Assessment of the Environment Risks of Reuse of Untreated Wastewater in Urban and Peri Urban Agriculture: A Case Study of Nairobi in Kenya

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ABSTRACT

A study was carried out to determine pollution levels in soil and crop as a result of wastewater reuse for irrigation in Nairobi and establish the benefits and risks associated with this. Irrigation waters (raw sewage), soil and crop samples were collected from Kibera and Mailisaba wastewater irrigation farms during the dry and wet season. Irrigation water was analyzed for both physical and chemical parameters. Soil and crop samples were analyzed for heavy metals: lead, cadmium and chromium. Heavy metals in waters, soils and crops were determined by Atomic Absorption Spectrometry (AAS) method. Crops sampled were maize, kales, black nightshade and arrowroots that represented grain, exotic leafy vegetable, indigenous leafy vegetable and root crop respectively. Samples for analysis were obtained from roots, stems, leaves and grains. Soils were sampled from plots containing maize and kales and black nightshade over depths of 0-30 cm and 30-60 cm. Household questionnaires were also administered to collect data on farmers' perspective on wastewater use for irrigation.

The results showed that wastewater is reused in agriculture in many countries worldwide mostly because of inadequate water supply. Wastewater is also used because it has nutrients and is available all year round. Kibera and Mailisaba farmers however complained of some crops being adversely affected by the quality of the wastewater. Mailisaba farmers were more aware of the health risks than Kibera farmers with 7.7% of respondents at Kibera compared to 37.9% at Mailisaba. Crop selection is one of the risk mitigation strategies in using wastewater for irrigation as most of the crops grown including kales, maize, amaranth, black nightshade,

cowpeas, spinach, arrowroots, are cooked before consumption. Another mitigation strategy, as cited by farmers, is wearing of protective clothing. Nevertheless, many of the farmers confessed to not using any protective clothing.

Most of the farmers produce crops for sale at the local markets with some of the produce being consumed at the household level. From the farmers' perspective, the main benefits of wastewater farming are: food security and nutrition (35.8% of the respondents); source of income (33.7%) and employment (15.1%).

In both sites, pH of the water was within the permissible range while Electrical Conductivity (EC) at Mailisaba was higher than the recommended level for irrigation. EC of Mailisaba irrigation water was in the range slight to moderate degree of restriction (0.7-3.0 mg/l), an indication that treatment would be required to avoid salinization of soils. Dry season average values for nitrates (NO3) were 97.32 mg/l at Kibera and 126.46 mg/l at Mailisaba while wet season values were 16.45 mg/l and 25.38 mg/l respectively. The average nitrate values placed the wastewater at "slight to moderate" (5-30 mg/l) restriction for both sites during the wet season and "severe" (>30 mg/l) restriction during the dry season. Given that farmers usually irrigate during the dry season, these results indicate that the wastewater may not be suitable for irrigation as it poses a threat to the environment. Farmers at both sites chose to grow leafy vegetables such as kales, spinach, black nightshade and cowpeas, which give high yields probably due to excessive nitrogen in the irrigation water.

Lead and Cadmium in irrigation water were within the safe concentrations for crop production (<5.0 and <0.01 mg/l respectively). These metals pose no risk to crop

growth. They may however pose a risk to human health if they accumulate in the soils to levels where they become bioavailable and accumulate in the edible parts of the crops. Chromium values exceeded the standards, indicating that extended use of wastewater for irrigation has the potential for accumulation of chromium in soils and could be a threat against public health. Farmers at both sites indicated that they would rather die a slow death from heavy metal toxicity than die today of starvation. The Nairobi wastewater has quality that may be termed as acceptable for crop production. It therefore has a potential for being used in agricultural production. This use should be encouraged as a disposal method for wastewater. However, some form of treatment may be necessary to reduce the concentrations of parameters such as nitrates, EC and heavy metals that were found to be excessive.

Cadmium was not detected in irrigation waters at both sites but its presence in soil and crops was noted, indicating the possibility of accumulation in both soil and crops. Accumulation of the three metals in soil was found to be in both 0-30 cm and 30-60 cm layers with the levels ranging as follows: 0.40 – 98.66 ppm for Lead, 0.01 – 9.69 ppm for Cadmium and 0.06 - 74.30 ppm for Chromium. Lead levels pose no risk as they were within the allowable limits (50 – 300 ppm) for agricultural soils. Cadmium was above the allowable limits (1 - 3 ppm) posing a major risk to human health. The three heavy metals were found in the different crop parts (roots, stems, leaves and grains) for the four crops tested. During the dry season, the concentration of Lead in crops ranged from 16.17 to 74.83 ppm, Cadmium from 3.33 to 13.98 and Chromium from 0.63 to 47.17 ppm. These ranges indicate a definite accumulation from wastewater to soil and from soil to crops (bioaccumulation).

The results showed decreased concentrations of all the metals during the wet season at both sites regardless of depth and cropping system. The highest concentration of heavy metals in soils was that of lead in the two cropping systems and at both sites. Although the heavy metal levels in soils were found to be within the allowable limits, the levels may pose threat to human and animal if wastewater farming is allowed to continue without anything being done to reduce the levels of the pollutants in the wastewater.

The results point to the recommendation that some form of treatment be considered to make the wastewaters safe for reuse in irrigation of food crops. In addition, there is need for awareness creation among farmers and consumers on the risks associated with wastewater reuse for irrigation.