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A Baseline study on heavy metal in agricultural soils from selected small scale farms in Trinidad.

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Abstract

Heavy metal contamination in soils can pose a significant threat through accumulation in agricultural produce. The purpose of the study was to investigate the levels of Cd, Pb, Zn, Cu, Ni in soils from six sweet potatoes (*Ipomoea batatas*) farms in Trinidad. Aliquot 1.00g of dried soil was predigest overnight (12hrs) with10mL of HNO_3, followed by exhaustive digestion on a heating block at 130ºC for 3hrs. Samples were cooled, dilute to 5 mL with deionized water, filtered through Whatman No. 542 filters and made up to 50 mL. Samples were then analyzed using Flame Atomic Absorption Spectrometry (FAAS). A Certificate reference soil, NIST SRM 2709a Montana soil was analyzed to determine the % recovery for Cd, Pb, Zn, Ni and Cu. The concentrations of heavy metals in soils were to the Finnish guidelines for ecological and health risks. The mean concentrations of Zn, Pb, Ni, Cu and Cd (58.6, 10.3, 13.5, 11.8 and 0.50 mg/kg respectively), which suggest that the soil is safe for food cultivation.

Key words: farm soil, heavy metal, Trinidad, threshold value.

1.0 Introduction

Trace amounts of metals such as Zn and Cu are essential for plant growth. However, increased concentrations of metals such as Cd, Pb, Hg, As and Cr in soil is on global concern as it may affect agricultural production and elicit toxic effects on plants affecting food quality and safety (Islam et al. 2007; Ramtahal et al. 2016).Soil is an important sink for chemical pollutants from various sources, and acts as a natural buffer by controlling the fate and transport in the environment(Yu et al. 2016). Soil support plants roots, and provides water and nutrients for plant growth and supports the whole living system including plant pathogens and nematodes and bacteria (Alabouvette and Steinberg 2006; Silva and Uchida 2000). Heavy metal intake via soil-crop has been considered as the predominant pathway of human exposure to environmental heavy metals in agricultural area(Liu et al. 2007)

Heavy metals in soil may either be found naturally or introduced from anthropogenic activities. Natural sources include atmospheric emissions from volcanoes, transport of continental dusts, and weathering of metal-enriched rocks. The main anthropogenic sources include; mining, smelting, waste disposal, urban effluent, vehicle exhaust, sewage sludge, pesticides and fertilizer application (Zhao 2013). However in many areas, r irrigation using polluted water sources is the principal caused of contamination in urban agricultural land (Mahmood and Malik 2014; Balkhair and Ashraf 2016).

Very limited published data is available concerning metal concentrations in soils of Trinidad, The objective of the current study was to establish a baseline study on the concentration of heavy metals, Cd, Pb, Zn, Cu and Ni in soils of six selected farms.

2.0 Materials and Method

All laboratory glassware utensil used were washed and cleaned with 10 % Nitric acid, rinsed with deionized water and dried in an oven at 50^0C. All reagents used were of Analytical Grade.

2.1 Sample collection and preparation

Soil samples were collected from 6 sweet potato farms located in Central Trinidad (Fig.1). Each field was subdivided into 5 parts (4 corners and the centre) and samples were collected between 0-20 cm placed in sealed polythene bags and transported on ice to the laboratory for analysis. Soil samples were dried for 48 hrs and homogenised and sieved (<2mm) to remove large rock pieces.

Figure 1: Location of farms used for sampling highlighted in red

2.2 Extraction and analysis of samples

2.2.1 Optimization of an effective extraction procedure for the analysis of heavy metals in soil

The analytical method for determination of Cd, Pb, Zn, Cu and Ni in soil was optimize for HNO3 and aqua regia (3:1, HCl: HNO_3) extraction. Aliquot 1.0g soil samples were weighed in triplicate into digestion tube and pre-digested overnight (12 hrs.) with 10 mL of aqua regia (3:1, HCl: HNO_3), followed by exhaustive digestion on a heating block at 130°C for 3hrs. Digested extracts were cooled, dilute to 5 mL with deionized water, filtered through

Whatman No. 542 filters and made up to 50 mL, for Cd, Pb, Zn, Cu and Ni determination by Flame Atomic Absorption Spectrometry (FAAS). A Certificate reference soil, NIST SRM 2709a Montana soil was analyzed in triplicate with this method and the % recovery for Cd, Pb, Zn, Ni and Cu was determined.

2.2.2 Optimization of HNO3 extraction procedure for comparison

The same procedure was repeated using 10 mLHNO_3 extraction for soil reference material (NIST SRM 2709a) compared to HNO3 and aqua regia (3:1, HCl: HNO_3) extraction and the results are compared in the table 1.

3.0 Statistical Analysis

The concentrations for each metal across farm soils was tested using one-way ANOVA, and where significant difference (P<0.05) were detected, this was followed by a Tukey multiple comparison test to identify which metals and sites were significantly different.

4.0 Results and Discussion

Table 1: Mean concentration ± Std. deviation and % recovery NIST Certified Reference Materials – SRM 2709a (EPA Method 3050B)

Extractable Methods SRM -HNO_3	Metals	Mean Certified Value (mg/kg)	Measured Mean Value (mg/kg)	% Recovery
	Cd	0.50	0.27	54
	Pb	9.55	8.25	86.3
	Zn	78.0	66.1	84.7
	Cu	26.0	24.6	94.6
	Ni	65.0	62.9	96.7
SRM-Aqua Regia				
	Cd	0.50	0.00	0.0
	Pb	9.55	7.15	74.9
	Zn	78.0	72.8	93.3
	Cu	26.0	22.9	88.1
	Ni	65.0	50.0	76.9

According to the quality control test (NIST SRM 2709a) (Table 1) Total HNO_3 extractable method was used for this research due to better recovery of Cd.

Table 2 – Measured metal concentrations in soils from Sweet potato farms relative to Finnish standard values. The guideline values are defined on the basis of either ecological risks (e) or health risks (h)

Metal	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Overall Mean	Threshold value	Guideline value
Cd (mg/kg dw)									
Range	0.29-0.85	0.21-0.44	0.46-0.81	0.51 -0.65	0.56-0.82	0.06-0.80			
Mean	0.484	0.350	0.602	0.589	0.632	0.329	0.50	1	10 (e)
Stdev	0.217	0.090	0.129	0.060	0.109	0.312			
Pb *(mg/kg dw)*									
Range	10.6-14.6	9.61-11.4	10.4-12.2	11.6-13.4	6.62-11.0	5.62-7.1			
Mean	12.1	10.6	11.5	12.9	8.31	6.26	10.3	60	200 (h)
Stdev	1.86	0.813	0.825	0.713	1.79	0.167			
Zn *(mg/kg dw)*									
Range	67.6-86.5	71.2-83.8	87.6-97.6	39.7-50.5	21.4-34.3	27.3-31.9			
Mean	79.1	78.1	93.3	44.4	27.6	29.3	58.6	200	250 (e)
Stdev	7.14	5.07	5.21	4.34	4.72	2.32			
Cu *(mg/kg dw)*									
Range	13.6-14.9	8.69-17.7	11.8-16.9	10.5-20.0	4.02-14.6	7.06-9.77			
Mean	14.1	12.9	15.3	12.7	7.19	8.45	11.8	100	150 (e)
Stdev	0.482	3.19	2.04	4.12	4.25	1.06			
Ni *(mg/kg dw)*									
Range	13.0-16.9	18.5-21.0	20.6-23.1	7.04-13.1	4.56-6.85	4.55-6.14			
Mean	15.5	19.7	25.1	9.74	5.63	5.07	13.5	50	100 (e)
Stdev	1.57	0.928	7.45	2.49	0.953	0.650			

Accordingly, the analysis results from this study were compared with the Finnish standards (Table 2) (Tóth et al. 2016).

There are no WHO guidelines for heavy metal concentrations in soil. However Toth et al. (2016) have noted that the Finnish standard values (Ministry of the Environment, Finland, 2007) represent a good approximation of the mean values of different national systems in Europe (Carlon et al., 2007) and India (Awasthi, 2000) and have been applied in an international context for agricultural soils (UNEP, 2013).

The ANOVA showed that Cd concentrations (0.33-0.63 mg/kg) between all farms were not significantly different ($P<0.05$). The mean Cd concentrations in these soils falls within the Cd concentrations sampled across soils in Trinidad and Tobago cacao plantations (0.3 – 1.7 mg/kg) by Ramtahal et al.2016.

Table 3 – Distribution of mean heavy metal concentrations in soils of six sweet potato farms in Trinidad.

Metal	Heavy metals in farm soils (F1 through F6) ranked by mean concentration (mg/kg dry wt.). Means linked by underlining are not significantly different (P<0.05).					
Cd	F5	F3	F4	F1	F2	F6
	0.632	0.602	0.589	0.484	0.350	0.329
Pb	F4	F1	F3	F2	F5	F6
	12.9	12.1	11.5	10.6	8.31	6.26
Zn	F3	F1	F2	F4	F6	F5
	93.3	79.1	78.1	44.4	29.3	27.6
Cu	F3	F1	F2	F4	F6	F5
	15.3	14.1	12.9	12.7	8.45	7.19
Ni	F3	F2	F1	F4	F5	F6
	25.1	19.7	15.5	9.74	5.63	5.07

As shown in Table 3, the mean concentration of Pb in soils were significantly different (P<0.05) between some farms. The overall mean for lead was 10.3 mg/kg. The mean concentrations of Zn in soils were significantly different (P<0.050) for some farms. The overall mean concentrations of Zn was 58.6 mg/kg. The overall mean concentrations of Cu was 11.8 mg/kg, but no clear conclusion can be reached regarding significant differences in concentrations between farms. For Ni (overall mean 13.5 mg/kg) there is no significant difference (P<0.05) between farms F5 and F6, but no clear conclusion can be reached regarding significant differences in concentrations between the other farms. The overall mean concentrations of heavy metals in soils distributed between the farms were Zn >Ni>Cu>Pb>Cd.

Conclusion

None of the heavy metal concentrations measured in soils from a range of sweet potato farms in central Trinidad exceeded a recognized threshold indicating a need for further investigation regarding health or ecological risks. Accordingly, the concentrations of these heavy metals in Trinidad soils are not a hazard for sweet potato production."

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