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IWMI-Ghana

Domestic wastewater from Korle-Bu Teaching Hospital in Central Accra used directly for vegetable production

Wastewater Use for Urban Agriculture

Editorial

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Increasing volumes of domestic, hospital and industrial wastewater are being produced in rapidly growing cities around the world. Wastewater treatment is costly and even in those cities that are able to procure funding to build treatment plants, only a small percentage of the total wastewater volume is treated and the rest is left to flow into natural water bodies. Most of the water only receives primary treatment. Many treatment plants in cities in the South go into disuse after a short period of time due to insufficient funds for operation and maintenance.

Part of this untreated wastewater is used by urban, periurban and rural men, women and children from different caste and class groups who practice urban agriculture or related activities such as dairy production, agroforestry, orchards, toddy tapping, teak or other wood harvesting, floriculture or aquaculture (see the article on Hyderabad on page 13, the Dakar case on page 35, Hubli Dharwad on page 31 and Kolkata on 29).

This wide variety of users has a variety of motives for using untreated or partly treated wastewater. In semi-arid and arid areas it is often the only source of water available and it is available year-round. It is also an inexpensive source, not just of water but also of nutrients. In fact, farmers often need less or no additional fertilisers. It can be easily channelled from city drains or from a river to the fields or carried in watering cans. Using this water is also attractive as these fields are often conveniently located near city markets where the produce is sold, or are near urban-based buyers who go directly to the (peri)urban plots.

WASTEWATER SOURCES

The sources of wastewater include rivers, city drainage canals, spouts from city sewage and drainage channels that drain onto the fields below, ponds and tanks, shallow wells, house drainage spouts and channels, etc. The composition of the wastewater also varies according to its origin. There is storm water and other urban run-off, grey water (domestic water that is wastewater without urine and faeces) or black water (domestic wastewater with urine and faeces) as well as industrial wastewater, hospital and other institutional and commercial establishment wastewater and combinations of all of these (each with varying concentrations). Industrial wastewater may contain a wide range of pollutants, heavy metals being the most well-known example, some of which are not acutely toxic either for the crop, the soil or for the consumer but over time may be damaging to either or all of these (see Senegal case on page 35).

THE NEED FOR TYPOLOGIES

Typologies of wastewater use are currently being developed and adapted (e.g. by IWMI and HR Wallingford) for the purpose of standardising categories employed to define and describe this use in local and national level studies. These typologies will serve as tools for undertaking assessments of the extent of wastewater use in certain key countries around the world. The results of these assessments can then serve to better inform policy-makers at various levels.

Van der Hoek (forthcoming) with IWMI differentiates between direct and indirect use of wastewater according to whether the wastewater is undiluted (direct use from a sewer, e.g.) or diluted with natural surface water such as a river before use. It also categorises the water by the relative strength of the different types of wastewater in a given urban area, the extent (amount of type of treatment) of wastewater treatment, and the use of wastewater in formal (via irrigation infrastructure with a level of permission and control by state agencies) or informal (at many, scattered points) irrigation schemes. Cornish facilitated the revision of this typology at the Hyderabad experts' meeting (see page 4) and suggests the following diagram (Cornish, forthcoming).

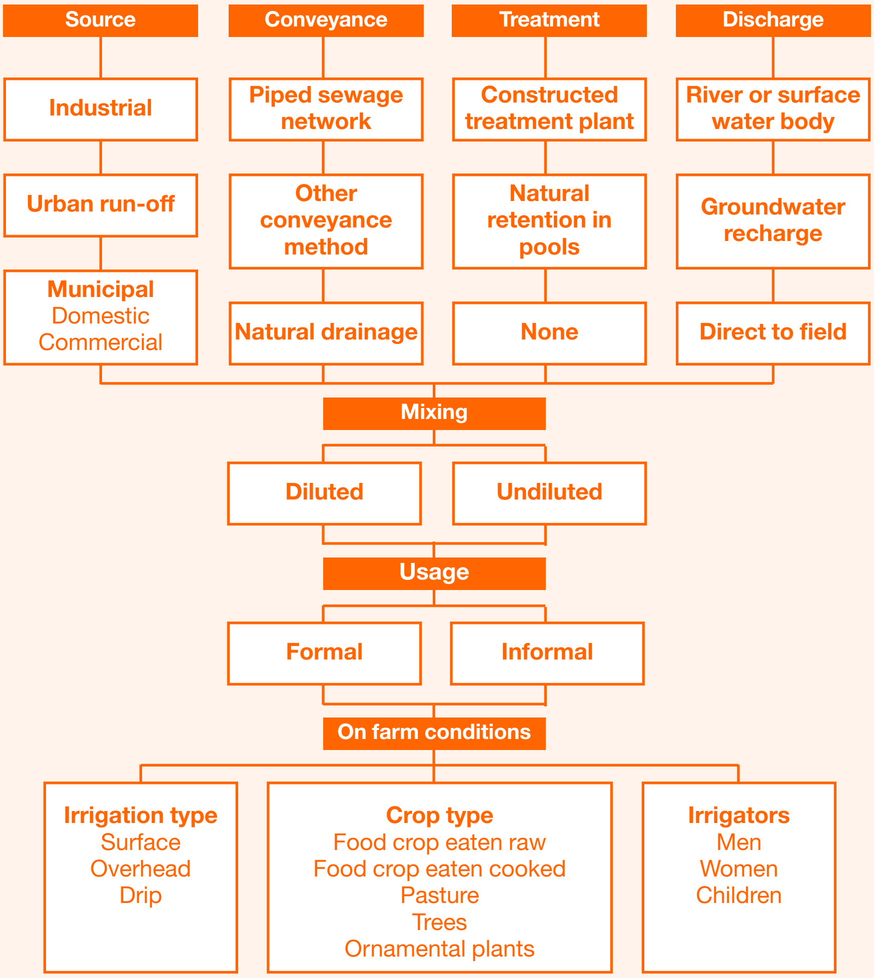

Figure 1 Typology of wastewater irrigation (see page 47 for definitions)

HEALTH-RELATED ASPECTS

Farmers use wastewater out of necessity and it is a reality that cannot be denied or effectively banned. However, wastewater use for urban agriculture is often negatively perceived by the public and by government officials. However, wastewater use for urban agriculture is negatively perceived by the public and government officials, and this contributes to the negative image of urban agriculture.

A major obstacle in the process of minimising the risks of wastewater use lies in the non-recognition of urban agriculture as an urban livelihood strategy. The adoption of any measure or policy therefore depends upon whether the authorities and policy-makers take the activity of urban agriculture itself seriously (see also the Ouagadougou Study visit summary on page 13).

The main risk for the public arises when vegetable or salad crops, grown with untreated wastewater, are consumed raw. This practice can be linked to cholera and typhoid as well as faecal bacterial diseases, bacterial diarrhoea and dysentery for the consumers of wastewater-irrigated produce. There is further evidence that agricultural workers in wastewater-irrigated fields and consumers of wastewater-irrigated produce are more likely to get intestinal helminths infections. These infections are due to *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), *Ancylostoma duodenale* and *Nector americanus* (hookworms) (see Faruqui on page 19 or the discussion on Guidelines on page 7).

There are, however, also cases that show that contamination of products also takes place between the field and actual consumption, e.g. in the market or even in the home of the consumer e.g. through unhygienic handling. There is a need for

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Harvested Para grass along the Musi River in Hyderabad (page 14)

rigorous (epidemiological) research to determine the type and degree of health risk, the paths of contamination and the likelihood of infection. This is to determine the real risks that may be attributed to wastewater irrigation and other wastewater-dependent activities such as livestock rearing (see the reference to a programme on page 42) and aquaculture (see the case of Kolkata on page 29) in a particular geographical area. The risks should be assessed according to the type of activities for which the wastewater is being used, the type of irrigation method (see the case on Kumasi on page 11) and the type of user group that has the most direct contact with the water. Such studies will increase the understanding of wastewater use and perhaps dispel its pejorative image. This qualitative and quantitative research and


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analysis should include recommendations on appropriate follow-up measures, regulations and policies.

LOW-COST TREATMENT TECHNOLOGIES

Next to a lack of recognition of the issue by governments, an often-mentioned problem is the funding of wastewater treatment infrastructures and the maintenance of these. Low-cost, appropriate, and decentralised treatment technologies can be developed, with the particular users involved. Examples are tanks in which organic matter and suspended solids settle if the user allows sufficient time before irrigating. CEPIS (see page 18) is promoting the integration of treatment systems and agricultural use in Latin America. However, integrated planning between treatment authorities and agriculture is not a common phenomenon (see the Mexico case on page 33).

Decentralised small-scale community operated systems and stabilisation tanks have also been built for successful use for fisheries (see the Dakar and Kolkata experiences on page 35 and 29). The Middle East and Near Africa (MENA) countries have very scarce water supplies, but also have greater economic resources to treat water. Some countries in this region have established integrated plans to use treated wastewater for agriculture (page 20). The other option for providing cleaner water to farmers is through source reduction. The degree of faecal contamination of water can be reduced through the use of environmental sanitation technologies (see the Peru and Mexico experiences on page 37 and 39) and with domestic filtering of soapy water for gardens.

Industrial pollution of surface water bodies should also be reduced by, for example, proper zoning, registration and monitoring of industries and financial and technical incentives for waste minimisation (as suggested by Odurukwe for Abe in Nigeria, page 40).

GUIDELINES

The WHO's recommendations of wastewater treatment and crop restrictions introduced in 1989 are considered by many governments as the legal framework, even though they are not intended for absolute and direct application in every country. The present WHO guidelines, almost exclusively promoting wastewater treatment and crop restrictions, do not take the reasons for wastewater use (such as the lack of treatment possibilities) and the positive impact into consideration (this issue and the discussion on page 7). The revised guidelines (to be published by the WHO in 2003), will be part of a first volume and a second volume will contain case studies of wastewater use and users to provide evidence concerning some of the ways in which wastewater benefits low-income households.

USERS' NEEDS AND PERCEPTIONS

The farmers perception of wastewater quality, economic value and health issues needs careful attention to better inform planning initiatives of the policy-makers and the urban authorities (see the Ouagadougou case on page 24 and the Hyderabad case on page 14). Farmers using wastewater in different locations (urban, periurban or rural; high or low rainfall areas; wealthier or poorer regions, e.g.) have different needs. Other factors that vary across locations are: the source of the wastewater; land-tenure issues; land values and land taxes; infrastructure, like the availability of electrical power; and the legal framework. Flexible "response scenarios" could be developed for each of these specific locations or for similar localities to identify appropriate risk reducing strategies that are technically, economically, socio-culturally and politically compatible (see the discussion on page 7).

INSTITUTIONS

Various governmental agencies are involved in shaping the policy framework in which wastewater-related activities are inserted. Often, there is little convergence between the laws and policies that these different institutions uphold related to urban and periurban agriculture and

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wastewater use. There is a need for researchers studying these issues, NGOs and farmers to engage with policy-makers at various levels to encourage a well-integrated, supportive policy environment. There is also a need for strengthening institutions, to fund sewage-collection systems and other improvements in sanitary conditions, and to enact by-laws that can enhance urban safe vegetable production (see the Kumasi case on page 11) as well as the production of other agricultural and aquaculture produce.

EDUCATION, INFORMATION AND AWARENESS-RAISING

Raising awareness among farmers, policy-makers, polluters, marketers, consumers and others is seen by many as the immediate and most important strategy to reduce the health risks in most low-income countries (see the summary of the IWMI-RUAF wastewater E-conference held in 2002 on page 4 and the Ouagadougou Study visit organised by RUAF and CREPA on page 13).

Education and information-sharing need to be tailored to each type of group that engages in wastewater dependent activities, as the use patterns of each set of actors is very different. Consumers are also a heterogeneous group, using different types of wastewater-produced items. Producers, workers and consumers need to be included in information campaigns, training and information-sharing fora, so that hygiene can be improved and associated diseases prevented. Municipal authorities often do not include urban farmers as "real" "irrigation farmers" and therefore do not provide any extension (see the Tamale and Kumasi cases on page 10 and 11). Awareness raising could diminish risks related to wastewater irrigation and possibly have a wider impact in combating hygiene-related diseases in general.

As the Hyderabad Declaration states wastewater use for livelihood activities in urban and periurban areas is a reality that planners and policy-makers must face. Financial resources should be made available for these institutions to implement appropriate measures to protect and support these livelihoods as well as to improve the health of the environment, the users and the consumers.

The Hyderabad Declaration

The International Water Management Institute (IWMI) in collaboration with the International Development Research Centre (IDRC) convened a meeting of minds through an international workshop entitled *Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities,* which was held in Hyderabad, India from 11-14 November 2002. The workshop objective was to critically review experiences with the widespread use of untreated wastewater in agriculture focusing on the livelihoods of the poor, and health and environmental risks. Participants were diverse with a presence of 47 groups of researchers and practitioners from 27 national and international institutions.

The livelihood implications of wastewater irrigation as well as the human health and environmental impacts are clear. Management options identified with partners and stakeholders consider the common situation of wastewater use without options for treatment and include improved health safeguards, awareness raising, cropping restrictions, appropriate techniques, low-cost alternatives (also on-farm), and pollutant-source management. However, many involved in wastewater-treatment, agriculture, sanitation and urban planning have ignored the practice and its implications.

A number of case studies covering different regions of the world, and comprising applications of wastewater ranging from the treated to the untreated were extensively discussed and debated. Three workgroups addressed issues of assessing the global use of wastewater, the health and environmental implications and related guidelines, and institutions and future research directions. Two major breakthroughs were:

(1) a common vision and agenda for the future contained in the Hyderabad Declaration which follows below; and
(2) the discussion with the World Health Organisation (WHO) to take into account the realities in reviewing the guidelines for wastewater use in agriculture.

The Hyderabad Declaration on Wastewater Use in Agriculture

1. Rapid urbanisation places immense pressure on the world's fragile and dwindling fresh water resources and over-burdened sanitation systems, leading to environmental degradation. We as water, health, environment, agriculture, and aquaculture researchers and practitioners from 27 international and national institutions, representing experiences in wastewater management from 18 countries, recognise that:

1.1 Wastewater (raw, diluted or treated) is a resource of increasing global importance, particularly in urban and periurban agriculture.
1.2 With proper management, wastewater use contributes significantly to sustaining livelihoods, food security and the quality of the environment
1.3 Without proper management, wastewater use possesses serious risks to human health and the environment.

2. We declare that in order to enhance the positive outcomes while minimising the risks of wastewater use, there exist feasible and sound measures that need to be applied. These measures include:

2.1 Cost-effective and appropriate treatments suited to the end use of wastewater, supplemented by guidelines and their application.
2.2 Certain activities to take place where wastewater is insufficiently treated, and until treatment becomes feasible:
(a) development and application of guidelines for untreated wastewater use that safeguard livelihoods, public health and the environment;
(b) application of appropriate irrigation, agricultural, post-harvest, and public health practices that limit risks to farming communities, vendors, and consumers; and
(c) education and awareness programmes for all stakeholders, including the public at large, to disseminate these measures.
2.3 Health, agriculture and environmental quality guidelines that are linked and implemented in a step-wise approach.
2.4 Reduction of toxic contaminants in wastewater, at source and by improved management.

3. We also declare that:

3.1 Knowledge needs should be addressed through research to support the measures outlined above.
3.2 Institutional coordination and integration together with increased financial allocations are required.

4. Therefore, we strongly urge policy-makers and authorities in the fields of water, agriculture, aquaculture, health, environment and urban planning, as well as donors and the private sector to:

Safeguard and strengthen livelihoods and food security, mitigate health and environmental risks and conserve water resources by confronting the realities of wastewater use in agriculture, through the adoption of appropriate policies and the commitment of financial resources for policy implementation

14 November 2002, Hyderabad, India

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downstream of the city, used for irrigation by urban and periurban farmers, are heavily polluted. The high levels of nutrients can be an advantage to farmers, but on the other hand, the high levels of pathogens require careful wastewater use to avoid health risks for farmers and consumers. As chemical pollutants in the wastewater are within tolerable limits, their impact on the environment and human health seems to be minimal. The informal methods of irrigation used by farmers (watering cans, buckets, water hoses) increase the risk of contamination of crops (contact of water with edible parts) and of farmers (general exposure). But, the current institutional and policy frameworks concerning wastewater use in farming remain a patchwork with related by-laws and other policies that are missing or hardly practicable in developing country contexts and for farmers that depend on wastewater irrigation for their survival.

As a long-term solution, a comprehensive improvement of the urban sanitation infrastructure is required, but lack of resources makes it unlikely in the near future. With expanding urban populations and food needs, it is likely that the use of wastewater for food crops will prevail. Raising awareness and education as a means to improve the situation has been suggested by a large number of survey respondents as well as in the wastewater related e-conference. Such awareness creation could target households, farmers, vegetable sellers, consumers and the local authorities, depending on the local situation and the best entry point for risk reduction. In order to devise better irrigation and cropping strategies for using the available water, with its inherent disadvantages and benefits, more research on the subject is needed.

A comprehensive understanding of the situation, which includes farmers' level of awareness, technical know-how, livelihood patterns, perception, social constraints, land and water rights, etc. are vital to laying the foundation for practical policy and guideline formulation. Finally, data on the extent and importance of wastewater use especially in and around cities such as Kumasi is needed for better decision-making, thus avoiding partial and myopic judgments, on which current policies are sometimes based. This will require corresponding institutional strengthening and functional research-policy linkages.

Ouagadougou Study Visit

Wastewater in Urban Agriculture, a Challenge for Municipalities in West Africa

This five-day event took place from 3-7 June 2002, and was organised by ETC-RUAF together with CREPA headquarters in Ouagadougou, Burkina Faso, financed by CTA Netherlands. It consisted of a combination of paper presentations, working group discussions and site visits. There were 29 participants.

WORKSHOPS

Three thematic papers and seven case studies were presented. The seven cases focused on cities in Benin, Burkina Faso, Cameroon, Ghana, Mali, Mauritania and Senegal. Although wastewater use is common in all but Benin, the sources and conditions differ more than one might expect. This gave a lively discussion and exchange of views.

SITE VISITS

Different sites in and around Ouagadougou were visited where a number of farmers were available to answer questions or discuss certain issues. The first site, **Kossodo**, is a large farming area that uses untreated wastewater from an industrial zone, with most water coming from a brewery and a leather tannery. The farmers, of which many are women, apply a number of strategies to avoid using the worst quality water. **Paspanga** is situated in between the artificial lake and a busy part of town. An open wastewater sewage channel separates the town from the plots. This channel carries wastewater from several industries as well as some domestic wastewater. The farmers were both men and women, each with their own plots. The farmers were organised and presented a paper with the four main problems, all concerning lack of inputs. The insufficient amount of water available was named as the number one problem. Water from the sewer is only used when wells run dry. **Kamboinse** is on the shore of an artificial lake. There are vegetable plots fed by water from channels dug from the lake into the fields. The water was very low in the lake and no crops were grown at the time of the visit. The only disease mentioned here is Bilharzia. **Boulmiougou** is another gardening site next to an artificial lake. A large number of farmers was present. Strawberries are a speciality from this site. All of the water (including drinking water) comes from wells although cleaner water is available by pumping from a deep borehole.

In all of the cases, water *quantity* and not water *quality* was seen as a regular problem. Moreover, health was not (admitted to be) a special problem (see also page 24).

RECOMMENDATIONS

The recommendations of the workshop (see **www.ruaf.org** for the full text of the Ouagadougou Declaration in French) focused on Socio-Economic Aspects; Institutional Aspects; and Health and Environmental Aspects, and are directed at farmers, farmer organisations and NGOs, municipalities, government and researchers.

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A river polluted with wastewater in Ghana

What could be seen as a general and important conclusion is that urban agriculture itself is not taken sufficiently serious by authorities although studies are available in nearly all countries in which its importance is qualified and even quantified. This underestimation leads to insufficient consideration in town policy and planning, inadequate laws and by-laws and other texts, insufficient consideration and use of its potential in waste management and perhaps above all, insufficient consideration in the allocation of resources. The discussions on hygiene and behaviour provoked interesting debates on cause and effect, and transmission routes: producers, sellers and consumers; in all three stages, contamination as well as prevention may take place. Noteworthy are those recommendations that speak of the need of extension work to urban producers and consumers on the subject of health, hygiene and risky behaviour. Epidemiological studies are needed to review and adapt the current guidelines, to discover and quantify actual risks and to describe realistic paths of contamination.

Electronic Conference

Agricultural Use of Untreated Urban Wastewater in Low Income Countries

From 24 June to 5 July 2002, IWMI and ETC-RUAF organised an electronic conference on strategies that may be applied to reduce the health risks associated with the use of untreated, partially treated or diluted wastewater in agriculture, whilst maintaining or enhancing the social and economic benefits for the poor urban citizens involved in irrigated production.


Kranjac-Berisavljevic

The main drain in Tamale, Ghana

The use of urban wastewater in agriculture is a widely established practice. Institutions and individuals who lead wastewater treatment and sanitation initiatives globally have largely ignored this practice and its implications. The conference attempted to bridge this gap by setting up a focused discussion based on the experiences of a wide range of participants from the field of water resources, agriculture, human health and ecological impacts. Rather than focusing on (end-of-pipe) treatment of wastewater, the emphasis of the discussion was on:

a. Strategies to ensure proper health-risk management by the users of the untreated or partially treated wastewater; and
b. Strategies to prevent and reduce chemical pollution by industries of domestic sewage water and rivers that are used for irrigation.

The conference itself was divided into two sessions. During the ***first week*** of the conference, the focus in both topics was on the ***analysis*** of the actual situation and trends, and the analysis of the effectiveness of certain strategies. During the ***second week*** of the conference, the discussion put more emphasis on the ***formulation of recommendations*** for policy development and action planning. The discussion in reality did not adhere to this rigidly, nor did it adhere rigidly to the two topics outlined – with some of the topic 2 issues being discussed in topic 1 and *vice versa*.

In total, 333 participants from 72 countries registered and many more followed the discussions by visiting the RUAF website on the Internet. About 54% of the participants had a background in research institutes and universities, 3% in municipalities, 25% in NGOs or CBOs, 9% in governmental organisations, and 5% were students. There were 143 contributions received for the discussions and some 21 papers were added to the "Background papers" section of the conference website. These are encouraging numbers, indicating a strong interest to gain access to and discuss alternative approaches and methods, which can be applied in on-going or future projects. The following key issues were discussed:

TOPIC 1: PROPER MANAGEMENT BY FARMERS

SOCIO-ECONOMIC BENEFITS OF WASTEWATER USE

Social benefits of wastewater use have been addressed under the notion of the livelihoods- generation capacity of wastewater agriculture, employment opportunities offered to women through vegetable cultivation thanks to the availability of wastewater, and the different layers of society which benefit from it. In this regard, the potential to reduce urban poverty provided by wastewater agriculture must be understood, and attempts should be made to associate wastewater-use initiatives with poverty-alleviation programmes of donors. Quantification of the economic benefits was discussed for Ghana and Pakistan (also in this *UA Magazine* issue).

PAYMENT FOR TREATMENT

The possibility of **cost sharing** between residential communities and farmers was raised. Residents should pay because they are the generators but because the water has a value for farmers as the users, it was suggested that they contribute to the treatment cost as well. Treatment costs could be reduced substantially through applying cost-effective treatment technology and applying the treated wastewater to commercial crops, which would generate some of the costs of treatment. Alternatively, farmers could treat the wastewater themselves before use for growing vegetables, as shown in a Latin American study, (although this supposes secure land tenure); or let private companies bid for wastewater treatment and resale opportunities.

COSTS OF WASTEWATER USE FROM HEALTH AND ENVIRONMENTAL RISK PERSPECTIVES

Related to the farmer response to *health risks*, it was suggested that observable health risks are better understood than non-observable abstract concepts (such as bacteria, heavy metals, etc.). An idea was emitted that contamination also occurs during transport, processing and sale of consumable products, which might be more important (to tackle) than

RUAF e-conference
The RUAF electronic conferences are designed as platforms to facilitate the exchange of experiences and debate between: urban planners, representatives of municipal departments and policy advisors; researchers (universities, research centres, thematic networks); and technical staff of NGOs, international and local projects, and other persons with an interest in these issues.
At **www.ruaf.org** you can find more information on this, and two previously organised electronic conferences:
2002: Methodologies for Urban Agriculture (six topics, with CIP-SIUPA)
2001: Health, Land-Use Planning and Food Security (three parallel sessions, with FAO)

Summarised by **Judith Kaspersma**, *(RUAF)*

direct contamination.

The studies may not be conclusive. Some participants indicated the need for more research on the actual health impacts of wastewater use on consumers and workers in the production and processing/marketing of products. The exposure of women to the hazards of wastewater poses the additional risk of rapid transmission to family members through contaminating food during preparation on their return from the fields.

The following environmental risks were discussed:

- risk of pollution of groundwater if wastewater flows continuously;
- steady reduction in yields and crop diversity and soil quality (permeability) after initial increases, due to salinisation of the soils;
- reduction in fruit quality;
- increased incidence of weeds;
- heavy metals, especially cadmium; and
- possibly profound effects in arid and semi-arid areas from the introduction of wastewater agriculture, on crop-pest reproduction cycles and populations.

RISK-MANAGEMENT STRATEGIES

Regulation of irrigation water quality and the problems related to standards setting and monitoring Participants called for the adaptation, or development, of new guidelines for untreated or diluted wastewater, which are designed to be flexible so they can be adapted to the local conditions. The approach of "acceptable risk levels" and "response scenarios" were proposed as viable alternatives. Convincing national and municipal authorities of these approaches is seen as important in setting suitable guidelines.

Facilitating change through awareness raising, education and providing relevant and timely information to target groups Many viewed targeted health education as the most realistic, practical and cost-effective measure to reduce health risks. NGOs and the media may have to play a vital role. Target groups are policy-makers, farmers, consumers, micro-enterprises and other tradesmen, and local authorities.

Crop selection and certification of produce (labelling) Crop selection is a suitable strategy given the variation in absorption of certain chemicals by different crops. Labelling and subsequent higher prices if needed, may improve customer confidence.

Improving upon irrigation practices and their limitations Irrigation techniques vary in application of water to roots or leafy parts of crops. Rotation of wastewater application over fields or in time (if possible), are also suggested.

Therapy of affected persons, like deworming campaigns were suggested as cheap(er) alternatives.

Providing alternative sites and sources of water for relocating affected farmers Incorporating urban agriculture in urban planning requires the vision that agriculture and wastewater use are intrinsic parts of a city's processes and recycling efforts.

On-farm complementary treatment Treatment options were suggested in cases where regulation of water quality is possible and where city treatment of wastewater does not achieve the desired standards.

Remediation of heavy metal contamination of soils Heavy metals were seen to cause the highest risk. Several remediation techniques were discussed.

Participation of stakeholders in decisions relating to wastewater use for maximum impact Dialogue and negotiation between citizens and farmers and others will result in applied, practical and implementable solutions. Here the concept of "acceptable risk levels" and "response scenarios" were discussed.

ROLE OF RESEARCHERS IN IMPROVING THE PRACTICE OF WASTEWATER-BASED AGRICULTURE

A more holistic, integrated and multidisciplinary approach to understanding all the implications of wastewater use was called for. The importance of developing a typology of wastewater/farmers, to address issues in a concerted and universal manner was highlighted. The role of scientists and researchers should be to provide knowledge and information on the "current best practices" and to communicate this information in a form that is understandable to the different stakeholder groups. Effective outreach to policy-makers is also a role for the scientific community. Research on wastewater use in urban and periurban agriculture should be better focused, more participatory and action oriented.

TOPIC 2: PREVENTION AND REDUCTION OF INDUSTRIAL CONTAMINATION

Water used for agriculture particularly in the urban and periurban contexts is often polluted by domestic and industrial sources. Often these wastes are combined in the city drainage and sewerage systems, due to lack of awareness, planning or technical means, and together pollute agricultural water sources. Whilst domestic sewage in spite of posing a risk from pathogens, has the advantage of containing nutrients, most industrial wastewater has only the disadvantage of posing a health risk due to chemical contaminants. Limiting the mixing of industrial wastes in domestic sewage is one means of reducing risks from exposure to chemicals.

The discussion centred around the **reasons why domestic sewage is contaminated with industrial wastewater, possible solutions to avoid such contamination, and low-cost options and methods for treatment** of wastewater which may or may not be a mix of domestic sewage and industrial wastewater.

The main impacts of industrially polluted wastewater on urban agriculture sites were from soil salinisation and heavy metal accumulation. These problems could be solved by lime application to acidified soils, restricting the cultivation of crops susceptible to accumulations depending on their physiognomy, and applying other methods like phyto-extraction. In-farm treatment using Kaolin, has been tried on an experimental basis. One possible integrated approach to address the existing situation is to apply waste-management principles at the generation points (households, industries, commercial establishments, hospitals; and the user points (farms); so that overall relative quality improvements are achieved.

LOW-COST OPTIONS AND METHODS FOR TREATMENT OF WASTEWATER

In most developing countries, the lack of financial resources limits the construction of treatment facilities (low cost or otherwise); and even when they do exist, the operation and management of the systems are constrained once more by finances. The solution may be to find treatment alternatives that are robust enough to stay operational at a moderate cost.

Stabilisation ponds still remain the most cost-effective technology while also removing pathogens. In this regard, activated sludge plants require 80% more investment than stabilisation ponds, but are not capable of meeting health guidelines.

Balancing Health and Livelihoods

Adjusting Wastewater Irrigation Guidelines for Resource-poor Countries

In many low-income countries, less than 10 percent of the urban wastewater is collected in piped sewerage systems and treated. Usually, large volumes of wastewater end up in gutters and open drains and are heavily polluting streams near the city. Here it has been used for decades for year-round or dry-season irrigation of perishable cash crops, such as vegetables, taking advantage of market proximity. This urban and periurban agriculture is more exposed to environmental pollution, including urban wastewater, compared to other farming systems. Due to the common lack of larger industries in resource-poor countries, health risks for farmers and consumers are mostly related to microbiological water contamination from domestic sources (and not industrial pollution).

To protect farmers' and consumers' health, the World Health Organisation (WHO) published guidelines for the safe use of wastewater in agriculture (Blumenthal, 1989, WHO, 1989), currently under revision[1]. The purpose of the 1989 guidelines was to guide design engineers and planners in the choice of wastewater-treatment technologies and water-management options. The acceptable levels of microbiological contamination included in the guidelines were derived from the results of the available epidemiological studies related to wastewater exposure, use and treatment. In addition, health-protection measures (mainly risk-management measures) were considered, especially crop selection, wastewater-application measures (e.g. drip irrigation) and human exposure control particularly through protective clothing. Integration of these measures and the adoption of a combination of several protection measures were encouraged (WHO, 1989). Where economic constraints limit the level of wastewater treatment that can be provided, a disease-control approach has been suggested, potentially using less strict microbiological guidelines and more management measures for health protection (Blumenthal, *et al*., 2000; Peasey, *et al*., 2000).

APPLICATION OF THE GUIDELINES

The application of the guidelines, however, has been found to be difficult in many field situations, for example in India and West Africa, as recently discussed during an expert meeting in Hyderabad (see page 4). To take into account urban and periurban agriculture, adjustments were suggested, especially in relation to the following three points:

❖ In many countries, wastewater treatment is not possible due to low municipal/governmental resources, and small, old or non-extendable sewerage systems. As the WHO microbiological guidelines expect certain levels of wastewater treatment, their enforcement in situations without any realistic option for treatment would stop hundreds or thousands of farmers from irrigating along increasingly polluted streams, and put their livelihoods at risk, but would also affect food traders and general market supply.

❖ Especially in market-oriented urban agriculture[2], it is difficult to apply the recommended additional health-protection measures. Highly specialised farmers use every free space with water access to cultivate cash crops, especially those of a perishable nature. Although their plots are often small, irrigation allows for year-round farming and these farmers are able to escape from the poverty trap (e.g. Danso, *et al*., 2002a), while a contribution to the overall urban vegetable supply and diversified diets is made as well. The small land sizes and insecure land tenure are however significantly constraining farmers' ability to invest in farm infrastructure, such as drip irrigation or on-farm sedimentation ponds. Crop restriction is also often unrealistic as only cash-crop production corresponding to market demand provides the profit on which farmers' livelihoods are based. Thus a change like from vegetables to tree crops would be unrealistic from the land-tenure perspective and also ignores farmers' livelihood strategies (except where non-vegetable cash crops are suitable, e.g. olive trees in the Middle East). In addition, recommendations to change irrigation systems or cease irrigation before harvest usually do not work out, as products such as lettuce would become damaged within a few days from lack of water. Finally, many field interviews show that farmers do not perceive the need for protective clothing (see page 24). All of these constraints to the application of the current wastewater guidelines are common in urban agriculture and not the exception.

❖ Finally, the microbiological part of the current WHO guidelines have often been used or cited in isolation from the other protective measures (also pointed out in the Hyderabad workshop). A reason might be that the defined critical

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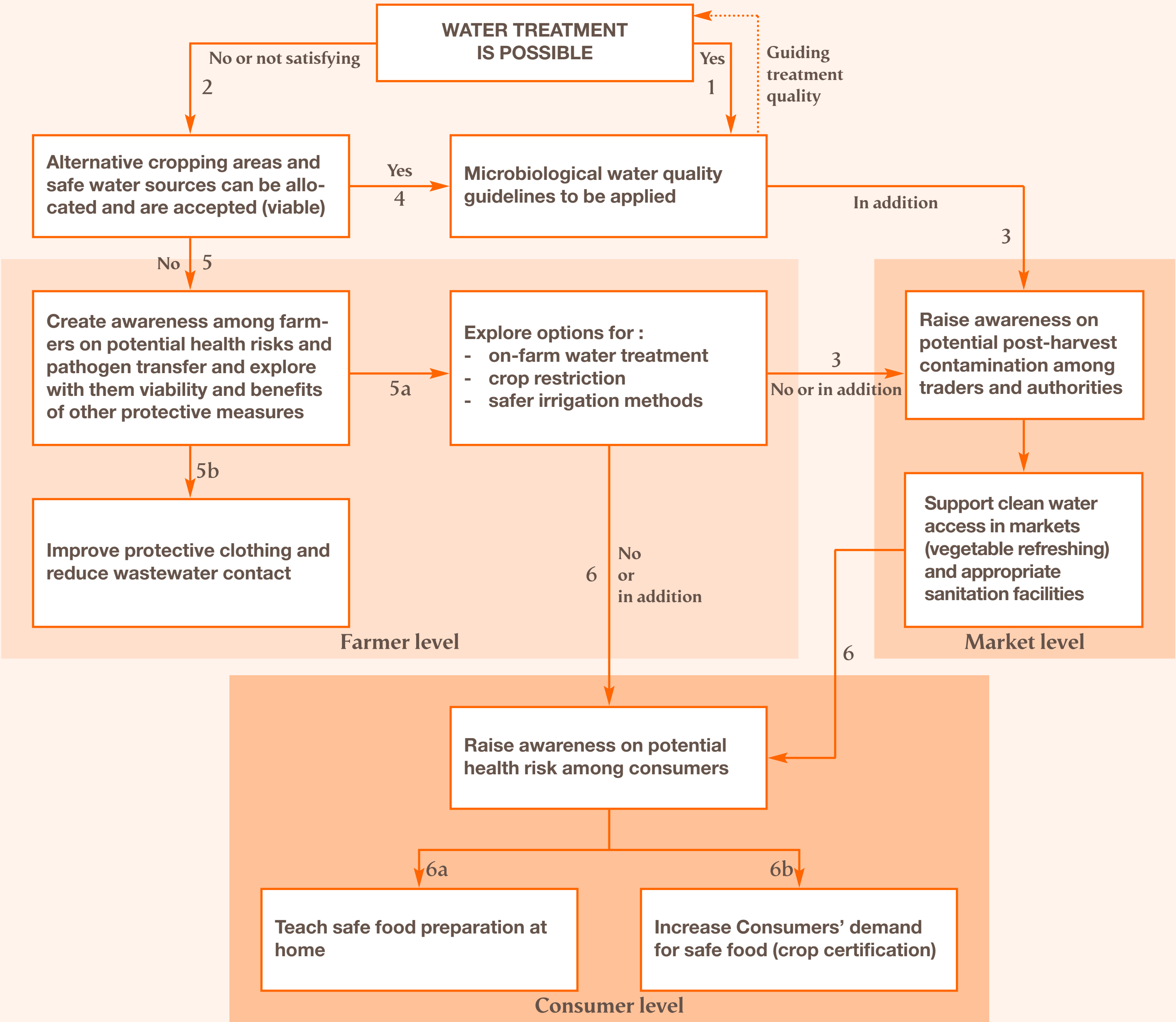

Figure 1: Flow diagram of a decision-making process on locally appropriate health-protection measures

levels appear easier to apply for authorities and institutions than the support of other safety measures for health-risk reduction.

ADJUSTING THE GUIDELINES

With regard to these difficulties, it was suggested that the WHO guidelines need to be adjusted for better application in wastewater exposed urban and periurban agriculture in resource-poor countries. The overall goal should be to find a better balance between safeguarding consumers' (and farmers') health and safeguarding farmers' livelihoods. A stepwise implementation approach for the guidelines (cf. Von Sperling and Fattal, 2001) was thought to be helpful in that it considers different levels of water treatment and recommendations for regions or countries where (improved) treatment is no realistic option. To achieve this, greater emphasis should be placed on further protective measures, which consider the limitations of the current additional measures. This could include other measures on the farm, including better land allocation, but also targeting post-harvest contamination of crops during transport and marketing, which takes place independent of irrigation water quality.

The additional livelihoods perspective can give the health guidelines more dynamism. The Ghana example showed for instance that urban farmers specialised in vegetable irrigation with polluted surface- or wastewater do gain several times more income than their rural colleagues specialising in rainfed agriculture. This allows them to take better advantage of health-care facilities and to pay for medication, which might offset some of the risks through wastewater exposure.

LOCALLY APPROPRIATE HEALTH-PROTECTION MEASURES

A flow diagram of a decision-making process on locally appropriate health-protection measures has been developed (see Figure 1). This process considers experience in Ghana and elsewhere where wastewater is used directly or indirectly for urban and periurban agriculture, and where municipal wastewater treatment is not a realistic option in the short or medium term. The elements of the decision strategy are as follows: (*numbers in the text refer to the diagram*):

❖ Where monitoring of wastewater treatment is possible from institutional and financial point of view, the microbiological guidelines for wastewater irrigation should be applied. In this situation **(1)** the guidelines should assist design engineers in setting the standard of the treatment system from the perspective of crop production[3].

❖ Where the establishment or maintenance of a functional wastewater-treatment facility is not a realistic option, the concerned authorities still have different possibilities for reducing health risks to farmers and consumers. First of all, they are asked to explore alternative water sources or cropping areas **(2)** with higher quality water (e.g. groundwater). In Cotonou, for example, the authorities allocated new land for urban farmers with the possibility of groundwater access while in Accra; the Water Research Institute is currently exploring groundwater use in wastewater irrigated urban areas. To be successful, these alternatives have to be explored together with the farmers. Additional measures might be recommended if post-harvest contamination is likely **(3)**.

❖ If alternative land and safe water sources are available and accepted by the farmers, it might be possible to apply the microbiological guidelines **(4)**. If water quality, however, cannot be guaranteed, agricultural engineers should investigate possibilities of **(5a, 5b)**:

a) alternative irrigation technologies and irrigation methods reducing:
   1) farmer's exposure (e.g. during water fetching and application),
   2) crop contact (e.g. surface instead of overhead irrigation), and
   3) microbiological water contamination levels (e.g. through improved and better located shallow wells);
b) crop selection and patterns taking market demand, cultural preferences and gender balance in cultivation/marketing into account;
c) on-farm water treatment options, such as simple sedimentation tanks, taking into account land-tenure arrangements, labour constraints and farmers' interest and ability for on-site investments; and
d) awareness campaigns for irrigating farmers on their own and on consumers' health risks, plus guidance on health protection measures.

In all of these cases, alternative risk reducing approaches have to be technically as well as socio-economically and culturally viable. No implementation should be suggested without consideration of farmers' perceptions, attitudes, suggestions and constraints.

❖ It can also be crucial to focus on post-harvest contamination on markets **(3)**; i.e. on the availability of clean water for vegetable handling, especially crop washing and "freshening up" as well as general hygienic conditions for traders (e.g. availability of sufficient sanitation facilities). This must also be combined with related education and awareness campaigns. Authorities should also consider the well established but often officially ignored informal vegetable markets (e.g. in upper class suburbs), and insist on the availability of clean water. Related costs are likely to be insignificant in comparison with effective wastewater treatment.

❖ Risks to consumers **(6)** should be addressed by sensitising households on the health implications related to polluted irrigation water, **and** to unhygienic produce handling. Recommendations will have to consider local diets and food preparation behaviour and options. Improved vegetable washing and (if possible) cooking can significantly reduce possible health risks through wastewater irrigation or post-harvest contamination **(6a)**. A related (long-term) target is to raise consumers' demand and willingness to pay for safe food **(6b)**. This could catalyse awareness shifts also among traders, farmers and authorities. Crop certification could become an option (Westcot, 1997). However, this transition has still a long way to go in many countries, keeping in mind the dominance of more obvious health risks such as HIV, malaria and lack of drinking water as well as general sanitation facilities (Danso, *et al.*, 2002b). The strategies related to **markets** and especially **consumers** should also receive attention in situations of functional treatment and applied wastewater-irrigation guidelines. The reason is that post-harvest contamination through unhygienic crop handling might take place independently of enforced or non-enforced irrigation guidelines.

CONCLUSIONS

Without question, the enforcement of microbiological guidelines or crop restrictions remains important, but a better balance between safeguarding consumers' (and farmers') health and safeguarding farmers' livelihoods should be made, especially in situations where the required water treatment or agronomic changes are unrealistic. More holistic approaches are required which go beyond the current ones. While in Accra (Ghana), for example, urban farmers using wastewater were arrested, the municipality of Cotonou in Benin provided new land for agriculture where groundwater can be accessed with, for example, treadle pumps. Alternative water sources, other cropping areas or improved irrigation methods are valuable measures for health-risk reduction. However, further research is needed into hygienic food marketing as well as the safe food preparation at home as important options to tackle the wastewater problem in low-income countries. Scientific data on actual risk reduction through the various measures described above are still insufficient. It is finally recommended that the new guidelines be presented in a more integrated way, to avoid the concentration on wastewater treatment to the exclusion of management measures for health protection.

NOTES

(1) A summary of the rationale for the development of the wastewater guidelines, and a brief history of guideline development is given in "Water quality: Guidelines, Standards and Health" published by the WHO, following a meeting of experts in Stockholm, 1999 (Havelaar, *et al.*, 2001).
(2) We refer here to market-oriented open-space vegetable growers, not backyards.
(3) From this perspective, microbiological contamination should receive more attention than, for example, the degradable organic matter content (which can be a valuable source of e.g. nitrogen).

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Sources and Quality of Water for Urban Vegetable Production

(Tamale, Ghana)

The municipality of Tamale is the most urbanised district in the entire northern part of Ghana. It has 293,879 inhabitants and a population growth rate of about 2.7%, and it serves as an administrative and educational centre. The municipality covers an area of about 922 km².

Tamale also has some industries for primary processing of raw materials such as cotton, shea nut (*Vitelaria paradoxa*) and rice. It lies within the Guinea savannah agro-ecological zone and is characterised by high temperatures averaging 29°C and one rainy season (<1,000mm), falling between April and October. The other months are very dry, leaving domestic and agricultural sectors to struggle for the meagre water resources available from small dams and dugouts. Urban gardening is the important source of vegetables for the urban population. Crops grown in the gardens include maize, cabbage, carrots, local leafy vegetables, tomatoes and many fruit types, such as papaya, banana, etc.

Approximately one third of the population in Tamale is served with potable water, while the rest depends on dams and dugouts that retain runoff from the previous rainy season. Groundwater availability is limited in a few hand-dug wells and boreholes, with depths ranging from 18-122m, depending on the nature of the rock material present beneath the soil horizons. The yield of wells and boreholes in the area is generally poor, and the drilling success rate is also low. Out of 18 boreholes drilled in Tamale Municipality in 1997, only three were successful and these yielded between 12-50 l/s.

This situation makes vegetable gardeners use almost any water that they can lay their hands on, regardless of its source and especially during the dry season. For instance, in Kamina (a study site), farmers use water directly from a broken-down sewage-treatment plant. At six sites, the sources were identified and the water analysed for physiochemical and microbiological parameters during the 2000/2001 dry season to determine its suitability for vegetable production. (The results are given in a table, available on **www.ruaf.org.**)

Thirty farmers and relevant institutions were also interviewed. Most of the respondents mentioned that land acquisition did not represent a problem. Most of the respondents are young men (traditional rules do not allow women to own land), comprising school dropouts, or students who could not continue their education due to financial constraints. Of the respondents, 57% mentioned that vegetable gardening is their part-time occupation, supplementing other sources of income. Constraints include lack of financial resources for good quality inputs such as certified seeds and pesticides. About 23% use only compost on their plots. Most of the farmers indicated that they use both organic and inorganic fertiliser, when the funds are available. Farmers usually apply water to their plots using buckets or watering cans, once or twice daily.

WATER QUALITY

All the water sources (1-6) are routinely used for vegetable production in the municipality. The area cultivated at each site varies between 1-10 ha but the area fluctuates every season depending on the water availability and number of farmers engaged in the work.

The physiochemical parameters are within tolerable limits for irrigation water except the faecal-coliform levels, which were for all sites higher than $2*10^6$ faecal coliforms per 100 ml. Irrigation water standards for vegetables are set at less than 10^3 faecal coliforms per 100 ml. This is a clear indication of improper disposal of faecal waste. The municipal authorities echoed this with observations that there is no functional sewerage system or any specific disposal site.

Interviews with the vegetable farmers show that the availability of water for dry-season gardening is not so much of a problem, especially for those who use drains as their water source. However, the Ghana Irrigation Development Authority, which is the division of the Ministry of Food and Agriculture responsible for the development of irrigation in the country, does not recognise these farmers as "irrigation farmers" and does not provide help or any form of training. The Tamale Municipal Assembly holds the same view. Currently, no NGO or government agency is directly responsible nor interested in providing educational and hygiene-awareness programmes to the vegetable farmers.

RECOMMENDATIONS

It is clear from this initial study that vegetable production using polluted water is a regular practice in Tamale Municipality and a large quantity of local leafy vegetables, cabbage, carrots, tomato and other crops are being produced using this same resource, especially during the long dry season. This is, however, driven by the demand for water more than the nutrients in polluted water. Though the physiochemical parameters are tolerable, the levels of faecal contamination are high, hence risky to the health of both consumers and the general public. As this kind of farming is crucial for the livelihoods of the people in the area and also contributes significantly to urban food security, there is the need to give it recognition. The relevant actors, such as local authorities, government institutions, researchers, etc. should embark on a joint approach to look for better strategies to make the practice less risky as it continues to be an important income generating activity for many people in the area.

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Watering cans are often used for irrigation in Kumasi

IWMI-Ghana

Wastewater Use in Informal Irrigation

in Urban and Periurban Areas of Kumasi, Ghana

Kumasi is the second largest city in Ghana, with a population of 1 million people. The average amount of water used is 72 litres/capita/day for pipe-borne water users. Households are the main source of wastewater in the city. Black water from 64% of the population ends up in septic tanks and public toilets; this wastewater is supposed to be collected by trucks and taken to a faecal treatment plant, but it reached its capacity years ago (Leitzinger and Adwedaa, 1999). Twenty–two percent (22%) of the population use different types of latrines and 6% defecate in the bush. The remaining (i.e. max. 8%) of the population has access to piped sewerage systems (for black and grey water) connected to sewage-treatment plants, which, however, are mostly dysfunctional due to insufficient maintenance and/or too low capacity. Typical examples are the two largest plants at Asafo (serving 1.2% of the population) and the one at Kwame Nkrumah University of Science and Technology (KNUST). While the Asafo plant is usually limited by poor operating conditions, the KNUST plant has been completely out of order for more than ten years now. Raw sewage from the university premises flows to a "wetland" linked to a small stream, which is used for urban vegetable irrigation. Other smaller sewage-treatment plants mainly serve private premises and local institutions.

The use of wastewater for food crops will prevail

While this describes mostly the situation of black water, grey water from urban households (not connected to sewerage systems, i.e. from up to 90% of the population) is discharged via storm water drains and gutters into surface streams flowing through Kumasi. The effluents of the faecal and sewage treatment plants are also discharged into these streams. They show pollution levels with faecal coliforms of up to 10^{10}/100ml while the recommended maximum level for vegetable irrigation is 10^{3}/100 ml. As Kumasi is traditionally a commercial and transport centre, with one of the largest markets in West Africa, the industrial sector is not much developed. Hence, industrial wastewater is not significant in quantitative terms and heavy metals are not of concern (Cornish *et al.*, 1999).

IRRIGATION PRACTICES AND HEALTH RISKS

Along all of these streams, irrigated urban and periurban vegetable production is practised. In most cases, manual fetching with watering cans and buckets is dominant, while motorised pumps and hoses are less often used than in neighbouring Lomé and Cotonou. The irrigation method is always similarly independent of crops and water sources, and not appropriate when considering the bad water quality observed. The common method of irrigation with watering cans is likely to result in more produce contamination than when using systems like drip, furrows or bowls where water is applied near the roots of the crop. However, the farmers' decision regarding which type of irrigation method to use is influenced by small farm sizes and land insecurity, especially in urban areas, which result in hesitation to invest in infrastructure.

Irrigation takes place in the morning and evening. Due to the short growing cycle of many vegetables and their fragile nature (loss of attractive appearance), irrigation continues until harvesting day. As most pathogens survive on crops for about 15 days, they are carried to the markets and into consumers' homes. Farmers rarely wear protective clothing or take any protective measures when applying water, or pesticides for that matter. Some are aware of such measures but cannot afford them or give them little priority.

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No extension services are offered to farmers on irrigation practices, related protection, etc.

SOCIO-ECONOMIC BENEFITS

About 500 urban farmers are involved in bottomland vegetable farming throughout the year, with up to 15,000 farmers cultivating in the periurban areas during the dry season. While most farmers, especially in urban Kumasi, are men, women dominate the marketing. With an estimated area of 11,900 ha under dry-season vegetable farming around Kumasi, revenue generation from irrigation has been estimated from farm surveys to be as high as US $6 million (US $500/ha/yr) with profits of at least US $4 million (Cornish, *et al.*, 2001). A significant part of this is derived from irrigation using polluted stream water, especially downstream of Kumasi. Thus "wastewater irrigation" not only supports urban diets but also gives employment to producers and sellers and contributes to Kumasi's economy. As a comparison, the whole area under "formal" irrigation in Ghana (irrigation schemes with a dam) currently covers less than 9,000 ha.

In urban areas, farmers grow non-traditional vegetables like lettuce, cabbage and spring onions on open spaces, with water access throughout the year. They rely on this as their major source of income. The kind of vegetables grown depends mostly on actual market demand, water availability and farmers' specialisation and experience with certain crops. Many farmers combine two to three crops in a growing season and report many harvests per year especially for lettuce. This high production level makes Kumasi independent of, for example, lettuce and spring onion production from outside the city. Periurban farmers prefer maize, yam or cassava cultivation during the wet season, for both marketing and subsistence purposes. However, more and more farmers with access to water in addition cultivate vegetables such as okra, garden eggs and tomatoes in the dry season. This can double their farm income (Danso, *et al.*, 2002).

Besides the health risks, wastewater irrigation also does provide benefits to the society. For instance, a large amount of nutrients are not wasted, but retained for crop production. The nutrient contribution of wastewater used for irrigation is shown in Table 1. Farmers are generally aware of the general nutrient value of the wastewater, but are not using the wastewater for fertilisation, but rather as a source of water. In addition, they apply poultry manure in large amounts and high frequency to match nutrient leaching from irrigation (Drechsel, *et al.*, 2000).

INSTITUTIONAL ASPECTS

The Kumasi Metropolitan Assembly (KMA) has by-laws addressing environmental sanitation. Liquid-waste collection and treatment by service providers is governed by regulations. Any treatment plant that is constructed must be certified by the KMA and the Environmental Protection Agency (EPA). This certification addresses the issue of city drainage and pollution control, among other things. There is no specific clause regulating irrigated vegetable farming in the city; the closest one is the national land policy, which stipulates that no activity including agriculture is supposed to be done within 100m of water bodies. However, while this should protect water bodies in rural areas from e.g. pollution, it is supposed to strengthen their capacity for flood prevention in urban areas. Here, illegal construction of houses and shops is a major concern of city authorities, and urban farming is often tolerated as it prevents other types of encroachment.

The Accra Metropolitan Assembly (AMA) by-laws on the other hand, address the issue of vegetable cultivation in the city. In 1995, the AMA enacted a law for the "growing and safety of crops". It states that: *"No crops shall be watered by the effluent from a drain from any premises or any surface water from a drain which is fed by water from a street drainage".* The penalty is three months imprisonment or/and a fine not exceeding ¢100,000 (US $50 in 1995 which is US $13 in 2002). This by-law is seldom enforced, but whenever there has been any enforcement, it has been drastic, such as with the arrest of urban farmers. With regard to the bad water quality used for irrigation in parts of Accra, this step appears reasonable; however, it is neither tackling the whole problem nor its roots. The problems are not only that irrigation-water quality is alarming in the cities and for those downstream, and that one hardly finds any vegetables in the markets with coliform counts of less than 1,000 per 100 ml. As arresting all concerned farmers is no meaningful option, the question is how to enforce the by-laws against water pollution. The answer is that these by-laws need amendments that offer viable alternatives to the farmers (see article on Guidelines on page 7). In addition, any individual prosecution would be a farce as government institutions such as hospitals, ministries, learning and research institutions and others contribute to water pollution just like every household not connected to a sewerage system. In fact, the pollution of our streams is facilitated through the continuous construction of storm-water drains along every street. Urban water pollution is not yet a municipal priority topic, but should become one to tackle the wastewater problem at the source.

CONCLUSIONS AND RECOMMENDATIONS

Wastewater collection, treatment and/or disposal in Kumasi city is in a deplorable state and lacks necessary infrastructure. This state of affairs also extends to the disposal of solid waste, sludge, etc. As a result, water bodies, especially in and

Table 1: Nutrient application with irrigation water in and around Kumasi, based on analytical data

	Calculation base	Cornish *et al.*, 1999	Data from IWMI Ghana
Area	Periurban	Periurban	Urban
Amount of water applied per year	200 mm	200 mm	1000 mm
Total N (kg/ha)	2-50	8-40	10-200
P2O5 (kg/ha)	170-200	40-240	130-300
K (kg/ha)	-	80-150	240-470

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downstream of the city, used for irrigation by urban and periurban farmers, are heavily polluted. The high levels of nutrients can be an advantage to farmers, but on the other hand, the high levels of pathogens require careful wastewater use to avoid health risks for farmers and consumers. As chemical pollutants in the wastewater are within tolerable limits, their impact on the environment and human health seems to be minimal. The informal methods of irrigation used by farmers (watering cans, buckets, water hoses) increase the risk of contamination of crops (contact of water with edible parts) and of farmers (general exposure). But, the current institutional and policy frameworks concerning wastewater use in farming remain a patchwork with related by-laws and other policies that are missing or hardly practicable in developing country contexts and for farmers that depend on wastewater irrigation for their survival.

As a long-term solution, a comprehensive improvement of the urban sanitation infrastructure is required, but lack of resources makes it unlikely in the near future. With expanding urban populations and food needs, it is likely that the use of wastewater for food crops will prevail. Raising awareness and education as a means to improve the situation has been suggested by a large number of survey respondents as well as in the wastewater related e-conference. Such awareness creation could target households, farmers, vegetable sellers, consumers and the local authorities, depending on the local situation and the best entry point for risk reduction. In order to devise better irrigation and cropping strategies for using the available water, with its inherent disadvantages and benefits, more research on the subject is needed.

A comprehensive understanding of the situation, which includes farmers' level of awareness, technical know-how, livelihood patterns, perception, social constraints, land and water rights, etc. are vital to laying the foundation for practical policy and guideline formulation. Finally, data on the extent and importance of wastewater use especially in and around cities such as Kumasi is needed for better decision-making, thus avoiding partial and myopic judgments, on which current policies are sometimes based. This will require corresponding institutional strengthening and functional research-policy linkages.

Ouagadougou Study Visit

Wastewater in Urban Agriculture, a Challenge for Municipalities in West Africa

This five-day event took place from 3-7 June 2002, and was organised by ETC-RUAF together with CREPA headquarters in Ouagadougou, Burkina Faso, financed by CTA Netherlands. It consisted of a combination of paper presentations, working group discussions and site visits. There were 29 participants.

WORKSHOPS

Three thematic papers and seven case studies were presented. The seven cases focused on cities in Benin, Burkina Faso, Cameroon, Ghana, Mali, Mauritania and Senegal. Although wastewater use is common in all but Benin, the sources and conditions differ more than one might expect. This gave a lively discussion and exchange of views.

SITE VISITS

Different sites in and around Ouagadougou were visited where a number of farmers were available to answer questions or discuss certain issues. The first site, **Kossodo**, is a large farming area that uses untreated wastewater from an industrial zone, with most water coming from a brewery and a leather tannery. The farmers, of which many are women, apply a number of strategies to avoid using the worst quality water. **Paspanga** is situated in between the artificial lake and a busy part of town. An open wastewater sewage channel separates the town from the plots. This channel carries wastewater from several industries as well as some domestic wastewater. The farmers were both men and women, each with their own plots. The farmers were organised and presented a paper with the four main problems, all concerning lack of inputs. The insufficient amount of water available was named as the number one problem. Water from the sewer is only used when wells run dry. **Kamboinse** is on the shore of an artificial lake. There are vegetable plots fed by water from channels dug from the lake into the fields. The water was very low in the lake and no crops were grown at the time of the visit. The only disease mentioned here is Bilharzia. **Boulmiougou** is another gardening site next to an artificial lake. A large number of farmers was present. Strawberries are a speciality from this site. All of the water (including drinking water) comes from wells although cleaner water is available by pumping from a deep borehole.

In all of the cases, water *quantity* and not water *quality* was seen as a regular problem. Moreover, health was not (admitted to be) a special problem (see also page 24).

RECOMMENDATIONS

The recommendations of the workshop (see **www.ruaf.org** for the full text of the Ouagadougou Declaration in French) focused on Socio-Economic Aspects; Institutional Aspects; and Health and Environmental Aspects, and are directed at farmers, farmer organisations and NGOs, municipalities, government and researchers.


IWMI-Ghana

A river polluted with wastewater in Ghana

What could be seen as a general and important conclusion is that urban agriculture itself is not taken sufficiently serious by authorities although studies are available in nearly all countries in which its importance is qualified and even quantified. This underestimation leads to insufficient consideration in town policy and planning, inadequate laws and by-laws and other texts, insufficient consideration and use of its potential in waste management and perhaps above all, insufficient consideration in the allocation of resources. The discussions on hygiene and behaviour provoked interesting debates on cause and effect, and transmission routes: producers, sellers and consumers; in all three stages, contamination as well as prevention may take place. Noteworthy are those recommendations that speak of the need of extension work to urban producers and consumers on the subject of health, hygiene and risky behaviour. Epidemiological studies are needed to review and adapt the current guidelines, to discover and quantify actual risks and to describe realistic paths of contamination.

The city of Hyderabad, with its surrounding nine municipalities, had a population of 6 million in 2001 in 500 sq. km and is one of the fastest growing Indian cities[1]. The Musi river which runs through Hyderabad is dry upstream of the city except for four months during the monsoons when it receives 700-800 mm of rainfall. However, domestic, hospital and industrial wastewater released from the twin cities of Hyderabad and Secunderabad converts it into a perennial river.

Urban vegetable plots along the Musi River, Hyderabad

IWMI-India

Livelihoods and Wastewater Irrigated Agriculture

Musi River in Hyderabad City, Andhra Pradesh, India

In the urban areas, water from the drains empty from spouts in the walls along the city roads into the fields below along the Musi. This drainage water, which is from both domestic and industrial sources, is channelled to several contiguous plots of land. It is sometimes supplemented by water pumped from the river or, less commonly, from shallow wells along the riverbanks. It is used by approximately 250 households for agriculture on a total of about 100 ha of land in the urban area along the Musi river. Most of the urban agriculture is practised along a 5 km-stretch of the river in the city from the Purana pul bridge to the Amberpet bridge (see Figure 1). It is a green area within a busy area of the Old City and helps to improve air quality.

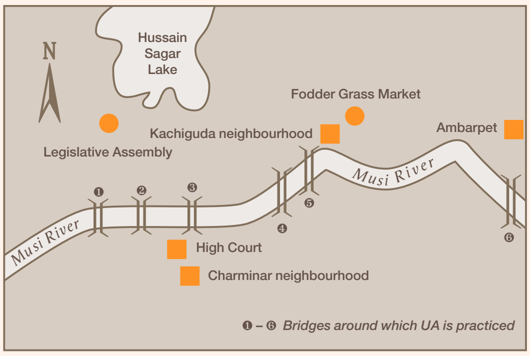

Figure 1: Urban Research Sites

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SAMPLING AND DATA COLLECTION

Household interviews were conducted to collect information on types of livelihood activities based on wastewater. In the urban areas, 50 female and male respondents were interviewed from a random sample of 33 households. The respondents were classified according to their respective roles as beneficiaries: Landowners , 50%; Renters, 16; Casual labourers, 12; Permanent labourers, 10; Caretakers, 8; Grass market vendors, 4. These percentages reflect total numbers in the urban area. Government officials were interviewed for information on the sanitation infrastructure and the legal and institutional environment of urban agriculture.

Water quality samples were taken at several points. In the urban area water quality was checked at the Chaderghat Bridge (4), where a sample was tested. More frequent monitoring needs to be conducted to get a better indication of water quality in each season.

SANITATION AND WATER QUALITY

The sewerage network covers only sixty-two per cent of the city. There is only one sewage treatment plant (STP) with primary and secondary treatment capabilities and a second STP with primary treatment capabilities only. In total, these plants treat 133 million litres per day (MLDs) of water. This treated sewage, and the untreated sewage estimated at 327 MLDs, is diverted to the Musi River. Plans for new and upgraded existing plants aim to treat 630 MLDs by 2006.

There are 12 industrial areas within 30 km of Hyderabad city which include electro-plating, lead extraction/battery units, pharmaceutical and jewelry industries. The Common Effluent Treatment Plants (CETPs) are not able to treat the varied effluents adequately. The CETP and industries that do not bring their effluents to the CETP discharge their effluents into the Musi and other water bodies.

The BOD and COD values are quite low in Hyderabad (see Table 2). MPN values indicate high levels of faecal contamination, which increases the health risks of the wastewater to farmers and agricultural labourers in direct contact with it. The risk to the consumer is expected to be lower since none of the vegetables grown are consumed raw. However, no quality-assurance tests were done on the vegetables. The EC and TDS values are higher than those recommended by the FAO guidelines. However, since the major crop is para grass which is able to withstand higher salinity conditions, this water may not have a detrimental effect. Total Nitrogen is higher than FAO guidelines but all heavy metals are within safe limits.

Wastewater UA provides livelihoods to the lowest income groups

TYPES OF CROPS GROWN

A variety of crops are grown in this area. The predominant crop is para grass, which is used for fodder, amounting to 65%. Green leafy vegetables are grown on small sections for subsistence and for sale. Other crops that make up only 1% include fruit trees as well as crosandra and jasmine flowers. These products are mainly used by household members.

LAND TENURE

In almost all urban locations surveyed, the land is owned by a single caste community of Hindus belonging to the *kachi* community now included in the category of Backward Caste (BC). This is in contrast to the periurban and rural areas where landowners belong to a multiplicity of caste groups.[2] The average landholding here is 0.4 ha of irrigated land. In the Indian context, these farmers are therefore categorised as small farmers.

Table 1: Results of Water Sample in Urban Area (Chaderghat Bridge)

Parameter	Concentration	Irrigation water quality standard
BOD (mg/l)	105	-
COD (mg/l)	352	-
MPN (total coliform)	4.6 x 10 10	-
TN (mg/l)	25	5.0
EC (ds/m)	2.1	0.7
TDS	1012	450
Zn (ppm)	0.32	2.00
Cu (ppm)	0.13	0.2
Chloride (mg/l)	151	-
Cr (ppm)	0.04	0.1
Pb (ppm)	0.07	5.00

Laws Affecting Urban Farmers

- In 1986, the Andhra Pradesh Government banned wet cultivation in city premises and the power (electricity) supply to the farmers for irrigation was cut off.
- The value of the land in the Musi bed for compensation for the construction of bridges or other government project or activity has been declared as Rs. 800 per sq yard but according to one of our respondents, the actual value of the land should be Rs. 10,000 per sq yard.
- Before 1976, the loss of vegetables after flooding was being compensated (Rs.1,000 to 800) but after 1976 this compensation was terminated.
- Until 1995, a land tax was being collected (Rs. 480 per acre/year) considering all the land on the Musi bed as agricultural land. But after 1995, the Town Survey declared the land as Commercial land and is asking the farmers to pay a commercial tax on that land.
- The land cannot be legally sold.
- No person can build anything on this land.
- There is no legal procedure with the Town Survey regarding the transfer of ownership rights or title of the land.
- The width of the river channel is 100 meters and the rest of the land is supposed to be private, titled land (personal communication, Secretary to the Chief Commissioner of Land Administration).

LABOUR MARKET AND ROLES OF MEN AND OF WOMEN

Men and women involved in wastewater agriculture play different roles in urban agriculture depending on the beneficiary category they belong to. Only landowners who have sufficient household labour cultivate vegetables, since labour is expensive. Most household labour for vegetable production is female. Female landowners carry out almost all of the fieldwork, including irrigation. The women who grow vegetables reserve a portion for household consumption and a portion for sale (see Table 3 for income data). Amongst the dairy producers, the men in the family usually do the fieldwork. Men and women tend and milk the buffaloes and sell the milk or yoghurt. They keep the livestock next to their houses in the city.

The casual labourers are male or female migrants from a drought-prone district. Some were squatters on the banks of the Musi and were relocated to an urban resettlement area. Most are BCs. Permanent labourers work year-round on one plot and are from drought-prone states. They get lodging with the landowner, and salary of approximately € 33/month [3].

The caretakers are men or women who live with their families on the land in small huts or tents. They are either *lambadis* (ST) or from the BC. They sell the various tree leaves to customers who come to the plot. Some also work the land for pay equal to casual labour.

INCOME FROM WASTEWATER USE

Urban agriculture with wastewater benefits the landowners from crop income, from fodder grass for livestock, from rental income and from crops used by household members. For one hectare of land, the annual income is approximately € 2,812 for 1 ha of para grass, € 833 for 1 ha of leafy green vegetables, € 470 for one hundred banana plants, € 33 for 20 coconut palm trees, and € 625/ha/year in rental income from para grass. Table 3 summarizes the average annual incomes for the different crops grown.

Wages for casual and permanent labourers in urban areas are slightly higher than in the periurban and rural areas. There is, however, a wide wage gap

Table 2: Costs of production and income generated from main wastewater dependent activities (3)

Activity	Cost of production per hectare (Rs. and €)	Income (Rs. and €)	Average annual income (Rs. and €)
Leafy vegetables (Rs/ha/month)	Rs. 3,750/€ 78 per month	Rs.5,000/€ 104 per month	Rs. 40,000/€ 833 per year
Banana (for 100 plants)	Rs. 7,200/€ 150 per year	Rs. 22,500/€ 470 per year	Rs. 22,500/€ 470 per year
Coconut (for 100 palms)	Rs.7,200/€ 150 per year	Rs. 10,000/€ 208 per year	Rs. 10,000/€ 208 per year
Para grass per ha	Rs. 45,000/€ 937 per year	Rs. 90,000-180,000/€ 1,875-3,750 per year	Rs. 135,000/ € 2,812 per year
Para grass (rent collected Rs/ha/month)	NA	Rs. 2,500/€ 52 per month	Rs. 30,000/€ 625 per year
One milch buffalo	Rs. 500/€ 10.40 per month	Rs. 2,000/€ 42 per month	Rs. 16,000/€ 333 per year

between women and men. However, women find employment for more days per year than men in the urban areas (30 days versus 10 labour days for men).

In the case of casual and permanent labourers, additional income is gained through other activities. Females tend to work as housemaids for several houses, earning approximately € 9.40 per month and also work as construction workers where they earn € 1.25 per day. Men, on the other hand, tend to work mainly as construction workers and earn € 1.67 per day.

WASTEWATER FODDER GRASS MARKET AS AN ECONOMIC HUB

From Figure 2 it is clear that fodder grass cultivation is a very important activity in the area. It provides an economic hub around which a number of dependent beneficiaries revolve.

Much of the land dedicated to fodder production is rented to dairy producers. A few own the land. They save by cultivating much of the feed for their livestock. The renters with livestock do the cutting of the grass themselves. Buffaloes are the preferred consumers of this fodder because they provide more milk with a higher fat content, which receives a higher price than cow's milk. Household members also consume this milk, thus saving on this expenditure.

The fodder grass market is located within 10 minutes of where most urban agriculture is practised. Approximately 50% of the fodder grass grown is sold in the market. The other half is used directly by farmers who produce it for their own livestock. The important role it plays economically is symbolised by the promise made recently by the home minister to donate 2,000 square yards of land for a new grass market, in the Kachiguda neighbourhood of the city where most of the urban farmer/landowners and livestock keepers live and keep their animals.

This informal market operates through four salesmen who get a commission of 5% for each grass bundle. Daily, thirty mid-sized vehicles carrying 5 tonnes each transport the grass to the market. These vehicles when fully loaded, generate employment for 40 casual labourers as well as for one truck cleaner and one truck driver. Preliminary estimates indicate that 1,260 casual labourers, fodder-grass salesmen, truck drivers and truck cleaners are employed per day by the landowners and renters.

USERS' PERCEPTIONS ON HEALTH ISSUES AND WASTEWATER USE

The informants had mixed reactions on the health risks associated with using wastewater. Urban and periurban farmers are less exposed to wastewater than are rural farmers who grow paddy and therefore spend long hours standing in the wastewater during puddling, transplanting, weeding and harvesting.

There were mixed perceptions as to the health impacts. One 40 year-old female urban farmer told us: "I never had any health problems due to the use of this wastewater for irrigation". However, in general, urban, periurban, as well as rural farmers complained of rashes and skin irritation when exposed to wastewater for long periods of time. The response of this 68 year-old permanent labourer in Hyderabad city was typical:

I irrigate the field and am exposed to this water all the time. Skin irritations are a common problem with constant itching of the skin on the legs and arms. Mosquito bites and bites of other small insects in the water are also common. I get a fever at least once a month which I think is due to all of these insect bites. But I never had any major health problems due to this water.

This aspect has not been studied in depth and further reasearch will have to be conducted to shed more light on these issues.

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IWMI-India

Women transplanting rice along the river

LEGAL-INSTITUTIONAL ENVIRONMENT

Box A explains the institutional and legislative environment. Interestingly, all of the governmental institutions seem to deny that there are any benefits associated with this form of agriculture. Some, like the Department of Urban Agriculture within the Ministry of Agriculture, deny its very existence. The only exception is the urban farmers' association. The laws affecting urban agriculture are described below in Box B. These are not proactive in supporting urban agriculture. The only law that favoured urban agriculture was repealed in 1976.

We are just able to fill our stomachs

The urban farmers' association has worked as a pressure group in the past to stop a project to channel the river in the urban area through a covered canal and to establish parks along its banks. It is highly likely that this group could act as a pressure group that could work towards stimulating recognition by governmental agencies of the existence and of the positive impact of urban agriculture on livelihoods. From this might follow a gradual change towards the adoption of legislation that will support urban agriculture.

CONCLUSIONS

Wastewater agriculture in this urban area along the Musi river, provides livelihoods to a diverse group of people from different caste groups and represents a broad spectrum of social classes, ranging from the lower middle class to very low-income groups of urban dwellers, to temporary and permanent migrants from rural areas. These socio-economic characteristics determine the type of wastewater-related activity in which they will be involved.

The agriculture and livestock activities based mainly on a fodder grass market seem well-suited to the only type of water available (wastewater). While banana and coconut occupy a good proportion of the urban agricultural land area studied, the income from leafy vegetables, which occupy only 1% of the land, exceeds the income from the other two crops. Unlike the other crops, leafy vegetables pose a greater risk to the consumer but conclusive studies have not yet been conducted.

However, even though there is a flourishing business from urban agriculture with wastewater, it continues to be a hidden economy, existing in busy areas of an ever-growing megalopolis that will only produce more wastewater in the future. The agriculture is neither recognised nor supported as of yet by the government. Pressure groups like the urban farmers' association have proven to be powerful in the past and could successfully wage campaigns to safeguard their livelihoods in the future.

NOTES

(1) Handbook of Statistics of Ranga Reddy, 2001:157
(2) The *kachi* community received land in repayment of favours to their rulers, some by late 17th century. The names on the land titles are rarely changed. Land disputes are resolved by a *kachi* association.
(3) 1 Euro (€) = approx. 1 USD

Institutions Regulating Urban Agriculture

❖ **Bhagya Nagar Kisan Sangh (BNKS)** farmers' association was formed by urban farmers in response to the government initiative to ban cultivation on Musi bed in urban areas. It mainly functions as a platform where farmers gather to exchange information and consult one another on any legal issues related to their land.

❖ **Revenue Department (Collectorate)** is a government department that collected an annual land tax on all urban property until about 1999.

❖ **Municipal Corporation of Hyderabad (MCH)** coordinates solid waste collection, transportation and disposal. It does not permit buildings to be constructed in river flood plain (along riverbanks). It removes illegal settlements upon the recommendation of the Revenue Office.

❖ **Commissioner of Land Administration** enforces the Urban Land Ceiling Act of 1976 limiting urban plot size to 4,000 sq ft (370 m^2) and outlawing sale of land along the Musi river. The main reason that they wish to enforce this Act, according to the Secretary to the Chief Commissioner of Land Administration, is so that farmers do not sell the land and hurt air quality due to loss of the green area (personal communication, August 27, 2002).

❖ **Hyderabad Urban Development Agency (HUDA)** plans and regulates city space. A master plan drafted for the projected population of 2011 for Hyderabad city covers residential plots, industry, transport, amenities and eco assets but the extent of agricultural land not projected. According to same master plan, sewage load is estimated at about 2560 MLD for the projected pop. for 2011 (ranging from 9.5 to 11.3 million). The master plan also suggests decentralised Sewage Treatment Plants (STP). In one section of draft master plan, this proposed: "in peripheral areas and in the No-Development Zones, urban agriculture should be encouraged."

❖ **Hyderabad Metropolitan Water Supply and Sewerage Board HMWS & SB** are responsible for the provision of water to the city and for construction and maintenance of dams, pipelines and canals for surface water and wells for groundwater. They are also responsible for operation and maintenance of two STPs and the sewerage system. Three new treatment plants and upgrades of the two existing STPs have been proposed by HMWS & SB.

❖ **Andhra Pradesh Pollution control Board (APPCB)** assesses the quantity of water consumed by private and public sources and methods for discharging water. They perform regular water-quality tests along Musi.

❖ **National River Conservation Project** is made up of various institutions (such as HMWS&SB) that are currently planning measures to clean up Musi river.

Reality and **Potential**

Integrated Systems for the Treatment and Recycling of Wastewater in Latin America

The amount of people living in cities has increased to over 360 million by the start of the 21st Century (73.6% of its total population). In many cases, the growing pressure this rising population has exerted on water and land resources has overwhelmed government efforts to achieve planned urban growth and has compelled governments to give priority to potable water and sewerage service systems. This has happened to the neglect of both the treatment of wastewater and the disposal of solid waste.

More information on the project is available on the CEPIS website: www.cepis.ops-oms.org/ Wastewater/Regional Project

The Pan-American Health Organisation (PAHO) points out that in 1998 less than 14% of the 600 m^3/s of wastewater in Latin America received some sort of treatment prior to its disposal in rivers or in the sea. Just 6% of this water receives acceptable treatment. In addition, the fact that 40% of the urban population in the region shows an incidence of infectious diseases associated with water means that such drainage constitutes a major means for the transmission of parasites, bacteria and pathogen viruses, and therefore requires urgent attention.

Tabel 1: Water and sanitation conditions in Latin America for 1998

Population with potable water	93%
Population with sanitation	90%
- with sewer systems	63%
- with other systems	27%
Treated waste water	14%
- with secondary treatment	6%

PAHO, 2001

Agricultural activities carried out in the periphery of cities have been severely affected, having to opt for the use of wastewater as their only alternative for survival. This is reflected in the existence of more than 500,000 ha of agricultural land being directly irrigated with untreated wastewater (Bartone, 1990), in addition to an even larger land area irrigated with surface water contaminated by urban sewage that normally exceeds health-quality standards (i.e. regarding faecal coliforms and nematodes) as recommended by the World Health Organisation (WHO, 1989).

In Latin America, a limited amount of separate collectors for domestic wastewater, rainwater and industrial sewage exists. Mixed collection systems result in an increased amount of sewage to be treated and adequately disposed.

The Regional Report on Evaluation 2000 in the Region of the Americas (PAHO, 2001) refers to the limited coverage of sanitation and wastewater treatment in Latin America as an evident failure. This failure is partly blamed on the use of unsuitable technologies (more typical in developed countries) and due to the high amounts of investment required, as well as the high operating costs of these systems.

PROMOTION OF INTEGRATED SYSTEMS FOR THE TREATMENT AND RECYCLING OF WASTEWATER

Twenty-two years ago, PAHO'S Pan-American Center for Sanitary Engineering and Environmental Sciences (CEPIS) started the programme for the Treatment and Recycling of Wastewater, to increase the use of appropriate technologies for domestic wastewater treatment within the region.

In 2000, Canada's International Development Research Centre (IDRC) and PAHO/WHO signed an agreement whereby CEPIS would carry out a research programme on integrated systems for the treatment and recycling of wastewater in Latin America.

The aim was to provide cost-efficient solutions for managing domestic wastewater in agricultural activities within cities, and by reconciling the interests of stakeholders responsible for the treatment of urban wastewater and of farmers using this water for irrigation.

To achieve such a goal, a regional inventory of treatment systems currently in operation is being promoted, as well as of related agricultural activities. Twenty case studies were selected, representing four wastewater management situations (see table).

The Project is financing three stages of collection and analysis of information in these locations. In the first stage, *General Studies*, the more general aspects in 18 cases were considered. In the second stage, *Complementary Studies*, 11 of the 18 cases were selected for an evaluation of technical, environmental, economic, social and cultural aspects, and to prepare a preliminary proposal for the integration of treatment and recycling of wastewater in agriculture. In the third and last stage, *Feasibility Studies*, seven cases out of the previous 11 were selected, to promote the socialisation and development of these proposals among the main local actors. Programme activities also include producing and disseminating documentation, strategies and guidelines on this issue for the region, as well as a series of national seminars and donor tables.

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LESSONS LEARNED

The programme was able to identify the critical aspects to be taken into consideration in the design and management of integrated systems for the treatment and recycling of domestic wastewater.

- ❖ The explosive growth of big cities has pressed for a prioritisation in the use of surface water for public supply and electrical generation. As a logical consequence, agricultural activities around and within cities have opted to use wastewater as the only alternative for their survival.
- ❖ Institutional and socio-economic requirements are of special relevance. The selection of technological options is done under political and institutional decisions usually made without much coordination.
- ❖ Most decisions regarding control parameters for water quality, treatment technology, distribution of associated cost, disposal of wastewater and its use in irrigation, to name just the most important ones, are made unilaterally and with almost no participation of other interested groups.
- ❖ There is a need to create mechanisms and spaces for coordination and consensus between those responsible for regulating and managing domestic wastewater, and sewage-user or –affected groups.
- ❖ In most countries legislation does not consider the health quality of wastewater in terms of human pathogens. When it does, it is not applied due to a series of restrictions such as a limited or weak monitoring and control capacity and because of the social pressure exerted by users.
- ❖ Institutions responsible for domestic wastewater management lack the capacity to assume the investment and operating costs of treatment. This is mostly because cities and city representatives have failed to understand or perform their duty in the treatment of generated wastewater.
- ❖ The cost of treatment (if existing) has not yet been incorporated into water and sanitation service rates, except in the special cases of Mendoza, Argentina, and (partially) in Cochabamba, Bolivia.
- ❖ The potential of integrating treatment and recycling as a mechanism to reducing investment and operating costs in both activities has still not actually been understood.
- ❖ The growing conflict of interests between technology providers from developed countries, public health officials and wastewater-treatment operators is leading to an unsustainable situation. In Cochabamba, Bolivia, one private company that attempted to install an activated mud plant had to leave the country after the violent rejection of the population, of increased rates to finance it.
- ❖ In other cases, conflicts have reached different proportions but are similarly worrisome: Mexico, a country where it is estimated that some 350,000 ha are irrigated with untreated wastewater, has established a limit of 5 nematode eggs per liter of water in its legislation as a health-quality parameter for effluents from treatment plants, as none of their activated mud plants can reach the level of less than one nematode egg per litre of water recommended by the WHO.
- ❖ Some experiences remarkably resemble this programme's proposal to integrate treatment with agricultural recycling of wastewater. In Mendoza, Argentina, some 2,000 ha of agricultural land are irrigated with effluent treated in 300 ha. of stabilisation lagoons receiving 1,400 l/s from a population of 320,000 inhabitants. Nevertheless, agricultural treatment and recycling fall under the responsibility of entities that carry out their activities without much coordination between them.
- ❖ In Colombia, companies responsible for the treatment of domestic wastewater will be subjected to high penalties if they dump effluent containing pollutants that exceed the limits established by legislation. In Ibagué, a city of 430,000 inhabitants, untreated wastewater is dumped in the rivers criss-crossing the city, and this water is later used to grow rice in some 26,000 ha. That city's water company was considering installing an activated mud plant and, under a CEPIS programme initiative, has started negotiating with the rice growers' association on the treatment of the wastewater they use in order to reach the health standards required for affected farmers. In turn, they have offered part of their land area to implement the final stage of the treatment prior to taking the effluent to other farmlands or bodies of water.
- ❖ One of the most important aspects still to be developed is the epidemiological follow-up of the different wastewater-treatment systems implemented in the region. There is not enough information regarding the incidence of diseases associated with the handling, growing and consuming of products irrigated with wastewater.

It is necessary to continue to develop dissemination activities, training and technical assistance for the treatment and sanitary use of domestic wastewater in Latin American countries and in the Caribbean. In addition to these dissemination activities, it is anticipated that the CEPIS programme will support pilot experiences in countries where the agricultural use of wastewater is a little-known alternative, such as in the cases of Fortaleza in Brazil and Liberia in Costa Rica. It is expected that results from these experiences will provide plenty of information for the establishment of strict but at the same time enabling legislation.

Tabel 2:

Cities	Treated	Untreated
With reuse	Antofagasta (Chile)	Mezquital (Mexico)
	Cochabamba (Bolivia)	San Augustin (Peru)
	Juarez (Mexico)	San Martin (Argentina)
	La Vega (Dominican Rep.)	Santiago (Chile)
	Mendoza (Argentina)	
	Tacna (Peru)	
	Texcoco (Mexico)	
	Villa El Salvador (Peru)	
No reuse	Fortaleza (Brazil)	Ibague (Colombia)
	Maracibo (Venezuela)	Jinotepe (Nicaragua)
	Portoviejo (Ecuador)	Luque (Paraguay)
	Puntarenas (Costa Rica)	Solola (Guatemala)

In the Middle Eastern and North African countries under MENA[1], water is the key development issue. The average rate of the region's annual population growth is one of the highest in the world (around 2.6 per cent) while the region faces scarce natural water supplies. As a result, average renewable fresh water availability in the region has dropped to about 1,433 m³ per year, while many countries in the region fall well short of that. For example, in 1999, the annual renewable freshwater available per person in Jordan, Tunisia and Yemen was 148, 434 and 241 m³, respectively, and these values are projected to drop drastically by 2025 (World Bank, 2001). As well, the available water is of a lower quality because of increasing pollution and over-pumping.


IDRC

In Jordan, INWRDAM have trained a plumber who, in turn, is training others to install the systems

Wastewater Treatment and Reuse for Food and Water Security

This situation is compounded by the high urbanisation rate in MENA. It varies from 1.8 per cent in Egypt to 4 per cent in Palestine and 5.3 per cent in Yemen (with an overall rate for MENA of 3.2 per cent, which is higher than the rate for developing countries as a whole). With 79 per cent of the population already living in cities in Jordan, and 88 per cent in Lebanon, the average for the region as a whole is already 53 per cent (United Nations Secretariat, 2002 and Population Reference Bureau, 2002). Within the region, about 80 per cent of fresh water is used for agriculture. Even with low urban tariffs, the value of water is at least 10 times higher in urban areas than it is in agricultural areas (Gibbons, 1986). As a result, water will increasingly be taken out of agriculture and put into urban areas. This means that the region will increasingly suffer from twin and related problems of food and water insecurity.

Wastewater reuse is permissible for all purposes

Many countries wish to increase fresh water supplies to domestic and industrial usage, and at the same time expand irrigated agriculture. For example, Tunisia wishes to increase the area of irrigated agriculture by at least 30,000 hectares (ha), and Egypt, by 880,000 ha (World Bank, 2000). How can these seemingly contradictory objectives be reconciled? The answer is water-demand management; more efficient water use within all sectors. One specific component is to use treated domestic wastewater for industry, for some municipal purposes such as flushing toilets and irrigating green spaces, but, above all, for urban and periurban agriculture (UPA).

BENEFITS

There are several benefits in using treated wastewater. First, it preserves high quality and expensive fresh water for potable use. The cost of secondary-level treatment for domestic wastewater in MENA, an average of US $0.5/m³, is cheaper than developing new drinking water supplies in the region (World Bank, 2000). Second, collecting and treating wastewater protects existing sources of valuable fresh water, the environment, and public health. In fact, wastewater treatment and reuse (WWTR) not only protects valuable freshwater resources, but also can supplement them through aquifer recharge. If the benefits of environmental and public health protection were correctly factored into economic analyses, wastewater collection, treatment and reuse would be among the highest priorities for scarce public and development funds. Third, if managed properly, treated wastewater can sometimes be a superior source for agriculture than fresh water sources. It is a constant water source, and nitrogen and phosphorous in the wastewater may result in higher agricultural yields than freshwater irrigation, negating the need for additional fertiliser application. Research projects in Tunisia and Saudi Arabia have demonstrated that treated effluent had superior

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non-microbiological chemical characteristics than that in groundwater for irrigation. Most importantly, treated wastewater had lower salinity levels (WB, 2000).

CASE STUDIES

The countries in the region that practise wastewater treatment include Kuwait, Saudi Arabia, Oman, Syria, UAE and Egypt. However, only Israel, Tunisia and Jordan practise wastewater treatment and reuse as an integral component of their water management and environmental protection strategies.

PROBLEMS

The main problem with the use of wastewater is the threat to public health, the soil and water if reuse is not done carefully. While the main impact on health from reuse in developing countries is from diseases caused by helminths, such as roundworm, hookworm and guinea worm, microbial pathogens pose the second largest threat. The worst-case situation occurs when untreated wastewater is used to irrigate vegetables or salad crops that are then eaten raw. This practice resulted in the cholera outbreak in Amman, Jordan in 1981. Unfortunately, there are many on-going instances of raw wastewater reuse which, without doubt, result in occasional gastro-intestinal illness, but have the potential for causing widespread illnesses. For example, due to water scarcity, the irrigation of market vegetables such as eggplant and cucumber with raw wastewater flowing in the Kedron Valley, West Bank is common. Components in wastewater that are most toxic to some crops include sodium, chloride and boron.

Raw wastewater can also salinise soils, and the grease in this water can reduce soil permeability and aeration by clogging pores. Both microbial pathogens and nitrates from wastewater can contaminate shallow aquifers.

These obstacles are real, but not insurmountable. In 1989, the World Health Organisation published the *Guidelines for the safe use of wastewater and excreta in agriculture and aquaculture* (WHO, 1989), to protect public health. These guidelines identify necessary treatment levels depending on whether the irrigation will be restricted (e.g. cereal, industrial, fodder crops or pastures and trees), or unrestricted (e.g. irrigation of crops likely to be eaten uncooked, sports fields and public parks). Even the most stringent treatment levels in the WHO guidelines can be met by a series of wastewater-stabilisation ponds. In addition to identifying a combination of treatment and crop restrictions, the WHO guidelines also outline safe waste application methods and control of human exposure, to protect public health.

Grey Water Reuse in Urban Agriculture in Jordan

With its low and rapidly decreasing per capita water availability of 148 m^3/p/y, less fresh water will be available for agriculture in Jordan. One means of addressing this threat to food security is to treat and reuse domestic wastewater in UPA. An IDRC-supported project found that 16 per cent of the households in Amman already practice UPA, mainly for the production of fruits, vegetables and herbs. The annual value of UA in Amman is US $4 million — already 2.5 per cent of the total value of agriculture in Jordan (Government of Jordan, 2002). The problem is that only 40 per cent of wastewater in Jordan is collected and treated. The necessary rehabilitation and expansion of conventional sewerage and wastewater-treatment systems will take time and millions of dollars.

IDRC's research partners have come up with a new approach to combat food insecurity — helping the poor to harvest water at the household level. The systems consist of minor plumbing modifications that divert water from showers and bathroom and kitchen sinks through small-scale, natural filters in each household allowing residents to recycle water for reuse in home gardens. Grey water reuse is much safer than combined wastewater reuse because greywater contains no pathogens from the toilet. Also, because most "wastewater" is simply "grey water," diverting it from the public sewerage system can dramatically reduce the costs required for installing and expanding such systems. In this pilot project, grey water-treatment systems were installed in 25 homes in Ain Al Baida, Jordan, and households members were taught how to set up efficient gardens. Systems were also installed at the main mosque in the community, and at a girl's school.

The project has exceeded expectations. The grey water effluent meets standards for restricted irrigation, and households are using it to irrigate eggplants, herbs and olives. Impact on poverty and water use is still being measured. However, an IDRC study on a previous untreated grey water-reuse project found that the community was able to offset food purchases and generate income by selling surplus production, and by saving or earning an average of 10 per cent of its income. Initial water savings were about 15 per cent. The economic impact of this project is likely to be much higher because the grey water recovered in the first project was only about 30 per cent of domestic water, whereas in the current project it has already reached about 60 per cent. Furthermore, previously overflowing septic tanks, that cost at least US $60/yr to pump out have not been pumped since the project began. Economic benefits certainly have been significant enough to impress the neighbours of the original beneficiaries, they are now installing the systems at their own cost, proving that households recognise that wastewater treatment can save them or make them money. The Inter-Islamic Network on Water Resources Development and Management (INWRDAM), has improved the original design developed in Palestine with innovations making the systems safer and more efficient. The media in the filters is either gravel or pieces of old irrigation piping. A simple bag filter eliminates clogging associated with previous systems. INWRDAM also developed an environmentally friendly dishwashing liquid that prevents soil salinisation arising from grey water reuse, and has begun training workshops on grey water reuse for low-income settlements in Syria and other network countries. The Jordanian Deputy Minister of Social Welfare has visited the Jordan project and is interested in the potential for the systems to alleviate poverty. Also, the Water Authority of Jordan (WAJ), a part of the Ministry of Water, is testing the effluent quality of the systems, at its own cost.

For instance, sprinkler irrigation is discouraged. Also, where fruit trees are irrigated with treated wastewater, irrigation should cease two weeks before fruit is picked, and no fruit should be picked up off the ground. Crops and soil can be protected by readily available information on what types of crops and soil are sensitive to wastewater irrigation. Groundwater and surface water can be protected by mapping sensitive areas, such as shallow aquifers used for drinking, and banning wastewater irrigation in those areas.

Given the emphasis that Islam, like other religions, places on cleanliness, there is also a persistent notion within the region that wastewater reuse is against Islam. However, as noted in *Water Management in Islam*, published jointly by IDRC-UNU Press (2001), wastewater reuse is permissible for all purposes, including *wudu*, provided that the wastewater is treated to the required level of purity for its intended use and does not result in any adverse public health effect. Wastewater reuse is being practised with the accordance of religious authorities in Oman, UAE and Saudi Arabia. The kingdom is currently reusing about 20 per cent of its treated wastewater in refineries and for irrigating forage and landscape crops (Faruqui, *et al.*, 2001).

Another obstacle is that except for some of the richer gulf countries in MENA, mechanical treatment of wastewater has not proven sustainable in periurban areas or in smaller towns or cities, because chemical and energy costs are high and operation and maintenance is frequently not carried out. Within its Cities Feeding People programme, the IDRC is currently developing a network of decentralised, low-cost natural waste-treatment systems for reuse nearby. Pilot projects include trickling filters for grey water reuse in the low-density hilly settlements surrounding Jerusalem, aquatic wetlands using water lettuce or duckweed in the Jordan Valley, and low-mechanical content activated sludge in Egypt. See boxes.

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Grey water collected in piping along exterior walls of households

CREATION OF AN ENABLING ENVIRONMENT

Based on the experiences of countries such as Israel, Tunisia and Jordan, which have successful treatment projects

Duckweed Wastewater Treatment and Reuse for Fodder, West Bank

This project aims to protect the environment and improve food security by pilot-testing the use of duckweed, a floating plant, to treat wastewater in small, decentralised communities in the Jordan Valley, West Bank. In the past five years, there has been a growing recognition of the effectiveness of this tiny aquatic plant to treat wastewater at a much lower cost than mechanical treatment plants. Because duckweed is 40 per cent protein by weight and grows so quickly, it can serve as an excellent feed supplement for poultry, livestock and fish, and can even be served in salads. An integrated system can both treat wastewater and provide income and employment opportunities for local residents who sell the produce raised on duckweed. In addition to reducing biological oxygen demand (BOD) and Total Suspended Solids (TSS) levels, duckweed efficiently reduces nitrogen and phosphorous levels in wastewater. But the operation of duckweed systems is still an art rather than a science, and while plants flourish in some locations, it is difficult to grow them in others.

This project will optimise various operating parameters for an integrated duckweed wastewater-treatment system at the Agricultural Development Society (ADS) training farm outside of Jericho, in the West Bank, a few hundred metres from the Jordan River and the Dead Sea.

Despite the political obstacles that have slowed down the Palestinian research team — their office was blown up, they have been shot at, they have endured long delays at checkpoints, and sometimes cannot reach the project site — it has still made some valuable preliminary findings:

Duckweed thrives between 25-30 degrees Celsius — previous systems in Amman and Hebron did not function because of the cold in winter at these high altitude locations. On the other hand, in the summer, when temperatures exceed 40 degrees Celsius in the Jordan Valley, the duckweed will have to be shaded with trellises. The duckweed is growing well — even in water with salinity as high as 3,000 ppm, and is being harvested twice a week. The effluent from the duckweed pond meets the standard for restricted irrigation. The dried feed has already been tested on chickens as a feed supplement with very good results — the average weight of the chickens fed by duckfeed was 17 per cent higher than for chickens that were not fed fodder. Furthermore, the chickens have whiter meat that increases their marketability for farmers. These factors, plus the savings in fodder cost of about 15 per cent, have led to an enthusiastic response by farmers in the area.

This case indicates that when decentralised wastewater treatment leads to opportunities for periurban farmers to generate income, they are willing to contribute to its costs. The Palestinian Researchers have visited duckweed ponds in Bangladesh, which has resulted in an important south-south transfer of knowledge. The Palestinian Ministry of Agriculture, the National Agriculture Centre, and the Palestinian Agricultural Relief Committee all have visited the project and are following the results closely.

In the coming years, fresh water will have to be preserved solely for drinking

relative to other countries in the region, governments in MENA need to do the following to create an enabling environment to encourage safe wastewater treatment. First, treatment must form part of an integrated water-management strategy at the basin level, with multi-disciplinary linkages between different sectors such as environment, health, industry, agriculture and municipal affairs. For instance, the main producer of wastewater — municipalities — must interact with the main user, urban agriculture. Urban/rural planning must be integrated so that industries are not situated in locations where their effluent, often high in dangerous constituents such as heavy metals, will contaminate water meant for the biggest user, agriculture.

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An average household saves or generates 10 per cent of its income

Second, it is the duty of governments to facilitate the participation of stakeholders in wastewater-treatment projects, including supporting NGOs working in institution building at the local level. Safe and sustainable decentralised projects will never be established without the willing participation of the beneficiaries.

Third, there is a need to disseminate existing knowledge about the danger of raw wastewater reuse, safe reuse guidelines and the position of Islam on wastewater reuse. Knowledge of cost-effective treatment technologies and crop and soil protection must also be disseminated and site-specific research carried out to fill missing gaps. Perhaps most importantly, the economic benefits of successful decentralised wastewater-treatment projects must be disseminated to periurban households and farmers, who will only then be willing to contribute to the costs of WWTR.

Finally, to ensure the protection of public health and the environment, governments must regulate and monitor quality of effluent, reuse practices, public health, crop-water quality, and soil and groundwater quality.

CONCLUSIONS

Domestic wastewater treatment is one tool to address the food and water insecurity facing many countries in MENA. In the coming years, in most MENA countries valuable fresh water will have to be preserved solely for drinking, for high value industrial purposes, and for high value fresh vegetables and salad crops consumed raw. Where feasible, most other crops in arid countries will have to be grown increasingly, and eventually solely, with treated wastewater.

And this wastewater will be reused in urban and periurban city gardens and farms, close to where it is generated. Reuse of wastewater in UPA allows city dwellers, particularly the poor, to produce crops valued in MENA such as onions, eggplants and olives, to generate income and feed themselves. Urban agriculture is growing in MENA — for instance, 16 per cent of the households in Amman already have urban gardens, and annual value of UA in the city is estimated at US $4million, which is already 2.5 per cent of the value of agriculture in Jordan as a whole. IDRC-supported projects in MENA are demonstrating that it is possible to develop decentralised wastewater-treatment systems that meet the standards for restricted irrigation for reuse in urban agriculture. For instance, a grey water reuse project in Jordan allowed a community to offset food purchases and make money by selling surplus production, saving or earning an average of 10 per cent of its income. A project in Palestine has helped periurban farmers save 15 per cent on fodder costs and raise healthier, higher-value chickens, by supplementing their feed with duckweed from a community wastewater treatment plant. Furthermore, in both projects, it is clear that periurban households or farmers are willing to contribute up to the full costs of wastewater treatment if it can be demonstrated that they will generate income or save money as a result.

The economic, social and environmental benefits of WWTR in UA are clear. To help the gradual and coherent introduction of such a policy, which protects the environment and public health, governments shall have to adapt an integrated water-management approach, facilitate public participation, disseminate existing knowledge, generate new knowledge, and monitor and enforce standards.

Note

(1) In this paper, the MENA region includes the following countries where IDRC supports projects: Algeria, Egypt, Jordan, Lebanon, Morocco, Palestine, Sudan, Syria, Tunisia and Yemen.

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Perceptions of Ouagadougou **Market Gardeners** on Water, Hygiene and Disease

Urban farming – particularly in the form of market gardening[1] – has become part of the environment in African cities. A city like Ouagadougou has 48 market gardening sites dispersed in 14 sectors of the city

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Assessing health risks during a field visit in Ouagadougou

African urban studies address this form of farming from various angles. This study[2] focuses on the issue of health. It has been well established that by reusing wastewater and/or polluted water, urban market gardening constitutes a potential health risk for both producers and consumers (Cissé, 1997).

However, the issue here is to know whether market gardeners, who were born in town or arrived there as a result of rural-urban migration, *perceive* the use of wastewater as risky, particularly with respect to health. Have these farmers incorporated their knowledge of this risk into their transfer from rainfed farming practices to (urban) farming that includes the use of wastewater?

This study (conducted between 1993 and 1998) is based on the following hypotheses.

- ❖ The perception of market gardeners regarding water and wastewater encourages practices that increase the risk of contamination.
- ❖ Market gardeners' notion of contamination and of the concepts "healthy" and "unhealthy" explains their resistance to the current "medical" notion of hygiene and subsequent exposure to parasitic diseases.
- ❖ Gardeners' perception of disease (e.g. diarrhoeic diseases) encourages behaviour that is favourable to parasitic infections.
- ❖ These parasitic infections are also linked to gardeners' nutritional behaviour.

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PERCEPTIONS OF WATER AND HEALTH RISKS

By asking market gardeners to compare their practices with those of rainfed farming, we sought to measure their degree of awareness of the specific risks related to the use of wastewater and the subsequent consumption of these products. It was found that market gardeners perceive themselves as "farmers" in all respects similar to rainfed agriculturists, except for the way in which they provide water to the plant. Market gardeners summarise this difference as follows: *"here, we are our own rain"*. Why do market gardeners only perceive a difference in terms of how water is provided to the plant and not in relation to the quality of the water?

Market gardeners perceive water in several ways. The different representations of water are sometimes contradictory, but never totally rule each other out. One perception associates water with life, regardless of its appearance. Of course, the purest water is that which falls from the sky and the water that comes from wells. But other water, even that which we refrain from drinking, such as wastewater from factories, is not the object of any sort of "hygiene taboo". Direct observations show that the market gardeners do not consider this water as dirty, nor that certain hygienic precautions need to be taken. Women and men soak their hands in this water and then go on to eat, breast feed babies, etc. without washing them.

Paradoxically, wastewater is placed on the same level as "pure water" from the sky or wells. It can still be reduced to its basic state, i.e. that of a liquid substance that is both mythical and vital. Women at Tanghin mentioned: *"We cannot differentiate between potable water and water that is not... Water is water. Water does not cause vomiting."*

If wastewater is considered equivalent to potable water, then how can one establish the link between water and some diseases, and is there a possibility to include water-borne diseases into the gardeners' various representations of water?

The link between water and diseases has never been established directly, through water consumption, or indirectly through the consumption of certain products. Market gardeners categorically reject any possibility of being victims of water-borne diseases and thus contaminating members of their families. They do not have reason to think that water should be considered as a medium through which diseases known to them are transmitted. Market gardeners have translated their own conception of contamination or the absence of contamination by a meaningful proverb: *"When an abscess is on the camel's hump, do not pierce the donkey's back."* This means that the source of the diseases should not be sought in water, and moreover that the cause of illnesses suffered by family members should not be found in garden practices, particularly when they do not even come to the site: *"How do you expect my child, for example, to suffer (in my place) from pain because of food that I ate (but which he did not)?".*

There is reason to believe that the water on farmers' own sites is drinkable for them. By "potable water", they mean water that does not cause illness, which is the water they use: *"You can drink water on your own site without falling ill, and then drink water from another site and get ill."* Another remark follows the same line of thinking: *"Since we are used to drinking water on our site, if we change environments, for example if we go to Côte d'Ivoire or Ghana, the water we drink there may make us fall ill. With time, we will get used to the water in that environment, but when we return we will encounter the same problems again".*

According to the market gardeners, "*habit is a second form of hygiene*"; i.e., direct water consumption in itself does not generate disease. But what about the consumption of their products, such as cabbage, carrots, eggplant and tomatoes?

PERCEPTION OF THE CONTAMINATION OF MARKET GARDENING PRODUCTS

The link between certain diseases and the consumption of market gardening products (including raw food) is even less manifest. Market gardeners emphasise that they consume part of what they produce, whether it is cooked or raw, at home or on the site. In their view, market gardening products, be they raw or cooked, should not be considered to be different from other food. All foods can make one sick, not because of its intrinsic quality, but depending on the "strength of the stomach" that receives it.

This strength of stomach (i.e. the individual's "biological capital") is not the only issue in the manifestation of disease. Market gardeners believe that it depends first on God, and second on bad luck. After citing headaches, stomach ache, malaria, backache and chest pains as the most common illnesses in their environment, they added: "*But there are no diseases specific to market gardeners, we are human beings like you. All diseases come from God and we know of no other origin."* They also believe that illness is due to bad luck: "*One cannot be in good health eternally. One falls ill at intervals of a month or two." "The human being cannot live eternally in good health, he can often fall ill."* These principles underlie the illnesses affecting adults as well as children. But regarding children, there are other representations of illnesses, particularly diarrhoea.

REPRESENTATIONS OF ILLNESSES AND DIARRHOEA

The market gardeners' view on diseases, in general, and diarrhoea in adults and infants, in particular, is not based on a single unified perception. "*Diarrhoea in adults is an illness like any other; it can be due to the food, if it does not agree well with you. In infants, diarrhoea is frequent, one often sees loose stools, and stools with blood, followed by fever."*

Market gardeners who hold these views ignore the probable causes of diarrhoea in their children. For those working in Kossodo, only God is responsible for the children's diarrhoea: *"We do not allow our children to eat just anything. We supervise their food. When they fall ill, we cannot know whether it is due to the food, the water or the air. If we know that certain food might cause diarrhoea in children, we avoid giving it to them. Diarrhoea, like all other diseases, come from God".*

Special reasons for diarrhoea in children are provided by market gardeners in Abattoir: "*Diarrhoea in children may be due to the change of season. The cold weather just like the heat modifies the rhythm of blood circulation. As a result, the child has to have diarrhoea to be able to adapt."* Another reason given is: "*Diarrhoea in children is sometimes due to the fact that men continue to have sexual relations with their wives, who have just delivered."*

CONCLUSION

Observations at the market gardening sites and in homes confirm the above, namely that the water used by market gardeners is not considered to be polluted nor likely to cause illness through contamination, either on the site where they spend most of their time during the day, or at home where they return in the evening, unconcerned about bringing along any dirt.

In this absence of a perceived link between health risks and the use of wastewater, the perception of water contamination and disease occupy a pivotal place, and are part and parcel of the knowledge and know-how of market gardeners.

The concept of hygiene is a question of experience and how the relationship between water and disease is perceived. From the viewpoint of a "health culture" in which there is no place for the notion of germs, the biomedical categorisation of "health risks" cannot make any sense. Even in the West, prior to the 19th century and before the discovery of bacteria, the link between dirt and disease, hygiene and pathogens was not perceived (Douglas, 1981). This lack of awareness should be taken into consideration in all training programmes aimed at changing the "health culture".

NOTES

(1) Market Gardening, in French *maraîchers*, refers to vegetable and fruit production, predominantly for sale at local markets (this last differentiates it from Kitchen Gardening).

(2) The research project on the use of polluted water in urban market gardening is funded by the Department of Development and Cooperation (DDC) of the Swiss Foreign Affairs Ministry and the National Swiss Fund for Scientific Research (FNRST).

The link between water and disease is not seen

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Urban sprawl creates challenges and problems like the inability to provide adequate municipal services, increased demand for food, environmental degradation and unemployment of the newly migrated people from rural areas. Municipal authorities also face problems with solid waste management and wastewater disposal. Urban agriculture can play an important part in addressing these problems. Food is produced and available in the city, environmental quality may be improved, and employment opportunities for poor families provided.

IWMI-Pakistan

Blockage by farmers in Channel 4, Faisalabad

Economic and Institutional Issues

of Wastewater Use in Faisalabad, Pakistan

Despite these benefits, policies to support the development of urban agriculture are still very rare. Urban planners tend to exclude agriculture from their sights. Agriculture is "by definition" not practised in cities, and is often seen as "economically unimportant" or as "a temporary phenomenon" (Dresher *et al.*, 2000). A key factor perpetuating the biases against urban agriculture is the colonial concept of the city which remains embedded in the minds of decision-makers, leading to limited availability of, or poor access to, land and water resources. Consequently, urban farmers have to seek alternate sources of water and land. Unavailability of canal water and brackish groundwater further compel farmers to use untreated wastewater for food and fodder production to sustain their livelihoods.

Wastewater is used because of the bad quality of groundwater

STUDY AREA

This study was conducted in Faisalabad, the third most populated city of Pakistan, with about two million people in its municipal boundary. In spite of its large size (about 122 km^2), the city retains its village character with many pockets of agricultural land within the municipal boundaries and animals kept in most residential colonies (although cattle and buffalo are no longer permitted within the city limits: Water and Sanitation Agency, 1993). The old parts of the city have developed along the concept of mixed residential and commercial areas.

The green areas can be divided into three categories: agricultural, recreational and institutional (see figure 1). Recreational areas include parks, green belts and stadiums while research farms and playgrounds of college, university and research institutes are examples of institutional green areas. Agricultural land is situated towards the periphery of the city, most often waiting for the development of housing schemes. People can use this land for agriculture, but inaccessibility of irrigation water, unawareness and the temporary nature of plots restrict people's using it for agricultural purposes. No planned agricultural land is present in the city for food production. All institutional areas, recreational areas and most of the agricultural areas receive canal water. Agricultural areas that do not receive canal water or an insufficient supply, use sewerage water for irrigation.

The estimated sewerage flow of Faisalabad is 25.55 m^3/s. Untreated wastewater in the east is discharged into the Maduana drain and both treated/untreated sewage drains in the Paharang to the west. These drains discharge into rivers (the Ravi and the Chenab, respectively). The wastewater is led to the drains through five channels. From an irrigation point of view, channels 3 and 4 are the most important, because agricultural land has direct access to these channels. Channel 3 carries predominantly domestic sewage and channel 4 carries wastewater mainly of an industrial origin. See Figure 1 for the city's land-use patterns.

The major crops grown within the municipal boundary are wheat, fodder and vegetables. Wheat is consumed by the

Satiana Road channel ends

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farmers as a staple food, with a little left over as a marketable surplus. Vegetables are offered in the market for sale to the urban population and fodder is produced for animals held in the urban areas for transportation purposes. There are about 20,000 donkeys, 1,000 horses and mules and 300 bulls engaged in transportation business.

SURVEY

In a survey conducted within the municipal boundaries of Faisalabad City, data from primary and secondary sources were collected. Maps showing roads and villages in the periphery of Faisalabad City, the location of areas irrigated with wastewater, and the sewerage network, open channels (sludge carriers) and location of disposal works within the Faisalabad municipal boundary were made. Furthermore, data were collected on the cropped area of villages present in municipal boundaries, on wastewater generation, wastewater quality at different locations, etc. Several visits to the wastewater area further assisted in developing an understanding of the current status and practices of wastewater and the crops grown. Semi-structured interviews were conducted with the following groups: Farmers (five farmers from each wastewater site); "*Numberdars*[1]" (heads) of four villages that receive wastewater; the Sub-Divisional Officer, Irrigation and Power Department (IPD), who supervises the canal's passing through the city; Director of Town Planning, Faisalabad Development Authority (FDA); and the Director of Planning and Development, who is a legal advisor of the Water and Sanitation Agency, WASA.

RESULTS

The unavailability and unreliability of canal water, and the bad quality of groundwater are the main reasons for using wastewater. Agricultural sites using wastewater are located in the city. The water channels leading canal water to these sites are often clogged with city garbage. In those areas where the agricultural fields are higher than the watercourse, water hardly reaches the land. As well, most of the agricultural sites are located at the tail reaches of the irrigation system, so water remains scarce there. Groundwater in Faisalabad generally has a high content of total dissolved solids (TDS), ranging from 350 mg/l near the irrigation canal (due to seepage) to 2,700 mg/l at deeper sources (Water and Sanitation Agency, 1993). In most of the agricultural sites, groundwater is highly unsuitable for irrigation. Therefore, the farmers seek alternative sources of irrigation. Another important reason for farmers to use wastewater is its nutrient value that helps save in fertiliser costs. Farmers do not acknowledge the potential harmful impacts of wastewater on health so they do not hesitate in using wastewater for vegetables or fodder. Farmers mentioned that they want to continue to use wastewater for crop production. However, the main problem is that chemicals and hazardous industrial waste are often mixed with domestic wastewater, and this affects crop growth. Secondly, the lack of a proper legal framework and infrastructure prevents a clear view of the farmers' responsibilities and privileges.

Other problems were more site-specific and are described below.

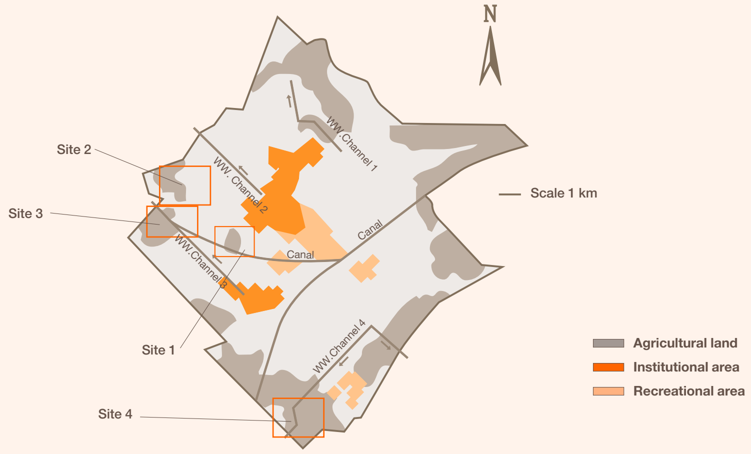

Figure 1: Land-use pattern in Faisalabad City, Punjab Pakistan

ABBREVIATIONS

NEQ	National Environmental Quality Standard
Rs	Rupees (Pakistani Currency)
FDA	Faisalabad Development Authority
WASA	Water And Sanitation Agency
TMA	Tehsil Municipal Administration (Previously Municipal Corporation)
IPD	Irrigation and Power Department

Site 1

This area receives wastewater from the street drains. Data about the quality of this water are not available. Almost all of the water is used for irrigation purposes. Farmers consider this to be a good source of irrigation, but in the rainy season there are difficulties with drainage. This site is located in the middle of a populated area and the food products from these farms are prone to theft. From the WASA point of view, residents of that area do not dispose of their wastewater in the sewer line (as it could have been sold to farmers at another place), so WASA not only loses sewerage fees but also the wastewater discharge in WASA channels is reduced. At this site, about 20 hectares of land is being cultivated, the major crops being fodder and vegetables. In the winter all of the land is covered with vegetables, but in summer both fodder and vegetables are grown.

Site 2

In this site, farmers receive very little canal water, and are as a result dependent on wastewater, which is mainly of domestic origin, and has a pH of about 7 and a BOD of 300 to 350 mg/l. This area is near the rim of the city and is less developed. Farmers purchase the rights to pump wastewater from the main sewer line (manholes). Farmers have full control over the wastewater because they can pump water according to their own needs. However, the cost of pumping and the water rate paid to WASA do increase the cost of irrigation. Farmers pay about Rs 8,000 (US $ 140)[2] for water rights and spend about Rs 30,000 (US $ 526) for fuel. Farmers who do not have a pump have to purchase water at a rate of Rs 240 for irrigation of all their crops per time per acre (10.4 US $ per ha). This cost is very high compared to canal water, which ranges from Rs 60 (for wheat) to Rs 177 (for sugarcane) per acre for all irrigation events. Due to the current expansion of roads, the manholes have become inaccessible and therefore the farmers must carry water from the stabilisation ponds, which costs about Rs 2,500 (US $ 44) per hour per week for one year.

Site 3

Site three receives wastewater from channel 3 that carries mainly household wastewater, though industrial effluents are also mixed in to some extent, now and then contributing about 5 percent of total flow. Wastewater in this channel has an average BOD of 480 mg/l. WASA auctions the right to use wastewater of this channel. The highest bidder is responsible for the retailing and distribution of wastewater from this channel. Here, both the farmers and bidder face a problem. Farmers hold the view that wastewater should not be sold because it is "waste". The bidder demands higher prices than that paid for canal water, and therefore the farmers feel that the bidder is getting higher prices, due to his monopoly. The lack of proper infrastructure for conveyance of wastewater aggravates this problem, as farmers near the wastewater channel do not give other farmers access. Non-cooperative behaviour of farmers leads to a limited use of wastewater from channel 3, causing the bidder to not be able to meet his costs and therefore ultimately go out of business.

Site 4

This site does not receive canal water due its topographic position. Firstly, land near the head of the watercourse is lower. Secondly, the overall shortage and frequent breach hardly allows the canal water to reach this site. Groundwater is extremely brackish and unfit for irrigation, so the farmers have to rely completely on the use of wastewater, which is either pumped or diverted by breaking the sidewall of channel 4. Due to the presence of industries alongside this channel, its wastewater is mainly of industrial origin. The quality of this channel has therefore restricted farmers to only growing tolerant crops like wheat and fodder. None of them can grow vegetables here because irrigation this water can burn vegetable crops. In the case of wheat and fodder, this water is furthermore not supplied at the tillering stage, as the plants are at that point too tender and susceptible to toxic elements. The unavailability of other sources of irrigation and the use of industrial wastewater has a negative impact on the livelihoods of these farmers. Farmers grow fodder for their livestock and wheat for household consumption. Their daily business is financed through the selling of milk.


IWMI-Pakistan

Wastewater being pumped out from Channel 4, Faisalabad

DISCUSSION

Pakistan is lacking legislation to effectively manage environmental resources and to control its pollution problem. The first major legislative effort was the environmental protection ordinance of 1983, but this has not yet been implemented (Water and Sanitation Agency, 1993). Another act was passed on September 3 1997 by the national assembly, but the procedural detail and description of the regulatory mechanisms are lacking. This act states that:
"...no person shall discharge or emit or allow the discharge or emission of any effluent or waste or air pollutant of noise in an amount, concentration or level which is in excess of the National Environmental Quality Standards.....".

Farmers don't want to pay too much for 'Waste'water

There is no provision of using untreated or semi-treated wastewater for agricultural purposes. According to the Standards for Municipal and Liquid Industrial Effluents, COD and BOD of wastewater should not exceed 150 mg/l and 80 mg/l respectively (Government of Pakistan, 1993). But WASA does not have enough resources to test and treat all of the wastewater so it has to dispose of it on land or in surface water channels without treatment. WASA's supplying of wastewater for use in agriculture is in fact a violation of the existing environmental regulations. WASA does not have the legal support for the development of infrastructure for untreated wastewater distribution for the use in agriculture. Selling of wastewater for agriculture is on an *ad hoc* basis, keeping in view the urgent need of farmers who are facing acute shortages of canal water and are willing to the face health risks associated with wastewater use.

WASA recovers some of the cost of wastewater collection and disposal by selling wastewater to farmers on an *ad hoc* basis, but due to the lack of by-laws and a legal framework, the allocation, distribution and prices are fixed on the basis of farmers' demand for water, the rates ending up being substantially higher than the canal water rates. Due to higher prices, farmers try to "steal" water from open channels/sludge carriers. In case of a conflict among the farmers, they try to get a stay order from the court against this illegal use of wastewater for agriculture on the basis of NEQs (National Environmental Quality Standard), to damage the interests of others. So, farmers and bidders do not invest in the development of the wastewater-distribution system due to this situation.

Poor quality of wastewater prohibits urban planners from using wastewater in green belts and parks. They think that this practice will firstly reduce the amenity value of parks and recreational sites, and secondly, that it will expose the urban population to health risks. Therefore, the canal water in parks and greenbelts is used, or they are kept vacant without any plantations.

There is a need to define a proper policy framework for the use of wastewater for urban agriculture in a productive and non-hazardous way. It is suggested that WASA consider the following three aspects:

i) by-laws for the use, pricing and distribution of wastewater;
ii) development of infrastructure to convey water to the farm-gate; and
iii) collection of wastewater rates for its use in agriculture, to stop the monopoly position of some farmers with respect to this resource.

NOTES

(1) Usually people call them *Numberdars*, but in official documents the word "*Lamberdar*" is used. *Numberdars* are responsible for collecting the revenues for the Irrigation and Power Department (IPD). A *Numberdar* is not a regular employee of the department, and receives about 6 percent of the revenue as a salary. Socially, a Numberdar is considered to be the village head. This job is transferred to his son after his death.
(2) 1 US Dollar = 57 Pakistan Rupee

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Integrated **Resource Recovery** Project

in Kolkata, India

Cities consume resources and produce both liquid and solid waste. The disposal of these wastes is increasingly becoming a problem. However, waste must be regarded as a resource for the sustainable urban development. Agriculture has always been an intrinsic part of Asian cities. In many Asian cities, the composting of separated solid waste and recycling of waste and sewage water used to be a tradition. These conventional methods are being renewed as urban agriculture is found to be providing employment, food and nutrition, land management and environmental improvement.

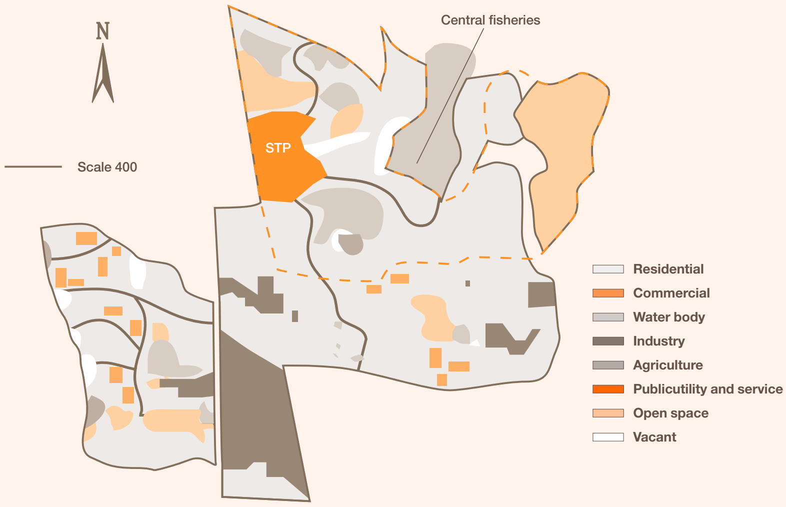

Figure 1: Project area, Integrated Recovery Project, Bandipur

Kolkata (formerly Calcutta) has one of the largest recycling zones in India with age-old practices of fish culture and vegetable production. A large number of sewage-wastewater-fed fisheries have been developed on the wetlands in lagoon types of ponds in which fish are cultivated, and where sunlight, water hyacinths and phytoplankton are used to clean the water.

The urban authorities are encouraging the indigenous system of aquaculture. Three projects in the periurban areas of the Calcutta Metropolitan area have been taken up with the participation of local people, fishermen and the village council/municipal government. The Community Based Wetland Ecosystem (CBWE) was first introduced in 1995 in Titagarh, a northern suburban industrial town within the metropolitan area. The project in Titagarh is presented here and is now known as the Integrated Resource Recovery Project. It is officially recognised by Kolkata Metropolitan Development Authority, and has generated wide interest from the local urban bodies and village councils.

Appropriate legislation needs to be developed

THE PROJECT AREA

Kolkata produces one third of its requirement of fish in sewage wastewater-fed lagoons and a similar share of its vegetables utilising natural compost and recycled wastewater.

The study area is located on the east bank of the river Hoogly (a tributary of the Ganges), 22 km north of Kolkata within the metropolitan area, with an estimated population of 344,700 in 2001. Most of the people are industrial workers and belong to the economically weaker section. The study area covers Titagarh town, which is basically an industrial town and Bandipur rural land unit (mouza). See Figure 1 for a map of the project area.

THE SYSTEM

Titagarh has an old sewage treatment plant (STP) with a capacity to treat 9.08 million litres of sewage per day (mld). As this plant was found to be inadequate, a new stabilisation tank system was proposed with a capacity of 14.10 mld to bring the total capacity to 23.18 mld. This new stabilisation tank system (STS) has been built in Bandipur, 2 km from Titagarh. The system at Bandipur, which includes wastewater treatment and reuse for aquaculture, is termed as the Resource Efficient Stabilisation Tank System. The system is used for the treatment of raw sewage discharged by the people of Titagarh and parts of Barrackpore municipality, mainly from commercial and domestic sources. The cost of the Bandipur STS is much cheaper than the Titagarh STP, because the latter consumes cost intensive electrical and mechanical energy, whereas the Bandipur STS is based on a natural process.

The Activated Sludge Treatment Plant (ASTP) at Titagarh

A splitter box before the inlet to the primary settling tank allows 4.54 mld of sewage directly into an oxidation pond, while the rest of the 4.5 mld sewage is treated in the activated sludge treatment plant. Here the sewage first enters into a primary sedimentation tank, after which the effluent is sent into three equal capacity aeration tanks for mechanical aeration. After this process of mechanical aeration, the effluent is sent to three secondary settling tanks. The return of the effluent from the secondary settling tanks to the aeration tanks is such that 50% of the sewage flow is returned to the aeration tank. From the settling tanks, the final effluent is led into the storm-water tank, where part of it goes into the river, and the other part is led through two canals, into the adjoining farmland. An area of 23.8 hectares of land is irrigated with treated effluent from the STP, and

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5.35 hectares are irrigated with untreated waste lifted from the canal by a portable centrifugal pump.

Resource Efficient Stabilisation Tank System at Bandipur

The process at Bandipur, wastewater treatment and aquaculture, is known as the "resource efficient stabilisation tank system". It is a project based on ten years' of experience with the sewage-fed fisheries in east Kolkata. The system, which was commissioned in 1995 comprises a series of aerobic, facultative and maturation ponds.

The design flow considered 14 mld of raw wastewater (BOD of 200 mg/L and faecal coliform numbering 1 x 10^7 per 100 ml). The retention times at the design flow are 1, 5 and 4 days respectively for aerobic, facultative and maturation ponds. The stabilisation tanks are designed to produce an effluent suitable for aquaculture reuse with a faecal coliform count of under 10^4 per 100 ml.

Fish culture is currently practised in both the facultative and maturation ponds. This is essentially an interim measure, as the wastewater flow is currently around one third of design flow. This method is not only cost effective but also requires less land since the maturation pond is used for fish production. The ponds are simple and cheap to construct. The method does not require skilled operation and is easy to maintain. Properly designed ponds give a consistently good performance. The method is suitable wherever land is cheap and readily available.

The high productivity of these sewage-fed fishponds is due to the high content of nutrients in the wastewater, while the high alkalinity stimulates the production of phytoplankton, a primary product1 in the fish food chain. It also generates an abundant quantity of algal photosynthetic oxygen. Fish yields were recorded to be approximately 7 tonnes per hectare per year. The stabilisation tanks at Bandipur are rented out to a local fish farmer who normally pays Rs 50,000 (1,250 Euros in 2001) p.a. to the local *panchayat* and approx. 2,750 Euro p.a. to the Calcutta Metropolitan Water and Sanitation Authority (CMW&SA), an agency of the metropolitan development authority. This aquaculture enterprise provides employment for 50 people, and produces high quality animal protein for the low-income group of local beneficiaries.

The integrated complex of Bandipur and Titagarh has been leased out to 110 farmers. Around 30 to 32 types of vegetables (exotic and indigenous) are cultivated, depending on the season and the climatic conditions. Some of the more profitable vegetables are spinach, Chinese onion, coriander, cauliflower, kidney beans, lettuce, etc. An estimated quantity of 3,060 tonnes of vegetables is produced by the farmers annually. About 800 persons are engaged.

In Titagarh and Bandipur, the solid and liquid wastes are mostly commercial and domestic in nature. The industrial solid and liquid wastes must be separately treated from domestic waste; otherwise, they can contaminate valuable wastewater resources.

CONCLUSION

The experience and techniques mentioned here could act as an example for other municipalities. With declining employment in the industrial sector and the growth of the informal sector, the urban poor and low-income families are increasingly shifting towards urban agriculture for survival. Urban agriculture should be given more attention for its potential to support a sustainable urban environment, generating employment and reducing (municipal) investment in waste management.

It is of great value that the Metropolitan Development Authority in Kolkata has included wastewater recycling in its urban development programme, but appropriate legislation needs to be developed. Furthermore, wastewater use for urban agriculture does not relieve the planners and policy-makers of their responsibility to further improve the quality of life of urban poor. Social wealth requires synergy and co-ordination between locally rooted innovation and central guidance.

Box 1: Methodology used in the Project Area of Titagarh STP

Properties of Waste: An analysis of samples of the primary treated sewage of the Titagarh STP, which was released for agriculture and aquaculture indicated the parametric values of: Ph - 7.5 to 8; Total alkalinity of - 300 to 400 ppm; CO_2 - 30 to 50 ppm; P_2O_5 - 8 to 12 ppm and COD - 150 to 200 ppm. Digested sludge exhibited: Ph - 7.5 to 8; Organic carbon - 3 to 4.2 mg per 100g; Nitrogen – 85 to 98 mg per 100g; and Phosphorous - 15 to 209 mg per 100g of soil.

Soil Bed Preparation The land is prepared by hand with spades and comb-like splitted spades, in July. Compost (of waste) is spread over the land and mixed with the soil, making the level of the land about 5 to 10 cm high, and non-biodegradable elements are removed. Inorganic fertiliser is also spread to quicken the process of decomposition. The term "*Ulti Koop*" refers to turning the (15-20 cm of) soil over by a spade. Plot size and drainage facilities depend upon crop, season and cultivation. After three months of cultivation, compost is added for a second time.

Application of Sludge, Effluent and Compost The effluent from the treatment plant is taken directly to the fields via 600 mm diameter concrete pipes. Sludge, either from the treatment plant or from the oxidation ponds, is periodically removed, dried and applied by farmers as organic manure. Garbage is purchased by the farmers, separated and composted.

Source: *Kolkata (Calcutta) Metropolitan Development Authority, 2001*

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A. Bradford

Next to the orchards many farmers plant small vegetable plots

Crop Selection
and Wastewater Irrigation
Hubli-Dharwad, India

The twin city of Hubli-Dharwad generates approximately 60 million litres of wastewater per day (Hunshal, et al., 1997), which is discharged untreated from the open city drains (wastewater nallahs) into natural courses that flow into the hinterlands. Along the main wastewater nallahs, three distinct cropping systems are apparent: vegetable production (see Bradford, et al., 2002); field crops with vegetables; and agroforestry.

This article will address the latter cropping system, as out of the three systems, agroforestry has the potential of reducing the high risks that are associated with wastewater irrigation. In addition, the gender implications from wastewater irrigation will be briefly addressed, as will wastewater-irrigated fodder production.

The spatial variation of the cropping systems results from a combination of factors which include labour availability, farm size, market access, village conformity and soil types, with the overriding aspect being the availability of wastewater itself. In the city and suburbs where the wastewater supply is guaranteed, intensive vegetable production occurs. In locations where the supply is erratic and unreliable, field crops and agroforestry predominate. In field crops, such as cotton and wheat, wastewater irrigation is simply used to start the field crop season earlier. This brings added advantages over rainfed agriculture as the crops that are harvested earlier bring higher market prices, as once the market is inundated with produce from rainfed systems, the market price tumbles.

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AGROFORESTRY SYSTEMS

In India, wastewater irrigated agroforestry has long been recognised as a strategy to dispose of urban wastewater, while also rehabilitating and greening wastelands (see Das and Kaul, 1992). In the periurban villages of Budarsingi and Katnur on the main Hubli *nallah*, all farmers bordering the *nallah* engage in some kind of wastewater irrigated agroforestry practice. In other locations, only sporadic planting of trees on farm boundaries and the occasional agroforestry practice can be observed. The benefits from agroforestry include reduced irrigation requirements and therefore reduced exposure of farmers to wastewater. During the dry season, vegetable crops are irrigated every two days while tree crops are irrigated every ten days. Furthermore, farmers who have adopted agroforestry systems, have reported a substantial increase in income from the produce as a result.

WASTEWATER IRRIGATED AGROFORESTRY PRACTICES

In Budarsingi and Katnur, the main wastewater irrigated agroforestry practices are "tree predominant" orchard systems and agrosilviculture, consisting of spatially mixed perennial-crop combinations (Young, 1997). The two most important tree species are sapota (*Achras zapota*) and guava (*Psidium guajava*); other common species are coconut (*Cocos nucifera*), mango (*Mangifera indica*), arecanut (*Areca catechu*) and teak (*Tectona grandis*). Species found on farm boundaries include neem (*Azadirachta indica*), tamarind (*Tamarindus indica*), coconut and teak. Other less common species are banana (*Musa paridasiaca*), ramphal (*Annona reticulata*), curry leaf (*Murraya koenigii*), pomegranate (*Punica granatum*), lemon tree (*Citrus limon*), galimara (*Casuarina equisitifolia*) and mulberry (*Morus indica*).

Tree predominant orchard systems are planted as a single crop of either sapota or guava or a mixture of the two, with tree spacing of 6-7 metres. Next to the orchards many farmers plant small vegetable plots which are also irrigated with wastewater. Farmers with larger landholdings also plant additional field crops adopting similar cropping patterns to the field crop systems found on the Dharwad transect. The agrosilviculture systems consist of tree rows containing a mixture of sapota and guava. The trees are spaced along the rows at intervals of 6-7 metres and each row is planted approximately 9 metres apart. The land between each row is used for field crops.

AGRICULTURAL CONSTRAINTS

Farmers in Budarsingi and Katnur identified rigorous weed growth as the main constraint to agroforestry. Even though fruit pests and disease were evident, the low incidence meant that many farmers took no control measures and as such pesticides were not used on the agroforestry plots. Weeds were identified as problematic, particularly *Parthenium hysterophorus*. Farmers attribute the wide spread of the weed to seeds that are carried in the wastewater and then pumped onto the fields. Farmers reported that even though the *Zygogramma* beetle was established, the beetle (an introduced bio-control agent) could not multiply fast enough to control

A. Bradford

Innovative farmer standing before a row of sewage-irrigated teak intercropped with Achras zapota and Psidium guajava; the soil in the foreground has been prepared for a kharif crop of sorghum.

the increasing weed problem. As a result, removal by hand was the main weed-control measure and consequently most farmers reported labour shortages. Additional crop problems reported by farmers included the early dropping of fruit from trees and the softening of fruit while still growing; farmers identified wastewater irrigation as the causal factor for both of these problems. Indeed, a similar problem was reported with apples irrigated with wastewater which resulted in "detrimental effects on fruit quality by decreasing flesh firmness and increasing incidence of core flush" (Meheriuk and Neilsen, 1991: 1269).

GENDER IMPLICATIONS OF WASTEWATER IRRIGATION

The high nutrient loading from wastewater greatly increases the incidences of weeds; the farmers also attribute this to seeds that are carried in the wastewater and then pumped onto the fields. Consequently, as the main weed control method is hand tillage, the weeding accounts for the high labour inputs associated with wastewater irrigated cropping systems. Household members meet these labour-input needs and within the household women normally carry out these tasks; likewise, when farm labourers are hired they are more likely to be women due to the cheaper labour costs. Census data also confirm that a higher proportion of women are engaged in urban agriculture. Budds and Allen (1999) reported that the male population mainly seized the non-farm opportunities, as the wages are higher than in the agricultural sector (for example, building labourers earn 70 rupees per day, as opposed to farm labourers earning 50 rupees). As well as perpetuating their positions as the poorest social group, women's exposure to the hazards of wastewater – pathogens, toxins and organophosphate pesticide residues - is also increased as they spend full days working in the fields. Furthermore, once the day's work is finished, the women return to their households and carry out evening chores, including food preparation and cooking, thereby increasing the risk of pathogen transfer to other family members if basic hygienic standards are not maintained.

FODDER PRODUCTION

An additional wastewater-irrigation system can be found just outside Maradagi village on the Dharwad *nallah*. Since 1995, a small-scale dairy farmer has been irrigating a one-acre plot of Napier grass (*Pennisetum purpureum*) with wastewater and borewell water on an alternating daily basis. The grass is grown throughout the year and used as fodder for eight dairy cows and two bullocks stalled nearby. An additional supplementary feed made from a rice by-product is also fed to the livestock. Changing from dry feed to the Napier grass fodder, the farmer reports a milk yield improvement of from 3-4 litres per day to 8 litres per day, an enterprising twofold increase.

REDUCING RISK

The main reason why farmers do not diversify and adopt more sustainable cropping systems is because "change" is associated with risk and farmers who depend on agriculture for their livelihoods will at all costs mitigate any perceived risks. The farmers who have adopted agroforestry practices have done so because they have either additional income generating opportunities or larger landholdings. This reduces their dependency on a single livelihood or small agricultural plot. Furthermore, farmers with larger landholdings are more likely to experiment with small plots of agroforestry and expand such experiments as they reap the benefits and gain confidence in the new practices. This process is clearly occurring in Budarsingi and Katnur, where wastewater-irrigated agroforestry systems have spread as a direct result of farmers observing the practices, and then adopting them once they are confident they work; in this case "change" is no longer perceived as a risk and thus agroforestry practices are freely adopted.

Adoption of agroforestry systems reduces farmers' direct contact with and exposure to sewage, due to the reduced irrigating requirements of tree crops in comparison to vegetables and field crops. In addition, the use of organo-phosphate pesticides is greatly reduced, as the diverse agroecosystems become more stable and less vulnerable to pest populations. This process could be enhanced through the extension of appropriate IPM strategies using participatory approaches such as farmer-field schools. These empower farmers through education and training which are designed to meet the needs of smallholders and marginalised farmers and to incorporate traditional pest-control methods. Therefore, the development of micro technologies at the farm level to reduce risk is a crucial component within this process. Examples of this process are clearly evident in Hubli-Dharwad, where some innovative farmers have diversified their agroecosystems by incorporating agroforestry practices.

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In 1999, IWMI explored the advantages and risks of the use of urban wastewater for crop production along the Guanajuato river. At least 140 hectares of land downstream of the city of Guanajuato(1), farmers in two periurban communities (San Jose de Cervera and Santa Catarina) irrigate with raw wastewater. The benefits from wastewater irrigation include additional water, nutrients and the benefit obtained for the treatment (Scott, et al., 2000).

Paula Silva-Ochoa

An overview of the Treatment Plant in Guanajuato, Mexico

The Impact of a Treatment Plant on Wastewater Irrigation in Mexico

The 1996 Mexican environmental regulation NOM-001-ECOL establishes the maximum amount of contaminants permitted in wastewater discharged into public water bodies or national property. This restriction aims to reduce wastewater disposal into the river and the negative impacts for health and the environment, through a fine of US $0.25 per cubic metre of untreated water that exceeds the permitted limits. However, the regulation also leads to a reduction in the nutrient values and forms a constraint to irrigation by waste-water. In accordance with this regulation, the public water-supply company of Guanajuato city, called SIMAPAG(2) constructed an activated sludge wastewater treatment plant, which started to operate in June 2002. In this article, the plant's benefits are reviewed. The aim is to give some preliminary answers to the research question: *How does the water-treatment plant influence the benefits of the use of wastewater for crop production?*

The need to assess these effects appears essential for future, since current national environmental laws and local policies will increase the volume of treated wastewater and actual will change the conditions of raw wastewater irrigation. In Guanajuato's Hydraulic Plan for 2000-2025, an additional 47% of wastewater is planned to undergo treatment, which together with the 16% of wastewater already treated, makes for a total of 53% of treated wastewater in the near future.

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The volume of residual waters generated in the 46 municipalities of Guanajuato total 207.13 million cubic meters per year. If this water could be used directly for agricultural purposes, it could irrigate around 20,500 ha, which is almost 5% of the actual irrigated land in Guanajuato (416,690 ha). There are 16 treatment plants in the urban areas and another 26 wastewater-treatment systems in the rural areas. The lack of technical and administrative capacity prevents the water treatment programmes from being carried out satisfactorily.

SIMAPAG AND THE TREATMENT PLANT PROJECT

Water supply for the city of Guanajuato (with a total population of around 106,000) is provided by SIMAPAG. There are 31 water-supply operator agencies like SIMAPAG in the state of Guanajuato. They act as financially autonomous public utilities with an independent administration. Only ten of these have a healthy financial status, but SIMAPAG had an outstanding performance in terms of financial surplus and overall efficiency (CEAG, 2001). The potable water-supply coverage is 95%, and sewer coverage 82%. Domestic connections represent almost 94% of the total number and there are very few commercial and industrial connections. The average production per connection is 27.7 m^3 and the average fee is US $0.59/$m^3$ (CEAG, 2001).

SIMAPAG constructed an activated sludge with chlorine treatment plant. The federal government contributed 24% of the funds, the local government 40%, and SIMAPAG the remaining 36%. In , the plant treatment design parameters are described. According to the average production per connection, the expected sewage effluent(3) from Guanajuato city is around 0.14 m^3/s, this is a volume of 6.3 million cubic metres. Until the treatment plant started to operate, this effluent was discharged into the Guanajuato River. Nowadays, 70% is treated, while the wastewater produced by the community of Marfil, representing the remaining 30% of untreated wastewater, is seweraged downstream of the treatment plant outlet. Currently, SIMAPAG has to pay annually US $472,500 for this remaining 30% of untreated wastewater.

WATER AND NUTRIENT VALUE

The treatment plant gives SIMAPAG the opportunity to sell the treated water. No commercial transaction has taken place as of yet, but there will be greater competition among the different sectors. Moreover, raw wastewater irrigation will have to compete against the use of treated water, since every cubic meter of untreated wastewater disposed in the Guanajuato River costs SIMAPAG a fine of US $0.25.

Thus the farmers' request to use raw wastewater will only arouse the interest of SIMAPAG if the farmers are willing to pay the fine expenses, which they cannot. The expected water productivity in small-scale irrigation systems is only around

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A diversion point in Guanajuato River
for the irrigation canal

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Table: Plant treatment design parameters

Parameter	Unit	Influent	Effluent
Discharge design	Lps	140	140
Total Suspended Solids (TSS)	Mg/l	217	<60
Total Biological Oxygen Demand (BOD)	Mg/l	337	<60
Total Nitrogen (Kjeldahl)	Mg/l	82	< 35
Faecal coliforms	MPN P/100 ml	6.2 X 10^6	<1000
Total Phosphorous	Mg/l	11	< 20

Source: Aqua Orbi Ingenieros S.A. De C.V, 2001

US $0.15/$m^3$ (Silva, *et al.*, 2000). A higher productivity could be reached, even up to US $0.50/$m^3$, if more profitable crops like vegetables are cultivated. But these vegetables are consumed raw, which is restricted under regulation NOM-001-ECOL-1996. The operation cost of one cubic metre of treated water is US $0.11. By means of a 10% charge for sanitation services, SIMAPAG recovers US $0.04/$m^3$ from the domestic users and US $0.08/$m^3$ from industrial and commercial users. In order to be profitable, the selling price for the treated wastewater should be at least US $0.07/$m^3$. Industrial customers could pay up to US $0.50/$m^3$, which would give a surplus of US $0.43/$m^3$.

The existing concentration of nitrogen phosphorous in the effluent is enough to meet the nutrient requirements for alfalfa, the most common cultivated crop. Farmers show very little concern regarding the reduction of nutrients due to the water treatment process upstream, since the treated water still has a high content of nutrients. Water users are more afraid about water-level reduction in the river than about nutrient reduction in the river effluent. The sludge would represent another important source of nutrients.

The storage and elimination of this material is one of the major operational problems, while the area that could benefit from the waste-treatment plant is around 20 to 30% of the total study area. Unfortunately for the moment, the solid waste is taken to a landfill.

FOREGONE TREATMENT COST IMPACT

It is obvious that wastewater irrigation was not considered as an alternative method for wastewater treatment. The selection of the water-treatment process was entirely based on environmental regulation NOM-001-1996. The reason behind this is the great percentage of irrigated land without water entitlement. SIMAPAG only recognises the land that has a regular water right. Annually, this is legally granted to 300,000 to 500,000 m^3, which represents just 30 to 50 ha.

Theoretically, the water-treatment plant in Guanajuato city would produce treated water for all types of landscape irrigation, including for example, golf courses and parks (though with higher maximum limits than for agriculture). However, there is presently no reuse process in place except for irrigation for agriculture.

Nevertheless, if the produced treated water is not sold; the capital investment will not be justified. The cost and difficulty in operating and maintaining conventional treatment plants to meet the specified guidelines means that they are not recommended where waste-stabilisation ponds and wastewater storage and treatment reservoirs can be used (Blumenthal, *et al*, 2000).

CONCLUSIONS AND RECOMMENDATIONS

The major potential impact of the water-treatment plant is the possible reduction in wastewater discharge in the river, if the treated water is sold to an industrial consumer outside the Guanajuato River sub-basin. However, this would lead to competition over the water. The position of the farmers is weak because only 30 to 40 ha have proper water entitlement. This impact is not affected yet, because of additional sources of urban wastewater entering into the river downstream of the treatment plant.

Further research is needed to identify conditions under which the substantial benefits of wastewater irrigation can be captured while financial sustainability of the water-supply utilities is maintained. There are several aspects that need to be analysed regarding the relationship of the urban production of treated water and wastewater irrigation such as:

- ❖ a water market for treated effluent and its commercial feasibility in irrigation (comparison between the use of treated water and raw wastewater);
- ❖ water rights conflicts;
- ❖ hydrological impact of selling the treated water outside the sub-basin;
- ❖ water-quality assessment at the final use point (e.g., farm level for irrigation); and
- ❖ an accounting of nutrients lost from raw wastewater.

Notes

(1) Very often the state and its capital city have the same name in Mexico. Unless it is mentioned, Guanajuato refers to the province of Guanajuato and not to the city.
(2) SIMPAG stands for *Sistema de Agua Potable y Alcantarillado de Guanajuato* in Spanish, or the "Guanajuato Water Supply System".
(3) This figure comes from the assumption that 70% of the total produced water per outlet will be seweraged.

Reuse of Untreated Wastewater in Market Gardens in Dakar, Senegal

In Senegal twenty-six percent of the population lives below the international poverty line of US $1/day. These conditions threaten food security. In order to generate income and feed their families, more and more people are practising urban agriculture. However, they lack safe and affordable irrigation water, and many farmers use untreated water.


RUAF Video

Collecting water from a pond for irrigation of crops

Within Dakar, the most important section of the Niayes[1] in terms of food production is the Niayes de Pikine. In this large area inside the city limits, horticulture is prevalent. The zone is threatened by both urban development and saline intrusion. Over the last 30 years, the portion of the Niayes zone in Dakar has shrunk by 56 ha (10%).

The Senegalese government has recognised the importance of horticulture in this area (including in the urban areas). However, the activity remains firmly lodged in the informal sector. As from 1984, the state formally attempted to incorporate horticulture into its national economic plans and development strategies. In 1994, this effort culminated in the creation of the Department of Horticulture, whose aim is to support small-scale agriculture (plots between 225 and 500 m^2) through credit programmes, training, and access to tools, fertilisers and pesticides. While government support for urban farmers has been negligible to date, it is encouraging that the socio-economic benefits of small-scale urban farming are being recognised.

CHARACTERISTICS AND CONSTRAINTS

About 60% of the vegetables consumed in Dakar are produced within that city. The dominant types of crops grown by urban farmers in the Niayes zone are lettuce, tomatoes, onions and jaxatu (a type of eggplant). The farmers earn a profit of about FCFA 43,000 (US $64)[2] per harvest (based on oral surveys). Using the four most commonly cultivated crops (lettuce, tomato, eggplant and onion) the study found that on average, farmers were able to harvest five crops per year. The net average annual profit for each farmer is then 215,000 FCFA (US $320), or 589 FCFA (US $0.88) per day—less than the international poverty line of US $1/day. While this figure may seem low, the actual amount of profit generated may be less important if the urban farmers were to become completely self-sufficient in vegetables. Considering food purchases of the poor in the urban areas of developing countries can easily amount to 50% - 80% of their income, this is a considerable benefit to the improvement of family wealth. Moreover, these figures probably vastly underestimate the income of the urban farmers: most of the time, farmers do not want to show what they own.

The use of untreated wastewater for irrigation itself could become a constraint to urban gardening in Dakar. Certainly, environmental issues associated with untreated wastewater reuse such as clogging of soil particles and contamination of soil could potentially become a problem if greater quantities of wastewater are reused. Furthermore health effects arising from consumption of contaminated produce could restrict the practice, particularly if serious illness results and the public becomes more aware of the prevalence of wastewater reuse. At least in the short term, a much greater obstacle to urban agriculture in Dakar is the insecurity of land tenure.

FARMERS AND INSTITUTIONS INVOLVED

The majority of the farmers (88%) in Dakar are men, married (80%) and less than 45 years old, with a primary responsibility of feeding their families. However, most of the sellers are women, and help out during the harvests, or act as intermediaries, selling their crops to merchants and market gardens. A slight majority of the urban gardeners (58%) are former farmers who migrated to Dakar from rural areas over the last decades of drought. Other farmers are former artisans (19%),

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fishermen (4%) and business people (2%) who have all fallen on hard times. Some of the farmers have university degrees. For 75% of the farmers, this activity constitutes their main occupation. 38% of the farmers are Wolofs, 23% Toucouleur, and 19% Séréres, but all ethnic groups are represented, and the practice does not appear to be restricted to only the poorest of these. The central local institutions acting on questions of urban agriculture and wastewater use are the GIEs (Groupes d`Intérêts Economiques). GIEs are local economic associations that work to develop local businesses and economic activity. In addition to local representatives, NGOs and the like, they are often made up of urban agriculture groups. Certain groups of urban farmers are particularly dynamic and have developed adaptive approaches to poverty alleviation in their communities. However, the results of their work have been limited


RUAF Video

Saturation ponds where grey water from surrounding houses is treated

and dispersed (Enda/IFAN, 2002). Nevertheless, due to their close proximity to civil society, they remain important actors to be engaged.

Officially, the practice of wastewater reuse is banned, however, recognising its prevalence, little is done by authorities to curtail the activity. In response to water scarcity, the *Ministère de Hydraulique* has developed two macro plans that are supposed to improve the effectiveness of management and the quantity of available water. The first programme, the Sectoral Water Project (PSE) was developed in 1996. Its central aim was to increase the amount of available water by drawing on surface water from the lake *Guiers* and extending the water-provision network of Dakar. The second programme is known as the Long-Term Water Project (PLT) and is a five-year plan (2002-2007) that touches on wastewater policy in urban areas. Notably, *Office Nationale de l'Assainissement* (ONAS) has recognised the prevalence of raw wastewater reuse for agriculture and has proposed the decentralisation of wastewater treatment if such technology can be proven effective (Egziabher, *et al.*, 1994). ONAS envisions a decentralised management including the creation of 160 small-scale community operated systems and 60,000 on-site treatment systems. Moreover, they explicitly recognise the value of wastewater reuse under the assumption that it be done with a minimal risk to health wherever possible. The impact of these two programmes on urban water management will be significant. On questions of wastewater, the Ministry of Health and the Ministry of Environment are important actors. Unfortunately, they have not yet been fully engaged in the process of researching the impacts of wastewater reuse. Meanwhile, things are moving on well. Recently, hygiene students presented their graduation work on the use of wastewater in urban agriculture. While the practice of wastewater reuse is prohibited by the Health and Environment ministries, the city authorities are conscious of its existence. In March 2002, the Dakar declaration was signed by seven mayors and city councillors from West Africa, in support of the development of the urban agriculture sector. Moreover, the declaration specifically noted that the reuse of wastewater occurs and poses potential health risks. However, recognition is not yet action and although many mayors are supportive (for example, the mayor of Pikine), they do not yet have the capacity to act.

RECOMMENDATIONS AND POLICY SUGGESTIONS

Recommendations should take into consideration both that the farmers need to earn an income for their families and that public health (including the health of the farmers themselves) needs protection. Attempts to meet the WHO guidelines through various treatment options should be explored while at the same time investing other non-treatment management options, some of which are outlined in the same WHO source.

The first recommendation is of course (to try to assure) treatment of domestic wastewater for unrestricted use. Irrigation methods can be organised into both means of distributing the raw wastewater to the plants to minimise contamination of the plants, and precautions that the farmers can take to protect their own health. The main irrigation method currently practised, use of watering cans, accentuates the risk of contamination of the plants and farmers. In fact, the research project confirmed that lettuce irrigated with watering cans has higher levels of contamination by faecal coliforms and streptococcus than lettuce irrigated by hosing water into the furrow (Enda/IFAN, 2002). Another obvious recommendation is to practise the crop restrictions recommended by the WHO, banning the irrigation of raw salad crops with wastewater except for that which meets the quality outline for unrestricted irrigation. In practice, this may be challenging, as crops such as lettuce and tomatoes are some of the most profitable crops for urban farmers in Dakar. An education programme for farmers, the public, and municipal officials are furthermore essential.

The current research project (supported by the IDRC) has identified the lack of collaboration between important institutions, both non-governmental, such as the farmers themselves, groups representing them (the GIE), and governmental organisations such as the municipalities (the municipality of Dakar), and national-level departments. It is recommended that the development of regional networks be created to facilitate the exchange of information and improve the efficiency of finding appropriate treatment and non-treatment options for wastewater use. It is evident that in Dakar a multi-stakeholder process for the development of appropriate policies as well as appropriate guidelines for the use of wastewater (including water-quality standards) are required.

Notes

(1) A narrow but long fertile zone of land that stretches along the coast of Senegal from Dakar to St. Louis.

(2) onversion based on October 2002, rate of f CFA 667.87 = US $1.

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"Ecological Park" on San Juan de Lurigancho, Lima


Juan Carlos Calizaya

There are approximately 6 billion inhabitants in the world. By the end of 2000, 31 countries with an approximate population of 480 million people had a chronic deficit of fresh or potable water. Each year, 54% of the available fresh water is used. If the consumption per person remains the same, we will be using 70% of the total by the year 2025, only as a result of the increase in population. If the per capita consumption of all countries in the world would reach the levels of the more developed countries, this would be 90% of all the available water. Currently, more than 20% of water used for personal consumption is going towards urban irrigation activities. Thus, in the year 2025, it will no longer be possible to irrigate urban green areas with potable water. Peru is among the most affected countries.

Prevention Today, Solutions Tomorrow

The Case of Lima, Peru

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In Peru, as in many other Latin American countries, the informal occupation of land in periurban areas like slums results in a scarcity of suitable locations for proper housing, let alone agriculture. Basic water and drainage services are in deficit in the peripheral human settlements of these cities, and this situation will continue in view of the high cost of these facilities and the low income per household.

Located in the central coast of the country and on an extremely arid band of land in South America, Lima is a case that requires urgent attention. While the projected worldwide supply of fresh water in 2025 will be 5,100 m3/inhab/year (now 9,000 m^3), the Peruvian coast on that year we will have only 1,000 m^3/inhab/year of fresh water available. However, Lima has more than 1.1 million residents without this service; only 4% of the sewage in Lima is treated, the rest being dumped into the sea, the rivers or directly on the ground.

Public investment is necessary to provide service coverage to the for whom the number of socially excluded people who lack access to water and sanitation, but economic crisis forces investments to be directed to solve food emergencies, health and domestic production problems. However, the problem of feeding and caring for the health of populations living in extreme poverty will not be solved if people lack potable water and suffer from wastewater pollution. It is time for the state to promote policies focused on greater prevention, to be conscious that fresh water for human consumption is a non-renewable resource, and that this requires the enforcement of three national policies:

- to declare a state of emergency in the Peruvian sanitation sector, and to become aware of the gravity of the problem;
- to establish a campaign to change the attitude of the population regarding the irrational consumption of potable water, especially in the disposal of faeces and in urban irrigation; and finally
- to promote and support local governments in the implementation of systems to recycle treated grey water for urban agriculture.

SAN JUAN DE LURIGANCHO

In 1998, the Urban Development Institute CENCA assumed the challenge of fostering and promoting a sustainable attitude concerning the use of potable water in Peru, with excellent results. The promoted system has become a benchmark for alternative sanitation systems for local entities, and has an application in urban agriculture. Although it is still not consolidated as an explicit policy, the first steps towards acceptance have been taken.

Unfortunately, the prevailing model of water and drainage management is centred on a consumption-intensive, high profitability approach. This has resulted in an irrational exploitation of water, as it encourages consumer attitudes and technologies that are not responsive to the imbalance this could bring as well as the alteration of ecosystems. The described system promises to redu ce pollution, preserve the environment, while improving environmental education and awareness, generating household savings and providing inputs (water and compost) for urban agriculture. It is not exclusively for the poor, as other higher-income population groups can adopt it. At the same time, it takes into account the objective restrictions of access to the conventional system that many settlers will have during a good number of years. This implies that special attention must be given to the cultural aspects of the beneficiaries.

Children in Lima gather around a "small plot" at school

Francisco Arroyo

ECODESS

A pilot project is being executed in the district of San Juan de Lurigancho on environmental sanitation, called ECODESS, which stands for Ecology and Development with Sustainable Sanitation. It is a comprehensive micro-system of collection, treatment and recycling of household solid and liquid waste, divided into two sub-systems:

❖ A household system, which includes a bathroom, a sink and a grey water collection network, which in turn leads to a "grease-trapping chamber" and a phyto-treatment channel for filtration.

❖ A neighbourhood system that, combined with a second collection network, collects the water coming from all the plots that use the ECODESS system, and conveys it to a phyto-treatment channel, where it is filtered a second time before being stored in a cistern. From there it goes into the underground irrigation network used to keep green areas.

The conventional hydraulic conveyance system used in Peru and especially in Metropolitan Lima is a difficult problem to solve. The sustainability of this project, from a technical point of view, lies in the relative simplicity of its technology in terms of application, use and maintenance. Materials are easy to obtain, as they are available in the areas where the project is to be implemented.

Training by experts further guarantees the continuity of the process. The involvement of the Health Sector in local issues like the follow-up of the system is another element that will contribute to the adequate supervision of the project after the installation is completed. Organisational forms to involve the population in the operation of the system, such as the Environmental Management Committees and the Park Committees, ensure continuity. The raising of ecological awareness among the population as a whole and not only among direct users is important, but it is from the identification and commitment of the members of each household that the system becomes an immediate and long-term daily practice.

The costs are lower than those of the conventional system. This is basically related to the cost for the installation of the external network up to the front of the house, as conventional drainage represents expenses of no less than US $600 per dwelling, while for ECODESS, the expense to be covered by each household for the external installation does not exceed 150 dollars. On the other hand, the system of environmental dry toilets, or eco-toilets, entails significant savings in the household consumption of water, and provides inputs to improve the gardens and arable lots. Currently, more than 100 dwellings in settlements of the district of San Juan de Lurigancho are using this system, and the surface of irrigated land extends over 700m^2. An analysis of costs made by the Municipality of San Juan de Lurigancho reveals that the monthly expenditures made to convey irrigation water to 40% of park areas in the district would serve to set up eight new parks with an area of 400 m^2, complete with irrigation systems using phyto-treated grey water. The local water-recycling system used to irrigate urban green areas and urban agriculture plots is an alternative that can replace oxidation pools in small spaces or slums, as these require large areas and high costs.

The recycling of wastewater favours the state of the urban ecosystem. Furthermore, this intervention generates both temporary and permanent jobs, as well as a local market for inputs and by-products, like a small company that manufactures eco-toilets, phyto-treatment channels, grease-trapping mechanisms, fertilisers like compost, and greenhouses in green areas and for urban agriculture.

FUTURE CHALLENGES

The challenges relate to the implementation of a long-term strategy to consolidate a policy, or rather a discipline, for the consumption of water and its sustainable treatment. This policy must include the fact that Lima is a water-stressed area, and that by the year 2015, expenses to overcome this crisis will be greater.

ECODESS is only one tool in this challenge. There are other tools to assist in this process. However, from the perspective of environmental sanitation and recycling of water for green areas and urban agriculture, the goal of these strategies is to consolidate a policy of sustainable sanitation and rational water use. The institutions involved in ECODESS are committed to carrying out the following actions:

❖ Establishment of a Group of National Work in Ecological Sanitation; with universities, NGOs, environmental movements, urban agriculture practitioners and local governments. Promoting urban environmental management practices with local perspective, involving local organizations.

❖ Dissemination of information on the system and its advantages at all levels, social sectors and in both urban and rural areas.

❖ Technical training of functionaries and technicians in several institutions on water, sanitation, health, urban agricultural production, food security and local management of the urban environment.

❖ Influencing the development of adequate regulations. Pilot experiences must contribute to generate regulations that give more openness to these systems.

❖ Environmental education, especially in schools, focusing on changes in the attitude of people should be one of the key elements required to change environmental management practices.

Ecological Sanitation and Urban Agriculture

Local treatment and recycling of sewage (soapy "grey" water) and the reduction or even non-generation of wastewater are viable options that should be considered and supported within a municipal policy of sanitation and sewerage systems, that also takes urban agriculture into the equation.

Such solutions are legitimate, especially since many municipalities lack the capacity to provide costly drainage works and water-treatment plants, even in the more economic and viable versions, such as stabilisation ponds. This is especially true for the urban zones located in steep and/or stony terrains, as well as for those municipalities with problems of water supply. In Latin America and the Caribbean, this counts for 60% of the cities.

The main challenge for this type of solution is the need to provide information, set up demonstration sites with families and/or public institutions, organise meetings and participatory workshops to analyse the problems and their possible solutions, and to establish municipal incentives for those who adopt these technologies, as contributions of building materials and/or rebates in property taxes or water charges.

A CHANGE OF PARADIGM

Ecological sanitation is an alternative to the linear "solutions" to carry waste (excreta, soapy water, industrial water, etc.) to rivers, ponds, underground waters and seas that cause serious problems of pollution and public health. In municipalities with water shortages and a lack of other resources, it is neither viable nor recommended to "use 15,000 litres of treated or potable water per person per annum to evacuate 35 kg of faeces and 500 litres of urine *per capita* each year. In developing countries, more than 90% of the sewage is discharged without treatment" (Esrey, *et al.,* 2001: 13).

Ecological sanitation also forms a viable alternative to "latrines", the conventional solution for poor people in developing countries. This "drop and deposit" model encounters serious problems, especially in densely populated areas where the subsoil is impermeable, aquifers are shallow, or are prone to flooding. There is the risk that groundwater will become contaminated with pathogens like nitrates, leading to the pollution of potable water as well as irrigation water used for urban agriculture.

Ecological sanitation is based on an ecosystems approach. The nutrients and organic matter contained in human excreta must be considered as a resource and properly treated for its contribution to food-production systems. Ecological sanitation further allows for recovering and recycling nutrients in a safe and non-polluting way, with zero discharge. This is especially relevant in its relationship with urban agriculture, as it allows for a closing the cycle of nutrients, facilitating the cultivation of legumes and other vegetables in an ecological way, without agrochemicals (*see Figure 1*). This technology addresses households and requires community involvement. Ecological sanitation further serves to improve the family diet and its economy, as well as the self-esteem of its members. It also strengthens beneficial, responsible and committed community relations.

The proposed techniques include:

- ❖ Dry toilets with diversion of urine.
- ❖ Gravel, sand and purifying aquatic plant filters.
- ❖ Composting, which gives a secondary treatment to solid excreta from dry toilets.
- ❖ *Organoponics:* a production system that uses urine as its main source of fertilisers.

The "*Organoponics*" technique developed in Mexico by CEDICAR A.C. (Arroyo, 2000) consists of the production of small gardens in containers using urine as a liquid fertiliser, and soapy water that is filtered domestically to irrigate the gardens.

THE MEXICAN EXPERIENCE

In Mexico, several experiences have been recorded regarding the implementation of ecological sanitation programmes. The more negative experiences result from the implementation of technologies without prior work in the communities. This is often the case with unilateral initiatives by local governments, which although well intentioned, are felt as an imposition. To some extent they are not connected to the expectations of the population and therefore rejected. As a result, many dry toilets, for example, are now used as sheds or small chicken coops.

The more positive experiences mostly coincide with preparatory work having been carried out with user populations, including: demonstration sites in the same community or visits to other communities that have adopted these technologies; community diagnostic workshops with an emphasis on ecological considerations; collective analysis of problems and possible solutions in which the advantages, disadvantages, viability and freedom to adopt the technology and its methods are discussed and decided upon by each household. Although this point is the most important, local governments or other central government units must give additional incentives or assistance in order to build dry toilets, install grey water filters and collectors to catch rainwater.

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Aba is a booming commercial city in southeast Nigeria. It covers a surface area of about 40,000 km2 and has a population of more than 1 million people according to the 1991 population census of Nigeria. The city is presently experiencing a quick and unplanned growing spurt due to massive migration. Several large companies present, including Unilever, International Equitable, Coca Cola, Nigerian Breweries, etc., medium-sized paint-manufacturing, beverage and food-processing industries, as well as a huge amount of smaller industries. These companies together generate a large volume of wastewater.

IWMI-India

Upper Anicut, a dam in Musi River, Hyderabad

Wastewater Non-Management

in Aba City, Nigeria

There are many people within the urban and periurban areas of Aba who engage in different forms of crop production, which include arable crops, vegetables and horticulture. Most of these agricultural practices are rainfed because Aba has a regular distribution of rain. But there is also irrigated agriculture especially during the dry season (between the months of October and March). Dry-season vegetable production yields much higher profits. The main sources of irrigation water of agricultural sites in the urban and periurban areas of the city include the Aba River, open drains carrying water from the main roads and household wastewaters. The Aba River accounts for about 90% of the total sources.

RESULTS OF WASTEWATER NON-MANAGEMENT

Due to the poor wastewater-management system in the city, Aba River is heavily polluted with both toxic and heavy metals from industrial wastewater. There is no central sewerage system and there are no septic tanks for domestic wastewater. The sewers for industrial wastewater coming from big industries and the open drains used for the wastewater of medium- and small-scale industries are channelled in such a way that their contents spill into the Aba River.

This pollution of the Aba River is very likely to increase in the next decade. There is inadequate or hardly any treatment of the waste-water carried out by the industries, and no efforts are made to change this situation. Information on basic waste-management techniques is inadequately provided to industry and there are no financial/ technical incentives in place for industries to manage their wastewater.

The locations of the industries are unplanned, and most of the industries are even illegally operating in the city since they are not registered with the relevant body: the Environmental Health Sanitation Authority (EHSA). There is no dialogue between the (financial department of the) municipality and the EHSA towards in granting approval for the establishment of industries. The EHSA is not able to effectively monitor the industry due to the lack of proper legislation, and it faces inadequate capacity in terms of manpower, training and tools.

RECOMMENDATIONS FOR IMPROVEMENT

The following measures, if well implemented, will assist in improving the city's wastewater management:

- Local authorities should review the existing waste-management regulations and adapt or develop them, especially towards making them more stringent to offenders.
- Registration with the EHSA should be mandatory for all industries.
- Effective monitoring of industries should be ensured by employing more people and by providing them with relevant training.
- Provision of (information on) waste-minimisation techniques to industries should be sought.
- Economic incentives should be given to industries that are willing to implement waste-minimisation strategies but lack the required capital.

NGOs can and should contribute to the encouragement of proper wastewater management, for instance by organising workshops and seminars for industry and government on the importance of proper waste management, on technical and/or economic measures, as well as by studying and monitoring the current situation and to inform the public about pollution and about those industries that effectively have implemented waste minimisation.

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Policy Brief

Treatment and Use
of Wastewater for Urban Agriculture

THE FORMULATION OF MUNICIPAL POLICIES FOR URBAN AGRICULTURE

Increasingly, municipal governments are interested in urban agriculture for its benefits in the areas of food security, health, environment and employment. This series of guidelines is based on the latest scientific and technological developments and innovative practices experienced in cities throughout the Latin American Region. This is a good source of inspiration to share and improve.

"Using wastewater has become an alternative in view of the lack of access to potable water services in periurban and rural areas. It also responds to the immediate needs of the population". Donatilda Gamarra. Town Councillor and President of the Special Environmental Programme Committee, Municipal District of Villa El Salvador, Peru.

Developing programmes for the treatment and use of wastewater for urban agriculture basically involves managing health risks and facilitating the adoption of adequate technologies at city or neighbourhood level while optimising their benefits. Adopting facilitating policies and defining the financial sustainability of wastewater treatment and use systems is necessary.

TEN ACTIONS IN POLICY FORMULATION

1. Applying risk management strategies

In many cases, wastewater is the only source of water for irrigation. Once this reality is accepted, guidelines and mechanisms must be developed in the first place, in order to decrease the health risks associated with the use of untreated wastewater for agriculture, and then the treatment thereof must be promoted.

2. Educational and political campaigns

Many people think that participatory awareness-raising or information campaigns targeted at several actors are the most realistic, cheap and effective way to facilitate the understanding of existing strategies for the management of health risks. These strategies include monitoring water quality, choosing crops, adequate management of irrigation techniques, and treatment of produce.

3. Monitoring water quality

In San Juan de Lurigancho (in Lima, Peru), the NGO CENCA and the municipal government reached an agreement with the Agrarian University of La Molina for the monitoring of the quality of wastewater used for agriculture in the city.

4. Choice of crops

Choosing crops to grow in relation with the quality of wastewater is a key factor, because there are large variations in the way plants absorb pathogens and heavy metals.

5. Applying adequate irrigation and crop-treatment techniques

Adoption of adequate technologies for the treatment of wastewater is important. The flows of industrial and domestic wastewater must be properly segregated.

6. Choosing a treatment technology

The most interesting treatment options are those that eliminate pathogens but retain the nutrients present in the water. An example of this is found in stabilisation ponds, which are also a good alternative to the treatment and use of water at a city scale. Investment costs are up to 80% lower and operation costs are up to 90% lower than costs associated with more sophisticated technologies, such as aerated or mud-activated plants. However, stabilisation ponds require large areas of urban land. There are other alternative sanitation systems, which have been extensively tested in several cities in the region.

7. Changing policies and establishing a facilitating regulatory framework

The treatment and use of wastewater must be part of a coherent and facilitating legal and regulatory framework, aimed at including it in the physical planning of cities.

8. Incorporating treatment and use into urban planning

In the District of Villa El Salvador (Lima, Peru), the municipal government incorporated the construction of treatment plants and the use of wastewater for irrigation in collective leisure areas, like Parque de la Alameda de la Juventud, into its Urban Development Plan. The local government is currently analysing the possibility of setting aside spaces in the same area for family or community UA plots. However, the use of urban land for this purpose requires careful planning.

9. Determining financial sustainability and calculating costs and benefits

In order to make the implementation of treatment plants economically sustainable, integrated wastewater treatment and use systems must be developed. It is important to calculate all the direct and indirect costs and benefits of the system and to define who should assume the costs of treating and using wastewater.

10. Defining the price for wastewater treatment and use

Applying the "polluter pays" principle must be a priority: both the local industries and the urban population must assume the cost of treating the wastewater they generate. At the same time, farmers must pay for the use of treated water, just like they pay to use fresh or potable water. Only in cases of low-income and marginalised producers, should the cost be assumed by the central or local government as a social inclusion policy.

(Summary by Mariëlle Dubbeling, UMP-LAC)

More Information

This Policy Paper is part of a series of 9 papers on urban agriculture: ❖ Urban Agriculture: an on-going urban activity ❖ Harvesting democracy: local consultative processes in UA ❖ UA, land management and physical planning ❖ The hidden investment: the implementation of micro-credit programmes in UA ❖ Giving use to what is discarded as useless: using organic waste in UA ❖ Treatment and use of wastewater for UA ❖ Urban agriculture: equal opportunities for men and women ❖ UA and urban food security ❖ Strengthening small agribusinesses: processing and commercialisation of UA.

The Series has been validated through Local Multi-stakeholder Consultations carried out in 10 cities in Latin America and the Caribbean and at a Regional Consultation conducted in Lima, Peru (on September 11-13, 2002), where representatives of several local and national governments and civil society were present. The entire series are in Spanish and available on the web page of the Urban Management Programme for Latin America and the Caribbean: www.pgualc.org.

Livestock and **Urban Waste** in East Africa

Rapid urbanisation has not been accompanied by equitable economic growth and has resulted in increased urban poverty. As a result of this worsening of urban poverty, many low-income households suffer from extremely limited livelihood security. Increasing demand for land in cities for housing favours urban livestock keeping, as it requires less or no land and promises higher returns per unit of land utilised.

REFERENCES

- Ishani, Z, PK Gathuru and D Lamba. 2002. Scoping study of Urban and Peri-urban poor livestock keepers in Nairobi, Mazingira Institute, Kenya.
- Ossiya, S, N Ishagi, L Aliguma and C Aisu. 2002. Urban and Peri-urban livestock keeping in Kampala City – a scoping study. Ibaren Konsultants, Kampala, Uganda.

This study was commissioned and financed by DFID's Livestock Production Programme, UK, and is based on five city case studies, which have been conducted by local research teams (for further details please refer to the full document which can be found on: ***www.nida.or.ug***

A workshop on these experiences will be organised by DFID, NRI and the LPP Partners and supported by RUAF in Nairobi, Kenya: January 27-30, 2003.

Compared to urban crop production, livestock can be shifted easily to other urban areas as they become available. The urban poor engage in urban livestock keeping as a response to limited alternative livelihood options and food insecurity, but they often lack control over and access to basic inputs.

LIVESTOCK AND LIVELIHOODS IN EAST AFRICA

With the objectives to understand the current situation of poor urban livestock keepers in East Africa, and to identify areas where future research could make a contribution to the development and promotion of this activity for the poor, five city case studies were selected in Tanzania, Uganda, Kenya and Ethiopia. The cities were Dar es Saalam, Kampala, Kisumu, Nairobi, and Addis Ababa.

The case studies reveal that urban livestock keeping benefits the poor and provides an accessible means of diversifying livelihood activities. Furthermore they show that especially vulnerable groups, such as female-headed households, children, retired people, widows and people with limited formal education are particularly involved in urban livestock keeping as a form of social security strategy (Ossiya et al. 2002). Urban livestock keeping contributes to food security, income and employment generation, savings and insurance systems and social status. It provides easily convertible assets for covering important expenditures (such as school fees, health treatments).

LIVESTOCK AND WASTE

There are also, however, various externalities involved in livestock keeping (e.g. zoonoses, environmental contamination, product safety) which require addressing. There is **strong evidence** from all the case studies **that animal waste disposal causes environmental and public health dangers** (Ishani, *et al.*, 2002). Urban livestock keeping also competes for water resources with human consumption as the demand for water for this activity is not taken into account by the supply services. In many slum areas, municipal water has to be bought and therefore other water sources, which are often contaminated, are accessed for livestock and men.

RECOMMENDATIONS FOR RESEARCH AND POLICY

Research studies are required to assess in more detail the current and potential impact these negative externalities have on urban people and to contribute to the development of strategies to overcome or minimise them.

Livestock waste management

Research is necessary to understand how water and public health problems will develop with increasing livestock numbers and over time. Parallel to understanding the scope and dimensions of this problem, research is required to provide improved waste-management technologies adapted to the specific circumstances of the poor. An important research component would be the potential for the intensification of urban/periurban and rural linkages in terms of nutrient flow.

Water availability

Currently, city planners do not take into account the water demands of urban livestock keepers. This results in competition for resources, overuse and conflicts between neighbours. Studies are needed which quantify the current and future water demand by urban livestock keeping, and to identify potential water management strategies.

Zoonoses

The existing and potential health risks for humans caused by the transmission of diseases from livestock have to be assessed in greater detail. Relevant information is needed to advise policy-makers and city authorities on these issues in order to provide guidance for the formulation of pro-poor urban livestock legislation. Aspects related to zoonoses, which need to be taken into account for the formulation of new legislation is food quality standards and quality control processes.

The study also shows that poor livestock keepers are marginalised from existing knowledge and improved technologies. There is a clear opportunity to improve the current management system through capacity development and information sharing. However, in order to achieve this, organisation and networking among poor livestock keepers is required to improve the access to services, information, technologies and markets.

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WATER MANAGEMENT IN ISLAM.

Faruqui, Naser I, Asit K Biswas and Murad J Bino. 2001. United Nations University Press and International Development Research Centre, Ottawa, Canada.

This volume presents Islamic perspectives on a number of proposed water-management policies, including water-demand management, wastewater reuse, and higher tariffs. The book opens avenues for a wider dialogue amongst researchers working at identifying the most promising water-management policies, adds to our knowledge of some of the influences on formal policy and informal practice, and makes these ideals available to a broader public. *Water Management in Islam* will interest researchers, scholars, and students in natural resource management, Islamic studies, Middle Eastern studies, development studies, and public policy.

VISITE D'ETUDE ET ATELIER INTERNATIONAL SUR LA RÉUTILISATION DES EAUX USÉES EN AGRICULTURE URBAINE: UN DÉFI POUR LES MUNICIPALITÉS EN AFRIQUE DE L'OUEST ET DU CENTRE

2002 CREPA, ETC-RUAF. CTA. (In French: English Title, Study Visit and International Workshop on the Reuse of Wastewater for Urban Agriculture). Proceedings of the study visit cum workshop held in Ouagadougou, Burkina Faso from 3-7 June 2002.

This report contains ten papers (three general subjects and seven city case studies) and a detailed description of the workshop and the study visits in and around Ouagadougou. All activities are reported from three angles, which reflect the main themes: socio-economical aspects, health and environmental aspects and institutional, juridical and financial aspects. The working group findings are presented together with a set of recommendations to various groups of stakeholders. The represented cities are Cotonou, Benin; Kumasi, Ghana; Dakar, Senegal; Nouakchott, Mauretania, Bamako, Mali; Yaounde, Cameroon and Ouagadougou, Burkina Faso.

A FRAMEWORK FOR ANALYZING SOCIOECONOMIC, HEALTH AND ENVIRONMENTAL IMPACTS OF WASTEWATER USE IN AGRICULTURE IN DEVELOPING COUNTRIES

Hussain, I, L Raschid, MA Hanjra, F Marikar and W van der Hoek. 2002. IWMI Working Paper 26. International Water Management Institute, Colombo, Sri Lanka.

www.cgiar.org/iwmi/pubs/working/WOR26.pdf

The biggest challenge faced by policy-makers at present, is how best to minimise the negative effects of wastewater use, while at the same time obtain the maximum benefits from this resource. While most of the impacts of wastewater use, both negative as well as positive, are generally known, a comprehensive evaluation of the benefits and costs of these impacts has not as yet been attempted. Conventional cost-benefit analysis is not adequate to evaluate wastewater impact due to its environmental and "public good" nature. To fill this gap in knowledge, this paper attempts to develop a comprehensive assessment framework applying available and tested techniques in environmental economic analysis, for the comprehensive evaluation of the costs and benefits of wastewater. The periurban area of Faisalabad, Pakistan is chosen to represent this context.

GUIDELINES FOR WASTEWATER REUSE IN AGRICULTURE AND AQUACULTURE: RECOMMENDED REVISIONS BASED ON NEW RESEARCH EVIDENCE

Blumenthal, Ursula J, Anne Peasey, Guillermo Ruiz-Palacio and Duncan D Mara. 2000. Report summary of WELL Task No. 68 (Part 1). London School of Hygiene & Tropical Medicine, Loughborough University, UK (67 pp).

www.lboro.ac.uk/well/resources/well-studies/summaries-htm/task0068i.htm

WELL is the **DFID**-funded resource centre promoting environmental health and well-being in developing and transitional countries. WELL is designed to coordinate and provide services for water, sanitation and environmental health programmes to DFID and other agencies. The WELL website is a focal point of information about water and environmental health and related issues in developing and transitional countries. This study reviews the WHO (1989) Guidelines for Wastewater Reuse in Agriculture and Aquaculture in the light of recent epidemiological studies.

ÉPURATION DES EAUX USÉES ET L'AGRICULTURE URBAINE (WASTEWATER TREATMENT AND URBAN AGRICULTURE)

M Gaye and S Niang. 2002. ENDA Tiers Monde, Dakar, Sénégal (354 pp). *(In French)*

This book gives detailed insights into wastewater research and treatment in Senegal. It has three parts: 1) Sanitation policies in Senegal and participation of the inhabitants in the demand management; 2) making use of wastewater for urban agriculture in Dakar; 3) treatment efficiency of wastewater through stabilisation ponds. It gives an overview of water and sanitation in Africa and Senegal in particular: relevant institutions, existing policies and treatment efforts. A project of ENDA Senegal is described in more detail, discussing the revolving fund, the involvement of the population as well as the collection and treatment of domestic wastewater. Part two reviews the use of wastewater in urban agriculture; one source is real wastewater, the other comes from shallow natural wells (*Céans*) from which the water is seen as clean but in fact contains much the same pollutants as wastewater. Part three describes the treatment plants of Castors and Diokoul and their efficiency in removing pollutants and pathogens. Thanks to the details and description of methodologies in this book, it can serve well for anybody wanting to undertake a similar wastewater-treatment *cum* -reuse research in another sub-Saharan country.

THE MANGO CITY: URBAN AGRICULTURE IN BELÉM

Isabel Maria Madaleno. 2002. *In Portuguese*: *A Cidade das Mangueiras: Agricultura Urbana em Belém do Pará,* which can be purchased through **www.gulbenkian.pt, educa@gulbenkian.pt**, or directly from FUNDAÇÃO CALOUSTE GULBENKIAN – Av. De Berna, 45 A – 1067-001 Lisboa, Portugal.

The wettest city in Brazil, Belém - also known as the "mango city" - has more than one million inhabitants. Its natural environment is dominated by islands, deep rivers and narrow green waterways, and by plain alluvial soils suitable for almost any kind of vegetable crops. This book describes the evolution of the metropolis, explaining how what we see in the very many illustrations is deeply intertwined with the history of the country, about the human occupation and devastation of Amazonia, focusing in particular on Brazilian Pará. It is a tribute paid to a hard-working and ingenious people, who against all odds survive in one of the poorest metropolises in Latin America, frequently complementing their monthly income with fruits, herbs, spices, medicinal plants, and all sorts of animals.

TIERRA VACANTE EN LAS CIUDADES LATINOAMERICANAS
(Vacant Land in Latin American Cities) Nora Clichevsky (ed.). 2002. (*In Spanish*). Lincoln Institute of Land Policy Information Services, Cambridge, USA (144 pp). US$15.00. ISBN 1-55844-149-2 (Fax: 617-661-7235 or 800-526-3944; e-mail: help@lincolninst.edu; or website: **www.lincolninst.edu**)
This book identifies the many problems related to vacant urban land, as well as the opportunities that it presents. It is the culmination of a research project coordinated by the editor between 1997 and 1999, in which the issues around vacant land in five cities (Buenos Aires, Argentina; Rio de Janeiro, Brazil; Quito, Ecuador; Lima, Peru; and San Salvador, El Salvador) were analysed and compared. A great variety of vacant land situations coexist in Latin American cities, but there are common threads throughout the region. The problems derived from vacant lots include increased costs for the provision of infrastructure in low-density areas, as well as long commutes and high transportation costs related to growth further from the urban centre. The essays suggest that, at this moment when urban planning and management are being refined in many Latin American countries, vacant land could play an important role in the dynamics of cities and metropolitan areas. The creative use of vacant land could be beneficial to all social sectors.

Selected Publications by IWMI
(www.cgiar.org/iwmi/pubs)

- **Urban Wastewater: A Valuable Resource for Agriculture: A Case Study from Haroonabad, Pakistan** Van der Hoek, Wim, Mehmood UlHassan, Jeroen Ensink, Sabiena Feenstra, Liqa Raschid-Sally, Sarfraz Munir, Rizwan Aslam, Nazim Ali, Raheela Hussain and Yutaka Matsuno. Research Report 63. International Water Management Institute.
- **Use of Untreated Wastewater in Periurban Agriculture in Pakistan: Risks and Opportunities** Ensink, HJ Jeroen, Wim van der Hoek, Yutaka Matsuno, Sarfraz Munir and M. Rizwan Aslam. Forthcoming. Research Report 64. International Water Management Institute.
- **Health Risks of Irrigation with Untreated Urban Wastewater in the Southern Punjab, Pakistan** Feenstra, Sabiena, Raheela Hussain and Wim van der Hoek. 2000. The Institute of Public Health, Lahore, Pakistan and Pakistan Program, International Water Management Institute.
- **Urban-Wastewater Reuse for Crop Production in the Water-Short Guanajuato River Basin, Mexico** Scott, C.A., J. Antonio Zarazua and G. Levine. 2000. Research Report no. 41, International Water Management Institute, Colombo, Sri Lanka (34 pp).
- **Wastewater Reuse in Agriculture in Vietnam: Water Management, Environment and Human Health Aspects - Proceedings of a Workshop held in Hanoi, Vietnam, 14 March 2001** Raschid-Sally, Liqa, Wim van der Hoek and Mala Ranawaka (eds). 2001. IWMI Working Paper 30. International Water Management Institute, Colombo, Sri Lanka (48 pp).
- **For us, this Water is Life: Irrigation Under Adverse Conditions in Mexico. In: Buechler, S., Water and Guanajuato's Ejido Agriculture: Resource Access, Exclusion and Multiple Livelihoods** Buechler, Stephanie. 2001. PhD dissertation. Sociology. Binghamton University, Binghamton, New York, USA.
- **Wastewater Use in Agriculture: Review of Impacts and Methodological Issues in Valuing Impacts.** Hussain, Intizar, Liqa Raschid, Munir A Hanjra, Fuard Marikar and Wim van der Hoek. 2002. Working Paper no. 37. International Water Management Institute. Colombo, Sri Lanka.

WebSITES

www.cgiar.org/iwmi/
A major source of information on the topic of water is the International Water Management Institute, whose mandate is "improving water and land resources management for food, livelihoods and nature. Their site provides a number of updates, policy papers, publications as well as a free subscription to their electronic bulletins.

www.iwapublishing.com/template.cfm?name=water_intelligence_online
International Water Association (IWA-) Publishing provides information services on all aspects of water, wastewater and related environmental fields. It includes *Water21*, the IWA membership magazine, and a broad range of journals, books, scientific & technical reports, manuals, newsletters and electronic services. *Water Intelligence Online* is a new online service providing access to a wide selection of valuable information. Also available are the abstracts of the papers from the Workshop: "Use of Appropriately Treated Domestic Wastewater in Irrigated Agriculture", Wageningen University, The Netherlands (April 24, 2002).

www.cleanh2o.com/ww/
This wastewater engineering virtual library (VL) is part of the VL, which is one of the oldest web-based catalogues. Unlike commercial catalogues, it is run by a loose confederation of volunteers, who compile pages of key links for particular areas in which they have expertise. This part of the VL is focused on the USA.

www.sandec.ch
SANDEC is the Department of Water and Sanitation in Developing Countries at the Swiss Federal Institute for Environmental Science and Technology (EAWAG ***www.eawag.ch/e_welcome.html***) in Duebendorf, Switzerland. Its activities centre on problems of sustainable development in economically less developed countries. Its mandate is to assist in developing appropriate and sustainable water and sanitation concepts and technologies adapted to the different physical and socio-economic conditions prevailing in developing countries. The SANDEC research activities focus on use of waste, wastewater and as a recent topic: urban agriculture.

www.cepis.ops-oms.org
The website of the Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente (the Pan American Centre for Sanitary Engineering and Environmental Sciences) is in Spanish and English and focused on Latin America. It contains a wealth of information on publicationd, events, training materials, etc.

weather.nmsu.edu/hydrology/wastewater/
The *Middle East Wastewater Use Clearinghouse* is a site established to promote knowledge about the use of wastewater on agricultural land to increase the limited water resources available in the Middle East. The project is a cooperative effort of San Diego State University's Middle East Development programme, the Peres Centre for Peace and the International Arid Lands Consortium, and is supported by USAID. The site has information on the project and related issues.

www.ihia.org.uk/
The International Health Impact Assessment Consortium (IMPACT) is a multi-agency partnership formed to help further the research, study and practice of Health Impact Assessments.

EVENTS

METHODOLOGIES FOR RISK ASSESSMENT OF WASTEWATER REUSE ON GROUNDWATER QUALITY (Sapporo, Japan)

30 June – 11 July 2003

This symposium is part of the 33rd General Assembly of the International Union of Geodesy and Geophysics. Subjects include: threshold value of soil degradation under wastewater application, processes in the soil, crop production and quality, risk for human health.
More information: Mr Steenvoorden of ALTERRA, The Netherlands; e-mail: j.h.a.m.steenvoorden@alterra.wag-ur.nl

FIFTH MEETING ON ORGANIC AGRICULTURE (Havana, Cuba)

27-30 May 2003

Organised by the ACTAF (Cuban Association of Agricultural and Forestry Engineers), this conference will discuss new experiences related to integrated systems of natural resource management, appropriate technologies, social and economic aspects, environmental aspects, and the contribution of (organic) urban agriculture to sustainable urban development. The conference language will be Spanish.
More information: Nilda Pérez Consuegra: nilda@isch.edu.cu

COURSE ON URBAN AGRICULTURE AND SUSTAINABLE DEVELOPMENT (Santa Maria, Brazil)

May 2003

This course is being planned by the Research Group on Tourism and Development of Camobi. Email: turodes@ccr.ufsm.br Or by mail: Grupo Turismo e Desenvolvimento; Caixa Postal 5042 – Camobi; CEP 97.111-970 - Santa Maria – RS, Brazil.

2ND INTERNATIONAL SYMPOSIUM ON ECOLOGICAL SANITATION "ECOSAN - CLOSING THE LOOP" (Lübeck, Germany)

7-11 April 2003

Conventional forms of centralised sanitation are coming under increasing criticism. Especially because of the enormous investment involved, the huge operating and maintenance costs, high water consumption and other drawbacks, they are not suitable as a blanket solution for developing countries, particularly in arid climate zones. The GTZ sector project on ecosan has started in May 2001. The objective is to investigate ecosan systems, establish them in national and international guidelines and prepare them for dissemination. During this Symposium a conference on Sustainable Sanitation will be held.
www.gtz.de/ecosan/english/symposium2.htm

WORLD WATER FORUM (Kyoto, Japan)

16-23 March 2003

The Third World Water Forum will be held in Japan (Kyoto, Shiga and Osaka, who share the water resources of the Lake Biwa-Yodo River Basin). The forum is gathering submissions through a range of activities including Regional Conferences on individual themes in various regions around the world and the publishing of the World Water Action Report. The Virtual Water Forum is providing a discussion platform. The session can be accessed at the World Water Forum website
www.worldwaterforum.org/for/en/fshow.393 You can enter this session as a guest or register as a participant, in which event the WWF will send you the necessary ID and password. More information: www.worldwaterforum.org

IDRC WATER DEMAND FORUM NO. 4 ON DECENTRALISATION OF WATER MANAGEMENT (Cairo, Egypt)

3-5 February 2003

The International Development Research Centre is supporting the promotion of water-demand management strategies through the WDM Forum. A series of Water Demand Management Forums have been organised. Wastewater Reuse, Water Valuation, Public-Private partnerships and Decentralisation of water management. The Fourth Forum on *Decentralisation of water management* is aimed at decision-makers from the Middle East and North Africa. The First Water Demand Forum was held in **Rabat Morocco, 26-27 March 2002** and focused on Wastewater Reuse. The second forum focused on Valuation and was held in **Beirut Lebanon, 25-27 June 2002**, and the third on Public-Private Partnerships was held in Amman, Jordan 15-17 October. For more information please visit www.idrc.ca/waterdemand/

WATER, POVERTY, AND PRODUCTIVE USES OF WATER AT THE HOUSEHOLD LEVEL (Johannesburg, South Africa)

21-23 January 2003

This International symposium will discuss practical experiences, new research, and policy implications, from innovative approaches to the provision and use of household water supplies. Please contact one of the symposium organisers: IRC International Water and Sanitation Centre, Delft, The Netherlands (Dr PB Moriarty : moriarty@irc.nl); or the Department of Water Affairs and Forestry, South Africa
(B Schreiner or D Versfeld).

WATER AND WASTEWATER: PERSPECTIVES OF DEVELOPING COUNTRIES (New Delhi, India)

11-13 December 2002

This conference aimed to focus on the various inter-linked aspects of water availability to provide a forum for chalking out strategies that may be useful to the developing countries. For information, please contact: Prof. Rema Devi Organising Secretary WAPDEC wapdec2002@yahoo.com Their website is www.iitd.ac.in/wapdec.

ENVIRONMENTAL AND PUBLIC HEALTH RISKS FROM URBAN, INDUSTRIAL AND NATURAL SOURCES IN SOUTH EAST ASIA (Hanoi, Vietnam)

10-12 December 2002

This Seminar is organised jointly by UN-ESCAP, IWMI and the National Institute for Soils and Fertilisers (NISF). More information can be obtained from NISF (ncvinh-nisf@ftp.vn) or UN-ESCAP (wees.unesscap@un.org).

WASTEWATER USE IN IRRIGATED AGRICULTURE: CONFRONTING THE LIVELIHOOD AND ENVIRONMENTAL REALITIES (Hyderabad, India)

11-14 November 2002

See the report as well as the Hyderabad Declaration on page 4.

GREEN CITIES, SUSTAINABLE CITIES CONGRESS (Midrand - Johannesburg, South Africa)

18-21 November 2002

The following subjects were discussed: Sustainable Urban Greening and Sustainable Development; Social Implications; Poverty Alleviation and Economics; Technical Aspects.

For more information, contact the Green Cities Congress Secretariat: Van der Walt & Co, Randburg, South Africa: Tel: +27 11 789-1384; Fax: +27 11 789-1385; e-mail ierm@vdw.co.za; www.ierm.org.za/greencities/

ECOLABELS AND THE GREENING OF THE FOOD MARKET (Boston, Massachusetts, USA)

November 7-9, 2002

This conference, organised by Tufts University and US Department of Agriculture, was a response to the rapidly growing use of ecolabels, which has raised several questions: How credible are they? More information: visit www.nutrition.tufts.edu/conted/ecolabels

EXCHANGE MEETING AND SEMINAR ON URBAN AGRICULTURE (Ath, Belgium)

23-26 September 2002

This seminar was organised by the Haute École Provinciale du Hainaut Occidental (Ath), Institut de la Vie (Bruxelles), PRELUDE international (Bruxelles), Solidarité Socialiste/FCD/DTS (Bruxelles). This seminar brought together about 30 farmers and experts from East, Central and West Africa and from Europe with the intention to share experiences in urban agriculture, visit urban agriculture sites in Belgium and France, to discuss possibilities of promoting urban agriculture, find solutions such as building and consolidating partnerships and networks and to identify relevant research programmes. Case studies from both African and European participants were presented. The event ended with the formulation of recommendations and conclusions and the drafting of a common charter of Urban Agriculture.
For more information (including the results), please contact: Prof Michel Ansay, Institut de la Vie, mansay@ulg.ac.be

WORKSHOP ON URBAN AGRICULTURE (Lima, Peru)

18-20 September 2002

This workshop, organised by the Cities Feeding People (IDRC) Programme and hosted by ITDG, Peru, reviewed results, impacts and lessons learned from a second generation of urban agriculture projects in Latin America and the Caribbean. The proceedings of the workshop will be published in early 2003 and copies will be made available from the Cities Feeding People Programme.

IFOAM ORGANIC WORLD CONGRESS (Victoria, Canada)

August 21st to 28th.

Although it was planned for 800 participants, about 1,300 people from 92 countries participated in this 14th International IFOAM Organic World Congress. See for information: www.cog.ca/ifoam2002/ to order the proceedings.

STUDY VISIT/WORKSHOP: REUSE OF WASTEWATER IN URBAN AGRICULTURE, A CHALLENGE FOR MUNICIPALITIES IN WEST AFRICA (Ouagadougou, Burkina Faso)

3-7 June 2002

Refer to page 13 or visit the RUAF website at www.ruaf.org.

INTERNATIONAL FORUM RETHINKING THE CITY (Montreal, Canada)

27 June 2002

This meeting gathered a large number of high-level policy-makers and business representatives from LAC, Canada and Italy. The event provided a good platform for speakers, mostly local governments and the private sector, to openly express and then illustrate their views regarding local governance, focusing on the interaction of public and private sectors.
More information: www.ems-sema.org/eventos/montreal/index_i.html

URBAN POLICY IMPLICATIONS OF ENHANCING FOOD SECURITY IN AFRICAN CITIES (Nairobi, Kenya)

27-31 May 2002

This workshop was organised by UNHCS in partnership with the FAO, IDRC and SIUPA (CIP-based Strategic Initiative on UPA). The minutes of the workshop are published. Contact: Urban and Regional Economy Unit, Urban Economy and Finance Branch, UNCHS (Habitat), P.O. Box 30030, Nairobi, Kenya.
Tel: +254 2 624521; Fax: +254 2 623080; e-mail: rose.muraya@unchs.org.

FEEDING CITIES IN THE HORN OF AFRICA: DECLARATION OF ADDIS ABABA (Ethiopia)

7-10 May 2002

The report of this three-day workshop "Feeding Cities in the Horn of Africa" is now available on cd-rom. For further information, please contact: Michael Wales, Horn of Africa Food Security Initiative, FAO Investment Centre, Rome; Tel: 0039-06-5705-5432; e-mail: Michael.Wales@FAO.org.

NETWORKING

CITY CONSULTATION ON URBAN AGRICULTURE AND FOOD SECURITY IN QUITO, ECUADOR ON CD-ROM

IPES, the Urban Management Programme - Regional Office for Latin America and the Caribbean (UMP-LAC/HABITAT) and the IDRC have produced a multi-media CD-ROM on the participatory process of dialogue, action planning and municipal intervention on urban agriculture in the city of Quito, Ecuador (from September 1999 until September 2001). The CD-Rom is only available in Spanish and can be ordered for US $15 (excluding costs for postage). Please contact the Urban Management Programme in Quito (e-mail: marid@pgu-ecu.org or Fax at +593.2.2282361 - ext 110-)

URBAN AGRICULTURE POLICY ADVISORY TOOLS FOR LOCAL GOVERNMENTS IN LATIN AMERICA AND THE CARIBBEAN

As part of its "closing the loop" activities, the Cities Feeding People programme initiative of the IDRC collaborates with UMP-LAC/UNCHS- HABITAT/UNDP, and its anchoring institute IPES to produce a set of Policy Briefs (see page 41). These briefs are known in Spanish as "*Directrises o lineamientos de Politica*", and are intended for local governments in the LAC Region. The general content include arguments for better municipal policies on UA, examples of good municipal practice, practical planning and management guidelines, and resources. The Briefs will be disseminated in 20,000 copies (in both Spanish and English) to municipal urban governments throughout the Region.
For more information: Please contact Marielle Dubbeling at the Urban Management Programme in Quito (email: marid@pgu-ecu.org or Fax at +593.2.2282361 - ext 110-)

AGROPOLIS INTERNATIONAL RESEARCH AWARDS IN URBAN AGRICULTURE

Call for Applications

The AGROPOLIS International Graduate Research Awards Programme was launched by the International Development Research Centre (IDRC) in 1998 to support innovative Master's and Doctoral level research in urban agriculture. To date, the AGROPOLIS programme has helped 27 students carry out field research in developing countries. Their work covers a broad scope, from the impact of wastewater use in urban and periurban agriculture in Ghana, to trials of local feed resources to strengthen animal smallholdings in Vietnam, or an exploration of gender issues in commercial urban agriculture in Botswana. AGROPOLIS awardees are making significant contributions to the advancement of urban agriculture in many parts of the world.

Up to 14 awards will be granted annually, at least 5 of them at the Master's level. AGROPOLIS covers field research expenses up to CA $20,000 a year, for periods ranging from 3 to 12 months. Applicants must be citizens or permanent residents of a developing country or of Canada: at least two-thirds of the awards will be made to researchers from developing countries. All applicants must be registered full-time at a university. Starting this year, the AGROPOLIS Program will also offer up to two post-doctoral awards to promising researchers who have obtained a Ph.D. in urban agriculture or a related field and who wish to specialise further.

The deadline for applications is January 31, 2003.

For more information: AGROPOLIS International Graduate Research Awards in Urban Agriculture, IDRC, PO Box 8500, Ottawa, ON, Canada K1G 3H9, Tel: (613) 236-6163, ext. 2040; Fax: (613) 567-7749. Email: agropolis@idrc.ca Website: www.idrc.ca/cfp.

RUAF USERS SURVEY

In total 53 people responded to the question **"How do you locally apply the information provided by RUAF"**, that was raised by RUAF in an e-mail to all persons in the UA-contacts database having an e-mail address. The responses to our request came from all the corners of the world. The contributions varied in length between a short word of thanks to long essays and suggestions for improvement. The reactions are all very positive showing the wide use of information for inspiration, networking and sharing information, research, training and education or in local policy and programme development. These experiences and suggestions for improvement of the RUAF services will be discussed in the next RUAF partner meeting in February 2003 and will be taken into consideration in future work of RUAF.

On 1 October a random draw from the 53 entries took place and the three lucky winners were: Ysmary Trejo, Habitat from Venezuela, Ken Hargesheimer, Garden/Mini-Farms Network, from the United States and Almitra Patel, from India. The winners have been contacted and were given a choice between two packages of publications on Urban Agriculture. Congratulations to these winners!! RUAF would also like to thank all the other respondents for their contribution.

Abbreviations and Definitions

- **BOD** Biochemical Oxygen Demand
- **COD** Chemical Oxygen Demand
- **TSS** Total Suspended Solids
- **TDS** Total Dissolved Solids
- **Grey water** (domestic) wastewater from kitchen and bathroom
- **Black water** wastewater with excreta, urine and associated sludge
- **Sludge** is the settled matter after stabilisation of organic matter in wastewater through some process. It may have an offensive odour and a mud-like appearance.
- **Faecal coliforms** are bacteria found in the faeces of warm blooded animals; the numbers found in water indicate the level of faecal or sewage pollution and the numbers found in treated wastewater indicate the effectiveness of wastewater treatment.
- **Intestinal Nematodes** the most common are round worms, hookworms, and whipworms which carry the highest risk of infection.
- **Guideline limits** indicate the maximum level of pollution at which persons would not be at risk of infection. For restricted irrigation, no more than one viable human intestinal nematode egg per litre is permissible, whereas for unrestricted irrigation additionally no more than one thousand faecal coliform bacteria per hundred millilitres are allowed.
- **Wastewater stabilisation ponds** comprise one or more series of anaerobic, facultative and maturation ponds. They consist of shallow, usually rectangular "lakes" into which wastewater continuously flows and from which a stabilised effluent is discharged. Anaerobic and facultative ponds are primarily for the removal of organic matter, although they are very effective in removing intestinal nematode eggs. Maturation ponds are used mainly for the removal of excreted bacteria and viruses.
- **Bioremediaton** is accomplished through the use of plants and trees that uptake water and reduce nitrogen and host microbial organisms and some heavy metals in the water.
- Other **alternative methods** consist of gravel, reeds or vetiver grass which serve as filtration mechanisms as well as to reduce the amount of nitrogen in the water. These are sometimes combined with the use of water hyacinth or duckweed as bioremediators and with solar radiation aquatic ponds that kill pathogens.
- **Restricted irrigation** applies to water used for irrigating a restricted range of crops, for example, cereals, fodder crops, pasture, trees, and crops, which are processed before consumption.
- **Unrestricted irrigation** refers to water that can be used to grow any crops using any irrigation method without health risks including crops that can be eaten raw.
- **Diluted** Effluent mixed with other water before use in irrigation.
- **Undiluted** No significant dilution of the effluent in a river or other water body before use in irrigation.
- **Formal use** Use of wastewater with a certain level of permission or potential control by state agencies (alse suggested are: Authorised and Planned use).
- **Informal use** Use of wastewater without permission and control by state agencies (alse suggested are: Unauthorised and Unplanned use).