Improving management of urban wastewater use in agriculture, Rajshahi, Bangladesh

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Untreated wastewater is used informally for irrigation in many developing countries. This use needs to be managed to reduce the risks while maintaining its benefits. This paper documents the experience and lessons from a project in Rajshahi, Bangladesh, that aimed to do this. In line with the 'multi-barrier approach' advocated by the World Health Organization, a learning alliance approach was adopted whereby local stakeholders were brought together to analyse the issues, and implement a participatory action plan to deal effectively with the wastewater problem. The process resulted in negotiation between parties that rarely communicated previously and led to demand-driven actions including engineering solutions, policy review and community awareness programmes. While it built capacity and resulted in integrated solutions, it was resource intensive, and as the work is recent its sustainability is yet to be reviewed. This approach could facilitate stakeholders to effectively tackle wastewater reuse if certain constraints are overcome.

Keywords: wastewater, agriculture, irrigation, sanitation, learning alliance, participatory action plan, WHO guidelines, risk

Wastewater use in agriculture is a growing phenomenon

WASTEWATER USE IN AGRICULTURE is a growing phenomenon (Scott et al., 2004) especially where population densities are increasing and freshwater is scarce. The nature of this use varies considerably from the planned use of wastewater following treatment to the use of contaminated water bodies. Raschid-Sally and Jayakody (2008) define three categories:

- Direct use of treated wastewater.
- Indirect use of untreated wastewater, when water is abstracted from a river that receives wastewater. In this instance the farmer may or may not be aware of the contamination.

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- Direct use of untreated wastewater, where fields are irrigated directly from sewage outlets. This usually comes about when traditional irrigation channels are used for urban drainage.

The global extent of wastewater use in agriculture is not fully known although several studies have compiled such information (Hamilton et al., 2007; Jiménez et al., 2009). One reason for this is the inherent difficulties associated with the various definitions of wastewater reuse. In particular it is difficult to estimate the extent of indirect use of untreated wastewater. Considering that global wastewater production is estimated to be 1,500 km^3 per year (UNESCO-WWAP, 2003), and that more than 80 per cent of wastewater in developing countries is discharged untreated (UNESCO-WWAP, 2009), this has the potential to pollute a considerable quantity of fresh water, which may be used downstream for agricultural purposes. UNESCO estimates that 50 per cent of the population of developing countries depends on polluted water sources for various livelihood activities (Shiklomanov, 1999).

Half of the population of developing countries depends on polluted water for livelihood activities

This presents a major challenge for many developing countries. They are producing large quantities of wastewater that may have benefits for agriculture, particularly because water is available throughout the year, but which also poses risks to human and ecosystem health (WHO, 2006; Jiménez et al. 2010 forthcoming). Tackling this multidimensional issue is not easy, especially as financial resources are often limited and technical capacity does not always match the needs. Where unplanned wastewater use currently takes place and where there are inadequate facilities or funding to effectively address the issue, the World Health Organization (WHO, 2006) advocates a pragmatic approach designed to reduce health risks in the short term and therefore ensure that all countries achieve the same level of protection. The approach is based on interventions taking place along the whole pathogen chain from wastewater generation, to use on fields, to the point at which crops are consumed. Some of the proposed interventions target farmers and others target consumers. Interventions range from the introduction of alternative (e.g. non-food) crops, irrigation techniques that reduce contact between wastewater and crops, use of protective clothing, to vegetable washing and cooking. This 'multi-barrier approach' also includes wastewater treatment and does not imply a two-tier system in which wealthy countries treat their wastewater before use and developing countries are expected to rely on inferior options. In fact it provides a practical and progressive approach tailored to the capacity of each country, whereby the health risk reduction can be more immediate and potentially sustainable, at the same time as meeting the ultimate goal of reducing the quantity of untreated wastewater released to the environment and used in agriculture.

WHO advocates a pragmatic approach designed to reduce health risks in the short term

However, even implementing some of the less conventional and supposedly shorter-term, less complex and costly 'non-treatment' interventions has not proved to be easy in developing countries. The informal nature of wastewater use and the fact that it is often illegal makes it difficult to address the target group and implement measures that appear to support the practice, or to enforce measures that may not be immediately desirable to farmers. Furthermore the WHO *Guidelines for the Safe Use of Wastewater, Excreta and Grey Water* (2006) are not yet widely disseminated to local authorities, agriculture departments and farmers, and therefore awareness of the options is limited in the places where they are needed. The challenge is to determine how some of the options suggested in the WHO Guidelines can be put into practice.

The challenge is to put the WHO Guidelines into practice

Planning for multi-barrier interventions

This paper presents a case study in which a variety of stakeholders, including local authorities, agriculture departments, city residents (wastewater producers and consumers of wastewater produce), wastewater farmers, non-governmental organizations (NGOs) and academic institutions were brought together to review the existing wastewater use situation and to suggest, and where possible implement, appropriate options in line with the 'multi-barrier approach'. A primary objective was to encourage the stakeholders to think about all the problems associated with wastewater management and use in agriculture, along the entire chain from wastewater production to consumption of wastewater irrigated crops – colloquially known as 'flush to fork'. The next step was to facilitate them to identify barriers along that chain.

Stakeholders are encouraged to consider the risks of wastewater use along the chain from 'flush to fork'

The case study arises from the Wastewater Agriculture and Sanitation for Poverty Alleviation in Asia (WASPA Asia) project. This project was funded primarily by the Asia Pro Eco II Programme of the European Commission from December 2005 to December 2008. It was implemented in Sri Lanka and Bangladesh, in cities where informal wastewater agriculture was already taking place. In Kurunegala, Sri Lanka, the main crop was paddy, which was irrigated through a canal system. This posed different and lower health risks to farmers, their families and consumers. This is because the farmers do not enter the drains, as they do in Rajshahi, and because the rice grain does not come into direct contact with the wastewater; it is husked; and is always eaten cooked. In Rajshahi, Bangladesh, key wastewater-irrigated crops included vegetables such as cauliflower and tomato. These crops may be eaten raw and can present a greater health risk along the harvesting to consumption chain, due to transmission of pathogens to other crops in the market, to the hands of transporters and traders, These crops may be eaten raw and can present a greater health risk

and ultimately into the kitchen. The case of Rajshahi, Bangladesh, is presented here because of the many points at which interventions could be introduced to reduce these risks (for a broader review of the processes used in the WASPA Asia project see Evans and Varma, 2009; Varma et al., 2009[Q1]; and Smits et al., 2009[Q1]).

In both cities there was inadequate sanitation, open drains that were illegally used as sewers and no wastewater treatment facilities (in Kurunegala the Government Teaching Hospital had a non-functioning activated sludge plant). These conditions also occur in many other cities across Bangladesh and South Asia. For example 26 per cent of the urban population of Asia have no sanitation facilities and approximately 50 per cent of households are not connected to a sewer (UNESCO-WWAP, 2009).

This paper first provides a summary of the rapid assessments undertaken to understand the setting and issues that needed to be tackled. The process followed is then briefly explained, including the development of a learning alliance (LA) and the planning and implementation of the participatory action plan (PAP) for Rajshahi. The specific activities in the PAP that were undertaken are described including the negotiation and collaboration required to complete these activities and the final outputs. Examples of the actions undertaken are presented to provide generic experiences and more importantly lessons that can be applied in similar projects. Although the lessons relate specifically to the implementation of barriers to reduce risk in wastewater agriculture, the process and lessons from the LA and PAP development are applicable to many other situations.

Materials and methods

The storm water drainage system also receives significant quantities of domestic and commercial wastewater

Rajshahi City is located in the north-west of Bangladesh and had a population of approximately 0.8 million in 2005 (Bangladesh Bureau of Statistics, 2005). The city has an extensive drainage network that, although initially designed to collect storm water, now also receives significant quantities of domestic and commercial wastewater including effluent from healthcare facilities and small industries, in particular the silk industry. There are no wastewater treatment plants and many households use settlement tanks to collect their domestic wastewater – these are commonly referred to as septic tanks but in reality they are not properly designed or maintained and provide little treatment apart from the settlement of solids before the wastewater is discharged illegally into the drains. Most of the drains are uncovered and as a result they also receive large amounts of solid waste (Clemett et al., 2007). The agricultural area selected for project implementation is 98 ha in extent and farmed by 250 farmers (Jayakody et al., 2007). It is irrigated by two main drains: Circuit House Drain and Dargapara Drain.

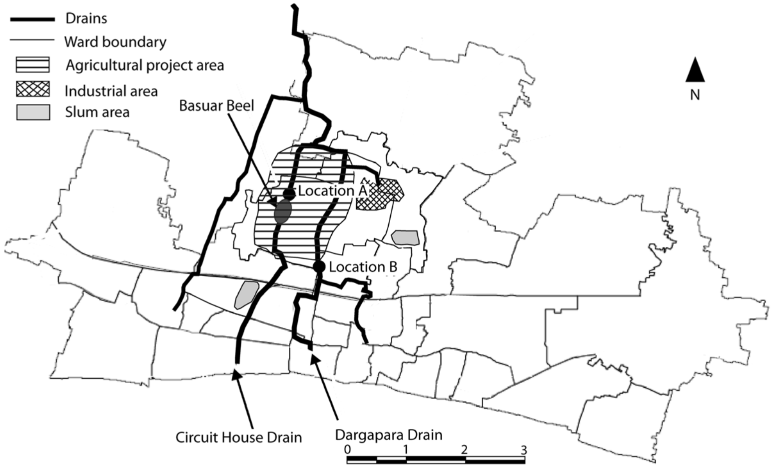

Figure 1 Agricultural project area and drainage system in Rajshahi, Bangladesh. Water quality sampling locations are also denoted

Farmers use wastewater because they do not have access to any other reliable water source

A variety of crops are grown around Rajshahi but, as can be seen from Figure 2, the mix of crops grown in the wastewater-irrigated area is more diverse and includes several vegetables. Farmers in this area use wastewater because they do not have access to any other reliable water source and because the year-round availability of wastewater means that they do not have to practise any form of crop rotation. It also allows them to grow high-income crops.

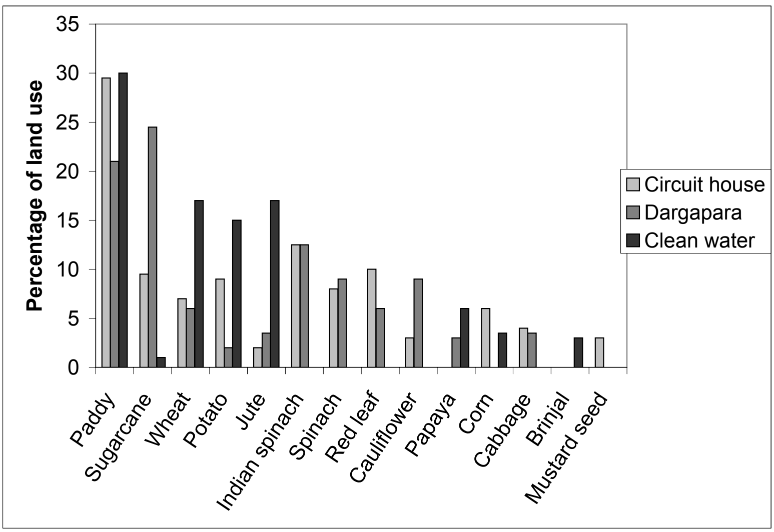

Figure 2 Percentage of the land area covered by the main crops in the wastewater (Circuit House and Dargarara) and clean water-irrigated areas.

The project included a number of interlinked but diverse disciplinary aspects and was therefore undertaken by a multi-disciplinary team from Bangladesh, Sri Lanka and Europe. The Bangladesh team from NGO Forum for Water Supply and Sanitation was responsible for the overall facilitation of the process, and included a sociologist, health specialist, agricultural specialist, an engineer and a process documentation officer. The team was supported by specific technical inputs from the International Water Management Institute (IWMI) and the COSI Foundation, in Sri Lanka, on agriculture, water quality and parasitology; and the International Water and Sanitation Centre (IRC) in the Netherlands on institutional analysis, LAs and PAPs. In addition, several local NGOs took on specific roles such as coordinating farmers meetings. The entire team worked very closely together.

Rapid assessment

The whole wastewater system from production to use was explored

The first step in the approach was for the project team to increase their own and the other stakeholders' understanding of the whole wastewater system from production to use, and work with the stakeholders to identify the problems that were of most concern to them. This research covered the policies and institutions of relevance to the sector: existing agricultural practices and farmers' perceptions; the sanitation, hygiene and waste management situation in the city; and water quality analysis. A quick (six month) assessment was made of these issues through:

- separate interviews on agricultural practices and health perceptions of farmers and sanitation and health issues in the household;
- focus group discussions on agricultural and wastewater issues with residents and farmers;
- transect walks along the drains with various stakeholders from the LA;
- mapping (using both GPS and community maps) of drains, wastewater inlets and potential sources of pollution that were additional to household wastewater: for example, hospitals, clinics, industries (small and medium) and other commercial enterprises (hotels, restaurants, markets);
- water quality analysis along the drains (one sampling event with three replicate samples).

Water quality measurements were taken at nine locations

Water quality measurements were taken at nine locations along both drains from the urban to agricultural areas in February 2007; that is, towards the end of the dry season when the contaminant and pathogen concentrations are likely to be highest as there is minimal dilution of the drain water by storm water runoff events. This is also the period when the farmers rely most heavily on the wastewater drains for irrigation. While the water quality data gathered was not extensive it was able to provide an impression of the situation that could be presented in the LA meetings. It was seen as a first step to stimulate discussion and to identify areas that would require more detailed data collection for decisions to be made.

Developing the learning alliance (LA)

Learning alliances are multi-stakeholder platforms that facilitate the scaling up of innovations

In parallel, the project team worked to establish a LA with the stakeholders in the city. A LA is a series of multi-stakeholder platforms at different institutional levels intended to facilitate the scaling up of innovations (Smits et al., 2007). It is defined as a:

> process undertaken jointly by research organizations, donor and development agencies, policy makers and the private sector through which good practices, in both research and development, are identified, shared, adapted and used to strengthen capacities, improve practices, generate and document development outcomes, identify future research needs and potential areas for collaboration and inform both public and private policy decisions (Lundy and Gottret, 2006).

The LA was designed to bring the local stakeholders together to analyse and address the issues, deal with conflicting interests, strengthen capacity and collaboration (Smits et al., 2007; Verhagen et al., 2008), improve the sense of ownership, responsibility and accountability and increase the likelihood of sustainability. The LA members were supported to develop a PAP with strategies and activities that could be jointly undertaken by the project team and stakeholders. A schematic of the process undertaken by the WASPA Asia project is provided in Figure 3. The process was iterative, whereby the steps of understanding the situation, planning, implementing and assessing were all repeated as the project progressed.

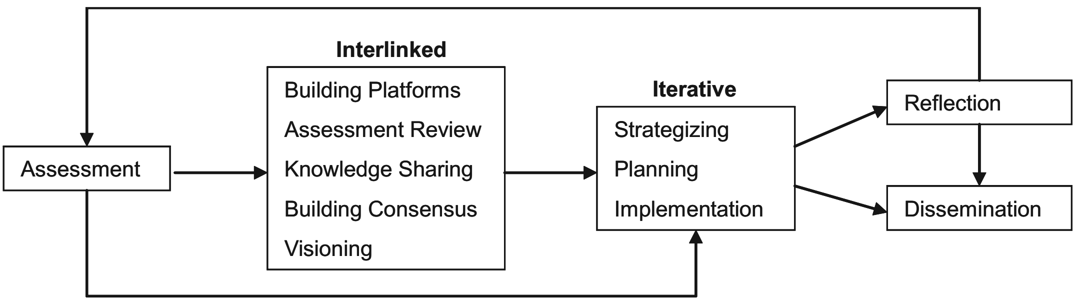

Figure 3 The WASPA Asia project process
Source: Evans and Varma (2009)

The LA included representatives from: the local farming community; Rajshahi City Corporation (RCC); Ward Commissioners (official community representatives); Rajshahi Development Authority (RDA); the Department of Agriculture Extension (DAE); the Bangladesh Small and Cottage Industries Association (BSCIC); National Association of Small and Cottage Industries of Bangladesh (NASCIB); Rajshahi Medical College Hospital (RMCH); Clinics Association; Bangladesh Environmental Lawyers Association (BELA); and local partner NGOs.

Results

Crop yields and water quality

Problems included smells, skin diseases, reduced crop yield and damage to irrigation pumps

Despite the benefits of wastewater use, farmers identified a number of problems associated with the wastewater including smells, skin diseases, mosquito nuisance, pest attacks, reduced crop yield and damage to irrigation pumps due to the high solid waste content in the water. The comparison of crop yields between the fields irrigated with wastewater and nearby fields irrigated with groundwater indicated that while the paddy yield is lower for the wastewater plots with an average yield of 3.9 t/ha compared with 4.7 t/ha for the groundwater plots, the wheat yields were similar for both areas with average yields of 3.4 t/ha (Jayakody et al., 2007). The study also found that the quantity of fertilizer used varied significantly between farmers in both areas and that the application rates used did not reflect the government guidelines or the nutrient concentrations in the wastewater. This highlighted the need the farmers had for information and collaboration with the DAE and led to additional soil analysis and modifications to common fertilizer recommendations by the DAE (ongoing).

The water quality measurements indicated that the main potential health risks from wastewater irrigation to wastewater farmers and also the communities residing near the drains appear to be microbial and parasitological contamination. In most cases the water quality was within the standards for disposal to irrigated land specified in the Bangladesh Environmental Conservation Rules, 1997 (Government of Bangladesh, 1997). The faecal coliform counts, however, were consistently above that recommended in the WHO *Guidelines for the Safe Use of Wastewater, Excreta and Grey Water* (2006) (Table 1).

WHO recommends less than 1 helminth ovum per litre of irrigation water

Parasitological data was collected at three points, two in the city and one at the start of the agricultural area. The limited sampling was partly due to the fact that facilities and skills for this task are limited in the area and partly because an indication of the presence of parasites was sufficient; the WHO (2006) recommends less than 1 helminth ovum per litre of irrigation water (WHO, 2006). The results show that the WHO Guidelines were significantly exceeded

Table 1 Baseline water quality analysis (February 2007)

Parameter	*Unit*	*A*[3]	*B*	*C*	*D*	*E*	*G*	*H*	*I*	*J*	*X*	*Y*	*Water quality guidelines*[2]
pH		6.85	6.7	5.45	6	6.67	6.75	6.85	7.01	7.01	7	7	**
Temperature	°C	21	21	22	27	25	23	24	24	25	25	23	40–45
Total dissolved solids	mg/l	1,040	920	1,200	1,000	1,160	1,200	1,040	960	1,040	*	*	2,100
Electrical conductivity at 25°C	mS/cm	1,200	1,152	1,315	1,246	1,255	1,501	1,535	1,589	1,575	*	*	1,200
Nitrate (as N)	mg/l	0.2	0.2	0.2	0.3	1.8	0.3	0.3	0.2	0.2	0.4	0.2	10
Nitrite (as N)	mg/l	0.006	0.006	0.004	0.146	0.796	0.008	0.006	0.005	0.005	0.032	0.012	**
Free ammonia	mg/l	14.5	15	30.4	24.5	18	37	36.2	38.8	37	1.2	1.9	15
Total nitrogen (as N)	mg/l	17	27	37	28	27	42	54	43	41	2	3.2	100
Orthophosphate (as PO4)	mg/l	4.3	4.4	9.1	6.5	5.2	10.8	9.9	10.3	10.4	0.2	0.1	**
Total phosphorus (as P)	mg/l	4.9	4.6	9.7	8.9	6.4	11.4	9.9	12.2	14	0.4	0.6	10
Boron	mg/l	0.5	0.1	<0.1	0.1	0.2	0.2	0.1	0.3	0.3	<0.1	<0.1	2
Potassium	mg/l	*	*	*	21.4	26.8	28.6	26.8	28.6	35.7	1.6	2.7	**
Sodium (Na)	mg/l	*	*	*	88.9	106.7	111.1	111.1	115.6	120	48.9	71.7	**
Calcium (Ca)	mg/l	*	*	*	67.7	88. 9	88.3	108.5	113.0	116.0	48.0	104.5	**
Magnesium (Mg)	mg/l	*	*	*	18.9	27.6	24.1	25.6	28.7	30.6	9.3	26.7	**
Sodium absorption ratio (SAR) calculated[1]	mmol/l				13.5	14.0	14.8	13.6	13.7	14.0			**
Coliform	CFU/ 100 ml	$2x10^8$	$2x10^8$	$2x10^7$	$3x10^6$	$2x10^6$	$1x10^7$	$2x10^7$	$2x10^7$	$1x10^7$	$5x10^1$	$2x10^1$	**
Faecal coliform		$2x10^7$	$1x10^7$	$2x10^7$	$2x10^4$	$4x10^3$	$4x10^3$	$8x10^3$	$4x10^5$	$6x10^6$	0	0	$1x10^3$
COD	mgO2/L	200	124	261	83	151	241	185	153	189	12	15	400
BOD5 at 200C	mgO2/L	65	52	112	22	52	112	70	72	80	<1	<1	100
DO	mgO2/L	0.9	0.9	0	2	2	1.4	0	1.8	0.2	1.4	0.8	4.5–8
Total suspended solids	mg/l	90	70	180	80	160	140	90	40	110	5	20	200
Iron (Fe)	mg/l	*	*	*	0.8	5.27	2.4	1.48	1.45	2.28	4.49	6.95	2
Mercury (Hg)	mg/l	2	2	1	1	1	1	1	2	21	1	1	10
Arsenic (As)	mg/l	*	*	*	0.005	0.007	<0.003	<0.003	<0.003	0.005	0.019	0.047	0.2
Cadmium (Cd)	mg/l	*	*	*	0.003	0.007	0.004	0.008	0.006	0.006	0.003	0.007	0.5
Chromium (Cr)	mg/l	*	*	*	<0.02	0.04	0.05	0.08	0.09	0.12	0.11	0.1	1
Copper (Cu)	mg/l	*	*	*	0.04	0.06	0.02	0.03	0.04	0.04	0.02	0.03	3
Lead (Pb)	mg/l	*	*	*	0.31	0.4	0.4	0.36	1.03	0.44	0.48	0.55	0.1
Nickel (Ni)	mg/l	*	*	*	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	1

Notes:
[1] SAR was calculated only for the drain water where the Ca, Mg and Na were tested.
[2] Guideline values are those specified in the Bangladesh Environmental Conservation Rules 1997 for disposal to irrigated land (Government of Bangladesh, 2007). The exception is the faecal coliform parameter which is from the WHO Guidelines (2006).
[3] A = Circuit House Drain within the city; B = Circuit House Drain further along the drain past residential areas; C = Circuit House Drain inlet to Basuar Beel; D = Basuar Beel; E = Circuit House Drain outlet from Basuar Beel and start of the agricultural area; G = Dargapara Drain entry point to the city; H = Dargapara Drain entry point to agriculture area; I = Dargapara Drain exit point from agriculture area; J = Dargapara Drain after confluence with industrial drain; X = Groundwater well near Basuar Beel in Basuar Village; Y = Groundwater well near Basuar Beel in Basuar Village. Sampling point locations are denoted in Figure 1.

(Table 2). Parasitic protozoa, hookworms, round worms and cestodes were found in the samples, indicating faecal contamination. The fluke eggs are thought to be of animal origin, as they are not reported from humans in Bangladesh. The increase in fluke and other worm eggs at the outlet of Basuar Beel (location E) suggests a new source of contamination, possibly animals, the latrines that empty directly into the *beel* or the inlet of another drain just before the sampling point.

Leafy vegetables such as spinach are known to benefit from high nutrient concentrations

The nutrient concentrations were also found to be high but this is unlikely to have serious health implications since the water is not used for drinking. The negative agricultural impacts noted by the farmers and common to wastewater-irrigated areas are excessive vegetative growth at the expense of grain yield and also a higher incidence of pest attacks (Pescod, 1992). In contrast, leafy vegetables such as spinach are known to benefit from the high nutrient concentrations.

Concentrations of the metals iron (Fe), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb) and nickel (Ni) in the wastewater were found to be below the WHO (2006) recommended maximum concentrations for crop production (Table 1). This indicates that these contaminants are also unlikely to be a major cause for concern at the project site; at least in the short term (Pescod, 1992). A survey of the factories in the nearby BSCIC area was conducted to review the industry types, specific processes and chemicals used. The survey supported the water quality measurements as the industries were not found to be contributing significant quantities of heavy metals to the wastewater. Although it is unlikely that the wastewater from these industries will present significant risks to agriculture or to the health of farmers in the near future, this does not mean that prudent measures should not be taken to minimize the pollution.

Solid waste in the open drains was perceived as a major problem

Solid waste deposited in the open drains was perceived as a major problem by many of the stakeholders in Rajshahi. For the farmers the problem is quite severe because the solid waste can enter and block the pumps used to pump water from the drains onto the fields. This causes damage to the pumps that can be expensive to fix and interrupts the farmer's irrigation schedule.

Table 2 Baseline parasitological analysis (February 2007)

	Number in sediment of 10 l sample		
Parasite	*Location A*	*Location B*	*Location E*
Cysts of *Entamoeba coli*	47	30	7
Ova of fluke spp.	12	15	1,500
Larval forms (parasitic and non-parasitic)	8	5	2–3
Other worm eggs (*Ascaris* and cestode spp.)	28	33	1,200
Ova of hookworms	1	–	–

Sanitation and hygiene situation

> Some activities brought villagers into direct contact with the wastewater

A sanitation and hygiene assessment focusing on the communities living along the drain, near the agricultural area and Basuar Beel (Figure 1), indicated that they engaged in a number of domestic and income-generating activities that bring them into direct contact with the wastewater. These included not only irrigation but also bathing, and the washing of clothes and utensils in the *beel*. The majority of households surveyed (n=87) use sanitary latrines with concrete squatting pans and floors (62 per cent), 37 per cent use pit latrines with no improvements such as squatting pans, and 1 per cent use hanging latrines. Despite the good physical sanitation infrastructure, the survey found that hygiene practices, such as hand washing, are not routinely practised and the community members made little connection between the disposal and use of wastewater and possible negative impacts on health (Amerasinghe et al., 2007). Furthermore at least 12 of the latrines empty directly into the *beel* and others flow into ponds, suggesting that improvements could be made in the storage and treatment of wastewater.

The institutional setting

An institutional assessment was also conducted to understand the responsibilities and activities of the relevant organizations in the areas of sanitation, wastewater management, agriculture and environment. This analysis was essential to identify the roles that each stakeholder group should play in the LA and in the implementation of the PAP. There are a number of government organizations that are responsible for different aspects of sanitation and wastewater management including RCC in the metropolitan area and the Department of Public Health Engineering (DPHE) outside the RCC area and also in the low income areas within the city. There appeared to be inadequate coordination between the various agencies and even less engagement with community members in spite of the official local government channels such as ward commissioners and councillors. There was no single organization that addressed issues of wastewater use from either the agricultural or urban wastewater management perspective.

> There appeared to be inadequate coordination between the various agencies

It was also found that, although laws relating to wastewater management and drainage maintenance exist, their enforcement is limited owing to lack of manpower and considerable uncertainty over who is responsible for which aspects. A change of practice and of mindset is therefore needed to integrate wastewater planning into urban and agricultural water resource management. This requires the involvement and strong collaboration between the relevant government departments, principle polluters and farming community (Ara et al., 2007).

Doing things differently: Participatory action planning

The project team reported on the preliminary background assessments to the LA, which provided a starting point for them to analyse the situation as they each perceived it and the problems they experienced. This knowledge-sharing exercise helped to build consensus and create an understanding of the opportunities and constraints that are faced by various stakeholders. The project team also provided an overview of the multi-barrier approach to wastewater use to encourage them to think about all the options available to address these issues. This was essential as initially the stakeholders all wanted a comprehensive sewerage network for the city and a large wastewater treatment plant. In addition the farmers wanted an alternative source of water. Neither was feasible in the short term because of costs and technical constraints, and in the case of irrigation water because there is no nearby canal system and no available groundwater supply.

Initially stakeholders wanted large investments in infrastructure

Based on this shared understanding and discussions, the LA members defined the local priorities for managing the urban wastewater used for agricultural production. They proposed three visions to address the issues:

- improved wastewater management and treatment in the city;
- improved management and treatment of wastewater from industries and medical clinics; and
- improved quality of wastewater for agriculture to enhance crop yields and minimize health risks.

A series of strategies and activities were proposed to achieve each vision. These were negotiated over several months and were included in a comprehensive PAP to be implemented by the relevant stakeholders in collaboration with the project team. The activities were prioritized and those that were easily achievable were rapidly implemented – a strategy that was intended to motivate stakeholders and stimulate them to work on other activities that required more significant negotiation, planning and research. Because the PAP had been developed as a whole unit, implementing the most critical or easily implemented first did not negatively impact on any other activities.

The activities implemented are listed in Box 1 and some are described more fully below. At the time of writing the activities have only recently been implemented and therefore little comment can be made regarding long-term uptake or sustainability; however, where possible, participatory monitoring findings have been included. The main purpose of this section is to show how, through negotiation and comprehensive planning, locally appropriate solutions can be selected and systems to maintain them agreed upon. This would be far less likely to happen if stakeholder groups were to act alone.

Locally appropriate solutions can be selected and systems to maintain them agreed upon

Box 1. PAP activities implemented in Rajshahi (2007–2008)

Construction of a garbage trap in the drain
Agricultural training for wastewater farmers
Nutrient management study and development of training tools
Hygiene promotion to wastewater farmers
Street drama with food handling, solid waste and hygiene messages
Dissemination of products with wastewater and sanitation messages
Review of relevant regulations and their implementation
Feasibility study for small-bore sewerage system
Study on cleaner production solutions for small industries
Awareness raising on cleaner production for small industries
Scoping study to improve the treatment capacity of Basuar Beel

Construction of a garbage trap. The farmers requested that solid waste should not reach their field and proposed that a trap should be built across Dargapara Drain on the outer limits of the urban area (Figure 1). The location was selected by RCC and the farmers after some negotiation, and the trap was designed by the project team and RCC engineers. After several discussions it was agreed that the long-term operation and maintenance of the trap would be performed by RCC who are already responsible for cleaning drains and streets. Since the official completion of the WASPA project (December 2008), RCC has continued to maintain the garbage trap and is currently considering construction of another garbage trap on Circuit House Drain. Local stakeholders confirm that since the installation there is considerably less solid waste in the drain.

Garbage trap on the drain

Agricultural practices could be improved in order to make use of the nutrients and reduce health risks

Training for farmers using wastewater. The farmer survey, water quality analysis and discussions revealed that agricultural practices could be improved in order to increase productivity and income, make use of the nutrients in the wastewater and reduce health risks. Hygiene practices associated with the use of wastewater were promoted in meetings held twice a month over a period of 12 months between project staff, local partner NGOs and farmers. These meetings enabled the project team to provide information but more importantly farmers shared their concerns and experiences and sought support from one another to develop appropriate solutions. This is much more sustainable than relying on external information, especially in a project with a set time frame. The LA also linked these farmers to other organizations that could provide them with support and technical information such as DAE and the Civil Surgeon's Office.

The DAE now supports the farmers in this area far more than it did before. DAE had previously felt that these farmers did not need support and had marginalized them because they were not from an official irrigated area. However, the DAE was extremely interested in the issue of fertilizer management where nutrients are provided in wastewater and also in the wide variety of crops grown in the area. As a result the DAE engaged in research on these issues and provided training for the farmers on fertilizer and pesticide application rates, crop rotation and soil quality. They also produced fertilizer guideline pamphlets based on soil and water samples from the project area. Training sessions were conducted by the DAE Chief Metropolitan Officer with over 100 farmers attending in several sessions. A high attendance rate at these sessions illustrates the farmers' willingness to learn ways to improve their farming practices and the fact that they have been under-supported by DAE in the past. To date, the DAE has continued to have strong interactions with the farmers including monitoring to ensure that the fertilizer guidelines are followed. Farmers from the project area are now also part of the integrated crop management (ICM) group coordinated by DAE and this means that interaction between the two stakeholders is likely to continue.

The farmers are now also part of the integrated crop management group

Community awareness of hygiene practices, sanitation and handling of wastewater crops. Many of the stakeholders felt that a general improvement in hygiene and sanitation practices was required to reduce health risks in the city. Different options were discussed for addressing this, especially with the Civil Surgeon's Office and community members. It was agreed that a community awareness campaign would be conducted across the whole city and that it would be undertaken cautiously so that the livelihoods of wastewater farmers were not negatively affected by the campaign. This was a joint decision made by both the LA members and the project team. As such the programme, implemented with

The community awareness campaign had to be conducted cautiously

Street theatre publicized hygiene messages

the support of the Civil Surgeon's Office and building on their existing campaign methods, focused on food safety in general rather than only on the risks of wastewater-irrigated crops. Posters and calendars were disseminated to households, clinics and markets; these portrayed messages such as hand washing, the washing of vegetables before consumption, and the consequences of throwing solid waste in the drains. Street theatre performances were also conducted all over the city every night for a week. These performances drew large crowds who, when interviewed, appeared to have thoroughly grasped the message. The performances were also filmed so that they can be used again.

Review of regulations and their implementation. A review of relevant regulations and laws in Bangladesh and Rajshahi, and identification of the roles and responsibilities of organizations in relation to these laws, was considered crucial by the LA members. They felt that it was necessary to identify factors hindering the effective implementation of the regulations and based on this to make suggestions for improvement. In collaboration with the Bangladesh Environmental Lawyers Association (BELA), the project team commissioned a review by Rajshahi University. This review indicated that wastewater is typically not acknowledged as a major element of water management in existing laws and policies in Bangladesh. In addition there is considerable complexity and confusion with regard to the power of

Wastewater is typically not acknowledged as part of water management in existing laws in Bangladesh implementing authorities, in particular conflicting administering power between various national and local government bodies. The review recommended: the development of a more comprehensive water policy that covered wastewater use; substantial improvement to the environmental laws to go beyond their existing focus on industrial pollution; integration of the term 'wastewater' into existing laws; improvement in the coordination between agencies implementing the various acts associated with wastewater management; and delegation of greater authority to local governments to implement existing laws. The report was presented to the LA by Rajshahi University, and BELA intends to take up this issue in future projects.

One of the main desires of all the stakeholders was wastewater treatment

Feasibility study of small-bore sewage system. One of the main desires of all the stakeholders was wastewater treatment. The project team therefore commissioned a study by the Bangladesh University of Engineering and Technology (BUET) into the feasibility of separating toilet waste and conveying it though a small-bore sewage (SBS) system to an appropriate treatment facility (e.g. a waste stabilization pond or constructed wetland). As the treatment of wastewater is largely unregulated and unmonitored, the initial stage of this activity was to map and quantify the wastewater (domestic and industrial) discharged to the open drains in Rajshahi, and to understand the different methods used by households and industries to treat and dispose of their wastewater. This understanding built on the baseline survey. The SBS system was recommended to be designed and installed in a step-wise manner whereby each of the major catchment drains was sequentially upgraded.

The RCC was fully involved in the investigation by BUET as RCC would ultimately be responsible for commissioning an SBS system if it felt it suited its purposes. BUET also conducted a survey of residents to obtain their opinions before proposing any technical solutions. The BUET team received a positive response and many stakeholders that had originally believed that conventional sewers and a large-scale treatment plant were the only option, became open to alternative solutions. At the end of the project period discussions were ongoing between BUET and RCC, and proposals were being planned.

The silk factories produce the largest amount of wastewater

Investigation of cleaner production options for local industries. Although there are various types of industry in the Bangladesh Small and Cottage Industries Association (BSCIC) area in Rajshahi, it is dominated by silk factories and these units produce the largest amount of wastewater. Although the baseline survey of the factories found that they were not contributing significant quantities of pollutants to the wastewater, their contribution was nonetheless perceived as a potential risk by the stakeholders. As a result, Jahangirnagar University was commissioned to undertake a survey of the processes and chemicals used, and developed a series of cleaner production options that could be implemented in the silk factories to reduce the pollution.

This study was done in close collaboration with BSCIC and the National Association of Small and Cottage Industries of Bangladesh (NASCIB), who facilitated the university to work with one silk factory to introduce cleaner production solutions on a pilot basis. The solutions proposed ranged from basic changes, such as improved housekeeping, process optimization and raw materials substitution, to more significant modifications such as new technology and new product design. Based on this pilot study, the university conducted a workshop with other factory owners and workers to provide information and training and disseminated cleaner production guidelines (see http://www.iwmi.cgiar.org/waspa/publications.htm). The study demonstrated to the factories that simple methods can be adopted to save money, time and energy, while simultaneously reducing the pollutants. It also demonstrated to other stakeholders that there are simple yet effective options that could be tried before wastewater treatment plants are necessary, especially as these are small industries with limited production and restricted budgets to invest in effluent treatment.

Simple yet effective alternatives to wastewater treatment plants could be tried

Investigation of natural wastewater treatment options. Water quality measurements indicated that Basuar Beel is currently acting as a form of waste stabilization pond, with microbial processes reducing the organic load and small particles settling out (including helminth eggs). The stakeholders, particularly RCC and farmers, wanted to assess and quantify the existing natural treatment capacity of the *beel* and to provide feasible options to enhance these treatment processes. Jahangirnagar University was commissioned to undertake this study. This work supported the feasibility study on SBS by BUET in potentially providing a low cost option for wastewater treatment across the city, since there are many similar lakes, ponds and *beels*.

A series of options and recommendations to improve the wetland's treatment capacity were presented to the LA members. As with the previous study, Jahangirnagar University's involvement was intended to promote knowledge development and sharing between national stakeholders and thereby increase opportunities for out-scaling to other areas in the country, which was an important element of the project.

Discussion and lessons learnt

Lessons from the LA approach

The LA approach provided the platform for all stakeholders to think about and implement opportunities to reduce risks for human and

The LA approach provided the platform for all stakeholders to consider how to reduce risks to health

environmental health. In applying this approach a number of lessons were learnt that are of relevance to other projects that plan to involve stakeholders in order to better inform the research process or to develop locally acceptable interventions.

Developing and facilitating the LA. The initial stages of developing the LA were critical to successful implementation of the project. For example a comprehensive stakeholder analysis was necessary to ensure that all relevant stakeholders were included. Once the stakeholders were identified it took considerable effort by the project team to build a strong working relationship with them. Frequent contact through telephone calls, personal meetings and letters was required and while this was time consuming it was necessary to gain and maintain their interest and support.

Once the LA was established, the success of the meetings and the belief in shared outcomes was dependent on creating an atmosphere that allowed open discussion in which all stakeholders felt heard and respected. This relied on strong facilitation from an experienced person who could handle the various priorities and reactions of the different stakeholders (Verhagen et al., 2008). This was initially a problem in the WASPA project and an external facilitator was hired for meetings in which the visions and strategies for the PAP were developed. As the project progressed and the LA members became more relaxed with one another, the project team was able to facilitate the meetings themselves.

Few farmers' organizations exist in Bangladesh

It was not only during the LA meetings that the project team needed to ensure that participation was equitable. The team also had to establish a structure at the community level so that all farmers could have adequate representation of their ideas in the LA. Although in many countries farmers' organizations already exist, this is rarely the case in Bangladesh. The project team and local NGOs, who were also part of the LA, therefore worked with DAE to establish an informal structure through which farmers could discuss issues and report them to the LA, and through which decisions taken in the LA could be reported back to the farmers.

Since the completion of the WASPA project, the LA does not continue to meet formally but there continues to be significantly greater interaction between various stakeholders. For example, they invite each other to organizational events and have informal discussions on the issue of wastewater management. The facilitation of this continued workable relationship between the stakeholders is a considerable achievement of the LA approach.

Time and resources. What the 'sub-activities' highlight is that the LA approach is very time- and resource-intensive and requires particular skills. Compared with a conventional planning approach with less

The LA approach is very time- and resource-intensive

discussion and negotiation, even before planning can commence it takes considerable time to: identify the relevant stakeholders; build working relationships; introduce the concepts; and discuss background information and issues with the LA members. Agreement from all the stakeholders, each with their own priorities and needs, and development of common shared visions, also takes a significant amount of time.

More time was needed to support the engineering interventions proposed

Given the fixed project time frame, this meant that there was limited time available for the implementation phase of the project and more importantly to work towards ensuring the sustainability of the actions taken. For example, it would have been beneficial to have more time to support the initiation and planning of the engineering interventions proposed in the studies of SBS feasibility, cleaner production and Basuar Beel. Viewing this from a more positive standpoint, however, the outcome of the project was a number of physical interventions and activities designed to encourage behavioural change, which were proposed, agreed and accepted by the recipients. This has considerable advantages over interventions that have not been arrived at through stakeholder consultation (Smits et al., 2007). Furthermore the entire project has opened a range of stakeholders up to new ideas around health risk reduction in wastewater management and use.

Impacts on scaling-up. The intention had been to scale-up the interventions from the city level LA to a national level LA but the time taken to develop the city level LA meant that insufficient resources were put to developing a national platform. Avenues for scaling-up were still explored through bilateral meetings at the national level, sharing experiences and findings through national and international conferences, and partnering with universities. Nevertheless it undoubtedly would have been better if there had been time and resources (mainly manpower) to form a national level LA, as the progress was encouraging and this would also have increased the legitimacy of the project.

Lessons from participatory planning and implementation

The examples of activities planned and implemented collaboratively by the project team and the LA members provide a number of important insights and guidance on how to achieve more from participatory processes in the future. They also showed the need to address the WHO-advocated multi-barrier approach for health risk reduction through multi-stakeholder processes. Some insights are outlined below.

Negotiation and agreement. The development of a PAP and undertaking the activities demonstrated that the LA members were able to effectively negotiate a mutually acceptable plan and agree on the specifics of its implementation. For example the RCC and farmers initially wanted the garbage trap in different locations but after some discussion and site visits they agreed on a mutually convenient place. They also considered different options for management of the trap and jointly agreed that it would be conducted by the RCC as this was likely to offer a longer-term solution. Such negotiations rarely if ever take place between government agencies and community members but the outcome was beneficial to both parties. This example also highlights the importance of long-term plans for operation and maintenance and that no interventions should be implemented without such plans being in place.

Previously government agencies were concerned with infrastructure development, social services and knowledge transfer to the farmers

Responsibility, accountability and involvement. It was initially difficult to motivate stakeholders to take responsibility for initiating interventions and without the project team leading the activities it is unlikely that they would have happened. This is understandable since the project came with a preconceived idea of the issues to address, which although of some concern, were not of the utmost importance to the stakeholders. Previously the bigger issues for the government agencies had been infrastructure development, social services and transfer of technical knowledge to the farmers. The farmers had been primarily concerned with water and fertilizer availability and marketing of their produce. The challenges and opportunities related to wastewater was a new issue for many of the stakeholders. As a result acceptance of responsibility was slow and funding and mandates for action did not always exist. The time component is again an issue here. Even if certain stakeholders agree on certain actions, their budgets do not allow them to be implemented until the next financial year. The drawback of this was that the stakeholders were not accountable for the success of the PAP during the project period and this hampered progress.

The project team overcame these challenges to an extent by attempting to implement some activities quickly to increase momentum and stimulate involvement. By rapidly implementing activities that were easily achievable, LA members and the wider community saw that the project had the potential to make a significant difference. This made them more supportive of other aspects of the PAP that required more negotiation, stakeholder involvement and commitment. The approach appeared to work with the implementation of activities speeding up considerably in the last nine months of the project. By this stage the WASPA project had built a substantial level of awareness among the stakeholders. The stakeholders' involvement in the construction, operation and maintenance of the garbage trap, assistance in selection of strategic locations for the hygiene awareness campaigns, and the frequent interactions between the farmers and DAE are indications of this heightened awareness.

Frequent interactions between the farmers and DAE are indications of this heightened awareness

Information sharing. Continuously providing the stakeholders with updated information, for example sharing results of progress monitoring and the status of the activities was also vital for maintaining interest and enthusiasm. Increasing the flow of information, ideally in both directions, should be an objective of all participatory projects and identifying and improving tools to achieve this in the given setting should be an ongoing part of the process (Warner, 2005). For this project a number of methods were adopted including meetings, newsletters and field visits.

Long-term monitoring, operation and maintenance must be planned for

Planning for monitoring, operation and maintenance. Monitoring is the main assurance of the sustainability of the solutions implemented. While the project team was responsible for monitoring within the project period, it was important to work with the stakeholders to develop sustainable monitoring systems that take into account the available local resources. It is essential that long-term monitoring, operation and maintenance are considered during the planning stages, particularly for technical interventions, otherwise solutions may rapidly become defunct for various reasons including human, institutional and technical capacities, budgeting and cash flow.

Conclusions

The LA approach increased the likelihood of more realistic, integrated and acceptable interventions

This project demonstrated the value of a multi-stakeholder approach for designing and implementing interventions to safeguard public health, especially in relation to a multi-barrier approach, as advocated by WHO (2006). The LA approach increased the probability that interventions are more realistic, integrated and mutually accepted. The approach also helped to build the capacity and awareness of the stakeholders and in so doing increased their responsibility and ownership of issues and solutions implemented. This is necessary to maximize the project's impact on policy and practice and to ensure that the issues associated with the use of wastewater in agriculture continue to be addressed after the project period. Key lessons from the project were as follows:

- The initial stages of the stakeholder process are critical to increase stakeholder buy-in.
- Sufficient information on issues and solutions should be provided to allow informed decisions.
- Stakeholder processes can be time- and resource-intensive but the outputs and outcomes are likely to be acceptable and therefore more effective and sustainable.
- Fostering responsibility and ownership is essential. One means of doing this is to show results progressively by rapid implementation of activities that are simpler to achieve.

Based on the lessons it is recommended that future projects supporting multi-stakeholder processes for interventions in the sanitation and food safety context (or any other) should have flexible milestone plans, be undertaken over five rather than three years and have a certain budget allocation for the implementation of the mutually agreed interventions.

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