Implementation of the WHO guidelines for the safe use of wastewater in Pakistan: balancing risks and benefits

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ABSTRACT

The use of wastewater in agriculture is receiving renewed attention as a result of increasing global water scarcity. Wastewater use potentially poses a risk to public health if not properly managed. In Pakistan the use of wastewater in agriculture is already common, though in most cases its use is unregulated and wastewater untreated. In a four year study in Faisalabad, Pakistan, the risks and benefits of the use of untreated wastewater in agriculture were assessed. The study found an increased risk of intestinal disease in wastewater farmers but also found major financial and nutritional benefits for farmers and consumers in the city of Faisalabad. This paper presents a policy approach for the implementation of the WHO guidelines for the safe use of wastewater in agriculture in Pakistan.

Key words | guidelines, irrigation, Pakistan, wastewater, water quality

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INTRODUCTION

The use of wastewater in agriculture poses a dilemma. On the one hand, wastewater is often the only source of irrigation water for urban and peri-urban farmers; on the other hand, it can be a health hazard for farmers and consumers. There is sufficient epidemiological evidence that infection with intestinal nematodes is the major human health risk associated with the agricultural use of urban wastewater. Irrigation water quality guidelines have been set to protect human health but the guideline limit for nematode eggs in irrigation water has been subject to discussion (Blumenthal *et al.* 2000). Recently, the World Health Organization (WHO) published revised *Guidelines for the Safe Use of Wastewater, Excreta and Greywater* in agriculture and aquaculture (WHO 2006*a*). The revised guidelines are based on the principle that there should be no excess disease in populations exposed to wastewater. In addition to the earlier established wastewater quality guideline of ≤ 1 human intestinal nematode egg per litre, a tolerable additional burden of disease of $\leq 10^{-6}$ disability-adjusted life years lost per person per year as a result of wastewater irrigation has been added (WHO 2006*a*). The new WHO guidelines put an emphasis on the development of national wastewater use standards, by encouraging countries to adapt the guidelines in accordance to their own social, cultural, economic and environmental conditions (WHO 2006*a*), though only a few countries have actually done so.

Pakistan is a country in which the use of untreated wastewater in agriculture is common but which has not set national guidelines, nor has it provided directions on risk reduction measures, resulting in a situation where untreated wastewater use is banned by some and encouraged by other local authorities. Most of Pakistan has an arid climate, which makes agriculture almost impossible without irrigation. Rapid population growth and limited natural water resources provide huge challenges for agriculture in Pakistan. Planned and controlled use of wastewater would be a good alternative to conventional water sources in peri-urban areas and could in combination with other measures help alleviate Pakistan's looming water crisis.

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However, before its use can be promoted, a realistic national wastewater quality standard has to be established and a set of practical and enforceable control measures needs to be developed.

In 2001 the International Water Management Institute (IWMI) started a research programme on the risks and benefits of untreated wastewater irrigation in Pakistan. In the period from February 2001 to April 2005 epidemiological studies were undertaken in the city of Faisalabad in conjunction with monitoring of soil, groundwater and produce quality, and economic analyses. The overall aim of the research was to develop a set of control measures which would minimize risks but maintain benefits to farmers. This paper summarizes the findings of 4 years of wastewater research in Pakistan, proposes national water quality standards and gives recommendations for the safe(r) use of wastewater in agriculture in Pakistan.

PAKISTAN AND FAISALABAD

Pakistan's population stood at 136 million at the last census in 1998 but is expected to have doubled to 272 million by 2030 (UNPD 2003). The majority of this growth will take place in urban conglomerates where the population is expected to almost triple in the same time period (UNPD 2003). Although an estimated 95% and 92% of the urban population has access to improved drinking water supply and sanitation, respectively (WHO/UNICEF 2004), only 2% of all cities and towns in Pakistan with a population over 10,000 inhabitants have wastewater treatment facilities. Approximately 30% of the urban wastewater is used in agriculture, 5% is disposed of into irrigation canals, while the remaining 65% is disposed of into Pakistan's rivers or, as is the case for the city of Karachi, into the Arabian Sea. Untreated wastewater was used in peri-urban agriculture in approximately 80% of all cities (Ensink *et al.* 2008).

Faisalabad is Pakistan's third largest city with a population of just over 2 million in 1998. Untreated wastewater was used at nine different sites, totalling 2,200 hectares, in and around the city. The city has one wastewater treatment plant, but even at the wastewater treatment site, farmers have gained access to untreated wastewater following lengthy court battles. Wastewater farmers pay an annual water fee to the local water supply and sanitation utility depending on the nutrient value of the wastewater. Vegetables, wheat and fodder are the main crops which are cultivated with wastewater.

LIVELIHOODS AND FOOD SECURITY

The main reason for farmers in Faisalabad and other cities in Pakistan to use wastewater is the absence of a suitable alternative water source. Other reasons are the fertilizer value, the proximity to urban markets and the reliability of wastewater supply. The importance of wastewater is reflected by the willingness of farmers to pay high land and water fees for access to wastewater. These fees were on average six times higher than those for regular irrigation water (Ensink *et al.* 2004). High land and water fees were recovered as wastewater farmers had higher cropping intensities, were able to meet crop water demands through shorter irrigation intervals and higher water applications and made large savings on chemical fertilizer applications. This resulted in substantially higher farm incomes estimated at US$600 per hectare higher for wastewater farmers than for regular farmers (Ensink *et al.* 2008).

In and around Faisalabad vegetables were only grown with untreated wastewater, while in Pakistan as a whole it was estimated that 26% of the total vegetable production was produced with untreated wastewater. Savings in fertilizer and reduced transport time (cost) further meant that locally produced vegetables were found to be 60% cheaper than those imported from outside the city (Ensink *et al.* 2004). The reduction in transport time can be expected to impact on produce quality, as past studies have shown that a short time between harvest and consumption will prevent nutritional degradation (Klein 1987; Shewfelt 1990).

A wide diversity of vegetables are grown with wastewater in Pakistan; spinach and cauliflower are most commonly cultivated. Vegetables are high in micronutrients and vitamins and form an essential part of a healthy diet. Wastewater irrigation, by lowering production cost and preserving its nutritional quality, makes vegetables more widely available and thus makes an essential contribution to urban food security.

RISKS TO FARMERS AND CONSUMERS

Pathogens in wastewater pose a direct risk to farmers, produce handlers and children playing in agricultural fields but also indirectly to consumers of wastewater irrigated produce. Other potential health risks associated with wastewater irrigation are contamination of groundwater by faecal coliforms, nitrate and nitrites and the accumulation of heavy metals in soil and consequently their possible uptake by plants (Pescod 1992).

It has been well established that the main health risk in relation to wastewater irrigation is infection with intestinal nematodes (WHO 2006*a*). This is particularly so because nematodes have a low infective dose where a single egg can cause an infection, there is little to no acquired immunity, and because eggs can survive for prolonged periods in the agricultural environment (Blumenthal *et al.* 2000). In Faisalabad, wastewater contained high nematode (700 eggs l^{-1}), and *E. coli* (5.3×10^7 *E. coli* 100 ml^{-1}) concentrations and was unfit for use in agriculture according to WHO guidelines. Hookworm and *Giardia intestinalis* were the two parasitic infections associated with occupational exposure to wastewater irrigation. Although epidemiological studies showed that the use of wastewater was a major risk factor for these infections, the public health impact was small. Even among adult wastewater farmers hookworm prevalence was relatively low (14%), most likely because of self-medication with anthelminthic medication. *Giardia intestinalis* prevalence was very high (77%) but the large majority (73%) of the cases were asymptomatic (Ensink 2006).

For a number of reasons, the health risks associated with the consumption of wastewater irrigated vegetables were also smaller than expected. In the first place, most vegetables cultivated with wastewater were not consumed uncooked. Secondly, pathogen concentrations on vegetables were very low (1.9 *E. coli* g^{-1} and 0.7 egg g^{-1}) as a combined result of the adopted bed and furrow irrigation technique, which prevents direct contact of irrigation water with agricultural produce, and environmental conditions, which promoted rapid pathogen die-off (Ensink *et al.* 2007). Concentrations of *E. coli* (14.3 *E. coli* g^{-1}) and nematode eggs (2.1 egg g^{-1}) on vegetables were much higher in the market than in the wastewater irrigated fields, indicating that post harvest contamination due to unsanitary handling played a more important role than the quality of the irrigation water (Ensink *et al.* 2007).

Wastewater in Faisalabad was of predominantly domestic origin with high salinity and nutrient, but low heavy metal concentrations. Heavy metals, salt and nutrients can accumulate in soil, thereby possibly inhibiting growth and leading to yield reductions (Pescod 1992). Farmers acknowledged that, as a result of untreated wastewater, a variety of sensitive crops could no longer be grown, but were quick to emphasize that the chosen crops thrived on wastewater and claimed no reductions in yield. Soil salinity was found to be comparable or even lower compared with regular irrigation water irrigated fields; probably a result of leaching, as wastewater farmers applied more water compared with regular farmers.

Sites which had been wastewater irrigated for over 30 years were found to have elevated concentrations of the most common heavy metals but at none of these sites did metal concentration in soil exceed accepted standards and more importantly no elevated levels of cadmium or lead were found in food grains or spinach (Ensink *et al.* 2008). Concentrations of nitrate and nitrite in groundwater, which in elevated concentrations could cause methaemoglobinaemia, were found to exceed the WHO drinking water guidelines (WHO 2006*b*). However, this was not considered to be a public health concern, because high natural salinity of the groundwater meant that it was already unpalatable and not used for drinking or other domestic purposes.

MANAGING RISK: UPSTREAM VERSUS DOWNSTREAM RISKS

The four year research in Faisalabad showed a negative impact of untreated wastewater use on the health of wastewater farming families. However, in the absence of wastewater treatment the only alternative to wastewater use in Pakistan is the disposal of untreated wastewater into rivers and irrigation canals. This could potentially pose much greater health risks as river and irrigation water serve as the only source of domestic water needs, including drinking, for millions of people in the rural areas of Pakistan, especially in areas with high natural groundwater salinity (van der Hoek *et al.* 2001). This presents a situation whereby either a small group of wastewater farmers is exposed to a known and relatively easy to contain health risk or a potentially much larger group of downstream water users is exposed to an unknown health risk if wastewater is allowed to be disposed of into surface water bodies.

To ban wastewater use in Pakistan would be counter-productive and unenforceable, as is acknowledged by local authorities throughout Pakistan (Ensink *et al.* 2004). However the current situation where wastewater irrigation is either not recognized or where authorities turn a blind eye is not sustainable either. Rather, clear policies are needed, balancing agricultural benefits and human health risks. We propose that the risks that are associated with the use of untreated (domestic) wastewater could be contained through a set of practical and enforceable measures. The first step would be to formalize on a national level, three local regulations which were found to have been agreed between farmers and local authorities throughout Pakistan. These are:

- Only produce that is consumed cooked can be grown with untreated wastewater.
- Root crops, or other crops that grow below the soil surface such as potatoes, onions and carrots cannot be grown with untreated wastewater.
- Vegetables should be cultivated and irrigated with the bed and furrow method.

To minimize the direct health impact of untreated wastewater use on farming families we propose:

- Biannual mass treatment of farmers and their children with anthelminthic drugs.
- General improvements in water supply and sanitation in wastewater villages and local produce markets.

Anthelminthic medication is manufactured in Pakistan and is readily available and cheap. Female health workers and Basic Health Units, which provide free medical care, were found to have large stocks of anthelminthic medication available. The availability of a health care infrastructure close to or in wastewater irrigated villages in combination with well-established wastewater farmer associations offers an excellent opportunity to distribute anthelminthic medication. Children could be successfully targeted through school-based (anthelminthic) programmes.

Most wastewater farmers belonged to weaker socio-economic groups and the study found lower levels of water supply and sanitation coverage in wastewater villages compared with regular farming villages (Ensink 2006). Investments in the improvement of local water supply and sanitation might provide greater public health benefits, and will be more cost effective than wastewater treatment. Improvements in local water supply will have the added benefit that more (clean) water will be available at local markets, which will improve post harvest practices and thus quality of the produce.

The use of footwear in irrigated fields, often suggested as a suitable preventive measure against hookworm infection, was considered uncomfortable and impractical by farmers and is unlikely to be an acceptable intervention in Pakistan.

PROPOSED WATER QUALITY STANDARD

The long-term solution to infectious diseases associated with wastewater irrigation is wastewater treatment and the enforcement of water quality guidelines. Von Sperling & Fattal (2001) recommended a step-wise approach for the introduction of water quality standards, because an unattainable guideline is counterproductive and will result in the standards being ignored. This step-wise approach would imply that the use of untreated wastewater irrigation is initially condoned until preliminary or full treatment can be provided. Current international nematode egg guidelines are based on only very few studies. Based on our studies in Faisalabad, Pakistan, and Hyderabad, India, we propose a provisional nematode guideline of 15 eggs per litre for unrestricted use of wastewater in Pakistan. This concentration did not result in an increased risk of hookworm infection, which is the most important risk for wastewater farmers in Pakistan (Ensink 2006). More information is needed on the survival of pathogens on soil and produce before a final guideline can be established.

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