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An assessment of the public health hazard potential of wastewater reuse for crop production. A case of Bulawayo city, Zimbabwe

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Abstract

Wastewater reuse is one possible way in which food production can be improved especially in developing countries where food is often scarce. However, the potential public health risks associated with wastewater use is of major concern. Health concerns are centered on pathogens and other health related pollutants that normally occur in the effluent. This research was conducted in Bulawayo, Zimbabwe during the period December 2005–May 2006. Bulawayo is a semi-arid area, with an average rainfall of 460 mm/annum and experiences frequent droughts. The study aimed at assessing the potential health impacts of effluent reuse for irrigating crops. Some 110 farmers are using wastewater for irrigation of vegetable crops on plots of about 500 m^2 each. Samples were collected from the effluent, the fields and vegetables and analyzed for selected quality parameters of health significance. Results were compared to national and international guidelines for effluent use in irrigation. Farmers' knowledge on potential risks and practices were investigated through interviews.

The results show that 70% of the respondents were aware of related health risks of using wastewater for irrigation. Respondents reported no major disease outbreaks. Mean values of pH were 8.1 and 7.3 for effluent and field soil and were within the FAO range of 6.5–8.5 for irrigation. Average temperature was 22.6 °C, while electrical conductivity ranged from 784 to 957 μS/cm and was less than the guideline value of 2000 μS/cm. Total coliforms in the effluent were found to be 7291 cfu/100 ml, while faecal coliforms were 5836 cfu/100 ml compared to the WHO limit of 1000 cfu/100 ml for irrigation. For effluent, cadmium were 0.04 mg/l and exceeded the long-term threshold limit of 0.01 mg/l, while lead was within the limit of 20 mg/l, with an average of 7.2 mg/l. No cadmium and lead were detected in the vegetables. It can be concluded that there is some health risks related to use of the effluent in the field, while for consumption of the vegetables there appears to be no risk. It is recommended that appropriate wastewater treatment mechanisms such as maturation ponds be put in place to reduce the coliform levels. Farmers must minimize direct contact with the effluent. The long-term impact of the irrigation on the soil for about 30 years and the seasonal impact to see variations on results need further studies.

Keywords: Effluent; Health risk; Irrigation; Vegetables; Wastewater use

1. Introduction

The use of urban wastewater for crop production is receiving increased attention in most parts of the world due to the increasing scarcity and high cost of fresh water resources and food especially in semi-arid and arid regions. Due to the nature of sewage, fears have been expressed on the possible heath hazards associated with effluent use. Health considerations are centered on the pathogenic organisms that are normally present in effluent, build up of toxic materials within the soil, and subsequently within the plant and animal tissue, which might eventually reach the human food chain.

In the region, according, Khouri et al. (1990) South Africa had 70 M^3/yr of reclaimed wastewater use representing 16% of the volume of sewage generated in 1998 and Tunisia had 75% of sewage reused for irrigation in

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1987. The use of wastewater for agricultural purposes may be particularly attractive since this may allow for the expansion of intensive agriculture while preserving limited resources of good quality water for the rapid urban growth. Diseases that may be caused by wastewater use can be divided into communicable (microbiological quality) and non-communicable (chemical constituents). Communicable diseases that can be caused by wastewater use include typhoid, cholera, and salmonella type diseases and non-communicable diseases may result from occupational injury of agricultural workers and from consumption of crops which would have taken up heavy metals and other hazardous chemicals from wastewater (Gumbo, 2005).

Water shortages are affecting the city of Bulawayo. The city has experienced some periods of drought spells in the past years. The need for a reliable agricultural water supply is therefore critical. Options such as reuse of effluent from treatment plants for agriculture is the only feasible way. However, due to the nature of sewage, fears have been expressed about the possible public health hazard associated with effluent reuse in agricultural crop production. In Zimbabwe, wastewater irrigation has been practiced but was mostly restricted to pasture irrigation. Pasture lands consisting of star grass have been grown on soils on which mixed treated effluent and sludge has been deposited for over 30 years and research has shown that Pb and Cd are taken up by plants from the soil, thereby making pants potential sources of contamination for human and animals (Madyiwa et al., 2004). The main objective of the study is to assess the public health hazard potential of using municipal effluent for agricultural crop production. Specifically, the study aimed at determining the effluent quality and its suitability for irrigation, estimate the soil quality, where wastewater is applied and to determine the presence of the heavy metals cadmium and lead in the vegetables grown on the land that was irrigated with effluent.

2. Materials and methods

2.1. Description of the study site

The study was conducted on Luveve farming area in Bulawayo, the second largest city in Zimbabwe. Bulawayo has a population of about 1 million, located in the drought prone, semiarid Matabeleland region and receives about 460 mm per annum. It has a hot wet summer from October to March with average temperatures of 25 °C and a cool dry season with an average temperature of 15 °C for the rest of the year (Taigbenu and Ncube, 2005).

The Luveve farming area is located about 12 km West of the Bulawayo city centre just after Luveve high-density suburb. The effluent comes from the waste stabilization ponds, which serve suburbs such as Entumbane, Makokoba, Magwegwe, Lobengula, Caldery and Luveve.

According to one of the city officials, the Luveve farming area has been irrigated using wastewater since 1972 when a brewery company owned the farm and sorghum was the major crop grown there. The city council took over the farm in 1995 after the company offered it to the council for the benefit of needy Bulawayo residents who are now cultivating various food crops. The major types of crops being grown include covo(*Brassica oleracea* variety, *acephala*) sugar beans (*Glycene max*) and maize (*Zea mays*). Produce is both for subsistence and commercial purposes. Sandy soils are the predominant soils and the surrounding Savanna woodlands are dominated by *compretum species* and *cericia species.*??

The farming area has about 1100 farmers from Bulawayo's poor surburbs, who were chosen by the city council based on their socially poor backgrounds. Each farmer has one plot of about 500 m^2. Farmers use the flood system to irrigate their fields from earth-lined canals.

2.2. Data collection

The research methods involved collection of effluent, soil and vegetable samples and analyzing them for selected parameters. Sample bottles were soaked overnight in dilute hydrochloric acid before use and were rinsed two times with the sample to be collected before filling with sample as recommended by APHA (1985).

Effluent samples were collected as grab samples at 30 min interval for 8 h during working hours of the day at three different sites along the canal. Parameters which were measured in the field include electrical conductivity which was measured using a TETRA CON 325, 340i conductivity meter, turbidity using a portable turbidity meter 350IR, temperature and pH using an Ecoscan pH 5/6 mV/pH meter. The concentrations of calcium, magnesium, potassium, (author to confirm) cadmium and lead in the effluent were determined using the Atomic Absorption Spectrophotometer (PU 9100). Parameters that were analysed in the laboratory for the effluent were nitrogen, total phosphorous, calcium, magnesium, potassium, lead and cadmium.

Faecal and total coliform in the wastewater were only determined using ELE Paqualab Kit. Composite samples of vegetables were collected from the field at different sites. The vegetables were first washed with distilled water to remove surface contamination following recommendations by USEPA (1983). The plant materials were then packed into polythene bags, placed in a cooler box and taken to the laboratory for analysis. The analysis of metal accumulation in vegetables was done following recommendations by Harold et al. (1985).

A structured questionnaire was administered to 110 farmers (10% of the farmers) to obtain information on the residential location of the farmer, major crop type grown, period of wastewater application, health related diseases awareness, occurrences of diseases and problems faced in wastewater application.

Questionnaires were also administered to six local authorities to get information on land application, period