International Journal of Hygiene and Environmental Health 215 (2012) 255–269

Contents lists available at SciVerse ScienceDirect

International Journal of Hygiene and Environmental Health

journal homepage: www.elsevier.de/ijheh

Wastewater irrigation and environmental health: Implications for water governance and public policy

Munir A. Hanjra[a,b,*], John Blackwell[a], Gemma Carr[c], Fenghua Zhang[d], Tamara M. Jackson[a]

[a] Charles Sturt University, Wagga Wagga Campus, NSW 2678, Australia
[b] Future Directions International, Perth, WA, Australia
[c] Centre for Water Resource Systems, Vienna University of Technology, Austria
[d] Shihezi University, Shihezi City 832003, Xinjiang, China

ARTICLE INFO

Article history:
Received 14 February 2011
Received in revised form
12 September 2011
Accepted 17 October 2011

Keywords:
Climate change
Carbon credits
Global change
Urbanization
Poverty
Sustainability

ABSTRACT

Climate change is a large-scale and emerging environmental risk. It challenges environmental health and the sustainability of global development. Wastewater irrigation can make a sterling contribution to reducing water demand, recycling nutrients, improving soil health and cutting the amount of pollutants discharged into the waterways. However, the resource must be carefully managed to protect the environment and public health. Actions promoting wastewater reuse are every where, yet the frameworks for the protection of human health and the environment are lacking in most developing countries. Global change drivers including climate change, population growth, urbanization, income growth, improvements in living standard, industrialization, and energy intensive lifestyle will all heighten water management challenges. Slowing productivity growth, falling investment in irrigation, loss of biodiversity, risks to public health, environmental health issues such as soil salinity, land degradation, land cover change and water quality issues add an additional layer of complexity. Against this backdrop, the potential for wastewater irrigation and its benefits and risks are examined. These include crop productivity, aquaculture, soil health, groundwater quality, environmental health, public health, infrastructure constraints, social concerns and risks, property values, social equity, and poverty reduction. It is argued that, wastewater reuse and nutrient capture can contribute towards climate change adaptation and mitigation. Benefits such as avoided freshwater pumping and energy savings, fertilizer savings, phosphorous capture and prevention of mineral fertilizer extraction from mines can reduce carbon footprint and earn carbon credits. Wastewater reuse in agriculture reduces the water footprint of food production on the environment; it also entails activities such as higher crop yields and changes in cropping patterns, which also reduce carbon footprint. However, there is a need to better integrate water reuse into core water governance frameworks in order to effectively address the challenges and harness the potential of this vital resource for environmental health protection. The paper also presents a blueprint for future water governance and public policies for the protection of environmental health.

Crown Copyright © 2011 Published by Elsevier GmbH. All rights reserved.. All rights reserved.

Backdrop

Global socio-demographic and environmental change poses unprecedented challenges to mankind. Drivers of global change such as climate change, population growth, urbanization, industrialization, and rising income, living standard, and water and energy demand will all characterize wastewater futures in the developing countries. These forces will be confounded by slowing productivity growth, falling investment in irrigation and agriculture worldwide, loss of biodiversity, risks to public health, soil salinity, land degradation, land use and land cover changes and water scarcity (Molden, 2007) as well as potential disruptions to virtual water trade (Wichelns, 2011). Future population growth and water scarcity pose significant risks to global food security (Hanjra and Qureshi, 2010). Population growth and water scarcity also drive the need to reuse wastewater for irrigation and other uses in many countries (Scheierling et al., 2010). For instance, water scarcity is a major driver of farmer's willingness to use recycled water (Menegaki et al., 2007). Poor households often rely on this resource for their livelihood and food security (Ensink et al., 2004). They may accept the environmental and health risks due to the economic benefits of using wastewater for irrigation (Wichelns and Drechsel, 2011). Wastewater is both a resource and

* Corresponding author at: Charles Sturt University, Wagga Wagga Campus, NSW 2678, Australia.
E-mail addresses: mahanjra@hotmail.com, mhanjra@csu.edu.au (M.A. Hanjra).

1438-4639/$ – see front matter. Crown Copyright © 2011 Published by Elsevier GmbH. All rights reserved.. All rights reserved.
doi:10.1016/j.ijheh.2011.10.003

a problem (Rutkowski et al., 2007). It is a drought-proof, renewable supply of water that can keep water resources from shrinking and waterways from becoming polluted. For instance, fertilizer and energy cost savings arising from recycling of nutrients in the wastewater and the water content are a direct benefit to the farmers as well as to the environment. Wastewater irrigation can supply plant food nutrients inexpensively, mitigate water scarcity, save disposal costs, reduce pumping energy cost and thus minimise carbon emissions to the environment. Fertiliser availability is constrained in a resource-limited world. It is essential that phosphorus that sits in wastewater is recycled to avoid exhaustion of reserves of this unsubstitutable nutrient (Dawson and Hilton, 2011).

However there are negative health and environmental risks of wastewater irrigation that need to be addressed, such as excess nutrients (Kalavrouziotis et al., 2008), pathogens (Kazmia et al., 2008), saline salts and heavy metals (Li et al., 2009). These can negatively impact human health (Toze, 2006), biosafety (Feldlite et al., 2008), soil and groundwater resources (Khan et al., 2008a; Walker and Lin, 2008), and the natural and built environment (Rongguang et al., 2008). These can also result in negative consumer attitude towards the use of wastewater for irrigation. Research findings compiled from studies around the globe (Keraita et al., 2010) suggest that awareness of health risks is not high among farmers. However, 89% of the farmers interviewed in two case studies in Nepal linked untreated wastewater use with negative health outcomes, specifically skin irritations (Rutkowski et al., 2007). Wastewater governance issues, due to weak institutions and policy failures that plague most developing countries, compound these environmental and health risks (Asano and Levine, 1996).

In the future the volume of wastewater generated by domestic, industrial and commercial sources will continue to increase with population growth, urbanization, economic development and improvements in living standards. The demand for wastewater for irrigation will also continue to increase, especially by the millions of small farmers who depend on wastewater irrigation to produce high valued crops for urban markets. These farmers would have fewer alternative sources of irrigation water or livelihoods outside agriculture (Qadir et al., 2010). Improved management of wastewater use can offer positive-sum solutions in human welfare and the environment. Reliable estimates of future wastewater supply and demand are needed for better planning and risk management, but the limited information available on wastewater use and the informal agriculture that uses it makes future projections difficult (Asano and Levine, 1996). The fact that wastewater continues to be excluded from water accounting also adds to this difficulty (Arntzen and Setlhogile, 2007).

Concern about the sustainability of water use for feeding future human population is the strong motivation to understand the potential of wastewater use and nutrient energy recycling in irrigated agriculture. It may also provide useful information to develop various innovative governance strategies to meet the current and future water demand, and new approaches for adjusting to the urbanization and developing mega cities in Asia. The socioeconomic benefits from wastewater use in agriculture have so far been inadequately differentiated and quantified. A better understanding of the positive and negative environmental health impacts of wastewater use in agriculture can lead to a better understanding of the significance of wastewater as a resource and can highlight implications of its use on livelihoods and social equity in developing countries.

This paper builds on our previous works (Hanjra, 2000a,b, 2001) – that were the basis of two working papers (Hussain et al., 2001, 2002) and a recent paper (Hanjra et al., 2011) that focussed on the economic valuation of biophysical and socioeconomic impacts of wastewater management in an age of climate change. This paper offers a perspective on drivers of global change such as population growth, urbanization, rising income and improving living standard, industrialization, and urban water demand to characterize wastewater futures in developing countries. Empirical evidence is presented on the benefits and risks of wastewater irrigation on crop productivity, soil resources, groundwater quality, aquaculture, property values, environmental health, public health, infrastructure constraints, social concerns and risks, and poverty and social equity. It also demonstrates that how wastewater management can reduce the water footprint and energy footprint of food production on the environment and offer the possibility to earn carbon credits. Future opportunities to address water scarcity and food security issues by beneficial use of wastewater in agriculture under changing climate are identified.

Wastewater as a resource

Wastewater is composed of 99% water and 1% suspended, colloidal and dissolved solids. Municipal wastewater contains organic matter and nutrients (N, P, K); inorganic matter or dissolved minerals; toxic chemicals; and pathogens (Asano et al., 1985). The pollutants belonging to the same category exhibit similar water quality impacts (NRC, 1996). The composition of typical raw wastewater (Table 1; Hussain et al., 2001, 2002; Carr et al., 2011) depends on the socioeconomic characteristics of the residential communities and number and types of industrial and commercial units, such that global demographic and economic change also has implications for environmental health protection and wastewater governance approaches. The paper does not discuss the agricultural wastewater or irrigation return flows.

Guidelines for wastewater reuse in agriculture – wastewater governance

Wastewater contains microbes and chemicals that pose risk to human and environmental health. Wastewater governance refers to the guidelines, regulations, policies and laws that have been developed to guide wastewater use for agricultural and other uses, and to minimize the risk to public health and the environment.

Microbial guidelines

Wastewater contains a high concentration of excreted pathogens such as viruses, bacteria, heliminth, and fecal coliforms (Abu-Ashour and Lee, 2000). Intestinal nematodes, including the human roundworm (*Ascaris lumbricoides*), human hookworm (*Anclyostoma duodenale* and *Necator americanus*), and the human whipworms (*Trichuris*), pose the highest risk. Communicable diseases such as cholera and typhoid fever can be transmitted by wastewater irrigation of vegetable crops, if consumed raw (Shuval et al., 1997).

To protect public health, WHO (1989) guidelines recommended no more than one viable human intestinal nematode egg per liter for *restricted irrigation*; plus no more than one thousand fecal coliform/100 ml for *unrestricted irrigation*. These guidelines were stringent (Shuval et al., 1997) and hence revised. The revised guidelines (Table 2; WHO, 2006a,b) are based on the target approach and tolerable burden of disease expressed as Disability-Adjusted Life Years. This approach gives developing countries greater flexibility in applying the guidelines through treatment and non-treatment options (WHO, 2006a,b). Future guidelines may bundle economic and social incentives with regulations to better protect public health. Too little emphasis on water quality requirements will lead to situations of unacceptable impact, while too stringent

Download English Version:

https://daneshyari.com/en/article/2588923

Download Persian Version:

https://daneshyari.com/article/2588923

Daneshyari.com