Chapter 14
Transforming Urban Wastewater into an Economic Asset: Opportunities and Challenges

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Abstract We conclude the book with a reflection on the potential of urbanization to catalyze the recovery and use of water, nutrients and energy from wastewater, with a particular emphasis on low-income countries. We recall the charge set forth in the introduction and we reflect on the 'take home messages' in each of the chapters. Our goal is to summarize the challenges, requirements and research gaps we must address to make wastewater an asset and to continue promoting innovative business thinking in the water and sanitation sector.

Keywords Economics · Water reuse · Markets · Urbanization · Wastewater business

14.1 Urbanization and Resource Recovery

The resources embedded in the municipal wastewater generated annually across the globe could theoretically irrigate and fertilize millions of hectares of crop land and produce energy for millions of households. However, only a small portion of these waters is currently treated, and the portion which is safely reused is very small

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compared to the scale of the water scarcity discussion. This apparent disconnect is due largely to social, institutional and economic issues, including regional gaps in wastewater collection and treatment capacities, social resistance against reuse, and poor business planning, leading to limited expectations of cost recovery.

However, global change, and in particular those developments which are changing resource flows and allocations, such as urbanization, are generating significant demand for food, water and energy, often more than what is easily available, thus providing new opportunities for transforming the resources embedded in wastewater into valuable assets. Planning for resource recovery and reuse is gaining momentum in water policy and urban development circles, as reuse oriented investment strategies offer notable potential for supporting to different degrees various development goals, including poverty reduction, food security, achieving sustainable agriculture, improving potable water supplies, resource conservation, sustainable energy, and climate change adaptation. Resource recovery and reuse can thus fit well within a Green Economy or any climate change adaptation strategies.

Water scarcity and water competition will be strong factors in this context, but growing cities often face also practical challenges in developing water resources to meet their citizens' needs. For example, there may be insufficient space for reservoirs, or challenges involved in laying pipelines to transport water to new suburbs. In these circumstances, additional supply from indirect potable reuse may be necessary, even if scarcity is not strictly an issue (GWI 2009).

Increasing urbanization and wastewater generation also brings new responsibilities, given the high risk of pollution and the imperative to safeguard public health and ecosystems. Thus, safety is a primary requirement of any resource recovery program, especially in the challenged peri-urban interface, which still receives in many countries large amounts of untreated urban return flows. Well managed urbanization can lead reuse-oriented water systems, yet care is needed to safeguard public health and sustain ecosystem services at the rural-urban frontier.

Opportunities for investing in reuse are particularly notable where urban and peri-urban agriculture creates demand for nutrients and water derived from solid and liquid waste. In many low-income countries, the informal sector is responsive to these opportunities, and while significant in size, the sector is weak in compliance with safety requirements where most of the recovered resources derive from untreated wastewater. The challenge is thus twofold: (1) to introduce safety into existing (informal) reuse activities, and (2) to move beyond the technical possibilities of the informal sector to enhance the value proposition, by involving more customer segments and revenue streams, following the successful examples of water, nutrient and energy recovery from wastewater as reported in Chaps. 11, 12 and 13, and in USEPA (2012) and Lazarova et al. (2013).

Resource recovery and reuse are increasingly attractive alternatives for enhancing urban water supply, given the high costs of alternatives, such as inter-basin transfers and new water storage projects. In addition, environmental concerns related to marine outfalls and landfills for sludge disposal, and increasing interest in sustaining ecosystem services, such as water purification and nutrient cycling (Reid et al. 2005), also motivate investments in resource recovery and reuse.

Governments and the private sector are beginning to realize the advantages of the "double value proposition", by which wastewater treatment generates both environmental and financial values (GWI 2009). Significant cost savings and potential revenue streams can be generated by reclaiming water for potable or industrial purposes. There are increasing opportunities also for large scale phosphorous and nitrogen recovery, and opportunities for in-house generation of the energy the wastewater treatment process needs. These and other examples, such as transforming wastewater or sludge into biomass, feed or high value protein, offer new business opportunities, which in turn can create new incentives for sanitation service delivery.

To go to scale and explore larger markets, reuse investors must look beyond traditional urban boundaries and support linkages between the sanitation, water supply, energy, landscaping and agricultural sectors. Much of the phosphorus used in agriculture today is discharged to rivers or aquifers, and eventually reaches the ocean floor. Incentives are needed to support phosphorous recovery from wastewater before a global shortage of phosphorus leads to much higher prices of fertilizer, with negative consequences for food production and livelihoods in poor countries. Waiting for phosphorus recovery technologies to become price competitive will be counter-productive from political, social, and market perspectives.

Building on the double value proposition requires innovative financing solutions and partnerships based on sound planning and business models for opening new markets, and promoting investments in services and technologies. To this end, wastewater use can be one important component of a larger resource recovery and reuse strategy which considers beyond financial aspects all economic and social benefits of treatment and reuse, and the business and market opportunities that reuse solutions offer. Opening the waste and sanitation sector to opportunities beyond safeguarding public health could facilitate a paradigm shift towards other business models in this sector than 'the municipality pays'.

14.2 Opportunities and Challenges to Reuse Solutions

Resource recovery and reuse solutions offer diverse economic opportunities, ranging from informal agricultural production to formal reuse of treated wastewater. Successful programs can support livelihoods and generate considerable value to regional economies. In many cases, cost savings is the primary goal of resource recovery, catalyzing for example on-site energy recovery for wastewater treatment, or phosphorous recovery before it precipitates where it is not accessible or wanted. In other cases, cost recovery motivates reuse, extending the reuse proposition to larger markets to break-even on operational and maintenance costs, or even to pay back the capital investment. However, there are also several challenges that resource recovery and reuse programs must address.

Challenge 1: Safety The primary challenge in promoting reuse is the imperative of ensuring safety—safeguarding human health and protecting the environment. Wastewater use in agriculture and other economic activities offers notable economic and social benefits, but also poses health and environmental risks, particularly where operational capacities and treatment levels are inappropriate and safety guidelines are ignored.

Safeguarding public health Advanced treatment technologies, such as membrane filtration, are increasingly popular and effective in removing pathogens and other pollutants to allow a large variety of reuse options. However, these technologies must match their environment, and must fit within the institutional capacity to maintain treatment standards. Often many treatment plants in developing countries have little effective impact, given the small percentage of collected wastewater. Many plants are poorly maintained and hardly performing as planned. Thus, the high investment, operation and maintenance costs of these technologies can limit their use in many low income settings. In these situations the use of low-cost technologies and alternative safety measures can be cost-effective and competitive in terms of safeguarding public health with about US$ 5 returns per dollar invested (see Chap. 3), although the range of reuse options will be limited. Where set standards are too stringent and enforcement capacities weak, there is a high risk that the informal reuse sector will continue business as usual.

Protecting the environment Environmental (and health) risks resulting from the disposal of treatment by-products, or the use of inadequately treated wastewater vary with the origin and type of the wastewater, the receiving water body and aridity. Thus treatment options to protect the environment against any combination of risk factors should be case specific. Depending on the location the risks can derive from toxic metals and metalloids above maximum allowable concentrations; excess nutrients causing nitrate pollution and water quality deterioration; salts or micropollutants such as residues from pharmaceuticals and personal care products, which can affect aquatic life. Only for some of these hazards, low-cost options based on biological processes are available, but additional data and further studies are needed to determine their long-term impact under increasing wastewater flows.

Challenge 2: Socio-economic Dimensions The second challenge pertains to social and cultural acceptability of wastewater and fecal sludge use. Stakeholder participation and trust building at the earliest stages of a reuse project are crucial. Public acceptance of water reuse is more likely in locations facing water scarcity, when wastewater is sufficiently treated, and positively branded. However, these criteria are not always sufficient reasons for the acceptance of reuse, especially when there are alternatives. Social, institutional and economic factors also play important roles in moving from informal to formal reuse, in understanding financial and social marketing options, and supporting the development of culturally acceptable and locally feasible guidelines and regulations. In many instances, gender dimensions of reuse also must be accounted for. These can include exposure and health risks as well as income opportunities, especially in peri-urban areas characterized by male out-migration.

Challenge 3: Appropriate Policies and Supportive Institutions for Motivating Reuse The third challenge is designing supportive public policy and building institutional capacities for the uptake of reuse solutions across scales. With increasing awareness for resource recovery, policy issues appear fairly straight forward in developed countries where public agencies determine water quality criteria and implement treatment protocols. However, the regulating and facilitating dimensions of reuse protocols differ. In many cases regulations do not match the available reuse options (Huibers et al. 2010) and can be stricter than necessary, even from a public health perspective (Mara et al. 2010). This increases treatment costs, while reducing the cost-competitiveness of resource recovery. An example is the application of stricter rules regarding the purity of recovered struvite than for mined rock-phosphate (Chap. 13).

Policy issues are generally more challenging in developing countries where waste collection, treatment, and disposal often are overwhelming tasks that absorb all available capacity, making resource recovery and reuse a secondary or future target. However, it is in this situation where regulatory capacities are often weak, and informal use of usually untreated wastewater is common. To minimize possible health risks, policies must support pathways and incentive mechanisms for interventions that should build on the long term strategy of achieving comprehensive wastewater collection and treatment, and also target risk awareness, safer irrigation practices by farmers, and increased food hygiene by consumers and communities.

Effective institutions and financial instruments also are needed to encourage safe reuse. These include guidelines for resource recovery, covering technical options and possible business models, operational manuals on health risk reduction, such as the WHO supported Sanitation Safety Planning Manual, social, financial and economic incentives for increasing reuse, and also compliance with safety measures, technical assistance, certification programs for reuse businesses, insurance packages covering personal and business risks, and public awareness regarding social benefits of reuse solutions across activities and scales. Most existing regulations and institutional frameworks cover only parts of this spectrum, and are often more restricting than facilitating or miss whole waste streams, like septage. A confounding institutional challenge relates to water governance with responsibilities for water supply, wastewater treatment and reuse spread over different entities. In Ghana, for example, even wastewater treatment is regulated by different ministries depending on the ownership of the facility serving e.g. a hospital, university or military camp (Murray and Drechsel 2011).

Challenge 4: Financing Reuse Solutions Most reuse solutions have public good dimensions and generate both private and (long-term) public benefits. The investment cost is substantial and must be financed by the enterprise promoting safe reuse. The financial costs are usually higher than financial benefits. Thus the economic benefits for environment and society must be assessed and budgeted. This is particularly important where wastewater must be priced attractively to encourage reuse and uptake. Such reuse models will struggle to achieve financial sustainability given the common low fresh water prices.

Economic analysis is helpful in understanding the wider benefits of reuse, which include the cost savings obtained, in comparison with alternative options for reducing water stress. Opportunities for generating revenue include the sale of nutrients and energy recovered from wastewater. The rising price of energy, and the increasing demand for plant nutrients in agriculture, over time, will enhance the profitability of businesses engaging in recovery and reuse. In the near term, public support for new firms will be needed to encourage new entrants to enter the wastewater recovery and reuse sector. Such support might be offered as low-interest loans for the initial investment costs, incentives that promote technology transfer, carbon credits, or cost-sharing arrangements in the context of public-private partnerships.

Challenge 5: Innovations and Future Markets Most water reuse projects can build on well-known wastewater treatment technologies. The situation is more dynamic in the domain of nutrient and energy recovery, where several innovations have appeared in recent years. New methods are available for recovering phosphorus from wastewater and for transforming dried and co-composted septage into pelletized fertilizer at low cost. Some of these technologies are not yet cost-competitive across scales. The same challenge applies to the upgrading of biogas to bio-methane, or the mechanized bioconversion of sludge to protein (e.g., for animal feed). Innovations will play a significant role in advancing resource recovery and reuse, especially in emerging markets.

The capital and operational costs of many appropriate technologies will be affordable in future, particularly as adoption becomes widespread. One example is the technology for treating water for use in irrigation. Agriculture might not generate the highest returns per m^3 but the sector can absorb significant amounts of water, generating additional benefits through such mechanisms as water trading. Other low-cost innovations, such as pond-based treatment systems, combined with the production of fish feed from duckweed, are sufficiently profitable to recover their capital investment. Where higher quality standards are required, water users (and not treatment providers) can undertake further treatment through their own investments on-site by using more advanced or more reuse-targeted technologies. Perhaps business thinking in itself is the most promising innovation in the sanitation sector, where enterprises can leap over potential challenges through innovative private-public partnerships for reaching larger markets and obtaining affordable finance. For instance, biogas upgrade projects are economically viable and enjoy substantial market demand, yet bottling remains at the experimental stage. Greater uptake by industry is needed to achieve economies of scale.

A particular example is phosphorous, recovered as struvite. A viable market for struvite use in agriculture might develop in future when the price of rock-phosphate rises substantially, due to increasing scarcity, making struvite production cost-competitive. Yet it might be wise for developing countries to begin investing in struvite production and marketing in the near term, rather than waiting for rock-phosphate prices to rise. If the price rise is abrupt, developing countries might be caught in a costly transition period in which the price of phosphorus becomes unaffordably high, while the national struvite production capacity is not yet sufficient to sustain successful agriculture and prevent a food crisis. Given the inherent uncertainty regarding precisely when the global supply of rock-phosphate will become limiting, it is not likely that many developing countries will invest on their own in struvite production and marketing. Yet support for such a program from international donors or corporate sponsors, to create for example national phosphorous depots from recovered struvite, might be very welcome and well timed.

Challenge 6: Methodological Issues Recovery and reuse solutions involve cross-cutting issues that transcend administrative, and disciplinary boundaries. Many reuse projects involve issues pertaining to economics, finance, sociology, health, the environment, engineering, water, energy, food, and plant nutrition. Developing a methodological framework reflecting these perspectives in a matrix of indicators that could serve policy makers is challenging. In addition to the financial costs and benefits, the social and environmental externalities of reuse projects have seldom been quantified, although an increasing number of tool kits and resources are available (see Chap. 7).

Despite significant advances in the development and application of environmental valuation techniques, some costs and benefits remain difficult to estimate empirically. Yet, in many cases, it is helpful to acknowledge the importance of indirect costs, externalities, and the public good aspects of recovery and reuse programs, with the goal of achieving a socially optimal level of investment. Some portion of that investment will continue to come from public sources in the near term, but we envision greater participation by private firms in future, as further research identifies a larger set of potentially viable business models.

14.3 Outlook

Our excitement in presenting this book builds largely from the opportunity to support business thinking in a sector that traditionally has relied on public funding, and to encourage the development of effective business models addressing resource recovery and reuse. We believe the private sector, supported by continued applied research and supportive policies and institutions, can spur the achievement of national and international sanitation and reuse targets within a reasonable time horizon, to the benefit of millions of households.

Finance will be the key to the reuse sector which has too long been driven by regulations rather than economic opportunities. The potential to reclaim wastewater for high value applications can create new revenue streams. GWI (2009, 2014) predicted that the municipal reuse market is on the verge of major expansion, especially towards higher value applications with a 2011–2030 growth rate of +271 %. The increasing pressure on natural freshwater resources will however be strongest from the agricultural sector, which can only be met through greater water usage. Over-exploitation of surface and groundwater resources is likely to be affecting millions of people by 2030 (GWI 2014), especially in peri-urban areas where 'treatment for reuse' as well as water swaps could become popular mitigation options for balancing urban and rural water stress.

Verifiable targets are needed to encourage reuse at scale also in view of the Sustainable Development Goals (OWG 2014). There is need for better data collection programs to support the assessment of resource recovery and to develop information for designing culturally acceptable reuse options. More research is needed also, regarding the impacts and cost-effectiveness of risk mitigation options and methods for promoting their adoption under different environmental, social, and economic conditions, particularly in peri-urban areas of low-income countries. Investments in resource recovery and reuse programs generally will enhance efforts to achieve food and nutritional security, alleviate water scarcity, and improve the reliability of energy supply, while helping to reduce urban-rural tension. The market for water and energy recovery from wastewater should become quite lively within the not-too-distant future.

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