WASPA ASIA

Knowledge Sharing Workshop on Wastewater Agriculture and Sanitation for Poverty Alleviation

3 March 2008

Rajshahi

Edited by Sharfun Ara

Contents

1 Introduction

The use of wastewater in irrigation is vital for many farmers who do not have direct access to clean irrigation water, but wastewater needs to be managed or treated properly before using it, to ensure it does not pose a health risk to farmers or consumers. Considering these key aspects, NGO Forum for Drinking Water Supply & Sanitation (NGO Forum) has been implementing the project “Wastewater Agriculture and Sanitation for Poverty Alleviation (WASPA Asia)” in Rajshahi, Bangladesh in collaboration with several project partners. Recently NGO Forum, the International Water Management Institute (IWMI) and the Stockholm Environment Institute (SEI), jointly organized a knowledge sharing workshop in Rajshahi to raise awareness about wastewater management and to provide options for improved management and treatment of wastewater, excreta and urine. The "WHO Guidelines for the Safe Use of Excreta, Grey water and Wastewater in Agriculture" formed an important part of the workshops and provided technical and non-technical options for risk reduction and barriers to disease transmission including various sanitation system solutions.

Mr. Rizwan Ahmed, Chief, National Resource Centre of NGO Forum and Team Leader of WASPA Asia project in Bangladesh focused on the significance of organizing the workshop to benefit various stakeholders, including government and non-government organizations, academics, and the private sectors, from sharing knowledge with others who are working in the fields of sanitation, agriculture and wastewater management. In order to achieve this material presented in the workshop and the discussions around it would be critical.

2 Presentations and Discussions

2.1 Summary of WASPA project findings to date in Bangladesh

WASPA Asia, an action research project funded by the European Commission under the EU Asia Pro Eco-II Programme started in December 2005 and will continue its ongoing activities up to December 2008. The project is being implemented in two cities: Kurunegala, Sri Lanka and Rajshahi, Bangladesh, and there are five partners involved with the implementation of the project.

The objectives of the workshop are:

- To discuss issues around wastewater management including the WHO guidelines for safe use of excreta, greywater and wastewater in agriculture.
- To provide knowledge on barriers to reduce risks to health
- To consider how these ideas can be brought into the Participatory Action Plans (PAPs) for Rajshahi, if relevant.

Activities so far include assessments to inform the process in areas including stakeholder analysis, water quality, industry, sanitation and agriculture. These were undertaken at the same time as activities to establish the Rajshahi Learning Alliance platform and were used to inform the process of developing the Participatory Action Plans, which were done with the active involvement of the stakeholders. This was followed by implementation of some of the plans including hygiene promotion training for wastewater farmers. Throughout this process documentation has taken place to enable the team and stakeholders to learn from the process.

Planned PAP activities include:

- Construction of garbage traps (with RCC and ward commissioner)
- Reduction of solid waste inflow through campaign(with ward commissioners)
- Investigation of cleaner production options in industrial area(with BSCIC & NASCIB)
- Workshop on regulations, CP and treatment
- Work with BSCIC and NASCIB on the implementation of pollution reduction measures
- Review regulations and their implementation and suggest improvements (BELA and Rajshahi University)
- Commission an investigation of appropriate wastewater treatment options for Bashuar Beel
- Training for wastewater using farmers on agricultural aspects(with DAE)
- Community awareness

Views and comments

Engineer Abul Bashar, Superintending Engineer of Department of Public Health Engineering (DPHE), Rajshahi focused on the current fertilizer crisis and the huge opportunity of using wastewater in the agriculture field. Particularly, the quality of wastewater which pours through the outlet and inlet points needs to be treated to reduce the health risks of the farmers as well as the consumers of the products. The sewerage line is linked with the drainage line of the Rajshahi City Corporation (RCC) area which was unplanned and means that the storm water drains contain raw sewage. Considering these circumstances RCC can play a significant role in reducing health risks of the farmers. **Mr. Bashar urged the concerned bodies of government and RCC to come forward and make efforts for ensuring that the existing laws of RCC as well as the industrial laws for the proper waste and wastewater management are pursued.**

Mr. Md. Rafiqul Islam, Project Officer of DASCOH, asked for a better understanding of the use of solid waste as fertilizer and emphasized the need for knowledge sharing to understand the facts.

Mr. SKL Mohammad Lalon, Chief Executive of NISKRITY, requested that the authorities ensure the supply of clean water for the city dwellers in RCC area and that drainage water should be treated so that it can be used safely in agriculture. The Bangladesh Water Development Board and RCC have significant roles to play through undertaking some research in this regard.

Mr. Md. Raihan Ali, Executive Director of Thanapara Swallows, was concerned about industrial waste in the drainage water in most of the RCC area, and hoped that the WASPA plan would address these issues.

Mr. Lalon requested the mutual cooperation between and among the bodies of the local government, NGO Forum and RCC regarding WASPA project and any other ventures.

Dr. Md. Shafiuddin Miah, Professor and Dean of the Department of Civil Engineering, RUET, Rajshahi was interested to know more about the activities that have been undertaken in the WASPA project to identify the contaminants in the wastewater and the types of health risks faced by the farmers due to using wastewater. The team reported on the initial findings (which can be found in the project reports and briefing notes) and agreed that some further work in collaboration with local organizations would be extremely valuable.

2.2 WHO Guidelines for the Safe Use of Excreta, Greywater and Wastewater in Agriculture

The WHO guidelines on the Safe Use of Excreta, Greywater and Wastewater in Agriculture, updated in 2006, have been very influential, and many countries have adopted or adapted them for their wastewater and excreta use practices. The Guidelines are presented in four volumes: Volume 1: Policy and regulatory aspects; Volume 2: Wastewater use in agriculture; Volume 3: Wastewater and excreta use in aquaculture; and Volume 4: Excreta and Grey water use in agriculture.

Volumes 2 and 4 of the Guidelines might be the basis for the development of international and national approaches (including standards and regulation) to tackle the health hazards associated with wastewater use in agriculture but it is important to note that the Guidelines themselves do not provide standards and are just a set of guiding principles or suggestions to protect health and agricultural output. As such, they provide a framework for national and local decision making regarding wastewater use in agriculture. The information is applicable to the intentional use of wastewater in agriculture and is also relevant where faecal contaminated water is unintentionally used for irrigation. In terms of the WASPA project these Guidelines could provide an integrated preventive management framework, including risk management options, proper techniques for fertilizing, crop restrictions, systematic documentation and monitoring system over the project activities, human exposures control and also in wastewater treatment. A summary of the WHO guidelines is provided in Annex 1.

Questions and views

Mr. Md. Hazrat Ali, Metropolitan Agriculture Officer of Department of Agriculture Extension (DAE) suggested that the way to involve the consumers and Learning Alliance platform members should be clearly defined and ensured. He also stated that health hazards could be reduced by covering the drainage system; therefore, there is a need for dialogue with the RCC regarding this issue.

Cards were distributed amongst the participants and some questions and suggestions were made by them as mentioned below.

Many of the participants requested that the RCC develop a plan to separate the storm water from the sewage by constructing a separate sewerage system. Unfortunately RCC were not available to respond to this but it was made clear by other participants that there was currently no action being taken in this regard.

In response to a query regarding the programme of improving the health system it was affirmed that WASPA project has planned to launch community awareness programme within the area where sanitation assessment had been undertaken as the status of hygiene practice has been reported to be low there.

2.3 Bangladesh - technical and non-technical aspects of treatment and reuse

This presentation focused on excreta related diseases, transmission of disease from excreta, transmission routes, types of toilets suitable for washers and acceptable for the wipers. He focused on the two aspects of wastewater used in agriculture including crop health (physicochemical quality of treated wastewater) and human health (microbiological quality of treated wastewater).

Restricted irrigation is a key aspect in the exposure scenario (involuntary soil ingestion) and two sub-scenarios including labour-intensive agriculture (developing country situation) and highly mechanized agriculture (industrialized country situation), and is essential for risk reduction. The choice of wastewater application method can also make an impact on the health status of farm workers, consumers and nearby communities, but the type selected must be a suitable technique within the local context.

3 Group Discussions: Findings

<u>Group 1:</u>

Recommendations

1. Systematic preservation of wastewater of RCC area
2. Ensuring the flow of treated wastewater in the drains from industries and hospital
3. Blockage of the linkage between household latrines and the drains
4. Encouraging farmers to use treated wastewater in agriculture
5. Installation of wastewater treatment plant

Responsibilities

1. RCC, Rajshahi Development Authority (RDA)
2. Industries and hospital authorities
3. Community and RCC
4. Media, DAE and NGOs.
5. RCC, RDA, donor agencies

Group 2:

Recommendations

1. Develop plan for wastewater management through mutual coordination of RCC and RDA
2. Construction, reconstruction and repairing of all canals within the RCC area
3. Proper implementation of the building construction regulations
4. Conduction of monthly monitoring of public health and agriculture related issues through proper initiatives of the DAE, RCC and DPHE
5. Reformation of the LA and arrange monthly meeting
6.

Group 3:

Risk identification and management

1. Risk prone area
2. Number of risk prone people
3. Crop selection
4. Irrigation system
5. Awareness among farmers
6. Research activities
7. Awareness among stakeholders

4 List of Participants

1. Mr. Shyamal Kumar Roy, Field Officer, CARITAS, Rajshahi.
2. Dr. Md. Akhter Hossain, Associate Professor, Rajshahi University, Rajshahi.
3. Mr. Md. Rafiqul Islam, Project officer, DASCOH, Rajshahi.

4. Dr. Md. Shafiuddin Miah, Professor and Dean, Department of Civil Engineering, RUET, Rajshahi.
5. Mr. Hanif Mohammad Murshidy, Asst. Engineer, LGED. Rajshahi.
6. Mr. Md. Shohidul Islam, ASI of Police, City Special Police, Rajshahi.
7. Mr. Sayeed Ahmed Kabir, Coordinator, BELA, Rajshahi.
8. Dr. Md. Sajedul Islam, Civil Surgeon, Rajshahi Civil, Health, GoB.
9. Mr. Salahuddin Muhamad Sumon, RU Correspondent, Bhorer Kagoj, Rajshahi.
10. Eng. Abul Bashar, S.E. Rajshahi, DPHE.
11. Mr. Md. Seddique Amin, Sr. Chemist, DPHE Lab, Rajshahi.
12. Ms. Alina Khatun Lina, Director (program), PARTNER, Paba, Rajshahi.
13. Mr. Rahima Razib, Executive Director, MSP, Rajshahi.
14. Mr. Sanker Chandra Barman, Deputy Manager, BRAC, Rajshahi.
15. Mr. Md. Rahanul Islam Rony, Asst. Town Planner, RDA, Rajshahi
16. Mr. Md. Ziaur Rahman, Admin Officer, TRINOMOOL, Rajshahi
17. Mr. Mithu Chandra Sarker, Information Officer, ASROY, Rajshahi.
18. Mr. Md. Hazrat Ali, Metro, Agril. Officer, DAE, Rajshahi.
19. Mr. Md. Shamsuzzaman, Project Officer, CARE, Rajshahi.
20. Mr. Hasan Millat, News Editor, Sonali Sangbad, Rajshahi.
21. Mr. SKL Mohammad Lalon, CE, NISKRITY, Rajshahi
22. Mr. Md. Raihan Ali, Executive Director, Thanapara Swallows, Rajshahi
23. Mr. Minhaz Uddin Minto, Director, BIKASH, Rajshahi.
24. Mr. Md. Jahangir Salim, Executive Director, SDP, Rajshahi.
25. Mr. Md. Nurul Islam, Field Facilitator, ASSEDO, Rajshahi.
26. Mr. Kh. Md. Joynal Abedin, Manager, C.R.S, Rajshahi.
27. Mr. Md. Siddiqur Rahman, Field Facilitator, SACHETAN, Rajshahi.
28. Mr. Md. Hasinul Islam, Executive Director, SACHETAN, Rajshahi.
29. Mr. Md.Robiul Alam, Executive Director, ASSEDO, Rajshahi.
30. Mr. Afzal Hussain, Director, RULFAO, Rajshahi.
31. Mr. Madhusudan, Executive Director, KBUS, Rajshahi.
32. Mr. Md. Mohsin Ali, Executive Director, Shapla, Rajshahi.
33. Mr. Md. Khaled Murshed, Regional Manager, NGOF Rajshahi.
34. Mr. Md. Kabir Uddin, FO, NGOF Rajshahi.
35. Mr. Mosarraf Hossain, Asso. Regional Officer, NGOF Rajshahi.
36. Mr. Md. Abul Hayat, Field Engineer, NGOF Rajshahi.
37. Ms. Alexandra Clemett, Researcher, International Water Management Institute (IWMI).
38. Mr. Thor Axel Stenström, Senior Research Fellow, SEI, Sweden.
39. Mr. Rizwan Ahmed, Chief of NRC and WASPA Project Team Leader, NGO Forum for DWSS.
40. Md. Maksudul Amin, Technical Specialist-WASPA-Asia project, NGO Forum for DWSS.
41. Ms. Sharfun Ara, Research & Documentation Officer Research, NGO Forum for DWSS.
42. Mr. Md. Shafiqul Islam, Agronomist, NGO Forum, Rajshahi.
43. Mr. Md. Mashiur Rahman, Communication Officer, NGO Forum, Rajshahi.

Annex 1: Summary of WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater, 2006

The United Nations General Assembly (2000) adopted the Millennium Development Goals (MDGs) on 8 September 2000. The MDGs that are most directly related to the safe use of wastewater, excreta and greywater in agriculture and aquaculture are “Goal 1: Eliminate extreme poverty and hunger” and “Goal 7: Ensure environmental sustainability.” The use of wastewater, excreta and greywater in agriculture and aquaculture can help communities to grow more food and make use of precious water and nutrient resources. However, it should be done safely to maximize public health gains and environmental benefits.

In 1973, the World Health Organization (WHO) produced the publication *Reuse of effluents: Methods of wastewater treatment and public health safeguards*. This document provided guidance on how to protect public health and how to facilitate the rational use of wastewater and excreta in agriculture and aquaculture. Technically oriented, the publication did not address policy issues *per se*.

A thorough review of epidemiological studies and other new information led to the publication of a second edition of this normative document in 1989: *Health guidelines for the use of wastewater in agriculture and aquaculture*. The guidelines have been very influential with respect to technical standard setting and also at the policy level, and many countries have adopted or adapted them for their wastewater and excreta use practices.

The present third edition of the Guidelines has been updated based on new health evidence, expanded to better reach key target audiences and reoriented to reflect contemporary thinking on risk management.

Box 1: What are the Guidelines?

The WHO Guidelines are an integrated preventive management framework for maximizing the public health benefits of wastewater, excreta and greywater use in agriculture and aquaculture. The Guidelines are built around a health component and an implementation component. Health protection is dependent on both elements.

Health component:

- establishes a risk level associated with each identified health hazard;
- defines a level of health protection that is expressed as a health-based target for each risk;
- identifies health protection measures that, used collectively, can achieve the specified health-based target.

Implementation component:

- establishes monitoring and system assessment procedures;
- defines institutional and oversight responsibilities;
- requires system documentation;
- requires confirmation by independent surveillance.

VOLUME I: POLICY AND REGULATORY ASPECTS

Policy Aspects

This chapter covers policy aspects as a basis of governance and the international policy framework. It includes policy aspects related to: implementation of WHO Guidelines to protect public health; wastewater, excreta and greywater use and its benefits and health risks; international policy implications and trade; cost-effective strategies for controlling negative health impacts; policy formulation and adjustment, based on objective defining, situation analysis, policy appraisal, needs assessment, political endorsement, dialogue and research. Institutional arrangements and inter-sectoral collaboration are also an important part of the chapter.

In developing a national policy framework to facilitate the safe use of wastewater, excreta and greywater in agriculture and aquaculture, it is important to define the objectives of the policies, assess the current policy environment, formulate new policies or adjust existing ones, and develop a national strategy. Environmental protection is a policy goal in most countries, from the viewpoints of both conservation of natural resources and ecosystem services and public health protection. Yet such a view overlooks the value of the source of water or nutrients for plant production and fish cultivation.

The main policy issues to investigate are:

• *Public health*: To what extent is waste management addressed in national public health policies? What are the specific health hazards and risks associated with the use of wastewater, excreta or greywater in agriculture and aquaculture? Is there a national health impact assessment policy? Is there a policy basis for non-treatment interventions in line with the concepts and procedures contained in the Stockholm Framework?

• *Environmental protection*: To what extent and how is the management of wastewater, excreta and greywater addressed in the existing environmental protection policy framework? What are the current status, trends and expected outlook with respect to the production of wastewater, excreta and greywater?

What is the capacity to management wastewater, excreta and greywater? What are the current and potential environmental impacts? What are the options for reuse in agriculture or aquaculture?

• *Food security*: What are the objectives and criteria laid down in the national policies for food security? Is water a limiting factor in ensuring national food security in the short/medium/long term? Are there real opportunities for the use of wastewater, excreta and greywater in agriculture and aquaculture to (partially) address this problem? Is reuse currently practiced in the agricultural production system? Has an analysis of the benefits and risks of such waste use been carried out?

The steps to develop a policy are:

- establishment of a mechanism for ongoing policy dialogue;
- defining objectives;
- situation analysis, policy appraisal and needs assessment;
- political endorsement, dialogue engagement and product legitimization;
- research

Regulation

This chapter provides an overview of the technical issues that regulators should consider when developing new or modifying existing regulations for the safe use of wastewater, excreta and greywater in agriculture and aquaculture. Essential functions in regulation include:

- identification of hazards;
- generating evidence for health risks and the effectiveness of possible health
- protection measures to manage them;
- establishing health-based targets to manage health risks;
- implementing health protection measures to achieve the health-based targets; and
- system assessment and monitoring.

It also covers pathogen reduction options such as excreta storage, greywater treatment, disinfection and so on, as summarized in Table 1.

Table 1: Pathogen reductions achievable by various health protection measures

Control measure	Pathogen reduction (log units)	Notes
Excreta storage without fresh additions	6	The required pathogen reduction to be achieved by excreta treatment refers to stated storage times without addition of fresh untreated excreta. Pathogen reductions for different treatment options are presented in chapter 5 of Volume 4.
Greywater treatment	1–>4	Values relate to the relevant treatment options. Generally, the highest exposure reduction is related to subsurface irrigation.
Localized (drip) irrigation with urine (high-growing crops)	2–4	Crops where the harvested parts have not been in contact with the soil
Materials directly worked into the soil	1	Should be done at the time when faeces or urine is applied as a fertilizer
Pathogen die-off (withholding time one month)	4–>6	A die-off of 0.5–2 log units per day is cited for wastewater irrigation. Reduction values cited are conservative to account for a slower die-off of a fraction of the remaining organisms.
Produce washing with water	1	Washing salad crops, vegetables and fruit with clean water
Produce disinfection	2	Washing salad crops, vegetables and fruit with a weak disinfectant solution and rinsing with clean water
Produce peeling	2	Fruits, root crops
Produce cooking	6–7	Immersion in boiling or close-to-boiling water until the food is cooked ensures pathogen destruction

Sources: Beuchat (1998); Petterson & Ashbolt (2003); NRMMC & EPHCA (2005).

The guidelines also provide recommendations for microbial monitoring, using *E.coli* as the parameter, and Helminth eggs, as shown in Table 2.

Table 2: Recommended minimum verification monitoring of microbial performance targets for wastewater and excreta use in agriculture and aquaculture

Activity/exposure	Water quality monitoring[a] parameters	
Agriculture	*E. coli* per 100 ml[b] (arithmetic mean)	Helminth eggs per litre[b] (arithmetic mean)
Unrestricted irrigation		
Root crops	$\leq 10^3$	≤ 1
Leaf crops	$\leq 10^4$	
Drip irrigation, high-growing crops	$\leq 10^5$	
Restricted irrigation		
Labour-intensive, high-contact agriculture	$\leq 10^4$	≤ 1
Highly mechanized agriculture	$\leq 10^5$	
Septic tank	$\leq 10^6$	
Aquaculture	*E. coli* per 100 ml[b] (arithmetic mean)	Viable trematode eggs per litre[b]
Produce consumers		
Pond	$\leq 10^4$	Not detected
Wastewater	$\leq 10^5$	Not detected
Excreta	$\leq 10^6$	Not detected
Workers, local communities		
Pond	$\leq 10^3$	No viable trematode eggs
Wastewater	$\leq 10^4$	No viable trematode eggs
Excreta	$\leq 10^5$	No viable trematode eggs

[a] Monitoring should be conducted at the point of use or the point of effluent discharge. Frequency of monitoring is as follows:

- Urban areas: one sample every two weeks for *E. coli* and one sample per month for helminth eggs.
- Rural areas: one sample every month for *E. coli* and one sample every 1–2 months for helminth eggs.

Five-litre composite samples are required for helminth eggs prepared from grab samples taken six times per day. Monitoring for trematode eggs is difficult due to a lack of standardized procedures. The inactivation of trematode eggs should be evaluated as part of the validation of the system.

[b] For excreta, weights may be used instead of volumes, depending on the type of excreta: 100 ml of wastewater is equivalent to 1–4 g of total solids; 1 litre = 10–40 g of total solids. The required *E. coli* or helminth numbers would be the same per unit of weight.

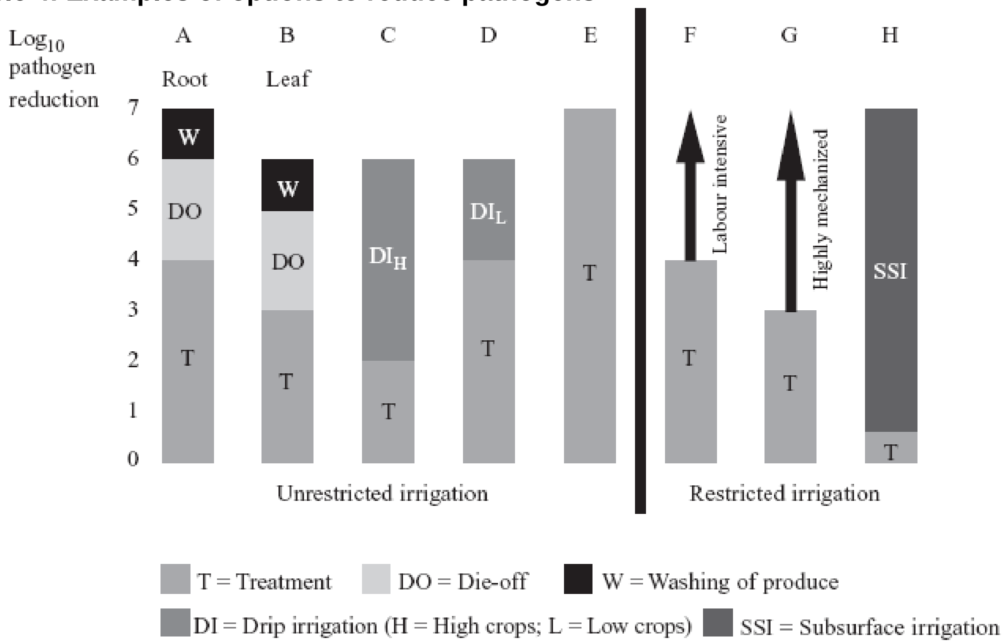
Volume 2: Wastewater Use in Agriculture

Volume 2 builds on Volume 1, providing more details. It describes the present state of knowledge regarding the impact of wastewater use in agriculture on the health of product consumers, workers and their families and local communities (Table 3). Health hazards are identified for each vulnerable group, and appropriate health protection measures to mitigate the risks are discussed. The purpose of this volume of the Guidelines is to ensure that the use of wastewater in agriculture is made as safe as possible, so that the nutritional and household food security benefits can be shared widely within communities whose livelihood depends on wastewater-irrigated agriculture. The Guidelines provide an integrated preventive management framework for safety applied from the point of wastewater generation to the consumption of products grown with the wastewater and excreta. There are many ways in which crops can be treated or managed to reduce viral, bacterial and protozoan pathogens, including irrigation method, die-off, washing practices and treatment, as shown in Table 4.

Table 3: Summary of health risks associated with the use of wastewater for irrigation

Group exposed	Health threats		
	Nematode infection	**Bacteria/viruses**	**Protozoa**
Consumers	Significant risk of *Ascaris* infection for both adults and children with untreated wastewater	Cholera, typhoid and shigellosis outbreaks reported from use of untreated wastewater; seropositive responses for *Helicobacter pylori* (untreated); increase in non-specific diarrhoea when water quality exceeds 10^4 thermotolerant coliforms/100 ml	Evidence of parasitic protozoa found on wastewater-irrigated vegetable surfaces, but no direct evidence of disease transmission
Farm workers and their families	Significant risk of *Ascaris* infection for both adults and children in contact with untreated wastewater; risk remains, especially for children, when wastewater treated to <1 nematode egg per litre; increased risk of hookworm infection in workers	Increased risk of diarrhoeal disease in young children with wastewater contact if water quality exceeds 10^4 thermotolerant coliforms/100 ml; elevated risk of *Salmonella* infection in children exposed to untreated wastewater; elevated seroresponse to norovirus in adults exposed to partially treated wastewater	Risk of *Giardia intestinalis* infection was insignificant for contact with both untreated and treated wastewater; increased risk of amoebiasis observed with contact with untreated wastewater
Nearby communities	*Ascaris* transmission not studied for sprinkler irrigation, but same as above for flood or furrow irrigation with heavy contact	Sprinkler irrigation with poor water quality (10^6–10^8 total coliforms/100 ml) and high aerosol exposure associated with increased rates of infection; use of partially treated water (10^4–10^5 thermotolerant coliforms/100 ml or less) in sprinkler irrigation is not associated with increased viral infection rates	No data on transmission of protozoan infections during sprinkler irrigation with wastewater

Table 4: Examples of options to reduce pathogens



Volume 3: Wastewater and Excreta use in Aquaculture

Volume 3 undertakes the same task for aquaculture as Volume 2 did for agriculture. It therefore gives health-based targets for waste-fed aquaculture.

Table 5: Health-based targets for waste-fed aquaculture

Exposed group	Hazard	Health-based target[a]	Health protection measure
Consumers, workers and local communities	Excreta-related diseases	10^{-6} DALY	Wastewater treatment Excreta treatment Health and hygiene promotion Chemotherapy and immunization
Consumers	Excreta-related diseases	10^{-6} DALY	Produce restriction Waste application/timing Depuration
	Foodborne trematodes	Absence of trematode infections	
	Chemicals	Tolerable daily intakes as specified by the Codex Alimentarius Commission	Food handling and preparation Produce washing/disinfection Cooking foods
Workers and local communities	Excreta-related pathogens	10^{-6} DALY	Access control Use of personal protective equipment
	Skin irritants	Absence of skin disease	Disease vector control
	Schistosomes	Absence of schistosomiasis	Intermediate host control
	Vector-borne pathogens	Absence of vector-borne disease	Access to safe drinking-water and sanitation at aquacultural facilities and in local communities Reduced vector contact (insecticide-treated nets, repellents)

[a] Absence of disease associated with waste-fed aquaculture-related exposures.

Volume 4: Excreta and Greywater use in Agriculture

Traditional waterborne sewerage will continue to dominate sanitation for the foreseeable future. Since only a fraction of existing wastewater treatment plants in the world are optimally reducing levels of pathogenic microorganisms and since a majority of people living in both rural and urban areas will not be connected to centralized wastewater treatment systems, alternative sanitation approaches need to be developed in parallel.

Volume 4 provides health-based targets for excreta and greywater use that may be achieved through different treatment barriers or health protection measures. The barriers relate to verification monitoring, mainly in large-scale systems, as illustrated in Table 6. The health-based targets may also relate to operational monitoring, such as storage as an on-site treatment measure or further treatment off site after collection. This is exemplified for faeces from small-scale systems in Table 7.

Table 6: Guideline values for verification monitoring of large-scale treatment systems of greywater, excreta and faecal sludge used in agriculture

	Helminth eggs (number per gram total solids or per litre)	***E. coli* (number per 100 ml)**
Treated faeces and faecal sludge	<1/g total solids	<1000/g total solids
Greywater for use in:		
• Restricted irrigation	<1/litre	$<10^{5}$ [a] Relaxed to $<10^{6}$ when exposure is limited or regrowth is likely
• Unrestricted irrigation of crops eaten raw	<1/litre	$<10^{3}$ Relaxed to $<10^{4}$ for high-growing leaf crops or drip irrigation

[a] These values are acceptable due to the regrowth potential of *E. coli* and other faecal coliforms in greywater.

Table 7: Recommendations for storage treatment of dry excreta and faecal sludge before use at the household and municipal levels

Treatment	Criteria	Comment
Storage; ambient temperature 2–20 °C	1.5–2 years	Will eliminate bacterial pathogens; regrowth of *E. coli* and *Salmonella* may need to be considered if rewetted; will reduce viruses and parasitic protozoa below risk levels. Some soil-borne ova may persist in low numbers.
Storage; ambient temperature >20–35 °C	>1 year	Substantial to total inactivation of viruses, bacteria and protozoa; inactivation of schistosome eggs (<1 month); inactivation of nematode (roundworm) eggs, e.g. hookworm (*Ancylostoma*/*Necator*) and whipworm (*Trichuris*); survival of a certain percentage (10–30%) of *Ascaris* eggs (≥4 months), whereas a more or less complete inactivation of *Ascaris* eggs will occur within 1 year.
Alkaline treatment	pH >9 during >6 months	If temperature >35 °C and moisture <25%, lower pH and/or wetter material will prolong the time for absolute elimination.

[a] No addition of new material.

Table 8: Recommended storage times for urine mixture based on estimated pathogen content and recommended crops for larger systems

Storage temperature (°C)	Storage time (months)	Possible pathogens in the urine mixture after storage	Recommended crops
4	≥1	Viruses, protozoa	Food and fodder crops that are to be processed
4	≥6	Viruses	Food crops that are to be processed, fodder crops[d]
20	≥1	Viruses	Food crops that are to be processed, fodder crops[d]
20	≥6	Probably none	All crops[e]

[a] Urine or urine and water. When diluted, it is assumed that the urine mixture has a pH of at least 8.8 and a nitrogen concentration of at least 1 g/l.

[b] Gram-positive bacteria and spore-forming bacteria are not included in the underlying risk assessments, but are not normally recognized as a cause of any infections of concern.

[c] A larger system in this case is a system where the urine mixture is used to fertilize crops that will be consumed by individuals other than members of the household from whom the urine was collected.

[d] Not grasslands for production of fodder.

[e] For food crops that are consumed raw, it is recommended that the urine be applied at least one month before harvesting and that it be incorporated into the ground if the edible parts grow above the soil surface.

Conclusion

These four volumes therefore provide important guidance on management of wastewater, greywater and excreta for productive end-use, which covers technical, policy and health issues. It is recommended that anyone working in these sectors should refer to these Guidelines, especially where unregulated use is currently taking place. It should also be noted that this use may be direct or indirect, where wastewater, greywater or excreta have contaminated sources of water that are being used for irrigation, as is likely to be the case in Sri Lanka and will increase as the population increases unless steps are taken now.