TOWARDS A NATIONAL POLICY ON WASTEWATER REUSE IN KENYA

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Abstract
Kenya is a water-scarce country with the capital city, Nairobi, receiving less than 100 l/capita/day. Potable water for irrigation and industrial use is generally unavailable, and this calls for alternative water sources. Despite use of wastewater being illegal in Kenya, it is used to irrigate over 720 ha in Nairobi. In order to justify the formulation of a national policy to support wastewater reuse, secondary data which included the authors' previous work was reviewed. In a study done between 2006 and 2007, the levels of nitrates (100 mg/l) and TDS (630 mg/l) in the wastewater were found to be within the acceptable NEMA standards. The concentration of lead was 0.1 mg/l while cadmium and chromium were non-detectable. However, levels of BOD and Coliform bacteria were higher than NEMA limits. This implied that Nairobi sewage needed to be treated for the removal of BOD, turbidity and microbial contamination. In order to allow for safe use of wastewater in Kenya, there is need to formulate a national wastewater reuse policy which provides guidelines for maximum allowable levels of pesticides, herbicides, and heavy metals in wastewater reuse. Such a policy should also indicate the required water quality monitoring frequency for faecal indicators (*Escherichia coli, faecal coliforms, enterococci*), and suggest the maximum allowable concentration of nutrients (nitrogen and phosphorus) which may are usually abundant in wastewater.

Key words: National policy, policy, wastewater, reuse

1.0 Introduction

Water scarcity in many parts of Kenya is a limiting factor against development activities. Hence, there is need for water saving and water enhancement strategies. The current water availability is estimated as 650 m^3/year per capita, and could drop to about 350 m^3/year by the 2020 (Ngigi and Macharia, 2006). With dropping per capita freshwater availability, there is increasing dominance of wastewater in the water balance and this makes wastewater a very important source of irrigation water for urban agriculture (Githuku, 2009).

Wastewater reuse is also referred to as water reuse, water reclamation, water recycling and wastewater reclamation in different parts of the world (McCornick *et al.,* 2004). However, wastewater reuse, as used here, specifically refers to the utilisation of treated or untreated effluent which is conveyed to a specific location for utilisation. Most often, the term refers to a deliberately planned process of treating and utilising sewage effluent.

Wastewater reuse can become a significant source of non-point source (NPS) pollution (Huang and Zia, 2001), including water pathogens. This can cause serious health risks when people are exposed to the contaminated wastewater. Shuval *et al*. (1997), for example, estimated very high annual risk of infectious hepatitis from regularly eating vegetable irrigated with raw wastewater. As urban populations grow, and as industrial development expands, wastewater volumes with more complex composition will rapidly increase, further increasing public health risks. Thus, the need for a comprehensive national policy on wastewater reuse cannot be overemphasised. This paper examines the status of wastewater reuse and its risks and discuses the need for a national wastewater reuse policy while proposing policy interventions that can be undertaken to prevent pollution in Kenya.

2.0 The Water Supply Gap in Kenya

Kenya is a water scarce country where most municipal councils are unable to supply their population with sufficient water. With the current population of about 38.6 million (Kenya National Bureau of Statistic, 2010) and the prevailing birthrate of about 4% per year, water scarcity will get worse over time. In 2006, the estimated total water available in Kenya was 20,291 million m^3 (UN-Water, 2006). The City of Nairobi gets most of its water from the Tana River Basin which has about 3,744 million m^3 of water, 16% of which is abstracted for domestic use in Nairobi. From Tana River Basin, the City of Nairobi extracts 420,000 m^3/day, which comes to about 100 l/person/day (Ministry of Water and Irrigation, 2007). This is what constitutes potable water supply in the city and is meant to be used for domestic purposes only. Therefore, urban agriculture is not catered for in the water supply plan of the city. Personal communication from Eng. Onchoke, the Deputy Director in charge of irrigation in Kenya's Ministry of Water and Irrigation, indicates that in year 2008 about 106,000 ha of land was under irrigation, and used 3,300 Million m^3/year of water. Potable water is used to flush toilets and wash cars, which are activities that could utilise water of much lower quality, such as treated wastewater.

Most people in Nairobi slums (89%) use shallow wells as the major source of domestic water and less than 10% have access to tap water (Kimani-Murage and Ngindu, 2007).

Kenya's Vision 2030 has attempted to address this lack of equity in the supply of potable water by advocating for the conservation of water sources, rainwater harvesting, and enhancing the utilisation of ground water (Government of the Republic of Kenya, 2007). The existing water policy does not include wastewater reuse.

Water availability is a function of rainfall. About every five years, Kenya experiences rainfall shortages lasting for 1 to 3 years. The country experienced droughts resulting in both human and ecological impact in 1928, 1933-1934, 1942 – 1944, 1952 – 1955, 1960, 1965, 1971-1975, 1984-1985, and 1998-2000. Kenya's Ministry of Water and Irrigation goal to avail water in sufficient quantity and quality by 2010 (Ministry of Water and Irrigation, 2007) has not been achieved. There is need to identify innovative ways of bridging the existing water supply gap and meet Kenya's industrial, domestic and agricultural water needs. One such method is wastewater reuse.

3.0 Water Quality Guidelines in Kenya

Kenya's National Environmental Management Authority (NEMA) has set out guidelines on irrigation water quality and quality requirement for discharge into the environment (Table 1). Schedules three, eight, nine and ten of the NEMA water quality standards give the quality standards for water to be discharged into the environment or to be used for irrigation or recreational purposes (Government of Kenya, 2006). Research has however shown that the quality of waste water in Nairobi generally falls within the NEMA guidelines. Githuku (2009), for example, analysed the quality of wastewater in Nairobi and found the levels of nitrates (100 mg/l) and TDS (630 mg/l) falling within the acceptable NEMA standards. Similarly, cadmium (0 mg/l) and chlorides (47.7 mg/l) were also with the acceptable limits. However, the levels of BOD and Coliform bacteria in the raw sewage were higher than NEMA limits. This makes it necessary for sewage to be treated for the removal of BOD, turbidity and microbial contamination.

Treated waste water in Kenya can contribute greatly in ameliorating the low availability of irrigation and potable water in the country. Kenyan towns that have a population of more than 100,000 people such as Nairobi, Thika, Nyeri, Malindi, Mombasa, Machakos, Mitaboni, Meru, Garissa, Kisii, Kericho, Nanyuki, Naivasha, Nakuru, Kitale, Eldoret, Bungoma, Webuye and Kakamega (JICA, 1998), have the possibility of producing enough wastewater for industrial use. However, many of these towns have no sewer systems. Despite this, the NEMA standards do not recognise wastewater reuse as a possibility. It is therefore necessary for Kenya to recognise wastewater as a resource and then specify necessary requirement for it to be used in industry, agriculture or any other purpose. A national policy on wastewater processing and reuse is necessary to enable the country enhance water availability for a variety of uses.

Table 1: Quality of raw sewage compared against Kenya's Water Standards

Parameter	Kenyan Irrigation Water Standard	Kenyan standard for discharge of Water into the environment	Raw Sewage Quality - Mailisaba	Units
TDS	1200	1200	630	mg/L
Cd	0.5	0.1	ND	mg/L
Cr	1.5	0.05	ND	Mg/L
Cl	0.01	250	47.7	mg/L
Total Coliform	Less than 1000	30	More than 1000	counts/100 ml
NO_3-N(Discharge into environment)	100	100	100	mg/L
SAR	6	---	1.6	meq/L
Lead	5	1.5	0.1	mg/L
BOD (Discharge into environment)	30	30	695	mg/L

ND = Non-detectable

This wastewater can be used in boilers and for toilet flushing, laundry, and air conditioning, cooling and processing, power generation and heavy construction (Andreadakis *et al.,* 2003). For restricted irrigation, where the food produced does not come into contact with contaminated soils, the required FAO standards are BOD_5 <25 mg/l, TSS <35 mg/l and faecal coliform <200/100 ml for 80% of the samples. For unrestricted irrigation, where different irrigation methods could be used, making the crop vulnerable to contamination, the standards are higher; BOD_5 <10 mg/l, TSS <10 mg/l and faecal coliform <5/100 ml for 80% of the samples (Andreadakis *et al.,* 2003). There is an urgent need to evaluate potential uses of wastewater and make this a component of a wastewater utilisation policy.

Many countries do not have a national policy for the treatment and reuse of wastewater. Jordan, however has such a policy, which recognises wastewater utilisation for irrigation of vegetables which are usually eaten cooked; irrigation of fruit trees, forests, industrial crops, and grains; discharge into streams and catchment areas; artificial recharge of groundwater; use in aquaculture (fish hatcheries); irrigation of public parks; and irrigation of fodder crops (McCornick *et al.,* 2004). To utilise wastewater, industries are constructed downstream of wastewater treatment plants, where it's possible to utilise treated wastewater for industrial processes. This would reduce the cost of manufactured goods and result in a cleaner environment.

4.0 Wastewater Reuse Status in Kenya

Although the urban poor continue to use wastewater for irrigation purposes, wastewater reuse in Kenya is illegal. A study undertaken in 2006 and 2007, for example, revealed that only 50% of the wastewater generated in Nairobi ends up in the treatment facilities while the rest is used for cultivation of over 720 ha using raw sewage (Githuku, 2009). The study established that over 100,000 households in Kahawa, Soweto, Kibera, Mailisaba, Maringo and Kariobangi South use raw sewage for cultivation (Figure 1).

In Kibera, the land used for wastewater farming belongs to National Social Security Fund (NSSF), who through informal arrangements allowed the farmers to use it for crop production since 1997. A typical plot size is 60 m by 20 m. Most of the farmers on this site are from Kibera slums, which are separated from the farm, by the Ngong River. The crops grown include sugarcane, fodder crops (napier grass), maize and vegetables (kales, spinach and indigenous African leafy vegetables such as amaranth and black nightshade) (Githuku, 2009).

About 75% of the produce grown in these areas, especially the vegetables, is sold while the rest is consumed at home. Marketing is done on farm. Farmers use wastewater because it provides not only soil moisture but also provides the nutrients necessary for plant growth. Hand-dug canal systems have been constructed to transport irrigation water through the farms. Farmers remove manhole covers and block the main sewer carrying sewage from the residential estates. This provides water to their farms.

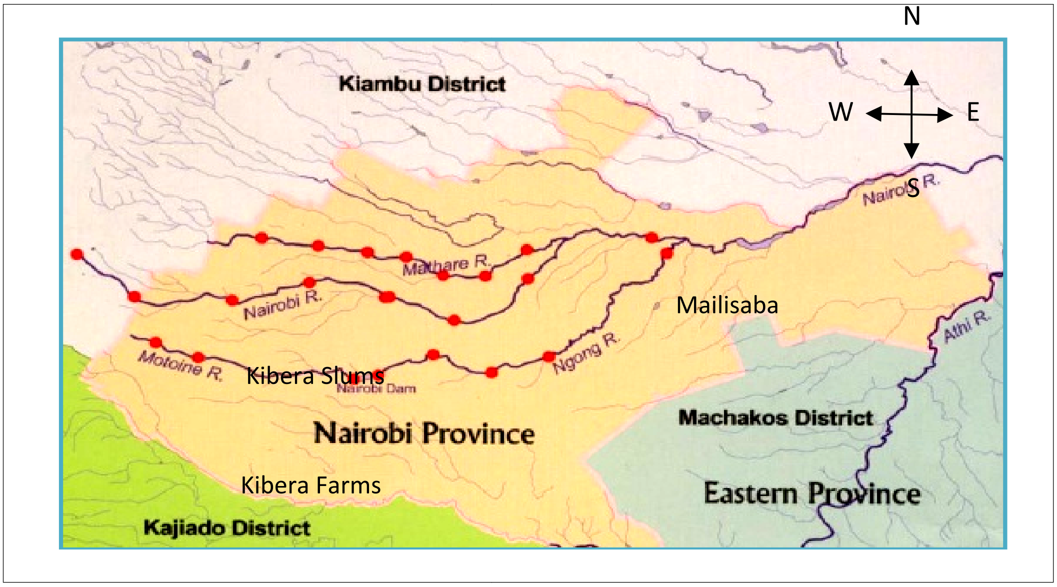

Figure 1: Nairobi River system and locations of Kibera and Mailisaba wastewater farms

5.0 Environmental and Public Health Risks of Wastewater Reuse

The Government of Kenya has proposed the Economic Recovery Strategy for Wealth and Employment Creation (ERS) in order to alleviate poverty in the country. To achieve this initiative, the ERS recognises water as a pivotal element in poverty reduction and emphasises the importance of providing services to the poor while ensuring adequate water for competing demands. Access to safe water and sanitation services, however still remains a challenge due to the ever increasing human population. Over-extraction of freshwater, mainly for agriculture, has led to significant degradation of rivers, lakes and aquifers. Hence, it is necessary to develop alternative sources of water and put in place a national policy to support wastewater reuse without enhancing environmental degradation.

Reuse of wastewater, however, is challenging as there are many public health and environmental risks associated with its utilisation. A recent study showed that in plots planted with maize, downstream of Nairobi's industrial areas, heavy metals such as lead exceeded the WHO safe limit of 84 ppm in agricultural soils. Cadmium in soil during the dry season also exceeded the WHO standard of 4 ppm for all cropping systems (Githuku, 2009). In soils planted with maize, downstream of the industrial area, chromium levels were as high as 80 ppm. To minimise such risks, guidelines and water quality standards are necessary.

Polluted water might expose people to health risks such as increased vulnerability to cancer as some chemicals in wastewater are carcinogenic; viral infections; and exposure to aerosol transmitted diseases (Ongerth and Ongerth, 1982). Further, Poucher *et al*. (2007) noted that although land application of sewage sludge can improve soil physical properties and increase soil organic matter content, there are also disadvantages such as the possible transfer of pathogenic micro-organisms to the soil which may include *Escherichia coli*, *faecal coliforms and enterococci.* In a study on the mineralisation of the herbicide Atrazine in slurries from soils irrigated with treated wastewater, Masaphy and Mandelbaum (1997) noted that the rate of herbicide mineralisation decreased significantly when soils were irrigated with wastewater. This indicated that the herbicide, which could be present in wastewater, had capacity to interfere with biochemical processes in the soil.

The European Union does not accept food substances with more than 0.2 ppm of Cadmium and 0.3 ppm of lead. Githuku (2009) found both heavy metals to be present in excess of the EU safe limits, in all food substances irrigated with wastewater in Nairobi. During the wet season, heavy metal concentration was relatively lower, perhaps because of dilution.

Feenstra *et al*. (2000) also studied the health risks of irrigation with untreated urban wastewater in Southern Punjab, Pakistan and found the population to be at risk from such diseases as diarrhoea, dysentery, skin problems, nail problems, typhoid and fever. Intestinal parasites resulting from exposure to wastewater were also quite prevalent. *Ascaris lumbricoides* infections were higher in the population exposed to wastewater, particularly the exposed male farm workers. People feeding on vegetables irrigated with wastewater in urban areas had comparatively higher incidences of hookworms than those from rural areas.

Scott *et al*. (2000) has summarised the major environmental threats of wastewater reuse. The authors observed that percolation of nutrient-rich waters through the soil can lead to the degradation of ground water. Over half of the water wells in Israel have nitrate content higher than 45 mg/l which exceeds the EU and US drinking water standards; while 20% of the wells have nitrates in excess of 90 mg/l (Scott *et al.,* 2000). This is associated with the fact that Israel uses treated wastewater for groundwater recharge. Furthermore, increased nitrate and phosphate could contaminate aquatic systems resulting in eutrophication, the consequences of which include loss of aesthetic appeal, increased dominance of tolerant species such as *Microsystis aeruginosa* that may cause fish kills, low species diversity but high productivity and increased growth of aquatic macrophytes (Chapman, 1996).

6.0 Formulation of a National Wastewater Reuse Policy

The public health and environmental risks discussed above suggest that there is need for a national wastewater reuse policy with guidelines for the maximum allowable levels of pesticides, herbicides, and heavy metals in wastewater to be used in irrigation. The wastewater reuse policy should also indicate the required water quality monitoring frequency for faecal indicators (*Escherichia coli*, *faecal coliforms, enterococci*) and suggest the maximum allowable concentration of nutrients (nitrogen and phosphorus) which may be abundant in wastewater.

A national wastewater reuse policy encompasses guidelines for treatments, discharge and utilisation wastewater. In order therefore to provide a national policy for wastewater reuse, there is need to separate wastewater reuse standards from the general standards that apply to water for domestic use (Scott *et al.,* 2000). The responsibility for maintaining the standards and observing the policy lies with the discharger, who may include a municipal authority or a factory. The discharger has a legal obligation to treat wastewater within the allowed time frame and to ensure the discharge complies with current standards (Cairncross, 2000).

An important element in considering wastewater reuse is that the public must accept the project, which calls for adequate awareness about possible health hazards associated with the reuse. In the peri-urban areas of Nairobi, Kenya, farmers have been utilising waste water for irrigation illegally. Currently, there is no policy in Kenya to guide wastewater reuse. A study should be done prior to the promulgation of such policy to assess the attitude of the population on the use of treated wastewater for drinking, food preparation, bathing, groundwater recharge, laundry, irrigation of dairy pasture, vegetable crops, and orchards; boating, air conditioning, toilet flushing, golf course lakes, lawn irrigation, golf course irrigation, and road construction. The water act and existing regulations or standards should be consulted in the formulation of wastewater reuse guidelines and policy.

A near-zero public health risk in wastewater reuse projects should be the aim of wastewater reuse policy. In situations where hazards are severe and the consequences of failure disastrous, public health objectives for reuse should be to develop standards that reduce risk to the lowest possible level (Ongerth and Ongerth, 1982). The wastewater reuse policy should focus on the population that faces the greatest risk. In the case of wastewater reuse for agriculture, farmers are at high risk because their interaction with the wastewater and consumers are also at high risk because some of the agricultural products are eaten raw (Feenstra *et al.,* 2000).

7.0 Conclusions and Recommendations

Kenya is a water scarce country which requires innovative ways to bridge the existing water supply gap and meet national industrial, domestic and agricultural water needs. Despite the fact that wastewater reuse is illegal in Kenya, it is widely used in the irrigation of urban farms increasing the exposure of the public to health and environmental risks. As expected, untreated wastewater in Nairobi has excessive levels of BOD. However, it has relatively low levels of heavy metals. Not withstanding, soils irrigated with wastewater in Nairobi have high levels of lead (84 ppm) and cadmium (4 ppm), exceeding WHO standards.

Wastewater treatment goals should mainly focus on BOD and solids removal which would give acceptable quality for reuse in irrigation and industrial processes. A national policy on wastewater reuse should be urgently formulated to provide guidelines for the maximum allowable levels of pesticides, herbicides, and heavy metals in wastewater reuse. It should also indicate the required water quality monitoring frequency for faecal indicators (*Escherichia coli, faecal coliforms, enterococci*) and suggest the maximum allowable concentration of nutrients (such as nitrogen and phosphorus) which may be abundant in wastewater.

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