Impacts of heavy metals on sustainability in Volos, Greece: reality or urban myth?

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The goal of this study is to monitor urban pollution caused by potentially hazardous elements (PHEs) in Volos, Greece, from 2018 to 2021. Furthermore, 248 soil samples were gathered in a period of 4 years, and the research area was around 3.65 km^2. For example, the business triangle under examination is bounded by the railway station, bus terminals, and the maritime port. Furthermore, the study was carried out in relation to the mandates of circular economy's schools of thought, the notion of urban sustainability, and the EU's Green Deal (EGD). Further, the levels of PHEs were revealed using data analysis and constructed maps. IBM SPSS 26.0 was used for statistical analysis, while QGIS 3.16 was used to create thematic maps. Briefly, this novel study observe urban pollution by PHEs based on two schools of thought in circular economy, urban sustainability, and EGD.

Heavy metals (HMs) or potentially hazardous elements (PHEs) are chemical nutrients with density above 6 $g*cm^3$ (Phipps, 1981). Human organisms as well as the flora and fauna are being affected positively by PHEs, when the latter are in insignificant amounts, however, when PHEs reach extreme levels, then plenty of problems come after (Bradl, 2002). Heavy metals buildup in soils is a source of worry in agricultural production owing to the negative impacts on crop development caused by phytotoxicity, as well as the health conditions of soil organisms (Asati et al., 2016; Golia et al, 2021). Hence, it is imperative that means, and mechanisms be developed in order to cope with the overaccumulation of PHEs in urban soils, then urban sustainability might be attainable and feasible.

Firstly, circular economy (CE) might provide the theoretical background for such an endeavor. The transition from a linear model into a circular economy scheme promotes the establishment of a sustainable and resilient system with plethora of social and environmental benefits and economic incentives (EMAF, 2021). Moreover, circular economy is composed by several schools of thought, however two of these schools are distinctive examples. For instance, 'regenerative design' and 'biomimicry' constitute two theoretical backgrounds that could be a channel for combating pollution and creating potential assets for environmental preservation (EMAF, 2013).

Secondly, sustainability is based on the triple bottom line (TBL), which is composed by 3Ps: people, planet, and profit (Elkington, 1997). Triple bottom line has been transformed into a new strategy, according to Sustainable Development Goals, now the new strategy is encompassed by 5Ps: people, planet, prosperity, peace, and partnership (UN, 2022). The above strategy ensures that the goals 11 and 12 should not be violated in order to establish sustainability, a case in point is urban sustainability (US) because of the previous goals (EMAF, 2019).

Having these in mind, urban sustainability is achievable, only if circular economy and the magnates of sustainability are applied in order to minimize the externalities of anthropogenic sources of pollution. Additionally, EU's green deal and UN's SDGs are profound examples of institutional initiatives and strategies which pay a lot of effort to implement viable and resilient nature-based solutions (NbS) (Europa, 2022; UN, 2022). All in all, phytoremediation is a NbS and 'best practice' that struggles to diminish the extravagant standards of PHEs in – urban or agricultural – soils (Akpor and Munchie, 2010). Implementation of phytoremediation – a green technology – could be tried via natural or induced phytoremediation (Rahman et al., 2014). These ways of phytoremediation apply, in fact, the notions of the two aforementioned schools of thought of CE and US as well.

The heavy metals that this case study would focus are: cadmium (Cd) and Zinc (Zn) (Figure 1). Cd and Zn can be emitted by the brakes of transport vehicles, or from maritime activities (Christophoridis and Stamatis, 2009; Bourliva et al., 2018). Extremely detrimental for human health is Cd, especially for heavy – smokers (WHO, 2017; WHO, 2019). On the other hand, Zn might arouse health problems like procrastination of physical and mental growth (Chasapis et al., 2020). As recommendations of this study are the plants: salix nigra and brassica napus, these plants are best practices because of their effective implementation in other relevant studies. For instance, salix nigra is appropriate for soils polluted by Cd, Mn and Zn (Massenet et al., 2021). Other study that advised the use of salix microcuttings was of Frenette-Dussaulta et al. (2019).

To recapitulate, salix nigra and brassica napus are the recommended best practices and NbS of this case study. In a nutshell, phytoremediation is a best practice and a NbS that encourages stakeholders into adapting them, because of their uncomplicated implementation and economical costs under the guidance of biomimicry and 5Ps.

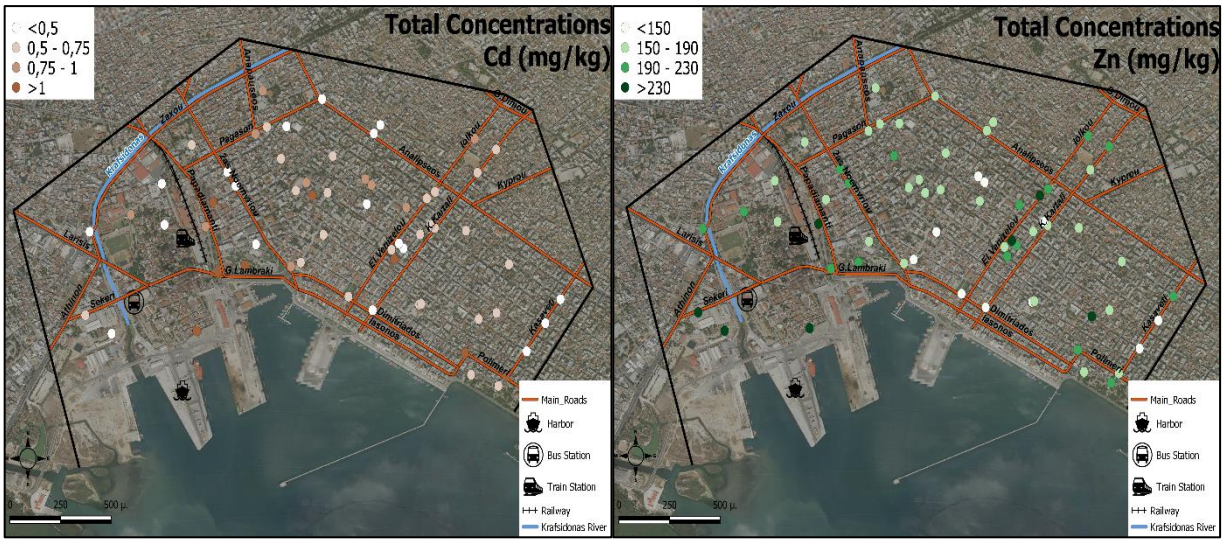

Figure 1: Total concentrations of Cd and Zn in Volos city, 2021

Akpor, O. B. and Muchie, M. (2010) 'Remediation of heavy metals in drinking water and wastewater treatment systems: Processes and applications', International Journal of the Physical Sciences Vol. 5(12), pp. 1807-1817.

Asati, A., Pichhode, M. and Nikhil, K. (2016) 'Effect of heavy metals on plants: an overview. International journal of application or innovation in engineering and management, vol 5, (3).

Bourliva, A., Kantiranis, N., Papadopoulou, L., Aidona, E., Christophoridis, C., Kollias, P., Evgenakis, M. and Fytianos, K. (2018) 'Seasonal and spatial variations of magnetic susceptibility and potentially toxic elements (PTEs) in road dusts of Thessaloniki city, Greece: A one-year monitoring period', Science of the Total Environment, 639, 417 – 427.

Bradl, H. (2002) 'Heavy metals in the environment: origin, interaction and remediation'. Academic Press, London, vol. 6.

Chasapis, C. T., Ntoupa, P-S. A., Spiliopoulou, C. A. and Stefanidou, M. E. (2020) 'Recent aspects of the effects of zinc on human health', Archives of Toxicology. 94. 1443 – 1460.

Christophoridis, A. and Stamatis, N. (2009) 'Heavy metal contamination in street dust and roadside soil along the major national road in Kavala's region, Greece',Geoderma 151, 257 – 263.

Elkington, J. (2013) Enter the Triple Bottom Line.

EMAF (2013) 'Towards the circular economy: Economic and business rationale for an accelerated transition'.

EMAF (2019) 'City governments and their role in enabling circular economy transition'.

EMAF (2021) 'The nature imperative: how the circular economy tackles biodiversity loss'.

Europa (2022) A European green deal. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

Frenette-Dussaulta, C., Benoista, P., Kadria, H., Pitrea,F. E. and Labrecque, M. (2019) 'Rapid production of willow biomass using a novel microcutting-based field planting technology', Ecological Engineering, 37-42.

Golia, E. E., Papadimou, S. G., Calavaris, C. and Tsiropoulos, N. G. (2021) 'Level of Contamination Assessment of Potentially Toxic Elements in the Urban Soils of Volos City (Central Greece)', Sustainability.

Massenet, A., Bonet, A., Laur, J. and Labrecque M. (2021) 'Co-planting Brassica napus and Salix nigra as a phytomanagement alternative for copper contaminated soil', Chemosphere.

Phipps, D. A. (1981) 'Chemistry and Biochemistry of Trace Metals in Biological Systems', In N. W. Lepp (Ed.), Effect of Heavy Metal Pollution on Plants: Effects of Trace Metals on Plant Function (1–54), Dordrecht: Springer Netherlands.

Rahman, M. A., Reichman, S. M., De Filippis, L., Sany, S. B. T. and Hasegawa (2014) 'Phytoremediation of toxic metals in soils and wetlands: concepts and applications', In: Environmental Remediation Technologies for Metal-Contaminated Soils, Springer Japan.

UN (2022) The 17 goals. https://sdgs.un.org/goals

WHO (2017) Guidelines for drinking-water quality. https://www.who.int/publications/i/item/9789241549950

WHO (2019) Exposure to cadmium: A major public health concern. https://apps.who.int/iris/bitstream/handle/10665/329480/WHO-CED-PHE-EPE-19.4.3-eng.pdf