19

Wastewater Irrigation and Health: Challenges and Outlook for Mitigating Risks in Low-Income Countries

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Abstract

Wastewater irrigation is a widespread and growing phenomenon that carries varying degrees of risk. Whether spontaneously practised in urban and peri-urban agriculture or planned as part of water reuse programmes, food and fodder production using untreated sewage or treated effluent can have serious human health implications for farmers and consumers, and can irreversibly degrade the environment. In low-income countries water pollution is often the result of inadequate wastewater collection and treatment, and unplanned release to receiving water bodies. Making wastewater irrigation safer depends on a location-specific combination of different pathogen barriers including, where possible, appropriate wastewater treatment. Ensuring that these strategies work in an integrated, mutually supportive manner requires a multi-sectoral paradigm shift in the common approach of wastewater management for disposal. Additionally, it is crucial to continue research (especially in developing countries) on the types and severity of risk, locally feasible mitigation options, the cost-effectiveness of safer wastewater irrigation practices compared to other interventions against diarrhoea and facilitating the adoption of 'non-' or 'post-treatment' options. This

concluding chapter presents an outlook for wastewater irrigation by integrating the major findings of the present volume, synthesizing key elements of the current global status and challenges of sanitation and wastewater irrigation with emphasis on the WHO Guidelines. It also highlights wastewater-governance opportunities with the greatest potential to support safe wastewater irrigation that simultaneously address the combined challenges deriving from the global sanitation, water and food crises.

INTRODUCTION

With the water and sanitation crises being main drivers of planned and unplanned wastewater irrigation, respectively, the recent rise in food prices renewed public interest in safe food production in and around cities. All three challenges (water, sanitation and safe food) are increasing as cities grow (Figure 19.1). According to the Comprehensive Assessment of Water Management in Agriculture, urban and peri-urban agriculture suffer most from poor water quality: already today urban farmers must rely on polluted water sources for irrigation in four out of five cities in the developing world (Raschid-Sally and Jayakody, 2008).

Over the past ten years growing interest in understanding untreated wastewater use for irrigation has produced a large array of publications and reports on the livelihood and food-supply benefits. It has also been made abundantly clear that the approach of banning this largely informal practice will not work (Scott et al., 2004). The key challenge is to maximize the benefits of wastewater use while

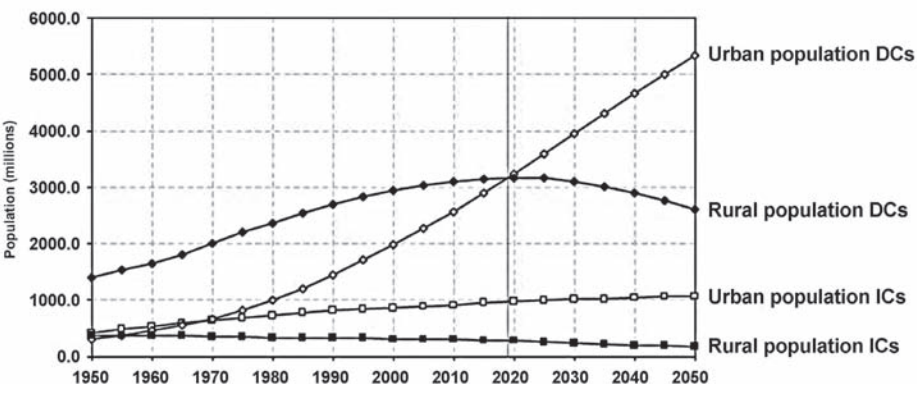

Figure 19.1 *World population from 1950, projected to 2050*

DCs = developing countries; ICs = industrialized countries.

Source: United Nations (2008)

protecting public health and the environment, i.e. making wastewater use safe while enhancing its value as a resource to address physical or economic water shortage (see the 2002 Hyderabad Declaration on Wastewater Use in Agriculture, www.iwmi.cgiar.org/health/wastew/Hyderabad_declaration.htm).

Urban and peri-urban agriculture flourishes in low-income countries as rural migrants move to cities where open plots and waste resources allow them to capitalize on the urban demands for traditional as well as non-traditional cash crops, like irrigated exotic vegetables consumed as salad. These demographic and production shifts on the food-supply side are coupled with the rising purchasing power of the urban middle class and proliferating urban markets on the demand side. The net result is an expansion of health-risk transmission pathways that may ensue from water pollution and wastewater irrigation.

Compared with rural populations, common pathways might differ. While in rural areas, exotic vegetables and raw salads might be unknown and safe drinking water is still a major challenge, the situation can be very different for urban dwellers. Although urban populations might benefit from improved diet and access to water and health care, distress-migration, increased numbers of immuno-compromised individuals (not least as a product of the AIDS pandemic), increasing street-food consumption and rising population densities of urban slum inhabitants without access to adequate sanitation constitute a new set of risk factors, 'hotspots' and possible pathways of epidemics.

The global hotspots for wastewater-irrigation-related health risks, and other health risks linked to inadequate sanitation and waste disposal, are: specifically those countries and regions where wastewater treatment, namely investing in and operating treatment plants, remains beyond the capacity of governments; and where diffuse exposure pathways exist both for wastewater irrigators (urban agriculture labourers) and especially consumers along the food chain. In such situations, it is essential to provide local governance with information on the variety of existing and possible options to minimize health risks.

In this final chapter, we summarize current understanding of wastewater irrigation by drawing heavily on other chapters in this volume, which are not cited directly here. The reader is encouraged to consult the contents of the entire volume, designed to develop the case for safe wastewater irrigation by laying out the current context, providing detail on risk assessment and mitigation, and finally considering governance and policy challenges and responses. We aim to provide an integrated outlook on wastewater irrigation and the mitigation of associated health risks in developing countries.

To characterize the multifaceted nature of the practice, we refer to the definitions in Chapter 1, but to capture for the reader the two most common but fundamentally different situations of wastewater use in terms of their geographic significance, drivers and challenges (Table 19.1), two types are highlighted here and referred to throughout this chapter:

1 Unplanned use of wastewater in agriculture is a very common and widespread practice in and around urban centres in the developing world, resulting primarily from inadequate sanitation and widespread pollution of surface-water bodies. This results in crops being irrigated with highly polluted water which might be untreated, partially treated or – in most cases – diluted wastewater. Such use occurs in humid and arid regions alike, and will continue to expand as long as investments in wastewater management do not keep pace with population growth and urbanization, leading to uncontrolled pollution of water sources.
2 Planned wastewater use is more common in drier regions where wastewater streams are generally channelled, after at least partial treatment, for controlled reuse in agriculture to offset water shortage. This practice is increasingly gaining ground given the prevailing water scarcity context.

The global extent of planned wastewater irrigation we estimate as an order of magnitude less than the former (see Figure 19.2).

In contrast to the common perception that the key challenge of wastewater irrigation is more a question of designing and implementing safe wastewater irrigation schemes, the common reality of unplanned wastewater irrigation puts authorities in need of immediate action to address the possible risks accruing from informal plots throughout urban and peri-urban spaces. Even if this might only result in 'damage control' (Drechsel and Raschid-Sally, 2009), it requires a framework for risk assessment and risk mitigation to prioritize and implement well-targeted and locally appropriate risk-management responses. This concept is based on the World Health Organization's 2006 *Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture* (WHO, 2006) which put significant emphasis on unplanned wastewater use.

This emphasis was indeed necessary. In many developing countries authorities are hardly equipped to address point pollution, and are increasingly lost in view of diffuse hazards. Risk-assessment methods have never been used; data for risk quantification is missing; and there is no local information on the effect of available mitigation measures in terms of safety, risk-reduction potential, and economic and cultural acceptability. The WHO Guidelines distinguish between those situations/countries where treatment alone will be able to break the pathogen cycle and those lower on the 'sanitation ladder', where only alternative approaches or a combination of treatment and non- (or post-) treatment practices will achieve acceptable risk reduction. This does not imply that there should be different standards for different countries. On the contrary, following the philosophy of the WHO Guidelines, all countries should aim at the same tolerable disease burden per person per year. However, how fast this target can be achieved will depend on the country's current situation, context, and managerial and human resource capacity to progress. A step-wise approach is recommended as each risk reduction is better than none, while being aware that the way chosen via different combinations of treatment and

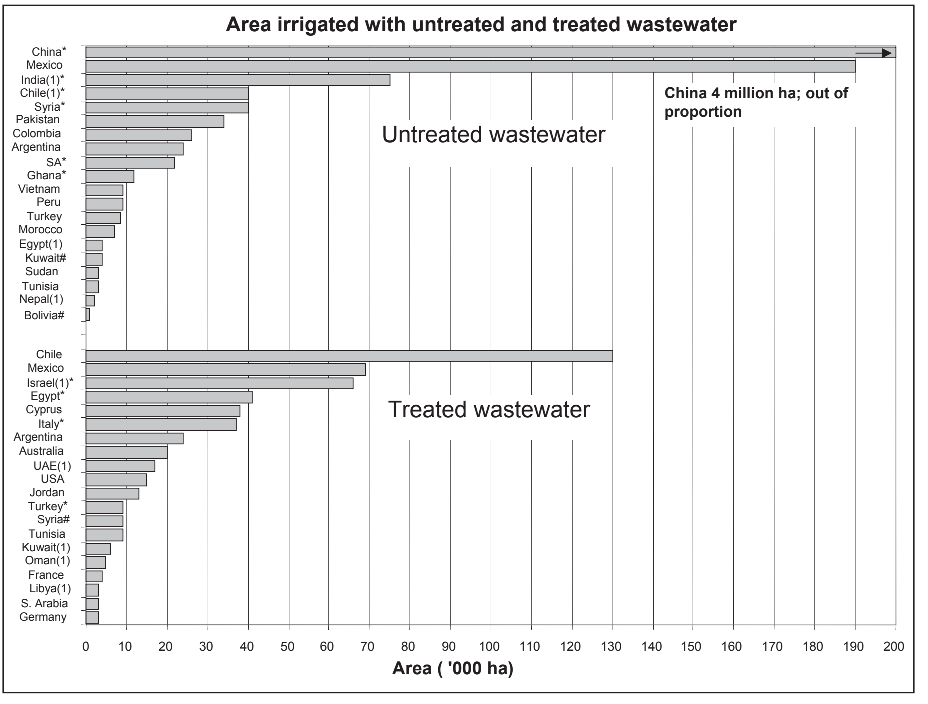

Figure 19.2 *Countries with greatest irrigated areas using untreated or treated wastewater*

* Data uncertain
(1) Area probably underestimated
Practice reported (incl. forestry), data missing

Sources: Jiménez and Asano (2008), modified; for China: Xianjun et al. (2003)

post-treatment options might change as the country develops from more human to technically based options.

Risk assessment, mitigation and the WHO Guidelines

The most important 'at risk' groups are, on the one hand, farmers or fieldworkers and their families, and, on the other, food consumers, especially where irrigated vegetables are eaten raw (e.g. lettuce, tomatoes). A third group sometimes mentioned is made up of those communities living close to wastewater irrigation areas (both planned and unplanned), where accidental contamination can take place. In most cases, these groups have differing levels of knowledge about the hazards they might face – when farmers know of occupational health risks they often accept them as part of their business, whereas consumers usually do not know about the source/treatment of their food and, if they did, they would prefer another source.

Table 19.1 *Characteristics of two principal wastewater irrigation types*

	Unplanned (indirect) use	Planned (direct) use
Management status	Unplanned activities along streams in/near urban centres	Planned use at a particular location
Climates	All climates, mostly driven by poor sanitation	Mostly arid, but also driven by economic water scarcity
Physical locations	Diffuse area	Specific sites near actual or potential treatment plants, or channelled to agriculture sites
Official recognition	Often informal sector	Formal sector
Water quality	Varies largely from untreated to partially treated to seasonally or generally diluted wastewater	Treated, partially treated, or also raw wastewater
Health-risk mitigation focus	Safer irrigation and post-harvest measures mostly for unrestricted irrigation	Treatment for reuse; crop restrictions possible
Existing institutional capacity	Low to moderate	Moderate to high
Main policy challenge	Balancing benefits against risks; pollution control	Wastewater governance for safe and productive reuse
Risk-mitigation challenge	Incentives to support adoption of risk-mitigation measures	Maintenance of treatment plants and control of post-treatment measures
Position on sanitation ladder	Lower ⟶	Higher

Also, in many developing countries consumers' educational status is low in view of 'germs' and their transmission.

WHO's change of focus from water-quality thresholds, i.e. critical pathogen levels in irrigation water, to health-based targets acknowledges the needs of developing countries still unable to afford the costs of large-scale wastewater management systems. While effluent-quality thresholds might work for particular treatment plants and related wastewater-reuse schemes, they can hardly be achieved in the much more common case of unplanned wastewater use along generally polluted streams. The new focus on health-based targets and multiple pathogen barriers provides local health-risk managers with the needed flexibility to address the situation of unplanned use. The new Guidelines therefore try to respond equally to the whole range of countries from low on the sanitation ladder (developing countries) to high (industrialized countries).

For the same health-based target, unplanned use and planned use of wastewater require however different risk-management approaches and corresponding guidelines (Table 19.1). This poses the question of whether the WHO Guidelines should better distinguish between different scenarios which could make them easier to read for stakeholders in different groups. The current global nature of the WHO Guidelines makes them unnecessarily complex, which is affecting their readability especially for policy makers and adoption. However, the number of practical examples as those presented in this book is increasing, showing that the new WHO Guidelines are feasible but as the approach is new more capacity building on their local adaptation is required.

With the target being healthy fieldworkers and consumers, local risk reduction can draw on a variety of measures, which can include not only wastewater treatment but also post-treatment options such as post-harvest pathogen die-off and safer methods of wastewater fetching, application and produce processing. Instead of a single measure providing the desired effect, the combination of such measures are together able to reduce the additional burden of disease from wastewater use in agriculture to acceptable levels.

The 2006 WHO Guidelines suggest a combination of quantitative microbial risk assessment and Monte Carlo simulations (QMRA-MC) to determine the possible risk level, or in other words the required pathogen reduction via a locally appropriate combination of health-protection control measures. However, even where the available data do not allow the application of QMRA, it is perfectly reasonable to stay on the safe side and aim at pathogen reduction of 5–6 log units on the irrigated produce, which can be achieved to safeguard consumers by different combinations of treatment and post-treatment options, depending on their availability and implementation potential which must be locally ascertained. A possible combination might be 2 log units through treatment, 3 log units from safer irrigation and pathogen die-off, and 1 log unit by produce-washing in clean water. This example only requires the laboratory capacity to analyse, for example, *E. coli* as the most common pathogen indicator, without stringent need to understand the theory of the Guidelines, QMRA and the concept of disability-adjusted life years (DALYs). However, the advantage of the QMRA would become obvious if the actual risk is lower and less effort (and related costs) is required to safeguard health.

There are still a large number of key issues to be addressed (Box 19.1).

Box 19.1 Key technical and socio-institutional challenges

Health-risk assessment

The WHO Guidelines are based on models which were largely developed and verified in developed countries. This raises the need for studies in developing countries to fine-tune or improve the existing risk-assessment approaches (actual exposure, dose-response estimates, immunity, etc.) and to improve our understanding of the match between easily collected and analysed indicator organisms and actual pathogens of local relevance, and eventually the results of the QMRA analysis. Another challenge is that risk assessment and (post-treatment) mitigation measures by and large only address pathogen-based threats while, especially in emerging economies, the inflow of industrial (or chemically polluted) wastewater requires increasing attention. There is a need to build on the work of Chang et al. (1995) to further develop quantitative chemical risk assessments (QCRA) tools, including computer-based applications similar to those for QMRA.

WHO Guidelines application

While the previous, simple, water-quality thresholds still look appealing, even if they are often unrealistic, the new more flexible approach – with many options, formula-based risk assessment needs and health-based targets expressed in DALYs – is understandably complex and requires significant interpretation for different situations if it is to implemented. So far, a common reaction of agencies, officials and others charged with managing wastewater, particularly indirect use, is that the Guidelines are simply too complex to understand and use. Meanwhile, to those planning direct wastewater use they are too general and miss the 'good old' conventional water-quality thresholds. In situations of planned reuse, however, the Guidelines support strict water-quality standards, if these can be maintained, and only recommend additional post-treatment measures if treatment alone cannot achieve the log reduction needed for the intended restricted or unrestricted irrigation. As summarized above, where institutions face the widespread challenge of indirect use and low internal management capacities, in practice it is not necessary to perform QMRA in order to apply the Guidelines, especially in situations where few, if any, local data are available. However, it will still require significant awareness creation to explain the options that the Guidelines offer in these and other settings.

Protecting fieldworkers

While most examples above refer to consumers, fieldworkers are best protected through wastewater treatment. However, because this might only contribute 2 log units of pathogen reduction, additional interventions may be required. A tolerable pathogen level can be assumed provided the workers and farmers are informed of their risks and accept risk-reducing measures, e.g. wearing protective clothing, avoiding water contact while fetching water (pumping instead of immersion) and applying water (furrows instead of overhead watering using cans), or via personal hygiene and/or regular anti-helminthic treatment. However, in practice, farmers' awareness of risks is often low or the perceived problems are considered part of the business.

Rethinking wastewater management

Where countries are moving towards planned direct use key challenges can be manifold, including legislation for wastewater use and pollution control, public-health engineering (locally implementable technologies for pathogen removal), economics (costs and benefits of the treatment and non-treatment options), and institutional capacities and linkages. In particular, the latter is required to constructively strengthen links between the sanitation and agricultural sectors, e.g. via multi-stakeholder platforms. What is most required is a paradigm shift to design treatment facilities, not for waste disposal, but to enhance conservation of resources with an economic value, through forward-linking 'Design for Service' concepts. This approach, which requires capacity building across conventional disciplinary boundaries, can work both ways by bringing treated wastewater on farm or bringing the principles of wastewater treatment to farmers. Indeed, there are many options for wastewater treatment at various scales that are simple in application, effective for pathogen removal and support reuse by maintaining crop nutrients.

Social acceptability

Social challenges related to safe wastewater irrigation have so far been viewed in terms of culturally rooted discomfort with reusing human waste, which is actually less frequent among farmers than anticipated. Much larger challenges concern the ability of individuals and farm communities to adopt and sustain post-treatment risk-mitigation options. This is important as the cost-effectiveness of these options is lost if they are not sustained after initial implementation; in other words, a lasting adoption is crucial. While the safety of direct use is predicated on functioning treatment plants, risk reduction in the informal sector will be largely based on the acceptance of safer irrigation or vegetable-washing practices. As farmers or traders might not see direct benefits in changing their behaviour, studies are needed to understand local knowledge and perceptions to suggest possible positive or negative incentives and social marketing approaches to promote recommended practices with the highest potential for local adoption. These challenges and options are not addressed in the current WHO Guidelines.

Integrated and comparative risks assessment beyond wastewater use

A key challenge is to think out of the wastewater box. There is a large variety of faecal–oral contamination pathways leading to diarrhoeal diseases (Fewtrell et al., 2007) of which this volume addresses just a few. Decision-makers, however, are looking at the larger picture of all the contributory risk factors. For them the key question should be ‘Which risk factors and pathways in my city are likely to cause a diarrhoeal outbreak and public-health crisis?’ To address this, it is necessary to compare the risk contribution from different sources and identify target-oriented mitigation measures, and then to evaluate those which most cost-effectively prevent diarrhoea, given prevailing resource constraints. The consumption of wastewater-irrigated vegetables might not be the most important hazard in this regard and, while this might be good news for the wastewater sector, it does not diminish the importance of the sanitation crisis.

Policy and governance implications

It is clear from the legacy of failed and costly sanitation strategies that the ‘one size fits all’ risk-mitigation approach is no longer appropriate for many countries. Based on this experience, which is reflected in the assessments included in this volume, WHO encourages a step-by-step incremental approach to the beneficial and safe use of wastewater whereby each step not only reduces risk but also builds the capacity of institutions to be able to methodically move forward to the next phase of wastewater and associated risk management. The incremental achievement of health-based targets can become visible through the gradual physical expansion of a sewer system, but equally through increasing political will for continuous investments in the health and sanitation sector.

However, to date the return on investment in wastewater treatment has had limited impact in the face of rapidly changing urban demographics and poverty. Investments in technologically complex treatment processes and policies have failed due to ill-planned, badly operated and badly managed facilities, under-resourced institutions, limited human-resource capacity and severe financial challenges. For example, a review of almost 200 wastewater treatment plants in Brazil – a relatively well-developed economy – has found that most are unreliable and prone to failure (Oliviera and von Sperling, 2008). The situation in sub-Saharan Africa is more severe. In Ghana, only 10 per cent of the approximately 70 wastewater and faecal-sludge treatment plants identified in the country still worked as planned and, even if all were working, less than 10 per cent of the urban wastewater would be treated (IWMI, unpublished). It is also clear that the lack of appropriate sanitation has health and cost implications. The Water and Sanitation Program of the World Bank has produced research illustrating that in the Philippines, Vietnam, Cambodia and Indonesia, US$9 billion are lost annually due to inadequate sanitation. This amounts to 2 per cent of their combined gross domestic product (Water and Sanitation Program, 2007).

As already noted in the context of beneficial wastewater management and use, health-risk reduction will require a combination of treatment and post-treatment options. Treatment, where feasible, is the ideal option but requires adequate planning and the selection of appropriate technology options. There are examples of middle-income countries, such as Mexico, Jordan and Tunisia, that have embarked on planned reuse, based on treatment. However, the pace is ultimately, if inadvertently, set by the case of intensive, commercially based agricultural economies such as California, which has invested huge amounts of funding in building, operating and maintaining a network of wastewater treatment plants. Furthermore, it is estimated that over the next 20 years, US$20 billion will be required to fund that state's planned infrastructure capital costs and maintain the existing network – 210 times the amount currently budgeted for the purpose (Food and Water Watch, 2008). It is worth adding that water infrastructure and treatment is among the least financially autonomous of all infrastructures when compared to telecoms, electricity, etc. (Serageldin, 1994), although financial studies have yet to be undertaken on the full benefits of water and wastewater infrastructure. Calls to fund and expand treatment in low-income countries must be matched with the ground reality and precious resources must be invested wisely to maximize the benefits to public health. Effective risk management requires a more graduated, methodical approach that integrates new actors in the wastewater-management process from the treatment plant to the farm and the consumer. The right combination of wastewater-treatment process and risk-management strategies remains the target.

We recognize that the situation of high sewerage coverage and related wastewater treatment is – at least in the short term – difficult to achieve in many resource-stressed countries, but it should remain the goal unless alternative approaches, such as water-saving ecological sanitation technologies, become implementable at a larger scale and reduce the general need for sewerage and pressure on treatment.

This would have multiple benefits as the troubling economic reality in the global economy is likely to exacerbate an already problematic situation when it comes to pollution control in low-income countries. The reduction of credit for bank lending for capital investment, an unstable bond market for governments and the anticipated decline in donor funds available will increase stress on the management of wastewater in fast-growing cities worldwide. We also recognize that the cost for sanitation, estimated by the UN Development Programme for low-income countries to range from 3–15 per cent of gross national product (United Nations, 2005) as a result of using a conventional approach, is very high and in many cases it will simply not be achievable. Under these circumstances, the most cost-effective way to significantly reduce the risks from wastewater irrigation remains the application of an integrated multiple-barrier risk-reduction approach such as presented in the WHO Guidelines and further developed in this volume.

Another advancement in thinking on wastewater management is that key actors in the management of wastewater also include farmers, traders, food caterers and consumers. For this added human contribution to be effective, behaviour-change will be required at all stages. While emerging research on the value of wastewater will broaden our knowledge of how economic incentives can modify behaviour, it is a fact that, to adopt safer practices, some along the 'wastewater chain' will need to do so without any obvious personal or business advantage. From a national planning perspective, this may be more difficult to implement and sustain than to have wastewater treatment as the principal strategy to mitigate health risk in this area. The challenge lies in effective awareness creation, and use of incentives and regulations. This implies the continued need for additional research on risk perceptions and drivers of appropriate technology adoption (see Box 19.1).

The options outlined in this volume – such as modifying irrigation practices, produce-washing and other forms of behavioural change – require concerted effort, but are less expensive than a complex treatment infrastructure and do result in considerable risk mitigation. For these reasons, the incremental approach suggested by the WHO Guidelines is of critical importance and post-treatment options will be of continued value.

Needless to say, a graduated approach to improving risk management will require significant investments in building capacity. A minimum commonsense requirement – and one that is rare given the numerous jurisdictional overlaps commonly seen – is that one agency or ministry be placed solely in charge of regulating wastewater management, coordinating reuse operations with the other concerned departments or ministries and directing investments in the sector. Given the lack of suitable governance responses at the moment, one should not overestimate the ability of national and local governments to respond to the WHO Guidelines in low-income countries. A renewed effort to tie the WHO

Guidelines to practice and existing wastewater governance systems will be a critical requirement in the coming years of development in this field.

Our collective understanding of wastewater use in agriculture has never been greater or more nuanced than it is now. The Accra Consensus (Box 19.2) demonstrates the growing understanding of the importance of a multifaceted response to address the complexities of water pollution and its impacts on food production and consumption. A combination of biophysical science, social, economic and policy analysis, and good politics and governance are required in order to reduce the impacts of wastewater-related health risks in the most effective way and to obtain win–win solutions from the sanitation, water and food crises triangle.

Box 19.2 The Accra Consensus: an agenda for research, capacity building and action on the safe use of wastewater and excreta in agriculture

To address key research challenges concerning health-risk assessment, risk mitigation and wastewater governance in developing countries, an expert consultation was held on 6–9 October 2008 in Accra, Ghana. The event was hosted by the International Water Management Institute, the International Development Research Centre and the World Health Organization as a follow-up to the consultation resulting in the Hyderabad Declaration (see above). The meeting brought together over 50 researchers, practitioners, agency staff and decision-makers and concluded with the following statement:

> *Rapidly expanding cities, escalating water scarcity, food supply and livelihood needs, particularly in low-income regions, are all driving the increasing demand for untreated and treated wastewater and excreta for agriculture. Although much progress has been made in our understanding of these issues since the 'Hyderabad Declaration' of 2002, significant challenges remain to make the use of wastewater and excreta in agriculture safe, economically productive, and sustainable.*
>
> *We – an expert group from 30 international, regional, and national research institutes, multilateral and bilateral bodies, and universities based in 17 countries – emphasize the need to support policy-makers around the world to make informed decisions that lead to cost-effective interventions that improve public health, promote sustainable sanitation, protect the environment, and support food security and economic development.*
>
> *Achieving this goal requires consolidation of information on the science and practice of wastewater and excreta use, and well-targeted research to address gaps in the evidence base needed to support informed decision-making. Therefore, we propose the following multi-disciplinary agenda for action:*

1 *Integrate health and economic impact assessments to determine the actual contribution of wastewater and excreta use to the burden of disease, particularly in low-income settings, and to prioritize interventions to improve health and livelihood outcomes.*
2 *Facilitate the adoption of the 2006 World Health Organization guidelines for the safe use of wastewater, excreta and greywater in low-income settings through the development and application of appropriate local practices and standards that take into account local capacities and resources. Specifically:*
   - *Fill data gaps on levels, transmission, persistence, and reduction of key pathogens along the environmental pathways from faecal origin to human exposure, and measure disease incidence among those exposed.*
   - *Rigorously evaluate – in multiple geographical contexts – a range of wastewater and excreta treatment approaches and other risk-mitigation strategies for their cost-effectiveness and impacts on health, livelihood and the environment.*
   - *Increase human, institutional and technical capacities in low-income settings to:*
     - *Detect important pathogens in human and environmental samples*
     - *Design and operate wastewater and excreta treatment systems that can be maintained in their ecological and economic context, and thereby support the safe and productive use of wastewater and excreta in agriculture*
     - *Develop and support effective participatory governance mechanisms for sustainable sanitation design and operation and safe and productive wastewater and excreta use.*

4 *Facilitate the exchange of information on best practices, including successful risk assessment and mitigation strategies, among partners around the globe through national and regional knowledge hubs and web-based data banks.*

Accra, 9 October 2008

Source: www.iwmi.cgiar.org/Research_Impacts/Research_Themes/Theme_3/Accra_Consensus.aspx

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