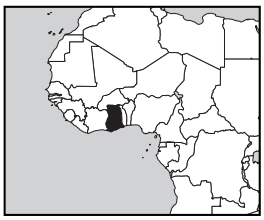

Influence of urban wastewater on stream water quality and agriculture in and around Kumasi, Ghana

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SUMMARY: This paper presents some findings from an ongoing International Water Management Institute research project in Ghana on urban wastewater use in agriculture. The paper focuses on the influence of urban wastewater on stream water quality and peri-urban agriculture in Kumasi, and aims to develop strategies to reduce environmental pollution and risks from agricultural use of wastewater. It drew on interviews with local authorities, sanitation services providers, vegetable producers, traders and consumers, and on an assessment of the existing sanitation infrastructure and water quality. With few industries in Kumasi, urban wastewater is generated mostly from domestic sources. Population increase and lack of investment have overstretched the few available sanitation facilities, and large volumes of untreated or partially treated wastewater end up in nearby streams. High levels of faecal coliform were recorded in the city and downstream, as well as on vegetables in Kumasi's markets, as contaminated wastewater streams are used for irrigation. Although urban and peri-urban agriculture has a positive impact on food supply and livelihoods, it poses health risks for farmers and consumers. The paper discusses the constraints on addressing these problems and makes some recommendations regarding low-cost strategies for safer use of available water, better urban decentralized wastewater management and increased public awareness.

I. INTRODUCTION

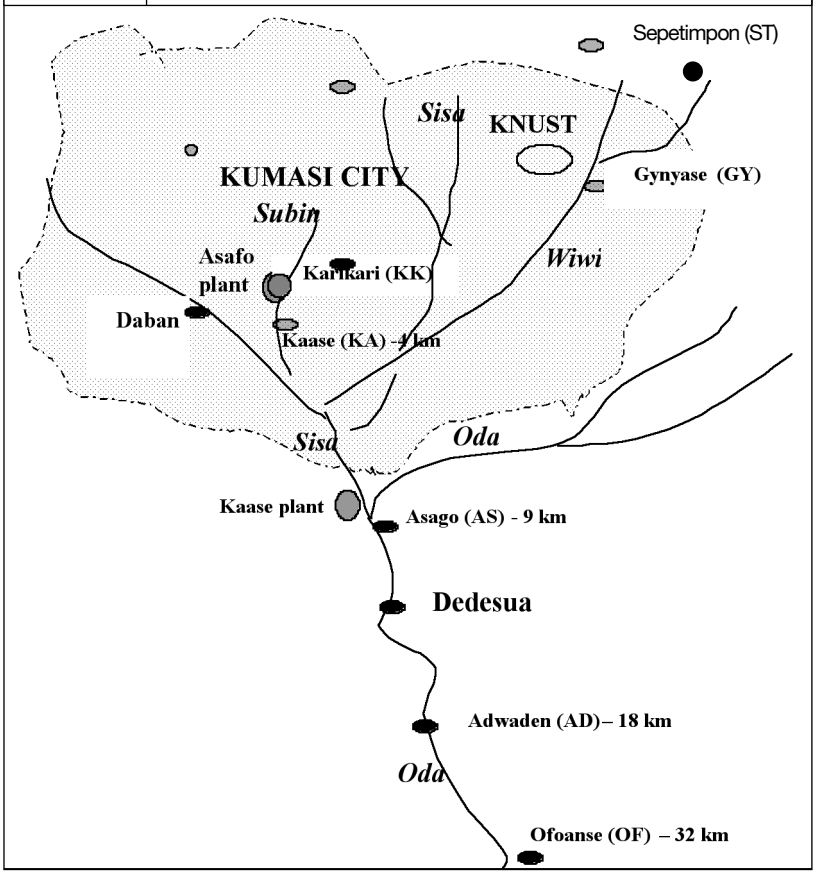
IN LOW-INCOME countries, population growth coupled with urbanization has outpaced the development of sanitation infrastructure, leaving the urban poor, especially, virtually without sanitation facilities in many countries. About 2.4 billion people worldwide lack access to basic sanitation, 80 per cent of them in Asia and 13 per cent in Africa.(1) Although sanitation coverage is better in urban than in rural areas, still more than 300 million urban residents lack sanitation facilities and the numbers are increasing.(2) In Africa, only 60 per cent of the total population has sanitation coverage, with coverage varying from 84 per cent in urban areas to 45 per cent in rural areas; and, in some countries, the figures are even worse – Rwanda and Congo, for instance, have less than 15 per cent coverage in urban areas.(3) Provision of adequate sanitation services, safe water supply and hygiene education can reduce mortality from diarrhoeal diseases by 65 per cent, and related morbidity by 26 per cent.(4) These issues were highlighted during the World Summit on Sustainable Development in Johannesburg in 2002(5) and the World Water Forum in Kyoto this year.(6)

1. UNDP (2002), *Human Development Report 2002: Deepening Democracy in a Fragmented World*, United Nations Development

In Ghana, 44 per cent of the total population of about 19 million lives in urban areas.[7] As in most countries in sub-Saharan Africa, Ghana's sanitation infrastructure is not well developed. More than 70 per cent of households in three of Ghana's ten administrative regions have no toilet facilities in or near their homes, and the available sanitation infrastructure for those that have it is inadequate. The consequences are worst in urban areas, which have very high population densities (in larger cities, there are growth rates of up to 4.4 per cent). A common sight as you walk through Ghana's major cities, for example Accra and Kumasi, are open stormwater gutters full of garbage and wastewater, and urban streams that look like large wastewater drains.

This paper focuses on the influence of urban wastewater on stream water quality and urban and peri-urban agriculture, as a step towards developing strategies to reduce the resulting environmental pollution and the risks to public health. Data were collected in 2002 in Kumasi, the second largest city in Ghana and the capital of the Ashanti region, the most populous administrative region in the country. Kumasi has one of the largest markets in West Africa. The metropolis covers an area of 223 square kilometres and currently has a population of almost 1.2 million – more than twice the number recorded during the 1984 census.[8] Kumasi is situated approximately 260 metres above sea level, and has a wet, semi-equatorial

Figure 1: Drainage network in Kumasi



2. UN–HABITAT (2002), "UN–HABITAT launches water and sanitation trust fund", Water for Cities, Quarterly Newsletter No 12, pages 1 and 3.

3. WHO, UNICEF and Water Supply and Sanitation Collaborative Council (2000), *Global Water Supply and Sanitation Assessment 2000 Report*, WHO/UNICEF, USA, 80 pages.

4. See reference 3.

5. www.johannesburgsummit.org

6. www.worldwaterforum.org

7. Ghana Statistical Services (2002), *2000 Population and Housing Census: Summary Report of Final Results*, Accra, Ghana, 62 pages.

8. See reference 7.

climate and temperatures averaging 28° C. Rainfall is weakly bi-modal, with an annual average of about 1,340 millimetres. The dry season (November to March) is sharp and pronounced. Four main streams (Daban, Sisa, Wiwi and Subin), flow through Kumasi city, with the Subin originating in and cutting through the city centre. They join the River Oda downstream (Figure 1).

II. THE WASTEWATER SITUATION IN KUMASI

a. Volumes and means of wastewater collection

ABOUT 38 PER CENT of Kumasi's residents use public toilets equipped with flush toilets, holding tanks or improved pit latrines. Most of the remainder of the population uses private facilities: 12 per cent use bucket or pan latrines,[9] 10 per cent pit latrines and 26 per cent household water closets linked to septic tanks ("man-holes") and seepage pits. Only 8 per cent of the population has toilets connected to a sewerage system, and the remainder has no toilet facilities at all. A similar situation exists in Ghana's capital, Accra. A total of about 20,000 cubic metres of wastewater is generated each day in Kumasi, but less than 10 per cent is collected for treatment.[10] Apart from that which enters the sewerage system (from 8 per cent of the population), Kumasi's grey water (wastewater from kitchens and washrooms) is "thrown out" through drains and stormwater gutters, and does not find its way into any treatment facility.

Most industrial activities in West Africa are concentrated in the coastal cities, which take advantage of sea transport. Being an inland city, Kumasi has limited industrial development; so industrial wastewater is not a significant factor. The principal generators of industrial wastewater in Kumasi are two breweries, a soft drinks bottling plant and the Kumasi abattoir which, together, generate a total of about 1,000 cubic metres of effluent daily, which ends up in the city's drains and nearby streams. Light industry generates significant amounts of non-collected waste oil and leachate.

b. Treatment and disposal

Most sewerage infrastructure in Kumasi was built in the 1970s when the population was only one-third its current level, and no significant extension to this infrastructure has taken place since. It was around this time that the two main conventional sewage plants in Kumasi were built, one at a local university (KNUST) and the other at Asafo, which covered some parts of the city centre. Neither has been in operation for over ten years. The university plant needs rehabilitation and enlargement, as the student population has increased from fewer than 1,000 in the 1970s to more than 10,000 now, and efforts are underway to get funds for this. Rehabilitation of the city centre plant is not feasible, but the local authorities are now promoting smaller, community-based treatment plants. Currently, there are three in operation in some suburbs in Kumasi. The authority is also encouraging private establishments, such as the larger hotels, to have their own treatment plants.

The other main problem in the city has been the management of faecal sludge – wastewater from the public toilets, septic tanks and bucket latrines that serve more than three-quarters of the city's population. There has been no permanent faecal sludge treatment in Kumasi. The few sites

9. This is a bucket or pan placed beneath a raised platform and used as a toilet in a room within a house. It is emptied manually by collectors when full, usually in under three days.

10. Keraita, Bernard (forthcoming), International Water Management Institute (IWMI), West Africa Office, c/o CSIR, Accra, Ghana.

that the authority obtains are "filled up" in a matter of months, and even obtaining sites is hard as most communities see treatment plants as a nuisance. Over the last few years, the city's main faecal sludge treatment plant has been at Kaase. This was meant to be a temporary plant for use during the African Cup of Nations games in 1998 but, as of March 2003, it was still the main one in use and received an average of 144 cubic metres of sludge per day.[11] The volume had reached 500 cubic metres per day in 2001 but had gone down to 180 cubic metres per day in 2002.[12] The Waste Management Department (WMD) attributed this mainly to vehicle breakdowns. The Kaase treatment ponds have long been filled beyond capacity, and untreated faecal sludge has been flowing into the River Subin. However, another plant at Buobai, which can handle 200 cubic metres per day, started operation in April this year.

The situation is even worse in other Ghanaian cities, for example Tamale, where faecal sludge is dumped into natural depressions or farm lands wherever there is an opportunity. In Accra, the few treatment plants that exist were filled to capacity years ago, and large amounts of sludge are dumped into the ocean.

Various technologies exist for wastewater treatment. Waste stabilization ponds seem to be best suited to Kumasi, as their removal of pathogenic micro-organisms is good and they are more cost-effective than other solutions.[13] Indeed, apart from the KNUST plant (which is a trickling filter type), all other plants in Kumasi, like most in Ghana, use this technology. As well as the initial design and construction costs, which are often prohibitive for authorities, various other issues come into play. For example, the Asafo plant (which was completed in the mid-1990s) is still operating below capacity (60 per cent of the intended population is connected) mainly because of the costs and unreliability of flushing water, the charges for using the plant, and the difficulties in making connections in the heavily built-up surroundings. The modern and costly UASB plant near the Korle lagoon in Accra has similar problems, and now receives only about one-third of its designated capacity. It has also been a challenge to maintain and rehabilitate plants to cope with the rise in populations in Ghana's urban areas.

c. Management of wastewater and sanitation infrastructure

The Kumasi Metropolitan Authority (KMA) is responsible for domestic waste management, while industries are responsible for their own wastes. The KMA has a strategic plan for sanitation, and bye-laws governing the city's public health and environmental sanitation. So far, management of sanitation facilities by the municipal authority has been less effective than by private parties,[14] leading to the encouragement of privatization of sanitation services in the city. The KMA is now engaged in promoting active involvement by communities and the private sector in more direct services such as the collection and haulage of faecal sludge, the operation and maintenance of facilities (public toilets, sewerage systems, treatment systems), and the collection of user charges.

However, much still needs to be done. According to the KMA's monitoring and evaluation report for 2002,[15] most public toilets in Kumasi – especially those run by sub-metro councils – are poorly maintained, leading to unsanitary environments. Children are even barred from using them and their faeces litter the surrounding areas. In some places, toilets

11. Leitzinger, C and D Adwedaa (1999), *Field Monitoring of the Faecal Sludge Treatment Plant in Kaase. A Practical Report*, Kumasi, Ghana and Zurich, Switzerland.

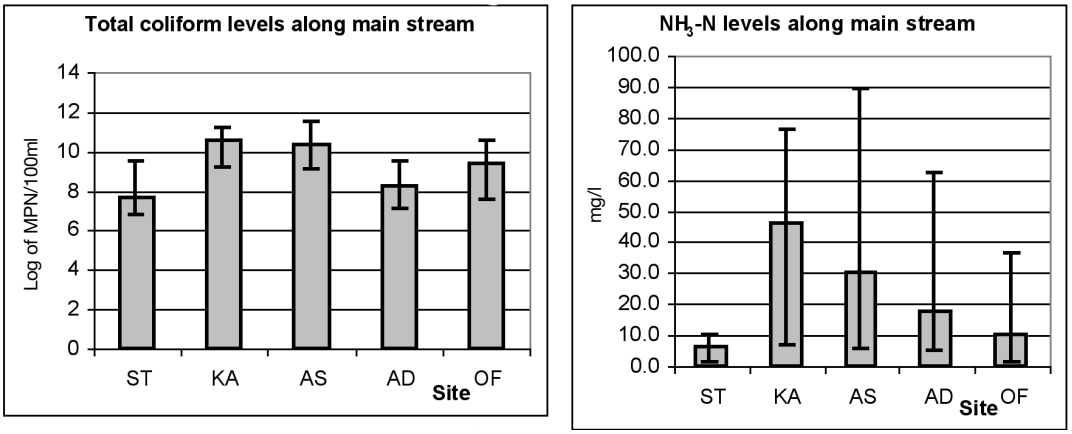
12. KMA (2003), *2002 Annual Report, Waste Management Division*, Kumasi Metropolitan Assembly, Kumasi, Ghana, 27 pages.

13. Mara, D and S Cairncross (1989), *Guidelines for the Safe Use of Wastewater in Agriculture and Aquaculture: Measures for Public Health Protection*, World Health Organization, Geneva, 189 pages.

14. KMA (1995), *Strategic Sanitation Plan for Kumasi*, 1996–2005, Kumasi Metropolitan Assembly, Kumasi, Ghana.

15. See reference 12.

Figure 2: Average total coliform and NH_3-N levels along the main stream,* and the range of values obtained



* Figures shown here are from samples taken from February to June 2002, covering both the dry and wet seasons in two-week to one-month intervals. Water samples were collected and taken for analysis in accordance with standard methods of water quality sampling and analysis.

SOURCE: APHA (1989), *Standard Methods for the Examination of Water and Wastewater*, 17th edition, American Public Health Association, Washington DC, 1,268 pages.

and latrines are being converted into sleeping apartments because of accommodation pressures in the city. Unhygienic pan or bucket latrines are still in use, and are emptied by private, unlicensed night-soil carriers, who end up dumping the contents into drains, streams and nearby bushes. Some landlords in some suburbs have connected their water closets to street gutters or streams.

III. WATER QUALITY IN WATER BODIES IN AND AROUND KUMASI

CHANGES IN WATER quality in water bodies in and around Kumasi are evident. This has been mentioned in local daily newspapers and, from time to time, there is a public outcry. Many people rely on the streams for irrigated farming and others even for domestic use. Asago, a village just downstream of the Kaase faecal sludge plant, is one of the most affected locations. Villagers have reported sickness, mostly among children, and a scarcity of fish such as tilapia in the local river, the Oda.

Worse still, according to a DFID–EPA study carried out between 1999–2000, there is ongoing groundwater contamination from the Oda that is affecting nearby shallow wells.[16] The study encouraged environmental self-monitoring and the use of simple water quality test kits, which were provided in junior secondary schools. As part of the IWMI project, an analysis of faecal coliform in the River Oda at Asago found levels of 10^7–10^9 per 100 millilitres. Despite dilution from the river, these levels are comparable to those for raw sewage,[17] which shows the effects of effluents from the broken-down faecal sludge treatment plant at Kaase. When interviewed, the chief of Asago village said:

"…we have been using the river for everything. Some time ago we used to drink and bathe in the river. But now it is dead, just dead. We can no longer use it even

16. McGregor, D, D Thompson, N Kotei and K Poku (2001), "The influence of Kumasi on peri-urban water quality: a problem of community health and floodplain agriculture?", paper presented at HR Wallingford workshop on Informal Peri-urban Irrigation – Opportunities and Constraints, KNUST, Kumasi, Ghana.

17. Feachem R J, D J Bradley, H Garelick and D D Mara (1983), *Sanitation and Disease: Health Aspects of Excreta and Wastewater Management*, published for the World Bank by John Wiley and Sons, New York.

for irrigating our crops. All because of Kumasi, this Kumasi city!"

Previous studies show that levels of heavy metals in water bodies in and around Kumasi are not very high,[18] as industrial pollution is negligible. However, inter-seasonal variations in water quality can be wide, especially after the first heavy rainfall.[19] In a two-week interval, PO_4 levels rose from less than 6 milligrams per litre in three sampling locations to more than 71 milligrams per litre. The high PO_4 levels, which could be of great value to farmers, cannot be attributed only to wastewater, but also to flushes from nearby farms where fertilizers and manures are intensively used.

In general, the nutrient load and microbiological pollution levels were low just upstream of the city (ST), reaching their highest just downstream of the city (KA), and decreasing further downstream (Figure 2; see also Figure 1 for the location of the sites). However, it is worthwhile to note that coliform levels in the stream are still too high (more than 10^6 per 100 millilitres of water even 32 kilometres downstream of the city. WHO guidelines restrict the use of irrigation water at faecal coliform levels higher than 10^3 per 100 millilitres.

18. See reference 16; also Cornish, G A, E Mensah and P Ghesquire (1999), *Water Quality and Peri-urban Irrigation: An Assessment of Surface Water Quality for Irrigation and its Implications for Human Health in the Peri-urban Zone of Kumasi, Ghana*, Report OD/TN 95, HR Wallingford, UK, September.

19. See reference 18, Cornish, Mensah and Ghesquire (1999).

IV. THE USE OF URBAN WASTEWATER IN URBAN AND PERI-URBAN FARMING

URBAN AND PERI-urban farmers in Kumasi have been using stream water and shallow wells for irrigation for some time. Irrigation is used mainly in vegetable farming, a common practice in urban areas in Ghana all year round, while in the peri-urban areas it is used mainly during the major dry season. Most of the lands being cultivated are near riverbanks, along stream courses or close to open drains for easy access to water. Currently, there are about 200 bottomland vegetable farmers in urban Kumasi, growing mainly lettuce, cabbage and spring onions, as well as about 60,000 households with backyards. As many as 12,800 farmers in the peri-urban areas of Kumasi have been recorded as growing dry season vegetables,[20] including such local vegetables as ayoyo and alefi, as well as okra, tomatoes and green peppers.

Watering cans are the most common means of irrigation in the urban area; only a few farmers use motorized pumps/hoses, which are more common in the peri-urban areas. Those using watering cans apply water directly to the crop, thereby increasing the possibility of crop contamination. A study was carried out to evaluate the effect of wastewater on the microbiological quality of urban-grown vegetables.[21] Sixty samples each of lettuce, cabbage and spring onions were collected from three different markets in Kumasi. Table 1 shows the range of total and faecal coliforms measured.

20. Cornish, G A, J B Aidoo and I Ayamba (2001), *Informal Irrigation in the Peri-urban Zone of Kumasi: An Analysis of Farmers' Activity and Productivity*, Report OD/TN 103, HR Wallingford, UK, February.

21. Amoah, Philip (forthcoming), International Water Management Institute (IWMI), West Africa Office, c/o CSIR, Accra, Ghana.

Table 1: Coliform levels in vegetables in major markets in Kumasi

	Total coliforms per gram	Faecal coliforms per gram
Lettuce	$1.5x10^7 – 2.0x10^9$	$3.9 x10^6 – 2.1x10^8$
Spring onions	$1.5x10^6 – 4.0x10^8$	$1.5x10^5 – 2.0x10^9$
Cabbage	$1.5x10^7 – 1.5x10^9$	$1.5x10^5 – 4.0x10^6$

SOURCE: Amoah, Philip (forthcoming), International Water Management Institute (IWMI), West Africa Office c/o CSIR, Accra, Ghana.

These are extremely high levels of vegetable contamination. It is striking to note that in terms of faecal coliform count, eating one gram of raw lettuce from the Kumasi markets is almost the equivalent of eating a similar amount of fresh faeces (10^7–10^9 coliforms per gram).[22] Although the link to the irrigation water polluted with *E coli* appears obvious, contamination could also result from the application of manure and from post-harvest handling during transportation and in the markets.[23] There is an ongoing IWMI study to establish the link and the relative contributions of irrigation water and marketing on crop contamination.

Despite the associated health risks, urban and peri-urban farming contributes significantly to various development goals such as poverty alleviation, employment and food security. In Kumasi, it has contributed remarkably to food supply and is a source of livelihood not only for the farmers but also for vegetable sellers and others in the post-harvest chain. For example, Kumasi's urban farmers produce about 90 per cent of all lettuce and spring onions consumed in the city. With average plot sizes of 0.1 hectares, urban farmers (who can have 9–11 harvests per year) can earn annual incomes of up to US$ 400–800, twice what they would earn from rural farming. For the peri-urban farmers who do irrigated dry-season vegetable farming, annual incomes are US$ 300–500.[24]

V. REACTIONS AND PERCEPTIONS OF STAKEHOLDERS

THE ACTUAL HEALTH risks from using polluted irrigation water have alarmed authorities and research institutions, and measures are being suggested to improve the situation at various entry points. These measures go beyond those recommended by the WHO (i.e. water treatment and crop selection) as these might not be feasible for either the city or the farmers. The entry points currently being investigated include sources of irrigation water, on-farm treatment methods, improved irrigation and agronomic practices, post-harvest crop handling in markets, and consumer education in vegetable washing.[25]

A survey of more than 300 farmers, vegetable sellers, consumers and authority representatives was conducted in Kumasi.[26] About 60 per cent of the farmers interviewed attributed the problem of water pollution to poor city sanitation. Although some complained of ailments, their main concern was the need for water to maintain crop productivity and thus their income. Likewise, vegetable sellers were mostly concerned with their incomes and less interested in discussing the quality of irrigation water. Only a minority said that it was wrong for farmers to use untreated wastewater for irrigation. About every second seller said that creating awareness among farmers, sellers and consumers on the risks involved would be the right way forward. Among the interviewed consumers, eight out of ten knew that some farmers used polluted water, and almost all of them knew that this could have health implications. However, up to 65 per cent thought that preventing water pollution and creating awareness through education were practical ways of reducing wastewater-related negative impacts. Only 10 per cent suggested stopping the farm use of polluted water. Despite this knowledge, there was very little demand and incentive for safer food production. A survey carried out in Accra in 2002 showed that more farmers used drain water than in Kumasi and many saw nothing wrong with this.[27]

22. See reference 17.

23. Drechsel, P, P Amoah, O Cofie and R Abaidoo (2000), "Increasing use of poultry manure in Ghana: is farmers' race consumers' fate?", *Urban Agriculture Magazine* No 2, pages 25–27.

24. Danso, G, P Drechsel, T Wiafe-Antwi and L Gyiele (2002), "Income of farming systems in around Kumasi", *Urban Agriculture Magazine* No 7, pages 5–6.

25. Drechsel, P, U Blumenthal and B Keraita (2002), "Balancing health and livelihoods: adjusting wastewater irrigation guidelines for resource-poor countries", *Urban Agriculture Magazine* No 8, pages 7–9.

26. Keraita, B (2002), "Wastewater use in urban and peri-urban vegetable farming in Kumasi, Ghana", MSc thesis (unpublished), Wageningen University, the Netherlands.

27. Obuobie, E (2003), "Institutional aspects of urban agriculture and wastewater use in Accra, Ghana", MSc thesis (unpublished), Wageningen University, the Netherlands.

Officials of the main city authority, the KMA, dislike wastewater irrigation and do not encourage it. Their main concern is that growing crops with unsafe water compromises the health of consumers. These officials recognize, however, the significant contribution of vegetables grown in urban and peri-urban zones, and indicate that the vegetables should be of good quality to improve the health of consumers. Farming along urban streams is often tolerated as the farmers prevent squatters and other users from being in these areas which are important for stormwater management.

The KMA, like other local authorities in Ghana, has bye-laws which address environmental sanitation concerns, such as the collection and treatment of wastewater by service providers, and other issues related to city drainage and pollution control. However, there is no specific clause that addresses the use of polluted water in urban farming. In Accra, on the other hand, there is a specific clause prohibiting "drainwater use" in urban farming. However, enforcement has proven ineffective. In addition, the Environmental Protection Agency (EPA) has made great efforts to extend its pollution-prevention strategies to schools via various environmental awareness campaigns. However, their efforts have foundered, as most of the large polluters are government institutions with broken sanitation facilities – hospitals, the local university and other learning institutions which are hard to prosecute or close down. This, in turn, makes any prosecution of individuals or private establishments a difficult task.

VI. CONCLUSION

AS IN OTHER major urban centres in Ghana, the sanitation infrastructure in Kumasi has been outpaced by population increases, making the management of urban wastewater ineffective. Large volumes of untreated or partially treated wastewater end up in nearby streams, causing high levels of pollution that affect various stream users. The municipal authority (KMA) is concerned and is actively exploring options for privatizing sanitation services. It also encourages private establishments to have their own sanitation facilities. The construction of conventional wastewater treatment systems in Kumasi is constrained by limited funds and, since most areas are already densely populated and heavily built up, it would be very costly to install provision that matched existing infrastructure. Thus, effective urban wastewater treatment does not look feasible in the near future, and farmers, as well as villagers downstream, will continue to have highly polluted water in their streams. Authorities will have problems enforcing the WHO wastewater irrigation guidelines (as part of the effort to protect consumers from contaminated food), as these demand certain wastewater treatment levels and do not consider the livelihoods aspect of wastewater irrigation. A balanced approach that considers both health care and livelihoods is recommended, and which focuses on low-cost options for risk reduction on farms and in markets. As the perception studies showed, an important element will be to raise public awareness on options to reduce health risks through vegetable washing at home, which is in any case necessary to address post-harvest contamination. In the long run, however, improved wastewater treatment has to remain the target. The challenge for today's city planning is to avoid the omissions of the recent past in the constantly growing city margins and to provide ground for decentralized sanitation infrastructure.