Potential of using hemp as an accumulator of heavy metals and a raw material for the production of bioconcrete – a review

M. Landrat[1], M. Lewandowski[1], K. Pikoń[1]

[1]Department of Technologies and Installations for Waste Management, Silesian University of Technology, 44-100 Gliwice, Poland

Keywords: biomass, phytoremediation, hemp, hempcrete, heavy metals, circular economy

Presenting author email: marcin.landrat@polsl.pl

The dominant majority of soil pollution, in the form of heavy metals, radionuclides, aromatic hydrocarbons and other chemical compounds, has its source in human activity and various branches of the economy (industry, power engineering, non-ecological agriculture) (Arik et al.,2010). The main sources of heavy metals and their compounds are most often combustion products generated in power plants and cement plants, engine exhaust gases, remains of artificial fertilizers and non-biological plant protection products, as well as waste generated from the use of photovoltaic panels, batteries and fuel cells (Rai et al., 2019). These compounds do not naturally decompose in the soil and also adversely affect its quality, ultimately getting into plant tissues (Borymski and Piotrowska-Seget, 2014). Increased levels of these compounds have a negative impact on the functioning of plants and, in the case of plants cultivated for food purposes, they ultimately reach the bodies of consumers, leading to poisoning and health effects, often contributing to the development of cancer. This is particularly important in the current economic situation, where as the world's population grows, the demand for food increases, and as a result, more and more arable land is required (Banuelos and Aiwa, 1999). Therefore, the need to extract contaminants from soil, in order to return areas to agricultural use is an essential action to meet the world's nutritional needs.

Numerous remediation methods often focus on the extraction, transport of contaminated soil and its further, most often thermal or chemical, treatment. However, these methods lead to derivative pollution, are energy-consuming and often destroy the natural soil microflora (Conesa et al., 2012). An alternative to these technologies are phytotechnologies (Udawat and Singh, 2020), biological methods of soil reclamation, most often using plants (Sarwar et al., 2017). The main advantages of phytotechnologies are their low cost, positive impact on the environment, and the production of easily managed waste in the form of biomass, which is a source of renewable energy (Conesa et al., 2012). Phytotechnologies usually exploit the ability of plants to absorb substances from the medium in which they grow. Metals and other contaminantions are absorbed by the roots or stabilized in their surroundings. Depending on the type and species of chosen plant, the process of accumulation of a specific polluting compound is different. The main phytoremediation methods classified as phytotechnology include (Todde et al., 2022):

- Rhizofiltration used to purify waterlogged land by accumulating metals in the root tissues of plants previously grown in hydroponics.
- Phytostabilization consisting in stabilizing pollutants in soil, around and on the surface of the root ball.
- Phytooxidation focusing on the uptake of pollutants from the soil, their further breakdown into less harmful compounds in the plant tissues, and finally their transpiration into the atmosphere.
- Phytoextraction, which involves the absorption of pollutants by the plant and their translocation throughout its entire biomass.

Plants used mainly for phytoremediation are called hyperaccumulators and these are the varieties/species of the plants that most effectively absorb pollutants while maintaining optimal and rapid growth (Rascio and Navari-Izzo, 2011). An examples of a hyperaccumulator that appears frequently in the literature are hemps.

Hemp (*Cannabis sativa*) is an annual plant cultivated for food and medicinal purposes, as a raw material for the production of textiles, and is also an effective source of biomass (Kraszkiewicz et al., 2019). Hemp is also highly effective in the process of phytoextraction of heavy metals from the soil, especially cadmium and zinc (Linger et al., 2005).

Another example of the use of hemp is the use of its stems to produce a biocomposite with the addition of lime binder, called hemp concrete (Asghari and Memari, 2024). This bioconcrete, due to the origin of its

ingredients, generates a very low or even zero carbon footprint during its production, which is a big advantage compared to traditional concrete based on sand and cement (Jami et al., 2016). Hempcrete has been tested from many angles as a building material and is characterized by high-quality thermal insulation and soundproofing properties, low density and good moisture drainage; however its biggest practical disadvantage is lower mechanical strength, which does not allow its use in load-bearing structures (Amziane and Sonebi, 2016), but many current research focuses on improving this parameter (e.g. by adding various substances or using a different binder) (Jami et al., 2019).

Following article contains a detailed review of the available literature on phytotechnologies, the use of hemp for the accumulation of heavy metals from the soil and the production of bioconcrete based on them. The combination of both mentioned uses of hemp aims to assess the potential for accumulation and stabilization of heavy metals in a building biocomposite, as part of a process consistent with the circular economy model.

Arik, F., Yaldiz, T. (2010) Heavy metal determination and pollution of the soil and plants of southeast Tavsanli (Kutahya, Turkey). Clean: Soil Air Water, 38 (11), 1017–1030.
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. Environ. Int. 2019, 125, 365–385.
Borymski, S.; Piotrowska-Seget, Z. Rhizosphere of metallophytes and its role in bioremediation of heavy metals. Chemik 2014, 68, 554–559.
Bañuelos, G.S.; Ajwa, H.A. Trace elements in soils and plants: An overview. J. Environ. Sci. Health Part A 1999, 34, 951–974.
Conesa, H. M., Evangelou, M. W. H., Robinson, B. H., & Schulin, R. (2012). A critical view of current state of phytotechnologies to re-mediate soils: Still a promising tool? The Scientific World Journal, 2012.
Udawat, P.; Singh, J. Phytoremediation: A way towards sustainable Agriculture. Int. J. Environ. Agric. Biotechnol. 2020, 5, 1167–1173.
Sarwar N, Imran M, Shaheen MR, et al. Phytoremediation strategies for soils contaminated with heavy metals: Modifications and future perspectives. Chemosphere. 2017;171:710-721.
Todde, G.; Carboni, G.; Marras, S.; Caria, M.; Sirca, C. Industrial Hemp (Cannabis sativa L.) for Phytoremediation: Energy and Environmental Life Cycle Assessment of Using Contaminated Biomass as an Energy Resource. Sustain. Energy Technol. Assess. 2022, 52, 102081.
Rascio, Nicoletta; Navari-Izzo, Flavia (2011). "Heavy metal hyperaccumulating plants: How and why do they do it? And what makes them so interesting?". Plant Science. 180 (2): 169–181.
Kraszkiewicz, A.; Kachel, M.; Parafiniuk, S.; Zając, G.; Niedziółka, I.; Sprawka, M. Assessment of the Possibility of Using Hemp Biomass (Cannabis sativa L.) for Energy Purposes: A Case Study. Appl. Sci. 2019, 9, 4437.
Linger, P.; Ostwald, A.; Haensler, J. Cannabis sativa L. Growing on Heavy Metal Contaminated Soil: Growth, Cadmium Uptake and Photosynthesis. Biol. Plant. 2005, 49, 567–576.
Asghari, N.; Memari, A.M. State of the Art Review of Attributes and Mechanical Properties of Hempcrete. Biomass 2024, 4, 65-91.
Jami, T.; Rawtani, D.; Agrawal, Y.K. Hemp concrete: Carbon-negative construction. Emerg. Mater. Res. 2016, 5, 240–247
Amziane, S.; Sonebi, M. Overview on biobased building material made with plant aggregate. RILEM Tech. Lett. 2016, 1, 31–38.
Jami, T.; Karade, S.; Singh, L. A review of the properties of hemp concrete for green building applications. J. Clean. Prod. 2019, 239, 117852.

The authors wish to thank the Silesian University of Technology for providing funding (08/030/BK_24/0131).