwater replenishment, industrial processes, and environmental restoration. Water reuse can provide alternatives to existing water supplies and be used to enhance water security, sustainability, and resilience [8].

Water reuse can be defined as planned or unplanned. Unplanned water reuse refers to situations in which a source of water is composed of previously used water. A common example of unplanned water reuse occurs when communities draw their water supplies from rivers, such as the Colorado and Mississippi Rivers, which receive treated wastewater discharges from upstream communities [8]. Planned water reuse refers to water systems that beneficially reuse a

recycled water supply. Often, communities will seek to optimize their overall water use by reusing water to the extent possible within the community before it is reintroduced to the environment. Examples of planned reuse include agricultural and landscape irrigation, industrial process water, potable water supplies, and groundwater supply management [8].

3. Water Recycling Terminology

According to the Texas Water Development Board (TWDB) report (2019) [9], there are two major categories of water reuse: direct reuse and indirect reuse. Both categories can be used for potable purposes.

- *Direct reuse* refers to reclaimed water piped directly from a wastewater treatment facility to a distribution system for beneficial use. Examples of direct reuse for nonpotable uses include piping treated wastewater to an industrial center for manufacturing, a golf course for irrigation, or a power plant for cooling.
- *Indirect reuse* refers to the discharge of reclaimed water back to an environmental buffer such as a lake, river, or aquifer, which is retrieved to be utilized again. Indirect reuse projects that involve a watercourse require a bed and bank permit from the state, which authorizes the permit holder to convey and subsequently divert water.
- *Direct potable* refers to using advanced treated reclaimed water piped directly into the distribution system or blended with the raw water supply and the water treatment plant.
- *Indirect potable* refers to using treated reclaimed water to augment drinking water supplies by discharging it to a water body, such as groundwater or surface water, and subsequent treatment for potable consumption.

4. Types of Water Recycling

According to a report by the EPA (2022) [8], sources of water for potential reuse can include municipal wastewater, industrial processes and cooling water, stormwater, agriculture runoff and return flows, and water produced from natural resource extraction. These water sources are adequately treated to meet “fit-for-purpose specifications” for a particular next use. "Fit-for-purpose specifications” are the treatment requirements to bring water from a particular source to the quality needed to ensure public health, environmental protection, or specific user needs. For example, reclaimed water for crop irrigation would need to be of sufficient quality to prevent harm to plants and soils, maintain food safety, and protect the health of farm workers. In uses where there is greater human exposure, water may require more treatment [8].

The DEQ (2011) [6] encourages the reuse of three general categories of water:

- *Graywater* refers to water from showers, baths, bathroom sinks, kitchen sinks, and laundries. Graywater can be reused for limited activities, such as subsurface irrigation, with minimal treatment.

- *Recycled water* refers to treated effluent from a municipal wastewater treatment facility. That can be reused for specific beneficial purposes.
- *Industrial wastewater* refers to treated effluent from an industrial process, manufacturing or business, or the development or recovery of any natural resource. An example of industrial wastewater is water derived from the processing of fruit, vegetables, or other food products.

5. Beneficial Uses For Recycled Water

The recycled water supply has been treated at a wastewater treatment plant to a safe standard for various household purposes. Although water reuse activities are limited to non-drinking water, many activities can occur, including flushing toilets, watering gardens, and washing cars. It is unsafe for drinking, so users should keep their recycled water supply clear from rainwater tanks and drinking water systems [10]. Specific water reuse activities depend on the water treatment and resulting quality. More reuse activities can occur with higher-quality water. As treatment technologies improve and public awareness of the benefits of water reuse increases, more innovative and urban uses of water will become more common [6].

According to a report by the EPA (2022) [8], here are some examples of water sources and use applications:

- Irrigation for agriculture, lawns, and gardens
- Irrigation for landscaping such as parks, rights-of-ways, playing fields, and golf courses
- Municipal water supplies
- Processing water for power plants, refineries, mills, and factories
- Indoor uses such as toilet flushing
- Dust control or surface cleaning of roads, construction sites, and other trafficked areas
- Concrete mixing and other construction processes
- Supplying artificial lakes and inland or coastal aquifers
- Environmental restoration
- Other uses include washing cars, and pets, filling water features and ornamental ponds (with no fish) and operating evaporative coolers and air conditioners [10].

According to the SAWater report (2022) [10], the recycled water supply is not for the following:

- Drinking
- Cooking or food preparation tasks such as rinsing vegetables
- Personal washing, including baths, showers, hand basins, and bidets or brushing of teeth
- Indoor cleaning
- Use in swimming pools and spas
- Recreational activities, including children playing under sprinklers.

5.1. What are the Environmental Benefits of Water Recycling?

In addition to providing a dependable, locally controlled water supply, water recycling provides tremendous environmental benefits. By providing an additional water source, water recycling can help us find ways to decrease water diversion from sensitive ecosystems. Other benefits include decreasing wastewater discharges and reducing and preventing pollution. Recycled water can also create or enhance wetlands and riparian habitats [11].

5.2. Water Recycling Can Decrease the Diversion of Freshwater from Sensitive Ecosystems

Plants, wildlife, and fish rely upon adequate water flows to their habitats to live and reproduce. The lack of adequate flow, as a result of diversion for agricultural, urban, and industrial purposes, can cause the deterioration of water quality and the health of the ecosystem. People who reuse water can supplement their demands by using a reliable source of recycled water, freeing considerable amounts of water for the environment and increasing flows to vital ecosystems [11].

5.3. Water Recycling Decreases Discharge to Sensitive Water Bodies

In some cases, the impetus for water recycling comes not from a water supply need but from a need to eliminate or decrease wastewater discharge to the ocean, an estuary, or a stream. For example, high volumes of treated wastewater discharged from the San Jose/Santa Clara Water Pollution Control Plant into the south San Francisco Bay threatened the area's natural saltwater marshes. In response, a $140 million recycling project was finished in 1997. The South Bay Water Recycling Program can provide 21 million gallons per day of recycled water for use in irrigation and industry. By avoiding the conversion of saltwater marsh to brackish marsh, the habitat for two endangered species can be protected [11].

5.4. Recycled Water May Be Used to Create or Enhance Wetlands and Riparian (Stream) Habitats

Wetlands provide many benefits, which include wildlife and wildfowl habitat, water quality improvement, flood diminishment, and fishery breeding grounds. For streams that have been impaired or dried from water diversion, water flow can be augmented with recycled water to sustain and improve the aquatic and wildlife habitat [11].

5.5. Water Recycling Can Reduce and Prevent Pollution

At the point when pollutant discharges to oceans, rivers, and other water bodies are diminished, the pollutant loadings to these bodies are diminished. In addition, in some cases, substances that can be pollutants when released into a waterway can be beneficially reused for irrigation. For example, recycled water may contain higher nutrients, such as nitrogen, than potable water. Applying recycled water for agricultural and landscape irrigation can provide an additional source of nutrients and lessen the need to apply synthetic fertilizers [11].

5.6. Recycling Water Can Save Energy

As water demand grows, more water is extracted, treated, and transported, sometimes over great distances, requiring a lot of energy. If the local water source is groundwater, the groundwater level becomes lower as more water is removed, increasing the energy required to pump the water to the surface. Recycling water on-site or nearby reduces the energy needed to move water longer distances or pump water from deep within an aquifer. Tailoring water quality to a specific use also reduces the energy needed to treat water. The water quality required to flush a toilet is less stringent than the water quality needed for drinking water and requires less energy. Using recycled water of lower quality for uses that do not require high-quality water saves energy and money by reducing treatment requirements [11].

Reusing water to save energy is more thoroughly discussed in the California Energy Commission's 2005 report: California's Water-Energy Relationship (CEC#700-2005-011-SF) [12]. This report highlights a large amount of energy required to treat and distribute water. Energy is required first in collecting, extracting, conveying, and distributing water to end users and second in treating and disposing of the wastewater once the end users have finished. Although it requires additional energy to treat wastewater for recycling, the amount of energy required to treat and transport other sources of water is generally much greater [11].

6. Water Recycling Regulations

According to the EPA (2022) [8], EPA does not require or restrict any type of reuse. Generally, states maintain primary regulatory authority (i.e., primacy) in allocating and developing water resources. Some states have established programs specifically addressing reuse, and some have

incorporated water reuse into their existing programs. EPA, states, tribes, and local governments implement programs under the Safe Drinking Water Act and the Clean Water Act to protect the quality of drinking water sources, community drinking water, and waterbodies such as rivers or lakes. Together, the Safe Drinking Water Act and the Clean Water Act provide a foundation from which states can enable, regulate, and oversee water reuse as they deem appropriate [8].

The EPA regulates many aspects of wastewater treatment and drinking water quality. The majority of states in the US have established criteria or guidelines for the beneficial use of recycled water. In 1980, the EPA developed a technical document entitled Guidelines for Water Reuse (PDF) (28pp, 614K), which contains a summary of state requirements, and guidelines for the treatment and use of recycled water [13]. State and Federal regulatory oversight has successfully provided a framework to ensure the safety of the many water recycling projects developed in the United States [11].

7. Risks of Water Recycling

The following are some "Cons of Water Recycling, Reuse, and Reclamation" (Better Meets Reality, 2021) [14].

7.1. Can Be Initially Expensive

According to epa.gov, "The treatment of wastewater for reuse and the installation of distribution systems at centralized facilities can be expensive compared to water supply alternatives such as imported water, groundwater, or the use of gray water on-site from homes." For example, in San Diego, "A permanent water recycling plant would cost an estimated $369 million".

7.2. Cost of Producing Recycled Water Can Be Expensive Relative to Some Other Water Sources

In regions where fresh water is ample or bountiful, water recycling can be more costly than other water sources such as surface water or groundwater extraction and use. Costs can include construction, dedicated infrastructure, quality monitoring and identifying contaminants, etc.

7.3. It Sometimes Has to Be Subsidized and Sold Below the Actual Supply Cost

Subsidy and sale at below the actual cost of supply may encourage its use in some parts of the world.

7.4. Can Need Its Own Dedicated Infrastructure and Pipe System

In places such as the U.S. or Australia, purple or lavender marked pipes for recycled water, taps, and other infrastructure (such as storage tanks) cost money and take up space.

7.5. Can Carry Commercial Risk and Economic Viability Concerns

There is demand risk, particularly in some regions. There are questions over whether some plants can be feasible from an economic perspective, at least in the short term.

7.6. Not All Recycled Water Can Be Used for Drinking Water, and Other Specific Uses

Recycled water cannot be used for drinking, cooking, bathing, filling pools, or several other uses.

7.7. The Public May Be Skeptical of Using or Consuming Recycled Water

The public's perspectives towards and social acknowledgement of recycled water can be poor, particularly for some types of recycled wastewater.

7.8. Can Have Institutional Barriers to Implementation

Institutional barriers may include water management authorities not making water recycling a priority compared to other water supply options or regulatory barriers.

7.9. Some Regions Have Inadequate or No Regulations on Specific Types of Water Recycling

According to epa.gov, "Most states [in the US] have regulations governing the quality of water recycling of reclaimed water from centralized treatment facilities, but only about 30 of the 50 states have regulations about water recycling of gray water".

7.10. Developing Countries May Reuse Water in An Unsafe Manner

Developing countries may use untreated wastewater for irrigation, becoming a public health and safety hazard. This water can also further contaminate soil and decrease soil health.

7.11. Can Have Difficulties During the Operation and Treatment Stage

According to the Better Meets Reality report (2021) [14], "Difficulties in contaminant identification may include the separation of inorganic and organic pollutants, microorganisms, colloids, and others".

7.12. Use Of Reclaimed Wastewater for Irrigation Can Have Risks

Risks from reclaimed wastewater may include contamination of the food chain, soil salinization, and accumulation of chemicals.

7.13. The Distance of Centralized Water Treatment Plants to Farms Can Be Too Far

The distance from farms to centralized treatment plants can be too great. However, on-site treatment may eventually solve this.

8. What is the Future of Water Recycling?

Water recycling has shown to be viable and effective in creating a new and reliable water supply while not compromising public health. Nonpotable reuse is a widely accepted practice that will keep on developing. However, in many parts of the United States, the use of recycled water is expanding to accommodate the needs of the environment and the growing demand for water supplies. Advances in wastewater treatment technology and health studies of indirect potable reuse have led many to predict that planned indirect potable reuse will soon become more common [11].

While water recycling is a sustainable approach and can be cost-effective in the long term, the treatment of wastewater for reuse and the installation of distribution systems initially be expensive compared to such water supply alternatives as imported water or groundwater. Institutional barriers and varying organisational needs can make it difficult to carry out water recycling projects. Finally, early in the planning process, agencies must implement public outreach to address any concerns and to keep the public involved in the planning process. Water recycling will assume a larger part of our general water supply as water demands and environmental needs grow. Working together to overcome water recycling and water conservation obstacles can help us conserve and sustainably manage our vital water resources [11].

9. Conclusion

Water recycling addresses a significant water supply in numerous regions of the world. Water reuse is the practice of using treated wastewater for a beneficial purpose. Water recycling is increasingly important in the U.S., Australia, Europe, and other regions. In the U.S., recycling water is a large and growing industry. We are using more recycled water as we become more water efficient. By treating wastewater and delivering it through a separate network, it can be used safely for a range of purposes. By expanding the accessibility of recycled water, safe, clean drinking water is saved for only that, notwithstanding food preparation and personal hygiene. Recycled water also lessens how much-treated wastewater is released into the ocean, reducing the environmental impact of our infrastructure. The future of water recycling depends on many factors, such as economic considerations, potential uses for reclaimed water, the stringency of wastewater discharge requirements, and public policies for conservation and protection.

References

[1] Department of Energy, " Reclaimed wastewater map," *Federal Energy Management Program*, U. S. Department of Energy, 2022. https://www.energy.gov/eere/femp/reclaimed-wastewater-map

[2] Diemer, D. M, "An overview of water recycling in the United States," Water Environment Research Foundation, 2007. https://www.niph.go.jp/soshiki/suido/pdf/h19JPUS/abstract/r14.pdf

[3] Rock, C., McLain, J. E., & Gerrity, D, "Water recycling FAQs," *Arizona Cooperative Extension*, 2012. https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1568.pdf

[4] Environmental Protection Agency, Guidelines for water reuse [PDF]. United States Environmental Protection Agency, 2012. https://nepis.epa.gov/Adobe/PDF/P100FS7K.pdf

[5] Environmental Protection Agency , Water recycling and reuse: The environmental benefits. United States Environmental Protection Agency. Pacific Southwest Region 9, 2017. https://19january2017snapshot.epa.gov/www3/region9/water/recycling/

[6] Department of Environmental Quality , " Water reuse: Using our water wisely, " *State of Oregon Department of Environmental Quality*, 2011. https://www.oregon.gov/deq/FilterPermitsDocs/waterreuse.pdf

[7] Environmental Protection Agency, "Clean watersheds needs survey (CWNS) – 2000 Report and Data," United States Environmental Protection Agency, 2000. https://www.epa.gov/cwns/clean-watersheds-needs-survey-cwns-2000-report-and data#:~:text=Clean%20Watersheds%20Needs%20Survey%20%28CWNS%29%20%E2%80%93%202000%20Report,on%20the%20costs%20for%20compliance%20with%20the%20CWA

[8] "Basic information about water reuse," *Environmental Protection Agency* , United States Environmental Protection Agency, 2022. https://www.epa.gov/waterreuse/basic-information-about-water-reuse

[9] TWDB . "Water reuse." *Texas Water Development Board*, 2019. https://www.twdb.texas.gov/publications/shells/WaterReuse.pdf#:~:text=The%20Texas%20Water%20Development%20Board%20%28TWDB%29%20published%20a,Texas%20to%20help%20communities%20assess%20direct%20potable%20reuse

[10] SAWater , " Reuse and recycled water," *South Australia Water*, 2022. https://www.sawater.com.au/my-home/saving-water/reuse-and-recycled-water

[11] "Sustainable Water: Extending the Lifecycle of Water ," From the EPA: Water recycling and reuse – The environmental benefits. United States Environmental Protection Agency, *Water Division Region IX*, 2018. https://sustainablewater.com/from-the-epa-water-recycling-and-reuse-the-environmental-benefits/

[12] California Energy Commission , California's Water-Energy Relationship (CEC#700-2005-011-SF), 2005. http://large.stanford.edu/courses/2012/ph240/spearrin1/docs/CEC-700-2005-011-SF.PDF

[13] Environmental Protection Agency , "Guidelines for water reuse," United States Environmental Protection Agency, 1980. https://nepis.epa.gov/Exe/ZyPDF.cgi/2001306I.PDF?Dockey=2001306I.PDF

[14] Better Meets Reality , "Pros and cons of water recycling, reuse, and reclamation," 2021. https://bettermeetsreality.com/pros-cons-of-water-recycling-reuse-reclamation/