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Challenging Conventional Approaches to Managing Wastewater Use in Agriculture

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Abstract

In developing countries urban wastewater management often fails to cope with increasing wastewater generation. Financial, technical and institutional limitations force authorities to discharge substantial amounts of untreated or partially treated wastewater into surface waters. Consequently, uncontrolled use of polluted water is increasingly common in the downstream peri-urban areas. Although wastewater use bears a significant risk on human health, such use is also productive and an asset for many. Agricultural use of wastewater is a strong manifestation of the urban–rural connection and transfers a waterborne risk from the wastewater disposal system to the food chain, requiring a paradigm shift in the approaches applied to risk minimization. Conventional models for urban wastewater treatment and management are based on top-down, technically driven approaches that do not, or do not sufficiently, consider the links between the social, economic and health aspects. This situation is understandable from historical and technological points of view, but does not provide innovative solutions to current problems in developing-country cities. A different approach is required, one that rethinks conventional wastewater system design and management. By adopting a systems approach to analysing both the water and food chains, one discovers the interactions of different stakeholders that treat and use (or abuse) water, the impacts on overall productivity and the risks. Governance systems to manage wastewater use in agriculture must

incorporate decentralization to accommodate thinking at the bottom layer, encourage stakeholder engagement and provide coordination and policy cohesion for managing risks jointly from both the water and food chains.

INTRODUCTION

In developing countries, population growth, urbanization and economic development result in ever increasing wastewater flows exceeding present capacities of management, treatment and proper handling. Many cities, in developing countries, are growing at unprecedented rates (4–8 per cent annually), outpacing the ability of city managers to cope (Davis, 2006); despite billions invested in improved wastewater management, Ujang and Henze (2006) argue that 95 per cent of wastewater generated enters the environment with no proper treatment.

Worldwide, pollution of surface water close to cities, with impacts extending to downstream agricultural areas, is evident (Raschid-Sally and Jayakody, 2008; Scott et al., 2004). This has resulted in more than 10 per cent of the world's population consuming food that is irrigated with wastewater of varying quality (WHO, 2006). Agricultural use of urban wastewater and polluted water more generally represents a challenge not only because poor water quality has environmental consequences, but also because it is linked directly to the food chain. This situation is likely to persist into the future (see Chapter 1) and will undoubtedly expand to new areas experiencing urban growth. For better health protection, it is imperative to simultaneously address health risks associated with both water pollution and food contamination. In fact, this is our interpretation of how best to apply, in the contexts of developing countries, the 2006 World Health Organization (WHO) Guidelines for the safe use of wastewater in agriculture.

Research compiled by the UN has concluded that the conventional model of collection, treatment and discharge of wastewater often fails due to high costs and low capacity to pay, problems associated with governance and overemphasis on technologically driven processes (UN-Habitat, 2006; Chapter 15 in this volume). Such technology-driven, centralized or decentralized systems aim at quality levels acceptable to protect the natural environment. This implies that developed-country standards are often applied in developing countries whether or not there exists the capacity, both financial and institutional, to manage systems to meet these standards. While the new WHO Guidelines for the safe use of wastewater in agriculture provide the opportunity to tailor standards to local requirements, existing institutional arrangements in developing countries have problems accommodating them. Furthermore, few wastewater-management systems consider agricultural effluent use from the perspective of water and nutrient resource recovery, an essential point when addressing environmental and economic feasibility. Our paper presents and discusses an alternative paradigm to respond to this problem.

We hypothesize that conventional models of wastewater management do not work as they insufficiently take into account the downstream users of wastewater and do not appropriately value the social, economic and health implications of wastewater flows. For this reason, decentralized water services such as closed-loop, source separation and other ecological sanitation techniques may have a better chance of success, because they rely on principles of integration, prevention and resource recovery, rather than treatment and disposal.

It is indicative to note that the Australian Senate has taken a stand that in replacing ageing urban infrastructure, more serious consideration must be given to decentralized forms of service provision particularly linked to water recycling (Stenekes et al., 2006).

Using a water-chain approach (Figure 14.1) based on systems management principles helps to define which upstream and downstream issues are at stake and how they are linked, enabling identification of the way in which responsibilities are distributed to various stakeholders. The purpose of conceptualizing water and wastewater using a systems approach is to allow the succession of events to be addressed, from where water is accessed (the source) through the various uses (and reuses), to where it is disposed of, which is usually the environment. Thus, we contend that such an analytical approach can improve management through allowing users to optimize the ways that the resource should be managed (see below). Such a management strategy seeks not only to improve water quality through sustainable waste treatment, but also responds to user requirements for water and nutrients.

Following a water-chain approach also shows how pollution can affect the food that humans consume. Understanding the parallel food chain along the various contamination pathways that exist from the farm through the various transportation and marketing chains to the consumer would help to facilitate the simultaneous improvement of water quality and food quality (see Chapter 12). Risk reduction through applying the multiple-barrier approach advocated by the WHO implies that interventions could be made partly along the water chain and partly along the food chain in order to achieve cumulative risk reduction. Thus, risk management would apply a combination of safer irrigation and agricultural practices and post-harvest food-safety measures, which require different institutional arrangements to those currently existing in most countries. Safe and acceptable wastewater use would require stakeholder engagement – this has been clearly shown even in developed countries, where stakeholder participation has been known to make or break a project (Keremane and McKay, 2007; Nancarrow et al., 2008; Stenekes et al., 2006; Tsagarakis and Georgantzís, 2003).

Accounting for all of the above, it is argued here that for developing countries a new paradigm for wastewater governance, that accommodates agricultural use, should be based on four fundamental precepts (discussed in subsequent sections of this chapter):

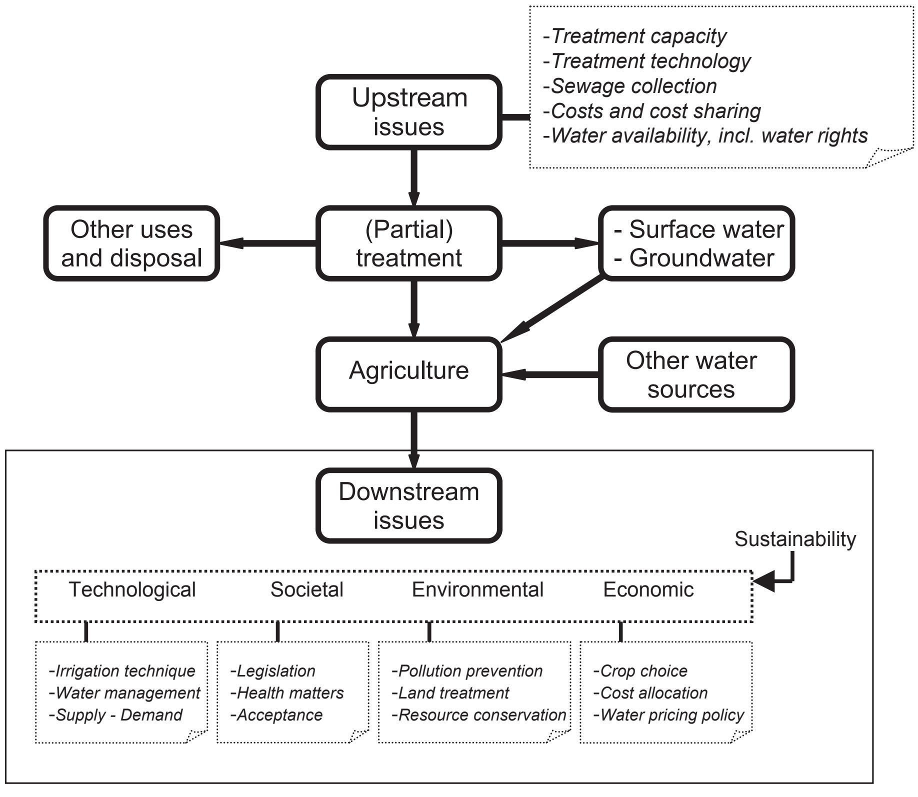

Figure 14.1 *The water chain: conceptual framework showing upstream-downstream links*

Source: Modified from Huibers and Raschid-Sally (2005)

- the use of the (reverse) water-chain approach to design wastewater systems;
- decentralization of wastewater management services and systems;
- policy coherence and coordination for linking sectors, attributes and costs;
- stakeholder involvement going beyond acceptance to involvement in decisions.

To effect this paradigm change, new institutional arrangements, including better coordination and collaboration, will be needed. This requires analysing existing institutions (both formal and informal) for wastewater management and food safety. Since much of the wastewater use takes place within urban and peri-urban areas, a review of the organizations for agriculture and urban planning will be required as well as a clear understanding of the balance of power, gaps, overlaps and ambiguities within all these sectors.

THE REVERSE WATER-CHAIN DESIGN APPROACH

Huibers and van Lier (2005), and Huibers and Raschid-Sally (2005) suggest that a water-chain approach to link upstream and downstream needs and issues is a helpful platform for negotiating and distributing responsibilities of various stakeholders along the chain. Despite problems with existing governance arrangements for wastewater, there is a considerable benefit to linking the use of wastewater to the way it is handled upstream. We further suggest that for sustainability, one has to go beyond simply the wastewater chain and establish the links with the food-contamination chain as these two are intimately linked via agricultural use. In both chains, there is a series of stakeholders that in their actions use the water and influence the quality (positively or negatively) of the water or food product. In order to support decision-making and to develop best management practices, it is useful to understand the links and relationships between stakeholders and the processes they are involved in.

In the conventional wastewater system, design and management are basically top-down. Farmers are passive receivers of polluted water and are often both poorly informed on the composition of the water and left out of decisions and negotiation within the system. They consequently have no say in how the wastewater is handled. The reverse water-chain approach implies that end-users can express their preferences on volumes and quality as they relate to intended use, costs and benefits. This way, wastewater is considered a resource rather than a waste product.

A key element of this approach is flexibility. Centralized approaches are often highly rigid and are designed with little regard to the particular context. Policy frameworks frequently specify end-of-pipe quality requirements, without always considering end use. Flexibility would allow for more local government discretion in standards applied to the use of wastewater for different crops now and those envisaged in the future.

In concept, the water chain resembles a production chain comprising numerous actors. Supply-chain management theories suggest optimizing the management of a production chain by coordinating the actions of the independent actors in a unified whole (Peterson et al., 2001). Supply-chain management has the following characteristics:

- It is a systems approach that views the supply chain as a whole and manages the flow of goods from the supplier to the ultimate customer.
- It stimulates strategic choices of two or more organizations in a production process to join efforts that realize optimal use of resources and converge in generating a product.
- It has a customer focus to create unique and individualized sources of customer value, leading to customer satisfaction.

Peterson et al. (2001) describe the relationships between the different stakeholders of a supply chain and their strategic options. At one end, stakeholders can position themselves as spot market buyers or sellers in which they act independently of other stakeholders within the supply chain. The other end is described as vertical integration where stakeholders recognize a common benefit when they cooperate within the supply chain to deliver a satisfactory good to the end recipient. The continuum moves from a low to a high intensity of coordination and control. Mutual trust is necessary to increase cooperation between agencies when a shared goal is pursued (Mentzer et al., 2001).

Evers et al. (2008) suggest that, when applied to the wastewater generation and effluent use process, these principles allow consideration of the system and the governance requirements from a different perspective. In applying these principles to a case study of peri-urban use of polluted water for agriculture in Hanoi, Vietnam, one concludes that Hanoi typifies the situation in many developing cities where spontaneous use of wastewater takes place within a management system in which each actor acts in a spot market with very few linkages to the other actors (Box 14.1).

Users of an urban wastewater source should be identified in relation to their intended use and conditions should be defined for wastewater supply, such as location, storage facilities and quality assurance. This would, in a supply-chain approach, lead to a negotiation process, which includes contribution to costs by the different stakeholders. In such a system the notion of wastewater swaps can be accommodated more easily, leading to more integrated water management.

An integrated approach also creates new flexibilities, as specific problems possibly can be solved in different ways and/or at different places in the chain, either in technical design or in the envisaged operation of the system (Huibers and van Lier, 2008). At its core, the design process requires the adoption of downstream user perspectives in order to be effective. Incorporating user perspectives in wastewater management matches recent trends in service delivery to enhance the power of service recipients in other domains. For instance, citizen report cards are used in Bangalore, India, to monitor service quality, while participatory budgeting is being used in several cities as a way to manage investments (World Bank, 2004). Such examples only work where there is political will for their adoption.

Moreover, the reverse water-chain approach should be accompanied by appropriate cost-recovery mechanisms. For example, if users are to determine, design and work with local authorities on the appropriate ways to harness the wastewater, the responsible authorities (whether the utility or the local government) must be empowered by the central government to develop ways to capture revenue from those using wastewater and benefiting from these services. Without such an accommodation, user-centric design has little hope of being sustainable.

BOX 14.1 HANOI PERI-URBAN USE OF WASTEWATER FOR AGRICULTURE

Hanoi is the capital and second largest city of Vietnam, with a population of over 3 million. An important driving force behind this urbanization process was the reopening of Vietnam to the world economy in the late 1980s. This reform, locally referred to as '*doi moi*', reduced the role of the state and opened up the Vietnamese economy to foreign capital. However, the state still plays a key role through a four-level governmental structure (state, municipal, district and communal). Each level has its own 'people's committee'. Institutions at lower levels have to refer their problems to higher levels which then give decisions downwards for implementation. This is a time-consuming process. Luan and Minh (2005) note that the system lacks synchronized coordination between, on the one hand, agencies that make decisions (higher level departments) and, on the other, agencies that are responsible for implementation (lower level departments). There is also a spatial separation on governance responsibilities of different departments in the so-called urban districts and the peri-urban districts of Hanoi municipality respectively. In addition, responsibilities concerning the water and food chains are divided among different departments (Evers, 2006).

Most urban residents of Hanoi have a flush toilet with a connection to the sewerage system where wastewater drains into water bodies within and around the city. A minority has functioning septic tanks from which the effluent (septic) is discharged into sewer lines and semi-open drainage canals. There is no other treatment of wastewater; therefore Hanoi has serious pollution of its ponds, lakes and rivers that serve agriculture. With regard to wastewater management, responsibilities are scattered among different departments: no department is fully responsible for urban wastewater management (see also Raschid-Sally et al., 2004).

Though the physical reality is that agriculture and urban wastewater are linked, the institutional reality is that they are strictly separated. Agriculture and irrigation officials acknowledge the existence of a physical wastewater chain when they are confronted with it. However, when asked directly if wastewater is used for irrigation most of them say no. This is understandable as in their view the river is the source of irrigation water. That this river water is in fact often diluted wastewater is usually not realized or fitting their institutional accountability. Department officials in Hanoi hardly knew about the policies and responsibilities of other departments that are recognized as stakeholders of urban wastewater management and agriculture (Luan and Minh, 2005). Farmers were also hardly able to name the responsible authorities of the urban wastewater chain.

DECENTRALIZATION OF WASTEWATER SERVICE PROVISION

Much of the argument in favour of decentralization in the management of wastewater stems from the evidence that:

- Centralized systems in developing cities are prone to mismanagement and malfunctioning, leading to eventual breakdown.

- Centralized conveyance and treatment are very expensive (UN-Habitat, 2006; World Bank, 2004).
- It is very difficult to provide adequate sanitation infrastructure and administrative coverage to peri-urban areas of developing cities due to their rapid expansion (UN-Habitat, 2006).

Above and beyond these arguments, a policy to maximize agricultural use of wastewater would further favour decentralized systems. While in a conventional design of a wastewater treatment plant its location is based on its (topographical) position vis-à-vis the wastewater producers (generally the lowest possible position is chosen to guarantee maximum gravitational inflow), its optimal location in an effluent use perspective would be at a higher level to maximize the irrigation command area downstream of the treatment plant. It can consequently be expected that optimum use of irrigable area would lead to the decision to site decentralized systems. This would also allow selection of locations best suited to control the wastewater inflow qualities and to exclude toxic-waste streams in the sewerage.

Small towns and peri-urban areas are often excluded from centralized services due to decreasing cost-efficiency and reasons of administrative/fiscal boundary. At the same time they are sufficiently 'rural' to accommodate or support agricultural activities. It is here that decentralized service provision that allows for water and nutrient resource recovery can have the maximum impact.

There have been numerous pilot efforts to decentralize the physical infrastructure for wastewater, often with the objective of increasing water recovery (Bakir, 2001; Brooks, 2002; Choguill, 1999). Collective biological treatment systems, household wastewater treatment, constructed wetlands and even larger systems such as waste stabilization ponds are low-tech solutions that offer promise, both from the standpoint of improved water quality and, eventually, reduced health risks for food. In relative terms, these systems are quite simple in design and function; as a result they present operational, financial and managerial advantages.

The 1990s saw a rapid increase in proponents of decentralization of management and operational responsibility and power to lower-level authorities. The main consideration was to increase the responsiveness of these authorities and 'democratize' governance by increasing public participation (Tannerfeldt and Ljung, 2006). A well planned and executed decentralization policy can provide a less expensive and better service, and improve water quality in the long term. There is broad agreement that decentralization is good practice (e.g. Bahri, 1999; Coombes and Kuczera, 2003; Maher, 2003). Argentina and Chile have had qualified successes by delegating some operations and management to user associations and the private sector. In Mexico, irrigation systems managed by user associations have increased cost recovery from 30 per cent to 80 per cent (Litvack and Seddon, 1999). In Ghana, the Community Water and Sanitation Project allows communities to own and operate their own water and sanitation systems. According to the agency responsible for the project, 78 per cent of the target groups respond that their water services have improved (Agodzo and Huibers, 2002) while most decentralised wastewater treatment facilities fell into disrepair. There are also other examples where decentralization of service provision has not been accompanied by appropriate capacity-building, budgeting or fiscal reforms that allow for local tariff setting and tax revenue collection (Tannerfeldt and Ljung, 2006).

There is often confusion about who is responsible and who pays for those services (World Bank, 2004). In some cases, municipal authorities have been delegated responsibility without the capacity to manage or legal ability to generate revenue. This has often led to a collapse in trust between local authorities and their constituents and a lack of accountability. One way to mitigate this problem is to enhance citizen engagement in decision-making in the context of decentralization (Pahl-Wostl, 2005). For instance, participatory budgeting, which is being practised in a growing number of cities, allows for a level of citizen decision-making over service delivery. Other solutions can be found in better policy coordination between the different levels of government at national, state and local levels.

Policy coherence and coordination for linking sectors, attributes and costs

Given these broad challenges, for user-centric wastewater management to be effective a necessary first step is to provide the appropriate legal backing for local governments to manage services such as wastewater provision. This would replace the driving force of current policy (based on health fears) with a more rational approach to how risks can be minimized and wastewater user benefits amplified. By negotiating the conditions of wastewater use, a change is possible in how project financing and costs are allocated.

Segregated budgets that allocate financing for specific projects are an important tool as opposed to trying to fund multiple activities with a common pool of funding (the latter option being open to political manipulation and ad hoc spending). Such an arrangement would allow utilities to collect fees from different polluters and end-users for the specific purpose of covering costs for services provided. The ‘polluter pays’ principle is widely accepted in most OECD countries, for example in Brussels, where 30 per cent of the costs of services are paid for through pollution charges associated with waste (OECD, 1998). Mexico charges for wastewater discharge permits that are effective in raising revenue to cover service costs (Bruns et al., 2005). Other mechanisms, such as the widely used increasing block tariff, encourage progressive financing where there are different cost-recovery mechanisms for high-income domestic households producing large amounts of wastewater versus low-income, or for large-scale industry versus small-scale commercial. In Tunisia, reclaimed water is currently used on 8000ha to irrigate vineyards, citrus and other fruit trees (olives, peaches, pears, apples and pomegranates), fodder crops (alfalfa, sorghum and berseem) and cereals. The regulations allow the use of secondary treated effluent for specific crops and the regional agricultural departments supervise the water reuse decree and collection of charges. Farmers pay about \$0.01 per m^3 for the reclaimed water irrigation. In Drarga, Morocco, a public participation programme led to the development of an institutional partnership between the local water-management stakeholders, the urban water users and the farmers' water-user group (USEPA/USAID, 2004). To increase sustainability of the new facilities, an additional fee for domestic water supply was levied and other cost-recovery mechanisms were under consideration.

Another challenge for user-centred wastewater management is that due to its sensitive nature and its status as a public good, water is most often legislated at the national level in terms of planning and rights, while municipal and public utilities are left to operate infrastructure services and carry out local planning. Two governance prerequisites are needed if the 2006 WHO Guidelines are to be implemented effectively. First is the immediate need to coordinate vertically between levels of government and horizontally across sectors, and second to link water quality with food quality.

Many national governments have created a multitude of institutions with different roles and responsibilities related to water and they often lack effective coordination (UN-Habitat, 2006). At the national level, ministries responsible for water, agriculture, environment, natural resources, urban development and health usually have some responsibility for water. National agencies (with varying degrees of separation from the government) will sometimes be charged with coordinating legislation, planning and management of the resource. To complicate things further, the administration of basic services is often divided amongst three levels of government: national, state (or provincial) and local (or municipal). An independent regulatory authority is often charged with ensuring appropriate pricing and compliance with environmental standards. This complex chain of actors might work well when properly funded and with access to the necessary expertise; however, in practice these conditions are rarely met. In such situations a first-level solution would be to set up a coordination body amongst responsible institutions which links across levels and sectors (agriculture, public health, urban water and sanitation, environment, economy, etc.).

Historically, the agriculture and sanitation sectors were always separate. This reflects the dichotomy between urban (wastewater disposal) and rural (agriculture) practices and management domains. In the new paradigm, governance for drinking water and sanitation must better coordinate with governance for agriculture; it is imperative to understand what incentives are needed for this partnership to work. As an example, the urban–rural link can also be epitomized in wastewater swaps, where water diverted from agriculture for urban use is returned to agriculture as wastewater (Scott et al., 2007). Such a system requires an appropriate legal and management framework that would facilitate negotiation between different user groups.

Integrated approaches are sometimes discouraged because regulatory responsibility for water management can be contradictory or split across different agencies. These agencies sometimes even work at cross-purposes from one another. With the multiple-barrier approach advocated by the WHO (2006) for wastewater use in agriculture, there is the further need to establish a bridge between water quality and food safety. Two different sets of institutions are thus involved. Water quality may be the prerogative of the environmental authority or the water authority or even sometimes the irrigation authority. Food quality is the responsibility of the public-health authorities, who may not necessarily be reporting to the ministry of health but rather to a local authority if there has been devolution of power.

At the national level there is a need for ministries and agencies responsible for agriculture, urban development, water, health and environment to accept that wastewater and pollution management require a cross-sectoral approach. However, it is also critical that vertical cohesion between national, state and municipal levels of governance be developed.

Stakeholder involvement

The pre-existing conditions for a change in paradigm are that a large and diffuse group of stakeholders is involved, and that no single organization or person has the capacity to implement and upscale the 'technology' required for sustainable wastewater use. The stakeholders differ, depending on whether wastewater use is spontaneous or planned, but involve in general: water users, farmers, consumers (of food grown with wastewater), national and local level authorities (responsible for agriculture, irrigation, sanitation, public health and environment), local level planning authorities where the technology will be put in place and various other actors with a stake, depending on the context of adoption.

Increasing recognition of the need for better stakeholder engagement requires that water service providers (water providers, wastewater agencies, irrigation agencies) consider participatory planning, shifting the attention from public acceptance of predetermined technological options towards ways in which that public participation can be successfully institutionalized. Participatory institutions encourage the development of shared values amongst diverse stakeholder groups and lead to innovative solutions for dealing with water management (see Chapter 18).

Examples of efforts to close the accountability gap between citizens and those that make policy are plentiful, with some notable successes. In Porto Alegre, Brazil, participatory budgets have allowed citizens to directly influence spending on services (World Bank, 2004). Such direct influence over how money is spent increases accountability and builds trust between local governments and their citizens. In Ghana, a new initiative by the World Bank involves civil society umbrella organizations in monitoring water and sanitation projects. Specifically the National Coalition of NGOs in Waste Management (NACONWAM) will monitor the Second Urban Environmental Sanitation Project, and the Coalition of NGOs in Water and Sanitation (CONIWAS) will monitor the Urban Water Project. This can be seen as a major step in institutionalizing participation.

Discussion

Surmounting the governance challenges that have so far impeded the effective devolution of wastewater management is a tall order. It will require political will on the part of elected officials and recognition of the inherent value of wastewater as a resource. Not least, it will require serious attention to accountability and ensuring that those using wastewater services are represented in the planning and design phases of solutions. The integration of users in the design and management of wastewater collection, treatment and use is the most effective way to improve accountability of designers and planners. Furthermore, with direct user engagement, planners and engineers would have the information required to develop systems that are far more responsive than current ones.

Good governance of wastewater requires stakeholder engagement at and across all the levels of the wastewater chain, although in practice this can be difficult. Municipalities are often in charge of basic service provision and play an operational role, while water and agriculture often fall under the jurisdiction of the state and various ministries. Consistently, it is the ministry of health that demonstrates the most reluctance to accept 'progressive' standards seeing any relaxation from international guidelines as substandard. This also partly explains the reluctance of national governments to delegate the appropriate authority to lower levels. Given these institutional barriers and the list of failed investments in conventional sanitation, the WHO (2006) suggested global health-based targets but gives countries flexibility in achieving them according to their possibilities and constraints using a step-wise approach (see Chapter 2). This opens the doors for central governments to set clear intermediate goals in order for local solutions to be implemented.

The advantage of using the combined water- and food-chain approach to manage risk is therefore consistent with the 2006 revision to the WHO Guidelines, which allows for progressive improvements in sanitation and risk management in the absence of full treatment. The model of decentralized systems, which presents its own set of challenges particularly in the promise to democratize service delivery, is nevertheless proving itself to be a useful solution in an increasing range of conditions. It should be at the centre of the new paradigm to manage risks to health associated with wastewater use.

Conclusions

The transfer of purely waterborne risks from the wastewater disposal system to the food chain through the use of wastewater in agriculture requires a paradigm shift in how we approach risk. Furthermore, it requires a fundamental rethinking of which viable governance mechanisms can be used to improve risk assessment and management approaches.

The combined water- and food-chain approach that we advocate needs to be accompanied by effective decentralization of financial and operational control as well as technical planning and management. Local governance reform, aid that stipulates clear guidelines associated with its expenditure and budgetary reform that requires increased stakeholder engagement will be needed. Municipalities could thus be seen as enablers and facilitators and not only as implementers.

A further implication is the strong urban–rural linkage that such use establishes, which can be addressed through the application of supply-chain management theories which try to optimize the management of a production chain by coordinating the actions of the independent actors into a unified whole. It follows that policy coherence among different sectors and different levels of government would be a central requirement for better wastewater management.

Planners can use the reverse water-chain approach to identify the intended uses of wastewater followed by better understanding of the needs, opportunities and constraints they face, leading to better engagement of users in improved wastewater management. Recognizing users and the role that they can play in monitoring for effective service delivery and financial accountability paves the way for flexible yet durable institutional frameworks.

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