WATER REUSE STANDARDS & REGULATIONS

UNIVERSITY OF WASHINGTON STRATEGIC ANALYSIS, RESEARCH & TRAINING (START) CENTER

REPORT TO THE BILL & MELINDA GATES FOUNDATION

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Executive Summary

Over half of the world's population is severely affected by water scarcity and this will be exacerbated with adverse impacts of climate change and population growth. While these climate hazards are experienced globally, a disproportionate burden is placed on developing countries, particularly, in sub-Saharan Africa. It is estimated that by 2050, over 5 billion people will live in water-scarce areas for at least one month each year (1). These figures are a call to embrace and act on opportunities for resource conservation and recovery.

Water reuse is one solution to the water scarcity impacting many countries globally. Treating wastewater from different sources and recycling for beneficial purposes can provide viable option to enhance efficiency and sustainability of water use. Water reuse technologies have been designed and implemented in both developed and developing countries. However, adhering to national and local policies, standards, and cultures is crucial to streamline effective implementation of these technologies.

While policies can inhibit certain kinds of water reuse technologies due to stringent standards, they can also streamline change and facilitate adoption of water reuse programs at a large scale. Not much is known about the national and local level guidelines and policies in developing countries around using recycled water for both potable and non-potable purposes. Hence, the aim of this report was twofold: to identify the regulatory landscape surrounding water reuse and to identify key insights to inform the development of water reuse projects in the future.

This report outlines some of the existing and adopted standards around reused water in different regions and sectors including industries, agriculture, recreation, and domestic use. The results are the combination of evidence found in the literature as well as insights from eight key informants from diverse disciplines working in the water and sanitation sector.

Key Findings

- **Water reuse standards and guidelines in developing countries are not explicit or are primarily absent**. In the absence of national guidelines, countries generally follow the international regulations from the US Environmental Protection Agency, World Health Organization, International Organization for Standardization (ISO) 30500, and United Nations Environment Program.
- The **Eastern Mediterranean region has higher water reuse rates** and regulations than most other regions. This may be due to their resource capacity combined with the pressure

from the changing climate and water scarcity that characterizes the region and necessitates the adoption of innovative solutions.

- While sub-Saharan Africa (SSA) has one leading example of a successful water reuse plant in Namibia but is simultaneously the region with the least number of water reuse projects being implemented. Challenges include financial and technical barriers to water reuse.
- In Asia, **China, Singapore, and India are leading the way** towards reusing water, and policies either exist or are being developed. More public-private partnerships are predicted to grow to foster water reuse projects, particularly in China.
- Most of the existing water reuse guidelines in the literature are **predominantly in the agriculture sector**, followed by sectors such as industry and urban. The two major processes in industry where wastewater is used are in boilers and coolers.
- **Community acceptance is a cornerstone in successful implementation** of water reuse schemes both in developed and developing countries. People are less inclined to use reclaimed water for direct physical use depending on the source of the water due to public health concerns. Overall, communities are likely to accept recycled water, however, robust outreach programs, transparent communication, and early public engagement initiatives are important.
- An accurate use of recycled water is **difficult to regulate** as people would use water as they see fit. Therefore, stringent regulations, similar to potable use purposes need to be developed for non-potable use such as handwashing or household gardening.
- **Pricing incentives and subsidies** have been used to garner more community support.
- Opportunities exist to develop standards that can address **the growing problem of toxic build-up** in the water such as microplastics, hormone disruptors, and toxic metals.

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Introduction

Project Overview

The Water, Sanitation & Hygiene (WSH) team at BMGF is working towards providing safely managed sanitation, primarily accelerating innovations in non-sewered sanitation technology and service delivery in densely populated regions of the world. Aligning with this effort, WSH is planning to market sanitation-oriented technologies that produce reusable water as a byproduct in low and middle-income countries (LMICs). However, water reuse standards and regulations are limited or absent in these settings.

To better understand the scope of existing water reuse standards and regulations in LMICs, the WSH team has collaborated with the University of Washington's Global Health Strategic Analysis and Research Training Program (START) team to conduct a landscape analysis of the existing or adopted standard and regulations for reused/recycled/reclaimed/treated water in LMICs. The findings from this research will allow the WSH team to develop strategies around adequate implementation of sanitation technologies and generate ideas for future investments, including gaps where further evidence generation and testing is needed.

Project Objectives

01

To **identify and review existing and/or adopted standards and regulations** for reusable water in LMICs to streamline implementation of sanitation-oriented technologies.

02

To **identify existing guidelines in other sectors** that could help assess water reuse standards and regulations in the sanitation industry.

03

To **understand community acceptance** and influencing factors for reused water in LMICs.

Method

The research was conducted in two phases between January and March 2023. In the first phase, as per the study focus, countries were divided into two tiers and information on water reuse standards and regulations were solicited accordingly with an interest in South Asia, Southeast Asia, Sub-Saharan Africa regions (Table 1). A mid-project check-in (pivot meeting) with the WSH team at BMGF was scheduled on February 9th to assess mid-quarter findings and strategize next steps for the second phase (Figure 1).

TIER 1 COUNTRIES	TIER 2 COUNTRIES
India	China
Bangladesh	Uganda
South Africa	Zambia
Senegal	Ghana

Table 1: Proposed countries of interest for water reuse standards and regulations

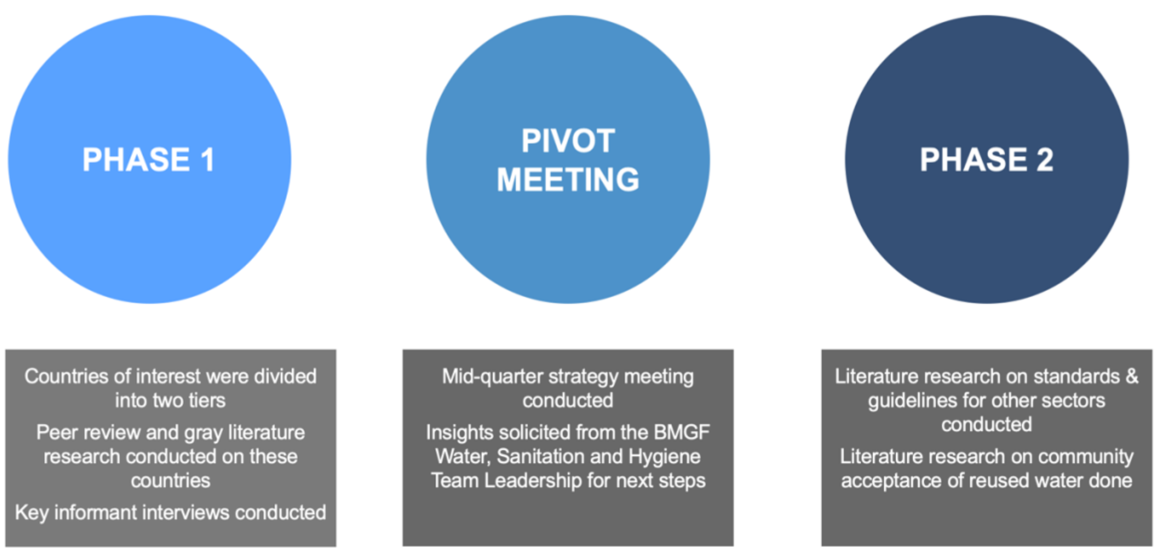

Figure 1: Study methodology describing each project phase.

Search terms used in PubMed and Google Scholar included “water reuse standards”, “water reuse regulations,” “recycled water.” We included both gray and published literature with a special emphasis on policy papers in the key countries of interest. Publication year was not an exclusionary factor as many policies have not been updated in decades and are still relevant to the water reuse landscape today.

National guidelines and policies were the focus for the gray literature review and similar search terms above were used to find reports and popular organizations working in this field. Additionally, we referred to the sources provided by the BMGF team and other researchers studying this topic. We included all relevant reports and proceeded with a snowball approach where we followed the references provided and links used by the primary sites.

A list of experts and key informants working in this field were provided by the BMGF team. Given the dearth of literature in this area, eight key informant interviews were conducted to obtain concrete evidence on individual countries or regions as well as bridge the gap in information unavailable in the published literature. Interviewees consisted of scientists, scholars, and policymakers working in water and sanitation industries in diverse institutions. List of these key informants is in Appendix 2.

After the pivot meeting, the second phase of the project primarily included literature search to identify standards and guidelines in sectors other than the sanitation industry as well as to explore studies on community acceptance of recycled water. Water reuse guidelines and standards in other sectors were searched using resources suggested by the key informants as well as snowballing approach of the reference list.

Search terms for community acceptance used in PubMed and Google Scholar included “social acceptance of reused water”, “community uptake”, “reused water acceptance”. References of relevant articles were followed to obtain other research articles on community uptake of reused water in developing countries.

Background

Despite continued global efforts, 1 in 4 people still lack safely managed drinking water and nearly half of the world (3.6 billion) does not have access to safe sanitation.(2) This water stress is exacerbated by global climate change and increasing population size. By 2050, it is estimated that over three quarters (216 million) of the world’s population will be affected by drought and water scarcity. In 2021, over 90% of drought related deaths occurred in developing countries.(1)

Therefore, there is an urgent need for resource recovery and ecosystem resilience. Water reuse has a potential to combat the ongoing global water crises as well as sanitation-related health hazards.

Recycled or reclaimed water as an alternative water source aligns with the world's growing transition to a circular economy, resourceful and efficient use of waste, by reducing the increasing freshwater demands.

Wastewater treatment and reuse have been observed in several fields such as industry, agriculture, urban reuse, and domestic purposes. Water reuse technologies have been developed to make water more accessible and safer. The BMGF's "Reinvent the Toilet Challenge" is one example showcasing the importance of water reuse technologies, particularly in the sanitation industry, to protect the environment and human health. The "off the grid" technology requires less energy and cost which provides a promising opportunity for water resource recovery particularly in areas with limited water supply or developing countries with poor resource capacity.(3) However, governing implementation of these water reuse technologies in developing countries is still a challenge.

Water reuse standards and regulations are essential to ensure public health and environment safety. Similarly, having a regulatory framework ensures transparency and encourages investments for further technological innovations. Lack of these regulatory policies can be a bottleneck for smooth implementation of water reuse technologies. Lack robust standards and regulations for water reuse in developing countries are seen as barriers to the effective use of recycled water. (4) Hence, this project aims to analyze the landscape of the water reuse standards and regulations in different sectors such as industry, agriculture, sanitation, recreation, and others primarily in low- and middle-income settings.

This report uses terms such as "recycled", "reclaimed", "reused" and "treated" alternatively to refer to reused water. Also, the findings for standards and regulations are inclusive of both greywater (wastewater generated from washing, kitchen appliances, bathroom sinks, etc.) and blackwater (related to contamination with feces, urine, and other toilet use) reuse purposes.

Results

As per our findings, water is reused widely around the world in three major categories: agriculture, industry, and urban and recreation. Though there are limited policies directly regulating reused and recycled water, where policy does exist tends to be in agriculture or general environmental discharge whether for agricultural irrigation or aquifer recharge. This is a starting ground for countries to express interest in the concept of reused water and sets the stage for further regulation in other industries to bloom.

Water Reuse Regulations by Region

MEDITERRANEAN

The Eastern Mediterranean region has higher water reuse rates and regulations than most other regions, likely because water scarcity and the impact of climate change in this region which necessitates the adoption of innovative solutions. This section discusses specific findings from The Kingdom of Jordan, Israel, Egypt, Tunisia, Turkey, and Syria.

The Kingdom of Jordan explicitly encourages and supports the use of recycled water given its extreme water scarcity and strain on existing resources that has been exacerbated by the influx of refugees. It is regulated by the “Water Substitution and Reuse Policy Jordan” (2016), and “Standards, regulations and legislation for water reuse in Jordan” (2001), which includes sections on legislation, public awareness, education, and technology research and development.(5) In Jordan, reuse is being prioritized for industry and agriculture, while freshwater is used for domestic purposes. OXFAM International initiated a reuse project at the household level in the Zaatari camp, the largest Syrian refugee camp in the world, home to nearly 80,000 people. The project began in 35 houses to assess effectiveness and public perception of water reuse. They found that the community was open and willing to use recycled water in gardens and the cost of delivering water decreased. While this project was socially accepted, the regulations were not followed. Instead of using the water for non-edible crops, they watered edible gardens with poor quality water which is dangerous and against the protocol. This example illustrates the need for public awareness and education or making sure water is safe and potable through increasing filtration. This case study recommended prioritizing high need families, piloting at institutional level like mosques, increasing filtration if there is human contact, and increasing community involvement and awareness in general. (5)

Like its neighboring countries, Israel is also pioneering and encouraging water reuse. Their reuse is regulated through the “2010 Standards on Treating Wastewater” which include additional requirements for irrigation using wastewater. It is also worth noting that Israel is one of the only countries with guidelines including requirements for salinity and buildup of toxic metals. (6)

In Egypt, the government recognizes the importance of reusing wastewater, though it is so tightly regulated that it prevents the legal use in many cases. According to the Egyptian code of reuse (501/2015), wastewater must be treated and mixed with fresh water to be used for irrigation. Regulations prohibit the usage of untreated wastewater for agricultural use. This code also prohibits the use of any treated wastewater for irrigating vegetables that will be consumed raw or cooked, citrus trees, and exported products, and schools’ open spaces. Despite these strict regulations, sources allude to informal reuse schemes managed illegal though largely licit networks. Many farmers do not have access to adequate sanitation systems and continue to use recycled water for irrigation that is not highly treated and managed by informal entities. Though this is not officially condoned by the government, one author suggests that this system allows the government to maintain some control over wastewater and manage discontent of farmers, while farmers are able to increase their benefit and yield.(7)

Additional countries practicing some form of water reuse include Tunisia, which was one of the first countries to launch its own national reuse program beginning in the early 1980s. This plan was primarily for agricultural and landscape irrigation. (8) Tunisia's current water code is still in place from 1975 but there is a push to draft a new one in 2023 to recognize the changing ecological and sociopolitical contexts. (9) Oman has similar guidelines that were adopted in 1993 by the Ministry of regional municipalities and environment (MD145-93) which regulates wastewater reuse primarily for agricultural purposes and discharge.(10) Water reuse in Turkey was officially legitimized in 1991 through the regulation for irrigational wastewater reuse issued by the Ministry of Environment and is currently regulated by the country's "Water Pollution Control Regulations." (11)

Furthermore, before the onset of conflict in Syria, the country was on track with their own water reuse guidelines including Water Legislation Law 31 (2005). These standards defined three classes of wastewater quality determining the crops to be irrigated. These standards were relatively high and in one case even more stringent than WHO guidelines in preventing vegetables that are consumed uncooked from being irrigated with "polluted" water. (12)

AFRICA

Despite the urgent need for water reuse in Africa, to our knowledge, there are few countries on the continent initiating water reuse projects. Many countries face financial and technical barriers to water reuse. Over 85% of urban dwellers in Africa are served with onsite sanitation systems and few cities within SSA have a central sewage system. Existing wastewater treatment plants are often not functional or overloaded, resulting in only about 1% of wastewater being treated overall and less than 5% of wastewater is being treated in most countries as seen in Figure 2 below from the "Country-level and gridded estimates of wastewater production, collection, treatment and reuse."(13) However, a few countries have been pioneers in the field of water reuse and developed their own policies and guidelines to guide their processes.

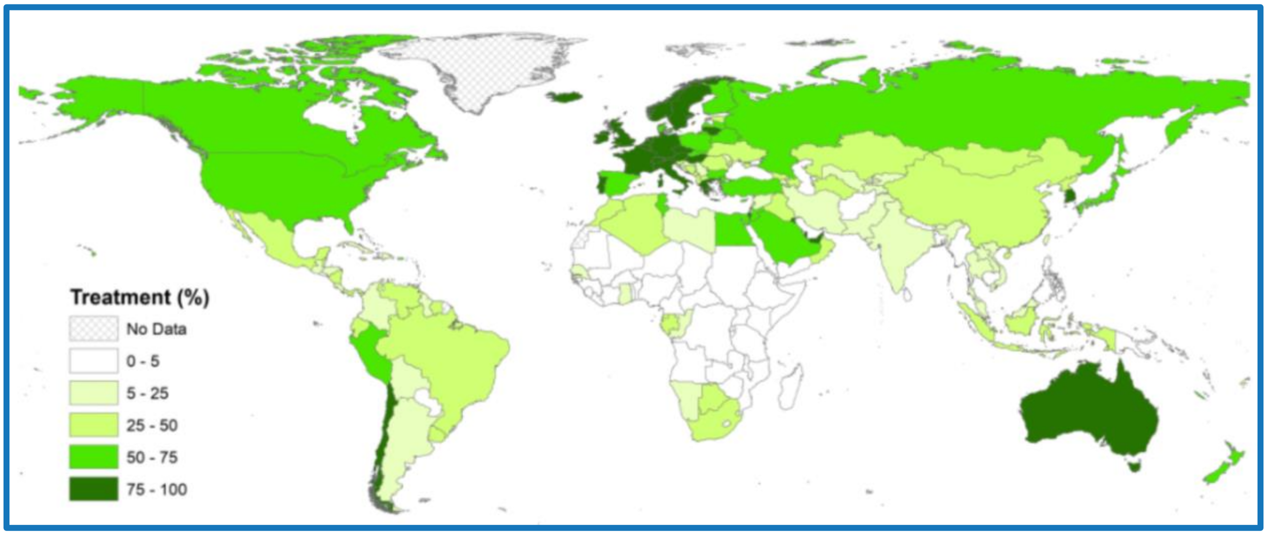

Figure 2: Wastewater Treatment Percent at the Country Scale (m³ yr⁻¹ per capita) (13)

South Africa has taken initiative to establish water reuse projects nationally due to pressing climate concerns and drought plaguing the country. While many countries struggle with drought, South Africa has the existing resources and infrastructure to begin addressing their extreme water scarcity through innovative solutions like water reuse. Though they are initiating water reuse projects, they are still lacking policy specific to water reuse. The Department of Water and Sanitation has provided a national water reuse strategy with guidelines for engineers in developing these projects usually at an industrial level.(14) While these guidelines exist, it is important to differentiate those suggested guidelines from formally adopted policy. Despite lacking national regulation from the South African government, Cape Town has explicitly included water reuse in its water strategy for industrial, commercial, and agricultural purposes. They additionally have guidelines for recharging the nearby Atlantis aquifer. Other South African water regulations and standards that do not explicitly mention water reuse but apply to water projects generally include the National Water Act (1998), National Environmental Management Act (1998), and the Water Services Act (1997). Furthermore, all water projects, not specifically reuse water projects, must undergo an Environmental Impact Assessment to ensure they pose minimal risk to the environment. (14,15)

Namibia is another African country that has taken initiative to boost water reuse through treatment plants. One example of this is the Goreangab Water Reclamation Plant in Namibia. This plant recycles water for potable reuse and catalyzed the creation of its own guidelines based on WHO and USEPA guidelines though they are not yet a national standard.(16) Other countries of similar contexts, including South Africa, have referred to these guidelines in the development of their own national standards.

On the contrary, in some countries where water reuse policies don't exist, there are policies related to water standards and discharge that may inhibit the reuse of wastewater. For example, in Senegal, the most recent National Water Policy (2007) made no mention of reuse, however the Hygiene Code Law 8371 Article 41 states "Discharge of wastewater is forbidden on all lands where fruits and vegetables consumed raw are grown, where the edible parts are grown in contact with the rubbish or wastewater. Organic fertilizers, manure, and compost cannot be utilized within one month before harvesting. Potable water must be used for rinsing crops."(17) Though this is not specific to water reuse, it would inhibit the use of recycled water on crops that is not treated to potable standards.

ASIA

Many countries in Asia face similar challenges related to water scarcity that implore the development of water reuse projects, however, differences exist as to the extent of formalized regulation and water infrastructure in place in each country. The need to include wastewater recycling guidelines is widely recognized in India. Policy is being developed, largely structured individually, and developed in isolation at the local level. Little has been done in terms of detailed guidance on treatment standards, types of reuse applications, design and operations and management, but there are some guidelines that exist.(18) One is the Manual on Sewerage and Sewage Treatment Systems developed by the Ministry of Urban development which explicitly lists wastewater reuse guidelines.(19) This document aims to increase target-based regulations, which are enforced and regularly monitored and financing mechanisms for their long-term operation. In the meantime, there is evidence that the WHO's guidelines (2006), and the USEPA (2012) water reuse guidelines are widely referenced throughout India. (20,21)

Many resources allude to policies and regulations that exist in China to encourage and monitor the use of recycled water. Though some were identified in this research, there are financial and linguistic barriers in accessing and fully analyzing these policies. The government is encouraging recycled water use in irrigation and recreation at both national and local levels.(22) Some of these standards include the China National Reclaimed Water Quality Standard and the China National Standard (2002-2007). More than 10 different national standard levels are closely related to water reuse. The international standard ISO TC 282 for water reuse in urban areas is also used in China.(23) Though specific policies are difficult to locate due to financial and linguistic barriers, there is evidence that they do exist and are being pioneered in cities Beijing and Tianjin. Beijing has developed a wastewater reuse network that includes many treatment plants owned by the government. It is expected that other cities will soon follow suit.(12,24)

Many countries may lack explicit water reuse guidelines but do in fact have guidelines that exist in the context of discharge into receiving bodies of water aquifer refill. This is the case for the

Philippines Revised Effluent Regulations (DAO-35) and though it is a far cry from regulating reuse for urban purposes, it is a starting ground for developing broader water reuse guidelines in the future.(12)

In Bangladesh, there is an awareness and emphasis around water reuse especially in textiles and agriculture. Though there are no formal guidelines, there are references to reuse and the “Capacity Development Project on Safe Use of Wastewater in Agriculture,” which suggests that guidelines are being considered and developed.(25) Despite the lack of regulation, untreated wastewater has been routinely used by farmers as it is an economically efficient mode of increasing yield which requires little infrastructure or enforcement.(26,27) This water is unregulated, and the direct human contact has resulted in illnesses for the farmers handling it which illustrates the need for increasing regulation with corresponding public awareness and accessibility through investing in the infrastructure.

International Water Reuse Guidelines

In the absence of national policy, countries commonly refer to the following global standards or regulations from high income countries:

- WHO Guidelines on Potable reuse: guidance for producing safe drinking water
- WHO Guidelines for the safe use of wastewater, excreta and greywater (Volumes 1-4)
- 2017 US EPA Potable Reuse compendium; Non-Potable Environmental and Economic Water Reuse (NEWR)
- International Organization for Standardization (ISO) 30500, NSF certification 350, and ISO/TC82 (23)
- UNEP: Development of performance indicators for the operation and maintenance of wastewater treatment plants and wastewater reuse (2011); Guidelines for municipal wastewater reuse in the Mediterranean region (2005)
- UN Water Program on Capacity Development - Proceedings on the UN-Water project on the safe use of wastewater and agriculture (2013)
- 2006 National water quality management strategy- Australian guidelines for water recycling: managing health and environmental risks (phase1)

Water Reuse Guidelines in Other Sectors

INDUSTRY

Industrial equipment is sensitive and prone to destructive effects of low-quality water such as corrosion, contamination, chemical reaction, etc.(28) Therefore, the reclaimed water used in industries needs to follow minimum criteria. Most industrial wastewater reuse regulations are from high income countries but may be followed globally or referenced in the development of a country's own national guidelines.

The two major processes in industry where wastewater is used are in boilers and coolers. This is true of most industries where wastewater may be reused including paper, textile, petroleum, iron, and steel, and increasingly technology. Hardness needs to be controlled or removed prior to use specifically in boilers. Calcium, magnesium, silica, aluminum, and alkalinity are some factors that should be controlled to avoid the erosion of materials. The required water quality depends on the pressure at which the boiler functions. Higher pressures generally require higher water qualities. "Table 15.2 Recommended Reused Water Quality in Cooling Towers" and "Table 15.3 Recommended Reused Water Quality in Boilers," adapted from the USEPA Guidelines for Water Reuse Report (2004) displays the required quality specific to recycled water in coolers and boilers and can be found in the Appendix 4. (28) It is worth noting that most of these commonly referred to guidelines are dated and slow to change as new regulations face financial and litigious barriers to being passed.

Regulations for water quality in industry that are not specific to reuse but are applicable include:

- **Canada:** *Water Quality Guidelines for the Iron and Steel Industry and Water Quality Guidelines for the Pulp and Paper Industry*. Canadian Council of Ministers of the Environment (CCME). Canadian Water Quality Guidelines (2008)
- **Canada:** *Water Quality Guidelines for the Petroleum Industry. Guidelines and Criteria for Water Quality Management in Ontario*. (1974)
- **Australia:** *Water Quality Guidelines for the Textile Industry: A Compilation of Australian Water Quality Criteria*, Australian Water Resources Council, Department of Environment and *Conservation (1974)*
- **China:** *The Reuse of Urban Recycling Water, Water Quality Standard for Industrial Water Consumption and GB50335 (2002): Code for design of wastewater reclamation and reuse*
- **United States:** *Environmental Protection Agency (EPA), Guidelines for Water Reuse, 600/R-12/618 (2012)*

URBAN AND RECREATION

Urban and recreational reuse is another category where we are seeing examples of recycled water. This includes but is not limited to landscape irrigation, fire protection, and toilet flushing. Regulations of water in this category generally apply to microbiological concerns as water used in urban settings or recreationally has more potential for human contact and hence, the required quality depends on whether the water body is in direct contact with humans. The most regulated microbiological concerns include *Escherichia coli*, fecal coliforms, *Enterococci*, and coliphages. Other limitations regulate pathogens and physical and chemical parameters that may be aesthetic in nature such as taste, odor, color, and turbidity.(28)

High income countries have higher rates of water used for recreational purposes. However, increasingly, some LMICs are using reclaimed water for tourism and golf course irrigation. "Table 16.5 Microbiological Water Quality Guidelines/Standards 100mL." adapted from *History and Applications of Microbiological Water Quality (2000)* (28) specifies regulations of recycled recreation water by country and can be found in Appendix 4.

Policies Regulating Recreational Water Reuse:

- **China:** GB/T 18921 (2002). *The reuse of urban recycling water-Water quality standard for scenic environment use*
- **Cyprus:** Cyprus Regulation K.D.269 (2005) *Agriculture, Recreation, and Aquifer recharge*
- **Mexico:** NOM-003- SEMARNAT (1997) Covers restrictions for biological pollutants for public reuse

Community Acceptance

Among many factors we examined, social and cultural acceptance of reused water is found to be one of the important drivers for successful implementation of recycled water projects. Community or social acceptance of reused water have been explored in many studies across different regions. (29–32) Social acceptability of recycled water is a universal phenomenon which is not only evident in low-income countries but also among countries with improved infrastructure and technology. Water reuse acceptance has, therefore, been conceptualized as an integrative aspect that pertains to water source, technology, and end use, and not merely the idea of its expansion for use. (32)

The source of water and intended use are key players for water reuse acceptance. Studies have corroborated the finding that consumers are less inclined to accept reclaimed water uses for purposes such as showering, swimming, or drinking and are more accepting of indirect uses such as outdoor irrigation, and flushing.(30) Figure 3 shows the relationship between the use of treated water based on the water sources compared to the reuse purposes. People seem to accept desalinated water more and reclaimed wastewater source the least, and have less inclination towards uses with direct physical contact.

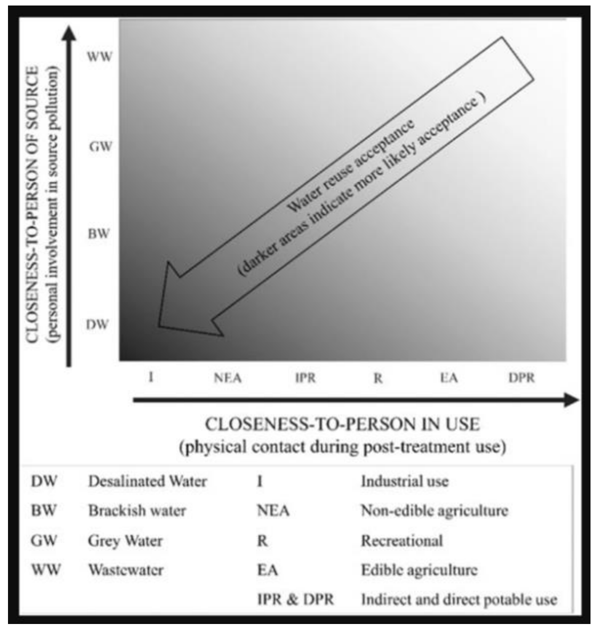

Figure 3: Patterns of water reuse acceptance comparing reuse purposes and water sources (32)

Our results identified several key factors as the determinants for public acceptance of water reuse. The most relevant ones include health concerns, trust in authorities that are involved in design and treatment of the water reuse system, costs, environmental impacts, and public awareness and knowledge on water scarcity and treatment technologies. (29,30,33) Figure 4 below taken from the Akpan et al 2020 study shows the recurring factors of community acceptance for wastewater reuse (WWR).

While these factors are prominent across country settings, the degree of acceptance for each determinant varies depending on the location and reused water characteristics. For example, studies show that people's concerns on effect of reused water on health risks range from 5% to 92% and public seem to be more relaxed in locations where water recycling projects are well established.(30) This also alludes to the fact that people's perception of risk could be related to their mistrust in governing authorities. Similarly, perceptions on quality of wastewater and it's impacts on health are shaped by the media. Water labeled as "recycled water" seems to receive more acceptance than inaccurate labels such as "toilet-to-tap" and the "disgust factor" associated with wastewater. (32,34)

Moreover, most studies found a positive correlation between awareness and knowledge provision and reuse water acceptance. A study in Cape Town, South Africa found behavioral change campaigns with repeated nudges on water consumption and safe use effective to influence water reuse and reduce freshwater consumption.(35)

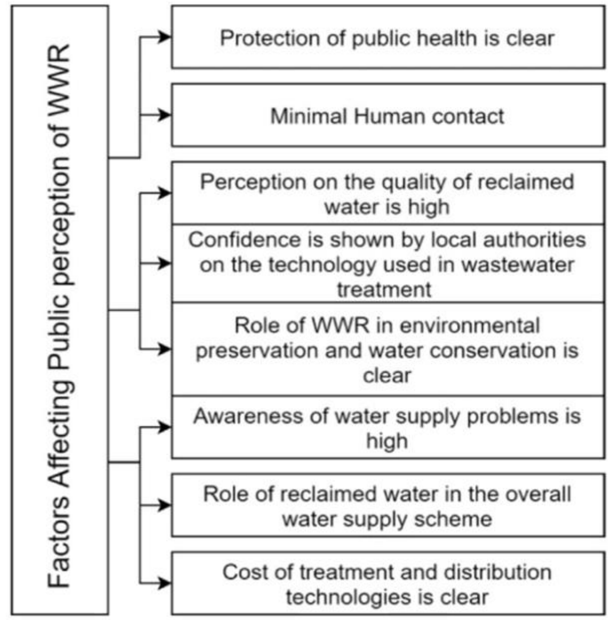

Figure 4: Relevant factors affecting community perception on reusing treated wastewater (33)

Studies investigating the association between socio-demographic predictors and community acceptance were mostly conducted in high income countries. In those regions, some predictors of high acceptance include age, education, gender, income, and religion. While evidence demonstrating the significance is mixed, older adults, male and people with higher education and income had higher acceptance level.(29,30)

Religion, on the other hand, was the most studied topic as well as an area of interest for this project. The influence of religion seems to be contextual. For example, Islamic communities in the United Kingdom, Kuwait, Bahrain, and Lebanon were less accepting of the recycled water for indirect potable use while a mix of Buddhists, Christian and Hindu communities in South Africa did not have religion as a priority concerning factor.(30,34) Nevertheless, this debate regarding the perception of reuse water in Islam was clarified by the United Nations University Press report stating that reused water was permitted with explanations from 18 scientists.(30) Moreover, the US EPA 2012 guideline also shared that the Islamic fatwas accept the use of treated water for irrigation and other purposes if the impurities have been removed and the smell, color, taste have been restored as the original water with supported evidence from scientific experts.(28)

A conceptual framework presented by Al-Saidi et al. demonstrates that water reuse acceptability is a long-term process of interdependence among components of people’s perception, politicization, individual level acceptance, and user adaptation. (32) Hence, a one-size-fits-all approach is not a viable option to address the intricacies of the issues rooted in the communities. Reused water is largely unaccepted due to associated public health risks and environmental concerns such as high soil salinity and reduced soil fertility. However, there is evidence of support towards reclaimed water as a result of enhanced public engagement, robust community mobilization and spirit of ecological security. For example, the successful NEWater project in Singapore utilized extensive media and public education programs with no use of technical jargons to gain public trust. (36) Similarly, in Peru, communities engaged in freshwater conservation were more inclined to accept resource recovery initiatives, and the socio-economic benefits such as promotion of tourism instigated positive attitudes towards recycled water.(37) Two additional case studies below showcase the successful public acceptance of treated wastewater use.

CASE EXAMPLES

Windhoek, Namibia: The direct potable reuse of treated wastewater is a historical and successful example of public acceptance of reused water. Namibia has been using recycled water since 1968 for potable use, where the highly treated reclaimed water is mixed directly in the drinking water pipeline that serves the water distribution network.(36) Public acceptance is one of the key cornerstones for the decade long success of this recycled water scheme. The city has invested in multiple upgrades to improve the quality of the water so that public confidence sustains along with sampling and testing the quality of the water periodically. Moreover, social acceptance is complemented with the political support, robustness in technology, and maintenance with skilled operating personnel. (4,38) Another important reason for the overwhelming positive support from the community is the absence of alternative options for reuse amid arid climate and high-water shortages.(36) Therefore, water reuse initiatives need to be recognized as a necessity instead of an option. Additionally, over the years, people have become “used to” the reclaimed water and are more accepting as the majority of the population are indifferent about the water source according to a survey on public perceptions in Windhoek.(4)

Orange County, California: Although established in a developed country, the Orange County Ground Water Replenishment System (GWRS) portrays a good example for the community’s acceptance towards indirect potable reuse of reclaimed water. They were highly successful in overcoming the “toilet-to-tap” misperception and winning international recognition. Along with very robust treatment technology, this was possible because of a rigorous outreach program conducted where the authorities and implementers involved were leading the community-engagement activities interfacing with consumer media, advertising through presentations, and garnering support from 21 city councils.(36)

Some of the important strategies to ensure social acceptance of recycled water projects include: the timing of engaging public with an opinion poll followed by a formal public approval, demonstration of benefits to end users and environment, early stakeholder involvement in planning and decision making, establishing trust and transparency in management, avoiding technical jargon when describing about the technology, communicating about risk management, engaging experts in outreach programs, and fortifying public’s knowledge on water scarcity and reusing water as current practices such as waste recycling.(30,32,36)

Key Insights

1. WATER REUSE REGULATIONS FOR PURPOSES APART FROM AGRICULTURE ARE LIMITED. IN THE ABSENCE OF NATIONAL POLICY, COUNTRIES MAY LOOK TO OTHER COUNTRIES WITH EXISTING POLICY OR THE WHO GUIDELINES

Throughout this research it became apparent that water reuse policies are limited and even nonexistent in many countries, specifically those that could most benefit from water reuse projects. Though national guidelines may not exist, countries may reference other sources for guidance in developing water reuse projects or in the effort to develop their own policy. In the absence of national policy, countries generally refer to WHO guidelines, specifically the “Guidelines for the safe use of wastewater, excreta and greywater” published in 2006. Along with international guidelines, countries frequently reference policies that exist within other countries to guide the development of their policy. These generally come from countries that have been pioneering water reuse including Australia, Singapore, and some states in the U.S. A full list of international guidelines referencing water reuse can be found in Appendix 1.

2. COMMUNITY INSIGHTS AND EDUCATION ARE CRITICAL IN SUCCESSFUL IMPLEMENTATION OF WATER REUSE PROJECTS

In order for water reuse guidelines to take effect, citizens and governing bodies must collectively acknowledge and allot value to water reuse as a mode of sustainable development and environmental stewardship. Like most global health interventions, when it comes to water reuse endeavors, community engagement can make or break a project. Many communities where water reuse projects have been initiated have experienced community hesitancy in using recycled gray or black water due to socio-cultural or religious beliefs. More extreme cases have been documented of community backlash and collective protest against using “toilet water.”(36) Lack of community consultation during the construction or planning can result in misconceptions around the safety of recycled water and thus a loss in their trust. This is most likely to happen in projects that are initiated by international parties or people not from the community in which the water reuse will take place.

Though hesitancy is common in introducing water reuse, the opposite is also true in some settings. For example, in Bangladesh, farmers have been recycling wastewater for agricultural purposes with no guidelines. The benefits of this are increased crop yield with natural fertilizer at no additional cost, though the lack of regulation has caused many farmers to become ill from contact with untreated wastewater. An analysis of social acceptability of untreated wastewater reuse revealed that in this setting it was socially acceptable by both farming and non-farming communities, though it was more dangerous than regulated water reuse systems that have incited backlash in other areas.(27)

To avoid and overcome community hesitancy, local engagement is critical. There is no one formula to guarantee community acceptance but it is clear that community engagement of any kind will increase acceptance and utilization of recycled water.

3. ACCURATE USE OF RECYCLED WATER IS DIFFICULT TO REGULATE

A third overarching finding that was corroborated by literature and KIIs is that people will use available water as they need it, regardless of the intended use. This was alluded to in multiple contexts, one of which was through the OXFAM reuse project in Jordan described above.(5) This point further emphasizes the need for community engagement and educational campaigns both to encourage the use of available recycled water and to prevent the use for intended purposes like drinking.

To avoid illness and harm caused to users through unintended use of reuse water, there are three possibilities. The first, suggested by two key informants, would be to treat reused water to potable standards. It must be at a level where if it is misused, people will not get immediately sick. Though this is guaranteed to increase the cost of technology and requires regular testing, it is the only way to eliminate risk of illness. A second possibility is to greatly enhance public awareness campaigns to teach people the intended purposes of the reused water and to caution against drinking non-potable recycled water. This community education should be done regardless, and will reduce, but not eliminate the risk of illness. The third option is to remove the user from the equation, thereby eliminating the risk of user mismanagement by engineering closed loop systems. For example, piping reused water directly to a garden or within a toilet.

4. COMMUNITY SUPPORT AND SUSTAINABILITY CAN BE GARNERED THROUGH PRICING INCENTIVES

Pricing incentives can lead to a willingness to participate and learn in communities where uptake of recycled water is slow. Countries that have already established water reuse programs frequently include a pricing element to garner support from constituents.

One example of financial support for water reuse and recycling is in China where the government offers subsidies and annuity payments for recycled water use. The government has plans to improve the financial viability of reuse projects by increasing tariffs in the long run. According to a key informant, these subsidies can make reclaimed water for flushing 20% the cost of fresh water.

A second example is in Israel where drinking water supplies to residents are priced higher than the reclaimed water used by farmers. This reflects the price of treatment and access as reused water for irrigation is lower than that of water for household use.

The cost of using recycled wastewater is lower than filtered water, depending on the treatment standard, and should be priced as such. Additionally, the nutrient contents reduce the costly use of fertilizers used in farming as well ensuring food security and livelihood support.

5. STANDARDS MUST RECOGNIZE LOCAL CAPACITY

External policies referenced in a given country must be realistic and attainable given the local capacity. Water reuse projects may be unattainable or unsustainable given startup costs, materials, personnel, and testing equipment. Guidelines that require specific testing capacity can inhibit uptake further. According to one KII, high technical standards and treatment guidelines can add confusion and hinder a country's willingness to pilot a water reuse program. LMICs often do not have adequate testing or laboratory capabilities, especially at a household level, and therefore reuse can be unsustainable and potentially even dangerous.

For example, the eThekwini declaration and international commitments in the Sanitation and Water for All set a standard of .5% of a signatory's Gross Domestic Product (GDP) should be allocated to sanitation, though Ghana is an example of one country that could not meet that metric and instead invested only 0.2% of its GDP.(39)

Additionally, one key informant emphasized on introducing a cost-effective approach where both economy and wastewater resources can be integrated and sustained since small countries would like to see successful examples from countries with similar resource capacities.With this in mind, it is beneficial to increase knowledge of other countries' policies that may be similar in capacity and GDP rather than only guidelines from high income countries (or blanket suggestions established by international organizations.

6. NEW POLICIES AND GUIDELINES SHOULD INCLUDE SPECIFICATIONS AROUND TOXIC BUILD UP

The final key insight is that developing and existing policies are evolving to include guidelines around toxic build up. Many current standards do not generally consider toxic metals, salinity, pharmaceuticals or hormones that build up in reused water. The WHO guidelines do include chronic exposures to things like arsenic and fluoride but are outdated and do not cover "emerging contaminants" such as pesticides, pharmaceutical products, and antibiotics in waste streams. (40) This is specifically a concern in high income countries where there is high use of antibiotics and hormones like estrogen from women taking the oral contraceptives. Israel is one country that has already adopted policy the 2010 standards include requirements for salinity and concentrations of toxic metals.

Treated water with intact biological and chemical contaminants can cause adverse health impacts and therefore existing and new guidelines should try to include this growing concern. One way to monitor this is to limit how many times water can be recycled in closed loop systems or to establish guidelines for the proportional mix of freshwater and recycled water to dilute these contaminants.

Strengths & Limitations

An extensive amount of information has been solicited in this report featuring a range of guidelines and policies particularly for developing country settings. The insights from eight key informants provide valuable and contemporary evidence around different water reuse projects across regions. This report also serves as a repository of resources for those interested in learning more about the regulations as well as community acceptance concepts in different countries and regions.

While the report offers breadth of evidence on water reuse in general and its regulations across regions, findings cannot be generalized within countries in these regions. The evidence was limited to the findings obtained within the project's timeline of 10 weeks. The report does not report in-depth information on various intricate components of water reuse such as cost, quality, and concentration of consumption, which could have offered more clarity for strategic decision-making.

Conclusion

Water reuse technologies must ensure that both human and environmental health risks are mitigated while introducing these treatment processes and plants. Water reuse standards and guidelines are significant in guiding technology developers and investors. Since developing countries are adversely impacted by climate change hazards, it is important to have policies for both direct and indirect water reuse in these settings. However, many countries lack national level guidelines and mostly adapt the international guidelines when necessary. While the international guidelines are quite stringent, these guidelines can vary based on the use purposes for each country's context. Regulating the accurate use of recycled water is difficult, therefore, having strict regulations in place is crucial.

Water reuse projects in developing countries are nascent and examples in high income countries with advanced technology are not as inspirational given most of these countries' poor financial and technical resource capacity. Therefore, understanding local resource capacity to not only implement but monitor safety concerns is paramount. Community engagement in planning and implementing water reuse projects as well as transparency in technologies being used help improve social acceptance in both developed and developing settings. Finally, acceptance is more likely when recycled water use is stressed as a necessity instead of an option to other water sources. Future research should include understanding volume consumption of water based on the context as well as cost implications.

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The START researchers in this team have diverse and interdisciplinary expertise in global health, implementation science, epidemiology, and business. This work was conducted by Priyanka Shrestha (project manager), Erin Ingle, Cami Rencken, and Kavya Niranjan under the faculty mentorship of Dr Akhtar Badshah. In addition, the team would like to acknowledge the support, time, and cooperation of the key informants whose expertise and insights paved the way for the project and made this work possible.

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Any specific questions or remarks on the report can be communicated at the following contact:

START Center: start@uw.edu

Appendix

1. Regulations Dashboard

Organization	Regulation	Year	Sector	Link
World Health Organization (WHO)	“Guidelines for the safe use of wastewater, excreta and greywater”	2006	Agriculture	https://www.who.int/publications/i/item/9241546859
United Nations Environment Programme (UNEP)	Guidelines for municipal wastewater reuse in the Mediterranean region	2005	Urban and Agriculture	https://wedocs.unep.org/rest/bitstreams/7336/retrieve
United Nations Environment Programme (UNEP)	Development of performance indicators for the operation and maintenance of wastewater treatment plants and wastewater reuse	2011	Engineering	https://wedocs.unep.org/bitstream/handle/20.500.11822/6623/11wg357_inf9_eng.pdf?sequence=1
United Nations Water Decade Programme on Capacity Development (UNW-DPC)	Proceedings on the UN- Water project “Safe use of wastewater in agriculture”	2013	Agriculture	https://collections.unu.edu/eserv/UNU:2661/proceedings-no-11_WEB.pdf
International Organization for Standardization (ISO)	ISO/TC282 Water reuse	Ongoing	All	https://www.iso.org/committee/4856734.html
Food and Agriculture “Water quality for Organization (FAO)	Water quality for agriculture	1994	Agriculture	https://www.fao.org/3/t0234e/t0234e00.htm

2. KII Dashboard

WATER REUSE STANDARDS & REGULATIONS - KEY INFORMANT INTERVIEWS DASHBOARD				
Name(s)	**Affiliation**	**Email**	**Profile Link**	**Key Takeaways**
Sun Kim	Retired, ex-BMGF WSH colleague	ISO30500toilet@gmail.com	https://www.linkedin.com/in/sun-kim-1271377/	Worked on the ISO 30500 standards; informed about the development of ISO standards and reference to TÜV SÜD; South Africa National Standard 30500" (SANS) is being adopted nationally. He has shared some contacts.
Daniel Yeh	University of South Florida	dhyeh@usf.edu	(19) Daniel Yeh, PhD, PE, BCEE | LinkedIn	Experienced in SA with eThekwini municipality to figure out an acceptable quality for treated black/grey water that could be reused for flushing; provided information on the EFT Guidelines; has sent many contacts particularly in SA and EPA (see next sheet)
Teddy Gouden	Consultant. Ex-eWS	goundented@gmail.com	---	Dept of water & sanitation in Durban is guided by the reconciliation strategy that is reviewed every 2 years. A feasibility study was done to assess which treatment system works in South Africa but stakeholder engagement was missing. Toilet to tap concept unaccepted; Department of WASH in Durban focuses more on drinking water; Countries in Africa are not ready capacity wise although climate change is a pressure in these countries. Has send many contacts (See next sheet)
Zifu Li	University of Science and Technology, Beijing	zifuli@ustb.edu.cn	Zifu LI | Head of the Department | Ph.D. | University of Science and Technology Beijing, Beijing | USTB	Beijing used recycled wastewater in Olympics 2008; China has different standards, at levels, industrial and local/provincial levels, and at national levels. More than 10 different national standard levels closely related to water reuse; the technical committee secretary is also in China. ISO TC 282, water reuse in urban areas; most standards are in Chinese and not open access; In China, grey water has relatively low pollutant load, and rainwater harvesting and greywater after treatment is mixed, the mixing has good feelings for the users because rainwater doesn't have so much color or other problems; Beijing has price incentive for reclaimed water, 1/5th the price if you flush using reclaimed water; Chinese regulations are not very different than the international ones.

Kai Udert	Eawag - Swiss Federal Institute of Aquatic Science and Technology	Udert, Kai Kai.Udert @eawag.ch	https://www.eawag.ch/en/about-us/portrait/organisation/staff/profile/kai-udert/show/	Mostly aware of ISO 30500 guidelines; water reuse purposes should be considered for guidelines; The Blue Diversion Autarky toilet (BDAT) provides hygiene and comfort without relying on water and wastewater infrastructure; study on socio-technical acceptance of BDAT in SA showed that people are willing but need to be sensitized with correct and transparent information on technology being used. He also sent contacts working in EAWAG (see next sheet)
Jan Willem	Gates Foundation	janwillem.rosenboom@gatesfoundation.org	https://www.linkedin.com/in/jan-willem-rosenboom-90988b1/	He is not directly involved in water reuse regulations; provided info on WHO guidelines and shared contacts who could be relevant to talk to (see next sheet); provided info on Vietnam's early approaches to treat fecal sludge; Suggested to focus on the context-specific need for guidelines; what are good examples; build monitoring capacity in countries.
Jacqueline Thomas	University of Sydney	jacqueline.thomas@sydney.edu.au	https://www.linkedin.com/in/drjacqueline-thomas/?originalSubdomain=au	Suggested clarifying what kind of water reuse we are looking at—grey water, black water, storm water; provided information on WHO's 4 volumes of water reuse guidelines; recommended to have potable level strict guidelines for non-potable use since people are somehow going to use it; countries do not have regulations and tend to rely on WHO based guidelines; She also mentioned the labs in developing countries do not have the research capacity to even do a risk-based assessment for aerosol bacteria or other complex pollutants; she provided a few examples and links to resources mainly WHO, Australia and Oman.
Christopher Corbin	Coordinator (Cartagena Convention Secretariat) UNEP	Christopher Corbin <christopher.corbin@un.org>	https://www.linkedin.com/in/christopher-corbin-12baa513/?originalSubdomain=jm	Many Caribbean countries have no/ outdated guidelines and lack comprehensive monitoring programmes regarding wastewater reuse; Wastewater Reuse does occur within the tourism sector for example for landscaping and irrigation of golf courses; (In Saint Lucia, wastewater has been used for irrigating cricket grounds); water regulations are being updated in some countries to include more specific bacterial and nutrients indicators; Trinidad & Tobago/ Barbados are developing guidelines and criteria for treated wastewater reuse; Costa Rica / Honduras also have guidelines based on the specific use of the wastewater; In some countries, there is concern about the reuse of treated wastewater for irrigation of edible crops and whether national monitoring systems are adequate to do comprehensive testing thus ensuring protection of human health; there is a strong socio-cultural resistance to the reuse of domestic wastewater and this needs to be addressed through comprehensive awareness raising; under a regional project and in collaboration with the RARE foundation, a regional workshop is being planned to promote behavioural change and gain greater acceptance for reuse of wastewater. This will demonstrate the value of wastewater reuse through working with local communities and farmers and promote the use of wastewater as a resource (closed loop systems).This includes demonstrating savings in the use of potable water, potential for extraction of nutrients, and use of biosolids for energy generation. The use of decentralized and nature-based solutions can also lower the cost of providing sanitation services in rural areas.

3. Resource Dashboard

Attachment can be found as a supplementary file.

4. Tables and figures from sources

WATER QUALITY GUIDELINES FOR COOLING TOWERS

TABLE 15.2 Recommended Reused Water Quality in Cooling Towers

Application Type	Required Treatment	Reused Water Quality	Monitoring	Protected Distance
Once-through	Secondary	• pH: 6–9 • BOD: 30 mg/L • TSS: 30 mg/L • Fecal coliform: 200 in 100 mL • Cl_2: 1 mg/L	• pH: Weekly • BOD: Weekly • TSS: Weekly • Coliform: Daily • Cl_2: Continuous	90 m to public access
Recirculating	Secondary disinfection (chemical coagulation and filtration may be required as well)	• pH: 6–9 • BOD: 30 mg/L • TSS: 30 mg/L • Fecal coliform: 200 in 100 mL • Cl_2: 1 mg/L	• pH: Weekly • BOD: Weekly • TSS: Weekly • Coliform: Daily • Cl_2: Continuous	90 m to public access (in the case of disinfection, this distance can be reduced)

Source: Adapted from United States Environmental Protection Agency (USEPA). 2004. *Guidelines for Water Reuse, Report 625/R-04/108*, Washington, DC.

WATER QUALITY GUIDELINES FOR BROILERS

TABLE 15.3 Recommended Reused Water Quality in Boilers

Drum Operating Pressure (psig)	0–300	301–450	451–600	601–750	751–900	901–1000	1001–1500	1501–2000	OTSG
Steam									
TDS max (ppm)	0.2–1.0	0.2–1.0	0.2–1.0	0.1–0.5	0.1–0.5	0.1–0.5	0.1	0.1	0.05
Boiler Water									
TDS max (ppm)	700–3500	600–3000	500–2500	200–1000	150–750	125–625	100	50	0.05
Alkalinity max (ppm)	350	300	250	200	150	100	n/a	n/a	n/a
TSS max (ppm)	15	10	8	3	2	1	1	n/a	n/a
Conductivity max (µmho/cm)	1100–5400	900–4600	800–3800	300–1500	200–1200	200–1000	150	80	0.15–0.25
Silica max (ppm SiO_2)	150	90	40	30	20	8	2	1	0.02
Feed Water (Condensate and Makeup, after De-aerator)									
Dissolved oxygen (ppm O_2)	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	n/a
Total iron (ppm Fe)	0.1	0.05	0.03	0.025	0.02	0.02	0.01	0.01	0.01
Total copper (ppm Cu)	0.05	0.025	0.02	0.02	0.015	0.01	0.01	0.01	0.002
Total hardness (ppm $CaCO_3$)	0.3	0.3	0.2	0.2	0.1	0.05	ND	ND	ND
pH at 25°C	8.3–10.0	8.3–10.0	8.3–10.0	8.3–10.0	8.3–10.0	8.8–9.6	8.8–9.6	8.8–9.6	n/a
Nonvolatile TOC (ppm C)	1	1	0.5	0.5	0.5	0.2	0.2	0.2	ND
Oily matter (ppm)	1	1	0.5	0.5	0.5	0.2	0.2	0.2	ND

Source: Adapted from United States Environmental Protection Agency (USEPA). 2012. *Guidelines for Water Reuse, 600/R-12/618*, Washington, DC.
n/a = not applicable.
ND = not defined.

MICROBIOLOGICAL WATER QUALITY GUIDELINES

TABLE 16.5 Microbiological Water Quality Guidelines/Standards 100 mL

	Shellfish Harvesting		Primary Contact Recreation			Protection of Indigenous Organisms	
Country	Total Coliform	Fecal Coliform	Total Coliform	Fecal Coliform	Other	Total Coliform	Fecal Coliform
USEPA, United States		14[a] 90% <43			*Enterococci* 35[a]		
California, United States	70[e]		80% <1000[i,j] 100% <10,000[k]	200[a,j] 90% <400[l]			
EEC,[b] Europe [5]			80% <500[c] 95% <10,000[d]	80% <100[c] 95% <2,000[d]	Fecal streptococci 100[c] *Salmonella* 0/L[d] Enteroviruses 0 PFU/L[d] *Enterococci* 90% <100		
UNEP [2,14]		80% <10 100% <100		50% <100[n] 90% <1000[n]			
Brazil [10]			80% <5000[m]	80% <1000[m]			
Colombia [7]			1000	200			
Cuba [8]			1000[a]	200[a] 90% <400			
Ecuador [11]			1000	200			
Mexico [12]	70[e] 90% <230		80% <1000[f] 100% <10,000[k]			10,000[e] 80% <10,000 100% <20,000	
Peru [9]	80% <1000	80% <200 200% <1000	80% <5000[f]	80% <1000[f]		80% <20000	80% <4000
Puerto Rico [4]	70[h] 80% <230			200[h] 80% <400			
Venezuela [17]	70[a] 90% <230	14[a] 90% <43	90% <1000 100% <5000	90% <200 100% <400			
France [18]			<2000	< 500	Fecal streptococci <100		
Israel			80% <1000[g]				
Japan [3]	70		1000			1000	
Poland					*E. coli* <1000		
Yugoslavia			2000				
People's Republic of China	Coli index <50[n]	14		<200[i]	Coli index <1000[i]		

Source: Adapted from Salas, H.J. 2000. *History and Application of Microbiological Water Quality Standards in the Marine Environment, World Health Organization (WHO).*

[a] Logarithmic average for a period of 30 days of at least 5 samples.
[b] Minimum sampling frequency—every two weeks.
[c] Guide.
[d] Mandatory.

References

1. Tsegai D, Medel M, Augenstein P, Huang Z. Drought in Numbers 2022 [Internet]. United Nations Convention to Combat Disertification; 2022 [cited 2023 Feb 3] p. 1–52. Available from: https://www.unccd.int/sites/default/files/2022-06/Drought%20in%20Numbers%20%28English%29.pdf

2. Water supply, sanitation and hygiene monitoring [Internet]. [cited 2023 Mar 31]. Available from: https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/monitoring-and-evidence/wash-monitoring

3. Silveti D, Andersson K. Challenges of Governing Off-Grid "Productive" Sanitation in Peri-Urban Areas: Comparison of Case Studies in Bolivia and South Africa. Sustainability. 2019 Jun 24;11(12):3468.

4. van Rensburg P. Overcoming global water reuse barriers: the Windhoek experience. Int J Water Resour Dev. 2016 Jul 3;32(4):622–36.

5. OXFAM. A Case Study on Greywater Reuse in Zaatari Camp. 2020.

6. Draft National Water Reuse Action Plan: Appendix G - Selected International Profiles [Internet]. [cited 2023 Mar 4]. Available from: https://www.epa.gov/sites/default/files/2019-09/documents/water-reuse-2019-appendix-g.pdf

7. Tawfik MH, Hoogesteger J, Elmahdi A, Hellegers P. Unpacking wastewater reuse arrangements through a new framework: insights from the analysis of Egypt. Water Int. 2021 May 19;46(4):605–25.

8. Bahri A, Drechsel P, Brissaud F. Water reuse in Africa: challenges and opportunities [Internet]. [cited 2023 Mar 4]. Available from: https://publications.iwmi.org/pdf/H041872.pdf

9. aashfaq. Overhauling Tunisia's Water Code: Ensuring Equitable and Sustainable Distribution of Water [Internet]. 2021 [cited 2023 Apr 5]. Available from: https://www.ndi.org/our-stories/overhauling-tunisia-s-water-code-ensuring-equitable-and-sustainable-distribution-water

10. SULTANATE OF OMAN. REGULATIONS FOR WASTEWATER RE-USE AND DISCHARGE [Internet]. 1993 [cited 2023 Mar 4]. Available from: https://www.pdo.co.om/hseforcontractors/Environment/Documents/Oman%20Laws/Misterial%20Decision%20-%20Guidelines/Wastewater%20Reuse%20and%20Discharge.pdf

11. Sanz L, Gawlik B. Water Reuse in Europe - Relevant guidelines, needs for and barriers to innovation. 2014.

12. Urban Water Reuse Handbook [Internet]. Routledge & CRC Press. [cited 2023 Mar 4]. Available from: https://www.routledge.com/Urban-Water-Reuse-Handbook/Eslamian/p/book/9781482229141

13. Jones ER, van Vliet MTH, Qadir M, Bierkens MFP. Country-level and gridded estimates of wastewater production, collection, treatment and reuse. Earth Syst Sci Data. 2021 Feb 8;13(2):237–54.

14. Swartz C. A Water Reclamation And Reuse Guide for South African Municipal Engineers [Internet]. Water Research Commission. 2022 [cited 2023 Mar 4]. Available from: https://www.imesa.org.za/wp-content/uploads/wrr-guide-web-2022.pdf

15. Water Reuse Gets a New Take in South Africa [Internet]. Water Reuse Gets a New Take in South Africa | Globalwaters.org. 2018 [cited 2023 Mar 4]. Available from: https://www.globalwaters.org/resources/blogs/wash-fin/water-reuse-gets-new-take-south-africa

16. sysop. Namibia's Embrace of Potable Water Reuse [Internet]. 2022 [cited 2023 Mar 4]. Available from: https://www.fluencecorp.com/recycling-wastewater-in-namibia/

17. Senegalese capital eyes wastewater reuse strategy [Internet]. Global Water Intelligence. [cited 2023 Apr 5]. Available from: https://www.globalwaterintel.com/news/2019/37/senegalese-capital-eyes-wastewater-reuse-strategy

18. Kelkar U. India Specific Recycle and Reuse Guidance Document [Internet]. Ministry of Urban Development, Govt. of India National Workshop on Wastewater Recycling and Presentation of Urban Water Awards 2011-2012. 2014 [cited 2023 Mar 4]. Available from: https://mohua.gov.in/upload/uploadfiles/files/4_%20India%20Specific%20Recycle%20%26%20Reuse%20Guidance%20Document%20-%20Is%20there%20a%20Need-March.pdf

19. CPHEEO:Central Public Health & Environmental Engineering Organisation (CPHEEO), Govt of India [Internet]. [cited 2023 Apr 5]. Available from: http://cpheeo.gov.in/cms/manual-on-sewerage-and-sewage-treatment.php

20. Governance of wastewater treatment and reuse in India| India Water Portal [Internet]. [cited 2023 Mar 4]. Available from: https://www.indiawaterportal.org/articles/governance-wastewater-treatment-and-reuse-india

21. Recycling and reuse of treated wastewater in urban India [Internet]. International Water Management Institute (IWMI). [cited 2023 Mar 4]. Available from: https://www.iwmi.cgiar.org/publications/resource-recovery-reuse/series-8/

22. Yi L, Jiao W, Chen X, Chen W. An overview of reclaimed water reuse in China. J Environ Sci. 2011 Oct 1;23(10):1585–93.

23. ISO - ISO/TC 282 - Water reuse [Internet]. [cited 2023 Mar 4]. Available from: https://www.iso.org/committee/4856734.html

24. Rodrigues S. China Reclaimed Water Reuse Regulations [Internet]. [cited 2023 Mar 4]. Available from: https://www.iwa-network.org/filemanager-uploads/WQ_Compendium/Cases/China%20Reclaimed.pdf

25. Ardakanian R, Sewilam H. Capacity Development for the Safe Use of Wastewater in Agriculture: A Collaboration of UN-Water Members & Partners [Internet]. 2012 [cited 2023 Mar 4]. Available from: https://www.ais.unwater.org/ais/pluginfile.php/225/mod_label/intro/proceedings-no8-web.pdf

26. Khatun A. Greywater reuse: a sustainable solution for water crisis in Dhaka, Bangladesh [Internet]. 2011 [cited 2023 Mar 4]. Available from: https://iebconferences.info/345.pdf

27. Sharmin A. Water and wastewater in Bangladesh, current status and design of a decentralized solution [Internet]. 2016 [cited 2023 Mar 4]. Available from: https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=8895656&fileOId=8895752

28. United States Environmental Protection Agency. 2012 Guidelines for Reuse [Internet]. 2012 [cited 2023 Mar 4]. Available from: https://www.epa.gov/sites/default/files/2019-08/documents/2012-guidelines-water-reuse.pdf

29. Prins FX, Etale A, Ablo AD, Thatcher A. Water scarcity and alternative water sources in South Africa: can information provision shift perceptions? Urban Water J. 2022 Jan 18;1–12.

30. Fielding KS, Dolnicar S, Schultz T. Public acceptance of recycled water. Int J Water Resour Dev. 2019 Jul 4;35(4):551–86.

31. Ravishankar C, Nautiyal S, Seshaiah M. Social Acceptance for Reclaimed Water Use: A Case Study in Bengaluru. Recycling. 2018 Jan 20;3(1):4.

32. Al-Saidi M. From Acceptance Snapshots to the Social Acceptability Process: Structuring Knowledge on Attitudes Towards Water Reuse. Front Environ Sci. 2021 Mar 19;9:633841.

33. Akpan VE, Omole DO, Bassey DE. Assessing the public perceptions of treated wastewater reuse: opportunities and implications for urban communities in developing countries. Heliyon. 2020 Oct 1;6(10):e05246.

34. Massoud MA, Kazarian A, Alameddine I, Al-Hindi M. Factors influencing the reuse of reclaimed water as a management option to augment water supplies. Environ Monit Assess. 2018 Sep;190(9):531.

35. Visser M, Booysen MJ, Brühl JM, Berger KJ. Saving water at Cape Town schools by using smart metering and behavioral change. Water Resour Econ. 2021 Apr;34:100175.

36. Kayhanian M, Tchobanoglous G. Water reuse in Iran with an emphasis on potable reuse. Sci Iran. 2016 Oct 1;23(4):1594–617.

37. Rodriguez DJ, Serrano HA, Delgado A, Nolasco D, Saltiel G. From Waste to Resource: Shifting paradigms for smarter wastewater interventions in Latin America and the Caribbean. Washington, DC.: World Bank; 2020.

38. Tortajada C, Nam Ong C. Reused water policies for potable use. Int J Water Resour Dev. 2016 Jul 3;32(4):500–2.

39. Gyampo M. Wastewater Production, Treatment, and Use in Ghana [Internet]. [cited 2023 Mar 4]. Available from: https://www.ais.unwater.org/ais/pluginfile.php/231/mod_page/content/188/wastewater_use_for_agriculture_in_ghana_editable_max.pdf

40. Guidelines for the safe use of wastewater, excreta and greywater Volume 2 Wastewater use in agriculture [Internet]. [cited 2023 Mar 4]. Available from: https://www.who.int/publications-detail-redirect/9241546832