Journal of Applied Life Sciences and Environment
https://jurnalalse.com

Original Article
https://doi.org/10.46909/alse-551049
Vol. 55, Issue 1 / 2022: 92-99

RESEARCH ON THE HEAVY METAL CONTENT IN ONION BULBS CORRELATED WITH SOIL FROM PRIVATE HOUSEHOLDS LOCATED IN THE COPŞA MICĂ AREA, CENTRAL ROMANIA

Bogdan Ştefan OPREA, Dumitru-Marian MOTELICĂ, Nicoleta Olimpia VRÎNCEANU, Mihaela COSTEA, Georgiana Iuliana PLOPEANU and Vera CARABULEA

National Research and Development Institute for Soil Science, Agrochemistry and Environment, 61 Mărăşti Blvd, District 1, 011464, Bucharest, Romania; e-mail: office@icpa.ro

*Correspondence: carabulea_vera@yahoo.com

Received: Nov. 21, 2022. Revised: Dec. 09, 2022. Accepted: Dec. 11, 2022. Published online: Dec. 22, 2022

ABSTRACT. Food safety and the high demand for food have represented worrisome problems worldwide in recent decades. It is well known that plants can accumulate metals from contaminated soil and through deposits from pollutant emissions released by contaminated sources. Cadmium, copper, zinc, and lead are poisonous elements. The accumulation of heavy metals in plants grown in polluted areas represents a major risk to human and animal health. Soil pollution with heavy metals is a global problem that has an unfavourable impact on the environment. For this study, data collected from 65 individual households located in the Copşa Mică area were used to estimate the bioaccumulation of four different heavy metals [cadmium (Cd), lead (Pb), zinc (Zn), and copper (Cu)] in onion bulbs in different scenarios, in correlation with the total metal content from the soil. The highest correlation coefficients were obtained for the regression curves established for the estimation of Cd ($r = 0.648^{***}$), Zn ($r = 0.592^{***}$), and Pb ($r = 0.525^{***}$) in onion bulbs. In the case of copper (Cu), the linear correlation coefficient was insignificant ($r = 0.088^{ns}$). The mean cadmium and lead values determined in the onion samples from the study area did not exceed the maximum stable levels for these contaminants in vegetables.

Keywords: heavy metals; vegetables; onion; pollution; bioaccumulation.

INTRODUCTION

One of the most popular vegetables, onions, has a wide range of applications. It can be eaten cooked or raw in a salad.

Onion composition varies and is influenced by genetic and environmental variables. Vegetables of high quality are crucial for human health. Nutrients are crucial to increase agricultural output and quality (Al-Fraihat, 2014). The main way contaminants (heavy metals) from the soil, including heavy metals, enter the human body is by ingesting contaminated food (Khan *et al.*, 2008). The rapid development of industrial sectors has harmed the environment due to increased levels of pollution, both in the air and in the soil (Toth *et al.*, 2016).

Moreover, the soil reaction (pH) and $CaCO_3$ content have major effects on metals' toxicity and their mobility within the soil (Waterlot *et al.*, 2017). Soil reactions influence the transport of heavy metals from soil to plants; thus, a higher Cd content in vegetables is recorded in acid soils (Liu *et al.*, 2018). Soil represents one of the most important factors for plant growth and development. The interaction between soil and plants is an example of the abiotic and biotic relationships in an ecosystem (Rai *et al.*, 2019). Heavy metal concentrations in plants are directly proportional to soil concentrations (Sun *et al.*, 2013).

Furthermore, the intensive use of pesticides causes an increase in the concentration of heavy metals, especially copper and zinc, in the first layer of soil, which are then absorbed by plants (Huang *et al.*, 2010; Yang *et al.*, 2011). Various metalloids can negatively influence human health, increasing morbidity (Rai *et al.*, 2019). Cd contamination can result in serious health consequences, such as lung disease, gastro-intestinal issues, prostate cancer, endocrine disorders, and heart effects (Martinez-Sanchez *et al.*, 2011).

Because cadmium is extremely mobile in soil, it may be gradually and regularly transported from polluted soils into plants and then into foodstuffs, exposing humans to cadmium through contaminated aliments (Liu *et al.*, 2018). Lead and cadmium have been noted to affect mostly the health of newborns and youngsters (Cao *et al.*, 2016). A high zinc concentration in an organism might compromise the human immune system (Zhou *et al.*, 2016). Muhammad *et al.* (2011), cited by Bibi *et al.* (2021), showed that a suitable zinc quantity is vital to form more than 300 distinct enzymes, although large amounts of this metal can cause anaemia, whereas a deficit results in immunological dysfunctions.

However, heavy metals, such as copper and zinc, are necessary for normal cognitive processes, development, and growth, but exceeding acceptable amounts might have negative consequences (de Oliveira *et al.*, 2014).

Excessive Pb exposure harms the reproductive system and kidneys and negatively influences cognitive abilities and evolution in youngsters (Rehman *et al.*, 2017). A heavy metal found in high concentrations in industrial areas is cadmium. An important source of cadmium pollution is anthropological activities (Akbari *et al.*, 2012). Plants rapidly absorb heavy metals (lead, cadmium, and chromium) through their roots and deposit them in their comestible parts (Heidarieh *et al.*, 2013; Taghizadeh *et al.*, 2017). The ability of plants to withstand stress is a method of reducing the damaging effects of metalloids. Plants have developed a technique to prevent heavy metal accumulation in their aerial parts using their root cells to neutralise the negative effects of contaminants (Krzeslowska *et al.*, 2010).

The capacity of different plant species to uptake and accumulate heavy metals varies considerably, and such discrepancies even exist among varieties (Säumel *et al.*, 2012). According to Geremies *et al.* (2010), as cited by Atabay *et al.* (2011), copper concentrations between 0.1 and 0.10 mg/ml inhibited the growth of onion leaves. The aim of this study was to estimate the bioaccumulation of cadmium (Cd), lead (Pb), copper (Cu), and zinc (Zn) from soil in onion bulbs harvested from households located in a very polluted area (Copșa Mică area, central Romania).

MATERIALS AND METHODS

In 2021–2022, a study was carried out on the heavy metal content of onion bulb samples harvested from the Copșa Mică area located in central Romania. Copșa Mică represents an area with an increased risk of pollution, especially at ground level, due to gas emissions from the factories in the area (Carbosin and Sometra) that operated in the past (starting in the 1930s) for approximately 60 years.

For this study, 65 samples of onion bulbs *(Allium cepa)* were collected from individual households in the polluted area (Axente Sever, Agârbiciu, Bazna, Copșa Mică, Micăsasa, Șoala and Târnava). Soil samples were collected from the topsoil (0–20 cm), air-dried at room temperature, crushed, and sifted through a 0.2-mm sieve to be analysed. The heavy metal content of the soil was determined using atomic absorption spectrometry (AAS).

The onion samples were washed until all contaminated soil was removed from the surface, and then they were crushed and put in the freezer. Subsequently, they were treated with nitric acid in a microwave digestion system. For the determination of heavy metal content, AAS was used (Flame GBC 932AA or Graphite furnace GBC SavanatAAZ).

Microsoft Excel 2002 was used for statistical processing and graphical representation of the data.

RESULTS

The content of heavy metals in the soil (*Table 1*) ranged between 0.07 and 35.81 mg/kg for Cd, between 15 and 952 mg/kg for Pb, between 71 and 1811 mg/kg for Zn, and between 25 and 132 mg/kg for Cu.

The heavy metal concentration in the onion bulbs (*Table 2*) had the following pattern: Zn > Cu > Pb > Cd. Zn was the heavy metal with the highest content identified in onion bulbs *(Allium cepa)* samples, ranging from 1.0 to 11.7 mg/kg. Cu content was the second highest, with values between 0.20 and 1.36 mg/kg. Pb and Cd content registered values between 0.009 and 0.136 mg/kg and between 0.007 and 0.106 mg/kg, respectively.

Figure 1 shows the logarithmic plots for power regression curves that estimate the stochastic relationship between the total amounts of Cd, Pb, Zn, and Cu in the soil and the amounts of those metals in onion bulbs. The Cd, Pb, and Zn contents of soil and the metal content of onion bulbs have strong connections, as characterised by the power correlation.

The values of the linear correlation coefficients for the three equations were significantly different from zero. There was no dependence between the two variables under consideration because the linear correlation coefficient only considerably deviated from zero in the case of Cu. The average levels of Cd and Pb found in the 65 samples of onions collected from the research area were below the upper limits set for these pollutants in vegetables.

Table 1 – Soil heavy metals content

Heavy metal	Min. value (mg/kg)	Max. value (mg/kg)
Cd	0.07	35.81
Pb	15	952
Zn	71	1811
Cu	25	132

Table 2 – Onion bulb heavy metal content

Heavy metal	Min. value (mg/kg)	Max. value (mg/kg)
Cd	0.007	0.106
Pb	0.009	0.136
Zn	1.00	11.7
Cu	0.20	1.36

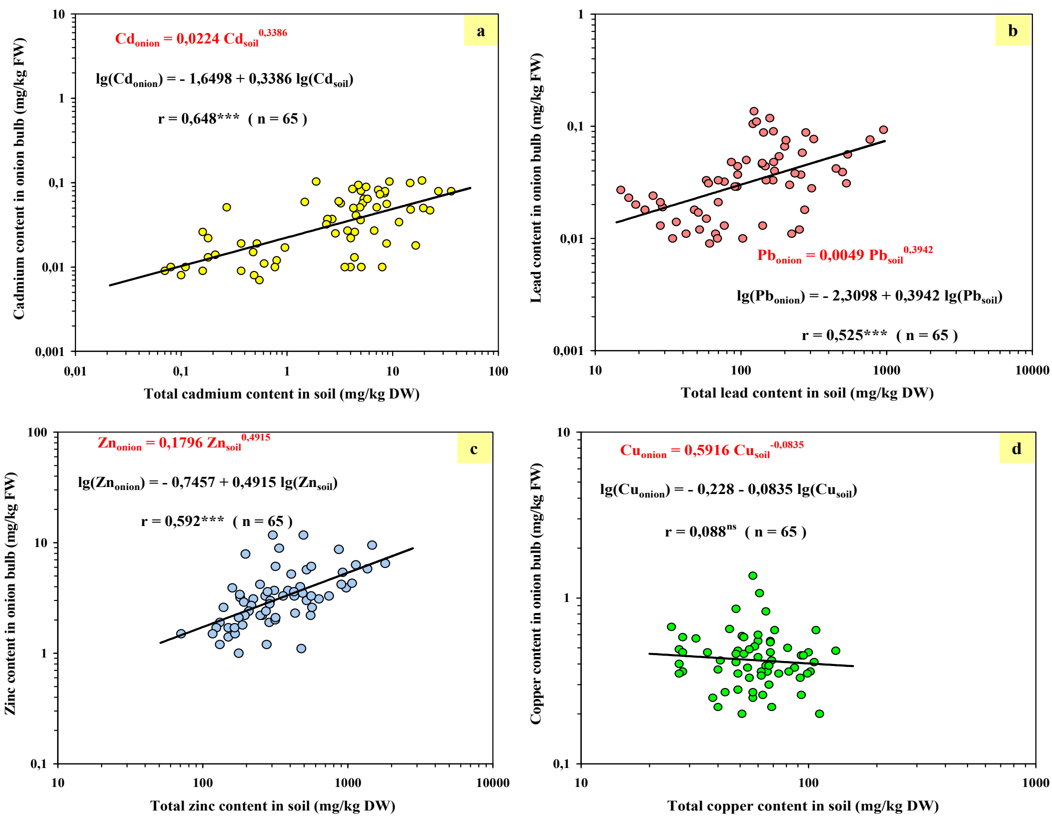

Figure 1 - Log-log diagrams for power regression curves that estimate the stochastic dependency between total cadmium (a), lead (b), zinc (c), and copper (d) contents in the soil (layer 0–20 cm) and cadmium (a), lead (b), zinc (c), and copper (d) contents in onion bulbs.

The values of the linear correlation coefficients for the three equations were significantly different from zero. There was no dependence between the two variables under consideration because the linear correlation coefficient only considerably deviated from zero in the case of Cu. The average levels of Cd and Pb found in the 65 samples of onions collected from the research area were below the upper limits set for these pollutants in vegetables.

DISCUSSION

Analysing the concentration of heavy metals in onion bulbs had the following pattern: Zn > Cu > Pb > Cd, as shown in Table 2. In this study, the Cd content of onion bulbs exceeded the maximum limit allowed in the European Union, according to Commission Regulation (EU) 2021/1323 (0.030 mg/kg wet matter). The analysed samples had a high Pb content (0.10 mg/kg wet matter), also exceeding the European limits set by Commission Regulation (EU) 2021/1317. Bystrická *et al.* (2015) reported that the Cd concentration ranged from 0.02 to 0.05 mg/kg, while the Pb content in all samples of the onions ranged from 0.05 to 0.21 mg/kg. Zn had a maximum value of 2.32 mg/kg, and Cu registered values between 0.67 and 1.06 mg/kg in Slovakia. Bedassa *et al.* (2017) indicated that onion leaves accumulate higher amounts of heavy metals than bulbs. The average results obtained by Atabay *et al.* (2011) in Turkey had the following values: 0.077 µg/g Cd, 0.340 µg/g Cu, 0.295 µg/g Pb and 0.594 µg/g Zn, which were similar to our results. Nwajuaku and Nweke (2019) demonstrated that onions are a very good indicator of the presence of heavy metals. Increased heavy metal concentrations inhibit root elongation.

A high Cd content in onion bulbs (0.063 and 0.066 mg/kg wet matter) was also reported by Bibi *et al.* (2021). Shroki *et al.* (2022) showed that the Cd and Pb content in the onion varieties analysed exceeded the accepted standard limits in Iran (0.05 mg/kg Cd and 0.1 mg/kg Pb). In general, onion leaves have a higher Zn and Cu content than onion bulbs (Kitata *et al.*, 2012). Cd and Pb content from soil samples exceeded the threshold values for sensitive land use (Ministry Order 756/1997).

CONCLUSION

The heavy metal contents of the onion bulbs and soil were analysed in this study. The pattern of metal concentration was Zn > Cu > Pb > Cd for both types of analysed samples (soil and onion bulbs). The Zn concentration had the highest value in both soil (1811 mg/kg) and onion bulbs (11.7 mg/kg), while Cd had the lowest value (soil = 35.81 mg/kg, onion bulbs = 0.106 mg/kg). However, Cd and Pb exceeded the limits set by the EU Commission Regulation, indicating the health risk arising from consuming onions in the researched area (Copșa Mică, central Romania).

Funding: This work was financed by project number PN 34.05.01 entitled: "Modeling the bioaccumulation of heavy metals in vegetables - a method used as scientific tool for development of a Good Practices Guide for growing vegetables in households in areas affected by industrial pollution" and project number 44 PFE /2021, Program 1 - Development of national research development system, Subprogramme 1.2 - Institutional performance – RDI Excellence Financing Projects.

Conflicts of Interest: There are no conflicts of interest associated with this study or work.

REFERENCES

Akbari, B.; Gharanfoli, F.; Khayyat, M. H.; Khashyarmanesh, Z.; Rezaee, R.; Karimi, G. Determination of heavy metals in different honey brands from Iranian markets. *Food Additives and Contaminants, Part B*. **2012**, 5(2), 105-111. https://doi.org/10.1080/19393210.2012.664173.

Al-Fraihat, A.H.; Ahmad, H. Effect of different nitrogen and sulphur fertilizer levels on growth, yield and quality of onion (Allium cepa L.). *Jordan Journal of Agricultural Sciences*. **2009**, *5*(2), 155-166.

Atabay, M.M.; Kekillioglu, A.; Arslan, M. Heavy metal accumulations of Allium cepa L. as a bioindicator for air pollution in Eregli, Turkey. *African Journal of Agricultural Research*. **2011**, 6, 6432-6439. https://doi.org/10.5897/AJAR11.676.

Bedassa, M; Abebaw, A; Desalegn, T. Assessment of Selected Heavy Metals in Onion Bulb and Onion Leaf (Allium cepa L.), in Selected Areas of Central Rift Valley of Oromia Region Ethiopia. *Journal of Horticulture.* **2017**, 4, 217. https://doi.org/10.4172/2376-0354.1000217.

Bibi, N.; Shah, M.H.; Khan, N.; Mahmood, Q.; Aldosari, A.A.; Abbasi, A.M. Analysis and health risk assessment of heavy metals in some onion varieties. *Arabian Journal of Chemistry*. **2021**, 14, 103364. https://doi.org/10.1016/j.arabjc.2021.103364.

Bystrická, J.; Musilová, J.; Tomáš, J.; Tóth, T.; Kavalcová, P.; Šiatkovský, O. Intake of heavy metals in selected varieties of onion (Allium cepa l.) Grown in the different locations/ Akumulacja metali ciężkich w wybranych odmianach cebuli (*Allium cepa* L.) uprawianych w różnych warunkach. *Environmental Protection and Natural Resources/Ochrona Środowiska i Zasobów Naturalnych*. **2015**, 26, 17-21. https://doi.org/10.1515/oszn-2015-0017.

Cao, S.; Duan, X.; Zhao, X.; Chen, Y.; Wang, B.; Sun, C.; Zheng, B.; Wei, F. Health risks of children's cumulative and aggregative exposure to metals and metalloids in a typical urban environment in China. *Chemosphere*. **2016**, 147, 404-411. https://doi.org/10.1016/j.chemosphere.2015.12.134.

Commission Regulation (EU) 2021/1317 of 9 August 2021 amending Regulation (EC) No 1881/2006 as regards maximum levels of lead in certain foodstuffs (Text with EEA relevance) (OJ L 286 10.08.2021, p. 1, ELI. Available online: http://data.europa.eu/eli/reg/2021/1317/oj (accessed on 22 August 2022).

Commission Regulation (EU) 2021/1323 of 10 August 2021 amending Regulation (EC) No 1881/2006 as regards maximum levels of cadmium in certain foodstuffs (Text with EEA relevance) (OJ L 288 11.08.2021, p. 13, ELI. Available online: http://data.europa.eu/eli/reg/2021/1323/oj (accessed on 22 August 2022).

de Oliveira, L.M.; Ma, L.Q.; Santos, J.A.; Guilherme, L.R.; Lessl, J.T. Effects of arsenate, chromate, and sulfate on arsenic and chromium uptake and translocation by arsenic hyperaccumulator Pteris vittata L. *Environmental pollution*. **2014**, 184, 187-192. https://doi.org/10.1016/j.envpol.2013.08.025.

Geremias, R.; Fattorini, D.; Fávere, V.T.; Pedrosa, R.C. Bioaccumulation and toxic effects of copper in common onion Allium cepa L. *Chemistry and Ecology*. **2010**, 26, 19-26. https://doi.org/10.1080/02757540903468144.

Heidarieh, M.; Maragheh, M.G.; Shamami, M.A.; Behgar, M.; Ziaei, F.; Akbari, Z. Evaluate of heavy metal concentration in shrimp (Penaeus semisulcatus) and crab (Portunus pelagicus) with INAA method. *SpringerPlus*. **2013**, 2, 1-5. https://doi.org/10.1186/2193-1801-2-72.

Huang, Y.; Lan, Y.; Thomson, S. J.; Fang, A.; Hoffmann, W.C.; Lacey, R.E. Development of soft computing and applications in agricultural and biological engineering. *Computers and electronics in agriculture*. **2010**, 71, 107-127. https://doi.org/10.1016/j.compag.2010.01.001.

Khan, S.; Cao, Q.; Zheng, Y.M.; Huang, Y.Z.; Zhu, Y.G. Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. *Environmental pollution*. **2008**, 152, 686-692. https://doi.org/10.1016/j.envpol.2007.06.056.

Kitata, R.B.; Chandravanshi, B.S. Concentration levels of major and trace metals in onion (*Allium cepa* L.) and irrigation water around Meki Town and Lake Ziway, Ethiopia. *Bulletin of the Chemical Society of Ethiopia*. **2012**, 26. http://dx.doi.org/10.4314/bcse.v26i1.4.

Krzesłowska, M.; Lenartowska, M.; Samardakiewicz, S.; Bilski, H.; Woźny, A. Lead deposited in the cell wall of Funaria hygrometrica protonemata is not stable–a remobilization can occur. *Environmental Pollution*. **2010**, 158, 325-338 https://doi.org/10.1016/j.envpol.2009.06.035.

Liu, C.; Chang, C.; Fei, Y.; Li, F.; Wang, Q.; Zhai, G.; Lei, J. Cadmium accumulation in edible flowering cabbages in the Pearl River Delta, China: critical soil factors and enrichment models. *Environmental Pollution*. **2018**, 233, 880-888. https://doi.org/10.1016/j.envpol.2017.08.092.

Martínez-Sánchez, M.J.; Martínez-López, S.; García-Lorenzo, M.L.; Martínez-Martínez, L.B.; Pérez-Sirvent, C. Evaluation of arsenic in soils and plant uptake using various chemical extraction methods in soils affected by old mining activities. *Geoderma*. **2011**, 160, 535-541. https://doi.org/10.1016/j.geoderma.2010.11.001.

Ministry Order No. 756 from November 3, 1997 for approval of Regulation concerning environmental pollution assessment, published in Official Monitor No. 303/6 November 1997.

Muhammad, S.; Shah, M.T.; Khan, S. Health risk assessment of heavy metals and their source apportionment in drinking water of Kohistan region, northern Pakistan. *Microchemical journal*. **2011**, 98, 334-343. https://doi.org/10.1016/j.microc.2011.03.003.

Nwajuaku, I.I.; Nweke, C.N. Comparative analysis of *Allium cepa* L. and white onion as bio-indicators of heavy metals inground water. *IRE Journals*. **2019**, 3, 96-101.

Rai, P.K.; Lee, S.S.; Zhang, M.; Tsang, Y.F.; Kim, K.H. Heavy metals in food crops: Health risks, fate, mechanisms, and management. *Environment international*. **2019**, 125, 365-385. https://doi.org/10.1016/j.envint.201.

Rehman, Z.U.; Khan, S.; Brusseau, M.L.; Shah, M.T. Lead and cadmium contamination and exposure risk assessment via consumption of vegetables grown in agricultural soils of five-selected regions of Pakistan. *Chemosphere*. **2017**, 168, 1589-1596. https://doi.org/10.1016/j.chemosphere.2016.11.152.

Säumel, I.; Kotsyuk, I.; Hölscher, M.; Lenkereit, C.; Weber, F.; Kowarik, I. How healthy is urban horticulture in high traffic areas? Trace metal concentrations in vegetable crops from plantings within inner city neighbourhoods in Berlin, Germany. *Environmental Pollution*. **2012**, 165, 124-132. https://doi.org/10.1016/j.envpol.2012.02.019.

Shokri, S.; Abdoli, N.; Sadighara, P.; Mahvi, A.H.; Esrafili, A.; Gholami, M.; Jannat, B.; Yousefi, M. Risk assessment of heavy metals consumption through onion on human health in Iran. *Food Chemistry*: X. **2022**, 14, 100283. https://doi.org/10.1016/j.fochx.2022.100283.

Sun, C.; Liu, J.; Wang, Y.; Sun, L.; Yu, H. Multivariate and geostatistical analyses of the spatial distribution and sources of heavy metals in agricultural soil in Dehui, Northeast China. *Chemosphere*. **2013**, 92, 517-523. https://doi.org/10.1016/j.chemosphere.2013.02.063.

Taghizadeh, S.F.; Davarynejad, G.; Asili, J.; Nemati, S.H.; Rezaee, R.; Goumenou, M.; Tsatsakis, A.M.; Karimi, G. Health risk assessment of heavy metals via dietary intake of five pistachio (Pistacia vera L.) cultivars collected from different geographical sites of Iran. *Food and chemical toxicology*. **2017**, 107, 99-107. https://doi.org/10.1016/j.fct.2017.06.035.

Tóth, G.; Hermann, T.; Da Silva, M.R.; Montanarella, L.J.E.I. Heavy metals in agricultural soils of the European Union with implications for food safety. *Environment international.* **2016**, 88, 299-309. https://doi.org/10.1016/j.envint.2015.12.017.

Waterlot, C.; Pruvot, C.; Marot, F.; Douay, F. Impact of a phosphate amendment on the environmental availability and phytoavailability of Cd and Pb in moderately and highly carbonated kitchen garden soils. *Pedosphere.* **2017**, 27, 588-605. https://doi.org/10.1016/S1002-0160(17)60354-0.

Yang, Q.W.; Xu, Y.; Liu, S.J.; He, J.F.; Long, F.Y. Concentration and potential health risk of heavy metals in market vegetables in Chongqing, China. *Ecotoxicology and Environmental Safety*. **2011**, 74, 1664-1669. https://doi.org/10.1016/j.ecoenv.2011.05.006.

Zhou, H.; Yang, W.T.; Zhou, X.; Liu, L.; Gu, J.F.; Wang, W.L.; Zou, J.L.; Tian, T.; Peng, P.Q.; Liao, B.H. Accumulation of heavy metals in vegetable species planted in contaminated soils and the health risk assessment. *International journal of environmental research and public health*. **2016**, 13, 289 https://doi.org/10.3390/ijerph13030289 https://dx.doi.org/10.3390/ijerph13030289.

Academic Editor: Dr. Isabela Maria Simion