Title	**Extending the "ecosan loop" to address health concerns from wastewater irrigation in urban and peri-urban areas**
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Short CV for Introduction Purposes (100 words max)	Bernard Keraita has a postgraduate training in irrigation and water engineering with a background on urban sanitation. He currently works with the International Water Management Institute (IWMI) in its West Africa Office in Ghana as a research officer. He has been working under a project on urban wastewater use in agriculture in low income countries for the last four years. He is lately researching into interventions for health risk reduction in wastewater irrigation at farm level.
Photograph attached (jpg)	

1. Wastewater Irrigation in sub-Saharan Africa

Farming of perishable crops is becoming a common phenomenon in urban and peri-urban zones in many developing countries. In Ghana, urban farming is done in virtually every empty space in and around the big cities, with farmers growing vegetables mainly during the dry season and adding cereals such as maize in the wet.

Traditionally, streams and shallow dugout wells have been the sources of irrigation water. However these water bodies are increasingly becoming polluted especially with faecal matter due to poor and inadequate sanitation infrastructure in the urban areas (Cornish and Kielen, 2004; Keraita et al., 2003; Keraita and Drechsel, 2004). The practice has definite health implications which need to be addressed (IRCWD, 1985; Shuval et al., 1986; Mara and Cairncross, 1989).

Though the focus of ecological sanitation approaches has been more on the localised level i.e. at excreta generation points and reuse in nearby fields, there is need now to upscale it to the watershed level to address health concerns from wastewater irrigation even at farms, more so in urban environments.

2. Measures to address human health concerns

2.1. Wastewater treatment based measures

Wastewater treatment has been long considered as the ultimate solution for reducing health risks in wastewater irrigation. Most conventional wastewater treatment systems have two treatment levels i.e. primary treatment where suspended solids and organic matter are removed and secondary treatment for removing biodegradable organics. Even the few systems that do tertiary treatment, they aim at removing of nutrients and toxic compounds (Metcalf and Eddy, 1995). Hence, conventional wastewater treatment systems don't focus on removal of pathogens; they are more designed to address environmental concerns. In addition, processes involved may be difficult and costly to operate in developing country situations as they have high energy, skilled labour and infrastructure and maintenance requirements (Carr and Strauss, 2001). Waste Stabilization Ponds (WSP), which are quite effective in removal of pathogens (Mara and Pearson, 1998), have large land requirements.
In any case they also need infrastructure layouts and maintenance. There is a growing advocacy for decentralised systems as opposed to the conventional centralised systems but the scale of decentralization that can effectively treat wastewater in a sustainable way is yet to be fully assessed in the contest of low-income countries. Observations made in Kumasi show that decentralized treatment systems need to be complemented by community mobilization, awareness raising etc to succeed as pilot systems in place are doing even worse than some centralized systems. Reality still stays that more than 90% of wastewater in developing countries receives no treatment (Homsi, 2000) and with WHO/UNICEF (2000) estimating wastewater treated by effective treatment plants at 35% in Asia and 14% in Latin America, the percentage for sub-Saharan Africa could be as low as less than 5%.

2.2. Banning wastewater irrigation

Mara and Cairncross (1989) advice for crop restrictions as a measure to protect produce consumers and they make it clear that it is not an adequate single control measure and give several conditions for it to be feasible. While this measure has been successful in some developing countries like Mexico, Chile and Peru (Blumenthal et al., 2000), it is inapplicable in low-income countries like those in Sub-Saharan Africa. Harassment by local authorities is

a common problem that you will hear from urban farmers. Destruction of crops has been reported in local dailies in Nairobi and Nakuru in Kenya (Daily Nation, 2001). Interviews carried out with the city authorities and some wastewater farmers in both cities confirmed the newspaper reports. Though harassment persists, this kind of farming continues as farmers say that it is their only source of income. In Accra, Ghana, there is a clear bylaw prohibiting wastewater irrigation (Local Government Bulletin 1, 1995:190). Like many bylaws, also this one is hardly being enforced. Banning wastewater use has failed as it is not all-inclusive and authorities are not giving any alternative solutions for farmers. In essence, farmers are not polluters as studies on water pollution in streams in Kumasi show (Keraita et al., 2003) but rather the failure of authorities to enforce sanitation guidelines and inadequate sanitation infrastructure.

2.3. The use of a multiple barrier approach

There is though a growing school of thought for the use of a multiple barrier approach instead of reliance of end-of-pipe solutions like using wastewater treatment only for health risk reduction. The focus of this thought is for low-income countries where effective wastewater treatment is not feasible and the use of untreated wastewater in irrigation is common. This entails looking at wastewater from sources of generation to consumption of the produce as an integrated system and identifying different entry points for risk reduction within this system. On each of these entry points like the ones identified by Drechsel et al. (2002), barriers are put in place leading to having a multiple effect in risk reduction.

There is also a strong focus on the user in this approach. Barriers are developed and evaluated using participatory methods approach for easy adoption. Even proven barriers or technologies could be redesigned and then adapted for local use. For example, using the farm as an entry point, WSP, which are proven for pathogen removal, could be downscaled to treat wastewater for 10 farmers farming on 1 ha in Accra. Some other barriers can be also non-treatment based like appropriate irrigation water management through proper irrigation scheduling and improving application efficiencies etc. The barriers though should also be cost-effective (low-cost technologies) and user friendly.

3. Ecosan in the farms

The use of the “multiple barrier approach” taps into three key features of ecological sanitation. For instance, wastewater treatment has been for long not designed for reuse. Here, wastewater treatment methods are designed in such a way that the effluents can be used as a resource. Knowledge from users and that from fields of environmental technology, irrigation science and social sciences is used to come up with appropriate treatment technologies. So, as every barrier is user-oriented, it even changes perceptions of many from seeing wastewater as a waste to a resource. Then, the approach focuses on reduction of health risks and pollution levels. The barriers are basically meant to reduce health risks and hence removal rates of pathogens that cause diseases are used to assess their effectiveness. Lastly, the approach aims to recover and recycle not only nutrients in wastewater but also water. Many farmers in water scarce countries like in the Middle East as well as in relatively more water abundant countries like Ghana, use wastewater as it is a reliable and more often the only source of water that they have, at least in the dry season. Use of the wastewater in agriculture will increase water productivity and make use of nutrients, that otherwise become a nuisance to the environment. It will also lessen the pressure on water resources as agriculture still uses more than 70% of available water in developing countries.

It should be well appreciated that ecological sanitation has moved a step further from the environmental sanitation that aimed at keeping the environment safe, clean and preventing

pollution by adding the recycling principles hence closing the eco-cycle. In addition, ecosan has strong principle of keeping the loop short by treating excreta on-site and reusing it for example in agriculture (Esrey et al., 1998). This of course ensures minimal pollution in land and water resources and reduction in the spread of health risks. But this principle is not applicable in some cases as reality in and around urban centres in low-income countries show. Not all excreta producers are interested or are in a position of reusing it due to diverse perceptions, interests, congestion in urban areas etc. Reality in many cities in low-income countries shows that wastewater users or those affected are not the generators. Most urban dwellers see it as a solved problem when wastewater is out of their compounds and care less on where it ends up in.

4. Addressing heath risks at farm level: an example of using low cost on-farm wastewater treatment and management methods

While a lot has been documented about existing conventional wastewater treatment technologies (Metcalf and Eddy, 1995), most of the low-cost technologies appropriate for low-income countries are still being on experimental levels. Some low-cost technologies being tested include the use of constructed wetlands, aquatic macrophytes such as duckweeds, water lettuce, algae based ponds and different filtration techniques such as slow sand filters, sedimentation ponds and the downscaling of the traditionally used waste stabilization ponds technology. Table 1 highlights some of these technologies.

Other than treatment options, control and management based measures can be put in place. For example to protect agricultural field workers and crop handlers, there should be provision (and insistence on the wearing) of protective clothing, maintenance of high levels of hygiene and immunization against (or chemotherapeutic control of) selected infections (Mara and Cairncross 1989).

Table 1: Low-cost treatment technologies in Africa

Technology	*Location*	*Description*	*Results*	*References*
Aquatic macrophytes	Kumasi, Ghana	Experimental using duckweek, water lettuce, algae based	-BOD reduced from 130 mg/l to less than 15 mg/l - faecal enterococci decreased from 1.18 X 10^5/ml to values below 100/ml	Awuah et al. (2001)
Aquatic macrophytes	Castor, Senegal	Community based using water lettuce	Treated to standards high enough to use directly for food production	Rose (1999)
Waste Stabilization ponds	Africa	Commonly used in municipalities	High pathogen and BOD reduction rates. But require huge spaces	Mara and Pearson (1998)
Biosand filters	Kenya, Mozambique	Used in households for water treatment	94% average faecal coliform removal rate in Kenya, 98% in Mozambique	Kaiser et al. (2002)

Risks to consumers can be reduced through cooking (for those not eaten raw) the produce before consumption and by high standards of food hygiene, which should be emphasized in the health education associated with wastewater use schemes. Local residents should be kept fully informed on the use of wastewater in agriculture so that they, and their children, can avoid these areas where wastewater irrigation is practised (Pescod, 1992). Proper wastewater management at farm level can also significantly reduce the ill effects. For

example, for edible parts should not be irrigated directly. Application could be made on the roots as opposed to the current common application on the leaves. In Nakuru, Kenya, a vegetable farmer took the local council to court for repeatedly destroying her wastewater irrigated vegetable farm. Though she used untreated wastewater, analysis from her vegetables showed no contamination, thanks to sound management during use at her farm (Daily Nation, 2001).

5. Conclusion

Addressing health concerns using the rather short ecosan loop based on current principles of source treatment is so far not very successful and does not address the health concerns of many urban and peri-urban farmers. Where the waste flow moves downstream additional measures are needed. Thus we propose a slight extension of the loop to encompass this reality where wastewater ends up on irrigated urban and peri-urban fields. Here, health risks can be addressed through on-farm treatment but also management principles for health risk reduction. Ecological principles aiming at low-tech resource recovery are the preferred choice. There exist a variety of option which have to be explored for various situations, where e.g. tenure security and other factors might limit the choice. Furthermore, extending the loop also will mean adapting ecosan principles to a wider scope i.e. not at localized levels like households, backyard gardens but also it to the watershed level especially in urban areas, where urban wastewater flows to many streams that flow through urban areas and affect many users downstream. These extensions and making use of the multiple barrier approach will make ecological sanitation more comprehensive especially in addressing health concerns from wastewater reuse in low-income countries and an interesting option in the larger Integrated Water Resources Management (IWRM) debate.

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