Influence of flood on level of the heavy elements in agricultural soil and the plant crops

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Abstract

This study was carried out to determine the levels of three heavy elements (As, Cd and Pb) in flooded arable soil and their accumulation in the most often cultivated vegetables. Evaluation of soil pollution of the studied area has been done using four indexes: contamination factor (C_f), geo-accumulation index (I_{geo}), potential ecological risk index (RI) and pollution load index (PLI). The target hazard quotient (THQ) and hazard index were used to assess human health risk of heavy elements. The I_{geo} and C_f values of heavy elements were in the decreasing order of As>Cd>Pb. Both indexes indicated that soil samples were unpolluted to moderately polluted by analysed elements. Additionally, this level of soil pollution has been confirmed by PLI index. Result obtained for RI showed that analysed soil undergoes moderate contamination by studied elements. Furthermore, the health risk assessment indicated that non-carcinogenic value was below the threshold level.

1. Introduction

Flooding caused by climate change is one of the most costly disasters that cause property damage, human casualties and contamination of soil with different contaminants (e.g. heavy metals), etc. Hydrological conditions such as intensity and duration of flooding and groundwater level, significantly affect the migration and accumulation of heavy elements in flooded soils. During the May 2014 heavy rain caused floods and erosion of soils in central and eastern part of Europe. Serbia was also affected by heavy rains, soils erosion and floods during the third week of May 2014, particularly the agricultural region located in the northern Serbian province of Vojvodina. Till now, there are no data available on the impact of flooding on arable soil and vegetables grown in the affected region. Therefore, the aim of this study was to determine the levels of three potential toxic elements (As, Cd and Pb) regulated by Serbian soil standard (OG RS 80/10, 2010) due to assess the pollution level, potential ecological risk as well as human health risk through consumption of different vegetables grown in the Serbian region.

2. Materials and methods

A total of 37 topsoil samples (0-30 cm) were collected from selected flooded locations. Each sample was a composite of 10 subsamples collected from a 100 m x 100 m grid. Additionally, available vegetables (potato, carrot, celery, parsnip and onion) were collected from the selected fields. 17 composite samples of each chosen vegetable species were prepared. After that, only edible parts of vegetables were analysed. The method applied for heavy element determination is previously published by Škrbić *et al*. (2013). Equations and classification criteria relating aused indexes were previously described by Škrbić *et al*. (2018). The target hazard quotient (THQ) and the hazard index (HI) were calculated according to USEPA (2011).

3. Results and discussion

Basic statistics for the analysed elements in the flooded and control soil samples are given in Table 1, together with the target and intervention thresholds set by Serbian regulation (OG RS 80/10, 2010) as well as background values.

The average concentration of Cd in celery, parsnip and carrot exceeded the maximum allowable levels sets by EC (2006)/Serbian regulation (2014) (Fig. 1). Also, average level of Pb (0.54 mg/kg) in carrot samples was almost 5 times higher than the maximum residue level of 0.1 mg/kg set by EC/Serbian regulation (Fig. 1). As were not detected in any analysed sample of vegetables. Concentrations of Cd and Pb detected in the analysed vegetables were notably above those determined in commercial vegetables collected from Serbian market, which concentrations in 90% the analysed samples were below LODs.

Table 1. Basic statistic of heavy elements (mg/kg) and soil pollution indexes

	As	Pb	Cd	
Min	1.47	3.82	0.11	
Max	8.57	44.26	13.89	
Mean	5.22	16.42	0.82	
Median	5.02	16.71	0.26	
Background values[1]	2.21	14.4	0.51	
Target values[2]	29	85	0.8	
Intervention values[2]	55	530	12	PLI
Cf	2.36	1.14	1.61	1.28
Igeo	0.47	0.23	0.32	RI
Er	23.62	5.70	48.24	77.56

[1] Background metal concentrations for agricultural soils (Ubavić et al., 1993).
[2] Serbian standard target values for soil (OG RS 80/10, 2010).

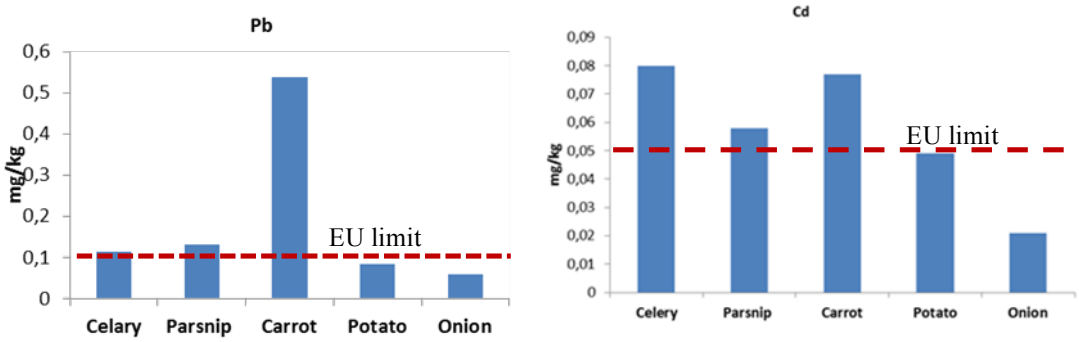

Figure 1. Average concentration of Pb and Cd in different vegetables collected from analysed flooded arable soil

4. Conclusion

To the best of the our knowledge, this is first investigation carried out in the flooded arable region (of Vojvodina Province) as attempt to assess health risk which might be attributed to chain soil-plant-human. Although, the average contents of Pb and Cd in some vegetables were found to be higher than the maximum allowable concentrations, their daily intakes were below the recommended safe limits. Total THQ of studied elements as well as HI didn't exceeded safe threshold indicating that potential risk is absent.

5. References

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