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An assessment of heavy metals concentration and microbial loading in vegetables irrigated with the treated wastewater

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Introduction

The increasing gap between fresh water supply and demand along with the projected effects of climate change demands that agriculture must reduce its share of freshwater use and look for alternative sources to meet the requirements. The reuse of urban wastewater for irrigation could make more clean water available for domestic and industrial sectors. Over the last two decades, the use of industrial or municipal wastewater (treated and untreated) in agriculture has increased in many semi-arid countries because it offers environmental and socio-economic benefits such as reduction in effluent disposal problems, supply of nutrients as fertilizers and improvements in crop production during the dry season. Despite these advantages, wastewater irrigation is replete with serious concerns about the accumulation of heavy metals in soils and uptake by food crops, that might be a potential health risk to the local inhabitants.

Currently, about 11 Bm^3 of wastewater is produced annually in GCC, of which 5.6 Bm^3 is treated to various levels of treatments. About 4.3 Bm^3 of this wastewater is used for agriculture. In the United Arab Emirates (UAE), current annual production of treated municipal wastewater is 600 million cubic meters (Mm^3), which is to reach to 1400 Mm^3 by 2030. Therefore, this

treated wastewater can be an attractive option for expanding available water supplies. This study is an attempt to quantify the uptake of heavy metals by kitchen vegetables grown with the treated wastewater.

Materials and methods

The field experiment was conducted on 1800 m^2 field block, which was divided into 18 sub-plots of 50 m^2 each (Figure 1). Six kitchen vegetables

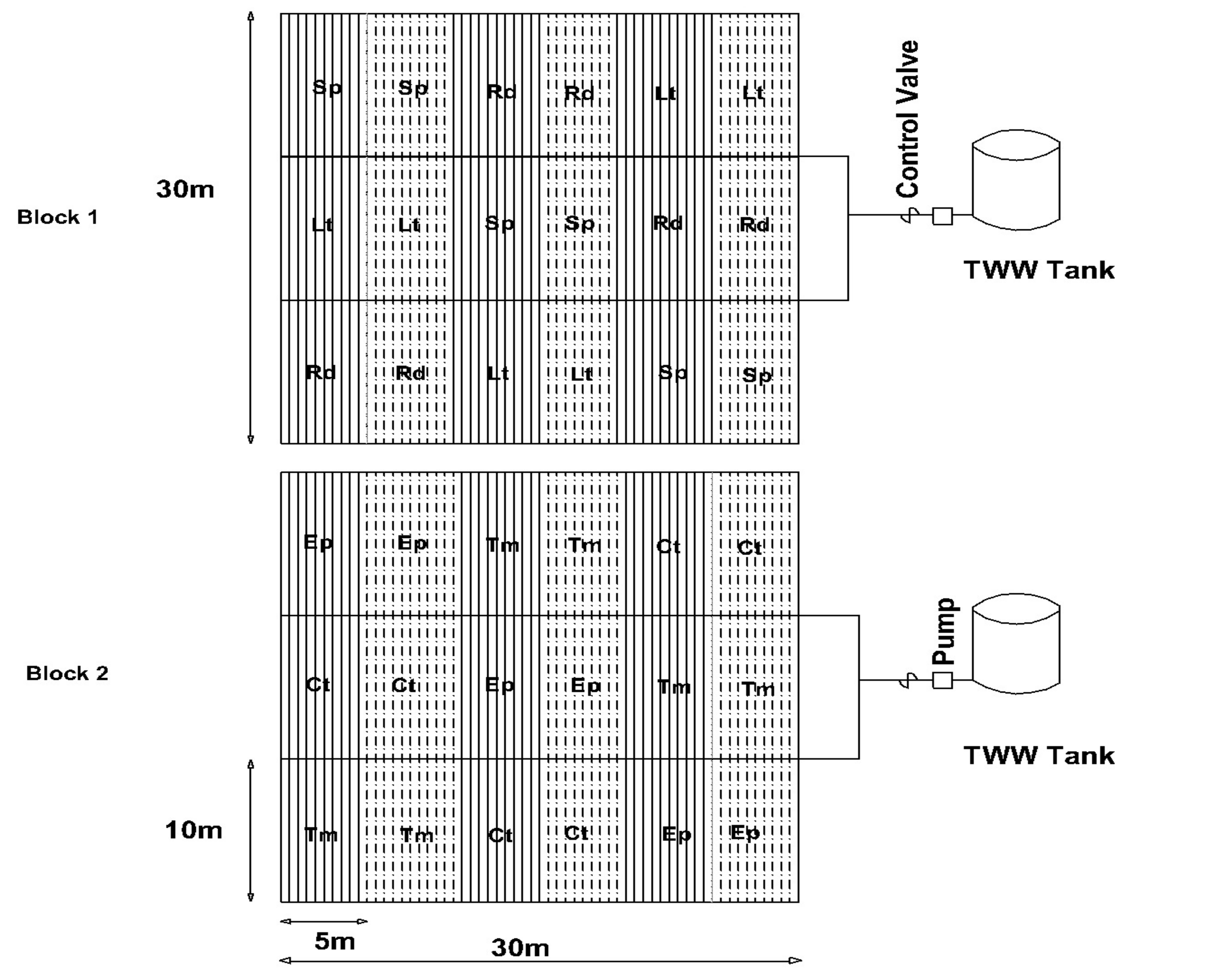

Figure 1: Layout of the experimental field (Ep = Eggplant; Ct = Carrot; Rd = Radish; Tm = Tomato; Lt = Lettuce; Sp = Spinach)

were selected for this experiment. These include Tomatoes, Eggplant, Lettuce, Spinach, Carrot, and Radish. All vegetables were irrigated with the tertiary treated municipal wastewater obtained from the Dubai Municipality. The quality of treated wastewater used in this study is given in below table.

Table 1: Chemical and biological properties of the treated wastewater

Parameters	Units	Results
E. Coli	CFU/100ml	2
Fecal Streptococci	CFU/100ml	3
Total Coliform	CFU/100ml	460
EC	dS/m	1.9
Potassium	mg/l	20.7
Chromium	mg/l	0.2
Copper	mg/l	0.2
Zinc	mg/l	0.27

Results

Assessment of heavy metal accumulation in soils

The highest concentration in the soil was found for nickel (Ni), followed by lead (Pb) and chromium (Cr). The lowest accumulation was found for Cadmium (Cd) followed by Cr and Ni. There were small differences in the levels of heavy metals in the soil profile before and after the experiment. The small accumulation of heavy metals in the soil shows that with this quality of treated wastewater, the risk of soil pollution is negligible.

Assessment of heavy metal contamination in food crops

The highest concentration of Cu was detected in all vegetables, followed by the substantial levels of Zn and Cr. The highest concentration of Fe was found in lettuce whereas its presence in all other vegetables was almost negligible (Figure 2). The concentration of Cu was highest in

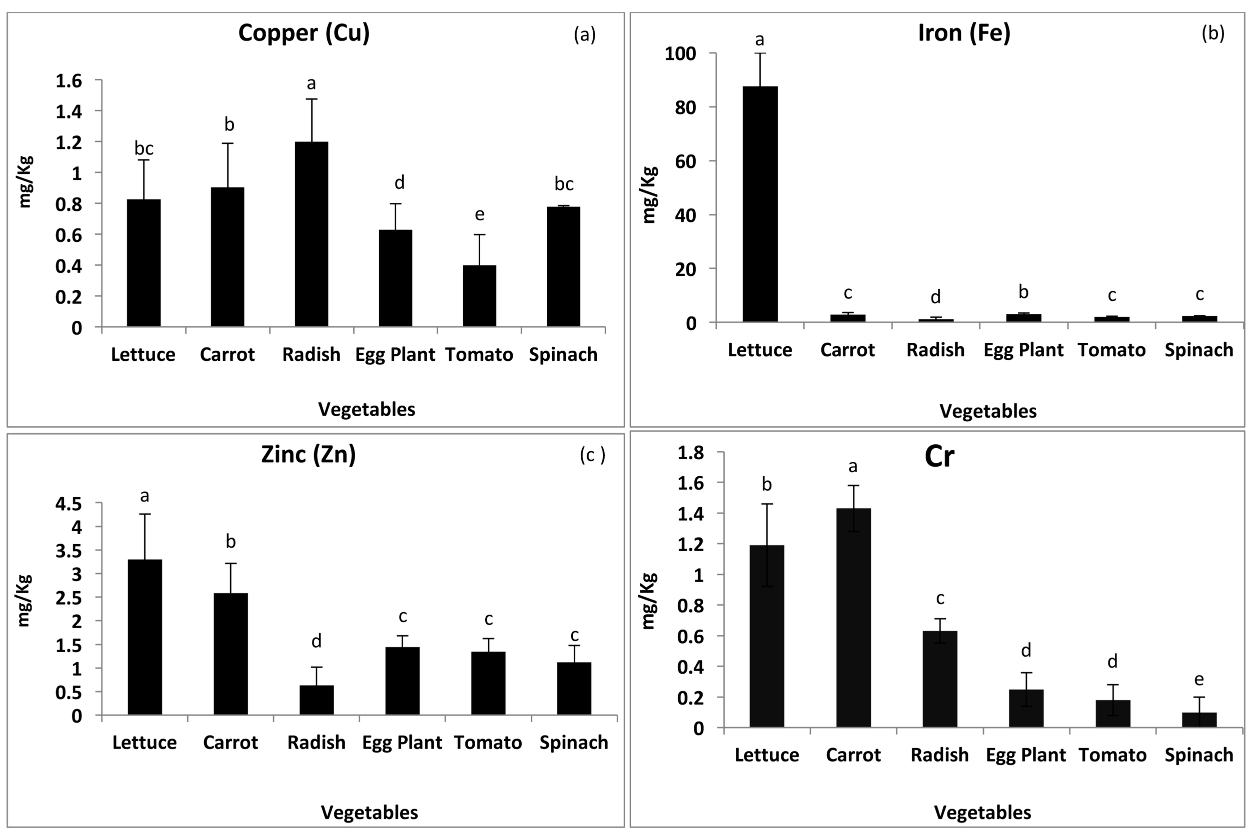

Figure 2: Heavy metal concentration in different vegetables irrigated with the treated wastewater. Error bars indicate standard deviation while the lower case letters shows significance at P<0.05.z

radish with comparable amounts in carrot, lettuce and spinach. The lower concentrations of Cu and Zn were observed in eggplant, tomato and spinach. The concentration of Cr was highest in carrots followed by lettuce and the lowest was found for spinach. Likewise, eggplant, tomato and spinach exhibited comparatively lower levels of Cr.

The concentrations of heavy metals were found significantly lower than the safe limits of heavy metals for vegetables described by WHO. This suggests that use of tertiary treated wastewater for irrigating vegetables in the desert environment does not pose serious threat in terms of accumulation of heavy metals in soils and vegetables. However persistent use of these vegetables might have negative impacts on human health.

Assessment of microbial loading in food crops

The highest level of total *Coliform* was recorded in spinach, followed by radish and eggplant. The lowest mean levels of total *Coliform* were observed in tomatoes and lettuce. The mean values of *Escherichia coli* bacteria contamination on different vegetables ranged from 2.4-10. Bacteria counts (*E-Coli*) on lettuce, tomatoes, eggplant and carrot were higher than radish and spinach, with spinach being the lowest (2.42).

Conclusions

The levels of trace metals in all vegetable samples were found within national food safety criteria. Leafy vegetables are more likely to accumulate trace metals whereas root and food crops seems less susceptible. The potential health risks posed by trace metals were found to be negligible indicating that consumption of vegetables irrigated with treated wastewater is safe for inhabitants. This may be due to the fact that the treated wastewater used in this study contains lower levels of heavy metals. For the wastewater containing elevated levels of heavy metals might pose higher risk for human health. Therefore, before endorsing irrigation with wastewater, a comprehensive evaluation of wastewater reuse on soil, plant and human health is required.