Understanding the Pipe Dreams of San Francisco Bay Area Recycled Water

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ABSTRACT

Historically, California has experienced natural periods of drought due to variable annual rainfall. Due to the ongoing climate crisis, these periods are increasing with severity and frequency. The San Francisco (SF) Bay Area depends on transported water from the Sierra Nevada mountains for all drinking water and has needed to regulate non-potable uses, such as irrigation. Recycling wastewater for non-potable reuse is a viable solution to lessen the demand on transported water in California. Although there is a water recycling facility in every SF Bay Area County, there is still an estimated 450,000 Acre Feet of wastewater per year that can be recycled. This research centrally examines the key issues that potential consumers and stakeholders have with expanding SF Bay Area recycled water. To answer this question, local experts and recycled water affiliates were interviewed, their answers were coded and organized into charts. The theme of education was found in most key drivers and barriers. Because the public lacks water reuse knowledge and how water infrastructure works, they do not demand access to recycled water. Additionally, SF Bay Area residents have not felt the effects of climate change as much as other areas due to the Mediterranean climate and holding senior water rights. To drive the demand for recycled water, the public must become more educated about water scarcity and the SF Bay Area's socioeconomic status in order to not divert unnecessary resources from disadvantaged communities in the Central Valley.

KEYWORDS

water reuse, water systems, non-potable reuse, recycled water stakeholders, water scarcity

INTRODUCTION

Due to the increasing severity and frequency of drought periods in California, as well as improper water management practices, much of the State is experiencing water scarcity. A central concept of water scarcity is the imbalance between supply and demand (Gleick and Cooley 2021). Precipitation in California is highly variable and seasonal due to its Mediterranean climate. The highest annual precipitation occurs in the Sierra Nevada Mountains, the snowpack forms natural reservoirs and releases during Summertime to provide most of California's water supply (Stewart and Graham 2020). Because of this, Federal and State Governments have institutionalized direct provision of water in California, in which water is transported from the Sierra Nevada Mountains into lower elevation municipalities via a complex network of aqueducts, canals, dams, and pumping stations (Reisner 1993). Droughts occur when the amount of water demanded by humans and the environment exceeds the amount provided by nature (Gleick and Cooley 2021). Although 2014-2017 was California's worst drought in over a 100 years, with the lowest precipitation and highest temperatures on record, it is forecasted that the severity of these periods of drought will increase (Stewart et al. 2020). Historically, the San Francisco Bay Area has not experienced severe effects of California's water scarcity due to the municipalities having senior water rights on the Tuolumne and Mokelumne rivers (Cooley et al. 2022). However, recent droughts and wildfires have created new challenges which highlight the value of local self-sufficiency for water usage (Cooley et al. 2022). For instance, on April 27th, 2021 EBMUD (East Bay Municipal Utility District) announced a Stage 1 drought and placed Alameda and Contra Costa Counties on irrigation restrictions in attempts to mitigate upcoming water shortages (Pook 2021). To ensure future water supply, San Francisco Bay Area municipalities need to formulate diverse water portfolios that can lessen their demand on transported water.

Recycling wastewater for non-potable reuse is a viable solution to lessen the demand on transported water in California. In general, recycled water facilities collect used domestic water and treat it to a State standard safe for reuse, potable water is safe for human consumption and non-potable is safe for irrigation, industrial, and other non-drinking purposes (Trejo 2021). Recent studies have shown that in 2020, California produced 3.1 million AFY (acre-feet of water per year) of municipal wastewater, yet only an estimated 728,000 AFY of wastewater was recycled (Cooley et al. 2022). Due to the divergence of waterways for human consumption that would otherwise deposit into the Ocean, California State environmental protection laws require San Francisco Bay municipalities to discharge a proportion of treated wastewater into the Bay for aquatic ecosystems. However, it is estimated that 1.8 to 2.1 million AFY is available for reuse in California (Cooley et al. 2022). Within the San Francisco Bay hydrologic region, around 497,000 AFY of wastewater is available for potential reuse, yet only about 49,000 AFY is being recycled (Cooley et al. 2022). To expand the existing recycled water systems, the public must support future projects otherwise they might be rejected or under-utilized (Bell et al. 2016). Previous studies have shown that even when the public is aware of water scarcity, if they lack knowledge of water reuse systems, they are resistant to implementing and using reclaimed water (Garcia-Cuerva et al. 2016). Therefore, it is imperative for the public to be educated on water reuse systems in order for future projects to succeed.

Adoption of non-potable recycled water has been challenging because of the general public's scientific illiteracy with water reuse systems and industry terminology. Previous studies have found that United States farmers are skeptical of irrigating with recycled water because they are unaware of long-term implications on soil and plant health, as well as human health risks (Ricart and Rico 2019). Farmer's willingness to use recycled water has been found to increase with their knowledge of water reuse systems, however they still lack the understanding of recycled water infrastructure and if it is reliable for future irrigation (Dery et al. 2019). The general public has also been found to be more accepting of using recycled water with higher knowledge of and concern for water scarcity yet become less willing to use the closer it comes in proximity to their homes (Steflova et al. 2018). This is because of the 'yuck factor', which is described as a psychological aversion to using recycled water based on the social and cultural perceptions of health risk (Ricart and Rico 2019). How recycled water facilities and municipalities have educated the general public on water reuse has greatly influenced willingness to use. The terminology that has been used to describe recycled water has changed over time as well as varied from local, State, and Federal governments. For example, studies have shown that the general public was more willing to use effluent described as 'recycled water' instead of 'treated wastewater' or 'treated sewage' (Ricart and Rico 2019). This makes it necessary for the public to be fully educated on recycled water systems to support their expansion.

The objective of this study is to explore the drivers and barriers of prospective recycled water consumers in the San Francisco Bay Area. My methods are conducting qualitative interviews with recycled water consultants and professionals in the San Francisco Bay Area and coding the interview results. My central research question asks what are the key issues that potential consumers have about adopting recycled water. To answer this question, I will analyze the key barriers potential consumers have as well as the key drivers to adoption of recycled water. Lastly, I am asking what are the key solutions that can increase the public demand for recycled water in the San Francisco Bay Area.

BACKGROUND

Basis of San Francisco Bay Area Recycled Water and Irrigation

Non-potable Reuse Treatment

Matheny et al. (2022) has laid out the recycled water treatment processes adapted across all current San Francisco Bay Area recycled water facilities. Non-potable recycled water can go through a four-step treatment process. Primary treatment is the initial step where raw sewage is filtered through screens to remove large objects. Secondary treatment is where biodegradables and colloidal organic matter is removed via aerobic and/or anaerobic biological processes. Tertiary treatment removes any remaining particulates through sand and/or carbon filtration, followed by chemical or non-chemical disinfection, such as chlorine, ultraviolet light, hydrogen peroxide, or ozone. Advanced treatment uses micro filtration followed by reverse osmosis to remove dissolved salts, this is not required by the Department of Public Health and is an expensive and energy intensive process. Yet, some agencies will use the advanced treatment for better quality and lower salinity.

Recycled Water Quality For Landscaping

Matheny et al. (2022) laid out standardized guidelines for irrigating San Francisco Bay Area landscapes with recycled water. The most important measurement of water quality for irrigation relies on the presence and concentration of total salts. Soluble salts in soil and water are measured by electrical conductivity (EC), expressed as EC_e for soils and EC_W for water. In the SF

Bay Area, conductivity is measured in deciSiemens per meter (dS/m) and converted into parts per million (ppm). The higher the salinity, the higher the conductivity will be, with distilled water equaling zero. Salinity is also measured as total dissolved solids (TDS), which includes concentrations of important metals, minerals, and salts in the water. Specific ions that are included in the TDS and measured in milligrams per meter (mg/l) are: boron, chloride, sodium, and bicarbonate. Other important factors for irrigating with recycled water include soil permeability and pH. In general, SF Bay Area contains clay soil types that do not drain quickly and can become compacted in urban settings. Permeability of soil is important because salt will build up within impermeable soil and can concentrate around plant roots causing reverse osmosis and physiological drought. Additionally, if plants uptake TDS during transpiration, damaging ions can cause leaf chlorosis and other burn symptoms. Native SF Bay Area plants are adapted to a Mediterranean climate with alkaline soil, up to 8.3pH, however a more acidic soil between 5.5-7pH is preferred. SF Bay Area landscapers need to check recycled water quality for pH, as it can reach levels greater than 8.5pH and may damage sensitive plant species.

San Francisco Bay Area Recycled Water Case Studies

EBMUD

East Bay Municipal Utility District (2019) provides the historical background of its recycled water as well as future goals. To decrease the demand on transported water from the Sierra Nevada mountains for drinking water during periods of water scarcity, EBMUD has adopted recycled water projects. In response to California’s 1987-1992 drought, EBMUD founded the Office of Recycled Water to create drought solutions with water reuse systems. EBMUD began recycling non-potable industrial-use water for their waste treatment facility in 1971. In 1990, EBMUD began installing purple water pipes underground for non-potable distribution, indicated separate from potable water by the pipe coloration. Currently, EBMUD services 1.4 million residents with potable water and pumps 9 MGD (million gallons per day) of non-potable recycled water to customers for irrigation and industrial use. To further reduce dependency on transportedwater, EBMUD has a current goal of recycling 20 MGD of water by 2040 and to expand their purple pipe system to reach more recycled water customers.

Santa Clara County and South Bay Water Recycling

South Bay Water Recycling (2014) provides historical background as well as future plans for water reuse in Santa Clara County. The San José-Santa Clara Regional Wastewater Facility (RWF) was established in 1959 and conducted secondary treatment on wastewater before disposing into the San Francisco Bay. In 1979 the Clean Water Act forced RWF to include tertiary treatment in order to comply with the Federal standards of effluent. In 1989, during a period of drought, the Environmental Protection Agency (EPA) issued a cease-and-desist order to the RWF, limiting the amount of dry weather discharge into the SF Bay in order to protect salt marsh habitats. To continue urban expansion, in 1998 the Cities of San José and Santa Clara, as well as tributary agencies, constructed the South Bay Water Recycling facility (SBWR) and began installing purple pipes throughout Santa Clara County to reduce the amount of effluent disposed into the SF Bay. Currently, RWF services 1.4 million residents across eight cities and unincorporated areas, and the SBWR serves 750 customers across 140 miles of purple pipes. In 2014, the Silicon Valley Advanced Water Purification Center (SVAWPC) was established, intaking the tertiary treated wastewater from RWF and purifying it to a CA State standard of drinking water, however it does not go through advanced oxidation and can not be labeled potable. Instead, the SVAWPC water is blended with SBWR recycled water to create high quality recycled non-potable water which can be used for advanced options such as toilet flushing. SBWR is a wholesaler of recycled water and Santa Clara County customers can purchase it via their local agencies. Currently the RWF treats 110 MGD to a tertiary level, about 13% of it gets transferred to the SBWR for distribution.

METHODS

Stakeholders

To understand the barriers and drivers of potential recycled water consumers in the SF Bay Area, I conducted semi-structured interviews with local water consultants, recycled water specialists, and a landscaper. I chose to speak with local water consultants because they had experience working with recycled water, as well as working with clients with no knowledge or interest in adapting to recycled water. The recycled water experts I interviewed were of importance because of their unique situated knowledge in SF Bay Area specific water reuse systems and how recycled water interacts with the local ecology. I chose to speak with a landscape specialist who has experience working with South Bay Water Recycling as well as EBMUD's recycled water.

Data Collection and Interview Coding

To ensure consistency in data collection, each semi-structured interview was conducted over the phone and not recorded. I wrote down questions in advance on a computer document and filled in responses while I was on the phone with each interviewee. Afterwards, I uploaded each interview document onto Taguette for coding. I coded interview content into three major categories within my framework of recycled water adoption: barrier, driver, and solution. When quotes were separated, I found common key issue topics within each category and further divided interview content into subcategories and created a table for visualization (Table 1). After all quotes were organized by tags and key issue sub-tags, I was able to perform qualitative analysis to find major themes.

Table 1. Interview tags and key issues

Tag	Key Issue
Barrier	Terminology
	Public outreach
	Quality concerns
	Cost of water reuse
	Infrastructure
Driver	Water Scarcity
	End of drain issue
	Golf Courses
	Policy
	Cost of potable water
	Public outreach
	Quality benefits
Solution	Holistic Management
	Innovation of infrastructure
	Climate crisis awareness
	Community outreach

RESULTS

Key Findings

I created Table 2 by replicating Table 1 and adding a third column for interviewee responses representing each tag and key issue. I found that many examples taken from quotes had overlap between tags regardless of what sector the interviewee resided in. A key theme of education stood out amongst every interviewee in local water consulting, recycled water specializing, and landscaping. All interview examples within an educational theme have an asterisk in front.

Table 2. Interview examples within each tag

Tag	Key Issue	Example
Barrier	Terminology	The original CA State terminology of 'treated sewage water' created public dislike and distrust. *Public unable to understand changing terminology and technical terms.
	Public outreach	*SF Bay Area didn't mitigate early negative responses to salt intolerant plants. *EBMUD has no training or certification process for the public.
	Quality concerns	EBMUD recycled water appears green and has an unpleasant odor. *Recycled water needs to be leached due to high salinity
	Cost of water reuse	Additional costs of landscape management to have ongoing lab testing of water and soil quality. *Irrigating with recycled water is a specialized job and costs more money.
	Infrastructure	*Recycled water quality varies across each facility and on a daily basis, causing uncertainty with end-users. *Landscapes using recycled water must install infiltration swales to prevent runoff.

Driver	Water Scarcity	Drought has created water insecurities of SF Bay Area reliance on transported water.
	End of drain issue and policy	Wastewater treatment facilities need to get rid of water in an environmentally friendly way. Wastewater dumping into the Bay is restricted due to environmental protection laws on endangered species.
	Golf Courses and policy	Golf courses will always have a demand for irrigation and are incentivized to invest in recycled water. Irrigation restrictions placed during droughts drive golf courses to invest in recycled water.
	Cost of potable water	Water scarcity has increased the cost of transported water.
	Public outreach	*South Bay Water Recycling provides training and certification to recycled water specialists. *San Jose provides continual information and outreach programs to the public.
	Quality	South Bay Water Recycling comes out clear and odorless, pleasant to use. *Recycled water contains good nutrients for plants and decreases the need for fertilizer usage.
Solution	Holistic Management	*Following guidelines provided by WaterReuse for irrigating makes switching to recycled water easy. *Evaluate the whole system, and must have knowledge of water, soil, and plant health.
	Innovation of infrastructure	Building satellite recycled water systems in higher elevations could reduce the pumping costs of moving recycled water around difficult landscapes. Invest in higher purification to eliminate unpleasant colors and odors.
	Climate crisis awareness	*Raise public awareness of the current climate crisis and future water shortages.
	Community outreach	*Raise public awareness of water infrastructure and why water reuse is important.

DISCUSSION

Every county in the San Francisco Bay Area hydraulic region has at least one water recycling facility, yet 497,000 AFY of wastewater is still available for reuse (Cooley et al. 2022). Although water scarcity in California is a key driver to adapting water reuse systems. The communication disconnect between sectors and stakeholders throughout the SF Bay Area is a major barrier for future expansion. Therefore, it is necessary to increase education and public outreach to inform people about the benefits of recycled water to ensure continual demand in the SF Bay Area. My results align with existing studies outside of the SF Bay Area, improving water reuse education has created more trust in water authorities and increased residents' willingness to use recycled water (Fu and Liu 2017). Even if the public is aware and concerned about water scarcity, if they lack knowledge of recycled water systems, they are reluctant to use it because of unknown health risk factors (Garcia-Cuerva et al. 2016). The success of any water reuse program heavily depends on public engagement and full understanding of the safety and acceptable applications of recycled water (Steflova et al. 2018). My research has attempted to interpret the gap in knowledge about SF Bay Area recycled water systems and to understand why there is still a significant amount of wastewater that is not being reclaimed for reuse.

SF Bay Area Recycled Water Inconsistencies

A key barrier to increasing public demand for recycled water in the SF Bay Area is the inaccessibility of knowledge. The California State government has created a decentralized recycled water policy, allowing each water agency to install their own methods as long as the quality is within the State parameters. Within the SF Bay Area, recycled water facilities have varying quality, with SBWR having higher quality than EBMUD, people who have used both systems do not fully understand why they are more willing to use one over the other in the same hydraulic region. This result shows that because there is not one centralized system with government agencies creating and controlling the recycled water systems; it has become difficult to understand the variation in quality (Lee and Jepson 2020). However, water scarcity has become a time sensitive issue due to the climate crisis and the SF Bay Area needs to increase communication across sectors instead of trying to unite agencies under one centralized authority.

Water Scarcity is the Catalyst to Recycled Water

Water scarcity in California is a key driver to expanding recycled water systems, but if the SF Bay Area public does not understand the alternatives to transported water, they will not demand recycled water. Drought induced water scarcity is a catalyst for agencies to adopt recycled water systems, yet to understand the factors that support or hinder public demand, attention on the intersections of water agencies – government – stakeholders and how they cooperate or have conflict is necessary (Lee and Jepson 2020). This means that public knowledge of water scarcity and awareness of climate change is not enough to increase the demand for recycled water. The public must have higher scientific literacy in current water systems, as found in the interview results, unless a person uses recycled water in the SF Bay Area, they have little to zero knowledge of how it works.

Improving Recycled Water Education

Water agencies within the SF Bay Area form a complex network of water infrastructure, to increase demand for recycled water, local agencies need to invest in public outreach. Through the interview process, a uniting theme was increasing public knowledge of recycled water systems. It is intrinsic that landscapers understand how to test recycled water quality and soil health, as well as how to read and use water quality indexes. Recycled water agencies need to communicate effectively with each other and produce easy to understand literature that is easily accessible on their websites and through active public outreach. If people become more familiar with scientific terminology and understand the associated benefits of recycled water, stakeholders will experience diminished opposition to expanding water reuse systems (Garcia-Cuerva and Binder 2016).

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