32nd WEDC International Conference, Colombo, Sri Lanka, 2006

SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

Farmer driven wastewater treatment: A case study from Faisalabad, Pakistan

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The use of wastewater in agriculture provides, besides the obvious risks, also benefits to farmers. This paper presents the case of Faisalabad where farmers used untreated wastewater even though effluent from the local waste stabilization ponds was available. Untreated wastewater had a higher nutrient value and lower salinity as compared to effluent from the WSP and its use resulted in a substantially higher farm income. An approach is therefore proposed in which farmers and wastewater managers enter into dialogue to find mutually beneficial solutions to provide wastewater for agriculture whilst minimizing health risks.

Introduction

It is estimated that world-wide over 20 million hectares of agricultural land are irrigated by untreated or partially treated wastewater (Scott et al., 2004). With increasing water scarcity and rapid urbanization this area is expected to further grow. The use of untreated wastewater could pose serious risks to public health and could threaten long term agricultural sustainability. However its use has also been associated with higher farm income as a result of increased water reliability, savings in chemical fertilizer cost and proximity to urban markets, which makes the cultivation of perishable and high valued produce like vegetables possible (Ensink et al., 2004).

Wastewater treatment and crop restrictions are the recommended methods to protect public health and guarantee long term agricultural production (Pescod, 1992; WHO, 1989). However conventional wastewater treatment methods remove, besides pathogens, also nutrients, thereby making treated wastewater less attractive for farmers to use as compared to untreated wastewater. Furthermore, crop restrictions limit farmers in their freedom to select the most profitable crops, vegetables, as these are subjected to the strictest water quality regulations.

A nation-wide survey in Pakistan found that the use of untreated wastewater in agriculture took place in 80% of all cities with a population of over 10,000 inhabitants (Ensink et al., 2004). Only 2% of these cities had wastewater treatment facilities.

In the period February 2000 – May 2005 the International Water Management Institute (IWMI) investigated the risks and benefits of untreated wastewater irrigation in Faisalabad, Pakistan. In Faisalabad farmers had access to treated wastewater from the local waste stabilization pond system but instead opted to use untreated wastewater for irrigation. This following lengthy legal court battles in which the right to use untreated wastewater was gained. This paper will present the results of an investigation into why farmers were reluctant to use final effluent and based on the findings of this investigation will argue for the need for a new approach to wastewater management and treatment.

Study area

Faisalabad is located in central Punjab province and is Pakistan's third largest city with a population of over 2 million inhabitants. The city is located in a predominantly agricultural area and is home to Pakistan's textile industry with over 250 large and small textile mills within its municipal boundaries. The groundwater aquifer underlying the city is brackish to saline and the city is dependant on River Chenab and seepage from irrigation canals for its domestic water supply. The local water supply and sanitation utility (WASA) estimated that it supplies over 170,000 m^3 of water per day to the city to meet its domestic and industrial water needs. Area wise approximately 60% of the city is connected to a sewerage system, though realistically, based on household connections, only 32% of the city is connected (FAUP, 2001). The city is one of eight cities in Pakistan with a wastewater treatment plant. The treatment plant in Faisalabad treats approximately 30% of the daily produced wastewater.

Wastewater treatment

The wastewater treatment plant in Faisalabad is a basic waste stabilization pond system (WSP), consisting of six anaerobic, two facultative and four maturation ponds (Figure 1). It was designed for an inflow of 90,000 m^3 per day and was constructed, with financial assistance from a foreign donor, at a site where untreated wastewater had been used for the past 50 years for the cultivation of vegetables, fodder, wheat and sugarcane.

The plant was constructed to provide irrigation water that is safe for use in agriculture. Final effluent was to be sold to farmers, which would contribute to the operation and maintenance cost of the WSP. The construction of the WSP was completed in 1998 but since it started operating, farmers have been reluctant to use final effluent from the WSP and have continued to use untreated wastewater. As a result final effluent is disposed of unused into a drain with untreated wastewater.

The costs to operate the WSP are approximately US$ 185,000, or 2.5% of the annual budget of the WASA.

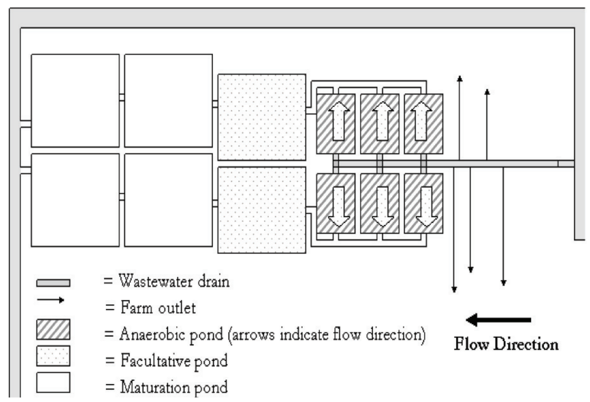

Figure 1. Layout of the WSP in Faisalabad

Farmer perceptions

A survey among 100 farmers (50 wastewater farmers and 50 farmers who could potentially have access to final effluent from the WSP) found that only 31% of the interviewed farmers were willing to pay for final effluent. Interestingly, the two farmer groups showed a stark contrast with only 2% of the wastewater farmers and 60% of the regular farmers willing to pay for final effluent. This reluctance to pay for or even use final effluent stemmed from the fact that farmers felt that it was unfit for use because of higher salinity (100%) and a lower nutrient value (61%) as compared to untreated wastewater.

All wastewater farmers mentioned a combination of three reasons for the use of untreated wastewater these were: the absence of another water source; the greater reliability of wastewater than regular irrigation water; and the high nutrient content of wastewater, which meant that the application of chemical fertilizer was minimized. The large majority (70%) of the wastewater farmers interviewed claimed not to use any chemical fertilizers; while a further 24% mentioned that they only used a particular fertilizer for a particular crop, for example phosphate fertilizer for the cultivation of cauliflower. Farmers made a clear distinction between what they called black water (untreated wastewater) and grey water (final effluent): black water was considered high in nutrients and low in salinity and thus desirable, and grey water was considered low in nutrients and high in salinity and should thus be avoided.

Wastewater irrigation

Wastewater farmers around the WSP have, since the construction of the treatment plant, organized themselves and gone to court to establish their rights to use wastewater. The first court cases granted farmers the right to use wastewater based on the fact that wastewater irrigation was the sole livelihood for these farmers because they did not have access to another water source. An appeal to this verdict ruled in favor of the WASA and banned wastewater irrigation; though this verdict was never implemented. Farmers and WASA have come to a compromise whereby farmers now pay for the use of wastewater. This water fee ranges from US$ 10 to US$ 62 per hectare per year depending on the quantity and the quality of wastewater. The highest fees were paid for untreated wastewater with lower fees paid for wastewater from anaerobic ponds.

Farmers have installed five permanent outlets in the drain which conveys untreated wastewater to the WSP. The average daily inflow into the treatment plant is 79,300 m^3 per day, of which 42,100 m^3 per day (59%) is diverted before it enters the treatment plant. A much smaller quantity of water is also diverted from the anaerobic and facultative ponds.

Farmers' claims about the reliability of wastewater were confirmed as only wastewater farmers were able to meet crop water demand for wheat and fodder (Figure 2), while farmers who used regular irrigation water were at most able to supply approximately 80% of crop water demand (Ensink et al., 2006).

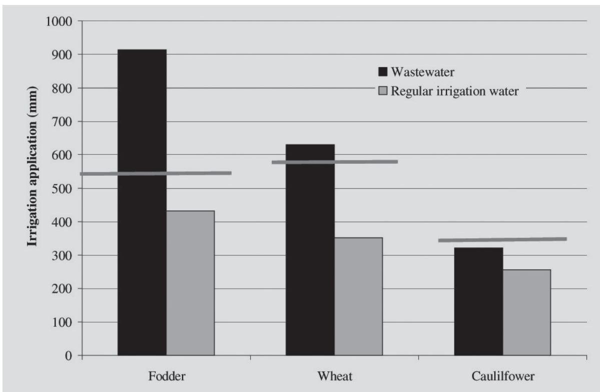

Figure 2. Irrigation application per crop type for wastewater and regular irrigated fields[1]

Source: Ensink et al., 2006

Wastewater quality

Untreated wastewater, final effluent and the performance of the WSP were monitored during a 12 month period from September 2001 to August 2002. Untreated wastewater was primarily of domestic origin and had a Biochemical Oxygen Demand (BOD) loading of medium strength (mean BOD concentration = 394 mg/l) and high pathogen (mean concentration = $2x10^7$ *E.coli*/l00 ml) (Ensink, 2006), which made wastewater unfit for use in agriculture based on World Health Organization guidelines (<1,000 *E.coli*/100 ml) (WHO, 1989). Nutrient concentrations in untreated wastewater were high and total nitrogen concentrations placed serious restrictions on its use for agricultural purposes (Figure 3). Total nitrogen concentrations in final effluent were considerably lower and for most of the year within guideline values.

Farmers mentioned that the use of untreated wastewater resulted in a reduced crop diversity and they were unable to grow root crops like carrots and radishes, however crops like cauliflower, cabbages and spinach which were most commonly grown on untreated wastewater and had a readily available market in Faisalabad were not affected by the high nitrogen concentrations.

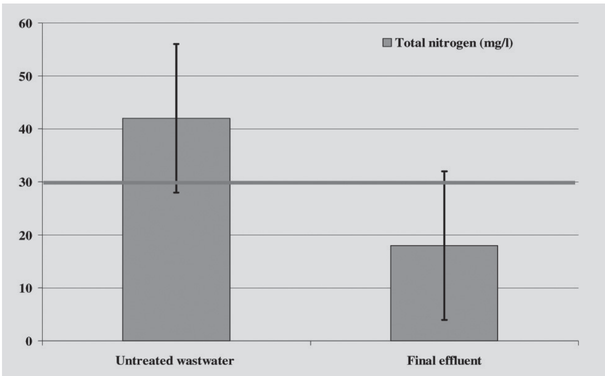

Figure 3. Mean total nitrogen concentrations in untreated wastewater and final effluent[2]

Source: Ensink et al, 2006

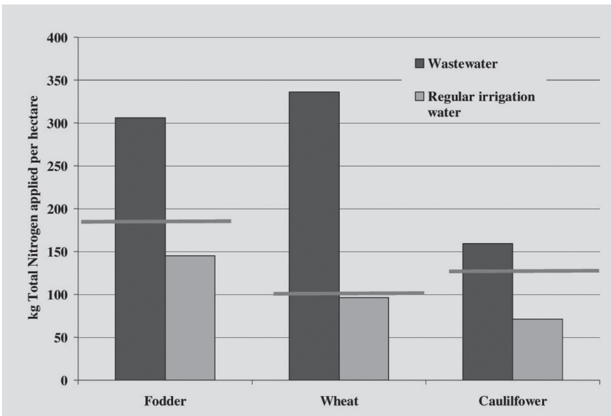

Figure 4. Nitrogen applications per crop type for wastewater and regular irrigated fields[3]

Source: Ensink et al., 2006

Wastewater farmers were able through the application of untreated wastewater to supply sufficient nutrients, especially nitrogen (Figure 4) to meet crop demands.

Because of the application of wastewater, wastewater farmers applied on average only 65 kg of fertilizer per hectare per year, as compared to the 530 kg per hectare per year applied by farmers who used regular irrigation water. This resulted in a total saving of over US$ 51,000 for the complete site and fully compensated the high water fees set by the WASA. Saving in fertilizer, higher cropping intensities and the cultivation of vegetables meant that wastewater farmers on average earned US$ 600 per hectare per year more than farmers who used regular irrigation water (Ensink et al., 2006). This confirmed farmers' claims about the beneficial impact of untreated wastewater use.

Farmers' concerns about the unsuitability of final effluent for the use in agriculture were confirmed by the salinity concentrations (expressed as Electrical conductivity in dS/m) in final effluent which were almost double that of untreated wastewater and exceeded FAO guidelines for agricultural reuse (Pescod, 1992) throughout the year (Figure 5.)

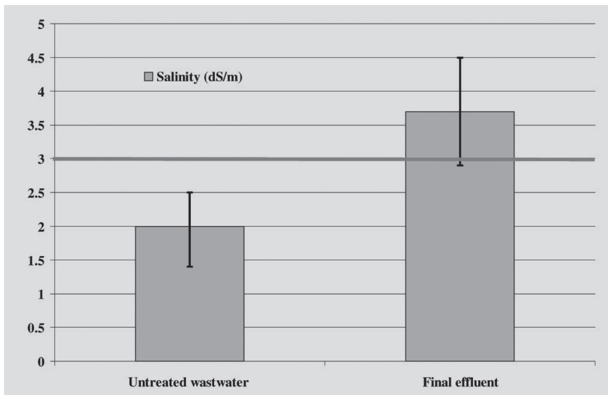

Figure 5. Mean salinity concentrations in untreated wastewater and final effluent[4]

Source: Ensink, 2006

WSP performance

The WSP in Faisalabad performed poorly as a result of a number of factors, which included: flaws in design; and the extraction of large quantities of untreated wastewater for the use in agriculture. These wastewater withdrawals resulted in a mean hydraulic retention time (HRT) of 46 days, which was almost 30 days longer than the design HRT of the WSP. This very long HRT in combination with Faisalabad's extreme climate, where temperatures can soar up to 48ºC in May, were to blame for the dramatic increase in salinity concentrations from untreated wastewater to final effluent (Ensink et al., draft).

The need for a new approach

These findings highlight the fact that conventional approaches to wastewater management and treatment may not be the most appropriate. A new strategy is required that considers the uses to which the wastewater or treated effluent will be put; and treats the water accordingly. Perhaps more importantly it must involve the wastewater users in planning and application of wastewater management and treatment measures.

This concept of participatory planning is not new and has been practiced in sanitation projects, with varying levels of effectiveness, for many years; however it is less commonly utilized in wastewater treatment, particularly for end-use in agriculture. The reasons for this are numerous, and include: the general perception that wastewater use is unhealthy and only acceptable following extensive treatment; wastewater treatment technologies imposed through donors; insufficient awareness of the benefits and reasons for wastewater use; and a lack of responsibility for wastewater management, which falls in various ways to a number of organizations including health authorities, agricultural organizations, the water supply and sanitation utility, as well as the waste producers and users.

Balancing needs

The WHO guidelines for the safe use of wastewater in agriculture have been revised recently in part because they concede that: "Overly strict standards may not be sustainable, and paradoxically may lead to less health-protection because they may be viewed as unachievable under local circumstances and, thus ignored" (WHO, 2006, draft). Furthermore, by treating to standards that are acceptable from a health perspective it is likely that other parameters such as nutrient value or salinity will also be altered, as is the case in Faisalabad. Therefore it may be necessary to treat water to a certain standard or in a particular way that balances health risks with agricultural requirements.

This balance is not a one way process whereby standards are relaxed to suit the needs of wastewater users, but is a process of negotiation in which wastewater managers learn what the needs of the farmers are and the farmers are made aware of the potential negative impacts of wastewater use, especially on health. The desired outcome is that of mutually acceptable standards for water quality and solutions for wastewater management.

Furthermore, the WHO (2006, draft) notes that: "Experience in many countries has shown that simply to ban the practice [of wastewater use] is not likely to have very much effect … but may make it more difficult to supervise and control…. A more promising approach is to provide support to improve existing use practices, not only to minimize the health risk but also to increase productivity".

Learning alliances

One approach being adopted to facilitate the discussion between the concerned stakeholders is that of Learning Alliances (LAs). This methodology has been used in several projects, most notably for water supply, basic urban services and sanitation (Moriarty et al., 2005) but is now being attempted in relation to the whole spectrum of wastewater management from its production to its use in agriculture. Such an approach has considerable potential in the case of Faisalabad, where the farmers are already taking collective action to convince WASA of their right to use wastewater.

A LA is a group of stakeholders (individuals or organizations) who are brought together into structured platforms in order to interact productively to find solutions to overcome technological, institutional and economic barriers to sustainable development along the water chain. The platforms are designed to break down barriers and thereby enhance the process of knowledge sharing, leading to the development of: locally appropriate innovations; ownership of the concepts and process; and the capacity of Learning Alliance members (IRC, 2004).

"The central premise of the Learning Alliance approach is that, by giving as much attention to the *processes* of innovating and scaling up innovation as is normally given to the subject of the innovation itself, barriers to uptake and replication can be overcome" (Moriarty et al., 2005) This approach has many advantages, one of which is that it overcomes the fragmentation of water management, which is typically dealt with as: domestic water supply; sewerage and wastewater drainage; irrigation; storm water management; and solid waste management (IRC, 2004); and does not even consider the potential of wastewater as a resource. Only by involving all those responsible for these sectors in a single platform in which wastewater is considered to be a resource, as happens with a LA, can water supply and wastewater be effectively managed.

LA for wastewater agriculture

The methodology is being used in the Wastewater Agriculture and Sanitation for Poverty Alleviation (WASPA) project in Bangladesh and Sri Lanka. The project aims to develop and implement solutions proposed by the stakeholders in Participatory Action Plans (PAPs) for: sanitation; in-stream management or treatment of wastewater; and optimal use in agriculture to protect farmers and consumers from negative health impacts, whilst maintaining or enhancing crop yield. What those solutions might be is entirely dependent on the stakeholder. They may require changes in practices or technical interventions such as constructed wetlands, improved irrigation practices or separating domestic and industrial waste; or more likely a combination of several of these. However to predict at this early stage what the PAPs may contain would be to circumvent the LA process, which is at the core of the LA model, and to reduce the stakeholders' freedom to innovate.

The project started in 2006 and plans to conduct detailed stakeholder workshops with stakeholders drawn from the communities (farmers and wastewater producers), as well as institutional representatives. The workshops are designed to foster an understanding between stakeholders regarding the constraints that people face in respect to wastewater disposal, treatment and use; and to allow stakeholders to analyze the institutions and mechanisms that are available to potentially provide these solutions. Gradually the different stakeholders will be brought together in clusters to discuss these issues in a carefully facilitated forum, so that they can understand the needs and constraints felt by other stakeholders.

Building effective LAs

Two key factors that are necessary to create effective LAs and sustainable, locally appropriate technologies are: good facilitation; and full participation of all stakeholders, including policy makers and local community members. Without strong facilitation true participation can not be achieved. For example, a single platform at the local level may include slum dwellers and the head of the local government administrative unit. The process of bringing such different stakeholders together would be gradual and would include awareness raising, consensus building, and sensitive facilitation skills, to ensure that all stakeholders have a voice and that the process is one of mutual learning rather than dominant stakeholders convincing other stakeholders that their opinions are correct!

The approach is not entirely new but builds on and brings together, a number of other concepts such as; action research, capacity building, multi-stakeholder platforms, agricultural knowledge and information systems, resource centers, and communities of practice (Moriarty et al., 2005).

A particularly effective example of a similar approach is that of the participatory total sanitation project pioneered in Bangladesh by the Village Education Resource Centre (VERC), WaterAid Bangladesh and a consultant Dr Kamal Kar. The project used a number of participatory techniques, including: “defecation transect walks”; sanitation mapping and participatory calculation of household waste production; and village processions. The outcome was that the community members were eager to address their sanitation problems, which they found to be an embarrassment when they were forced to show them to the outsiders in the project team. They therefore set about designing their own toilets of varying qualities and costs, but all of which showed tremendous innovation and ultimately resulted in an absence of open defecation in the study villages (Kar, 2003).

The lesson to be learnt from this project is that by allowing groups to analyze and understand their own situations they will produce innovations that are relevant and appropriate, even in situations where they were not previously aware of the necessity of such innovations. Most importantly they often came up with solutions that were as effective as those developed by experts but in a shorter time and with less cost (Kar, 2003). The LA process seeks to do just this but with groups of stakeholders who need to analyze not only their own situations but also how they impact on, or are influenced by, those of other stakeholders, and thereby produce unanimously acceptable solutions.

The additional advantage of LAs is that because they work at multiple levels (community, intermediate and national) they improve the potential for scaling-up, and capitalize on the somewhat intensive initial process of building LAs and facilitating the process. By taking such an approach there is the potential to develop solutions that provide adequate quantities of water of an appropriate quality to farmers, whilst protecting them from the negative health impacts of wastewater use, and still effectively treating the water to ensure the integrity of downstream water bodies and water supplies.

Implications for Faisalabad

The initial steps taken by the farmers to demand their rights to use wastewater, and their clear perceptions of the quality of wastewater compared to treated water, suggest that they are already in a strong position to enter into discussions with WASA. By developing a mutual awareness of each others’ beliefs and requirements it may be possible to come to a solution that results in at least partial treatment of the wastewater, which fulfils WASA’s objectives and ensures a reliable supply of adequate quality water to the farmers, whilst minimizing the health risks.

If such a solution were to be developed it would also provide a model for other areas in Faisalabad and other cities in the region.

Summary of main findings

- If incorrectly managed conventional wastewater treatment technologies like WSPs can raise salinity levels thereby making final effluent unsuitable for the use in agriculture.
- Although lack of access to an irrigation water source might be the key incentive for the use of wastewater, nutrient concentrations seem to be just as important to farmers who have used wastewater for prolonged periods.
- Farmer perceptions regarding the suitability of water sources should be taken into consideration when wastewater treatment technologies are considered.
- By bringing all relevant stakeholders together into Learning Alliances mutually acceptable, locally appropriate technologies can be developed by the stakeholders that meet the needs of wastewater managers, the inhabitants of cities, and urban and peri-urban farmers.

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Notes

1. Heavy lines indicate crop water requirements
2. Heavy line indicates upper limit of the severe restrictions for use guidelines (Pescod, 1992); error bars represent minimum and maximum concentrations.
3. Heavy lines indicate recommended nitrogen applications.
4. Heavy line indicates upper limit of the severe restrictions for use guidelines (Pescod, 1992); error bars represent minimum and maximum concentrations.

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