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Making urban excreta and wastewater management contribute to cities' economic development: a paradigm shift

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Abstract

Cities, as engines of economic growth and social development, require large quantities of natural resources to meet their inhabitants' economic and social needs. Good infrastructure and reliable service provision are key to sustaining cities' development. In this regard, they enhance investment opportunities and service access to vulnerable populations. In response to the lack of sanitation infrastructure, many governments, development agencies and NGOs usually implement programmes to provide latrines to poor and vulnerable populations. These programmes often do not link infrastructure provision and its necessary management requirements. As a result, the majority of 'latrine-based' cities do not have a reliable solution for emptying latrines, and for the transportation and treatment of faecal sludge and wastewater. When these infrastructures are available, they are disconnected from business opportunities which use resources such as water, nutrients or biosolids for their productive activities. This lingering failure in sanitation is putting a huge financial burden on municipalities who have to rely on permanent subsidies to operate and maintain infrastructures. The recent WHO guidelines on safe use of wastewater, excreta and greywater opens doors for reuse opportunities other than agricultural irrigation. It is leading towards a new paradigm. This paper discusses research needs to link urban sanitation management to cities' economic development agenda.

Keywords: Business in sanitation; Excreta; Faecal sludge; Resource recycling; Sanitation planning; Wastewater

1. Introduction

1.1. Growing cities: challenges for sanitation infrastructure and service provision

Less than 5 years remain to meet the Millennium Development Goals (MDGs) set out by the international community in 2000. Yet many countries—particularly in Africa and South Asia—are off track. Examples abound of slow or failing efforts: inadequate resources and weak governance contribute

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to over 10 million children dying annually of readily preventable diseases; only three-fifths of urban and one-quarter of rural low-income households in low income countries have access to improved sanitation facilities (World Bank, 2006). Since the world population is migrating towards cities, the share of the urban population is rapidly increasing and is expected to reach 55% by 2015.

Cities are engines of economic growth and social development fuelled by human activities, and require large quantities of natural resources to meet inhabitants' economic and social needs. For city managers, industrial or traditional activities taking place in the urban area are potential sources of revenue from taxes, rents and fees. In some countries, large cities contribute significantly to the GDP (UNCHS-Habitat, 2001). Hence infrastructure planning, such as for water, power or transport, primarily in cities, is a key element of sustained economic growth. The World Bank believes that infrastructure enhances investment opportunities and growth by increasing productivity, bridging markets, and facilitating trade. It also directly profits households by supplying basic elements necessary to guarantee quality of life, and satisfies the basic needs of poor or vulnerable populations, such as access to safe water and improved sanitation (World Bank, 2004).

Although the Millennium Development Goals have mobilized the international community, the report published in 2005 (United Nations, 2005) shows that half of the developing countries still lack improved sanitation and are far off track to meet the water and sanitation target: reducing by half, by 2015, the proportion of the people without sustainable access to safe drinking water and basic sanitation (Figure 1).

To date, global water and sanitation experts agree that it will need a dramatic change to meet the goal; there is an urgent need to go beyond '*business as usual*' (Schertenleib *et al.*, 2003). Past experiences (e.g. The Water Decade, 1980–1990) have shown that massive water and sanitation infrastructure provision without proper planning and user's involvement has led to dramatic failure (Lewis *et al.*, 1981). Among the failures, many wastewater treatment works built in Africa or Asia became dysfunctional after few years of operation, because of a lack of financial and human resources for proper operation and maintenance (Koné, 2002). As most donors realised that sewer systems were not at all appropriate in the majority of urban contexts, investment for sanitation infrastructure shifted to latrines provision programmes.

In urban areas of developing countries, on-site sanitation systems predominate over water-borne, sewered sanitation (Figure 1). In sub-Saharan Africa, more than 80% of houses in large cities and up to 100% in secondary towns are served by on-site sanitation facilities (Strauss *et al.*, 2000). Because of water scarcity and intermittent water supply services, and for financial-economic reasons, city-wide, sewered sanitation is not a viable option. Small-bore or low-cost satellite sewer systems might prove feasible in some selected urban areas. It is unlikely, though, that sewerage will be the predominant

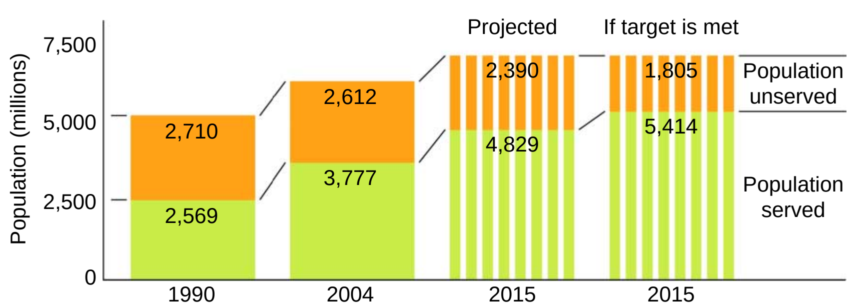

Fig. 1. World population with (served) and without (unserved) access to improved sanitation (Source: United Nations, 2005).

sanitation option of choice in developing countries in the foreseeable future. On-site sanitation installations will serve the growing urban populations in developing countries for decades to come.

1.2. The paradigm shift

In its latest guidelines on safe use of wastewater, excreta and greywater, WHO has introduced a new paradigm for dealing with sanitation in developing countries (WHO, 2006). Under conventional thinking, sanitary engineers had three intervention tools (sanitation infrastructure, water infrastructure and hygiene education) which were used in combination, or not, for interventions targeting public health improvements. The new guidelines are based on the quantitative microbial risk assessment approach (QMRA) which helps to identify a series of barriers and measures which reduce or block contamination. Hence, countries are left to define their own health target, depending on the type of wastewater, excreta or greywater usage and exposed risk. It links sanitation with agriculture productivity, agriculture business and, for the first time, opens doors to examine additional reuse pathways for wastewater, excreta or greywater. To support the implementation of the guidelines, a numbers of chapters covering non-technical aspects of sanitation and health management are introduced; they include: institutional arrangements, socio-cultural aspects, capacity development, private services provision, regulation and policy. This conception of sanitation interventions is a paradigm shift. Indeed, to apply the WHO guidelines, key national ministries will have to be involved: Health, Water and Sanitation, Agriculture, Environment, Finance, Planning, Justice, etc. The WHO guidelines are encouraging sanitary engineers to open their own networks to others. Engineers might easily convince their peers but they will have to adjust their technical language to suit a wider audience in order to achieve effective impact.

These guidelines reckon that national authorities do not have the means and sufficient capacity to enforce strict regulations. As urban farming with wastewater and excreta is continuously gaining importance, engineers will have a major role in devising technical barriers to reduce the health hazards. To reduce health risks related to urban farming, a possible treatment would be to provide farm-based treatment units which remove pathogens from polluted streams, wastewater and excreta. Such technical solutions should maximise nitrogen saving during the treatment process, if the effluent or biosolids produced (from faecal sludge treatment) are to be reused for irrigation or soil amendment purposes.

2. Research opportunities for linking sanitation infrastructure design and planning to business opportunities

Existing treatment systems are not designed to meet the challenge of removing pathogens and chemical pollutants while maximising nutrient saving and resource recovery at the same time. Furthermore, conventional approaches have been focused on building large (centralised) or small (decentralised) treatment units, often located far away from urban and peri-urban farmers' preferred zones, and they are not dedicated to agricultural practices. As planned by engineers, conventional wastewater treatment systems in developing countries are located in places which increase transport costs if farmers must sell their products. There is a need to balance urban farmers' needs and constraints due to sanitation infrastructure planning.

To link excreta and wastewater treatment works, for instance, with urban economic development agendas, the use of forage plants in macrophyte-based systems can be promoted. The expected income derived from the sale of forage is likely to contribute to keeping treatment works operational and to cover maintenance costs. Such infrastructure has a far greater urban economic development potential. Research opportunities may consist of maximising the nutritional and energetic value of forage grown on treatment units, maximising nutrient uptake efficiency, and minimising health risks for humans and animals.

2.1. Development of a framework for efficient sanitation service provision

2.1.1. On-site sanitation: a fact! More than 2,000,000,000 urban dwellers in developing countries use on-site sanitation facilities such as pit latrines, septic tanks and aqua privies for excreta and wastewater disposal. Due to water scarcity, unreliable water supply services and for financial-economic reasons, area-wide, sewered sanitation is not suitable in most areas of developing countries. Therefore, since the majority of the growing urban populations in developing countries will rely on on-site sanitation installations for decades to come, growing quantities of faecal sludge will have to be dealt with in the future.

Several international and national programmes are strongly committed in their specific agenda to promoting on-site sanitation as an important barrier against excreta-related disease. An increasing number of excreta disposal installations (latrines or septic tanks) are thus being constructed.

2.2. Technical implications of latrines

2.2.1. Collection. Pits are emptied mechanically by cesspit trucks or manually by labourers when they are full. While mechanically emptied sludge can be carried away from houses and discharged up to several kilometres from people's homes, the manually emptied sludge is usually deposited within the family compound, into nearby lanes or on open spaces. Surveys conducted in selected West African countries revealed that 30–50% of on-site sanitation facilities are emptied manually (CREPA, 2002; Blunier *et al.*, 2004). The main factors favouring manual emptying are the inability of households to pay for mechanical emptying, type of infrastructure and manner of usage. Traditional latrines allowing for liquid seepage produce sludges with a typical total solids content $> 10\%$ (Bösch & Schertenleib, 1985) and, therefore, are impossible to pump. Even though water is used for cleansing, 20–50% of the contents in the lower part of the latrine cannot be emptied mechanically as a result of their consolidation with time. In comparison, the TS content of a septic tank is typically $<2\%$, and thus more easily pumped.

Consequently, the type of on-site sanitation technology promoted and put in place may have a direct impact on the quantity of collected sludge. In most cases, since the sludge production rate of installations in use is not known, collectable or collected quantities are difficult to assess.

2.2.2. Treatment. Sludges collected from septic tanks are partially stabilised biochemically and thus conducible to rapid solids-liquid separation. Since sludges collected from latrines and unsewered public toilets are often barely mineralised and reveal high contents of solids, organic matter and ammonia, their treatment by low-cost options are far more challenging (Cofie *et al.*, 2006).

2.3. Institutional and financial implications of latrines

Financial, institutional and regulatory frameworks determine largely where and how faecal sludges are disposed of. Most on-site sanitation promotion programmes have not established the link between sanitation infrastructure provision at household and city level and its required maintenance and costs. Management of on-site sanitation infrastructure comprises: latrine emptying, faecal sludge haulage, treatment and safe reuse or disposal. The main criterion for a household to select a specific on-site sanitation technology is largely dependent on its financial means, i.e. affordability of the full or the non-subsidised part of the investment. Households are usually unaware or not informed of the running costs arising from emptying services, the appropriate emptying frequency or type of service providers to contact if necessary.

In almost every developing country, faecal sludge collection and haulage are conducted by private entrepreneurs. However, their important role and responsibilities as key stakeholders are not yet fully recognised and legalised. Many service providers run outdated vehicles manufactured in Europe, USA or locally adapted and equipped with low vacuum performance pumps. Manual emptying is widespread and preferred to mechanical emptying, as manual emptiers can remove all the accumulated and consolidated sludge that cannot be sucked by vacuum trucks. Private entrepreneurs and planners lack guidance in development of efficient faecal sludge emptying and haulage systems (Jeuland *et al.*, 2004).

Key research questions for the development of an enabling framework for efficient sanitation service provision include policy development and technological solutions contributing towards developing strategies, as well as financial-economic and institutional measures for private entrepreneur involvement and successful business operations. Such research programme should investigate innovative strategies leading to successful entrepreneurship and sustainable service delivery. There is also an urgent need to establish a database on the state-of-knowledge and a comprehensive set of technologies for latrine emptying and faecal sludge haulage. Such initiative will help development aid agencies and national governments to develop sound business opportunities for small-scale sanitation service providers.

2.4. Linking urban food production systems and sanitation technology design

There is clearly an opportunity for sanitary engineers to re-invent our role in the future of sustainable urban development, to join with urban planners, developers and policy makers, and to integrate sanitation infrastructure in the urban planning and development agenda. It is a matter of great concern that the present rate of economic growth, with its impact on global climate, is already overshooting the capacity of the earth's ecosystems to produce the required resources and to absorb the pollution caused by human activities (WWF, 2004). The impact of the expected doubling of the human population by the middle of the 21st century, most of which will take place in developing countries, calls for a clear environmental sustainability strategy for renewable resource management. Viable approaches towards environmental sustainability may (UNEP, 2006) encompass:

- waste treatment, recycling/reuse of nutrients, organic solids and treated wastewater (closing the loop); and
- biomass production with no or limited artificial fertilizer, for food and energy production.

Linking urban sanitation infrastructure and service provision to city economic development can draw financial resources for building infrastructure and securing operation and maintenance costs, as city planners might see the direct economic benefits. It is also an opportunity to close the nutrient loop in urban excreta and wastewater management. Such linkage can be established with agriculture, which is known to contribute an important share of the urban food supply. Indeed, it is estimated that 20 million people are engaged in different forms of urban agriculture in West Africa, and 60–100% of the consumed perishable vegetables are also produced within the city boundaries. In Ghana, for example, the footprint of informal irrigation in the rural-urban area is higher than the area under formal irrigation in the whole country (Drechsel *et al.*, 2006). Although its contribution to local economic development could be significant, decision makers are reluctant to legalise the practice because vegetables irrigated with untreated wastewater are still contaminated with pathogens (Koné *et al.*, 2007). In Accra, 280,000 urban dwellers (consumers and producers) benefit from urban vegetable farming everyday (Drechsel *et al.*, 2006). This figure also indicates the number of people at risk from wastewater reuse in urban agriculture.

2.5. Farm-based treatment units for reducing pathogen load and closing nutrient loop

Urban agriculture has drawn the attention of scientists, donor communities and international development agencies since its contribution to food security has been demonstrated. However, the current practices in urban farming continue to threaten the health of consumers and farmers. Urban agriculture products are mainly irrigated with untreated wastewater. When planning a centralized or decentralized treatment plant, existing farm locations are very often found to be inappropriate, hence forcing farmers to relocate or abandon (Dubbeling & Merzthal, 2006; Mubvami & Mushamba, 2006).

Solutions to reduce pathogen contamination of vegetables grown with untreated excreta and wastewater consist of limiting contact with the vegetables or post-treatment (i.e. washing or cooking prior to consumption). These measures do not significantly reduce pathogen concentrations in soil, where they find appropriate survival conditions. Helminth eggs, for example, are known to survive for years in irrigated soils (WHO, 2006).

Further research is needed to develop farm-based solutions. This may consist of treatment technologies operated by farmers, or groups of farmers, for treating the daily load of faecal sludge or wastewater need for irrigation or soil amendment. Such technologies should be designed to close the loop of water and nutrients (Koné *et al.*, 2002).

2.6. Forage-based treatment units for sustaining urban dairy systems

As part of the urban food production systems, urban dairies contribute to cities' food security by providing meat and dairy products (Wolf *et al.*, 2003). In semi-arid countries, livestock production relies mainly on natural pasture which is limited and, increasingly, is decreasing due to climate change. Rainfed fodder crop production is affected by the scarcity of rain. Natural pastures are reducing while cities' demand for dairy product is increasing (Sanon *et al.*, 2007). In Asian countries, the demand for dairy products is growing by 3.5% per year (Moran, 2005). As a mitigation solution, it is proposed to investigate the pollution removal efficiency of selected forage plants used as support on macrophyte-based systems treating wastewater or faecal sludge. Such systems could enhance the urban and peri-urban dairy system and its local economy, and provide revenue for treatment works operation. With the actual market price of dried weight forage in Thailand at 57–113 Euros/ton (Moran, 2005), it is estimated that excreta or wastewater fed *Echinochloa pyramidalis* treatment works will make a minimum income of 16,000 Euros/year.

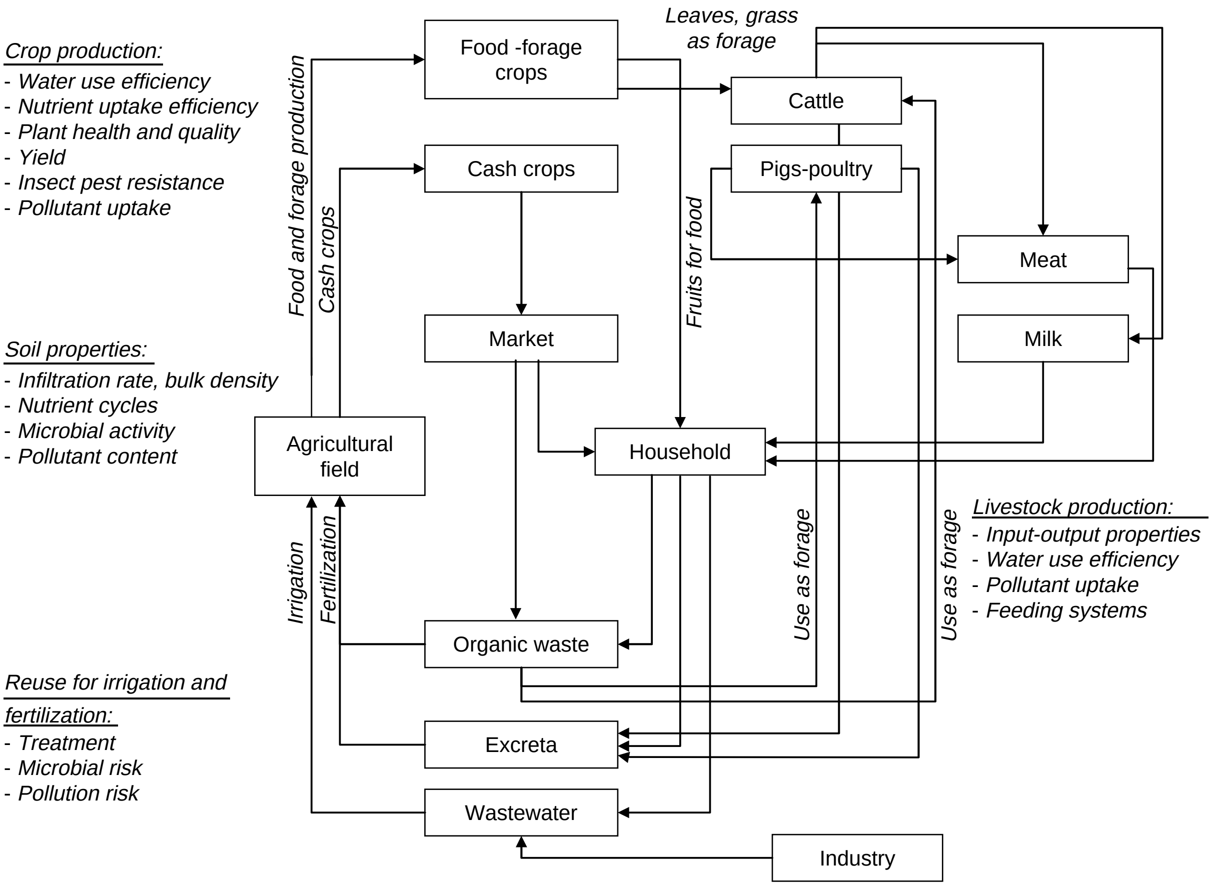

Fig. 2. Organic waste and wastewater reuse. The nutrients in human and animal excreta as well organic waste from markets and households can be used after treatment to produce cash and food, and forage crops in urban agriculture. Wastewater is a valuable irrigation resource in semi-arid climate regions (Holliger, 2006).

Key investigations in this area will consist of developing a set of cost-effective treatment technologies which allow integrating sanitation infrastructure into the cities' food production systems (Figure 2), hence closing the loop of nutrient and urban wastewater. Treatment systems which support dairy systems (forage production) should be given higher priority.

3. Conclusions

Excreta and wastewater treatment plant are designed to remove organic pollutants, nutrients and pathogens. Often located downstream, at the outskirts of the city, they are seldom linked to possible reuse or recycling activities. Hence, many treatment plants fail in developing countries due to the lack of proper incentives for maintenance. Although waste recycling and reuse opportunities exist in cities, the linkage between treatment units and market opportunities is still very weak. To develop sustainable sanitation systems where waste is valued as a resource, treatment units should be designed as processing factories producing goods for a targeted market. Beyond the conventional promotion of reuse into urban agriculture, many other opportunities to value domestic wastewater and excreta exist in growing cities in developing countries, and they should be sought out. However, in most cases today, the market potential is ignored and has not yet been extensively assessed. The approach of designing waste processing units to meet cities' economic development needs is innovative and needs a dramatic change in current strategic sanitation planning. It requires a good understanding of the role of key or potential stakeholders, a business plan for the future waste processing unit which identifies clear paths for nutrient promotion and resource recycling/reuse, and which identifies business opportunities in sanitation.

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