Water Economics and Policy, Vol. 4, No. 2 (2018) 1871002 (10 pages)

DOI: 10.1142/S2382624X18710029

World Scientific
www.worldscientific.com

Policy Nook

Published 4 May 2018

Addressing Trade-offs to Promote Safely Managed Wastewater in Developing Countries

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We cannot afford wasting municipal wastewater as this is a valuable resource of water, nutrients, and energy.

1. Introduction

Freshwater scarcity has increased over time and is expected to further intensify due to uneven distribution of water resources and population densities amid changing climate and rainfall patterns (Damania *et al.* 2017). Water-scarce countries, areas, and communities need to consider increasingly alternate water resources, such as treated wastewater, to narrow the water demand-supply gap, as water scarcity forms a major risk to the global economy (World Bank 2017) and water is increasingly considered an impetus for international cooperation to achieve sustainable development in a range of sectors.

While the use of treated wastewater needs to be a common practice in water-scarce areas, large volumes of untreated or inadequately treated wastewater are currently used as an irrigation source to grow a range of crops in developing countries (Qadir *et al.* 2010; Scheierling *et al.* 2011; WWAP 2017). Despite multiple benefits that wastewater brings to communities, the progress on treatment of wastewater and its fit-for-purpose use remains very slow in many developing countries (Drechsel *et al.* 2015). Estimates suggest that lower-middle-income

countries on average treat 28% of the generated wastewater; in low-income countries, only 8% of the wastewater generated is treated (Sato *et al.* 2013).

With focus on developing countries, this policy note addresses trade-offs between current practices of wastewater use – critical benefits to poor communities at the cost of health and environmental risks – and argues for safely managed wastewater through its collection, treatment, and fit-for-purpose use to protect population health and environment. While addressing trade-offs, the policy note also highlights the importance of a paradigm shift to promote safely managed wastewater by enhancing institutional capacity, implementing training and capacity building activities to develop skilled human resources capable of using evidence-based knowledge in dealing with complexities, undertaking comprehensive economic analysis while identifying and quantifying full range of potential benefits, and introducing flexible policy frameworks and ensuring political support.

2. Trade-Offs

The use of wastewater in untreated and inadequately treated forms damages the environment and people's health. For example, metal ion contaminants such as cadmium, mercury, and lead do not have essential function, but they are detrimental, even in small quantities, to plants, animals and humans, and accumulate because of their long biological half-life. Other metals and metalloids, such as manganese, zinc, and copper are essential micro-nutrients in small concentrations, but harmful to crops when they reach above maximum allowable concentrations (Hamilton *et al.* 2005). In addition, metals and metalloids, salts and pathogens accumulate in soils irrigated with wastewater, causing long-term soil degradation and the need for their removal from the soil, particularly from plant root zone (Corcoran *et al.* 2010). Heaving irrigation and leaching practices help remove these contaminants, but often shift pollution from wastewater-irrigated soils to groundwater (WWAP 2017). This scenario exposes urban and peri-urban populations to contaminated groundwater. This is a dangerous side effect, as groundwater is the primary source of drinking water and other domestic water needs for millions of people living in low-income communities (Dickin *et al.* 2016). Studies comparing wastewater and freshwater irrigated areas under similar agro-climatic and socio-economic conditions show environmental degradation and higher rates of water-borne diseases among children in areas irrigated with untreated or inadequately treated wastewater than in freshwater zones (Grangier *et al.* 2012).

Safely managed wastewater in agriculture protects the environment and health, and helps improve livelihoods of farming communities. In addition, when wastewater is safely managed, nutrient and energy recovery results in revenue generation

to enhance the economic value of wastewater and increases its cost recovery (Rao *et al.* 2017). Managing wastewater safely is in line with achieving Sustainable Development Goals (SGDs), particularly SDG target 6.3, which addresses improvement in 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 (https://sustainabledevelopment.un.org/sdgs).

3. Four Pillars Supporting Safely Managed Wastewater

The use of untreated and inadequately treated wastewater in most developing countries faces a challenge: it provides critical benefits to poor communities, but this often comes at the expense of health and environmental risks. Estimates suggest that the annual health cost per capita is 73% higher in areas irrigated with untreated wastewater than the health cost in freshwater-irrigated area (Grangier *et al.* 2012). If we do not embrace new thinking supported by specific follow up actions, we risk leaving the wastewater challenge to the next generations. Thus, there is a need to think for a win-win by shifting from health spending to preventative wastewater treatment to tap the benefits from fit-for-purpose use of wastewater and protect population health and environment.

Research and practice on wastewater use in developing countries have identified weak and fragmented institutional arrangements (Wichelns and Qadir 2015; WWAP 2017), limited human resources capable of tackling the complex issues arising from untreated wastewater (Liebe *et al.* 2013), inadequate financial assessments on the comparative evaluation of the economics of 'no action' and 'action' in managing wastewater (Wichelns and Drechsel 2011; Hernández-Sancho *et al.* 2015), and rigid policies and often inadequate political support (Liebe *et al.* 2013; WWAP 2017) as major challenges to safely managed wastewater. These challenges can arguably be addressed by taking key actions in the following four areas: **S**upportive institutions; **T**raining and capacity building; **E**conomic analysis; and **P**ertinent policies (STEP).

3.1. *Supportive institutions*

There are two key elements related to institutional settings in managing wastewater in developing countries: (1) Large diversity at the national level ministries and local level institutions for wastewater management; in several countries, there are more than one ministries or local institutions dealing with wastewater management; and (2) limited inter-ministerial and inter-institutional collaboration in addition to lack of coordination between ministries and local institutions,

mainly due to largely unclear and overlapping responsibilities and mandates. Consequently, there are bureaucratic hurdles in wastewater management at different scales.

There are no, or limited, institutional arrangements at the local level in most countries to regulate fit-for-purpose use of wastewater and collect revenue from the wastewater-irrigating farmers (Wichelns and Qadir 2015). Similarly, only few countries have farmer associations or water user associations to collaborate with local institutions for wastewater delivery to farmers' fields and regulated use of wastewater.

There is a need for supportive institutional arrangements and enhanced institutional collaboration to facilitate wastewater collection, treatment, fit-for-purpose use, and/or safe disposal. For example, local institutions can provide technical assistance regarding water diversion and irrigation methods at the farm level to reduce potential exposure of farm workers to harmful pathogens and chemicals. In addition, they can help in establishing a minimum period between the dates of last irrigation and crop harvest in reducing the risk of contamination from agricultural products. In return, the local institutions may consider implementing certification programs for consumer-safe farm produce, particularly in markets where local farmers sell their products, such as vegetables, from irrigated fields (Wichelns and Qadir 2015).

Although the private sector remained largely inactive in developing countries due to public sector taking lead in wastewater management, involvement of the private sector is gearing up with several functional set-ups of public-private partnerships in wastewater management. For example, As-Samra Wastewater Treatment Plant in Amman, Jordan is based on public-private partnership using build-operate-transfer (BOT) contract and World Bank as the Multilateral Investment Guarantee Agency (MIGA). As the public-sector funding for wastewater treatment is limited, the private sector involvement based on BOT is expected to catalyze wastewater collection and treatment opportunities in developing countries (Otoo and Drechsel 2018).

3.2. *Training and capacity building*

There is critical shortage of skilled human resources to deal with the complexity of wastewater management at different scales. Training and capacity building are essential in the public sector as the ministry personnel need to learn about new, economically feasible, and effective approaches of wastewater collection, treatment, and fit-for-purpose use or safe disposal. They also need pertinent information on the suitability of wastewater treatment systems for specific settings. The

professionals in the local institutions need to update their skills in safely managed wastewater, in addition to developing capacity to train wastewater-irrigating farmers to avoid or minimize health and environmental risks.

It is important to undertake capacity needs assessment to target need-specific training and capacity development. In a global project addressing capacity development on safe use of wastewater in agriculture in 71 developing countries from Asia, Africa, and Latin America and the Caribbean regions (http://www.ais.unwater.org/ais/course/view.php?id=6), capacity gaps were identified in the following key areas: (1) economics of wastewater treatment and use of treated wastewater in agriculture; (2) environmental impact assessment and management; (3) health risks and their management; and (4) gender, social and cultural aspects of wastewater management.

As seeing the world free of untreated wastewater is not expected anytime soon as it may take a few decades, there would be a need for interim measures and hands-on training of professionals and farmers on measures for safely managed wastewater until desired levels of wastewater treatment are achieved. This need to involve guidance and advise on specific fit-for-purpose options leading to safe and productive use of wastewater while considering its quality and quantity, socio-economic dimensions, health and environmental considerations, and existing regulations on the use of wastewater in different sectors (Wichelns *et al.* 2011).

Beyond training of professionals and wastewater-irrigating farmers, capacity development would also be needed at the household level in dry areas where greywater has potential use, but communities are not fully aware of the methods of separating greywater from black water and its treatment and safe use (Qadir *et al.* 2010). In wastewater-irrigated areas where risk awareness is low and not easy to develop, it is important to first determine how best to motivate and trigger behavior change, and then promote supportive actions leading to the adoption of gender-sensitive risk mitigation measures (Drechsel *et al.* 2013). This is evident in many cultures – Jordan, Tunisia, and Vietnam – where women do not only carry the main responsibility for hygiene and health but are also in charge of greywater or wastewater use. This connection offers significant potential for innovative training approaches to improve the social acceptance for fit-for-purpose use of greywater and wastewater.

3.3. *Economic analysis*

The economic evaluations of wastewater management in developing countries are usually restricted to financial feasibility analysis (Kfouri *et al*., 2009). In fact, there

are several cost and benefit components associated with a specific wastewater treatment and water reuse or disposal system.

The lack of wastewater treatment cost-recovery mechanisms in developing countries has led to low demand for cost-based supply of reclaimed water. The reasons are that both farmers and households have skepticism about the quality of the reclaimed water as they do not have access or means to monitor and verify the quality of water they use. In addition, the availability of untreated wastewater free of charge adds to the complexity of the whole issue and makes it difficult to convince farmers to pay anything for reclaimed water that is not of high quality (Drechsel *et al.* 2015).

The mismatch between water pricing and water scarcity is another important constraint affecting the whole process of wastewater treatment in most arid region developing countries where water pricing should also consider its scarcity value. Contrarily, the price of freshwater delivered to irrigators does not reflect even the cost of water supply. At best, some developing countries charge sufficient rates to cover operation and maintenance costs of wastewater treatment plants. In general, most arid region countries do not charge or control groundwater abstractions other than the fee for issuing permits for groundwater pumping, if applicable, and cost of groundwater pumping.

As part of the comprehensive economic analysis of wastewater management systems, there is a need to consider factors beyond costs on wastewater treatment plants (Hernández-Sancho *et al.* 2015), such as centralized and decentralized treatment options; levels of treatment (primary, secondary, and tertiary); intended fit-for-purpose reuse options; wastewater collection and conveyance infrastructure leading to wastewater treatment plant in locations where such infrastructure does not exist or needs repair; and transportation options for treated effluent to specific locations for intended reuse. In addition, the opportunity cost of water reuse should be considered under conditions where new uses and moving a given supply of water from one place to another specific location are anticipated. In doing so, the economic analysis therefore needs to consider the implications of wastewater distribution as well as market prices of suitable crops due to possible restrictions on crop choices based on the quality and quantity of reclaimed water in the anticipated reuse projects. In addition, the cost of customer service and billing and planning and engineering aspects of overall wastewater management processes should also be considered while undertaking economics of wastewater management.

Besides costs of wastewater management, there are direct or indirect benefits and cost savings stemming from wastewater treatment and fit-for-purpose use of treated wastewater, including: environmental benefits of treated wastewater leading to improvement in surface water quality, soil quality, groundwater quality; far less

spending on health cost of communities; possible increase in aesthetic values; provision of additional water supply; savings on fertilizer cost; increase in land rent and property value; social benefits; potential gains from the recovery of nutrients, energy, and precious metals; carbon credits; and ecosystem services, although functional markets for many of the ecosystem services are currently embryonic or nonexistent (Qadir *et al.* 2015). There is a need to undertake comprehensive economic assessments in given settings on the costs of ignoring needed investments and benefits from introducing innovative financial mechanisms to support and prioritize safely managed wastewater. This can be achieved by identifying full range of potential benefits associated with wastewater treatment and fit-for-purpose use of treated wastewater and quantifying and monetizing these benefits, to the extent possible and feasible, using approaches that should be objective and credible.

3.4. *Pertinent policies*

There are large differences between developed and developing countries about policy issues related to wastewater management. In developed countries, most wastewater is treated, and thus most of the wastewater used in agriculture is treated wastewater. The guidelines on the safely managed wastewater are in place. Policy issues in developed countries pertain largely to financial and economic considerations regarding the improvement and expansion of wastewater treatment facilities. Public officials and water management agencies motivate greater use of wastewater by providing financial incentives and increasing public awareness of the safety and benefits of using treated wastewater on farms, golf courses and urban landscapes (Wichelns and Qadir 2015).

The treatment of wastewater and use or disposal in the humid regions of developed countries, such as the eastern part of North America, northern Europe, and Japan are motivated by stringent effluent discharge regulations and public preferences regarding environmental quality. Treated wastewater is also used for irrigation, but this end use is not substantial in humid areas. The situation is different in the arid and semi-arid areas of developed countries, such as western North America, Australia, Parts of the Middle East, and southern Europe, where wastewater after treatment is used primarily for irrigation, given the increasing competition for water between agriculture and other sectors (Sato *et al.* 2013).

In developing countries, the policy issues also address financial and economic questions regarding investments in wastewater management, but the pace and scale of such investments are not sufficient to accomplish needed wastewater treatment in terms of desired quality and quantity (Wichelns and Qadir 2015). Thus, treatment

of wastewater is limited, as investments in treatment facilities have not kept pace with persistent increases in population and the consequent increases in wastewater volume in many countries. As a result, much of the wastewater is not treated, and much of the untreated water is used for irrigation in dry areas by small-scale farmers in largely informal settings with little ability to optimize the volume or quality of the wastewater they receive (Drechsel *et al.* 2015).

The policy options in developing countries and public officials must therefore support risk reduction measures that protect farm families, communities, food vendors, and consumers from the potentially harmful effects of exposure to the pathogens and chemicals in untreated wastewater. As interim strategies while full-scale wastewater treatment is achieved, some farm-based measures and low-cost treatment options can reduce the environmental and human health risks, in part to a significant extent (WHO 2006) by: (1) identifying geographical areas with elevated risks from potential sources of heavy metals; (2) assuring quality control by testing soil and plant samples from wastewater-irrigated areas to verify the level of risk; (3) identifying alternative varieties of the same desired crop that have low uptake of metals or convert the toxin to less toxic forms when grown in high-risk areas; (4) developing irrigation, fertilization, and residue management strategies that help to minimizing metal uptake by plants; (5) implementing crop restrictions by recommending crops posing no or lower health risks; and (6) zoning areas already posing high risks for non-agricultural purposes such as agro-forestry systems or land rehabilitation initiatives.

Policy decisions on wastewater management require pertinent data, easy-to-use models and approaches, a range of options and scenarios based on available data and resources and associated potential gains, and flexibility in decision making in specific national and local settings. This necessitates research- and evidence-based systematic information and data to be used by the governments at the national level and city/municipal authorities at the municipal/local level to ensure political support to make informed decisions by considering different options leading to the feasibility of investing in wastewater management options.

4. Need for a Paradigm Shift

While the world at large is embarking on achieving the 2030 Sustainable Development Agenda in an era of urbanization, higher living standards and economic growth, the challenge of large volumes of untreated wastewater still prevails as more than 80% of the world's wastewater is released to the environment without treatment (WWAP 2017). Pollution from untreated wastewater continues to affect human and environmental health adversely.

As an essential component of a circular economy, recovering energy, nutrients, and water from wastewater can generate new business opportunities while improving sanitation services (Otoo and Drechsel 2018). Following comprehensive analysis of the trade-offs of safely managed wastewater or lack of it, the costs of improved wastewater management are expected to outweigh by the benefits through gains in human and environmental health as well as recovery of energy, nutrients, and water.

There is a need for a paradigm shift to promote safely managed wastewater. Considering the acute problem of freshwater scarcity and emerging problem of water quality deterioration amid changing climate, the implementation of research-based options for wastewater treatment and use, supported by pertinent institutions and policy level interventions and skilled human resources, offers great promise for environment and health protection as well as livelihoods resilience. This has greater importance in areas where untreated or inadequately treated wastewater is used for irrigation and such irrigation is expected to increase in the foreseeable future. Also, this is equally important in an era when recovering water from the wastewater for use in agriculture and other sectors as well as recovering nutrients, energy, carbon credit, and precious metals are multiple revenue streams that enhance the economic value of wastewater and can increase cost recovery and even lead to innovative business opportunities.

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