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A Comparison of The Levels of Heavy Metals in Cabbages Irrigated With Reservoir and Tap Water

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ABSTRACT: A study was carried out in Malawi to determine the levels of heavy metals in cabbages grown in gardens irrigated with reservoir and tap water. The concentrations of cadmium, lead and chromium were determined in the leaf and in the corresponding soils in order to assess whether the amounts in the soils reflected the accumulation of heavy metals in plants. The results showed that the levels of the heavy metals in both the cabbages and soils irrigated with reservoir water were generally low. The concentration of cadmium in reservoir water irrigated cabbages was significantly higher ($p<0.05$) than that in tap water irrigated cabbages. The concentration of cadmium in both the dam water and tap water irrigated cabbages was much higher than the levels (0.2ppm) recommended by the European Union for leafy vegetables. The trend was opposite for lead; the amounts in reservoir water irrigated cabbages were lower than in tap water irrigated ones although the two were not statistically different. The higher concentrations in the leaf from both sites ($p<0.05$) compared to those in the soils could be an indication of hyper accumulation in the leaf. In contrast to cadmium, the concentration of lead in tap water irrigated cabbages was higher than that recommended by the European Union (0.3ppm) for leafy vegetables. There was no significant difference in the concentration of chromium in dam and tap water irrigated cabbages. The significantly higher concentration of chromium in the cabbages than in the soils for both dam and tap water irrigated fields could also be indicative of bio-accumulation of the metal in the leaf.

Key words: Cabbage, Heavy metals, Soil, Pollution

INTRODUCTION

Malawi has a population of 9.9 million people (Malawi Government, 2000) and most of these (80%) live in rural areas. The diet of the majority of the people is thick porridge made from maize meal and this is consumed with relish in form of vegetables mixed with groundnut powder.

Several varieties of vegetables are grown and these include cabbage (drum head), spinach, mustard and Chinese cabbage. Also grown are the local or indigenous varieties. While most of these are grown in ‘’dambo’’ areas during the dry seasons where water from the rivers is used for watering, either by irrigation or using watering cans, some are also grown in uplands. The latter are almost always watered using watering cans.Plants grown under field conditions continuously face various environmental constraints, of which an important and increasingly concern is pollution with heavy metals (Podar, 2004). These metals may be present as a deposit on the surface of the vegetable or may be taken up by the crop roots and incorporated into the plant tissue. In either case, the original source of the pollution may be from water borne sources such as effluents or from industrial or vehicular air pollution (Marshall and Agrawal, 2006). In Malawi, vegetables are fertilized by using either inorganic fertilizers or cattle or chicken manures. In other cases processed sewage sludge is also used. The latter however is a source of heavy metals most of which are toxic to humans (Kadewa, *et al.*, 2001). Vegetables grown in polluted areas can therefore be an important source of these toxic metals to people who consume them (LeCoultre, 2001; Podar, 2004). Research has shown that vegetables

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bio-accumulate heavy metals differently and this has been attributed to plant differences in tolerance to these metals. Furthermore, within the plant, there is accumulative partitioning of the metals in the leaves, fruit or roots (Itanna, 2002; Fitzgerald, *et al.,* 2003; Zawadzaka, *et al.*, 1990; Delibacak, *et al.*, 2002; MacFarlane, *et al.,* 2003). Some plants accumulate more in the leaves than in the roots and vice versa for others (Othman, 2001). Some studies have also shown that heavy metals tend to have a retarding phonological development on plants (Ryser and Saunder, 2006).

Bunda College of Agriculture is situated on the side of a hill. All the sewage from the premises runs downhill where the sewage pit is located. Further down from the sewage pit are fish ponds and a reservoir also used for fish farming and irrigation of vegetables. Surrounding the ponds and the reservoir are gardens where vegetables and other crops are grown and these are irrigated by the water from the reservoir. The sewage pit does not directly connect to the reservoir and the ponds but the overflow of the water from the pit during the rain season drains to both of them. Ground water seepage is also possible. Both these processes can carry the heavy metals from the sewage pit in to the reservoir and consequently irrigated to the vegetables gardens.Therefore consumption of the vegetables from these gardens may be a health risk to the population within and around the premises.

The objective of this work was therefore to determine the levels of heavy metals in cabbages irrigated with water from the reservoir and the same to those in cabbages irrigated using tap water. The specific objective was to determine the levels of cadmium (Cd) lead (Pb) chromium (Cr) in cabbages grown at the farm and away; to determine whether the soil levels reflect the accumulation of heavy metals in plants and to determine the difference in heavy metal concentrations in cabbages exposed to reservoir water and treated tap water.

MATERIALS & METHODS

The study was conducted at Bunda College of agriculture in Malawi. Ten Cabbages (drum head) and ten soil samples from the area around the College reservoir that is irrigated by reservoir water and a similar number of cabbages and soil samples from a garden 3km away that is irrigated by tap water were collected.

Soil samples were collected within the rooting depth (0-22 cm) of the plants at a time when the crop was fully under irrigation. The area was divided into homogeneous sections and 20 samples (10 from the reservoir irrigated area and 10 from the tap water irrigated area) were separately composite. Large chunks of soil were crashed and spread out to air-dry. The soil was crushed in a soil pulveriser to pass through a 60 mesh screen. To about 2.5 g soil sample (in triplicate) placed in 50 ml centrifuge tube 25 mL of Mehlich-3 Universal extraction solution was added (an aqueous solution of NH_4F, Na-EDTA, NH_4NO_3, HNO_3 and Acetic acid; pH is 2.0±0.1) (Mehlich, 1984) and the tube was capped and hand shaken for 5minutes, left to stand for 10 minutes and then centrifuged for 10 minutes. The sample was then filtered through to a 50 ml centrifuge tube. The fresh edible leaves from the 20 cabbages were stripped and washed to remove any residual soil or dust. The samples were placed in paper bags with adequate room for air movement within the bag, dried in a forced air oven at 55-60 ºC until the material snapped (48-72 h). The samples were then separately grounded in a mortar and thoroughly mixed. About 1.0 g ground sample (in triplicate) was weighed and put in a crucible to ash at 500 °C in a muffle furnace. Samples were allowed to cool in clean environment free from any breeze. Distilled water (5 mL) was added to dissolve the ash and this was then rinsed into a 50 ml polypropylene centrifuge tube with 15 mL of 1 N HCl (Nyirongo, 2001). This was repeated for each of the samples. The samples were analysed for heavy metals using Atomic Absorption Spectrophotometer method, model UNICAM 969 (AOAC, 2002).All data were analysed using Statistical Package for Social Scientist (SPSS) to separate the mean concentrations. A paired sample t-test was used to separate the mean concentration between tap and dam irrigation system. One-way ANOVA separated the means between and within groups of heavy metals.

RESULTS & DISCUSSIONS

Table 1 shows the concentrations of heavy metals in cabbages irrigated with reservoir and tap water. The concentration of cadmium in cabbage irrigated with reservoir water was 1.25± 0.13 ppm while this was 0.71±0.13 ppm in the cabbage irrigated with tap water. The concentration of lead was 0.21±0.13 ppm in the reservoir water irrigated cabbage and 0.67±0.07 ppm in that from tap water irrigation. The concentration of chromium was 0.12±0.05 ppm in the reservoir water irrigated cabbages and 0.11±0.05 ppm in the tap water irrigated cabbage.

Table 1. **Overall concentrations of cadmium, lead and chromium in cabbages irrigated with reservoir and tap waters**

	Heavy metal (mean ± SD ppm)		
Irrigation water	Cd	Pb	Cr
Reservoir	1.01±0.01[a]	0.00±0.00	0.05±0.01
Tap	0.16±0.01[b]	0.12±0.01	0.09±0.01

[a-b]Means with the same letter in a column are not significant at P= 0.05

Table 2 shows the concentrations of the heavy metals in the soils irrigated with dam and tap water. The concentration of cadmium in the reservoir irrigated water was 1.01± 0.01ppm while in the tap water irrigated soil it was 0.16±0.01ppm. The concentration of lead was 0.00±0.0ppm in dam irrigated soil and 0.12±0.01ppm in the tap water irrigated soil. The concentration of chromium was 0.09±0.01ppm in the reservoir irrigated soil and 0.05±0.01mg/l in the tap water irrigated soil.

Table 2. **Overall concentrations of cadmium, lead and chromium in the soil samples irrigated with reservoir and tap waters**

	Heavy metal (mean ± SD ppm)		
Irrigation water	Cd	Pb	Cr
Reservoir	1.25±0.13[a]	0.21±0.03	0.12±0.01
Tap	0.71±0.13[b]	0.67±0.07	0.11±0.01

[a-b]Means with the same letter in a column are not significant at P= 0.05

The results showed that the levels of the heavy metals in both the cabbages and soils were generally low. A possible explanation is the fact that the sludge was not directly used on the soils. Therefore, even if the levels of the metals could be high in the sludge, research has shown that these metals and especially the heavy metals are tightly held by the sludge matrix so that the dam water contained low concentrations (Elliott, *et al.*, 1990). The concentration of cadmium in dam water irrigated cabbages was significantly higher ($p<0.05$) than that in tap water irrigated cabbages. This could be attributed to the higher concentration of this metal in the reservoir irrigated soils as compared to the tap irrigated soils. Although reports have suggested that cadmium uptake by plants is determined by the total available cadmium concentration, soil pH and organic matter content (Podar, 2004). The contrast between dam and tap water irrigated concentrations in this study, could indicate that the sewage water had some impact as well. The concentration of cadmium in both the reservoir water and tap water irrigated cabbages was much higher than the levels (0.2 ppm) recommended by the European Union for leafy vegetables (Pless-Mulloli, *et al.*, 2001). The trend for lead was however the opposite in absolute terms for lead; the amounts in reservoir water irrigated cabbages being lower than in tap water irrigated ones although the two were not statistically different. The concentration of the metal in the soils, whether dam or tap water irrigated was also low or none. The concentrations in the leaf from both sites were much higher ($p<0.05$) than the concentrations in the soils and this could be an indication of hyper accumulation in the leaf. Transport of lead in surface soils is known to be quite high and the absence of this metal in the reservoir water irrigated soils and the very low amounts in the tap water irrigated ones could be a reflection of this. However, transport from plant roots to the shoots is usually very low and this restricts the influence of root uptake on lead levels in the plants (Berthelsen, *et al.*, 1995). Research has shown that lead is even more tightly bound to the sludge matrix than cadmium (Elliott, *et al.*, 1990). These three factors could explain the lower levels of lead compared to cadmium in reservoir water irrigated soils and hence in the cabbages. The observed concentration of lead in the reservoir water irrigated cabbages was also lower than that recommended by the European Union (0.3 ppm) for leafy vegetables (Pless-Mulloli, *et al.*, 2001) but the concentration in the tap water irrigated cabbages was higher than the allowed limit.

There was no significant difference in the concentration of chromium in reservoir and tap water irrigated cabbages. The lower levels observed in the leaf could be a reflection of the lower values that were observed in the soils. The significantly higher concentration of chromium in the cabbages than in the soils for both reservoir and tap water irrigated fields could indicate bio-accumulation of the metal in the leaf.

CONCLUSION

The results have shown that the use reservoir water can increase the intake of heavy metals by vegetables. Abundance in the vegetables seemed to be related to the amounts in the water. The higher concentration of cadmium in the plants than the allowed values could be a health risk to the consumers and although the concentrations of lead and chromium were below the recommended guidelines; their continued input into the soils could be hazardous to the consumers too. It is therefore recommended that although the reservoir water can still be used for irrigating the vegetables, there should be continuous monitoring of these metals in the vegetables to avoid toxic effects in the consumers. Further research into the uptake of the heavy metals by different vegetables under the same conditions would also be necessary. In addition, there is need to extend the study to include a broader range of other metals such as iron, manganese, zinc and arsenic.

REFERENCES

AOAC., (2002). Association of Official American Chemists. Official Methods of Analyses, 17th Ed. (Maryland, USA: AOAC).

Berthelsen, B. O., Steinnes, E., Solberg, W. and Jingsen, L. (1995). Heavy metal concentration in plants in relation to atmospheric heavy metal deposition. J. Environ. Qual., **24,** 1018-1026.

Delibacak, S., Elmaci, O. L., Secer, M. and Bodur, A., (2002). Trace element and heavy metal concentrations in fruits and vegetables of the Gediz River region. Int. J. water, **2,** (2/3), 196-211.

Elliott, H. A. Dempsey, B. A. and Maille, P. J., (1990). Content and Fractionation of heavy metals in water treatment sludges. J. Environ. Qual., **19,** 330-334.

Fitzgerald, E. J., Caffrey, J. M., Nesaratnam, S. T. and McLoughlin, P., (2003). Copper and lead concentrations in salt marsh plants on the Suir Estuary, Ireland. Environ. Pollut., **123** (1), 67-74.

Itanna, F., (2002). Metals in leafy vegetables grown in Addis Ababa and toxicological implications. Ethiopian J. Health Dev., **16** (3), 295-302.

Kadewa, W. W., Henry, E. M., Masamba, W. R. M. and Kaunda, C. C., (2001). Impact of sewage sludge application to horticulture: A case of the city of Blantyre. In: Proceedings of the first chancellor College Research dissemination conference, 291. Zomba, Malawi.

LeCoultre, T. D., (2001). A meta-analysis and risk assessment of heavy metal uptake in common garden vegetables. MSc Thesis. East Tennessee State University, USA.

Malawi Government, National Statistical Office (2000). Malawi: Demographic and Health survey. ORC, Macro, Zomba, Malawi.

MacFarlane, G. R., Pulkownik, A. and Burchett, M. D., (2003). Accumulation and distribution of heavy metals in the grey mangrove, *Avicennia marina(Forsk.*) Vierh: Biological indication potential. Environ. Pollut., **123**, (1), 139-151.

Marshall, F. and Agrawal, R., (2006). Heavy metal contamination of vegetables in Delhi. A report submitted to the UK Department for International Development. Retrieved on 1 July 2007 available from http://www.toxicslink.org/pub-view.php?pubnum=1.2.html

Mehlich, A., (1984). Mehlich-3 soil test extractant: A modification of Mehlich-2. Soil Sci. Plant Anal., **15**, 1409-1416.

Nyirongo, J. C. V. B., (2001). Soil fertility studies with compost and phosphate rock amendments at Lunyangwa and Bembeke research stations. MSc Thesis, University of Malawi.