Geogenic contaminants in water and vegetables and the aetiology of non-communicable diseases in mineralised areas: the case of Kadoma, Zimbabwe

UNIVERSITY OF ZIMBABWE

ONLINE CONFERENCE IWRA 2021

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INTRODUCTION

Elements released through natural as well as mining operations into agro-ecosystems can pose a serious threat to the health of communities that reside in mining towns even well after the cessation of mining activities. This study tests the hypothesis that geologic materials in mineralized areas contaminate water and vegetables and are associated with the distribution of non-communicable diseases observed in populations residing in the mining district of Kadoma, Zimbabwe. A plausible explanation for the etiology and prevalence of these diseases, hinges on the dispersion of potentially harmful geochemical elements in the soils, sediments and water and their bioaccumulation in the vegetables consumed by the local communities. Elements such as arsenic, cadmium, chromium, copper, lead, manganese, nickel and zinc that are associated with precious and base metal mineralisation, are amongst potentially harmful elements (PHEs) that have been linked to a variety of human health challenges. Arsenic and its compounds are known human carcinogens and has been linked to diabetes mellitus ad hypertension (7, 8). Lead has been linked to retarded mental development and behavioural problems in children.

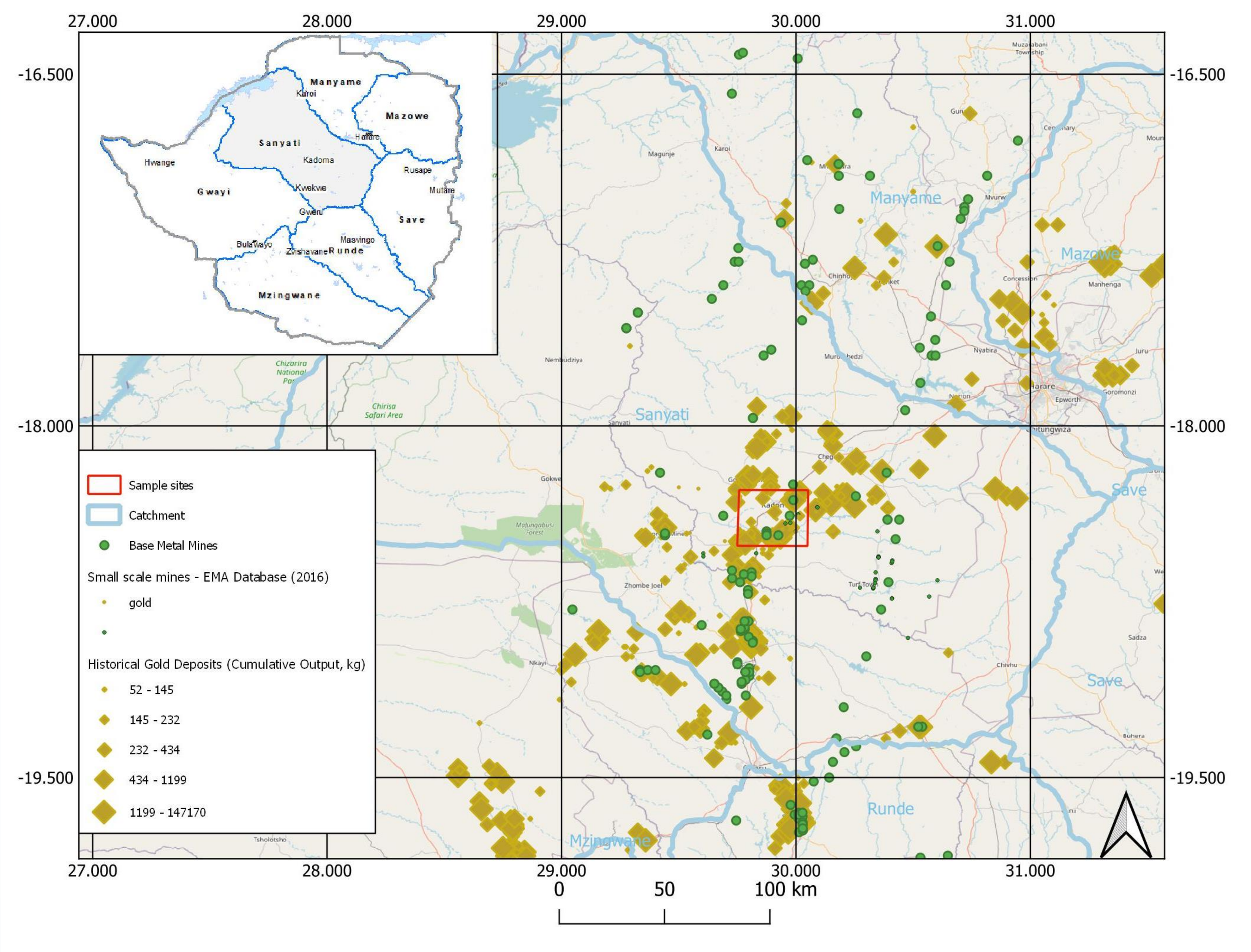


Fig 1. Location of the study area

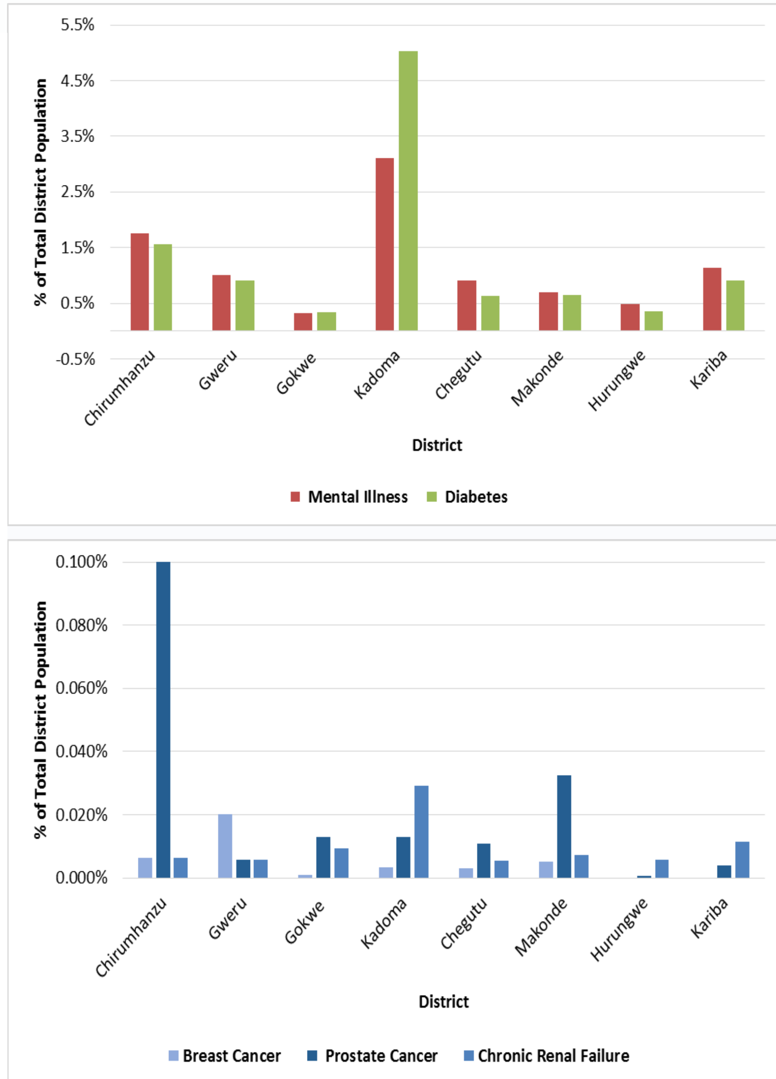


Fig 2. Percentage distribution of follow-up cases in 2012 for cancers, diabetes and mental illness by district, the Kadoma district shows notable spikes for some of the non-communicable diseases

OBJECTIVES

1. To characterise the occurrence of PHEs in water, soils and stream sediments in the Kadoma area and produce geochemical maps highlighting areas with above recommended PHE levels.
2. To measure concentrations of PHEs accumulating in vegetables grown in the district to ascertain their bio-availability and associated human health risk through consumption of these vegetables.

METHODOLOGY

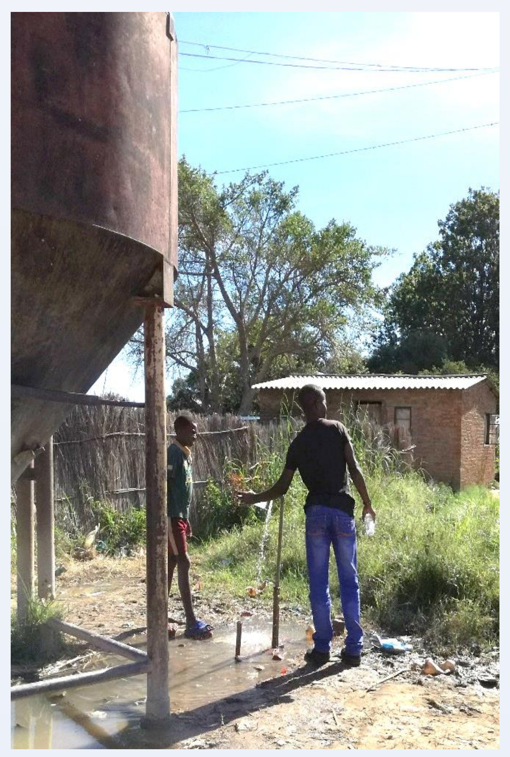
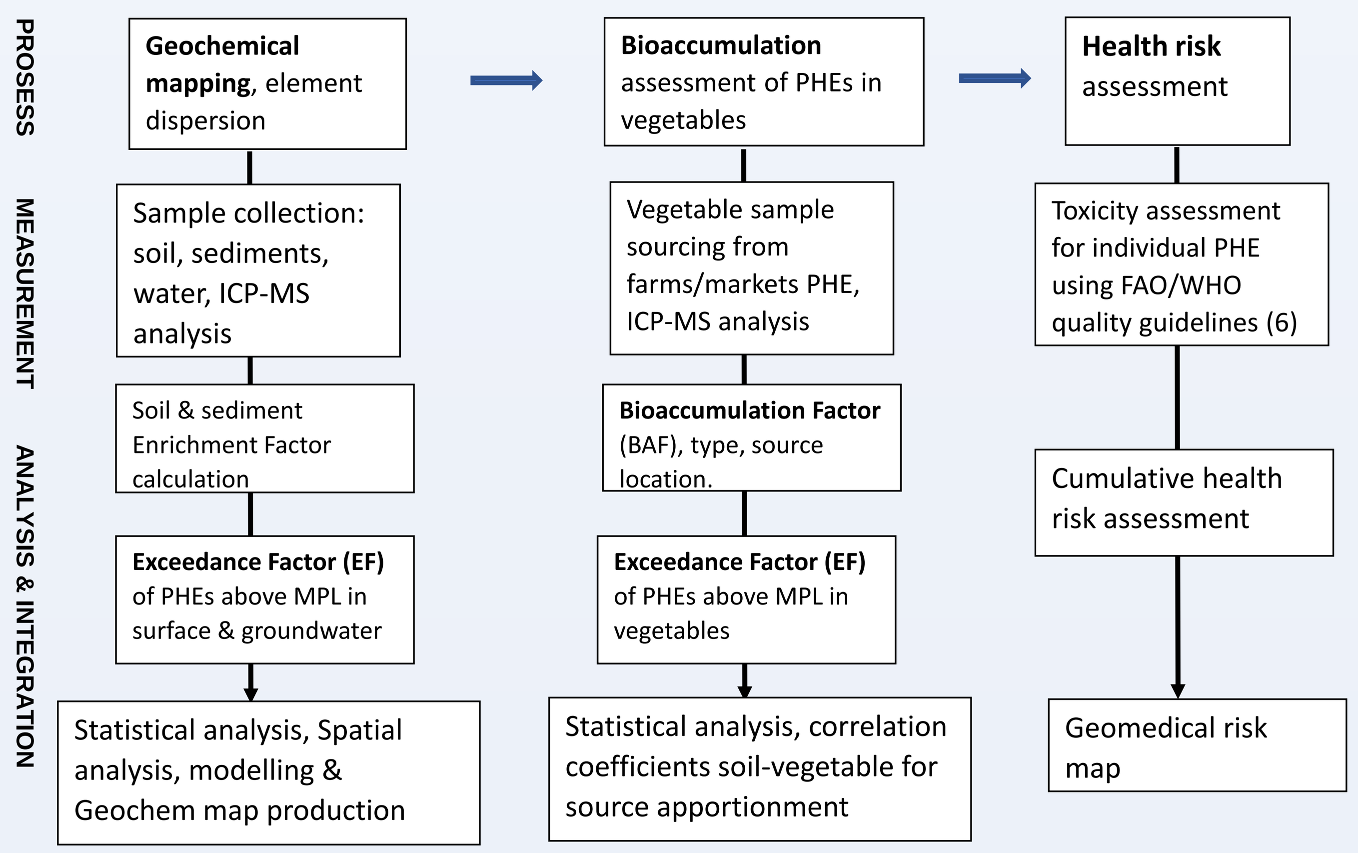
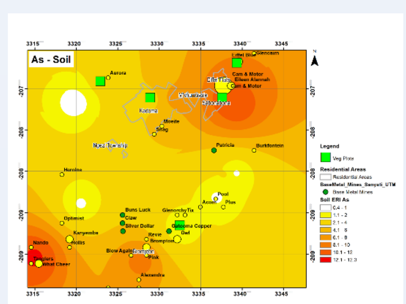


Fig 4. Sampling borehole water stored in a reservoir and supplied to one of the residential areas of the communities in the area



Bureau Veritas Laboratories

Spatial analysis and modelling tools



RESULTS & DISCUSSION

PHEs in water

In the water samples collected from streams and boreholes within the study area, the 4-season average exceeded the WHO maximum permissible level (MPL) at 12 of the 19 locations. All 5 of the boreholes sampled had values of arsenic that exceeded the MPL with EF values ranging from 1.28 to a maximum of 6.97. Surface water at K3 (Fig 5), whose micro-catchment hosts the largest gold mine workings of the district, As was 418 times above the MPL.

PHEs in soil and stream sediments

In the soils and stream sediments concentrations of PHEs followed the trend Cr > As > Ni > Cu > Zn > Co > Pb > Sb > Cd. Element concentrations that showed levels above background values were, As, Cr, Ni, Pb, Sb and Zn.

Bio-accumulation of PHEs in edible parts of vegetables

A comparison of the PHE levels in the vegetables against the FAO/WHO Codex MPL (6), revealed As, and Pb levels well above the limit. Some tomatoes had a concentration of lead of the order of 1400 times above the MPL while arsenic concentrations were also well above the MPL in all vegetable samples.

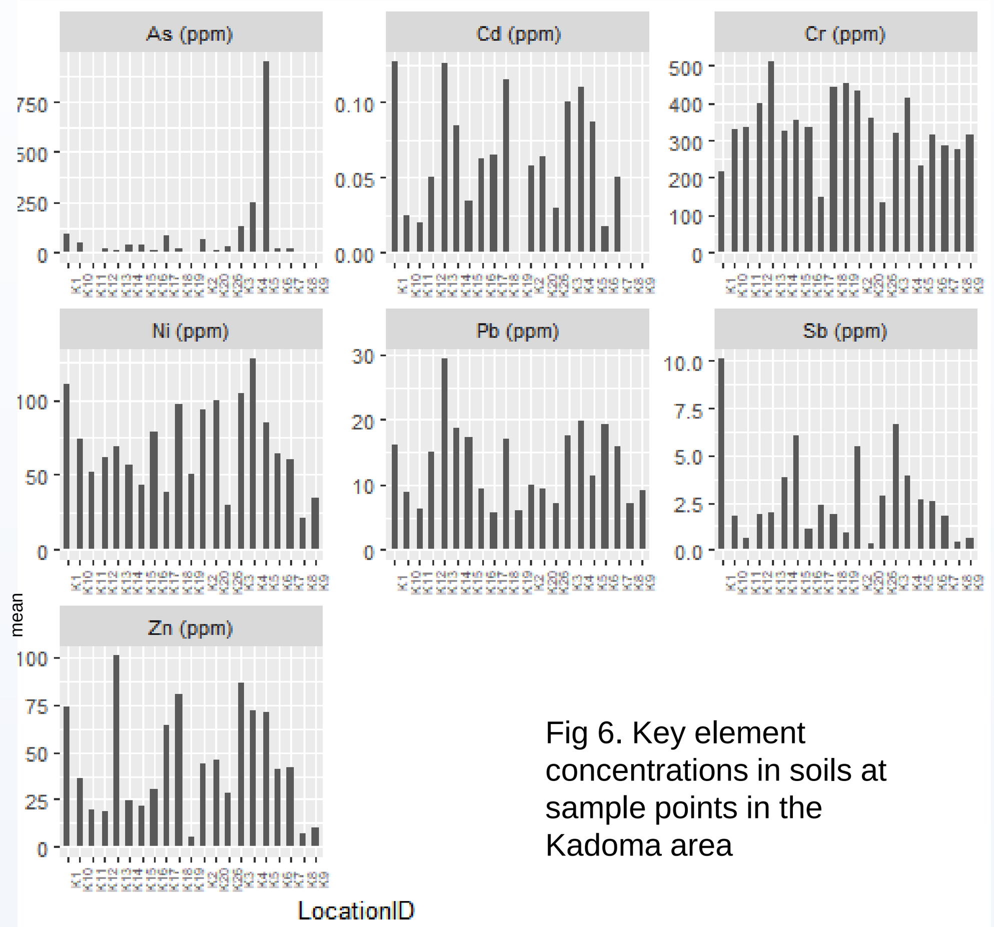


Fig 6. Key element concentrations in soils at sample points in the Kadoma area

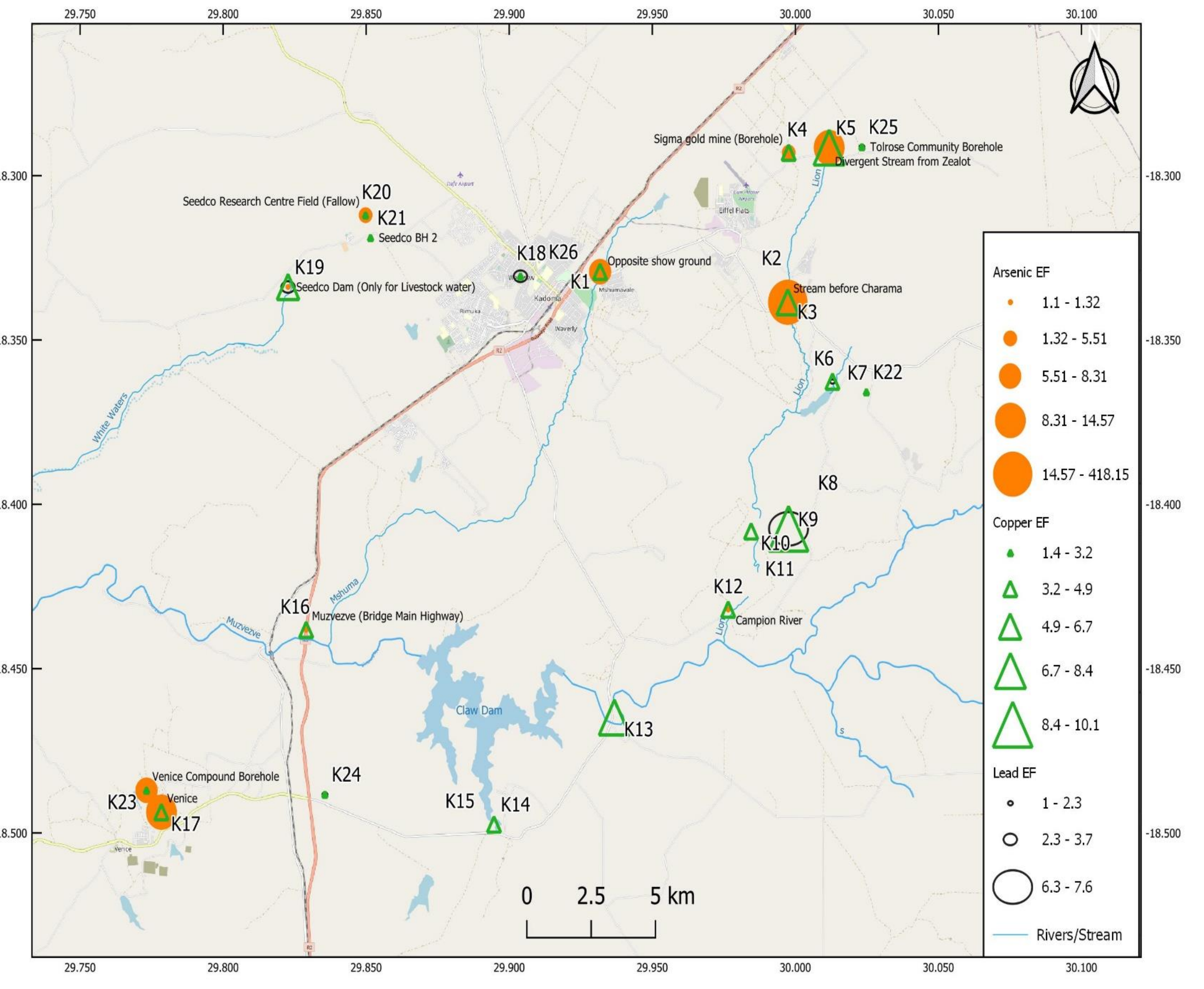


Fig 5. Exceedance Factor (EF) for arsenic, copper and lead in water samples, all on the map have concentrations above WHO MPL (i.e. EF>1)

Table 1. Average concentration of PHEs in vegetables from the Kadoma area (values in bold font) exceeded the FAO/WHO MPL

Element	As	Cd	Co	Cr	Cu	Ni	Pb	Sb	Zn
Units	mg kg^{-1}								
MPL: FAO/WHO	0.3	~0.05-0.2	---	---	40	---	~0.05-0.3	1	100
Cabbage	**5.80**	0.02	0.93	60.83	7.63	7.43	**30.17**	0.41	21.50
Carrot	**0.80**	0.05	0.58	26.90	9.70	3.00	**31.15**	0.07	24.40
African kale	**1.15**	0.03	0.72	13.15	4.70	3.80	**20.41**	0.10	29.35
Curly Kale	**2.50**	0.04	1.06	33.70	8.19	7.25	**40.75**	0.15	23.10
Rape	**4.77**	0.07	1.11	30.50	9.42	5.67	**30.73**	0.35	31.93
Okra	**1.00**	0.05	0.48	23.6	18.7	2.8	**21.81**	0.16	43.6
Onion	**1.30**	0.07	0.81	33.60	15.45	10.80	**54.96**	0.29	42.40
Pumpkin Leaves	**5.20**	0.02	1.65	83.65	19.37	16.10	**50.94**	0.35	36.70
Potatoes	**0.50**	0.08	0.46	6.40	5.26	1.20	**5.55**	0.03	16.30
Spinach	**5.65**	0.04	0.78	22.75	9.40	3.70	**18.65**	0.22	18.85
Tomatoes	**4.03**	**0.09**	0.88	56.23	26.63	5.95	**69.96**	0.52	20.93
Green beans	**0.60**	0.01	0.31	15.60	8.97	4.90	**11.21**	0.21	29.20

CONCLUSION

This study revealed potential health risks associated with high levels of arsenic, lead and copper in the surface and groundwater in the Kadoma area.

- Arsenic exceeded MPL in all vegetables and leafy vegetables were found to accumulate significantly higher amounts of PHEs than root vegetables.
- All vegetables grown in the area were found to have alarmingly high Pb levels, well above MPL.
- The risk of Cd exposure is associated only with tomatoes.
- Potential health risk through bioaccumulation of PHEs by vegetables may be mitigated by growing more of the tubers, and less of the leafy vegetables in enriched PHE areas.

Further studies into assessing potential health risks are recommended using estimates of daily average intakes and exposure pathways. This study illustrated the importance of cooperation between water, food, and public health sectors in better informing public policy and governance in water food and health.

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ACKNOWLEDGEMENTS & CONTACT

UNESCO/SIDA funding under the Mapping and Assessing the Environmental and Health Impacts of Abandoned Mines in Sub-Saharan African Countries Project

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