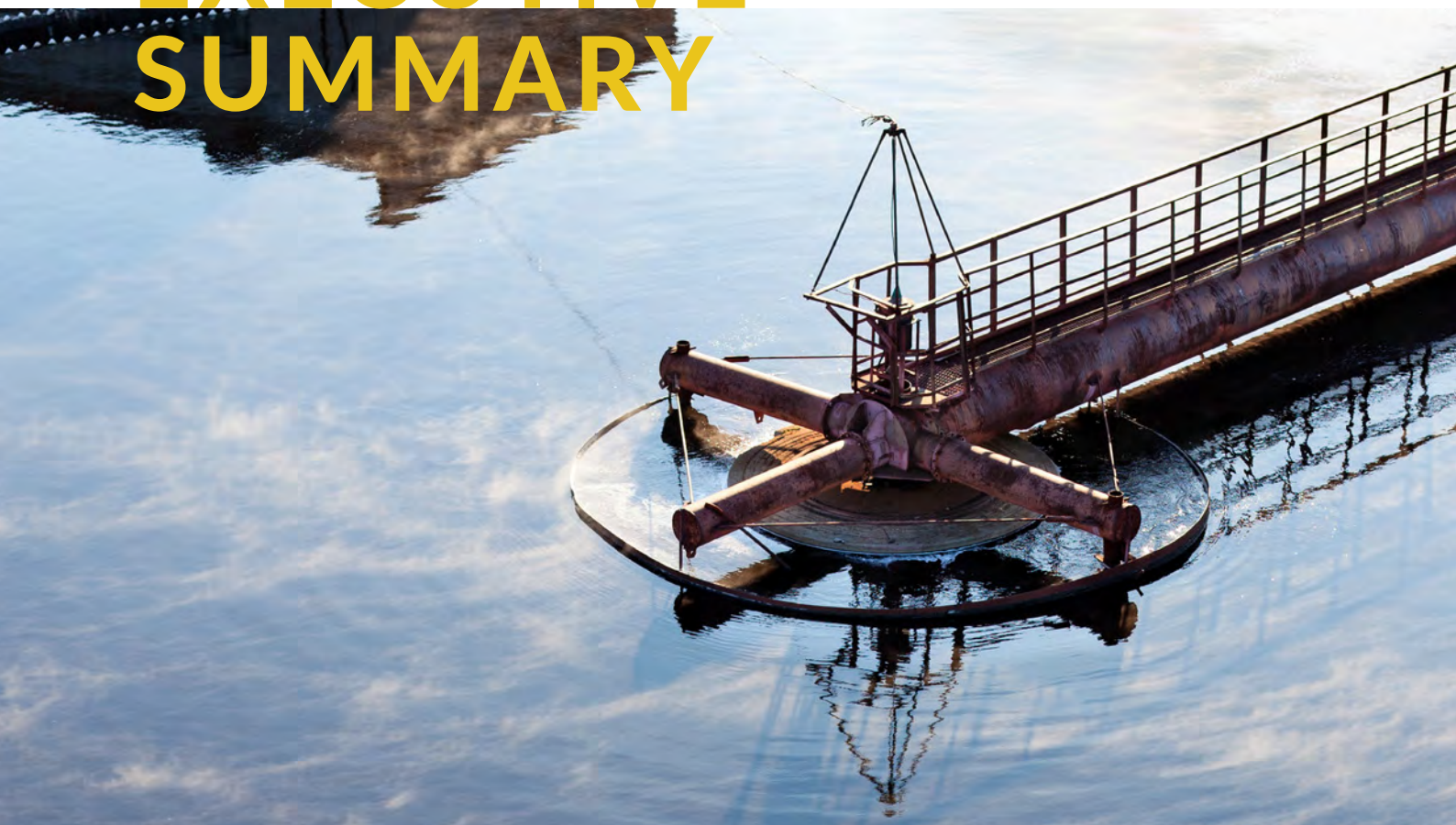
UN WATER

Report

The United Nations World Water Development Report 2017

EXECUTIVE SUMMARY



Wastewater

The Untapped Resource

United Nations Educational, Scientific and Cultural Organization

World Water Assessment Programme

In all but the most highly developed countries, the vast majority of wastewater is released directly to the environment without adequate treatment

Most human activities that use water produce wastewater. As the overall demand for water grows, the quantity of wastewater produced and its overall pollution load are continuously increasing worldwide.

In all but the most highly developed countries, the vast majority of wastewater is released directly to the environment without adequate treatment, with detrimental impacts on human health, economic productivity, the quality of ambient freshwater resources, and ecosystems.

Although wastewater is a critical component of the water management cycle, water after it has been used is all too often seen as a burden to be disposed of or a nuisance to be ignored. The results of this neglect are now obvious. The immediate impacts, including the degradation of aquatic ecosystems and waterborne illness from contaminated freshwater supplies, have far-reaching implications on the well-being of communities and peoples' livelihoods. Continued failure to address wastewater as a major social and environmental problem would compromise other efforts towards achieving the 2030 Agenda for Sustainable Development.

In the face of ever-growing demand, wastewater is gaining momentum as a reliable alternative source of water, shifting the paradigm of wastewater management from 'treatment and disposal' to 'reuse, recycle and resource recovery'. In this sense, wastewater is no longer seen as a problem in need of a solution, rather it is part of the solution to challenges that societies are facing today.

Wastewater can also be a cost-efficient and sustainable source of energy, nutrients and other useful by-products. The potential benefits of extracting such resources from wastewater go well beyond human and environmental health, with implications on food and energy security as well as climate change mitigation. In the context of a circular economy, whereby economic development is balanced with the protection of natural resources and environmental sustainability, wastewater represents a widely available and valuable resource.

The outlook is undeniably optimistic, provided action is taken now.

THE WORLD'S WATER: AVAILABILITY AND QUALITY

Globally, water demand is predicted to increase significantly over the coming decades. In addition to the agricultural sector, which is responsible for 70% of water abstractions worldwide, large increases in water demand are predicted for industry and energy production. Accelerated urbanization and the expansion of municipal water supply and sanitation systems also contribute to the rising demand.

Climate change scenarios project an exacerbation of the spatial and temporal variations of water cycle dynamics, such that discrepancies between water supply and demand are becoming increasingly aggravated. The frequency and severity of floods and droughts will likely change in many river basins worldwide. Droughts can have very significant socio-economic and environmental consequences. The crisis in Syria was, among other factors, triggered by a historic drought (2007–2010).

Two thirds of the world's population currently live in areas that experience water scarcity for at least one month a year. About 500 million people live in areas where water consumption exceeds the locally renewable water resources by a factor of two. Highly vulnerable areas, where non-renewable resources (i.e. fossil groundwater) continue to decrease, have become highly dependent on transfers from areas with abundant water and are actively seeking affordable alternative sources.

The availability of water resources is also intrinsically linked to water quality, as the pollution of water sources may prohibit different types of uses. Increased discharges of untreated sewage, combined with agricultural runoff and inadequately treated wastewater from industry, have resulted in the degradation of water quality around the world. If current trends persist, water quality will continue to degrade over the coming decades, particularly in resource-poor countries in dry areas, further endangering human health and ecosystems, contributing to water scarcity and constraining sustainable economic development.

WASTEWATER: GLOBAL TRENDS

On average, high-income countries treat about 70% of the municipal and industrial wastewater they generate. That ratio drops to 38% in upper-middle-income countries and to 28% in lower-middle-income countries. In low-income countries, only 8% undergoes treatment of any kind. These estimates support the often-cited approximation that, globally, over 80% of all wastewater is discharged without treatment.

In high-income countries, the motivation for advanced wastewater treatment is either to maintain environmental quality, or to provide an alternative water source when coping with water scarcity. However, the release of untreated wastewater remains common practice, especially in developing countries, due to lacking infrastructure, technical and institutional capacity, and financing.

WASTEWATER, SANITATION AND THE SUSTAINABLE DEVELOPMENT AGENDA

Access to improved sanitation services can contribute significantly to the reduction of health risks. Further health gains may be realized through improved wastewater treatment. While 2.1 billion people gained access to improved sanitation facilities since 1990, 2.4 billion still do not have access to improved sanitation and nearly 1 billion people worldwide still practice open defecation. In 2012, an estimated 842,000 deaths in middle- and low-income countries were caused by contaminated drinking water, inadequate handwashing facilities, and inappropriate or inadequate sanitation services.

However, improved sanitation coverage does not necessarily equate with improved wastewater management or public safety. Only 26% of urban and 34% of rural sanitation and wastewater services effectively prevent human contact with excreta along the entire sanitation chain and can therefore be considered safely managed.

Building on the experience of the MDGs, the 2030 Agenda for Sustainable Development has a more comprehensive goal for water, going beyond the issues of water supply and sanitation. SDG Target 6.3 states: "By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally." The extremely low level of wastewater treatment in low-income and lower-middle-income countries reveals an urgent need for implementing low-cost solutions and safe water reuse options to support the achievement of Target 6.3, which is critical for achieving the entire Agenda.

GOVERNANCE CHALLENGES

The benefits to society of managing human waste are considerable, for public health as well as for the environment. For every US$1 spent on sanitation, the estimated return to society is US$5.5.

Overcoming the practical difficulties of implementing water quality regulations can be particularly challenging. In order to realize the goals of water quality improvement and water resources protection, individuals and organizations responsible for various aspects of wastewater management need to comply and act in the collective interest. Benefits are only realized once everyone abides by the rules to protect water resources from pollution.

Involving citizens in decision-making at all levels promotes engagement and ownership. This includes decisions as to what types of sanitation facilities are desirable and acceptable, and how they can be securely funded and maintained over the long term. It is especially important to reach out to marginalized groups, ethnic minorities and people living in extreme poverty, in remote rural areas or in informal urban settlements. It is also essential to engage with women, as they bear the brunt of the health consequences stemming from the unsafe management of human waste.

TECHNICAL ASPECTS

Wastewater is roughly composed of 99% water and 1% suspended, colloidal and dissolved solids.

The consequences of releasing untreated or inadequately treated wastewater can be classified into three groups: i) harmful effects on human health; ii) negative environmental impacts; and iii) adverse repercussions on economic activities.

A circular approach to controlling and regulating various wastewater flows is the ultimate purpose of improved wastewater management. The management cycle can be broken down into four phases:

1 Prevention or reduction of pollution at the source

Approaches to water pollution control that focus on wastewater prevention and minimization should be given priority over traditional end-of-pipe treatment whenever possible. These include prohibiting or controlling the use of certain contaminants to eliminate or limit their entering into wastewater streams through regulatory, technical and/or other means. Remedial actions to clean up polluted sites and water bodies are generally much more expensive than measures to prevent pollution from occurring.

Monitoring and reporting of pollutant discharges to the environment and ambient water quality are necessary for achieving progress. If something is not measured, the problem cannot be defined and the effectiveness of policies cannot be assessed.

2 Wastewater collection and treatment

Centralized waterborne waste disposal remains the prevalent method for sanitation and for evacuating wastewater from domestic, commercial and industrial sources. Globally, about 60% of people are connected to a sewer system (although only a small proportion of the collected sewerage is actually treated).

Other sanitation options, such as on-site systems, are well suited to rural areas and low population density settings, but can be expensive and difficult to manage in dense urban environments.

Large-scale centralized wastewater treatment systems may no longer be the most viable option for urban water management in many countries. Decentralized wastewater treatment systems, serving individual or small groups of properties, have shown an increasing trend worldwide. They also allow for the recovery of nutrients and energy, save freshwater and help secure access to water in times of scarcity. It has been estimated that the investment costs for these treatment facilities represent only 20–50% of conventional treatment plants, with even lower operation and maintenance costs (in the range of 5–25% of conventional activated sludge treatment plants).

Low-cost sewerage systems have become a method of choice for neighbourhoods of all income levels. They differ from those used in conventional sewer design and focus on the concept that solid-free sewage is conveyed in the system. These systems lend themselves to community management and are very well suited to extend and expand existing systems or to connect satellite communities to centralized systems. They have also been used in refugee settings. One drawback is that they are not suitable for stormwater drainage.

Ecosystems can be effective in terms of providing economical wastewater treatment services, provided that these ecosystems are healthy, the pollutant load (and types of contaminants) in the effluent is regulated and the ecosystem's pollution carrying capacity is not exceeded. There are natural limits to the assimilative capacity of ecosystems, beyond which they are threatened and can no longer perform a purifying role.

3 Using wastewater as an alternative source of water

The use of untreated or diluted wastewater for irrigation has taken place for centuries. Reclaimed water also offers opportunities for a sustainable and reliable water supply for industries and municipalities, especially with a growing number of cities relying on more distant and/or alternative sources of water to meet increasing demand.

In general, water reuse becomes more economically feasible if the point of reuse is close to the point of production. Treating wastewater to a water quality standard acceptable by a user (i.e. 'fit-for-purpose' treatment) increases the potential for cost recovery. Wastewater use becomes all the more competitive when freshwater prices also reflect the opportunity cost of using freshwater, and when pollution charges reflect the cost of removing pollutants from wastewater flows.

The planned use of treated and partially treated wastewater for ecosystem services can increase resource efficiency and provide benefits to ecosystems by reducing freshwater abstractions, recycling and reusing nutrients, allowing fisheries and other aquatic ecosystems to thrive by minimizing water pollution, and recharging depleted aquifers.

4 The recovery of useful by-products

Wastewater's vast potential as a source of resources, such as energy and nutrients, remains underexploited.

Energy can be recovered in the form of biogas, heating/cooling and electricity generation. Technologies exist for on-site energy recovery through sludge/biosolids treatment processes integrated in wastewater treatment plants, allowing them to transition from major energy consumers to energy neutrality, or even to net energy producers. Energy recovery can also help facilities reduce operational costs and their carbon footprint, enabling increased revenue streams through carbon credits and carbon trading programmes. There are also opportunities for combined energy and nutrient recovery. Off-site energy recovery involves sludge incineration in centralized plants through thermal treatment processes.

The development of technologies for recovering nitrogen and phosphorus from sewage or sewage sludge is advancing. Phosphorus recovery from on-site treatment facilities such as septic tanks and latrines can be technically and financially feasible by transforming septage into organic or organic-mineral fertilizer. Moreover, faecal sludge presents a relatively lower risk of chemical contamination compared to sewerage biosolids.

It is likely that urine collection and use will become an increasingly important component of ecological wastewater management, as it contains 88% of the nitrogen and 66% of the phosphorus found in human waste – essential components for plant growth. With extractable mineral phosphorus resources predicted to become scarce or even exhausted over the next decades, its recovery from wastewater offers a realistic and viable alternative.

MUNICIPAL AND URBAN WASTEWATER

In the context of a circular economy, whereby economic development is balanced with the protection of natural resources and environmental sustainability, wastewater represents a widely available and valuable resource

The composition of municipal wastewater can vary considerably, reflecting the range of contaminants released by various domestic, industrial, commercial and institutional sources. Wastewater from domestic sources is usually relatively free of hazardous substances, but there are growing concerns about emerging pollutants including commonly used medications that, even at low concentrations, may have long-term impacts.

Accelerated urban growth poses several challenges, including dramatic increases in the generation of municipal wastewater. However, this growth also offers opportunities to break away from the past (inadequate) water management practices and adopt innovative approaches, which include the use of treated wastewater and by-products.

Wastewater generation is one of the biggest challenges associated to the growth of informal settlements (slums) in the developing world. There were more slum dwellers in 2012 than in 2000, a trend that will likely continue in the future. Slum dwellers frequently have to rely on unsewered communal toilets, use open spaces or dispose of faeces in polythene bags (i.e. flying toilets). Communal toilets are not widely used, due to a lack of water, poor maintenance, and the cost to the user. Finding a suitable place to go to the toilet is especially problematic for women, causing risks related to personal security, embarrassment and hygiene.

> **Wastewater use can add new revenue streams to wastewater treatment, particularly under conditions of recurring or chronic water scarcity [...] The recovery of nutrients (mainly phosphorus and nitrogen) and energy can add significant new value streams to improve the proposition of cost recovery**

INDUSTRY

The toxicity, mobility and loading of industrial pollutants have potentially more significant impacts on water resources, human health and the environment than actual volumes of wastewater. The first step is to keep the volumes and toxicity of pollution to a minimum at the point of origin, from concept to design and in operations and maintenance. This includes substitution with more environmentally friendly raw materials and biodegradable process chemicals, as well as staff education and training to address pollution-related issues. The second step is to recycle as much water as possible within a plant, thus minimizing discharge.

Small- and medium-sized enterprises (SMEs) and informal industries often discharge their wastewater into municipal systems or directly into the environment. Industries discharging into municipal systems or surface water have to meet discharge regulations to avoid fines, so in many cases end-of-pipe treatment is required at the plant before release. In some situations, however, industries may find it more economical to pay fines than to invest in treatment to meet regulations.

One notable opportunity for industrial wastewater use and recycling is the cooperation between plants through industrial symbiosis. This is best seen in eco-industrial parks that locate industries adjacent to one another in such a way as to take advantage of various wastewater flows and water and by-product recycling. For SMEs, this can be a significant way to save on wastewater treatment costs.

> In addition to enhancing food security, water reuse for agriculture can have significant benefits, including improved nutrition

AGRICULTURE

Over the past half century, the area equipped for irrigation has more than doubled, total livestock has more than tripled and inland aquaculture has grown more than twentyfold.

Water pollution from agriculture occurs when fertilizers (nutrients) and other agrochemicals are applied more heavily than crops can absorb them or when they are washed away. Efficient irrigation schemes can greatly reduce both water and fertilizer loss. Nutrients can also be released by livestock production and aquaculture.

Agriculture can be a source of several other types of pollutants, including organic matter, pathogens, metals and emerging contaminants. Over the last 20 years, new agricultural pollutants have emerged, such as antibiotics, vaccines, growth promoters and hormones that may be released from livestock and aquaculture farms.

If adequately treated and safely applied, domestic wastewater is a valuable source of both water and nutrients. In addition to enhancing food security, water reuse for agriculture can have significant human and environmental health benefits, including improved nutrition. The use of municipal wastewater is a common pattern in countries of the Middle East and North Africa, Australia, and the Mediterranean, as well as in China, Mexico and the USA. The practice has been most successful in urban and peri-urban areas, where wastewater is easily available, generally free of charge, and where there is a nearby market for agricultural products.

REGIONAL PERSPECTIVES

One of the main challenges related to wastewater in Africa is the overall lack of infrastructure for collection and treatment, which results in the pollution of often-limited surface and groundwater resources. African cities are growing quickly, and their current water management systems cannot keep up with the growing demand. However, this situation provides opportunities from improved urban wastewater management using multi-purpose technologies for water reuse and the recovery of useful by-products. Strong advocacy is needed to convince policy-makers of the phenomenal 'cost of inaction' in terms of socio-economic development, environmental quality and human health.

The use of safely treated wastewater has become a means of increasing water availability in several Arab states and has been included as a core component of water resources management plans. In 2013, 71% of the wastewater collected in Arab States was safely treated, of which 21% was used, mostly for irrigation and groundwater recharge. Integrated water resources management and nexus approaches that consider the linkages between water, energy, food and climate change provide a framework for considering avenues to support the improved collection, transfer, treatment and use of wastewater in the Arab region from a water security perspective.

By-products from domestic wastewater, such as salt, nitrogen and phosphorus, have potential economic value that can be used to improve livelihoods in the Asia-Pacific region. Case studies in South-East Asia have shown that revenues from wastewater by-products, such as fertilizer, are significantly higher than the operational costs of by-product-harvesting wastewater systems, providing evidence that resource recovery from wastewater is a viable and profit-producing business model. More needs to be done across the region to support municipal and local governments in managing urban wastewater and capturing its resource benefits.

The level of access to improved sanitation across the European and North American region is relatively high (95%) and wastewater treatment levels have improved during the last 15–20 years. Although tertiary treatment has increased gradually, significant volumes of wastewater are still collected and discharged without treatment, particularly in Eastern Europe. Demographic and economic changes have rendered the effectiveness of some of the larger centralized systems suboptimal, as exemplified by several oversized and maladapted systems in parts of the former Soviet Union. Cities throughout the region are facing the financial burden associated with repairing or replacing aging infrastructure.

The coverage of urban wastewater treatment in Latin America and the Caribbean has almost doubled since the late 1990s and is now estimated to have reached between 20% and 30% of the wastewater collected in urban sewerage systems. This improvement is mainly attributed to increasing levels of water and sanitation coverage, the improved financial situation of many service providers (which in recent years have made important advances towards cost recovery), and strong socio-economic growth in the region over the past decade. A further contributing factor was the integration of regional economies into global markets. Treated wastewater could be an important source of water supply in some cities, particularly those located in arid areas (i.e. Lima) or where long-distance transfers are required to meet growing demands, particularly during drought (i.e. São Paulo).

CREATING AN ENABLING ENVIRONMENT FOR CHANGE

Improved wastewater treatment, the increase in water reuse and the recovery of useful by-products support the transition to a circular economy by helping reduce water withdrawals and the loss of resources in production systems and economic activities.

Suitable legal and regulatory frameworks

An effective regulatory framework requires that the implementing authority has the necessary technical and managerial capacity and performs in an independent fashion, with sufficient powers to enforce rules and guidelines. Transparency and access to information motivates compliance by promoting trust among users with respect to the implementation and enforcement processes. Achieving progress will require a flexible and incremental approach.

Policies and regulatory instruments are implemented locally and need to be adapted to varied circumstances. It is therefore important that political, institutional and financial support be given to 'bottom-up' initiatives and small-scale local (i.e. decentralized) provision of wastewater management services.

New regulations regarding water reuse and the recovery of wastewater by-products are also required. There is often little or no legislation on quality standards for these products, creating market uncertainties that can discourage investment. Markets for these products could be stimulated by financial or legal incentives (i.e. compulsory blending of recovered phosphates in artificial fertilizer).

Cost recovery and appropriate financing mechanisms

Wastewater management and sanitation are generally considered to be expensive and capital-intensive. This is especially the case of large centralized systems, which require a large degree of up-front capital expenditure and relatively high operation and maintenance costs over the medium and long term to avoid rapid deterioration. The problem is further exacerbated by chronically lacking investment in the development of institutional and human capacity. However, the costs of inadequate investment in wastewater management are far greater, particularly when the direct and indirect damages to health, socio-economic development and the environment are taken into consideration.

Decentralized wastewater treatment systems can be used to offset some financial problems generated by centralized systems. When properly designed and implemented, such low-cost technologies can provide satisfactory results in terms of effluent quality, although they too require an appropriate level of operation and maintenance in order to avoid system failure.

Wastewater use can add new revenue streams to wastewater treatment, particularly under conditions of recurring or chronic water scarcity. Several different business models have been implemented where cost and value recovery offer a significant advantage from a financial perspective. However, revenues from the sale of treated wastewater alone are not generally adequate to cover the operational and maintenance costs of the water treatment facility itself. The recovery of nutrients (mainly phosphorus and nitrogen) and energy can add significant new value streams to improve the proposition of cost recovery.

Although revenues from wastewater use and resource recovery may not always cover their extra costs, the benefits from investments in water reuse may compare well with the cost of dams, desalination, inter-basin transfers, and other options to increase water availability.

Even when delivered to the tap, potable water remains generally undervalued and underpriced when compared to the total cost of the service. Treated wastewater must itself be priced lower than potable water in order

to gain public acceptance. Pricing water from all sources to better reflect its actual cost enables investments that can translate into affordable service delivery to all members of society, including the poor.

Minimizing risks to people and the environment

The discharge of untreated wastewater can have severe impacts on human and environmental health, including outbreaks of food-, water- and vector-borne diseases, as well as pollution and the loss of biological diversity and ecosystem services. Exposure of vulnerable groups, especially women and children, to partially treated or untreated wastewater requires specific attention. Limited awareness of health risks associated with wastewater use, due to poverty and low education, further contributes to these risks, in particular in developing countries. Whenever human exposure is considered likely (i.e. via food or direct contact), more rigorous risk management measures are required.

Building knowledge and capacity

Data and information on wastewater generation, treatment and use is essential for policy-makers, researchers, practitioners and public institutions in order to develop national and local action plans aimed at environmental protection and the safe and productive use of wastewater. Knowledge concerning the volumes and, perhaps even more importantly, the constituents of wastewater are necessary tools for protecting human and environmental health and safety. However, there is a pervasive lack of data relating to virtually all aspects of water quality and wastewater management, particularly in developing countries.

Appropriate and affordable technologies, both new and well established, need to be transferred from developed to developing countries in order to help them achieve SDG Target 6.3. Research is needed to improve the understanding of the dynamics of emerging pollutants and improve methods to remove these pollutants from wastewater. It is also essential to understand how external factors like climate change will impact wastewater management.

In order to enhance wastewater management, it is essential to ensure that the appropriate levels of human capacity are in place. Organizational and institutional capacity in the wastewater management sector is often lacking and, therefore, any investment – large-scale centralized wastewater management systems or smaller, on-site systems – is at stake.

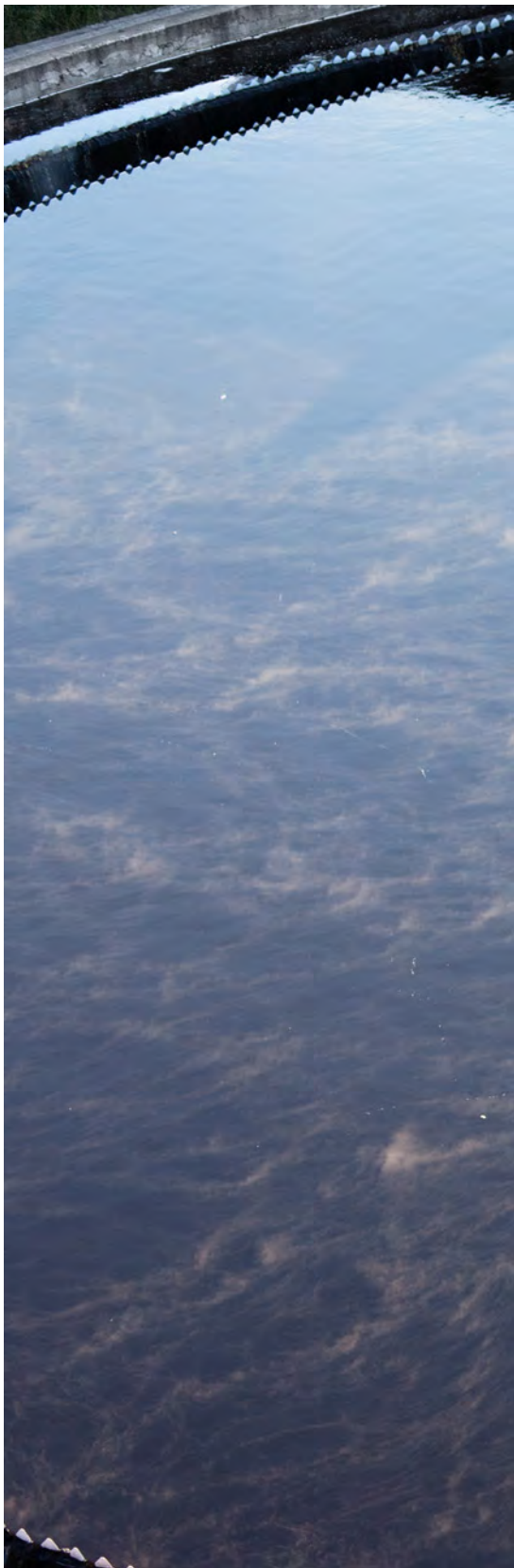
Public awareness and social acceptance

Even if wastewater use projects are technically well designed, appear financially realizable, and have incorporated appropriate safety measures, water reuse schemes can fail if planners do not adequately account for the dynamics of social acceptance. The use of wastewater often encounters strong public resistance due to a lack of awareness and trust with regard to human health risks. Awareness raising and education are the main tools to overcome social, cultural and consumer barriers. Such awareness campaigns need to be tailored to consumers with different cultural and religious backgrounds.

The health risks associated with water reuse need to be assessed, managed, monitored and reported on a regular basis in order to gain public acceptance and to maximize the benefits of using wastewater while minimizing the negative impacts. In the case of drinking water (i.e. potable water reuse), extensive information campaigns are required to build trust in the system and overcome the so-called 'yuck' factor.

CODA

In a world where demands for freshwater are continuously growing, and where limited water resources are increasingly stressed by over-abstraction, pollution and climate change, neglecting the opportunities arising from improved wastewater management is nothing less than unthinkable in the context of a circular economy.



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