Use and Management of Wastewater in Agriculture

Alexandra E. V. Evans
&
Priyantha Jayakody

Researchers,
International Water Management Institute,
Battaramulla.

Water quality will deteriorate in the coming years as a result of population growth, urbanisation, industrialisation and climate change. This will put even greater pressure on systems that involve wastewater or marginal-quality water for irrigation of food crops. The need to regulate and manage these systems will also intensify, but actions must not be at the expense of farmers who rely on these water sources for their livelihoods. Appropriate management options that take account of the economic and environmental benefits of wastewater use in agriculture, while minimising the health and environmental risks, are to be sought. For this to be possible, policymakers must acknowledge the importance of urban agriculture and seek pragmatic solutions based on policies and plans that have both measures that are feasible in the short term and longer-term aims.

Introduction

Increasing populations, changes in human activities, urbanisation and climate change are expected to intensify water scarcity and contribute to the deterioration of water quality in many countries. Greater quantities of water will be generated in cities from households, commercial units and industries and the predicted increases in the frequency and severity of rain storms will increase the run-off from urban areas and farms (Qadir, 2009).

This marginal-quality or wastewater is already used by many farmers, knowingly or not, for irrigation. In future, the number of people irrigating with wastewater or marginal-quality water could increase, which would present an even greater management challenge than currently exists. Planning for wastewater irrigation will be critical to make use of the water and nutrients that it contains, while minimising environmental and health impacts.

Sources of wastewater include surface runoff, city drainage canals, grey water (such as domestic bathing water and kitchen wastewater), black water (from toilets, which contains urine and faeces), hospital and industrial wastewater, agricultural run-off and combinations of all of these (van Veenhuizen *et al.*, 2007). Wastewater generated by municipal and industrial activities contains a variety of constituents at levels higher than those usually found in freshwater, including salts, metals, metalloids, residual drugs, organic compounds, endocrine disrupters, active residues of personal care products and pathogens.

Exactly what the wastewater contains and in what concentrations depends on the local situations, and in general, the most problematic constituent for wastewater irrigation is pathogens from domestic sources. As a result, irrigation with untreated, partly-treated or diluted wastewater can result in multiple impacts on both the environment and health. Many farmers, consumers and policymakers are not fully aware of these implications and wastewater irrigation often takes place without adequate regulation or support for farmers to manage its use appropriately (Qadir, 2009).

The reasons for the use of wastewater for irrigation are multifaceted and include lack of access to other water sources and pollution of the existing sources. The underlying factor is that, in many instances, wastewater provides an opportunity for people to grow food and support their household's livelihood either by producing food for home consumption or cash crops, particularly high value vegetables. This in turn can have a positive impact on the wider economy and the health of the population through improved nutrition.

Despite years of research and experience in many countries (Hamilton *et al.*, 2007), why wastewater irrigation occurs and how to manage it are still the topics of considerable debate around the world. Undoubtedly, the exact nature of the issue, the challenges that it poses and the potential solutions are country and even location specific.

Understanding the opportunities and constraints for wastewater use are therefore the first step in developing and initiating plans to maximise the benefits and minimise the risks. Several guidelines have been produced to assist governments in undertaking these reviews and developing policies and plans, of which the World Health Organization (WHO) Guidelines for the Safe Use of Wastewater, Excreta and Grey Water (2006) are arguably the most comprehensive, widely accepted and appropriate for all countries, since they provide guidelines that can be adapted to the local situations and either linked to existing country specific guidelines and regulations, or used to develop them.

Three major obstacles to attempts to minimise the risks of wastewater have been observed:

- The negative perceptions of consumers and policymakers, due to the health and environmental risks that it poses, as well as the difficulties that it can create for farmers;
- The lack of recognition of urban agriculture as an urban livelihood strategy, and thus the absence of appropriate associated policies; and

- The fact that many policymakers and government officials are unaware of the current extent of wastewater use, and therefore perceive that any interventions in the area of wastewater irrigation will actually initiate or increase wastewater use, rather than serve to regulate it and improve current conditions.

These views therefore fail to recognise the fact that the use of wastewater or marginal-quality water takes place, because at present, in some locations, there are no other options, or because wastewater is contaminating water bodies that are used for irrigation.

This paper reviews some of the recent findings on global wastewater use in agriculture and underlying reasons for its use. It presents some information about the Sri Lanka context and discusses how the opportunities and constraints associated with wastewater irrigation could be addressed here.

The Current Extent of Wastewater Agriculture

Although it is difficult to estimate global wastewater use due to the lack of data and complications over definition, the most widely quoted figure is that 20 million ha of land were irrigated with undiluted or partially-diluted wastewater in 2001 (Future Harvest, 2001). It has also been estimated that in the early 1990s, approximately 10% of the world's population consumed food grown on wastewater irrigated land; a figure which has probably risen markedly since then (Lunven; cited in Smit and Nasr, 1992). Although such practices are a threat to human health, they do provide important livelihoods benefits and perishable food to cities (Raschid-Sally and Jayakody, 2008).

A global study of 53 cities undertaken by IWMI shows that the main drivers of wastewater use in irrigated agriculture are a combination of three factors:

- Increasing urban water demand and related return flow of used but seldom-treated wastewater into the environment and its water bodies, causing pollution of traditional irrigation water sources.
- Urban food demand and market incentives favouring food production in the proximity of cities, where water sources are usually polluted.
- Lack of alternative (cheaper, similarly reliable or safer) water sources (Raschid-Sally and Jayakody, 2008).

In 31 out of 41 cities that responded on the reasons for wastewater use, there was a clear indication that farmers have generally little or no alternative (safer) water source than diluted wastewater, polluted river water or untreated wastewater (Raschid-Sally and Jayakody, 2008). Farmers with access to other sources will rarely seek to use wastewater (although some value the nutrients that it provides).

In South Asia, wastewater use is considered to be lower than in many other countries because of the high rainfall and consequent reduced necessity for alternative water resources (Hamilton *et al.*, 2007), however Raschid-Sally and Jayakody (2008) found the opposite; that wastewater agriculture was most prevalent in Asian cities, especially in Vietnam, China and India. Direct use of wastewater in Sri Lanka was found to be relatively low, but the pollution of water bodies used for irrigation suggests that this is still an important issue for the country to address.

Anuradhapura, Kandy and Kurunegala were studied by Jayakody *et al.* (2006) to quantify the extent of wastewater use and the livelihoods' significance of the practice. They calculated, based on total abstractions and the percentage used for domestic and industrial purposes, that wastewater production in the country is approximately 273 million m^3 per year. In the three study cities, 70% of the water supplied is estimated to be disposed of as wastewater, amounting to approximately 1.3 million m^3 of per year (Table 1), and since the level of industrialiation is low in the three cities studied, this wastewater is predominantly of domestic origin, although there are a number of commercial properties and several hospitals.

Table 1 : Water supply and wastewater generation in the cities in 2003

City	Anuradhapura	Kandy	Kurunegala
Actual LPCD	290	335	260
Water supply % Pop Covered	90	95	90
Water supply% area covered	100	100	100
% unaccounted	30	32	30
Water' supply m3/day	20440	25000	6863
Estimated wastewater generation m3/day	14308	17500	4804

LPCD - Litres per capita per day

Source : Jayakody et al., 2006

Pipe-borne sewerage facilities are relatively limited in Sri Lanka, with Colombo having the widest network covering 80% of the city compared to just 5% in Kandy, and none in Anaradhapura and Kurunegala (Jayakody *et al.*, 2006). Here, blackwater from toilets is disposed of to pits and septic tanks, while greywater and stormwater drainage are directed to surface water bodies. Colombo and many other coastal cities drain their wastewater directly into the sea. Anuradhapura city discharges wastewater to Malwathu Oya, Kandy to Meda Ela and Hali Ela, which flow into the Mahweli River, and Kurunegala drains into the Bue Ela, which flows onto Maguruoya (Jayakody *et al.*, 2006).

It was found that the available wastewater was used in two of the cities in the following way:

- In Kurunegala, irrigation water flows through the city and combines with urban drainage in Bue Ela, which is eventually used to irrigate rice. Irrigation releases are irregular, and in the dry season, wastewater is often the only water available.
- In Anuradhapura, wastewater enters the Malwathu Oya, is diluted and subsequently used for vegetable cultivation; greywater is also used directly for vegetable cultivation.

Compared to other countries where undiluted wastewater is used directly on crops, such as in Faisalabad, Pakistan (Clemett and Ensink, 2006), the situation in Sri Lanka seems to pose fewer risks because there is only a low level of industrial activity in the cities studied, and toilet water is generally not collected with the drainage water (although some illegal overflow connections exist). However, this does not mean that no risk exists, and that the situation should continue uncontrolled. This is because although risks are lower they are not absent. Furthermore, some specific locations may face more severe pollution that requires more regulation, and therefore there is the need for a policy and legislation to address such situations. Finally, urbanisation and industrialisation are likely to increase, which may create new or greater risks, for which the country should be prepared. The main concerns are the exposure of farmers, their families and consumers to parasitic worms, and disease-causing viruses and bacteria. Other constituents in the wastewater may also impact positively or negatively on crop production, and pollute groundwater.

Not only is wastewater used locally around cities but, as already mentioned, this wastewater finds its way into open water bodies and is used downstream for a number of purposes, of which irrigation is one. This means that many farmers may be, knowingly or not, using diluted wastewater. This situation will only increase as population densities grow and there is reduced capacity for on-site wastewater management (such as septic tanks), and if wastewater treatment infrastructure cannot keep pace with this growth.

Pragmatic Solutions and Opportunities

Preventing farmers from using polluted water sources or only disposing of wastewater to water bodies after treatment are the most comprehensive solutions to reducing the health and environmental risks associated with wastewater; but they are rarely practical. Firstly, the cost, planning, implementation and management implications of such a comprehensive treatment approach would be prohibitive. In India for example, it is estimated that investment in treatment capacity for the 73% of urban wastewater that is currently untreated would be US$ 65 billion, which is ten times more than the Government of India proposes to spend on it (Kumar, 2003; cited in Scott *et al.*, 2004). Secondly, the negative livelihoods impact on farmers and their families, and the potential nutritional and economic impacts on society would be huge. Policymakers, considering such a ban on irrigation with marginal quality water or wastewater, would need to make provisions for the large numbers of people who might be adversely affected. They would also need to ensure that they were able to enforce the related regulations (IWMI, 2003).

In the absence of alternative treatment and disposal options, using wastewater for irrigation is also a form of treatment, as it results in the removal of certain contaminants, thereby improving its quality. This option does not reduce the risks to farmers and consumers but the localised health risks may be more manageable than the dispersed public health problems (not to mention environmental and other livelihoods impacts) that arise in downstream communities if wastewater is discharged directly into lakes and rivers, especially if these are used as drinking water sources (IWMI, 2003).

Such an approach does not mean allowing the uncontrolled use of untreated wastewater, as this poses too much of a risk, but it can be part of a strategy that includes a number of components to improve water quality and protect health. The WHO recognised that such a "multi-barrier" approach could be a way in which to exploit local opportunities for addressing the complexities of wastewater agriculture. Their most recent Guidelines for the Safe Use of Wastewater, Excreta and Grey Water (2006) therefore provide a series of policy and management options that can be combined and developed into a comprehensive strategy. It is anticipated that the strategy would have short-term goals to protect health whilst maintaining the viability of livelihoods, whilst longer-term goals would be to improve the quality of the water being used for irrigation through upstream management (such as separating industrial and domestic waste and cleaner production options in industry) and improved sanitation infrastructure including appropriate wastewater and sludge treatment facilities for local conditions (Table 2).

Table 2: Multi-barrier Options to Risk Reduction

Approach	Description and who is protected
Crop restriction	Crops that pose less of a risk to health are chosen, for example any crops that are eaten cooked. Crops that are eaten raw or unpeeled pose the greatest health risk in terms of pathogenic organisms. The main beneficiary is the consumer.
Wastewater application techniques	The method by which the wastewater is applied can increase or reduce the degree of contact with the crop, and thus the risk. Drip or sub-surface irrigation are considered preferable to flood irriation; ridge and furrow is also preferable if the wastewater does not make contact with the crop. Depending on the method selected both the farmer and consumer may benefit.
Pathogen die-off between last irrigation and consumption	Time, temperature and desiccation can all result in the death of pathogens (although helminth eggs can survive for many months). By withholding irrigation water for a few days before harvesting, the health risk to consumers can be reduced.
Food preparation measures	Careful washing, especially with detergents or vinegar; peeling; and cooking, can all reduce the risk to consumers from pathogens.
Human exposure control	Protecting fieldworkers and nearby communities from exposure to wastewater can reduce health risks. An obvious way of doing this is through the use of protective clothing such as shoes and gloves.
Appropriate wastewater treatment	Treatment will always be an important part of the solution as it protects fieldworkers and consumers, as well as the wider environment and the population as a whole. However treatment can be difficult to implement and manage, and may be costly. Locally appropriate solutions must therefore be sought.

Source: WHO, 2006

The key features of any policy and strategy related to wastewater irrigation are that:

- They must have both short-term and long-term objectives. Those in the short term need to address immediate health concerns, while longer-term objectives will be to improve wastewater management and treatment, and may be markets for wastewater produce.

- They should protect the livelihoods of those people who are dependent on wastewater agriculture, whilst also reducing health risks.

- They should not re-locate the problem, for example, by banning wastewater irrigation but without putting alternative measures in place, which will only result in greater pollution of water bodies.

- They must be practical and cost effective.

- They would benefit from considering all sources of wastewater as part of a comprehensive policy, although the approaches for each may be different. Industrial and hospital wastewater need particular attention.

Conclusion

Wastewater agriculture is an existing practice that will only grow as human populations rise, and urbanisation and industrialisation increase. Unregulated wastewater agriculture is not acceptable, because of the health and environmental impacts. However, it is not feasible to prevent it, because this will have livelihoods impacts and wider implications for the economy and nutrition. It will also be costly and difficult to enforce, and will increase surface water pollution since application of wastewater to land is a form of treatment. It is therefore necessary to regulate and manage the practice, to be able to take maximum advantage of the benefits that it can bring. This will require a suite of interventions as part of a holistic plan that provides barriers to risks to the health of farmers and consumers, and ensures water of an adequate quality reaches the fields and in turn open water bodies. Achieving the correct balance will not be an easy task, and there is likely to be opposition to approaches that appear to condone wastewater agriculture, but the reality is that, it takes place because there is a lack of alternative water sources for some farmers, and it provides food in a world where food security is an increasing issue. By managing the practice, pollution of water bodies can be reduced and in the longer term, as infrastructure for wastewater management improves, it will be a valuable component of the country's agriculture sector.

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Footnote :

[1] This value includes the actual supply by the water supply board and the amount of water estimated to be used by the households from other sources such as wells.

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